

ATTACHMENT I
SINGLE HEATER TEST (SHT) SOFTWARE ROUTINE TESTING AND
VERIFICATION

SINGLE HEATER TEST (SHT) SOFTWARE ROUTINE TESTING AND VERIFICATION

This attachment provides documentation of software routine testing and verification for the Single Heater Test (SHT) model. The following software routines are related to MESH generation used in the SHT model: amb.f, bdryinselem.f, dkmmesh.f, dkmmeshamb.f, dkmmeshamb_mod_1D.f, dkmmeshamb_mod.f, dkmmesh_mod.f.

The software routine icpredkm.f takes an ambient equilibrated SHT model domain and adds the boundary conditions needed in the IC file used for heating simulations.

The routines tough_extract_frac.f and tough_extract_mtrx.f take the TOUGH2.OUT files and writes the temperature, liquid saturation, and pressure in column format along with their x, y, z coordinate locations for the fracture and matrix solutions.

The software routines Compare and read_temp_vs_time_models use post processed data to compare measured to simulated data.

The source codes of these routines are included in DTN: SN0003T0872799.012.

Software Routines

amb.f (Version 1)

The routine amb.f takes a MESH file obtained from the built-in meshmaker option in TOUGH2 and reformats the meshmaker MESH file to contain the boundary conditions (both top and bottom) required in the ambient initialization of the SHT model domain. The source code for the routine is the following:

```
character*5 name
character*80 BLOCK
character*10 volx
character*3 el
character*3 el1
character*3 el2
open(unit=16,file='MESH1.988',status='old')
open(unit=17,file='MESH',status = 'unknown')
2  read(16,5) name
5  format(a5)
   if(name.ne.'ELEM') go to 2
95  read(16,100) el, ne, ma2, volx, BLOCK(31:80)
100 format(a3,i2,13x,i2,a10,a50)
    if ( el(1:3) .eq. '  ' ) goto 306
    if ( el(3:3) .eq. '1') THEN
        ma2 = 3
c    volx = ' 1.0E+50'
        write(17,100) el, ne, ma2, volx, BLOCK(31:80)
        goto 95
    ELSE IF ( el(3:3) .eq. 'Z' ) then
        ma2 = 4
```

```

        volx = ' 1.0E+50'
        write(17,100) el, ne, ma2, volx, BLOCK(31:80)
        goto 95
    else
        write(17,100) el, ne, ma2, volx, BLOCK(31:80)
        goto 95
    end if

306  read(16,5) name
    if(name.ne.'CONNE') go to 306
105  read(16,101) BLOCK(1:80)
101  format(A80)
        if( BLOCK(1:3) .eq. ' ') goto 307

        write(17,101) BLOCK(1:80)
        goto 105

307  close(17)
    stop
    end

```

An excerpt from the TOUGH2 meshmaker created MESH file is the following (e.g., the input to the above routine). The input file name is: MESH1.988.

ELEME						
A11 1	1	.1063E-01	.2125E-01	.2125E-01	.2500E+00	.2500E+00
A21 1	1	.1619E-02	.0000E+00	.2125E-01	.2500E+00	.5381E+00
A31 1	1	.1619E-02	.0000E+00	.2125E-01	.2500E+00	.6143E+00
A41 1	1	.1063E-01	.0000E+00	.2125E-01	.2500E+00	.9024E+00
A51 1	1	.1063E-01	.0000E+00	.2125E-01	.2500E+00	.1402E+01
A61 1	1	.1050E-01	.0000E+00	.2125E-01	.2500E+00	.1899E+01
A71 1	1	.1050E-01	.0000E+00	.2125E-01	.2500E+00	.2393E+01
A81 1	1	.2125E-01	.0000E+00	.2125E-01	.2500E+00	.3140E+01
A91 1	1	.2125E-01	.0000E+00	.2125E-01	.2500E+00	.4140E+01
AA1 1	1	.2125E-01	.0000E+00	.2125E-01	.2500E+00	.5140E+01
AB1 1	1	.2125E-01	.0000E+00	.2125E-01	.2500E+00	.6140E+01
AC1 1	1	.2125E-01	.0000E+00	.2125E-01	.2500E+00	.7140E+01
AD1 1	1	.1063E-01	.0000E+00	.2125E-01	.2500E+00	.7890E+01
AE1 1	1	.1063E-01	.0000E+00	.2125E-01	.2500E+00	.8390E+01
AF1 1	1	.1063E-01	.0000E+00	.2125E-01	.2500E+00	.8890E+01
AG1 1	1	.1063E-01	.0000E+00	.2125E-01	.2500E+00	.9390E+01
AH1 1	1	.5242E-01	.0000E+00	.2125E-01	.2500E+00	.1087E+02
AI1 1	1	.5242E-01	.0000E+00	.2125E-01	.2500E+00	.1334E+02
AJ1 1	1	.5242E-01	.0000E+00	.2125E-01	.2500E+00	.1581E+02
AK1 1	1	.1063E-01	.2125E-01	.2125E-01	.2500E+00	.1729E+02
A12 1	1	.4306E-01	.8611E-01	.2125E-01	.1513E+01	.2500E+00
A22 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01	.5381E+00
A32 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01	.6143E+00
A42 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.9024E+00
A52 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.1402E+01
A62 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	.1899E+01
A72 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	.2393E+01
A82 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.3140E+01
A92 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.4140E+01
AA2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.5140E+01
AB2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.6140E+01
AC2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.7140E+01
AD2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.7890E+01
AE2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.8390E+01
AF2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.8890E+01
AG2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.9390E+01
AH2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	.1087E+02
AI2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	.1334E+02
AJ2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	.1581E+02

AK2 1	1	.4306E-01	.8611E-01	.2125E-01	.1513E+01	.1729E+02
A1Z 1	1	.1063E-01	.2125E-01	.2125E-01	.2075E+02	.2500E+00
A2Z 1	1	.1619E-02	.0000E+00	.2125E-01	.2075E+02	.5381E+00
A3Z 1	1	.1619E-02	.0000E+00	.2125E-01	.2075E+02	.6143E+00
A4Z 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	.9024E+00
A5Z 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	.1402E+01
A6Z 1	1	.1050E-01	.0000E+00	.2125E-01	.2075E+02	.1899E+01
A7Z 1	1	.1050E-01	.0000E+00	.2125E-01	.2075E+02	.2393E+01
A8Z 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	.3140E+01
A9Z 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	.4140E+01
AAZ 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	.5140E+01
ABZ 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	.6140E+01
ACZ 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	.7140E+01
ADZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	.7890E+01
AEZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	.8390E+01
AFZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	.8890E+01
AGZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	.9390E+01
AHZ 1	1	.5242E-01	.0000E+00	.2125E-01	.2075E+02	.1087E+02
AIZ 1	1	.5242E-01	.0000E+00	.2125E-01	.2075E+02	.1334E+02
AJZ 1	1	.5242E-01	.0000E+00	.2125E-01	.2075E+02	.1581E+02
AKZ 1	1	.1063E-01	.2125E-01	.2125E-01	.2075E+02	.1729E+02
A11 2	1	.2125E-01	.4250E-01	.8500E-01	.2500E+00	.2500E+00
A21 2	1	.3239E-02	.0000E+00	.8500E-01	.2500E+00	.5381E+00
A31 2	1	.3239E-02	.0000E+00	.8500E-01	.2500E+00	.6143E+00
A41 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	.9024E+00
A51 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	.1402E+01
A61 2	1	.2100E-01	.0000E+00	.8500E-01	.2500E+00	.1899E+01
A71 2	1	.2100E-01	.0000E+00	.8500E-01	.2500E+00	.2393E+01
A81 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	.3140E+01
A91 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	.4140E+01
AA1 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	.5140E+01
AB1 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	.6140E+01
AC1 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	.7140E+01
AD1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	.7890E+01
AE1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	.8390E+01
AF1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	.8890E+01
AG1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	.9390E+01
AH1 2	1	.1048E+00	.0000E+00	.8500E-01	.2500E+00	.1087E+02
AI1 2	1	.1048E+00	.0000E+00	.8500E-01	.2500E+00	.1334E+02
AJ1 2	1	.1048E+00	.0000E+00	.8500E-01	.2500E+00	.1581E+02
AK1 2	1	.2125E-01	.4250E-01	.8500E-01	.2500E+00	.1729E+02
A12 2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01	.2500E+00
A22 2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	.5381E+00
A32 2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	.6143E+00
A42 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.9024E+00
A52 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.1402E+01
A62 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	.1899E+01
A72 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	.2393E+01
A82 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.3140E+01
A92 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.4140E+01
AA2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.5140E+01
AB2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.6140E+01
AC2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.7140E+01
AD2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.7890E+01
AE2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.8390E+01
AF2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.8890E+01
AG2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.9390E+01
AH2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	.1087E+02
AI2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	.1334E+02
AJ2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	.1581E+02
AK2 2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01	.1729E+02
AJY18	1	.2499E+01	.0000E+00	.6603E+01	.1949E+02	.1581E+02
AKY18	1	.5065E+00	.1013E+01	.6603E+01	.1949E+02	.1729E+02
A1Z18	1	.1250E+00	.2500E+00	.6603E+01	.2075E+02	.2500E+00
A2Z18	1	.1905E-01	.0000E+00	.6603E+01	.2075E+02	.5381E+00
A3Z18	1	.1905E-01	.0000E+00	.6603E+01	.2075E+02	.6143E+00
A4Z18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02	.9024E+00
A5Z18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02	.1402E+01

A6Z18	1	.1235E+00	.0000E+00	.6603E+01	.2075E+02-	.1899E+01
A7Z18	1	.1235E+00	.0000E+00	.6603E+01	.2075E+02-	.2393E+01
A8Z18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-	.3140E+01
A9Z18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-	.4140E+01
AAZ18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-	.5140E+01
ABZ18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-	.6140E+01
ACZ18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-	.7140E+01
ADZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-	.7890E+01
AEZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-	.8390E+01
AFZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-	.8890E+01
AGZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-	.9390E+01
AHZ18	1	.6167E+00	.0000E+00	.6603E+01	.2075E+02-	.1087E+02
AIZ18	1	.6167E+00	.0000E+00	.6603E+01	.2075E+02-	.1334E+02
AJZ18	1	.6167E+00	.0000E+00	.6603E+01	.2075E+02-	.1581E+02
AKZ18	1	.1250E+00	.2500E+00	.6603E+01	.2075E+02-	.1729E+02

CONNE

A11 1A11 2	1	.2125E-01	.4250E-01	.2500E+00		
A11 1A12 1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01	
A11 1A21 1	3	.2500E+00	.3810E-01	.2125E-01	.0000E+00	
A21 1A21 2	1	.2125E-01	.4250E-01	.3810E-01		
A21 1A22 1	2	.2500E+00	.1013E+01	.3239E-02	.1000E+01	
A21 1A31 1	3	.3810E-01	.3810E-01	.2125E-01	.0000E+00	
A31 1A31 2	1	.2125E-01	.4250E-01	.3810E-01		
A31 1A32 1	2	.2500E+00	.1013E+01	.3239E-02	.1000E+01	
A31 1A41 1	3	.3810E-01	.2500E+00	.2125E-01	.0000E+00	
A41 1A41 2	1	.2125E-01	.4250E-01	.2500E+00		
A41 1A42 1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01	
A41 1A51 1	3	.2500E+00	.2500E+00	.2125E-01	.0000E+00	
A51 1A51 2	1	.2125E-01	.4250E-01	.2500E+00		
A51 1A52 1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01	
A51 1A61 1	3	.2500E+00	.2470E+00	.2125E-01	.0000E+00	
A61 1A61 2	1	.2125E-01	.4250E-01	.2470E+00		
A61 1A62 1	2	.2500E+00	.1013E+01	.2100E-01	.1000E+01	
A61 1A71 1	3	.2470E+00	.2470E+00	.2125E-01	.0000E+00	
A71 1A71 2	1	.2125E-01	.4250E-01	.2470E+00		
A71 1A72 1	2	.2500E+00	.1013E+01	.2100E-01	.1000E+01	
A71 1A81 1	3	.2470E+00	.5000E+00	.2125E-01	.0000E+00	
A81 1A81 2	1	.2125E-01	.4250E-01	.5000E+00		
A81 1A82 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01	
A81 1A91 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00	
A91 1A91 2	1	.2125E-01	.4250E-01	.5000E+00		
A91 1A92 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01	
A91 1AA1 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00	
AA1 1AA1 2	1	.2125E-01	.4250E-01	.5000E+00		
AA1 1AA2 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01	

A5Z18A6Z18	3	.2500E+00	.2470E+00	.2500E+00	.0000E+00	
A6Z18A7Z18	3	.2470E+00	.2470E+00	.2500E+00	.0000E+00	
A7Z18A8Z18	3	.2470E+00	.5000E+00	.2500E+00	.0000E+00	
A8Z18A9Z18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00	
A9Z18AAZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00	
AAZ18ABZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00	
ABZ18ACZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00	
ACZ18ADZ18	3	.5000E+00	.2500E+00	.2500E+00	.0000E+00	
ADZ18AEZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00	
AEZ18AFZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00	
AFZ18AGZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00	
AGZ18AHZ18	3	.2500E+00	.1233E+01	.2500E+00	.0000E+00	
AHZ18AIZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00	
AIZ18AJZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00	
AJZ18AKZ18	3	.1233E+01	.2500E+00	.2500E+00	.0000E+00	

An excerpt from the amb.f routine created MESH file is the following (the output from the routine). The output file name is: MESH. The values changed by the routine are in bold.

