T1300415 Faraday Isolator upper blade spring D0900541-v4
2/18/13

acceleration of gravity, m/s^2 $g := 9.8$

Faraday Isolator upper blade spring

E correction factor (see p. 4) $\rho := 0.9896$

new modulus of elasticity, Pa $E := 186 \cdot 10^{9} \cdot \rho$ $E = 1.84066 \times 10^{11}$

modulus of elasticity, psi $E_{psi} := \frac{E}{6895}$ $E_{psi} = 2.66955 \times 10^{7}$

Weight suspended

OFI without balance wts, lb $m_{wtlb} := 38.93 - 2$ $m_{wtlb} = 36.93$

variable balance wt, lbs $m_{v} := 2$

design weight, lbs $m_{bslb} := m_{wtlb} + m_{v}$

$m_{bslb} = 38.93$

suspended mass, kg $m_{mp}(m_{bslb}) := \frac{m_{bslb}}{2.205}$ $m_{mp}(m_{bslb}) = 17.65533$

yield stress of C-250 steel, Pa $S_{yieldms} := 1800 \cdot 10^{6}$

yield stress of C-250 steel, psi $S_{yieldmspsi} := S_{yieldms} \cdot \left(1.45 \cdot 10^{-4}\right)$

$S_{yieldmspsi} = 2.61 \times 10^{5}$

factor of safety (see p. 4) $FS := 3.58328$

working stress of C-250 steel, Pa
$S_{wms}(FS) := \frac{S_{yieldms}}{FS}$ $S_{wms}(FS) = 5.02333 \times 10^{8}$

working stress of C-250 steel, psi
$S_{wspsi} := S_{wms}(FS) \cdot 1.45 \cdot 10^{-4}$ $S_{wspsi} = 7.28383 \times 10^{4}$

number of springs
$N := 2$

mass supported by each blade spring, kg
$m_{bs}(m_{bslb}) := \frac{m_{mp}(m_{bslb})}{N}$ $m_{bs}(m_{bslb}) = 8.82766$

load on blade spring, N
$P(m_{bslb}) := m_{bs}(m_{bslb}) \cdot 9.8$ $P(m_{bslb}) = 86.51111$

arc of blade spring, rad
$\theta_m := \frac{\pi}{4}$ $\theta_m = 0.7854$

blade arc angle, deg
$\theta_{mdeg}(\theta_m) := \theta_m \cdot \frac{180}{\pi}$ $\theta_{mdeg}(\theta_m) = 45$

horizontal distance of suspension point from blade spring mount, in
$x_{bsin} := 9.918$

mounting location of blade spring
left of center, m
$x_{bs} := x_{bsin} \cdot .0254$ $x_{bs} = 0.25192$

radius of blade spring, m
$R_{bs}(\theta_m, x_{bs}) := \frac{x_{bs}}{\sin(\theta_m)}$ $R_{bs}(\theta_m, x_{bs}) = 0.35626$

radius of blade spring, in
$R_{bsin}(\theta_m, x_{bs}) := \frac{R_{bs}(\theta_m, x_{bs})}{.0254}$

$R_{bsin}(\theta_m, x_{bs}) = 14.02617$

length of blade spring, m
$l_{bs}(\theta_m, x_{bs}) := R_{bs}(\theta_m, x_{bs}) \cdot \theta_m$

length of blade spring, in
$l_{bsin}(\theta_m, x_{bs}) := \frac{l_{bs}(\theta_m, x_{bs})}{.0254}$

design width, in $b_{in} := 2.83$

Calculate thickness

$$t(m_{bslb}) := \left(\frac{12 \cdot P(m_{bslb}) \cdot R_{bs}(\theta_m, x_{bs})^2}{0.0254 \cdot E \cdot b_{in}} \cdot \sin\left(\frac{l_{bs}(\theta_m, x_{bs})}{R_{bs}(\theta_m, x_{bs})}\right)\right)^{\frac{1}{3}}$$

$$t(m_{bslb}) = 1.91674 \times 10^{-3}$$

thickness of blade spring, in $t_{in}(m_{bslb}) := \frac{t(m_{bslb})}{.0254}$ $t_{in}(m_{bslb}) = 0.07546$

incremental weight change with δt inch increase in thickness, lbs

$$\delta m_{\delta tbslb}(\delta t) := \frac{m_{bslb}}{N} \cdot \left[\left(\frac{t_{in}(m_{bslb}) + \delta t}{t_{in}(m_{bslb})}\right)^3 - 1\right]$$

$$\delta t := 0.0005$$

$$\delta m_{\delta tbslb}(\delta t) = 0.38948$$

maximum stress, Pa

$$S_{wms} := \frac{E \cdot t(m_{bslb})}{2 \cdot R_{bs}(\theta_m, x_{bs})}$$

$$S_{wms} = 4.95146 \times 10^8$$

maximum stress, psi $S_{wspsi} := S_{wms} \cdot 1.45 \cdot 10^{-4}$ $S_{wspsi} = 7.17962 \times 10^4$

