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Table 1 Glossary of variables used in the generic case, "tank" (This is part of the tank.DEF file, created automatically by the GENOPT processor, GENTEXT, with use of information, variable names and one-line definitions provided by the GENOPT user.)

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C=================================================================================================
C  ARRAY  NUMBER OF         PROMPT
C    ?   (ROWS,COLS)  ROLE  NUMBER   NAME                    DEFINITION OF VARIABLE
C                          (tank.PRO)
C=================================================================================================
C    n   (    0,    0)   2      10   GRAV     = acceleration of gravity
C    n   (    0,    0)   2      20   DIAVEH   = diameter of launch vehicle
C    n   (    0,    0)   2      30   AFTDIA   = diameter of the aft dome of the tank
C    n   (    0,    0)   2      35   AFTHI    = height of the aft dome of the tank
C    n   (    0,    0)   2      40   FWDDIA   = diameter of the forward dome of the tank
C    n   (    0,    0)   2      45   FWDHI    = height of the forward dome of the tank
C    n   (    0,    0)   2      50   FLTANK   = axial dist. from aft dome apex to fwd dome apex
C    n   (    0,    0)   2      55   ZAPEX    = global axial coordinate of the aft dome apex
C    n   (    0,    0)   2      60   DENPRP   = weight density of the propellant
C    n   (    0,    0)   2      65   ZCG      = global axial coordinate of the tank cg
C    n   (    0,    0)   1      70   THKAFT   = thickness of the tank aft dome skin
C    n   (    0,    0)   1      75   THKMID   = thickness of the tank cylinder skin
C    n   (    0,    0)   1      80   THKFWD   = thickness of the forward tank dome skin
C    n   (    0,    0)   1      90   STRSPC   = spacing of the tank orthogrid stringers
C    n   (    0,    0)   1      95   RNGSPC   = spacing of the tank orthogrid rings
C    n   (    0,    0)   1     100   STRTHK   = thickness of the tank orthogrid stringers
C    n   (    0,    0)   1     105   STRHI    = height of the tank orthogrid stringers
C    n   (    0,    0)   1     110   RNGTHK   = thickness of the tank orthogrid rings
C    n   (    0,    0)   1     115   RNGHI    = height of the tank orthogrid rings
C    n   (    0,    0)   2     125   ETANK    = Young's modulus of the cold tank material
C    n   (    0,    0)   2     130   NUTANK   = Poisson's ratio of the tank material
C    n   (    0,    0)   2     135   DENTNK   = mass density of the tank material
C    n   (    0,    0)   2     140   ALTNK    = coef.thermal expansion of tank material
C    n   (    0,    0)   2     150   IAXIS    = tank is vertical (1) or horizontal (2)
C    n   (    0,    0)   2     160   IZTANK   = strut support ring number in ZTANK(IZTANK)
C    y   (   10,    0)   1     165   ZTANK    = global axial coordinate of tank support ring
C    y   (   10,    0)   1     170   ZGRND    = global axial coordinate of "ground"
C    y   (   10,    0)   2     180   STRTYP   = type of strut arrangement
C    n   (    0,    0)   2     190   INPAIRS  = strut type number in NPAIRS(INPAIRS)
C    y   (    3,    0)   2     195   NPAIRS   = number of strut pairs
C    y   (    3,    0)   2     205   FITTNK   = length of end fitting attached to tank ring
C    y   (    3,    0)   2     210   FEATNK   = axial "EA" stiffness of tank-end strut fitting
C    y   (    3,    0)   2     215   ALFITT   = Coef.of thermal expansion of tank end fitting
C    y   (    3,    0)   2     220   FITVEH   = length of strut end fitting attached to "ground"
C    y   (    3,    0)   2     225   FEAVEH   = axial "EA" stiffness of "ground" end strut fitting
C    y   (    3,    0)   2     230   ALFITV   = coef.of thermal expan. of "ground" end fitting
C    y   (    3,    0)   1     240   ATANK    = circ.angle (deg.) to pinned tank end of strut
C    y   (    3,    0)   1     245   AGRND    = circ.angle to pinned "ground" end of strut
C    y   (    3,    0)   1     255   IDTUBE   = inner diam. of support tube active at launch
C    y   (    3,    0)   2     265   FACLEN   = length factor for strut buckling as a shell
C    y   (    3,    0)   2     270   DTSUP    = Average strut temperature minus ambient
C    y   (    3,    0)   2     275   ODINNR   = outer diam.of the orbital tube assembly
C    y   (    3,    0)   2     280   FLINNR   = Length of the orbital tube assembly
C    n   (    0,    0)   2     285   NTUBES   = Choose 1 or 2 tubes in the orbital tube assembly
C    n   (    0,    0)   2     295   ISTRUT   = index for simple strut (1), "PODS" strut (2)
C    y   (    3,    0)   2     305   WALTYP   = type of wall constructions in strut type STRTYP
C    n   (    0,    0)   1     315   WEBHI    = height of mid-tank T-ring web
C    n   (    0,    0)   1     320   WEBTHK   = thickness of mid-tank T-ring web
C    n   (    0,    0)   1     325   FLGHI    = width (height) of mid-tank T-ring flange
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C    n   (    0,    0)    1      330   FLGTHK   = thickness of mid-tank T-ring flange
C    y   (    3,    0)    2      340   RNGTYP   = propellant tank reinforcement type
C    n   (    0,    0)    2      350   IDUBAXL  = propellant tank reinforcement type number in
DUBAXL(IDUBAXL)
C    y   (    3,    0)    1      355   DUBAXL   = axial length of the propellant tank doubler
C    y   (    3,    0)    1      360   DUBTHK   = max.thickness of the propellant tank doubler
C    y   (    3,    0)    1      370   TRNGTH   = thickness of the tank reinforcement ring
C    y   (    3,    0)    1      375   TRNGHI   = height of the tank reinforcement ring
C    y   (    3,    0)    2      380   TRNGE    = hoop modulus of the tank ring
C    y   (    3,    0)    2      385   ALRNGT   = coef.of thermal expansion of the tank ring
C    n   (    0,    0)    2      395   ITHICK   = thickness index in THICK(ITHICK)
C    y   (   15,    0)    1      400   THICK    = thickness of a lamina
C    y   (   15,    0)    1      405   ANGLE    = layup angle
C    y   (   15,    0)    2      410   MATTYP   = Material type
C    n   (    0,    0)    2      420   JLAYTYP  = wall type number in LAYTYP(ILAYTYP,JLAYTYP)
C    n   (    0,    0)    2      425   ILAYTYP  = layer number in LAYTYP(ILAYTYP,JLAYTYP)
C    y   (   90,    3)    2      430   LAYTYP   = layer type index
C    n   (    0,    0)    2      440   IE1      = material type in E1(IE1)
C    y   (    3,    0)    2      445   E1       = modulus in the fiber direction
C    y   (    3,    0)    2      450   E2       = modulus transverse to fibers
C    y   (    3,    0)    2      455   G12      = in-plane shear modulus
C    y   (    3,    0)    2      460   NU       = small Poisson's ratio
C    y   (    3,    0)    2      465   G13      = x-z out-of-plane shear modulus
C    y   (    3,    0)    2      470   G23      = y-z out-of-plane shear modulus
C    y   (    3,    0)    2      475   ALPHA1   = coef.of thermal expansion along fibers
C    y   (    3,    0)    2      480   ALPHA2   = coef.of thermal expan.transverse to fibers
C    y   (    3,    0)    2      485   TEMTUR   = curing delta temperature (positive)
C    y   (    3,    0)    2      490   COND1    = conductivity along the fibers
C    y   (    3,    0)    2      495   COND2    = conductivity transverse to fibers
C    y   (    3,    0)    2      500   DENSTY   = weight density of the material
C    n   (    0,    0)    2      510   WGT      = objective=WGT*(empty tank mass) +(1-
WGT)*(conductance)
C    n   (    0,    0)    2      515   TNKNRM   = normalizing empty tank mass
C    n   (    0,    0)    2      520   CONNRM   = normalizing total strut conductance
C    n   (    0,    0)    2      530   IPHASE   = IPHASE=1=launch phase; IPHASE=2=orbital phase
C    n   (    0,    0)    2      540   NCASES   = Number of load cases (number of environments)  in
PRESS(NCASES)
C    y   (   20,    0)    3      545   PRESS    = propellant tank ullage pressure
C    y   (   20,    0)    3      550   GAXIAL   = quasi-static axial g-loading
C    y   (   20,    0)    3      555   GLATRL   = quasi-static lateral g-loading
C    y   (   20,    0)    3      560   TNKCOOL  = propellant tank cool-down from cryogen
C    n   (    0,    0)    2      570   JFREQ    = vibration mode type in FREQ(NCASES,JFREQ)
C    y   (   20,    4)    4      575   FREQ     = modal vibration frequency (cps)
C    y   (   20,    4)    5      580   FREQA    = minimum allowable frequency (cps)
C    y   (   20,    4)    6      585   FREQF    = factor of safety for freqency
C    n   (    0,    0)    2      595   JSTRES1  = stress component number in STRES1(NCASES,JSTRES1)
C    y   (   20,    6)    4      600   STRES1   = maximum stress in material 1
C    y   (   20,    6)    5      605   STRES1A  = maximum allowable stress in material 1
C    y   (   20,    6)    6      610   STRES1F  = factor of safety for stress, matl 1
C    y   (   20,    6)    4      615   STRES2   = maximum stress in material 2
C    y   (   20,    6)    5      620   STRES2A  = maximum allowable stress in material 2
C    y   (   20,    6)    6      625   STRES2F  = factor of safety for stress, matl 2
C    y   (   20,    6)    4      630   STRES3   = maximum stress in material 3
C    y   (   20,    6)    5      635   STRES3A  = maximum allowable stress in material 3
C    y   (   20,    6)    6      640   STRES3F  = factor of safety for stress, matl 3
C    n   (    0,    0)    2      645   JCOLBUK  = strut set number (1 for aft-most set) in
COLBUK(NCASES,JCOLBUK)
C    y   (   20,    3)    4      650   COLBUK   = buckling of a strut as a column
C    y   (   20,    3)    5      655   COLBUKA  = allowable for column buckling of strut
C    y   (   20,    3)    6      660   COLBUKF  = factor of safety for Euler strut buckling
C    y   (   20,    3)    4      665   SHLBUK   = buckling of strut as a shell
C    y   (   20,    3)    5      670   SHLBUKA  = allowable for shell buckling of strut
C    y   (   20,    3)    6      675   SHLBUKF  = factor of safety for shell buckling of strut
C    y   (   20,    3)    4      680   FORCE    = launch-hold force in a strut
C    y   (   20,    3)    5      685   FORCEA   = maximum allowable launch-hold force in strut
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C    y   (  20,    3)    6      690   FORCEF   = factor of safety for launch-hold force
C    y   (  20,    3)    4      695   TNKSTR   = maximum stress in the propellant tank
C    y   (  20,    3)    5      700   TNKSTRA  = allowable for propellant tank stress
C    y   (  20,    3)    6      705   TNKSTRF  = factor of safety for tank stress
C    y   (  20,    3)    4      710   TNKBUK   = propellant tank buckling load factor
C    y   (  20,    3)    5      715   TNKBUKA  = allowable for propellant tank buckling
C    y   (  20,    3)    6      720   TNKBUKF  = factor of safety for tank buckling
C    n   (   0,    0)    7      730   CONDCT   = WGTxTOTMAS/TNKNRM +(1-WGT)xCONDCT/CONNRM
C=================================================================================
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Table 2 Input data for the GENOPT processor, BEGIN (test.BEG file) (These input data are provided by the End user for the specific case called "test"; See Figs. 1 – 3.)