ELEME						
A11 1	3	.1063E-01	.2125E-01	.2125E-01	.2500E+00-	.2500E+00
A21 1	3	.1619E-02	.0000E+00	.2125E-01	.2500E+00-	.5381E+00

A31 1	3	.1619E-02	.0000E+00	.2125E-01	.2500E+00	-.6143E+00
A41 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00	-.9024E+00
A51 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00	-.1402E+01
A61 1	3	.1050E-01	.0000E+00	.2125E-01	.2500E+00	-.1899E+01
A71 1	3	.1050E-01	.0000E+00	.2125E-01	.2500E+00	-.2393E+01
A81 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00	-.3140E+01
A91 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00	-.4140E+01
AA1 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00	-.5140E+01
AB1 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00	-.6140E+01
AC1 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00	-.7140E+01
AD1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00	-.7890E+01
AE1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00	-.8390E+01
AF1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00	-.8890E+01
AG1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00	-.9390E+01
AH1 1	3	.5242E-01	.0000E+00	.2125E-01	.2500E+00	-.1087E+02
AI1 1	3	.5242E-01	.0000E+00	.2125E-01	.2500E+00	-.1334E+02
AJ1 1	3	.5242E-01	.0000E+00	.2125E-01	.2500E+00	-.1581E+02
AK1 1	3	.1063E-01	.2125E-01	.2125E-01	.2500E+00	-.1729E+02
A12 1	1	.4306E-01	.8611E-01	.2125E-01	.1513E+01	-.2500E+00
A22 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01	-.5381E+00
A32 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01	-.6143E+00
A42 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.9024E+00
A52 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.1402E+01
A62 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	-.1899E+01
A72 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	-.2393E+01
A82 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.3140E+01
A92 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.4140E+01
AA2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.5140E+01
AB2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.6140E+01
AC2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.7140E+01
AD2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.7890E+01
AE2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.8390E+01
AF2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.8890E+01
AG2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.9390E+01
AH2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	-.1087E+02
AI2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	-.1334E+02
AJ2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	-.1581E+02
AK2 1	1	.4306E-01	.8611E-01	.2125E-01	.1513E+01	-.1729E+02
A1Z 1	4	1.0E+50	.2125E-01	.2125E-01	.2075E+02	-.2500E+00
A2Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.5381E+00
A3Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.6143E+00
A4Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.9024E+00
A5Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.1402E+01
A6Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.1899E+01
A7Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.2393E+01
A8Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.3140E+01
A9Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.4140E+01
AAZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.5140E+01
ABZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.6140E+01
ACZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.7140E+01
ADZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.7890E+01
AEZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.8390E+01
AFZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.8890E+01
AGZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.9390E+01
AHZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.1087E+02
AIZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.1334E+02
AJZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02	-.1581E+02
AKZ 1	4	1.0E+50	.2125E-01	.2125E-01	.2075E+02	-.1729E+02
A11 2	3	.2125E-01	.4250E-01	.8500E-01	.2500E+00	-.2500E+00
A21 2	3	.3239E-02	.0000E+00	.8500E-01	.2500E+00	-.5381E+00
A31 2	3	.3239E-02	.0000E+00	.8500E-01	.2500E+00	-.6143E+00
A41 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.9024E+00
A51 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.1402E+01
A61 2	3	.2100E-01	.0000E+00	.8500E-01	.2500E+00	-.1899E+01
A71 2	3	.2100E-01	.0000E+00	.8500E-01	.2500E+00	-.2393E+01
A81 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.3140E+01
A91 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.4140E+01
AA1 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.5140E+01
AB1 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.6140E+01
AC1 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.7140E+01

AD1	2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.7890E+01
AE1	2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.8390E+01
AF1	2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.8890E+01
AG1	2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.9390E+01
AH1	2	3	.1048E+00	.0000E+00	.8500E-01	.2500E+00	-.1087E+02
AI1	2	3	.1048E+00	.0000E+00	.8500E-01	.2500E+00	-.1334E+02
AJ1	2	3	.1048E+00	.0000E+00	.8500E-01	.2500E+00	-.1581E+02
AK1	2	3	.2125E-01	.4250E-01	.8500E-01	.2500E+00	-.1729E+02
A12	2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01	-.2500E+00
A22	2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	-.5381E+00
A32	2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	-.6143E+00
A42	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.9024E+00
A52	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.1402E+01
A62	2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	-.1899E+01
A72	2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	-.2393E+01
A82	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.3140E+01
A92	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.4140E+01
AA2	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.5140E+01
AB2	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.6140E+01
AC2	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.7140E+01
AD2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.7890E+01
AE2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.8390E+01
AF2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.8890E+01
AG2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.9390E+01
AH2	2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	-.1087E+02
AI2	2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	-.1334E+02
AJ2	2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	-.1581E+02
AK2	2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01	-.1729E+02

AJY18	1	.2499E+01	.0000E+00	.6603E+01	.1949E+02	-.1581E+02
AKY18	1	.5065E+00	.1013E+01	.6603E+01	.1949E+02	-.1729E+02
A1Z18	4	1.0E+50	.2500E+00	.6603E+01	.2075E+02	-.2500E+00
A2Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.5381E+00
A3Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.6143E+00
A4Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.9024E+00
A5Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.1402E+01
A6Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.1899E+01
A7Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.2393E+01
A8Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.3140E+01
A9Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.4140E+01
AAZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.5140E+01
ABZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.6140E+01
ACZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.7140E+01
ADZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.7890E+01
AEZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.8390E+01
AFZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.8890E+01
AGZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.9390E+01
AHZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.1087E+02
AIZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.1334E+02
AJZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.1581E+02
AKZ18	4	1.0E+50	.2500E+00	.6603E+01	.2075E+02	-.1729E+02

CONNE

A11	1A11	2	1	.2125E-01	.4250E-01	.2500E+00
A11	1A12	1	2	.2500E+00	.1013E+01	.2125E-01
A11	1A21	1	3	.2500E+00	.3810E-01	.2125E-01
A21	1A21	2	1	.2125E-01	.4250E-01	.3810E-01
A21	1A22	1	2	.2500E+00	.1013E+01	.3239E-02
A21	1A31	1	3	.3810E-01	.3810E-01	.2125E-01
A31	1A31	2	1	.2125E-01	.4250E-01	.3810E-01
A31	1A32	1	2	.2500E+00	.1013E+01	.3239E-02
A31	1A41	1	3	.3810E-01	.2500E+00	.2125E-01
A41	1A41	2	1	.2125E-01	.4250E-01	.2500E+00
A41	1A42	1	2	.2500E+00	.1013E+01	.2125E-01
A41	1A51	1	3	.2500E+00	.2500E+00	.2125E-01
A51	1A51	2	1	.2125E-01	.4250E-01	.2500E+00
A51	1A52	1	2	.2500E+00	.1013E+01	.2125E-01
A51	1A61	1	3	.2500E+00	.2470E+00	.2125E-01
A61	1A61	2	1	.2125E-01	.4250E-01	.2470E+00
A61	1A62	1	2	.2500E+00	.1013E+01	.2100E-01

A61 1A71 1	3	.2470E+00	.2470E+00	.2125E-01	.0000E+00
A71 1A71 2	1	.2125E-01	.4250E-01	.2470E+00	
A71 1A72 1	2	.2500E+00	.1013E+01	.2100E-01	.1000E+01
A71 1A81 1	3	.2470E+00	.5000E+00	.2125E-01	.0000E+00
A81 1A81 2	1	.2125E-01	.4250E-01	.5000E+00	
A81 1A82 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01
A81 1A91 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00
A91 1A91 2	1	.2125E-01	.4250E-01	.5000E+00	
A91 1A92 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01
A91 1AA1 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00
AA1 1AA1 2	1	.2125E-01	.4250E-01	.5000E+00	
AA1 1AA2 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01
A5Z18A6Z18	3	.2500E+00	.2470E+00	.2500E+00	.0000E+00
A6Z18A7Z18	3	.2470E+00	.2470E+00	.2500E+00	.0000E+00
A7Z18A8Z18	3	.2470E+00	.5000E+00	.2500E+00	.0000E+00
A8Z18A9Z18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
A9Z18AAZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
AAZ18ABZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
ABZ18ACZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
ACZ18ADZ18	3	.5000E+00	.2500E+00	.2500E+00	.0000E+00
ADZ18AEZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AEZ18AFZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AFZ18AGZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AGZ18AHZ18	3	.2500E+00	.1233E+01	.2500E+00	.0000E+00
AHZ18AIZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00
AIZ18AJZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00
AJZ18AKZ18	3	.1233E+01	.2500E+00	.2500E+00	.0000E+00

The excerpt shown above from the primary MESH file obtained from the amb.f software routine is verified to be correct based on this comparison and a consistent total line count for each file (e.g., the input and output MESH files to/from amb.f). Therefore, the software routine functions as it should as shown in the testing/comparison method described above. The primary MESH file obtained from the amb.f software routine is the primary ambient initialization mesh that is converted to a DKM mesh file with the use of dkmmeshamb.f and dkmmeshamb_mod.f routines.

The range of validity for this routine is a TOUGH2 meshmaker generated initial primary mesh file with $n_x = 18$, $n_y = 35$ (direction of gravity), and $n_z = 20$.

The file name MESH1.988 is used as input for each of the SHT software routines described below since this file provides the unmodified elemental volumes needed in the calculations performed in by the routines. These routines are analyzed next.

The dkmmeshamb.f routine takes the MESH file obtained from the previous routine and converts it to a DKM mesh file. The dkmmeshamb.f routine is used in the TSPA-VA and the Median bulk Kb sensitivity analyses of the thermal testing AMR (N0000).

Before the dkmmeshamb routine is analyzed, an independent test problem was created to test and verify the method used in the DKM mesh generators. Since the Single Heater Test model domain is so large, a much smaller 3-D test problem was created to test and verify the internal procedural steps of this routine (and the heating mesh software routine source code, dkmmesh.f).

Small 3-D Test Case

The test case takes a small 3-D primary mesh and converts it to a dual permeability mesh as used in the TSPA-VA and the Median bulk Kb sensitivity analyses. This small test case is completely analogous to the larger SHT model domain, only much smaller. The test mesh file is for a 3

element X 3 element X 3 element 3-D model domain. Hence, the range of validity for the small testing problem is a 27 element domain. The test case primary mesh (generated by the meshmaker in TOUGH2 and modified by hand to have special boundary elements) is the following (Note: this test primary mesh file is equivalent to a mesh file created by the amb.f routine previously described). The source code routine for the sample small test problem DKM generator is the following:

```

c
c   This processor will read the MESH file for the SHT ECM model
c   and transform it into a DKM model.  It is problem specific
c   in that it is looking for certain element indicators such
c   as specific material identifiers. Only one fracture porosity
c   will be input and used to determine the matrix and fracture
c   volumes in the ELEME
c
c   Nick Francis 03/13/98
c
c
c
c
c
c
c
c
c2345678901234567890123456789012345678901234567890123456789012
c
c   implicit double precision (a-h,l,o-z)
c   character*5 name
c   character*5 elnamem
c   character*5 elnamef
c   character*3 el1
c   character*3 el1old
c   character*3 el2
c   character*3 el2old
c   character*3 el
c   dimension vol_i(27)
c
c... Enter input data such as fracture set dimensions,
c   fractures spacing, fracture porosity
c
c   write(*,*) 'What is the name of the input file?'
c   read(*, '(a)') infile
c   write(*,*)
c   write(*,*) 'Enter the dimension N=? of fracture set'
c   write(*,*) 'N=2 for 1-d, N=4 for 2-d, N=6 for 3-d'
c   read(*,*) xN
c   write(*,*)
c   write(*,*) 'Enter the fracture spacing in meters'
c   read(*,*) D
c   write(*,*)
c
c... compute the nodal distance for the fracture-matrix connection
c... it is based on the dimensionality of the fracture set
c

```

```

        if (xN .eq. 2.) then
            con_dm = D/6.
        elseif (xN .eq. 4. ) then
            con_dm = D/8.
        elseif (xN .eq. 6.) then
            con_dm = D/10.
        else
            write(*,*) 'you have made an error'
        end if

c
c
c... read in fracture porosity
    write(*,*) 'Enter the fracture porosity'
    read(*,*) phif
    write(*,*)

c... read in the DKM fmX specification
    write (*,*) 'Select a f-m connection: c=1, krl=2, other=3'
    read(*,*) idkfm

c... open up necessary files
    open(9,file='MESH1.988',status='old')
    open(10,file=infile,status='old')
    open(13,file='dkm.mesh',status='unknown')
10    format(a5)
100   format(a3,i2,13x,i2,2E10.4,10x,3E10.4)
101   format(20x,E10.4)
102   format('M',a2,i2,10x,'roccm',2E10.4,10x,3E10.4)
103   format('F',a2,i2,10x,'roccf',2E10.4,10x,3E10.4)
112   format('M',a2,i2,10x,'heatm',2E10.4,10x,3E10.4)
113   format('F',a2,i2,10x,'heatf',2E10.4,10x,3E10.4)
122   format('M',a2,i2,10x,'inslm',2E10.4,10x,3E10.4)
123   format('F',a2,i2,10x,'inslf',2E10.4,10x,3E10.4)
132   format('M',a2,i2,10x,'tunnm',2E10.4,10x,3E10.4)
133   format('F',a2,i2,10x,'tunnf',2E10.4,10x,3E10.4)
104   format(a3,i2,a3,i2,15x,i5,4e10.4)
105   format('M',a2,i2,'M',a2,i2,15x,i5,4e10.4)
106   format('F',a2,i2,'F',a2,i2,15x,i5,4e10.4)
107   format('F',a2,i2,'M',a2,i2,15x,i5,5e10.4)

c... determines the fmX type
c
    if( idkfm .eq. 1) then

        write(*,*) 'enter the constant multiplier'
        read(*,*) const
        fmX = const

    elseif ( idkfm .eq. 2) then

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'k_rl weighted connection'
        read(*,*) ckrl
        fmX = ckrl

    else