factor of safety $FS := \frac{S_{yieldms}}{S_{wms}}$ $FS = 3.63529$

Vertical Bounce Frequency

vertical height of suspension from blade spring mount, m

$$y_{bs}(\theta_m) := R_{bs}(\theta_m, x_{bs})\cdot(1 - \cos(\theta_m))$$

$$y_{bs}(\theta_m) = 0.10435$$

vertical height of suspension from blade spring mount, in

$$y_{bsin}(\theta_m) := \frac{y_{bs}(\theta_m)}{0.0254}$$

$$y_{bsin}(\theta_m) = 4.10817$$

unloaded height of blade spring, m

$$y_{max} := l_{bs}(\theta_m, x_{bs})\cdot\sin(\theta_m)$$

vertical distance blade moves, m

$$\Delta_y(\theta_m) := y_{max} - y_{bs}(\theta_m)$$

vertical distance blade moves, in

$$\Delta_{yin}(\theta_m) := \frac{\Delta_y(\theta_m)}{0.0254} \qquad \Delta_{yin}(\theta_m) = 3.68141$$

vertical resonant frequency based on blade depression, Hz

$$f_{0v}(\theta_m) := \frac{\sqrt{\frac{g}{\Delta_y(\theta_m)}}}{2\cdot\pi} \qquad f_{0v}(\theta_m) = 1.62933$$

effective spring constant, N/m

$$k := (2\cdot\pi\cdot f_{0v}(\theta_m))^2\cdot m_{mp}(m_{bslb})$$

effective spring constant, N/m

$$k = 1.85035 \times 10^3$$

incremental force for 0.25 lb weight change, N

$$\delta F := \frac{0.25}{2.205}\cdot g$$

height change with 0.25 lb added weight, m

$$\delta h := \frac{\delta F}{k}$$

$$\delta h = 6.00487 \times 10^{-4}$$

volume of suspended OFI, in^3

$$V_{OFIin} := 288.2$$

volume of suspended OFI, m^3

$$V_{OFI} := 288.2\cdot(.0254)^3 \qquad V_{OFI} = 4.72275 \times 10^{-3}$$

density of air, kg/m^3 $\rho_{air} := 1.2$

effective reduction in mass during pumpdown, kg $\Delta m := \rho_{air} \cdot V_{OFI}$ $\Delta m = 5.6673 \times 10^{-3}$

height change due to change in effective mass, m $\Delta h := \Delta m \cdot \frac{g}{k}$

$\Delta h = 3.00157 \times 10^{-5}$

height change vs temperature

Modulus variation with temperature, Pa/degC
(ref: Lisa Bates, et al; p.9 Vol 18, #1 Journal of Undergraduate Researach in Physics, and De Salvo P070095)

$R_{Et} := 2 \cdot 10^{-4} \cdot E$

$R_{Et} = 3.68131 \times 10^{7}$

Effective spring constant variation with temp, N/m-degC

$$R_{kt} := \frac{g \cdot m_{mp}(m_{bslb}) \cdot t(m_{bslb}) \cdot FS \cdot R_{Et}}{R_{bs}(\theta_m, x_{bs}) \cdot (1 - \cos(\theta_m)) \cdot 2 \cdot S_{yieldms}}$$

$R_{kt} = 0.11815$

Effective height variation with temp, m/degC

$$R_{ht} := \frac{-m_{mp}(m_{bslb}) \cdot g \cdot R_{kt}}{k^2}$$

$R_{ht} = -5.97058 \times 10^{-6}$

Blade height change with long-term creep

ref: De Salvo P070095

blade spring elongation, m $\Delta_y(\theta_m) = 0.09351$

long-term creep elongation, m $\Delta y_{creep} := 0.0044 \cdot \Delta_y(\theta_m)$

$$\Delta y_{creep} = 4.11434 \times 10^{-4}$$

effective balance weight loss
of blade due to initial creep aging, lbs

$$\delta F_{lb} := k \cdot \Delta y_{creep} \cdot \frac{2.205}{g}$$

$$\delta F_{lb} = 0.17129$$

Pendulum Frequency

length of pendulum, m $\quad l_{fiw} := 24.5 \cdot 0.0254 \qquad l_{fiw} = 0.6223$

pendulum frequency, Hz

$$f_{0p} := \frac{\sqrt{\dfrac{g}{l_{fiw}}}}{2 \cdot \pi} \qquad f_{0p} = 0.63159$$

WIDTH OF BLADE SPRING

WIDTH OF BLADE SPRING

constant factor, m

$$C(\theta_m, x_{bs}, m_{bslb}) := \frac{6 \cdot P(m_{bslb}) \cdot R_{bs}(\theta_m, x_{bs})}{S_{wms} \cdot t(m_{bslb})^2}$$

$$C(\theta_m, x_{bs}, m_{bslb}) = 0.10166$$

max blade width, in

$$l_{in} := l_{bsin}(\theta_m, x_{bs})$$

$$b_{in}(\theta_m, l_{in}, x_{bs}, m_{bslb}) := \frac{C(\theta_m, x_{bs}, m_{bslb})}{.0254} \cdot \sin\left(\frac{l_{in}}{R_{bsin}(\theta_m, x_{bs})}\right)$$

$$b_{in}(\theta_m, l_{in}, x_{bs}, m_{bslb}) = 2.83$$

$b_{in}(\theta_m, l_{bsin}(\theta_m, x_{bs}), x_{bs}, m_{bslb}) = 2.83$

$b_{in}\left(\theta_m, \frac{l_{bsin}(\theta_m, x_{bs})}{4}, x_{bs}, m_{bslb}\right) = 0.7808$ $\frac{l_{bsin}(\theta_m, x_{bs})}{4} = 2.75403$