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================================================================================
      N         $ Do you want a tutorial session and tutorial output?
   386.4000     $ acceleration of gravity: GRAV
       300      $ diameter of launch vehicle: DIAVEH
       200      $ diameter of the aft dome of the tank: AFTDIA
        50      $ height of the aft dome of the tank: AFTHI
       200      $ diameter of the forward dome of the tank: FWDDIA
        50      $ height of the forward dome of the tank: FWDHI
       400      $ axial dist. from aft dome apex to fwd dome apex: FLTANK
       100      $ global axial coordinate of the aft dome apex: ZAPEX
  0.2560000E-02 $ weight density of the propellant: DENPRP
       300      $ global axial coordinate of the tank cg: ZCG
  0.1000000     $ thickness of the tank aft dome skin: THKAFT
  0.1000000     $ thickness of the tank cylinder skin: THKMID
  0.1000000     $ thickness of the forward tank dome skin: THKFWD
        10      $ spacing of the tank orthogrid stringers: STRSPC
        10      $ spacing of the tank orthogrid rings: RNGSPC
  0.5000000     $ thickness of the tank orthogrid stringers: STRTHK
         1      $ height of the tank orthogrid stringers: STRHI
  0.5000000     $ thickness of the tank orthogrid rings: RNGTHK
         1      $ height of the tank orthogrid rings: RNGHI
  0.1000000E+08 $ Young's modulus of the cold tank material: ETANK
  0.3000000     $ Poisson's ratio of the tank material: NUTANK
  0.2500000E-03 $ mass density of the tank material: DENTNK
  0.1000000E-04 $ coef.thermal expansion of tank material: ALTNK
         1      $ tank is vertical (1) or horizontal (2): IAXIS
         2      $ Number IZTANK  of rows in the array  ZTANK: IZTANK
       150      $ global axial coordinate of tank support ring: ZTANK(  1)
       450      $ global axial coordinate of tank support ring: ZTANK(  2)
        50      $ global axial coordinate of "ground": ZGRND(  1)
       550      $ global axial coordinate of "ground": ZGRND(  2)
         1      $ type of strut arrangement: STRTYP(  1)
         2      $ type of strut arrangement: STRTYP(  2)
         2      $ Number INPAIRS of rows in the array  NPAIRS: INPAIRS
         4      $ number of strut pairs: NPAIRS(  1)
         4      $ number of strut pairs: NPAIRS(  2)
         5      $ length of end fitting attached to tank ring: FITTNK(  1)
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       5      $ length of end fitting attached to tank ring: FITTNK(  2)
  0.1000000E+08 $ axial "EA" stiffness of tank-end strut fitting: FEATNK(  1)
  0.1000000E+08 $ axial "EA" stiffness of tank-end strut fitting: FEATNK(  2)
  0.1000000E-04 $ Coef.of thermal expansion of tank end fitting: ALFITT(  1)
  0.1000000E-04 $ Coef.of thermal expansion of tank end fitting: ALFITT(  2)
       5      $ length of strut end fitting attached to "ground": FITVEH(  1)
       5      $ length of strut end fitting attached to "ground": FITVEH(  2)
  0.1000000E+08 $ axial "EA" stiffness of "ground" end strut fitting: FEAVEH(  1)
  0.1000000E+08 $ axial "EA" stiffness of "ground" end strut fitting: FEAVEH(  2)
  0.1000000E-04 $ coef.of thermal expan. of "ground" end fitting: ALFITV(  1)
  0.1000000E-04 $ coef.of thermal expan. of "ground" end fitting: ALFITV(  2)
      10      $ circ.angle (deg.) to pinned tank end of strut: ATANK(  1)
      10      $ circ.angle (deg.) to pinned tank end of strut: ATANK(  2)
      25      $ circ.angle to pinned "ground" end of strut: AGRND(  1)
      25      $ circ.angle to pinned "ground" end of strut: AGRND(  2)
       5      $ inner diam. of support tube active at launch: IDTUBE(  1)
       5      $ inner diam. of support tube active at launch: IDTUBE(  2)
  0.1000000     $ length factor for strut buckling as a shell: FACLEN(  1)
  0.1000000     $ length factor for strut buckling as a shell: FACLEN(  2)
    -100      $ Average strut temperature minus ambient: DTSUP(  1)
    -100      $ Average strut temperature minus ambient: DTSUP(  2)
       2      $ outer diam.of the orbital tube assembly: ODINNR(  1)
       2      $ outer diam.of the orbital tube assembly: ODINNR(  2)
       4      $ Length of the orbital tube assembly: FLINNR(  1)
       4      $ Length of the orbital tube assembly: FLINNR(  2)
       1      $ Choose 1 or 2 tubes in the orbital tube assembly: NTUBES
       1      $ index for simple strut (1), "PODS" strut (2): ISTRUT
       1      $ type of wall constructions in strut type STRTYP: WALTYP(  1)
       2      $ type of wall constructions in strut type STRTYP: WALTYP(  2)
   0.000001     $ height of mid-tank T-ring web: WEBHI
   0.000001     $ thickness of mid-tank T-ring web: WEBTHK
   0.000001     $ width (height) of mid-tank T-ring flange: FLGHI
   0.000001     $ thickness of mid-tank T-ring flange: FLGTHK
       1      $ propellant tank reinforcement type: RNGTYP(  1)
       1      $ propellant tank reinforcement type: RNGTYP(  2)
       1      $ Number IDUBAXL of rows in the array  DUBAXL: IDUBAXL
      30      $ axial length of the propellant tank doubler: DUBAXL(  1)
  0.1000000     $ max.thickness of the propellant tank doubler: DUBTHK(  1)
  0.2000000     $ thickness of the tank reinforcement ring: TRNGTH(  1)
   1.000000     $ height of the tank reinforcement ring: TRNGHI(  1)
  0.1000000E+08 $ hoop modulus of the tank ring: TRNGE(  1)
  0.1000000E-04 $ coef.of thermal expansion of the tank ring: ALRNGT(  1)
      12      $ Number ITHICK  of rows in the array  THICK: ITHICK
  0.1000000     $ thickness of a lamina: THICK(  1)
  0.1000000     $ thickness of a lamina: THICK(  2)
  0.1000000     $ thickness of a lamina: THICK(  3)
  0.1000000     $ thickness of a lamina: THICK(  4)
  0.1000000     $ thickness of a lamina: THICK(  5)
  0.1000000     $ thickness of a lamina: THICK(  6)
  0.1000000     $ thickness of a lamina: THICK(  7)
  0.1000000     $ thickness of a lamina: THICK(  8)
  0.1000000     $ thickness of a lamina: THICK(  9)
  0.1000000     $ thickness of a lamina: THICK( 10)
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 0.1000000      $ thickness of a lamina: THICK( 11)
 0.1000000      $ thickness of a lamina: THICK( 12)
      45        $ layup angle: ANGLE(  1)
     -45        $ layup angle: ANGLE(  2)
      45        $ layup angle: ANGLE(  3)
     -45        $ layup angle: ANGLE(  4)
      45        $ layup angle: ANGLE(  5)