```

```

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'other weighted connection'
        read(*,*) ckoth
        fmx = ckoth

    end if

c
c
c... store the element volumes from the original mesh
    i=1
1    read(9,10) name
    if (name .ne. 'ELEM') goto 1
32   read(9,101) vol_i(i)
    if (i .eq. 27) then
        goto 2
    else
        i=i+1
        goto 32
    end if

c... work on the ELEM portion of the mesh first
c... begin creating the DKM mesh from the working
c    ECM mesh

2    read(10,10) name
    if (name .ne. 'ELEM') goto 2
33   read(10,100) el, ne,ma2,volx, ahtx,x,y,z
    if (el .eq. ' ') goto 555

        if (ma2 .eq. 4) then

c
c... these are the air boundary elements

c... write the matrix element
        volxm = volx*(1.-phif)
        write(13,132) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element

        write(13,133) el(2:3), ne,volx,ahtx,x,y,z

        elseif (ma2 .eq. 5) then

c... these are the insulation elements

c... write the matrix element
        volxm = volx*(1.-phif)
        write(13,122) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element

        write(13,123) el(2:3), ne,volx,ahtx,x,y,z

c

```

```

        elseif (ma2 .eq. 2) then
c
c.... these are the heater elements

c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,112) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element

      write(13,113) el(2:3), ne,volx,ahtx,x,y,z

c
      elseif (ma2 .eq. 3) then
c
c... these are rock boundary elements
c   THEY ARE dkm elements
c
c... these are rock boundary elements
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z

      else

c... This are interior rock elements
c   THEY ARE dkm elements
c
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      ma2 = 7
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z

      end if

      goto 33

c.... work on the CONNE portion of the mesh next

555 read(10,10) name
      if (name .ne. 'CONNE') goto 555
      i = 1
      icheck=1

44  read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

c... write the matrix-matrix connection

```

```

45    write(13,105) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @    areax,betax
c... write the fracture-fracture connection
      write(13,106) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @    areax,betax

      if (icheck .eq. 1) then
C... write the fracture-matrix connection
      areax = xN*vol_i(i)/D
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el1(2:3),ne1,el1(2:3),ne1,isot,con_df,
      @    con_dm,areax,betax,fx
      i = i+1
      end if

      el1old=el1(1:3)
      el2old=el2(1:3)
      ne2old=ne2
      read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

      if (el1 .eq. ' ') goto 556
      if (el1 .eq. el1old) then
        icheck=2
        goto 45
      else
        icheck=1
        goto 45
      endif

556    areax = xN*vol_i(i)/D
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el2old(2:3),ne2old,el2old(2:3),
      @    ne2old,isot,con_df,con_dm,areax,betax,fx

      close(12)
      close(13)
      stop
      end

```

The primary MESH file used as input for this routine is the following. It includes boundary elements analogous to the boundary elements applied in the actual SHT model domain used in the AMR. This test mesh file is listed in its entirety.

ELEME		
A11 1	40.1063E-010.2125E-01	0.2125E-010.2500E+00-.2500E+00
A21 1	50.1050E-010.0000E+00	0.2125E-010.2500E+00-.7470E+00
A31 1	10.2125E-010.2125E-01	0.2125E-010.2500E+00-.1494E+01
A12 1	10.3188E-010.6375E-01	0.2125E-010.1250E+01-.2500E+00
A22 1	10.3149E-010.0000E+00	0.2125E-010.1250E+01-.7470E+00

A32 1	10.6375E-010.6375E-01	0.2125E-010.1250E+01-.1494E+01
A13 1	10.1594E-010.3188E-01	0.2125E-010.2375E+01-.2500E+00
A23 1	10.1575E-010.0000E+00	0.2125E-010.2375E+01-.7470E+00
A33 1	10.3188E-010.3188E-01	0.2125E-010.2375E+01-.1494E+01
A11 2	10.2125E-010.4250E-01	0.8500E-010.2500E+00-.2500E+00
A21 2	10.2099E-010.0000E+00	0.8500E-010.2500E+00-.7470E+00
A31 2	10.4250E-010.4250E-01	0.8500E-010.2500E+00-.1494E+01
A12 2	10.6375E-010.1275E+00	0.8500E-010.1250E+01-.2500E+00
A22 2	20.6298E-010.0000E+00	0.8500E-010.1250E+01-.7470E+00
A32 2	10.1275E+000.1275E+00	0.8500E-010.1250E+01-.1494E+01
A23 2	10.3188E-010.6375E-01	0.8500E-010.2375E+01-.2500E+00
A33 2	10.6375E-010.6375E-01	0.8500E-010.2375E+01-.1494E+01
A11 3	10.3125E-010.6250E-01	0.8500E-010.2375E+01-.7470E+00
A21 3	10.3087E-010.0000E+00	0.1900E+000.2500E+00-.7470E+00
A31 3	10.6250E-010.6250E-01	0.1900E+000.2500E+00-.1494E+01
A12 3	10.9375E-010.1875E+00	0.1900E+000.1250E+01-.2500E+00
A22 3	10.9262E-010.0000E+00	0.1900E+000.1250E+01-.7470E+00
A32 3	10.1875E+000.1875E+00	0.1900E+000.2375E+01-.2500E+00
A13 3	10.4688E-010.9375E-01	0.1900E+000.2375E+01-.7470E+00
A23 3	50.4631E-010.0000E+00	0.1900E+000.2375E+01-.1494E+01
A33 3	40.9375E-010.9375E-01	0.1900E+000.2375E+01-.1494E+01

CONNE

A11 1A11 2	10.2125E-010.4250E-010.2500E+00	
A11 1A12 1	20.2500E+000.7500E+000.2125E-010.1000E+01	
A11 1A21 1	30.2500E+000.2470E+000.2125E-010.1795E-08	
A21 1A21 1	10.2125E-010.4250E-010.2470E+00	
A21 1A22 1	20.2500E+000.7500E+000.2099E-010.1000E+01	
A21 1A31 1	30.2470E+000.5000E+000.2125E-010.1795E-08	
A31 1A31 2	10.2125E-010.4250E-010.5000E+00	
A31 1A32 1	20.2500E+000.7500E+000.4250E-010.1000E+01	
A12 1A12 2	10.2125E-010.4250E-010.7500E+00	
A12 1A13 1	20.7500E+000.3750E+000.2125E-010.1000E+01	
A12 1A22 1	30.2500E+000.2470E+000.6375E-010.1795E-08	
A22 1A22 2	10.2125E-010.4250E-010.7410E+00	
A22 1A23 1	20.7500E+000.5000E+000.2099E-010.1000E+01	
A32 1A32 1	30.2470E+000.3750E+000.6375E-010.1795E-08	
A32 1A33 1	10.2125E-010.4250E-010.1500E+01	
A13 1A13 2	20.7500E+000.3750E+000.4250E-010.1000E+01	
A13 1A23 1	10.2125E-010.4250E-010.3750E+00	
A23 1A23 2	30.2500E+000.2470E+000.3188E-010.1795E-08	
A23 1A33 1	10.2125E-010.4250E-010.3705E+00	
A33 1A33 2	30.2470E+000.5000E+000.3188E-010.1795E-08	
A11 2A11 3	10.2125E-010.4250E-010.7500E+00	
A11 2A12 2	10.4250E-010.6250E-010.2500E+00	
A11 2A21 2	20.2500E+000.7500E+000.4250E-010.1000E+01	
A21 2A21 3	30.2500E+000.2470E+000.4250E-010.1795E-08	
A21 2A22 2	10.4250E-010.6250E-010.2470E+00	
A21 2A31 2	30.2470E+000.5000E+000.4199E-010.1000E+01	
A31 2A31 3	10.4250E-010.6250E-010.5000E+00	
A31 2A32 2	20.2500E+000.7500E+000.8500E-010.1000E+01	
A12 2A12 3	10.4250E-010.6250E-010.7500E+00	
A12 2A13 2	20.7500E+000.3750E+000.4250E-010.1000E+01	
A12 2A22 2	30.2500E+000.2470E+000.1275E+000.1795E-08	
A22 2A22 3	10.4250E-010.6250E-010.7410E+00	
A22 2A23 2	30.2470E+000.5000E+000.4199E-010.1000E+01	
A22 2A32 2	30.2470E+000.5000E+000.1275E+000.1795E-08	
A32 2A32 3	10.4250E-010.6250E-010.1500E+01	
A32 2A33 2	20.7500E+000.3750E+000.8500E-010.1000E+01	
A13 2A13 3	10.4250E-010.6250E-010.3750E+00	
A13 2A23 2	30.2500E+000.2470E+000.6375E-010.1795E-08	
A23 2A23 3	10.4250E-010.6250E-010.3705E+00	
A33 2A33 2	30.2470E+000.5000E+000.6375E-010.1795E-08	
A33 2A33 3	10.4250E-010.6250E-010.7500E+00	
A11 3A12 3	20.2500E+000.7500E+000.6250E-010.1000E+01	
A11 3A21 3	30.2500E+000.2470E+000.6250E-010.1795E-08	
A21 3A22 3	20.2500E+000.7500E+000.6175E-010.1000E+01	
A21 3A31 3	30.2470E+000.5000E+000.6250E-010.1795E-08	
A31 3A32 3	20.2500E+000.7500E+000.1250E+000.1000E+01	

A12 3A13 3	20.7500E+000.3750E+000.6250E-010.1000E+01
A12 3A22 3	30.2500E+000.2470E+000.1875E+000.1795E-08
A22 3A23 3	20.7500E+000.3750E+000.6175E-010.1000E+01
A22 3A32 3	30.2470E+000.5000E+000.1875E+000.1795E-08
A32 3A33 3	20.7500E+000.3750E+000.1250E+000.1000E+01
A13 3A23 3	30.2500E+000.2470E+000.9375E-010.1795E-08
A23 3A33 3	30.2470E+000.5000E+000.9375E-010.1795E-08

The software routine source code generated DKM mesh file for the small 3-D the testing problem is the following. It also is listed in its entirety (since it is small enough). Note that the routine does not insert the headers required in a TOUGH2 simulation. These should be entered by a user who is familiar with the rules of TOUGH2.

M11 1	tunm0.1063E-010.2125E-01	0.2125E-010.2500E+00-.2500E+00
F11 1	tunmf0.1063E-010.2125E-01	0.2125E-010.2500E+00-.2500E+00
M21 1	inslm0.1050E-010.0000E+00	0.2125E-010.2500E+00-.7470E+00
F21 1	inslf0.1050E-010.0000E+00	0.2125E-010.2500E+00-.7470E+00
M31 1	roccm0.2125E-010.2125E-01	0.2125E-010.2500E+00-.1494E+01
F31 1	roccf0.2125E-010.2125E-01	0.2125E-010.2500E+00-.1494E+01
M12 1	roccm0.3187E-010.6375E-01	0.2125E-010.1250E+01-.2500E+00
F12 1	roccf0.3188E-010.6375E-01	0.2125E-010.1250E+01-.2500E+00
M22 1	roccm0.3148E-010.0000E+00	0.2125E-010.1250E+01-.7470E+00
F22 1	roccf0.3149E-010.0000E+00	0.2125E-010.1250E+01-.7470E+00
M32 1	roccm0.6374E-010.6375E-01	0.2125E-010.1250E+01-.1494E+01
F32 1	roccf0.6375E-010.6375E-01	0.2125E-010.1250E+01-.1494E+01
M13 1	roccm0.1594E-010.3188E-01	0.2125E-010.2375E+01-.2500E+00
F13 1	roccf0.1594E-010.3188E-01	0.2125E-010.2375E+01-.2500E+00
M23 1	roccm0.1575E-010.0000E+00	0.2125E-010.2375E+01-.7470E+00
F23 1	roccf0.1575E-010.0000E+00	0.2125E-010.2375E+01-.7470E+00
M33 1	roccm0.3187E-010.3188E-01	0.2125E-010.2375E+01-.1494E+01
F33 1	roccf0.3188E-010.3188E-01	0.2125E-010.2375E+01-.1494E+01
M11 2	roccm0.2125E-010.4250E-01	0.8500E-010.2500E+00-.2500E+00
F11 2	roccf0.2125E-010.4250E-01	0.8500E-010.2500E+00-.2500E+00
M21 2	roccm0.2099E-010.0000E+00	0.8500E-010.2500E+00-.7470E+00
F21 2	roccf0.2099E-010.0000E+00	0.8500E-010.2500E+00-.7470E+00
M31 2	roccm0.4249E-010.4250E-01	0.8500E-010.2500E+00-.1494E+01
F31 2	roccf0.4250E-010.4250E-01	0.8500E-010.2500E+00-.1494E+01
M12 2	roccm0.6374E-010.1275E+00	0.8500E-010.1250E+01-.2500E+00
F12 2	roccf0.6375E-010.1275E+00	0.8500E-010.1250E+01-.2500E+00
M22 2	heatm0.6297E-010.0000E+00	0.8500E-010.1250E+01-.7470E+00
F22 2	heatf0.6298E-010.0000E+00	0.8500E-010.1250E+01-.7470E+00
M32 2	roccm0.1275E+000.1275E+00	0.8500E-010.1250E+01-.1494E+01
F32 2	roccf0.1275E+000.1275E+00	0.8500E-010.1250E+01-.1494E+01
M13 2	roccm0.3187E-010.6375E-01	0.8500E-010.2375E+01-.2500E+00
F13 2	roccf0.3188E-010.6375E-01	0.8500E-010.2375E+01-.2500E+00
M23 2	roccm0.3148E-010.0000E+00	0.8500E-010.2375E+01-.7470E+00
F23 2	roccf0.3149E-010.0000E+00	0.8500E-010.2375E+01-.7470E+00
M33 2	roccm0.6374E-010.6375E-01	0.8500E-010.2375E+01-.1494E+01
F33 2	roccf0.6375E-010.6375E-01	0.8500E-010.2375E+01-.1494E+01
M11 3	roccm0.3124E-010.6250E-01	0.1900E+000.2500E+00-.2500E+00
F11 3	roccf0.3125E-010.6250E-01	0.1900E+000.2500E+00-.2500E+00
M21 3	roccm0.3086E-010.0000E+00	0.1900E+000.2500E+00-.7470E+00
F21 3	roccf0.3087E-010.0000E+00	0.1900E+000.2500E+00-.7470E+00
M31 3	roccm0.6249E-010.6250E-01	0.1900E+000.2500E+00-.1494E+01
F31 3	roccf0.6250E-010.6250E-01	0.1900E+000.2500E+00-.1494E+01
M12 3	roccm0.9373E-010.1875E+00	0.1900E+000.1250E+01-.2500E+00
F12 3	roccf0.9375E-010.1875E+00	0.1900E+000.1250E+01-.2500E+00
M22 3	roccm0.9260E-010.0000E+00	0.1900E+000.1250E+01-.7470E+00
F22 3	roccf0.9262E-010.0000E+00	0.1900E+000.1250E+01-.7470E+00
M32 3	roccm0.1875E+000.1875E+00	0.1900E+000.1250E+01-.1494E+01
F32 3	roccf0.1875E+000.1875E+00	0.1900E+000.1250E+01-.1494E+01
M13 3	roccm0.4687E-010.9375E-01	0.1900E+000.2375E+01-.2500E+00
F13 3	roccf0.4688E-010.9375E-01	0.1900E+000.2375E+01-.2500E+00
M23 3	inslm0.4630E-010.0000E+00	0.1900E+000.2375E+01-.7470E+00
F23 3	inslf0.4631E-010.0000E+00	0.1900E+000.2375E+01-.7470E+00
M33 3	tunm0.9373E-010.9375E-01	0.1900E+000.2375E+01-.1494E+01
F33 3	tunmf0.9375E-010.9375E-01	0.1900E+000.2375E+01-.1494E+01
M11 1M11 2	10.2125E-010.4250E-010.2500E+000.0000E+00	