$b_{in}\left(\theta_m, \frac{l_{bsin}(\theta_m, x_{bs})}{2}, x_{bs}, m_{bslb}\right) = 1.53158$ $\frac{l_{bsin}(\theta_m, x_{bs})}{2} = 5.50806$

$b_{in}(\theta_m, l_{bsin}(\theta_m, x_{bs}) \cdot 0.75, x_{bs}, m_{bslb}) = 2.22352$ $l_{bsin}(\theta_m, x_{bs}) \cdot 0.75 = 8.2621$

$b_{in}(\theta_m, l_{bsin}(\theta_m, x_{bs}), x_{bs}, m_{bslb}) = 2.83$ $l_{bsin}(\theta_m, x_{bs}) = 11.01613$

max width of blade spring, in $b_{inm}(\theta_m, x_{bs}, m_{bslb}) := b_{in}(\theta_m, l_{bsin}(\theta_m, x_{bs}), x_{bs}, m_{bslb})$

$b_{inm}(\theta_m, x_{bs}, m_{bslb}) = 2.83$

$\frac{C(\theta_m, x_{bs}, m_{bslb})}{2 \cdot .0254} = 2.00111$ $R_{bsin}(\theta_m, x_{bs}) = 14.02617$

Solid Works equation

$x := 0$

Solid Works equation

$$y_{down}(x) := -2.0024 \cdot \sin\left(\frac{x}{14.02617}\right)$$

$$y_{up}(x) := 2.0024 \cdot \sin\left(\frac{x}{14.02617}\right)$$

straight line eqtn

$$sl(l_{in}) := \frac{C(\theta_m, x_{bs}, m_{bslb}) \cdot \sin\left(\frac{l_{bsin}(\theta_m, x_{bs})}{R_{bsin}(\theta_m, x_{bs})}\right)}{2 \cdot 0.0254} \cdot \frac{l_{in}}{l_{bsin}(\theta_m, x_{bs})}$$

Stress at any Cross Section

maximum torque at mount, in-lb

$$\tau_{wall} := x_{bsin} \cdot m_{bs}(m_{bslb})$$

$$\tau_{wall} = 87.55278$$

stress at x, Pa

$$S(\theta_m, m_{bslb}, x) := \frac{6 \cdot P(m_{bslb}) \cdot R_{bs}(\theta_m, x_{bs}) \cdot \sin\left(\frac{x}{R_{bsin}(\theta_m, x_{bs})}\right)}{.0254 \cdot b_{in}(\theta_m, x, x_{bs}, m_{bslb}) \cdot t(m_{bslb})^2}$$

$$x := \frac{l_{bsin}(\theta_m, x_{bs})}{2} \qquad x := 0.1$$

Stress at position x, Pa

$$S(\theta_m, m_{bslb}, x) = 4.95146 \times 10^8$$

Stress at position x, psi

$$S_{psi}(\theta_m, m_{bslb}, x) := S(\theta_m, m_{bslb}, x) \cdot \left(1.45 \cdot 10^{-4}\right)$$

$$S_{psi}(\theta_m, m_{bslb}, x) = 7.17962 \times 10^4$$

Design Stress at position x, psi

$$S_{wspsi} = 7.17962 \times 10^4$$

summary of design parameters

weight of FI, lbs

$$m_{bslb} = 38.93$$

blade arc, deg

$$\theta_{mdeg}(\theta_m) = 45$$

blade length, in

$$l_{bsin}(\theta_m, x_{bs}) = 11.01613$$

thickness, in

$$t_{in}(m_{bslb}) = 0.07546$$

maximum width, in

$$b_{inm}(\theta_m, x_{bs}, m_{bslb}) = 2.83$$

radius of blade spring, in

$$R_{bsin}(\theta_m, x_{bs}) = 14.02617$$

horizontal distance of suspension point from blade spring mount, in

$$x_{bsin} = 9.918$$

vertical height of suspension from blade spring mount, in $y_{bsin}(\theta_m) = 4.10817$