     -45        $ layup angle: ANGLE(  6)
      45        $ layup angle: ANGLE(  7)
     -45        $ layup angle: ANGLE(  8)
      45        $ layup angle: ANGLE(  9)
     -45        $ layup angle: ANGLE( 10)
      45        $ layup angle: ANGLE( 11)
     -45        $ layup angle: ANGLE( 12)
       1        $ Material type: MATTYP(  1)
       1        $ Material type: MATTYP(  2)
       1        $ Material type: MATTYP(  3)
       1        $ Material type: MATTYP(  4)
       1        $ Material type: MATTYP(  5)
       1        $ Material type: MATTYP(  6)
       1        $ Material type: MATTYP(  7)
       1        $ Material type: MATTYP(  8)
       1        $ Material type: MATTYP(  9)
       1        $ Material type: MATTYP( 10)
       1        $ Material type: MATTYP( 11)
       1        $ Material type: MATTYP( 12)
       2        $ Number JLAYTYP of columns in the array, LAYTYP: JLAYTYP
      12        $ Number ILAYTYP of rows in this column of LAYTYP: ILAYTYP
       1        $ layer type index: LAYTYP(  1,  1)
       2        $ layer type index: LAYTYP(  2,  1)
       3        $ layer type index: LAYTYP(  3,  1)
       4        $ layer type index: LAYTYP(  4,  1)
       5        $ layer type index: LAYTYP(  5,  1)
       6        $ layer type index: LAYTYP(  6,  1)
       6        $ layer type index: LAYTYP(  7,  1)
       5        $ layer type index: LAYTYP(  8,  1)
       4        $ layer type index: LAYTYP(  9,  1)
       3        $ layer type index: LAYTYP( 10,  1)
       2        $ layer type index: LAYTYP( 11,  1)
       1        $ layer type index: LAYTYP( 12,  1)
      12        $ Number ILAYTYP of rows in this column of LAYTYP: ILAYTYP
       7        $ layer type index: LAYTYP(  1,  2)
       8        $ layer type index: LAYTYP(  2,  2)
       9        $ layer type index: LAYTYP(  3,  2)
      10        $ layer type index: LAYTYP(  4,  2)
      11        $ layer type index: LAYTYP(  5,  2)
      12        $ layer type index: LAYTYP(  6,  2)
      12        $ layer type index: LAYTYP(  7,  2)
      11        $ layer type index: LAYTYP(  8,  2)
      10        $ layer type index: LAYTYP(  9,  2)
       9        $ layer type index: LAYTYP( 10,  2)
       8        $ layer type index: LAYTYP( 11,  2)
       7        $ layer type index: LAYTYP( 12,  2)
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        1      $ Number IE1     of rows in the array  E1: IE1
  0.2100000E+08 $ modulus in the fiber direction: E1(  1)
   1600000.     $ modulus transverse to fibers: E2(  1)
   679000.0     $ in-plane shear modulus: G12(  1)
  0.2300000E-01 $ small Poisson's ratio: NU(  1)
   627000.0     $ x-z out-of-plane shear modulus: G13(  1)
   334000.0     $ y-z out-of-plane shear modulus: G23(  1)
  0.1000000E-05 $ coef.of thermal expansion along fibers: ALPHA1(  1)
  0.1000000E-04 $ coef.of thermal expan.transverse to fibers: ALPHA2(  1)
      170      $ curing delta temperature (positive): TEMTUR(  1)
  0.7270000E-02 $ conductivity along the fibers: COND1(  1)
  0.4370000E-02 $ conductivity transverse to fibers: COND2(  1)
  0.5700000E-01 $ weight density of the material: DENSTY(  1)
  0.5000000     $ objective=WGT*(empty tank mass) +(1-WGT)*(conductance): WGT
   10.00000     $ normalizing empty tank mass: TNKNRM
  0.2000000E-02 $ normalizing total strut conductance: CONNRM
        1      $ IPHASE=1=launch phase; IPHASE=2=orbital phase: IPHASE
        2      $ Number NCASES  of load cases (environments): NCASES
   25.00000     $ propellant tank ullage pressure: PRESS(  1)
   25.00000     $ propellant tank ullage pressure: PRESS(  2)
       10      $ quasi-static axial g-loading: GAXIAL(  1)
        0      $ quasi-static axial g-loading: GAXIAL(  2)
        0      $ quasi-static lateral g-loading: GLATRL(  1)
       10      $ quasi-static lateral g-loading: GLATRL(  2)
  -200.0000     $ propellant tank cool-down from cryogen: TNKCOOL(  1)
  -200.0000     $ propellant tank cool-down from cryogen: TNKCOOL(  2)
        4      $ Number JFREQ   of columns in the array, FREQ: JFREQ
       10      $ minimum allowable frequency (cps): FREQA(  1,  1)
       10      $ minimum allowable frequency (cps): FREQA(  2,  1)
       10      $ minimum allowable frequency (cps): FREQA(  1,  2)
       10      $ minimum allowable frequency (cps): FREQA(  2,  2)
       10      $ minimum allowable frequency (cps): FREQA(  1,  3)
       10      $ minimum allowable frequency (cps): FREQA(  2,  3)
       10      $ minimum allowable frequency (cps): FREQA(  1,  4)
       10      $ minimum allowable frequency (cps): FREQA(  2,  4)
   1.200000     $ factor of safety for freqency: FREQF(  1,  1)
   1.200000     $ factor of safety for freqency: FREQF(  2,  1)
   1.200000     $ factor of safety for freqency: FREQF(  1,  2)
   1.200000     $ factor of safety for freqency: FREQF(  2,  2)
   1.200000     $ factor of safety for freqency: FREQF(  1,  3)
   1.200000     $ factor of safety for freqency: FREQF(  2,  3)
   1.200000     $ factor of safety for freqency: FREQF(  1,  4)
   1.200000     $ factor of safety for freqency: FREQF(  2,  4)
        5      $ Number JSTRES1 of columns in the array, STRES1: JSTRES1
    140571      $ maximum allowable stress in material 1: STRES1A(  1,  1)
    140571      $ maximum allowable stress in material 1: STRES1A(  2,  1)
    104714      $ maximum allowable stress in material 1: STRES1A(  1,  2)
    104714      $ maximum allowable stress in material 1: STRES1A(  2,  2)
     10557      $ maximum allowable stress in material 1: STRES1A(  1,  3)
     10557      $ maximum allowable stress in material 1: STRES1A(  2,  3)
     14529      $ maximum allowable stress in material 1: STRES1A(  1,  4)
     14529      $ maximum allowable stress in material 1: STRES1A(  2,  4)
      6290      $ maximum allowable stress in material 1: STRES1A(  1,  5)
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      6290      $ maximum allowable stress in material 1: STRES1A(  2,  5)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  1,  1)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  2,  1)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  1,  2)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  2,  2)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  1,  3)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  2,  3)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  1,  4)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  2,  4)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  1,  5)