F11 1F11 2 10.2125E-010.4250E-010.2500E+000.0000E+00
F11 1M11 1 20.0000E+000.3333E+000.1063E-010.0000E+000.1000E-02
M11 1M12 1 20.2500E+000.7500E+000.2125E-010.1000E+01
F11 1F12 1 20.2500E+000.7500E+000.2125E-010.1000E+01
M11 1M21 1 30.2500E+000.2470E+000.2125E-010.1795E-08
F11 1F21 1 30.2500E+000.2470E+000.2125E-010.1795E-08
M21 1M21 2 10.2125E-010.4250E-010.2470E+000.0000E+00
F21 1F21 2 10.2125E-010.4250E-010.2470E+000.0000E+00
F21 1M21 1 20.0000E+000.3333E+000.1050E-010.0000E+000.1000E-02
M21 1M22 1 20.2500E+000.7500E+000.2099E-010.1000E+01
F21 1F22 1 20.2500E+000.7500E+000.2099E-010.1000E+01
M21 1M31 1 30.2470E+000.5000E+000.2125E-010.1795E-08
F21 1F31 1 30.2470E+000.5000E+000.2125E-010.1795E-08
M31 1M31 2 10.2125E-010.4250E-010.5000E+000.0000E+00
F31 1F31 2 10.2125E-010.4250E-010.5000E+000.0000E+00
M31 1M32 1 20.0000E+000.3333E+000.2125E-010.0000E+000.1000E-02
F31 1F32 1 20.2500E+000.7500E+000.4250E-010.1000E+01
M12 1M12 2 10.2125E-010.4250E-010.7500E+000.0000E+00
F12 1F12 2 10.2125E-010.4250E-010.7500E+000.0000E+00
F12 1M12 1 20.0000E+000.3333E+000.3188E-010.0000E+000.1000E-02
M12 1M13 1 20.7500E+000.3750E+000.2125E-010.1000E+01
F12 1F13 1 20.7500E+000.3750E+000.2125E-010.1000E+01
M12 1M22 1 30.2500E+000.2470E+000.6375E-010.1795E-08
F12 1F22 1 30.2500E+000.2470E+000.6375E-010.1795E-08
M22 1M22 2 10.2125E-010.4250E-010.7410E+000.0000E+00
F22 1F22 2 10.2125E-010.4250E-010.7410E+000.0000E+00
F22 1M22 1 20.0000E+000.3333E+000.3149E-010.0000E+000.1000E-02
M22 1M23 1 20.7500E+000.3750E+000.2099E-010.1000E+01
F22 1F23 1 20.7500E+000.3750E+000.2099E-010.1000E+01
M22 1M32 1 30.2470E+000.5000E+000.6375E-010.1795E-08
F22 1F32 1 30.2470E+000.5000E+000.6375E-010.1795E-08
M32 1M32 2 10.2125E-010.4250E-010.1500E+010.0000E+00
F32 1F32 2 10.2125E-010.4250E-010.1500E+010.0000E+00
F32 1M32 1 20.0000E+000.3333E+000.6375E-010.0000E+000.1000E-02
M32 1M33 1 20.7500E+000.3750E+000.4250E-010.1000E+01
F32 1F33 1 20.7500E+000.3750E+000.4250E-010.1000E+01
M13 1M13 2 10.2125E-010.4250E-010.3750E+000.0000E+00
F13 1F13 2 10.2125E-010.4250E-010.3750E+000.0000E+00
M13 1M23 1 20.0000E+000.3333E+000.1594E-010.0000E+000.1000E-02
F13 1F23 1 30.2500E+000.2470E+000.3188E-010.1795E-08
M23 1M23 2 10.2125E-010.4250E-010.3705E+000.0000E+00
F23 1F23 2 10.2125E-010.4250E-010.3705E+000.0000E+00
M23 1M23 1 20.0000E+000.3333E+000.1575E-010.0000E+000.1000E-02
F23 1F23 1 30.2470E+000.5000E+000.3188E-010.1795E-08
M33 1M33 1 30.2470E+000.5000E+000.3188E-010.1795E-08
F33 1F33 2 10.2125E-010.4250E-010.7500E+000.0000E+00
F33 1F33 1 10.2125E-010.4250E-010.7500E+000.0000E+00
M11 2M11 3 20.0000E+000.3333E+000.3188E-010.0000E+000.1000E-02
F11 2F11 3 10.4250E-010.6250E-010.2500E+000.0000E+00
F11 2M12 2 20.0000E+000.3333E+000.2125E-010.0000E+000.1000E-02
M11 2M12 2 20.2500E+000.7500E+000.4250E-010.1000E+01
F11 2F12 2 20.2500E+000.7500E+000.4250E-010.1000E+01
M11 2M21 2 30.2500E+000.2470E+000.4250E-010.1795E-08
F11 2F21 2 30.2500E+000.2470E+000.4250E-010.1795E-08
M21 2M21 3 10.4250E-010.6250E-010.2470E+000.0000E+00
F21 2F21 3 10.4250E-010.6250E-010.2470E+000.0000E+00
F21 2M21 2 20.0000E+000.3333E+000.2099E-010.0000E+000.1000E-02
M21 2M22 2 20.2500E+000.7500E+000.4199E-010.1000E+01
F21 2F22 2 20.2500E+000.7500E+000.4199E-010.1000E+01
M21 2M31 2 30.2470E+000.5000E+000.4250E-010.1795E-08
F21 2F31 2 30.2470E+000.5000E+000.4250E-010.1795E-08
M31 2M31 3 10.4250E-010.6250E-010.5000E+000.0000E+00
F31 2F31 3 10.4250E-010.6250E-010.5000E+000.0000E+00
M31 2M32 2 20.0000E+000.3333E+000.4250E-010.0000E+000.1000E-02
F31 2F32 2 20.2500E+000.7500E+000.8500E-010.1000E+01
M12 2M12 3 10.4250E-010.6250E-010.7500E+000.0000E+00
F12 2F12 3 10.4250E-010.6250E-010.7500E+000.0000E+00

F12 2M12 2	20.0000E+000.3333E+000.6375E-010.0000E+000.1000E-02
M12 2M13 2	20.7500E+000.3750E+000.4250E-010.1000E+01
F12 2F13 2	20.7500E+000.3750E+000.4250E-010.1000E+01
M12 2M22 2	30.2500E+000.2470E+000.1275E+000.1795E-08
F12 2F22 2	30.2500E+000.2470E+000.1275E+000.1795E-08
M22 2M22 3	10.4250E-010.6250E-010.7410E+000.0000E+00
F22 2F22 3	10.4250E-010.6250E-010.7410E+000.0000E+00
M22 2M23 2	20.0000E+000.3333E+000.6298E-010.0000E+000.1000E-02
F22 2F23 2	20.7500E+000.3750E+000.4199E-010.1000E+01
M22 2M32 2	30.2470E+000.5000E+000.1275E+000.1795E-08
F22 2F32 2	30.2470E+000.5000E+000.1275E+000.1795E-08
M32 2M32 3	10.4250E-010.6250E-010.1500E+010.0000E+00
F32 2F32 3	10.4250E-010.6250E-010.1500E+010.0000E+00
F32 2M32 2	20.0000E+000.3333E+000.1275E+000.0000E+000.1000E-02
M32 2M33 2	20.7500E+000.3750E+000.4199E-010.1000E+01
F32 2F33 2	20.7500E+000.3750E+000.4199E-010.1000E+01
M13 2M13 3	10.4250E-010.6250E-010.3750E+000.0000E+00
F13 2F13 3	10.4250E-010.6250E-010.3750E+000.0000E+00
M13 2M23 2	20.0000E+000.3333E+000.3188E-010.0000E+000.1000E-02
F13 2F23 2	30.2500E+000.2470E+000.6375E-010.1795E-08
M23 2M23 2	10.4250E-010.6250E-010.3705E+000.0000E+00
F23 2F23 3	10.4250E-010.6250E-010.3705E+000.0000E+00
M23 2M33 2	20.0000E+000.3333E+000.3149E-010.0000E+000.1000E-02
F23 2F33 2	30.2470E+000.5000E+000.6375E-010.1795E-08
M33 2M33 3	30.2470E+000.5000E+000.6375E-010.1795E-08
F33 2F33 3	10.4250E-010.6250E-010.7500E+000.0000E+00
F33 2M33 2	10.4250E-010.6250E-010.7500E+000.0000E+00
M11 3M12 3	20.2500E+000.7500E+000.6250E-010.1000E+01
F11 3F12 3	20.2500E+000.7500E+000.6250E-010.1000E+01
M11 3M21 3	20.0000E+000.3333E+000.3125E-010.0000E+000.1000E-02
F11 3F21 3	30.2500E+000.2470E+000.6250E-010.1795E-08
M21 3M22 3	20.2500E+000.7500E+000.6175E-010.1000E+01
F21 3F22 3	20.2500E+000.7500E+000.6175E-010.1000E+01
M21 3M31 3	20.0000E+000.3333E+000.3087E-010.0000E+000.1000E-02
F21 3F31 3	30.2470E+000.5000E+000.6250E-010.1795E-08
M31 3M32 3	30.2470E+000.5000E+000.6250E-010.1795E-08
F31 3F32 3	20.2500E+000.7500E+000.1250E+000.1000E+01
F31 3M31 3	20.0000E+000.3333E+000.6250E-010.0000E+000.1000E-02
M12 3M13 3	20.7500E+000.3750E+000.6250E-010.1000E+01
F12 3F13 3	20.7500E+000.3750E+000.6250E-010.1000E+01
F12 3M12 3	20.0000E+000.3333E+000.9375E-010.0000E+000.1000E-02
M12 3M22 3	30.2500E+000.2470E+000.1875E+000.1795E-08
F12 3F22 3	30.2500E+000.2470E+000.1875E+000.1795E-08
M22 3M23 3	20.7500E+000.3750E+000.6175E-010.1000E+01
F22 3F23 3	20.7500E+000.3750E+000.6175E-010.1000E+01
M22 3M32 3	20.0000E+000.3333E+000.9262E-010.0000E+000.1000E-02
F22 3F32 3	30.2470E+000.5000E+000.1875E+000.1795E-08
M22 3M33 3	30.2470E+000.5000E+000.1875E+000.1795E-08
F32 3F33 3	20.7500E+000.3750E+000.1250E+000.1000E+01
F32 3M32 3	20.0000E+000.3333E+000.1875E+000.0000E+000.1000E-02
M13 3M23 3	30.2500E+000.2470E+000.9375E-010.1795E-08
F13 3F23 3	30.2500E+000.2470E+000.9375E-010.1795E-08
M23 3M33 3	20.0000E+000.3333E+000.4688E-010.0000E+000.1000E-02
F23 3F33 3	30.2470E+000.5000E+000.9375E-010.1795E-08
F23 3M23 3	20.0000E+000.3333E+000.4631E-010.0000E+000.1000E-02
F33 3M33 3	20.0000E+000.3333E+000.9375E-010.0000E+000.1000E-02

The test problem source code generated the ELEM and CONNE blocks required for a TOUGH2 simulation (Not exactly in the format required to run the TOUGH2 code. Headers are not placed in by the routine; these are done by the analyst by hand). Sample hand calculations

are used to verify a correct implementation. They are the following. The user input required for the DKM mesh generator used in the sample test problem is:

- Fracture porosity = 2.33×10^{-4}
- $\text{fm}x = 1 \times 10^{-3}$
- $D = 2.0 \text{ m}$
- 1-D fracture set

The interface area is computed as:

- $A = 2V/D$, where V is taken from the primary mesh entry for the elemental volume

And the matrix element volume is computed as:

$$V_m = V \times (1 - \text{fracture porosity})$$

So, spot check (the numbers in bold above) the matrix and fracture elements for primary element **A22 1**. The element **A22 1** is converted to a matrix and fracture elements **M22 1** and **F22 1**. The matrix volume (**M22 1**) is computed by the routine as

$$V_m = V_{\text{prim}} \times (1 - \text{fracture porosity}) = 0.3149\text{E-}01 \times (1 - 2.33 \times 10^{-4}) = 0.3148\text{E-}01 \text{ (OK)}$$

The fracture volume is just the primary volume since the input deck contains the fracture porosity. The fracture-matrix interface connection is also checked for this same element. For an ISOT specified as 2 for the fracture-matrix connection, the interface distances ($d1$ & $d2$) are computed as the following:

$$\begin{aligned} d1 &= 0.0 \text{ (OK)} \\ d2 &= D/6 = 2/6 = 0.3333 \text{ (OK)} \end{aligned}$$

The interface area is computed as $A = 2V/D = 2(0.3149\text{E-}01)/2 = 0.3149\text{E-}01 \text{ (OK)}$. The fracture-matrix interaction parameter is input as **0.1000E-02** in the last column in the CONNE block. Other elements have been spot checked to be correct. In addition to the hand checks, it is possible to perform a line count to make sure each element and its connection is included in the resultant file from the DKM mesh generator. The primary mesh file is a 3X3X3 mesh such that 27 total volume elements result. The number of primary connections for this problem is 54. Recall that the primary mesh is obtained from the TOUGH2 meshmaker option with material element identifiers altered for different boundary elements. The translation from primary to DKM mesh creates the following number of ELEME entries and CONNE entries:

For ELEME: $2 \times 27 = 54$ (since what was once a single element now has a fracture and matrix component).