vertical bounce frequency, Hz $f_{0v}(\theta_m) = 1.62933$

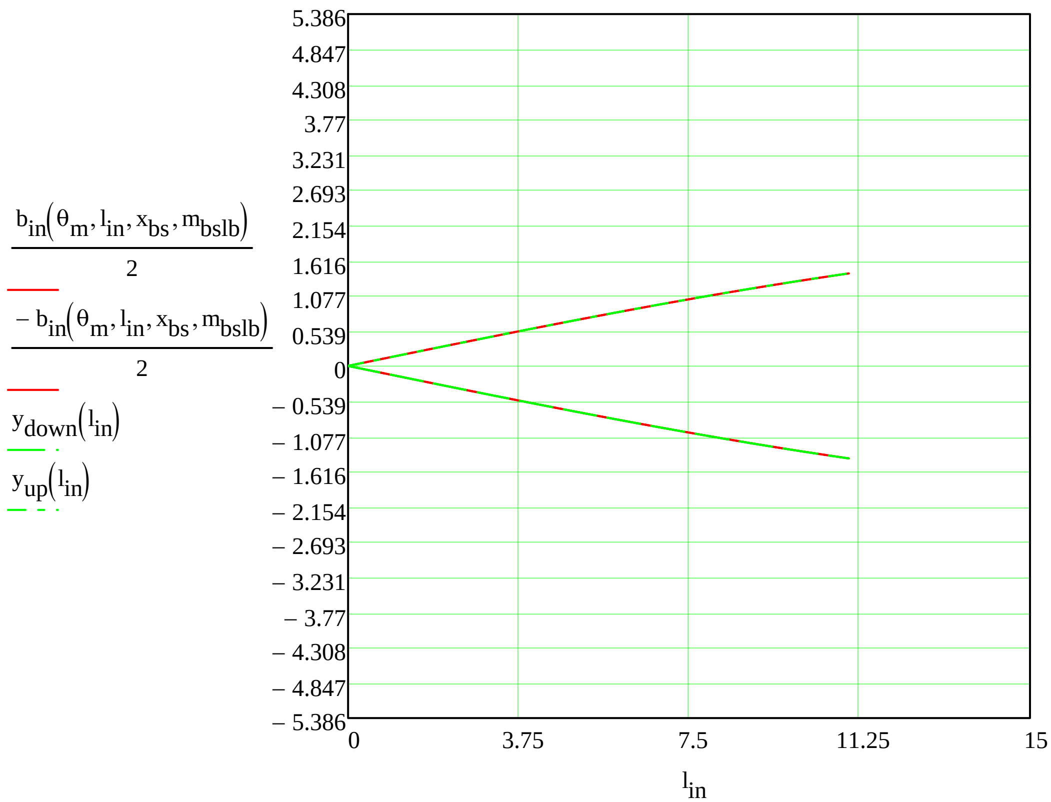
effective spring constant, N/m $k = 1.85035 \times 10^3$

pendulum frequency, Hz $f_{0p} = 0.63159$

straight line eqtn

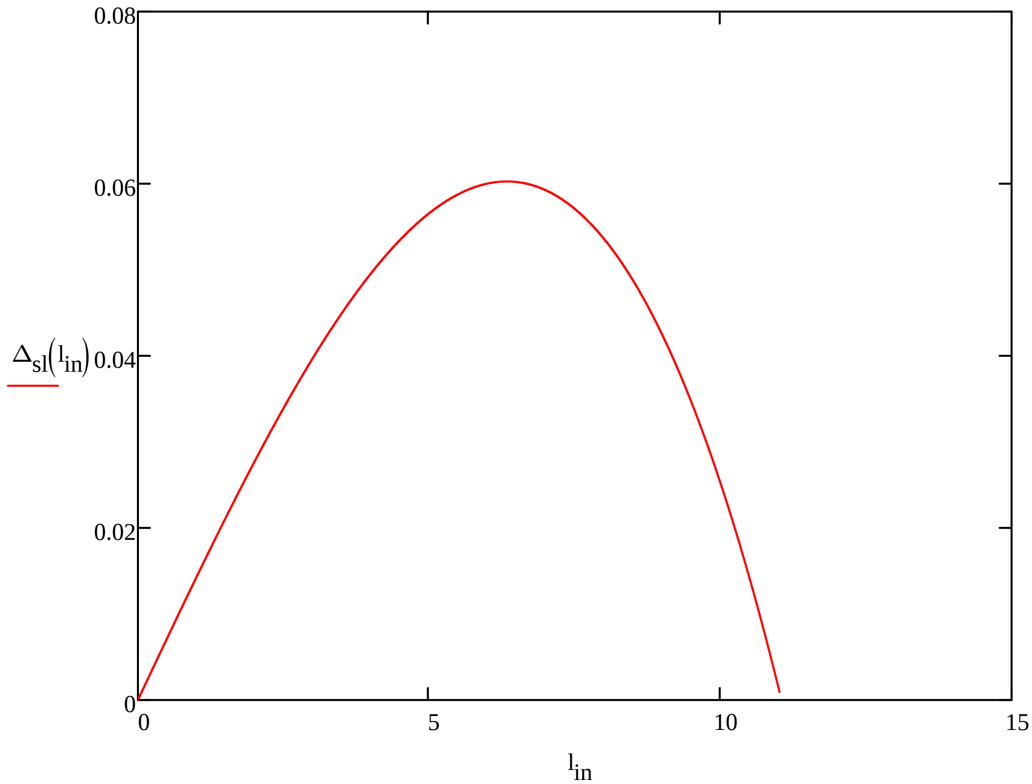
$$sl(l_{in}) := \frac{b_{inm}(\theta_m, x_{bs}, m_{bslb})}{2 \cdot l_{bsin}(\theta_m, x_{bs})} \cdot l_{in}$$