   1.500000     $ factor of safety for stress, matl 1: STRES1F(  2,  5)
    140571      $ maximum allowable stress in material 2: STRES2A(  1,  1)
    140571      $ maximum allowable stress in material 2: STRES2A(  2,  1)
    104714      $ maximum allowable stress in material 2: STRES2A(  1,  2)
    104714      $ maximum allowable stress in material 2: STRES2A(  2,  2)
     10557      $ maximum allowable stress in material 2: STRES2A(  1,  3)
     10557      $ maximum allowable stress in material 2: STRES2A(  2,  3)
     14529      $ maximum allowable stress in material 2: STRES2A(  1,  4)
     14529      $ maximum allowable stress in material 2: STRES2A(  2,  4)
      6290      $ maximum allowable stress in material 2: STRES2A(  1,  5)
      6290      $ maximum allowable stress in material 2: STRES2A(  2,  5)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  1,  1)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  2,  1)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  1,  2)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  2,  2)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  1,  3)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  2,  3)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  1,  4)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  2,  4)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  1,  5)
   1.500000     $ factor of safety for stress, matl 2: STRES2F(  2,  5)
    140571      $ maximum allowable stress in material 3: STRES3A(  1,  1)
    140571      $ maximum allowable stress in material 3: STRES3A(  2,  1)
    104714      $ maximum allowable stress in material 3: STRES3A(  1,  2)
    104714      $ maximum allowable stress in material 3: STRES3A(  2,  2)
     10557      $ maximum allowable stress in material 3: STRES3A(  1,  3)
     10557      $ maximum allowable stress in material 3: STRES3A(  2,  3)
     14529      $ maximum allowable stress in material 3: STRES3A(  1,  4)
     14529      $ maximum allowable stress in material 3: STRES3A(  2,  4)
      6290      $ maximum allowable stress in material 3: STRES3A(  1,  5)
      6290      $ maximum allowable stress in material 3: STRES3A(  2,  5)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  1,  1)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  2,  1)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  1,  2)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  2,  2)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  1,  3)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  2,  3)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  1,  4)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  2,  4)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  1,  5)
   1.500000     $ factor of safety for stress, matl 3: STRES3F(  2,  5)
         2      $ Number JCOLBUK of columns in the array, COLBUK: JCOLBUK
         1      $ allowable for column buckling of strut: COLBUKA(  1,  1)
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         1      $ allowable for column buckling of strut: COLBUKA(  2,  1)
         1      $ allowable for column buckling of strut: COLBUKA(  1,  2)
         1      $ allowable for column buckling of strut: COLBUKA(  2,  2)
         1      $ factor of safety for Euler strut buckling: COLBUKF(  1,  1)
         1      $ factor of safety for Euler strut buckling: COLBUKF(  2,  1)
         1      $ factor of safety for Euler strut buckling: COLBUKF(  1,  2)
         1      $ factor of safety for Euler strut buckling: COLBUKF(  2,  2)
         1      $ allowable for shell buckling of strut: SHLBUKA(  1,  1)
         1      $ allowable for shell buckling of strut: SHLBUKA(  2,  1)
         1      $ allowable for shell buckling of strut: SHLBUKA(  1,  2)
         1      $ allowable for shell buckling of strut: SHLBUKA(  2,  2)
         2      $ factor of safety for shell buckling of strut: SHLBUKF(  1,  1)
         2      $ factor of safety for shell buckling of strut: SHLBUKF(  2,  1)
         2      $ factor of safety for shell buckling of strut: SHLBUKF(  1,  2)
         2      $ factor of safety for shell buckling of strut: SHLBUKF(  2,  2)
     15000      $ maximum allowable launch-hold force in strut: FORCEA(  1,  1)
     15000      $ maximum allowable launch-hold force in strut: FORCEA(  2,  1)
     15000      $ maximum allowable launch-hold force in strut: FORCEA(  1,  2)
     15000      $ maximum allowable launch-hold force in strut: FORCEA(  2,  2)
         1      $ factor of safety for launch-hold force: FORCEF(  1,  1)
         1      $ factor of safety for launch-hold force: FORCEF(  2,  1)
         1      $ factor of safety for launch-hold force: FORCEF(  1,  2)
         1      $ factor of safety for launch-hold force: FORCEF(  2,  2)
   50000.00     $ allowable for propellant tank stress: TNKSTRA(  1,  1)
   50000.00     $ allowable for propellant tank stress: TNKSTRA(  2,  1)
   50000.00     $ allowable for propellant tank stress: TNKSTRA(  1,  2)
   50000.00     $ allowable for propellant tank stress: TNKSTRA(  2,  2)
         1      $ factor of safety for tank stress: TNKSTRF(  1,  1)
         1      $ factor of safety for tank stress: TNKSTRF(  2,  1)
         1      $ factor of safety for tank stress: TNKSTRF(  1,  2)
         1      $ factor of safety for tank stress: TNKSTRF(  2,  2)
         1      $ allowable for propellant tank buckling: TNKBUKA(  1,  1)
         1      $ allowable for propellant tank buckling: TNKBUKA(  2,  1)
         1      $ allowable for propellant tank buckling: TNKBUKA(  1,  2)
         1      $ allowable for propellant tank buckling: TNKBUKA(  2,  2)
         1      $ factor of safety for tank buckling: TNKBUKF(  1,  1)
         1      $ factor of safety for tank buckling: TNKBUKF(  2,  1)
         1      $ factor of safety for tank buckling: TNKBUKF(  1,  2)
         1      $ factor of safety for tank buckling: TNKBUKF(  2,  2)
=================================================================================
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Table 3 Feasible Optimum Designs for the Long Propellant Tank with 3, 4 and 5 Pairs of Struts at Each of 2 Axial Locations (Dimensions in inches and degrees. These optimum designs were obtained after the August 2012 and February 2013 updates to the "tank" software, struct.tank and behavior.tank.)