For CONNE: $2 \times 54 + 27 = 135$ (since each connection now has a fracture-fracture, matrix-matrix, and fracture-matrix component). Each checks out as can be verified above.

The line count is correct; none of the element specifications have been dropped by the mesh generator routine. Now the small problem routine is ready to be adapted to the larger SHT

model domain. This is done simply by changing the array size so that more than 27 elements can be read in the SHT model contains 12,600). The dkmmeshamb.f routine is adapted from the small test routine (shown above) as the following.

dkmmeshamb.f (Version 1)

```

c
c   This processor will read the MESH file for the SHT ECM model
c   and transform it into a DKM model.  It is problem specific
c   in that it is looking for certain element indicators such
c   as specific material identifiers. Only one fracture porosity
c   will be input and used to determine the matrix and fracture
c   volumes in the ELEME
c
c   Nick Francis 03/13/98
c
c
c... this is modified for the ambient ECM mesh
c   recall that this processor is problem specific
c   but can be made general by modifying  if statments
c   and format print statments
c
c
c
c
c
c
c
c2345678901234567890123456789012345678901234567890123456789012
c
c   implicit double precision (a-h,l,o-z)
c   character*5 name
c   character*5 elnamem
c   character*5 elnamef
c   character*3 el1
c   character*3 el1old
c   character*3 el2
c   character*3 el2old
c   character*3 el
c   dimension vol_i(12600)
c
c... Enter input data such as fracture set dimensions,
c   fractures spacing, fracture porosity
c
c   write(*,*) 'What is the name of the input file?'
c   read(*, '(a)') infile
c   write(*,*)
c   write(*,*) 'Enter the dimension N=? of fracture set'
c   write(*,*) 'N=2 for 1-d, N=4 for 2-d, N=6 for 3-d'
c   read(*,*) xN
c   write(*,*)
c   write(*,*) 'Enter the fracture spacing in meters'
c   read(*,*) D
c   write(*,*)

```

```

c... compute the nodal distance for the fracture-matrix connection
c... it is based on the dimensionality of the fracture set
c

```

```

        if (xN .eq. 2.) then
            con_dm = D/6.
        elseif (xN .eq. 4. ) then
            con_dm = D/8.
        elseif (xN .eq. 6.) then
            con_dm = D/10.
        else
            write(*,*) 'you have made an error'
        end if

```

```

c
c

```

```

c... read in fracture porosity
        write(*,*) 'Enter the fracture porosity'
        read(*,*) phif
        write(*,*)

```

```

c... read in the DKM fmx specification
        write (*,*) 'Select a f-m connection: c=1, krl=2, other=3'
        read(*,*) idkfm

```

```

c... open up necessary files
        open(9,file='MESH1.988',status='old')
        open(10,file=infile,status='old')
        open(13,file='dkm.mesh',status='unknown')
10      format(a5)
100     format(a3,i2,13x,i2,2E10.4,10x,3E10.4)
101     format(20x,E10.4)
102     format('M',a2,i2,10x,'roccm',2E10.4,10x,3E10.4)
103     format('F',a2,i2,10x,'roccf',2E10.4,10x,3E10.4)
112     format('M',a2,i2,10x,'heatm',2E10.4,10x,3E10.4)
113     format('F',a2,i2,10x,'heatf',2E10.4,10x,3E10.4)
122     format('M',a2,i2,10x,'inslm',2E10.4,10x,3E10.4)
123     format('F',a2,i2,10x,'inslf',2E10.4,10x,3E10.4)
132     format('M',a2,i2,10x,'tunrm',2E10.4,10x,3E10.4)
133     format('F',a2,i2,10x,'tunnf',2E10.4,10x,3E10.4)
142     format('M',a2,i2,10x,'rocbm',2E10.4,10x,3E10.4)
143     format('F',a2,i2,10x,'rocbf',2E10.4,10x,3E10.4)
152     format('M',a2,i2,10x,'roctm',2E10.4,10x,3E10.4)
153     format('F',a2,i2,10x,'roctf',2E10.4,10x,3E10.4)
104     format(a3,i2,a3,i2,15x,i5,4e10.4)
105     format('M',a2,i2,'M',a2,i2,15x,i5,4e10.4)
106     format('F',a2,i2,'F',a2,i2,15x,i5,4e10.4)
107     format('F',a2,i2,'M',a2,i2,15x,i5,5e10.4)

```

```

c... determines the fmx type
c

```

```

        if( idkfm .eq. 1) then

            write(*,*) 'enter the constant multiplier'
            read(*,*) const
            fmx = const

```

```

elseif ( idkfm .eq. 2) then

write(*,*) 'enter a constant multiplier if needed'
write(*,*) 'k_rl weighted connection'
read(*,*) ckrl
fmx = ckrl

else

write(*,*) 'enter a constant multiplier if needed'
write(*,*) 'other weighted connection'
read(*,*) ckoth
fmx = ckoth

end if

c
c
c... store the element volumes from the original mesh
      i=1
1    read(9,10) name
      if (name .ne. 'ELEME') goto 1
32   read(9,101) vol_i(i)
      if (i .eq. 12600) then
          goto 2
      else
          i=i+1
          goto 32
      end if

c... work on the ELEME portion of the mesh first
c... begin creating the DKM mesh from the working
c    ECM mesh

2    read(10,10) name
      if (name .ne. 'ELEME') goto 2
33   read(10,100) el, ne,ma2,volx, ahtx,x,y,z
      if (el .eq. ' ') goto 555

      if (ma2 .eq. 4) then

c
c... these are lower boundary rock boundary elements
c    THEY ARE dkm elements
c

c... these are rock boundary elements
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,142) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      write(13,143) el(2:3), ne,volx,ahtx,x,y,z

c... These are used in the heating mesh processor
c

```

```

c
c... these are the air boundary elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,132) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,133) el(2:3), ne,volx,ahtx,x,y,z
c
c
c      elseif (ma2 .eq. 5) then
c
c... these are the insulation elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,122) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,123) el(2:3), ne,volx,ahtx,x,y,z
c
c
c      elseif (ma2 .eq. 2) then
c
c... these are the heater elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,112) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,113) el(2:3), ne,volx,ahtx,x,y,z
c
c
c... these were used in the heating processor
c
c      elseif (ma2 .eq. 3) then
c
c
c... these are the upper rock boundary elements
c      THEY ARE dkm elements
c
c
c... these are rock boundary elements
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,152) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c      write(13,153) el(2:3), ne,volx,ahtx,x,y,z

```

```

        else

c... This are interior rock elements
c    THEY ARE dkm elements
c
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      ma2 = 7
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z

      end if

      goto 33

c.... work on the CONNE portion of the mesh next

555  read(10,10) name
      if (name .ne. 'CONNE') goto 555
      i = 1
      icheck=1

44   read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

c... write the matrix-matrix connection
45   write(13,105) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @ areax,betax
c... write the fracture-fracture connection
      write(13,106) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @ areax,betax

      if (icheck .eq. 1) then
C... write the fracture-matrix connection
      areax = xN*vol_i(i)/D
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el1(2:3),ne1,el1(2:3),ne1,isot,con_df,
      @ con_dm,areax,betax,fx
      i = i+1
      end if

      el1old=el1(1:3)
      el2old=el2(1:3)
      ne2old=ne2
      read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

      if (el1 .eq. ' ') goto 556
      if (el1 .eq. el1old) then
        icheck=2
        goto 45
      else

```

```

        icode=1
        goto 45
    endif

556     areax = xN*vol_i(i)/D
        con_df = 0.0
c...select isot=2 since it contains the vertical permeability
        isot=2
        betax=0.0
        write(13,107) el2old(2:3),ne2old,el2old(2:3),
@       ne2old,isot,con_df,con_dm,areax,betax,fxm

        close(12)
        close(13)
        stop
    end

```

Two input files are required to run this routine. One of the input files for dkmmeshamb.f is a resultant file from the software routine amb.f. Additionally, dkmmeshamb.f also requires the initial primary mesh file (the input file for amb.f called MESH1.988) so that it can read in the actual element volumes (recall some boundary elements were given large volumes) used to compute the interface area specified by the DKM for the matrix-fracture interface area. An excerpt of the resultant DKM mesh generated by dkmmeshamb.f for the TSPA-VA sensitivity study in AMR N0000 is shown below. In addition to the two large input files, the routine also calls for user input during runtime. The inputs provided during routine runtime for this particular case are the following:

```

What is the name of the input file?
MESH

Enter the dimension N=? of fracture set
N=2 for 1-d, N=4 for 2-d, N=6 for 3-d
2.

Enter the fracture spacing in meters
0.5319

Enter the fracture porosity
1.24E-04

Select a f-m connection: c=1, krl=2, other=3
1
enter the constant multiplier
8.0E-03

```

The input file name for this routine is: MESH. An excerpt of this file is the following:

ELEME									
A11	1	3	.1063E-01	.2125E-01		.2125E-01	.2500E+00	.2500E+00	
A21	1	3	.1619E-02	.0000E+00		.2125E-01	.2500E+00	.5381E+00	
A31	1	3	.1619E-02	.0000E+00		.2125E-01	.2500E+00	.6143E+00	
A41	1	3	.1063E-01	.0000E+00		.2125E-01	.2500E+00	.9024E+00	
A51	1	3	.1063E-01	.0000E+00		.2125E-01	.2500E+00	.1402E+01	
A61	1	3	.1050E-01	.0000E+00		.2125E-01	.2500E+00	.1899E+01	
A71	1	3	.1050E-01	.0000E+00		.2125E-01	.2500E+00	.2393E+01	
A81	1	3	.2125E-01	.0000E+00		.2125E-01	.2500E+00	.3140E+01	
A91	1	3	.2125E-01	.0000E+00		.2125E-01	.2500E+00	.4140E+01	

AA1 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00-.5140E+01
AB1 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00-.6140E+01
AC1 1	3	.2125E-01	.0000E+00	.2125E-01	.2500E+00-.7140E+01
AD1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00-.7890E+01
AE1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00-.8390E+01
AF1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00-.8890E+01
AG1 1	3	.1063E-01	.0000E+00	.2125E-01	.2500E+00-.9390E+01
AH1 1	3	.5242E-01	.0000E+00	.2125E-01	.2500E+00-.1087E+02
AI1 1	3	.5242E-01	.0000E+00	.2125E-01	.2500E+00-.1334E+02
AJ1 1	3	.5242E-01	.0000E+00	.2125E-01	.2500E+00-.1581E+02
AK1 1	3	.1063E-01	.2125E-01	.2125E-01	.2500E+00-.1729E+02
A12 1	1	.4306E-01	.8611E-01	.2125E-01	.1513E+01-.2500E+00
A22 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01-.5381E+00
A32 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01-.6143E+00
A42 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.9024E+00
A52 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.1402E+01
A62 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01-.1899E+01
A72 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01-.2393E+01
A82 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.3140E+01
A92 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.4140E+01
AA2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.5140E+01
AB2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.6140E+01
AC2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.7140E+01
AD2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.7890E+01
AE2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.8390E+01
AF2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.8890E+01
AG2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.9390E+01
AH2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01-.1087E+02
AI2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01-.1334E+02
AJ2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01-.1581E+02
AK2 1	1	.4306E-01	.8611E-01	.2125E-01	.1513E+01-.1729E+02
...					
A1Z 1	4	1.0E+50	.2125E-01	.2125E-01	.2075E+02-.2500E+00
A2Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.5381E+00
A3Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.6143E+00
A4Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.9024E+00
A5Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1402E+01
A6Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1899E+01
A7Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.2393E+01
A8Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.3140E+01
A9Z 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.4140E+01
AAZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.5140E+01
ABZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.6140E+01
ACZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.7140E+01
ADZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.7890E+01
AEZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.8390E+01
AFZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.8890E+01
AGZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.9390E+01
AHZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1087E+02
AIZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1334E+02
AJZ 1	4	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1581E+02
AKZ 1	4	1.0E+50	.2125E-01	.2125E-01	.2075E+02-.1729E+02
A11 2	3	.2125E-01	.4250E-01	.8500E-01	.2500E+00-.2500E+00
A21 2	3	.3239E-02	.0000E+00	.8500E-01	.2500E+00-.5381E+00
A31 2	3	.3239E-02	.0000E+00	.8500E-01	.2500E+00-.6143E+00
A41 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00-.9024E+00
A51 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00-.1402E+01
A61 2	3	.2100E-01	.0000E+00	.8500E-01	.2500E+00-.1899E+01
A71 2	3	.2100E-01	.0000E+00	.8500E-01	.2500E+00-.2393E+01
A81 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00-.3140E+01
A91 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00-.4140E+01
AA1 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00-.5140E+01
AB1 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00-.6140E+01
AC1 2	3	.4250E-01	.0000E+00	.8500E-01	.2500E+00-.7140E+01
AD1 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00-.7890E+01
AE1 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00-.8390E+01
AF1 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00-.8890E+01
AG1 2	3	.2125E-01	.0000E+00	.8500E-01	.2500E+00-.9390E+01
AH1 2	3	.1048E+00	.0000E+00	.8500E-01	.2500E+00-.1087E+02
AI1 2	3	.1048E+00	.0000E+00	.8500E-01	.2500E+00-.1334E+02

AJ1	2	3	.1048E+00	.0000E+00	.8500E-01	.2500E+00	.1581E+02
AK1	2	3	.2125E-01	.4250E-01	.8500E-01	.2500E+00	.1729E+02
A12	2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01	.2500E+00
A22	2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	.5381E+00
A32	2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	.6143E+00
A42	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.9024E+00
A52	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.1402E+01
A62	2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	.1899E+01
A72	2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	.2393E+01
A82	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.3140E+01
A92	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.4140E+01
AA2	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.5140E+01
AB2	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.6140E+01
AC2	2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	.7140E+01
AD2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.7890E+01
AE2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.8390E+01
AF2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.8890E+01
AG2	2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	.9390E+01
AH2	2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	.1087E+02
AI2	2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	.1334E+02
AJ2	2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01	.1581E+02
AK2	2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01	.1729E+02

...