$$l_{in} := 0, 0.001 .. l_{bsin}(\theta_m, x_{bs})$$



$l_{in} := 0, 0.001 .. l_{bsin}(\theta_m, x_{bs})$

difference from straight line $\Delta_{sl}(l_{in}) := y_{up}(l_{in}) - sl(l_{in})$



support of Faraday with two wires

yield strength of music wire, psi $S_{yieldpsi} := 280000$

factor of safety $FS_{wire} := 6$

working stress of music wire, psi $S_{wpsi} := \frac{S_{yieldpsi}}{FS_{wire}}$ $S_{wpsi} = 4.66667 \times 10^{4}$

working stress of music wire, Pa $S_{ws} := \frac{S_{wpsi}}{1.45 \cdot 10^{-4}}$ $S_{ws} = 3.21839 \times 10^{8}$

weight of FI, lbs $m_{bslb} = 38.93$

mass of FI, kg $m_{mp}(m_{bslb}) = 17.65533$

number of springs $N := 2$

mass supported by each blade spring, kg $m_{bs}(m_{bslb}) := \dfrac{m_{mp}(m_{bslb})}{N}$ $m_{bs}(m_{bslb}) = 8.82766$

number of wires per spring $N_w := 2$

diameter of wire, m $d_w := \sqrt{\dfrac{4 \cdot m_{bs}(m_{bslb}) \cdot g}{\pi \cdot S_{ws} \cdot N_w}}$ $d_w = 4.13672 \times 10^{-4}$

diameter of wire, in $d_{win} := \dfrac{d_w}{0.0254}$ $d_{win} = 0.01629$

length of Faraday wire, m $l_{fiw} := 16.4 \cdot 0.0254$ $l_{fiw} = 0.41656$

pendulum frequency, Hz $f_0 := \dfrac{\sqrt{\dfrac{g}{l_{fiw}}}}{2 \cdot \pi}$ $f_0 = 0.77196$

VIRGO data

deflection of blade, m $z_0 := 0.1$

creep time interval, hrs $t_{300} := 300$

35 deg C creep data with no aging

creep after 300 hrs, m $\Delta z_{35} := 90 \cdot 10^{-6}$

strain after 300 hrs, m/m $\varepsilon_{V35300} := \dfrac{\Delta z_{35}}{z_0}$ $\varepsilon_{V35300} = 9 \times 10^{-4}$

exponential creep rate, 1/hr

$$R_{creep35} := \frac{-1}{t_{300}} \cdot \ln\left(1 - \frac{\Delta z_{35}}{z_0}\right) \cdot 0.9$$