Decision Variable	3 strut pairs	4 strut pairs	5 strut pairs
THKAFT	1.030E-01	6.133E-02	5.509E-02
THKMID	5.488E-02	5.453E-02	5.308E-02
THKFWD	4.807E-02	5.825E-02	4.904E-02
STRSPC	9.202E+00	7.891E+00	6.772E+00
RNGSPC	9.515E+00	7.907E+00	6.467E+00
STRTHK	2.341E-01	2.601E-01	2.569E-01
STRHI	5.355E-01	6.714E-01	6.119E-01
RNGTHK	2.329E-01	4.095E-01	4.510E-01
RNGHI	5.355E-01	6.714E-01	6.119E-01
ZTANK(1)	1.500E+02	1.500E+02	1.500E+02
ZTANK(2)	4.500E+02	4.500E+02	4.500E+02
ZGRND(1)	7.753E+01	8.672E+01	9.860E+01
ZGRND(2)	5.350E+02	5.142E+02	5.025E+02
ATANK(1)	6.186E+00	6.000E+00	6.000E+00
ATANK(2)	6.173E+00	6.001E+00	6.000E+00
AGRND(1)	5.719E+01	4.500E+01	3.599E+01
AGRND(2)	6.000E+01	4.499E+01	3.600E+01
IDTUBE(1)	6.481E+00	5.617E+00	5.128E+00
IDTUBE(2)	7.080E+00	5.981E+00	5.409E+00
DUBAXL(1)	3.000E+01	3.000E+01	3.000E+01
DUBTHK(1)	5.308E-01	7.272E-01	7.817E-01
TRNGTH(1)	9.484E-02	3.218E-01	4.793E-01
TRNGHI(1)	4.742E-01	1.609E+00	2.396E+00
THICK(1)	8.017E=03	7.049E-03	6.406E-03
THICK(7)	7.899E-03	6.695E-03	6.045E-03
ANGLE(1)	1.003E+01	1.002E+01	1.000E+01
ANGLE(3)	1.003E+01	1.002E+01	1.119E+01
ANGLE(5)	1.003E+01	4.854E+01	4.883E+01
ANGLE(7)	1.000E+01	1.000E+01	1.108E+01
ANGLE(9)	1.000E+01	1.000E+01	1.111E+01
ANGLE(11)	1.000E+01	4.980E+01	4.903E+01
Objective = WGTxTOTMAS/TNKNRM +(1-WGT)xCONDCT/CONNRM with WGT = 0.5, TNKNRM = 10.0 lb-sec^2/inch, CONNRM = 0.002 BTU/hr-deg.R			
Objective	7.305E-01	9.099E-01	1.049E+00
TOTMAS	7.9226E+00	1.0473E+01	1.1246E+01
CONDCT	1.3377E-03	1.5450E-03	1.9469E-03