AJY18		1	.2499E+01	.0000E+00	.6603E+01	.1949E+02	.1581E+02
AKY18		1	.5065E+00	.1013E+01	.6603E+01	.1949E+02	.1729E+02
A1Z18		4	1.0E+50	.2500E+00	.6603E+01	.2075E+02	.2500E+00
A2Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.5381E+00
A3Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.6143E+00
A4Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.9024E+00
A5Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.1402E+01
A6Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.1899E+01
A7Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.2393E+01
A8Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.3140E+01
A9Z18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.4140E+01
AAZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.5140E+01
ABZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.6140E+01
ACZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.7140E+01
ADZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.7890E+01
AEZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.8390E+01
AFZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.8890E+01
AGZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.9390E+01
AHZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.1087E+02
AIZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.1334E+02
AJZ18		4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	.1581E+02
AKZ18		4	1.0E+50	.2500E+00	.6603E+01	.2075E+02	.1729E+02

CONNE

A11	1A11	2	1	.2125E-01	.4250E-01	.2500E+00	
A11	1A12	1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01
A11	1A21	1	3	.2500E+00	.3810E-01	.2125E-01	.0000E+00
A21	1A21	2	1	.2125E-01	.4250E-01	.3810E-01	
A21	1A22	1	2	.2500E+00	.1013E+01	.3239E-02	.1000E+01
A21	1A31	1	3	.3810E-01	.3810E-01	.2125E-01	.0000E+00
A31	1A31	2	1	.2125E-01	.4250E-01	.3810E-01	
A31	1A32	1	2	.2500E+00	.1013E+01	.3239E-02	.1000E+01
A31	1A41	1	3	.3810E-01	.2500E+00	.2125E-01	.0000E+00
A41	1A41	2	1	.2125E-01	.4250E-01	.2500E+00	
A41	1A42	1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01
A41	1A51	1	3	.2500E+00	.2500E+00	.2125E-01	.0000E+00
A51	1A51	2	1	.2125E-01	.4250E-01	.2500E+00	
A51	1A52	1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01
A51	1A61	1	3	.2500E+00	.2470E+00	.2125E-01	.0000E+00
A61	1A61	2	1	.2125E-01	.4250E-01	.2470E+00	
A61	1A62	1	2	.2500E+00	.1013E+01	.2100E-01	.1000E+01
A61	1A71	1	3	.2470E+00	.2470E+00	.2125E-01	.0000E+00
A71	1A71	2	1	.2125E-01	.4250E-01	.2470E+00	
A71	1A72	1	2	.2500E+00	.1013E+01	.2100E-01	.1000E+01
A71	1A81	1	3	.2470E+00	.5000E+00	.2125E-01	.0000E+00
A81	1A81	2	1	.2125E-01	.4250E-01	.5000E+00	
A81	1A82	1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01

A81 1A91 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00
A91 1A91 2	1	.2125E-01	.4250E-01	.5000E+00	
A91 1A92 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01
A91 1AA1 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00
AA1 1AA1 2	1	.2125E-01	.4250E-01	.5000E+00	
AA1 1AA2 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01
...					
A5Z18A6Z18	3	.2500E+00	.2470E+00	.2500E+00	.0000E+00
A6Z18A7Z18	3	.2470E+00	.2470E+00	.2500E+00	.0000E+00
A7Z18A8Z18	3	.2470E+00	.5000E+00	.2500E+00	.0000E+00
A8Z18A9Z18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
A9Z18AAZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
AAZ18ABZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
ABZ18ACZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
ACZ18ADZ18	3	.5000E+00	.2500E+00	.2500E+00	.0000E+00
ADZ18AEZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AEZ18AFZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AFZ18AGZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AGZ18AHZ18	3	.2500E+00	.1233E+01	.2500E+00	.0000E+00
AHZ18AIZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00
AIZ18AJZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00
AJZ18AKZ18	3	.1233E+01	.2500E+00	.2500E+00	.0000E+00

An excerpt of the resultant DKM mesh generated by dkmmeshamb.f for the TSPA-VA sensitivity study provided in the AMR is obtained from the file named dkm.mesh. (Note: this file name is not used in the SHT simulations. The results of the mesh that reside in the file name dkm.mesh, along with user added headers and spaces for ELEME and CONNE are placed directly into the TOUGH2.INP files required of a TOUGH2 simulation.) This abbreviated result shown below includes the appropriately user (not routine) placed header files that one would require for a TOUGH2 mesh file simulation.

ELEME		
M11 1	roctm0.1063E-010.2125E-01	0.2125E-010.2500E+00-.2500E+00
F11 1	roctf0.1063E-010.2125E-01	0.2125E-010.2500E+00-.2500E+00
M21 1	roctm0.1619E-020.0000E+00	0.2125E-010.2500E+00-.5381E+00
F21 1	roctf0.1619E-020.0000E+00	0.2125E-010.2500E+00-.5381E+00
M31 1	roctm0.1619E-020.0000E+00	0.2125E-010.2500E+00-.6143E+00
F31 1	roctf0.1619E-020.0000E+00	0.2125E-010.2500E+00-.6143E+00
M41 1	roctm0.1063E-010.0000E+00	0.2125E-010.2500E+00-.9024E+00
F41 1	roctf0.1063E-010.0000E+00	0.2125E-010.2500E+00-.9024E+00
M51 1	roctm0.1063E-010.0000E+00	0.2125E-010.2500E+00-.1402E+01
F51 1	roctf0.1063E-010.0000E+00	0.2125E-010.2500E+00-.1402E+01
M61 1	roctm0.1050E-010.0000E+00	0.2125E-010.2500E+00-.1899E+01
F61 1	roctf0.1050E-010.0000E+00	0.2125E-010.2500E+00-.1899E+01
M71 1	roctm0.1050E-010.0000E+00	0.2125E-010.2500E+00-.2393E+01
F71 1	roctf0.1050E-010.0000E+00	0.2125E-010.2500E+00-.2393E+01
M81 1	roctm0.2125E-010.0000E+00	0.2125E-010.2500E+00-.3140E+01
F81 1	roctf0.2125E-010.0000E+00	0.2125E-010.2500E+00-.3140E+01
M91 1	roctm0.2125E-010.0000E+00	0.2125E-010.2500E+00-.4140E+01
F91 1	roctf0.2125E-010.0000E+00	0.2125E-010.2500E+00-.4140E+01
MA1 1	roctm0.2125E-010.0000E+00	0.2125E-010.2500E+00-.5140E+01
FA1 1	roctf0.2125E-010.0000E+00	0.2125E-010.2500E+00-.5140E+01
MB1 1	roctm0.2125E-010.0000E+00	0.2125E-010.2500E+00-.6140E+01
FB1 1	roctf0.2125E-010.0000E+00	0.2125E-010.2500E+00-.6140E+01
MC1 1	roctm0.2125E-010.0000E+00	0.2125E-010.2500E+00-.7140E+01
FC1 1	roctf0.2125E-010.0000E+00	0.2125E-010.2500E+00-.7140E+01
MD1 1	roctm0.1063E-010.0000E+00	0.2125E-010.2500E+00-.7890E+01
FD1 1	roctf0.1063E-010.0000E+00	0.2125E-010.2500E+00-.7890E+01
ME1 1	roctm0.1063E-010.0000E+00	0.2125E-010.2500E+00-.8390E+01
FE1 1	roctf0.1063E-010.0000E+00	0.2125E-010.2500E+00-.8390E+01
MF1 1	roctm0.1063E-010.0000E+00	0.2125E-010.2500E+00-.8890E+01
FF1 1	roctf0.1063E-010.0000E+00	0.2125E-010.2500E+00-.8890E+01
MG1 1	roctm0.1063E-010.0000E+00	0.2125E-010.2500E+00-.9390E+01
FG1 1	roctf0.1063E-010.0000E+00	0.2125E-010.2500E+00-.9390E+01
MH1 1	roctm0.5241E-010.0000E+00	0.2125E-010.2500E+00-.1087E+02
FH1 1	roctf0.5242E-010.0000E+00	0.2125E-010.2500E+00-.1087E+02

M11 1	roctm0.5241E-010.0000E+00	0.2125E-010.2500E+00-.1334E+02
F11 1	roctf0.5242E-010.0000E+00	0.2125E-010.2500E+00-.1334E+02
MJ1 1	roctm0.5241E-010.0000E+00	0.2125E-010.2500E+00-.1581E+02
FJ1 1	roctf0.5242E-010.0000E+00	0.2125E-010.2500E+00-.1581E+02
MK1 1	roctm0.1063E-010.2125E-01	0.2125E-010.2500E+00-.1729E+02
FK1 1	roctf0.1063E-010.2125E-01	0.2125E-010.2500E+00-.1729E+02
M12 1	roccm0.4305E-010.8611E-01	0.2125E-010.1513E+01-.2500E+00
F12 1	roccf0.4306E-010.8611E-01	0.2125E-010.1513E+01-.2500E+00
M22 1	roccm0.6561E-020.0000E+00	0.2125E-010.1513E+01-.5381E+00
F22 1	roccf0.6562E-020.0000E+00	0.2125E-010.1513E+01-.5381E+00
M32 1	roccm0.6561E-020.0000E+00	0.2125E-010.1513E+01-.6143E+00
F32 1	roccf0.6562E-020.0000E+00	0.2125E-010.1513E+01-.6143E+00
M42 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.9024E+00
F42 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.9024E+00
M52 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.1402E+01
F52 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.1402E+01
M62 1	roccm0.4253E-010.0000E+00	0.2125E-010.1513E+01-.1899E+01
F62 1	roccf0.4254E-010.0000E+00	0.2125E-010.1513E+01-.1899E+01
M72 1	roccm0.4253E-010.0000E+00	0.2125E-010.1513E+01-.2393E+01
F72 1	roccf0.4254E-010.0000E+00	0.2125E-010.1513E+01-.2393E+01
M82 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.3140E+01
F82 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.3140E+01
M92 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.4140E+01
F92 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.4140E+01
MA2 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.5140E+01
FA2 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.5140E+01
MB2 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.6140E+01
FB2 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.6140E+01
MC2 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.7140E+01
FC2 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.7140E+01
MD2 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.7890E+01
FD2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.7890E+01
ME2 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.8390E+01
FE2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.8390E+01
MF2 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.8890E+01
FF2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.8890E+01
MG2 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.9390E+01
FG2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.9390E+01
MH2 1	roccm0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1087E+02
FH2 1	roccf0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1087E+02
M12 1	roccm0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1334E+02
F12 1	roccf0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1334E+02
MJ2 1	roccm0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1581E+02
FJ2 1	roccf0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1581E+02
MK2 1	roccm0.4305E-010.8611E-01	0.2125E-010.1513E+01-.1729E+02
FK2 1	roccf0.4306E-010.8611E-01	0.2125E-010.1513E+01-.1729E+02
...		
M1Z 1	rocbm0.9999E+500.2125E-01	0.2125E-010.2075E+02-.2500E+00
F1Z 1	rocbf0.1000E+510.2125E-01	0.2125E-010.2075E+02-.2500E+00
M2Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.5381E+00
F2Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.5381E+00
M3Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.6143E+00
F3Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.6143E+00
M4Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.9024E+00
F4Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.9024E+00
M5Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1402E+01
F5Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.1402E+01
M6Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1899E+01
F6Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.1899E+01
M7Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.2393E+01
F7Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.2393E+01
M8Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.3140E+01
F8Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.3140E+01
M9Z 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.4140E+01
F9Z 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.4140E+01
MAZ 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.5140E+01
FAZ 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.5140E+01
MBZ 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.6140E+01
FBZ 1	rocbf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.6140E+01
MCZ 1	rocbm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.7140E+01