$$R_{creep35} = 2.70122 \times 10^{-6}$$

time duration, hrs

$$t := 300$$

vertical blade deflection, m

$$\Delta_y(\theta_m) = 0.09351$$

$$z_0 := \Delta_y(\theta_m) \qquad z_0 := 0.1$$

total creep for 300 hrs @ 35 deg C, m

$$\Delta z_{35}(t) := z_0 \cdot \left(1 - e^{-R_{creep35} \cdot t}\right)$$

$$\Delta z_{35}(300) = 8.10036 \times 10^{-5}$$

time duration for 10yrs, hrs

$$t_{10} := 10 \cdot 365 \cdot 24 \qquad t_{10} = 8.76 \times 10^{4}$$

total creep for 10 yrs @ 35 deg C, m

$$\Delta z_{35}\left(8.76 \times 10^{4}\right) = 0.02107$$

Arrhenius creep rate acceleration

Boltzmann's constant1.38*10^-23, J/K

$$k_B := 1.38 \cdot 10^{-23}$$

Activation energy, J

$$E_a := 2 \cdot 1.6 \cdot 10^{-19}$$

$$E_a = 3.2 \times 10^{-19}$$

Temperature 1

$$T_1 := 40$$

$$T := 40$$

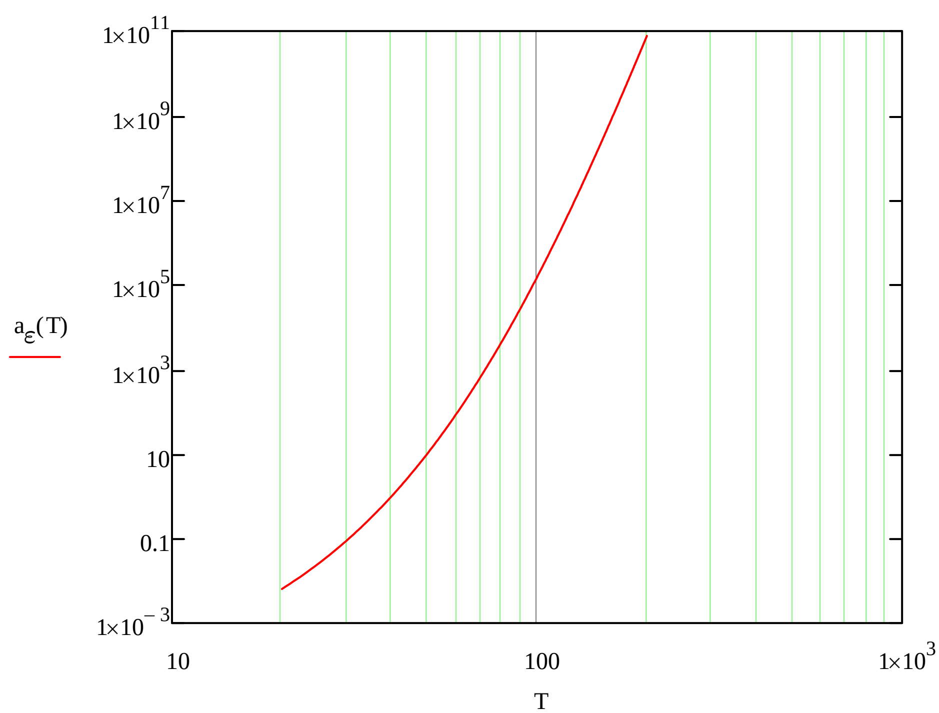
Creep temperature acceleration factor

$$a_{\varepsilon}(T) := \exp\left[\frac{E_a}{k_B}\cdot\left[\frac{T - T_1}{(T + 273)\cdot(T_1 + 273)}\right]\right]$$

$a_{\varepsilon}(T) = 1$

$T := 20, 20.5 .. 200$

$273 + 90 = 363$



Riccardo SURF data

inital blade displacement, m $z_0 := 0.336$

assymptotic creep, m $x_{max} := 0.0044 \cdot z_0$ $x_{max} = 1.4784 \times 10^{-3}$

$x_{max} := .00173$

60 deg C data $T := 60$

60 deg C creep time constant, hrs $\tau_{60} := 500000$

$a_{\varepsilon}(T) = 85.58511$

60 deg C time duration, hrs $t_{60} := 41 \cdot 24$ $t_{60} = 984$

$t := t_{60}$

$\tau := \tau_{60}$

Creep time dependence, m $x(t, T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau}\right)\right)$

$x(t, T) = 2.68169 \times 10^{-4}$

$x_{60} := 0.26 \cdot 10^{-3}$

90 deg C data $T := 90$

90 deg C time duration, hrs $t_{90} := 20 \cdot 24$ $t_{90} = 480$

90 deg C creep time constant, hrs $\tau_{90} := 33500000$

$t := t_{90}$

$\tau := \tau_{90}$

$a_{\varepsilon}(T) = 2.70234 \times 10^{4}$

Creep time dependence, m $x(t,T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau}\right)\right)$

$x(t,T) = 5.55408 \times 10^{-4}$

$x_{90} := 0.56 \cdot 10^{-3}$

150 deg C data $T := 150$

150 deg C time duration, hrs $t_{150} := 19 \cdot 24 \quad t_{150} = 456$

150 deg C creep time constant, hrs $\tau_{150} := 95000000000$

$t := t_{150}$

$\tau := \tau_{150}$

Creep time dependence, m $x(t,T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau}\right)\right)$

$x(t,T) = 1.16393 \times 10^{-3}$

$x_{150} := 1.17 \cdot 10^{-3}$

190 deg C data $T := 190$

190 deg C time duration, hrs $t_{190} := 14 \cdot 24 \quad t_{190} = 336$

190 deg C creep time constant, hrs $\tau_{190} := 4300000000000$

$t := t_{190}$

$\tau := \tau_{190}$

Creep time dependence, m $x(t,T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau}\right)\right)$

$x(t, T) = 1.5123 \times 10^{-3}$

$x_{190} := 1.51 \cdot 10^{-3}$

200 deg C data $T := 200$

200 deg C time duration, hrs $t_{200} := 20 \cdot 24 \quad t_{200} = 480$

200 deg C creep time constant, hrs $\tau_{200} := 2500000000000$

$t := t_{200} \qquad t_{200} = 480$

$\tau := \tau_{200}$

Creep time dependence, m $x(t, T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau}\right)\right)$

$x(t, T) = 1.73 \times 10^{-3}$

anamalous data, m $x_{200} := 1.51 \cdot 10^{-3}$

anamalous data, changed, m $x_{200} := 1.73 \cdot 10^{-3}$

$$\tau T_{slope} := \frac{\ln(\tau_{190}) - \ln(\tau_{60})}{\ln(190) - \ln(60)} \qquad \tau T_{slope} = 13.85231$$

Time acceleration factor

$$\tau_T := \begin{pmatrix} \tau_{60} \\ \tau_{90} \\ \tau_{150} \\ \tau_{190} \\ \tau_{200} \end{pmatrix} \qquad T := \begin{pmatrix} 60 \\ 90 \\ 150 \\ 190 \\ 200 \end{pmatrix}$$