Table 4 Behaviors of Feasible Optimum Designs for the Long Propellant Tank with 3, 4 and 5 Pairs of Struts at Each of 2 Axial Locations. These behaviors correspond to the optimum designs that were obtained after the August 2012 and February 2013 updates to the "tank" software, struct.tank and behavior.tank. See the previous table.)

Behavior	3 strut pairs	4 strut pairs	5 strut pairs
Load Case 1:			
FREQ(1,1)	1.297E+01	1.213E+01	1.234E+01
FREQ(1,2)	1.285E+01	1.205E+01	1.277E+01
FREQ(1,3)	1.287E+01	1.316E+01	1.331E+01
FREQ(1,4)	1.323E+01	1.337E+01	1.345E+01
STRES1(1,1)	8.599E+03	5.854E+03	5.632E+03
STRES1(1,2)	2.516E+04	2.493E+04	2.496E+04
STRES1(1,3)	4.301E+03	4.258E+03	4.257E+03
STRES1(1,4)	8.493E+01	1.000E-10	1.000E-10
STRES1(1,5)	6.380E+02	1.000E+03	1.001E+03
STRES2(1,1)	4.178E+04	6.137E+04	6.210E+04
STRES2(1,2)	9.007E+03	1.052E+04	1.051E+04
STRES2(1,3)	5.059E+03	6.534E+03	6.539E+03
STRES2(1,4)	9.131E+02	1.000E-10	1.000E-10
STRES2(1,5)	1.235E+03	3.438E+03	3.626E+03
COLBUK(1,1)	2.556E+00	2.368E+00	2.899E+00
COLBUK(1,2)	5.369E+03	1.256E+04	1.221E+04
SHLBUK(1,1)	3.420E+00	4.392E+00	4.340E+00
SHLBUK(1,2)	8.180E+01	1.365E+02	1.389E+02
FORCE(1,1)	6.808E+03	7.446E+03	8.520E+03
FORCE(1,2)	1.574E+04	1.489E+04	1.458E+04
TNKSTR(1,1)	5.215E+04	4.983E+04	4.999E+04
TNKSTR(1,2)	5.216E+04	4.983E+04	4.999E+04
TNKBUK(1,1)	6.194E+00	1.874E+01	1.955E+01
TNKBUK(1,2)	6.192E+00	1.874E+01	1.955E+01
Load Case 2:			
FREQ(2,1)	1.194E+01	1.205E+01	1.227E+01
FREQ(2,2)	1.197E+01	1.209E+01	1.266E+01
FREQ(2,3)	1.280E+01	1.315E+01	1.330E+01
FREQ(2,4)	1.322E+01	1.336E+01	1.344E+01
STRES1(2,1)	4.786E+04	7.228E+04	7.407E+04
STRES1(2,2)	2.980E+04	3.823E+04	2.716E+04
STRES1(2,3)	5.201E+03	6.952E+03	7.053E+03