F11 1F21 1	30.2500E+000.3810E-010.2125E-010.2125E-010.0000E+00	
M21 1M21 2	10.2125E-010.4250E-010.3810E-010.3810E-010.0000E+00	
F21 1F21 2	10.2125E-010.4250E-010.3810E-010.3810E-010.0000E+00	
F21 1M21 1	20.0000E+000.8865E-010.6088E-020.0000E+000.8000E-02	
M21 1M22 1	20.2500E+000.1013E+010.3239E-020.1000E+01	
F21 1F22 1	20.2500E+000.1013E+010.3239E-020.1000E+01	
M21 1M31 1	30.3810E-010.3810E-010.2125E-010.0000E+00	
F21 1F31 1	30.3810E-010.3810E-010.2125E-010.0000E+00	
M31 1M31 2	10.2125E-010.4250E-010.3810E-010.0000E+00	
F31 1F31 2	20.0000E+000.8865E-010.6088E-020.0000E+000.8000E-02	
M31 1M32 1	20.2500E+000.1013E+010.3239E-020.1000E+01	
F31 1F32 1	20.2500E+000.1013E+010.3239E-020.1000E+01	
M31 1M41 1	30.3810E-010.2500E+000.2125E-010.0000E+00	
F31 1F41 1	30.3810E-010.2500E+000.2125E-010.0000E+00	
M41 1M41 2	10.2125E-010.4250E-010.2500E+000.0000E+00	
F41 1F41 2	20.0000E+000.8865E-010.3997E-010.0000E+000.8000E-02	
F41 1M41 1	20.2500E+000.1013E+010.2125E-010.1000E+01	
M41 1M42 1	20.2500E+000.1013E+010.2125E-010.1000E+01	
F41 1F42 1	30.2500E+000.2500E+000.2125E-010.0000E+00	
M41 1M51 1	30.2500E+000.2500E+000.2125E-010.0000E+00	
F41 1F51 1	10.2125E-010.4250E-010.2500E+000.0000E+00	
M51 1M51 2	10.2125E-010.4250E-010.2500E+000.0000E+00	
F51 1F51 2	20.0000E+000.8865E-010.3997E-010.0000E+000.8000E-02	
F51 1M51 1	20.2500E+000.1013E+010.2125E-010.1000E+01	
M51 1M52 1	20.2500E+000.1013E+010.2125E-010.1000E+01	
F51 1F52 1	30.2500E+000.2470E+000.2125E-010.0000E+00	
M51 1M61 1	30.2500E+000.2470E+000.2125E-010.0000E+00	
F51 1F61 1	10.2125E-010.4250E-010.2470E+000.0000E+00	
M61 1M61 2	10.2125E-010.4250E-010.2470E+000.0000E+00	
F61 1F61 2	20.0000E+000.8865E-010.3948E-010.0000E+000.8000E-02	
M61 1M62 1	20.2500E+000.1013E+010.2100E-010.1000E+01	
F61 1F62 1	20.2500E+000.1013E+010.2100E-010.1000E+01	
M61 1M71 1	30.2470E+000.2470E+000.2125E-010.0000E+00	
F61 1F71 1	30.2470E+000.2470E+000.2125E-010.0000E+00	
M71 1M71 2	10.2125E-010.4250E-010.2470E+000.0000E+00	
F71 1F71 2	10.2125E-010.4250E-010.2470E+000.0000E+00	
F71 1M71 1	20.0000E+000.8865E-010.3948E-010.0000E+000.8000E-02	
M71 1M72 1	20.2500E+000.1013E+010.2100E-010.1000E+01	
F71 1F72 1	20.2500E+000.1013E+010.2100E-010.1000E+01	
M71 1M81 1	30.2470E+000.5000E+000.2125E-010.0000E+00	
F71 1F81 1	30.2470E+000.5000E+000.2125E-010.0000E+00	
M81 1M81 2	10.2125E-010.4250E-010.5000E+000.0000E+00	
F81 1F81 2	10.2125E-010.4250E-010.5000E+000.0000E+00	
F81 1M81 1	20.0000E+000.8865E-010.7990E-010.0000E+000.8000E-02	
M81 1M82 1	20.2500E+000.1013E+010.4250E-010.1000E+01	
F81 1F82 1	20.2500E+000.1013E+010.4250E-010.1000E+01	
M81 1M91 1	30.5000E+000.5000E+000.2125E-010.0000E+00	
F81 1F91 1	30.5000E+000.5000E+000.2125E-010.0000E+00	
M91 1M91 2	10.2125E-010.4250E-010.5000E+000.0000E+00	
F91 1F91 2	10.2125E-010.4250E-010.5000E+000.0000E+00	
F91 1M91 1	20.0000E+000.8865E-010.7990E-010.0000E+000.8000E-02	
M91 1M92 1	20.2500E+000.1013E+010.4250E-010.1000E+01	
F91 1F92 1	20.2500E+000.1013E+010.4250E-010.1000E+01	
M91 1MA1 1	30.5000E+000.5000E+000.2125E-010.0000E+00	
F91 1FA1 1	30.5000E+000.5000E+000.2125E-010.0000E+00	
MA1 1MA1 2	10.2125E-010.4250E-010.5000E+000.0000E+00	
FA1 1FA1 2	10.2125E-010.4250E-010.5000E+000.0000E+00	
MA1 1MA1 1	20.0000E+000.8865E-010.7990E-010.0000E+000.8000E-02	
FA1 1MA2 1	20.2500E+000.1013E+010.4250E-010.1000E+01	
FA1 1FA2 1	20.2500E+000.1013E+010.4250E-010.1000E+01	
...		
M5218M6218	30.2500E+000.2470E+000.2500E+000.0000E+00	
F5218F6218	30.2500E+000.2470E+000.2500E+000.0000E+00	
F5218M5218	20.0000E+000.8865E-010.4700E+000.0000E+000.8000E-02	
M6218M7218	30.2470E+000.2470E+000.2500E+000.0000E+00	
F6218F7218	30.2470E+000.2470E+000.2500E+000.0000E+00	
F6218M6218	20.0000E+000.8865E-010.4644E+000.0000E+000.8000E-02	
M7218M8218	30.2470E+000.5000E+000.2500E+000.0000E+00	

F7Z18F8Z18	30.2470E+000.5000E+000.2500E+000.0000E+00
F7Z18M7Z18	20.0000E+000.8865E-010.4644E+000.0000E+000.8000E-02
M8Z18M9Z18	30.5000E+000.5000E+000.2500E+000.0000E+00
F8Z18F9Z18	30.5000E+000.5000E+000.2500E+000.0000E+00
F8Z18M8Z18	20.0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
M9Z18MAZ18	30.5000E+000.5000E+000.2500E+000.0000E+00
F9Z18FAZ18	30.5000E+000.5000E+000.2500E+000.0000E+00
F9Z18M9Z18	20.0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
MAZ18MBZ18	30.5000E+000.5000E+000.2500E+000.0000E+00
FAZ18FBZ18	30.5000E+000.5000E+000.2500E+000.0000E+00
FAZ18MAZ18	20.0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
MBZ18MCZ18	30.5000E+000.5000E+000.2500E+000.0000E+00
FBZ18FCZ18	30.5000E+000.5000E+000.2500E+000.0000E+00
FBZ18MBZ18	20.0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
MCZ18MDZ18	30.5000E+000.2500E+000.2500E+000.0000E+00
FCZ18FDZ18	30.5000E+000.2500E+000.2500E+000.0000E+00
FCZ18MCZ18	20.0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
MDZ18MEZ18	30.2500E+000.2500E+000.2500E+000.0000E+00
FDZ18FEZ18	30.2500E+000.2500E+000.2500E+000.0000E+00
FDZ18MDZ18	20.0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MEZ18MFZ18	30.2500E+000.2500E+000.2500E+000.0000E+00
FEZ18FFZ18	30.2500E+000.2500E+000.2500E+000.0000E+00
FEZ18MEZ18	20.0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MFZ18MGZ18	30.2500E+000.2500E+000.2500E+000.0000E+00
FFZ18FGZ18	30.2500E+000.2500E+000.2500E+000.0000E+00
FFZ18MFZ18	20.0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MGZ18MHZ18	30.2500E+000.1233E+010.2500E+000.0000E+00
FGZ18FHZ18	30.2500E+000.1233E+010.2500E+000.0000E+00
FGZ18MGZ18	20.0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MHZ18MIZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FHZ18FIZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FHZ18MHZ18	20.0000E+000.8865E-010.2319E+010.0000E+000.8000E-02
MIZ18MJZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FIZ18FIJZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FIZ18MIZ18	20.0000E+000.8865E-010.2319E+010.0000E+000.8000E-02
MJZ18MKZ18	30.1233E+010.2500E+000.2500E+000.0000E+00
FJZ18FKZ18	30.1233E+010.2500E+000.2500E+000.0000E+00
FJZ18MJZ18	20.0000E+000.8865E-010.2319E+010.0000E+000.8000E-02
FKZ18MKZ18	20.0000E+000.8865E-010.4700E+000.0000E+000.8000E-02

As stated, it is noted that the proper headers required by TOUGH2 must be inserted by the user by hand (ELEM header and one blank space then CONNE header). This excerpt is shown with the user inserted headers in the correct format for a TOUGH2 simulation. A line count is also performed to ensure that the processor processed all lines given in the primary file. The primary mesh (the input for the processor) contains 12,600 elements and 36,110 connections. The processor output file for the ELEM portion of the mesh file contains $12,600 \times 2 = 25,200$ total elements (12,600 matrix, 12,600 fracture). The CONNE portion contains $36,110 \times 2 + 12,600 = 84,820$ total connections. These are correct so the processor is handling all lines from the primary mesh file.

The routine dkmmeshamb.f is also used for the median Kb sensitivity study described in the AMR N0000. The software routine used to generate this DKM mesh file is the same as above and the input file names: MESH1.988 and MESH are also the same as above. However, the routine user inputs are specified as the following:

```

What is the name of the input file?
MESH

Enter the dimension N=? of fracture set
N=2 for 1-d, N=4 for 2-d, N=6 for 3-d
2

Enter the fracture spacing in meters

```

0.1316

Enter the fracture porosity
3.435E-04

Select a f-m connection: c=1, krl=2, other=3
1
enter the constant multiplier
8.E-06

With these new user defined routine runtime inputs, the DKM mesh file for the ambient median Kb simulation is generated the same as in the previous case. The heating files are documented and checked next. The heating mesh file requires different boundary conditions than the ambient mesh files discussed above. The next software routine takes the initial primary mesh file (called: MESH1.988) and inserts the material identifiers used to denote the boundary elements (note: the user must define by hand the location of the heater elements within the model domain).

The range of validity for this routine is flexible. The routine is hardwired for a model domain with 12,600 primary volume, hence this is its applicable range. However, if the following two lines are changed in the routine

```
dimension vol_i(12600)  
if (i .eq. 12600) then
```

the range of validity of the routine is changed. The routine is somewhat problem specific in that the IF statements are looking for material identifiers (ma2 =) 3 and 4 (boundary elements), or 1 for the interior elements.

bdryinselem.f (Version 1.)

```
C  
C  
C      THIS IS USED TO PROCESS A HEATING MESH FILE FROM THE ORIGINAL FILE  
C      This will be used to process the boundary elements and the  
C      new insulation elements at the front face and the side face.  
C      This mesh has been further refined in the Z-direction MESH and  
C      must have +++ at the end of the file (first three spaces)  
C  
C  
      character*5 name  
      character*80 BLOCK  
      character*3 el  
      character*3 el1  
      character*3 el2  
      open(unit=16,file='MESH1.988',status='old')  
      open(unit=17,file='MESH',status = 'unknown')  
2      read(16,5) name  
5      format(a5)  
      if(name.ne.'ELEM') go to 2  
95     read(16,100) el, ne, ma2, block(21:30),BLOCK(31:80)  
100    format(a3,i2,13x,i2,a10,a50)  
  
      if ( el(1:3) .eq. '  ') goto 306  
  
      if ( el(2:2) .eq. 'K' .and. ne .ne. 18
```

```

@      .and. ne .ne. 17 .and. ne .ne. 16) THEN
    ma2 = 3
    Block(21:30) = '    1.0E+50'
    write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
    goto 95

    else if (el(3:3) .eq. '1'.and. el(2:2) .ne. '1'
@      .and. ne .ne. 18 .and. ne .ne. 17 .and. ne .ne. 16
@      .and. el(2:2) .ne. '2'.and. el(2:2) .ne. '3' ) then

        ma2 = 3
        Block(21:30) = '    1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if (el(3:3) .eq. 'Z'.and. el(2:2) .ne. '1'
@      .and. ne .ne. 18 .and. ne .ne. 17 .and. ne .ne. 16
@      .and. el(2:2) .ne. '2'.and. el(2:2) .ne. '3' ) then

        ma2 = 3
        Block(21:30) = '    1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if (el(3:3) .eq. '1' .and. el(2:2) .eq. '2'
@      .and. ne .ne. 18 ) then

        ma2 = 5
        Block(21:30) = '    1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if ( el(3:3) .eq. '1'
@      .and. el(2:2) .eq. '3' .and. ne .ne. 18) then

        ma2 = 5
        Block(21:30) = '    1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if (el(3:3) .eq. 'Z' .and. el(2:2) .eq. '2'
@      .and. ne .ne. 18 ) then

        ma2 = 5
        Block(21:30) = '    1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if (el(3:3) .eq. 'Z'
@      .and. el(2:2) .eq. '3' .and. ne .ne. 18) then

        ma2 = 5
        Block(21:30) = '    1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

```

```

    else if (el(3:3) .eq. '1' .and. ne .ge. 16 .and.
@    ne .lt. 18 .and. el(2:2) .ne. '1') then

        ma2 = 5
        Block(21:30) = ' 1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if (el(3:3) .eq. 'Z' .and. ne .ge. 16 .and.
@    ne .lt. 18 .and. el(2:2) .ne. '1') then

        ma2 = 5
        Block(21:30) = ' 1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if (el(2:2) .eq. '1') then
        ma2 = 4
        Block(21:30) = ' 1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if (el(2:2) .eq. '2' .and. ne .ne. 18
@    .or. el(2:2) .eq. '3' .and. ne .ne. 18) then
        ma2 = 5
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if ( ne .eq. 18) then
        ma2 = 4
        Block(21:30) = ' 1.0E+50'
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else if ( ne .eq. 17 .or. ne .eq. 16) then
        ma2 = 5
        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95

    else

        write(17,100) el, ne, ma2, block(21:30),BLOCK(31:80)
        goto 95
    end if

306  read(16,5) name
      if(name.ne.'CONNE') go to 306
105  read(16,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
101  format(a3,i2,a3,i2,a20,2e10.4,a30)
      if ( el1(1:3) .eq. '+++') goto 307

      if ( el1(3:3) .eq. '1' .and. el2(3:3) .eq. '1' .and.
@      el2(2:2) .ne. 'K' .and. el1(2:2) .ne. '1'
@      .and. ne2 .ne. 18 ) then
c      d1 = 0.0e+00