$\tau_{90} = 3.35 \times 10^{7}$

$\tau_{150} = 9.5 \times 10^{10}$

$\tau_{200} = 2.5 \times 10^{12}$

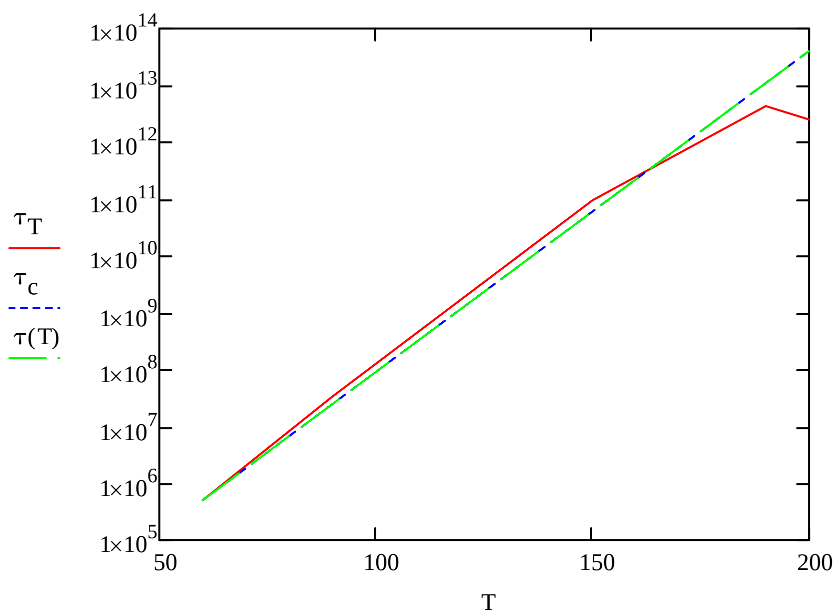
$\tau T_{slope} := 0.130$

$\tau T_{slope} := 0.130$

$$\tau_c := \begin{bmatrix} \exp\left[\ln\left(\tau_{60}\right) + \tau T_{slope}\cdot(60 - 60)\right] \\ \exp\left[\ln\left(\tau_{60}\right) + \tau T_{slope}\cdot(90 - 60)\right] \\ \exp\left[\ln\left(\tau_{60}\right) + \tau T_{slope}\cdot(150 - 60)\right] \\ \exp\left[\ln\left(\tau_{60}\right) + \tau T_{slope}\cdot(190 - 60)\right] \\ \exp\left[\ln\left(\tau_{60}\right) + \tau T_{slope}\cdot(200 - 60)\right] \end{bmatrix}$$

Time acceleration factor

$$\tau(T) := \exp\left[\ln\left(\tau_{60}\right) + \tau T_{slope}\cdot(T - 60)\right]$$



Creep time dependence, m

$$x(t,T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau(T)}\right)\right)$$

$$x\left(t_{200}, 200\right) = 1.03743 \times 10^{-3}$$

$$x_{200} := 1.73 \cdot 10^{-3}$$

$$t := t_{190}$$

$$T := 190$$

$$x(t,T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau(T)}\right)\right)$$

$$x(t,T) = 9.64689 \times 10^{-4}$$

$$x\left(t_{190}, 190\right) = 9.64689 \times 10^{-4}$$

$$x_{190} = 1.51 \times 10^{-3}$$

$$t := t_{150}$$

$$T := 150$$

$$x(t,T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau(T)}\right)\right)$$

$$x(t,T) = 1.43249 \times 10^{-3}$$

$$x\left(t_{150}, 150\right) = 1.43249 \times 10^{-3}$$

$$t := t_{90}$$

$$T := 90$$

$$x(t,T) := x_{max} \cdot \left(1 - \exp\left(-a_{\varepsilon}(T) \cdot \frac{t}{\tau(T)}\right)\right)$$