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STRES1(2,4)    1.079E+03      1.000E-10      1.000E-10
STRES1(2,5)    1.351E+03      4.108E+03      4.213E+03
STRES2(2,1)    4.523E+04      7.095E+04      7.368E+04
STRES2(2,2)    2.628E+04      3.772E+04      2.781E+04
STRES2(2,3)    5.138E+03      6.972E+03      7.060E+03
STRES2(2,4)    9.999E+02      1.000E-10      1.000E-10
STRES2(2,5)    1.297E+03      3.915E+03      4.226E+03
COLBUK(2,1)    1.988E+00      1.428E+00      2.597E+00
COLBUK(2,2)    2.440E+00      1.624E+00      2.729E+00
SHLBUK(2,1)    2.659E+00      2.648E+00      3.888E+00
SHLBUK(2,2)    2.953E+00      2.419E+00      3.646E+00
FORCE(2,1)     4.690E+03      6.904E+03      8.202E+03
FORCE(2,2)     1.379E+04      1.436E+04      1.426E+04
TNKSTR(2,1)    5.173E+04      5.046E+04      4.955E+04
TNKSTR(2,2)    5.172E+04      5.046E+04      4.955E+04
TNKBUK(2,1)    1.698E+01      1.446E+01      1.222E+01
TNKBUK(2,2)    1.707E+01      1.446E+01      1.222E+01
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Table 5 Feasible Optimum Designs for the Short Propellant Tank with 3, 4 and 5 Pairs of Struts Attached at the Midlength of the Tank
(Dimensions in inches and degrees. These optimum designs were obtained after the August 2012 and February 2013 updates to the "tank" software, struct.tank and behavior.tank.)

Decision Variable	3 strut pairs	4 strut pairs	5 strut pairs
THKAFT	2.619E-02	2.220E-02	5.315E-02
THKMID	6.518E-02	7.152E-02	1.089E-01
THKFWD	2.827E-02	3.031E-02	3.638E-02
STRSPC	3.000E+00	3.000E+00	3.000E+00
RNGSPC	4.370E+00	3.003E+00	3.519E+00
STRTHK	1.444E-01	1.557E-01	1.464E-01
STRHI	9.977E-01	1.000E+00	5.449E-01
RNGTHK	2.635E-01	1.579E-01	1.763E-01
RNGHI	9.977E-01	1.000E+00	5.449E-01
ZTANK(1)	1.750E+02	1.750E+02	1.750E+02
ZGRND(1)	9.595E+01	1.067E+02	1.059E+02
ATANK(1)	6.000E+00	6.000E+00	6.000E+00
AGRND(1)	5.357E+01	4.500E+01	3.600E+01
IDTUBE(1)	5.853E+00	5.177E+00	4.630E+00
DUBAXL(1)	3.000E+01	3.000E+01	3.000E+01
DUBTHK(1)	1.517E-01	1.852E-01	5.590E-01
TRNGTH(1)	1.000E-01	1.000E-01	4.041E-01
TRNGHI(1)	5.000E-01	5.000E-01	2.021E+00
THICK(1)	5.730E-03	5.587E-03	5.782E-03
ANGLE(1)	1.358E+01	1.264E+01	1.139E+01
ANGLE(3)	1.000E+01	1.000E+01	1.162E+01
ANGLE(5)	6.121E+01	6.532E+01	8.000E+01
Objective = WGTxTOTMAS/TNKNRM +(1-WGT)xCONDCT/CONNRM with WGT = 0.5, TNKNRM = 3.0 lb-sec^2/inch, CONNRM = 0.0006 BTU/hr-deg.R			
Objective	1.139E+00	1.214E+00	1.367E+00
TOTMAS	4.6626E+00	4.6609E+00	4.8641E+00
CONDCT	3.9246E-04	5.2505E-04	6.6764E-04

Table 6 Behaviors of Feasible Optimum Designs for the Short Propellant Tank with 3, 4 and 5 Pairs of Struts Attached at the Tank Midlength. (These behaviors correspond to the optimum designs that were obtained after the August 2012 and February 2013 updates to the "tank" software, struct.tank and behavior.tank. See the previous table.)