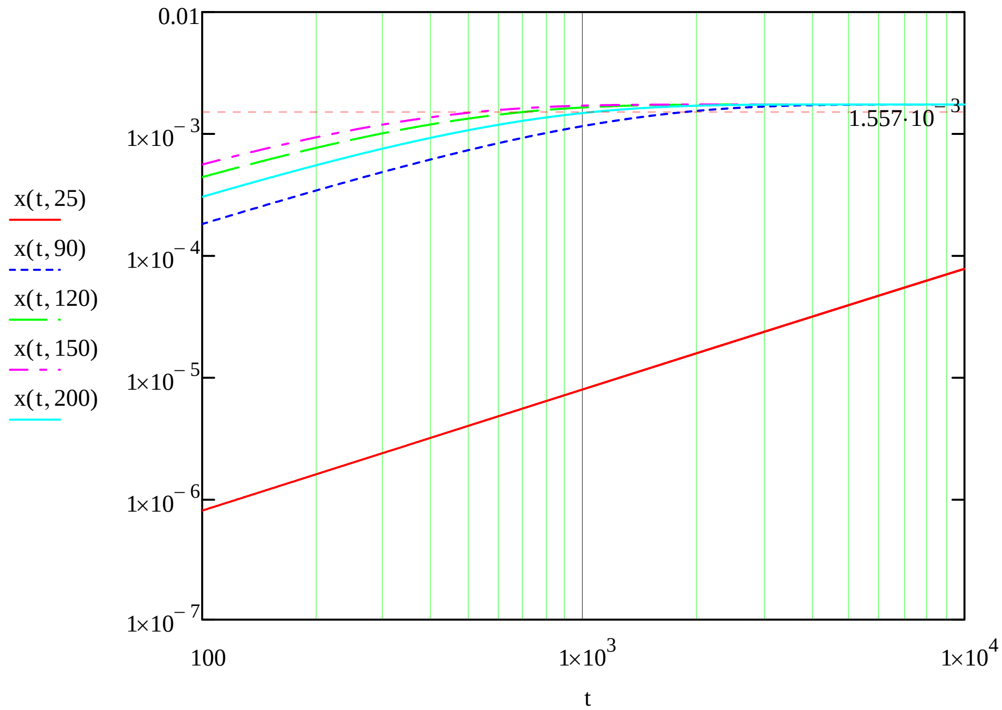
$$x(t,T) = 7.06737 \times 10^{-4}$$

$x(t_{90}, 90) = 7.06737 \times 10^{-4}$

$0.9 \cdot x_{max} = 1.557 \times 10^{-3}$

10 year duration, hrs $10 \cdot 365 \cdot 24 = 8.76 \times 10^{4}$

$t := 100, 101 .. 10000$



SLC Data

SLC vertical deflection, m

$$\Delta_y(\theta_m) = 0.09351$$

$$x_{max} := 0.0044\,\Delta_y(\theta_m)$$

Creep time dependence, m

$$x(t,T) := x_{max}\cdot\left(1 - \exp\left(-a_{\varepsilon}(T)\cdot\frac{t}{\tau(T)}\right)\right)$$

10 year duration, hrs

$$10\cdot 365\cdot 24 = 8.76\times 10^{4}$$

$$t := 8.76\times 10^{4}$$

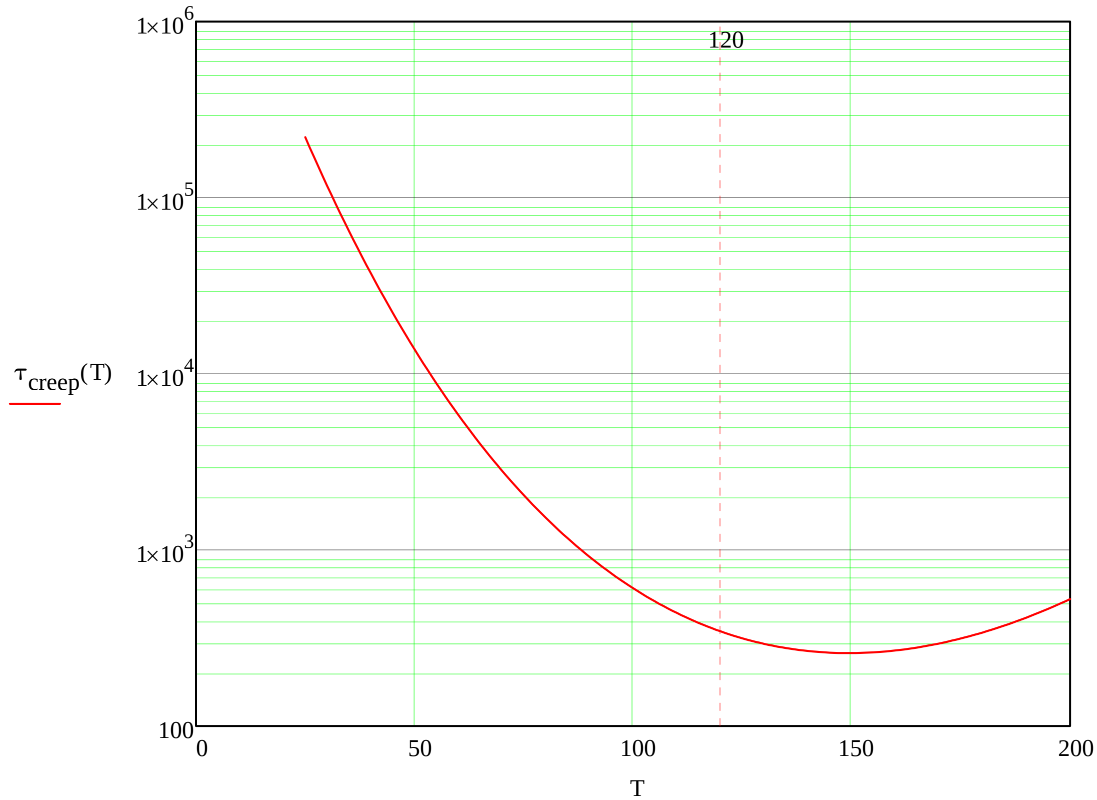
Blade temperaturae, deg C

$$T := 25$$

$$x(t,T) = 1.35133\times 10^{-4}$$

Creep time-constant, hr^-1 $\tau_{creep}(T) := \frac{\tau(T)}{a_{\varepsilon}(T)}$

$T := 25, 26 .. 200$



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$$\frac{330}{24} = 13.75$$