Behavior	3 strut pairs	4 strut pairs	5 strut pairs
Load Case 1:			
FREQ(1,1)	1.349E+01	1.582E+01	1.834E+01
FREQ(1,2)	1.263E+01	1.375E+01	1.280E+01
FREQ(1,3)	4.270E+01	4.216E+01	4.919E+01
FREQ(1,4)	4.050E+01	4.092E+01	4.726E+01
STRES1(1,1)	4.637E+03	5.179E+03	6.524E+03
STRES1(1,2)	3.933E+04	3.518E+04	3.026E+04
STRES1(1,3)	4.246E+03	4.247E+03	4.243E+03
STRES1(1,4)	1.000E-10	1.000E-10	1.000E-10
STRES1(1,5)	1.290E+03	1.042E+03	4.516E+02
COLBUK(1,1)	1.165E+00	1.438E+00	1.847E+00
SHLBUK(1,1)	2.324E+00	2.869E+00	3.831E+00
FORCE(1,1)	3.208E+03	2.408E+03	1.727E+03
TNKSTR(1,1)	5.020E+04	5.036E+04	4.997E+04
TNKBUK(1,1)	2.410E+01	1.504E+01	1.179E+01
Load Case 2:			
FREQ(2,1)	1.284E+01	1.378E+01	1.713E+01
FREQ(2,2)	1.203E+01	1.201E+01	1.195E+01
FREQ(2,3)	4.257E+01	4.172E+01	4.886E+01
FREQ(2,4)	4.045E+01	4.065E+01	4.701E+01
STRES1(2,1)	5.713E+04	5.412E+04	4.722E+04
STRES1(2,2)	4.514E+04	4.872E+04	4.952E+04
STRES1(2,3)	7.039E+03	7.043E+03	7.054E+03
STRES1(2,4)	1.000E-10	1.000E-10	1.000E-10
STRES1(2,5)	2.357E+03	1.868E+03	7.472E+02
COLBUK(2,1)	1.008E+00	9.991E-01	1.022E+00
SHLBUK(2,1)	2.010E+00	1.994E+00	2.121E+00
FORCE(2,1)	3.208E+03	2.408E+03	1.727E+03
TNKSTR(2,1)	5.021E+04	5.034E+04	5.044E+04
TNKBUK(2,1)	3.782E+01	3.533E+01	8.574E+00

Table 7 Comparisons between predictions from STAGS and from GENOPT/TANK for the earlier optimized long propellant tank with aft (Lower) and forward (Upper) sets of struts, 4 pairs of struts in each set. (The earlier optimum design is that obtained before the August 2012 and February 2013 updates to the GENOPT/TANK software, behavior.tank and struct.tank. This earlier optimum design is listed in the section entitled: "Section 10. DECISION VARIABLE CANDIDATES FOR THE OPTIMIZED SPECIFIC CASE CALLED "test": THE LONG PROPELLANT TANK WITH TWO SETS OF STRUTS, AFT AND FORWARD, 4 PAIRS OF STRUTS IN EACH SET")

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(a) Comparison of major-mass modes (modes in which there is significant strut extension/compression) followed by shell deformation modes (modes in which there is much less strut energy):

Mode Description	Vibration Frequency (Hz)	
	STAGS	GENOPT/TANK
Tank axial motion	13.46	12.06
Tank lateral-pitching mode 1	12.19 and 13.90	12.16
Tank lateral-pitching mode 2	16.25	15.28
Tank rolling motion	15.92 and19.82	17.79
n=2 circ. waves tank shell deformation	13.02	13.24
n=3 circ. waves tank shell deformation	12.19 and13.90	13.33
n=4 circ. waves tank shell deformation	15.92 and 16.19	16.68

(b) Comparison of Strut Forces from Load Case 1 and Load Case 2:

1. Load Case 1: 10G axial acceleration + 25psi internal pressure + tank cool-down

Strut	Value	Strut Forces (lbs.)	
		STAGS	GENOPT/TANK
Lower (aft)	Max.	-24611	-22693
	Min.	-24841	
Upper (forward)	Max.	53035	53554
	Min.	52767	

2. Load Case 2: 10G lateral acceleration + 25psi internal pressure + tank cool-down

Strut	Value	Strut Forces (lbs.)	
		STAGS	GENOPT/TANK
Lower (aft)	Max.	64401	60463
	Min.	-36298	-39393
Upper (forward)	Max.	65057	60471
	Min.	-38568	-40611

(c) Comparison of maximum strut stresses from Load Case 1 and Load Case 2:

1. Load Case 1: 10G axial acceleration + 25psi internal pressure + tank cool-down

Strut	Direction	Sense	Stress (psi)	
			STAGS	GENOPT/TANK
Lower (aft)	Fiber	Tension	973	4724
		Compression	23318	22060
	Transverse	Tension	510	4240
		Compression	816	0
	Shear	n/a	1216	914
Upper (forward)	Fiber	Tension	43607	52620
		Compression	4088	14160
	Transverse	Tension	2288	6671
		Compression	327	0
	Shear	n/a	1881	2328

2. Load Case 2: 10G lateral acceleration + 25psi internal pressure + tank cool-down

Strut	Direction	Sense	Stress (psi)	
			STAGS	GENOPT/TANK
Lower (aft)	Fiber	Tension	61017	63980
		Compression	34391	37110
	Transverse	Tension	2135	7016
		Compression	1334	0
	Shear	n/a	3182	3659
Upper (forward)	Fiber	Tension	53763	58880
		Compression	31873	34380
	Transverse	Tension	2807	7035
		Compression	1664	0
	Shear	n/a	2307	2584

(d) Comparison of struts buckling as columns:

Strut	Load Case	Compressive Load (lbs.)	Buckling Load Factor	
			STAGS (does not include tank flexibility)	GENOPT/TANK (does not include tank flexibility)
Lower (aft)	10G Axial	24841	3.99	4.163
	10G Lateral	36298	2.74	2.398
Upper (forward)	10G Axial	Tension	n/a	n/a
	10G Lateral	38568	3.00	2.645

(e) Comparison of struts buckling as thin shells:

Strut	Load Case	Compressive Load (lbs.)	Buckling Load Factor	
			STAGS	GENOPT/TANK
Lower (aft)	10G Axial	24841	4.73	5.314
	10G Lateral	36298	3.24	3.095
Upper (forward)	10G Axial	Tension	n/a	n/a
	10G Lateral	38568	3.65	3.210

(f) Comparison of strut forces in the Launch Hold condition:

Strut	Strut Force (lbs.)	
	STAGS	GENOPT/TANK
Lower (aft)	11157	7317
Upper (forward)	18143	14390