```

```

c      d2 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105
      else if ( el1(3:3) .eq. '1' .and. el2(3:3) .ne. '1' ) then

          d1 = 0.0e+00
          write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
          goto 105

      else if ( el1(3:3) .ne. '1' .and. el2(3:3) .eq. '1' ) then

          d2 = 0.0e+00
          write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
          goto 105

      else if ( el1(3:3) .eq. 'Z' .and. el2(3:3) .eq. 'Z' .and.
@      el1(2:2) .ne. '1' .and. el2(2:2) .ne. 'K'
@      .and. ne2 .ne. 18) then
c      d1 = 0.0e+00
c      d2 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105
      else if ( el1(3:3) .eq. 'Z' .and. el2(3:3) .ne. 'Z' ) then

          d1 = 0.0e+00
          write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
          goto 105

      else if ( el1(3:3) .ne. 'Z' .and. el2(3:3) .eq. 'Z' ) then

          d2 = 0.0e+00
          write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
          goto 105

      else if ( el1(2:2) .eq. 'K' .and. el2(2:2) .eq. 'K'
@      .and. ne2 .ne. 18) then
c      d1 = 0.0e+00
c      d2 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105
      else if ( el1(2:2) .eq. 'K' .and. el2(2:2) .ne. 'K' ) then
          d1 = 0.0e+00
          write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
          goto 105
      else if ( el1(2:2) .ne. 'K' .and. el2(2:2) .eq. 'K' ) then
          d2 = 0.0e+00
          write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
          goto 105

      else if ( el1(2:2) .eq. '1' .and. el2(2:2) .eq. '1'
@      .and. ne2 .ne. 18) then
c      d1 = 0.0e+00
c      d2 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)

```

```

      goto 105
    else if ( el1(2:2) .eq. '1' .and. el2(2:2) .ne. '1' ) then
      d1 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105
    else if ( el1(2:2) .ne. '1' .and. el2(2:2) .eq. '1' ) then
      d2 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105

    else if ( ne1 .eq. 18 .and. ne2 .eq. 18 ) then
c      d1 = 0.0e+00
c      d2 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105
    else if ( ne1 .eq. 18 .and. ne2 .ne. 18 ) then
      d1 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105
    else if ( ne1 .ne. 18 .and. ne2 .eq. 18 ) then
      d2 = 0.0e+00
      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105

    else

      write(17,101) el1,ne1,el2,ne2,BLOCK(11:30),d1,d2,BLOCK(51:80)
      goto 105

    end if

307  close(17)
      stop
      end

```

An excerpt of the input mesh file for this routine is the following (input file name is called: MESH1.988):

ELEME									
A11	1	.1063E-01	.2125E-01		.2125E-01	.2500E+00	-.2500E+00		
A21	1	.1619E-02	.0000E+00		.2125E-01	.2500E+00	-.5381E+00		
A31	1	.1619E-02	.0000E+00		.2125E-01	.2500E+00	-.6143E+00		
A41	1	.1063E-01	.0000E+00		.2125E-01	.2500E+00	-.9024E+00		
A51	1	.1063E-01	.0000E+00		.2125E-01	.2500E+00	-.1402E+01		
A61	1	.1050E-01	.0000E+00		.2125E-01	.2500E+00	-.1899E+01		
A71	1	.1050E-01	.0000E+00		.2125E-01	.2500E+00	-.2393E+01		
A81	1	.2125E-01	.0000E+00		.2125E-01	.2500E+00	-.3140E+01		
A91	1	.2125E-01	.0000E+00		.2125E-01	.2500E+00	-.4140E+01		
AA1	1	.2125E-01	.0000E+00		.2125E-01	.2500E+00	-.5140E+01		
AB1	1	.2125E-01	.0000E+00		.2125E-01	.2500E+00	-.6140E+01		
AC1	1	.2125E-01	.0000E+00		.2125E-01	.2500E+00	-.7140E+01		
AD1	1	.1063E-01	.0000E+00		.2125E-01	.2500E+00	-.7890E+01		
AE1	1	.1063E-01	.0000E+00		.2125E-01	.2500E+00	-.8390E+01		
AF1	1	.1063E-01	.0000E+00		.2125E-01	.2500E+00	-.8890E+01		
AG1	1	.1063E-01	.0000E+00		.2125E-01	.2500E+00	-.9390E+01		
AH1	1	.5242E-01	.0000E+00		.2125E-01	.2500E+00	-.1087E+02		
AI1	1	.5242E-01	.0000E+00		.2125E-01	.2500E+00	-.1334E+02		
AJ1	1	.5242E-01	.0000E+00		.2125E-01	.2500E+00	-.1581E+02		
AK1	1	.1063E-01	.2125E-01		.2125E-01	.2500E+00	-.1729E+02		
AL2	1	.4306E-01	.8611E-01		.2125E-01	.1513E+01	-.2500E+00		

A22 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01	-.5381E+00
A32 1	1	.6562E-02	.0000E+00	.2125E-01	.1513E+01	-.6143E+00
A42 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.9024E+00
A52 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.1402E+01
A62 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	-.1899E+01
A72 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	-.2393E+01
A82 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.3140E+01
A92 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.4140E+01
AA2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.5140E+01
AB2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.6140E+01
AC2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	-.7140E+01
AD2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.7890E+01
AE2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.8390E+01
AF2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.8890E+01
AG2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	-.9390E+01
AH2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	-.1087E+02
AI2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	-.1334E+02
AJ2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	-.1581E+02
AK2 1	1	.4306E-01	.8611E-01	.2125E-01	.1513E+01	-.1729E+02
...						
A1Z 1	1	.1063E-01	.2125E-01	.2125E-01	.2075E+02	-.2500E+00
A2Z 1	1	.1619E-02	.0000E+00	.2125E-01	.2075E+02	-.5381E+00
A3Z 1	1	.1619E-02	.0000E+00	.2125E-01	.2075E+02	-.6143E+00
A4Z 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	-.9024E+00
A5Z 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	-.1402E+01
A6Z 1	1	.1050E-01	.0000E+00	.2125E-01	.2075E+02	-.1899E+01
A7Z 1	1	.1050E-01	.0000E+00	.2125E-01	.2075E+02	-.2393E+01
A8Z 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	-.3140E+01
A9Z 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	-.4140E+01
AAZ 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	-.5140E+01
ABZ 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	-.6140E+01
ACZ 1	1	.2125E-01	.0000E+00	.2125E-01	.2075E+02	-.7140E+01
ADZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	-.7890E+01
AEZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	-.8390E+01
AFZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	-.8890E+01
AGZ 1	1	.1063E-01	.0000E+00	.2125E-01	.2075E+02	-.9390E+01
AHZ 1	1	.5242E-01	.0000E+00	.2125E-01	.2075E+02	-.1087E+02
AIZ 1	1	.5242E-01	.0000E+00	.2125E-01	.2075E+02	-.1334E+02
AJZ 1	1	.5242E-01	.0000E+00	.2125E-01	.2075E+02	-.1581E+02
AKZ 1	1	.1063E-01	.2125E-01	.2125E-01	.2075E+02	-.1729E+02
A11 2	1	.2125E-01	.4250E-01	.8500E-01	.2500E+00	-.2500E+00
A21 2	1	.3239E-02	.0000E+00	.8500E-01	.2500E+00	-.5381E+00
A31 2	1	.3239E-02	.0000E+00	.8500E-01	.2500E+00	-.6143E+00
A41 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.9024E+00
A51 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.1402E+01
A61 2	1	.2100E-01	.0000E+00	.8500E-01	.2500E+00	-.1899E+01
A71 2	1	.2100E-01	.0000E+00	.8500E-01	.2500E+00	-.2393E+01
A81 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.3140E+01
A91 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.4140E+01
AA1 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.5140E+01
AB1 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.6140E+01
AC1 2	1	.4250E-01	.0000E+00	.8500E-01	.2500E+00	-.7140E+01
AD1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.7890E+01
AE1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.8390E+01
AF1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.8890E+01
AG1 2	1	.2125E-01	.0000E+00	.8500E-01	.2500E+00	-.9390E+01
AH1 2	1	.1048E+00	.0000E+00	.8500E-01	.2500E+00	-.1087E+02
AI1 2	1	.1048E+00	.0000E+00	.8500E-01	.2500E+00	-.1334E+02
AJ1 2	1	.1048E+00	.0000E+00	.8500E-01	.2500E+00	-.1581E+02
AK1 2	1	.2125E-01	.4250E-01	.8500E-01	.2500E+00	-.1729E+02
A12 2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01	-.2500E+00
A22 2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	-.5381E+00
A32 2	1	.1312E-01	.0000E+00	.8500E-01	.1513E+01	-.6143E+00
A42 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.9024E+00
A52 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01	-.1402E+01
A62 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	-.1899E+01
A72 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01	-.2393E+01
A82 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.3140E+01
A92 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.4140E+01
AA2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01	-.5140E+01

AB2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-.6140E+01
AC2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-.7140E+01
AD2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.7890E+01
AE2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.8390E+01
AF2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.8890E+01
AG2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.9390E+01
AH2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-.1087E+02
AI2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-.1334E+02
AJ2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-.1581E+02
AK2 2	1	.8611E-01	.1722E+00	.8500E-01	.1513E+01-.1729E+02

...

AJY18	1	.2499E+01	.0000E+00	.6603E+01	.1949E+02-.1581E+02
AKY18	1	.5065E+00	.1013E+01	.6603E+01	.1949E+02-.1729E+02
A1Z18	1	.1250E+00	.2500E+00	.6603E+01	.2075E+02-.2500E+00
A2Z18	1	.1905E-01	.0000E+00	.6603E+01	.2075E+02-.5381E+00
A3Z18	1	.1905E-01	.0000E+00	.6603E+01	.2075E+02-.6143E+00
A4Z18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-.9024E+00
A5Z18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-.1402E+01
A6Z18	1	.1235E+00	.0000E+00	.6603E+01	.2075E+02-.1899E+01
A7Z18	1	.1235E+00	.0000E+00	.6603E+01	.2075E+02-.2393E+01
A8Z18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-.3140E+01
A9Z18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-.4140E+01
AAZ18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-.5140E+01
ABZ18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-.6140E+01
ACZ18	1	.2500E+00	.0000E+00	.6603E+01	.2075E+02-.7140E+01
ADZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-.7890E+01
AEZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-.8390E+01
AFZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-.8890E+01
AGZ18	1	.1250E+00	.0000E+00	.6603E+01	.2075E+02-.9390E+01
AHZ18	1	.6167E+00	.0000E+00	.6603E+01	.2075E+02-.1087E+02
AIZ18	1	.6167E+00	.0000E+00	.6603E+01	.2075E+02-.1334E+02
AJZ18	1	.6167E+00	.0000E+00	.6603E+01	.2075E+02-.1581E+02
AKZ18	1	.1250E+00	.2500E+00	.6603E+01	.2075E+02-.1729E+02

CONNE

A11 1A11 2	1	.2125E-01	.4250E-01	.2500E+00	
A11 1A12 1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01
A11 1A21 1	3	.2500E+00	.3810E-01	.2125E-01	.0000E+00
A21 1A21 2	1	.2125E-01	.4250E-01	.3810E-01	
A21 1A22 1	2	.2500E+00	.1013E+01	.3239E-02	.1000E+01
A21 1A31 1	3	.3810E-01	.3810E-01	.2125E-01	.0000E+00
A31 1A31 2	1	.2125E-01	.4250E-01	.3810E-01	
A31 1A32 1	2	.2500E+00	.1013E+01	.3239E-02	.1000E+01
A31 1A41 1	3	.3810E-01	.2500E+00	.2125E-01	.0000E+00
A41 1A41 2	1	.2125E-01	.4250E-01	.2500E+00	
A41 1A42 1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01
A41 1A51 1	3	.2500E+00	.2500E+00	.2125E-01	.0000E+00
A51 1A51 2	1	.2125E-01	.4250E-01	.2500E+00	
A51 1A52 1	2	.2500E+00	.1013E+01	.2125E-01	.1000E+01
A51 1A61 1	3	.2500E+00	.2470E+00	.2125E-01	.0000E+00
A61 1A61 2	1	.2125E-01	.4250E-01	.2470E+00	
A61 1A62 1	2	.2500E+00	.1013E+01	.2100E-01	.1000E+01
A61 1A71 1	3	.2470E+00	.2470E+00	.2125E-01	.0000E+00
A71 1A71 2	1	.2125E-01	.4250E-01	.2470E+00	
A71 1A72 1	2	.2500E+00	.1013E+01	.2100E-01	.1000E+01
A71 1A81 1	3	.2470E+00	.5000E+00	.2125E-01	.0000E+00
A81 1A81 2	1	.2125E-01	.4250E-01	.5000E+00	
A81 1A82 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01
A81 1A91 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00
A91 1A91 2	1	.2125E-01	.4250E-01	.5000E+00	
A91 1A92 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01
A91 1AA1 1	3	.5000E+00	.5000E+00	.2125E-01	.0000E+00
AA1 1AA1 2	1	.2125E-01	.4250E-01	.5000E+00	
AA1 1AA2 1	2	.2500E+00	.1013E+01	.4250E-01	.1000E+01

...

A5Z18A6Z18	3-	.2500E+00	.2470E+00	.2500E+00	.0000E+00
A6Z18A7Z18	3	.2470E+00	.2470E+00	.2500E+00	.0000E+00
A7Z18A8Z18	3	.2470E+00	.5000E+00	.2500E+00	.0000E+00
A8Z18A9Z18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
A9Z18AAZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00

AAZ18ABZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
ABZ18ACZ18	3	.5000E+00	.5000E+00	.2500E+00	.0000E+00
ACZ18ADZ18	3	.5000E+00	.2500E+00	.2500E+00	.0000E+00
ADZ18AEZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AEZ18AFZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AFZ18AGZ18	3	.2500E+00	.2500E+00	.2500E+00	.0000E+00
AGZ18AHZ18	3	.2500E+00	.1233E+01	.2500E+00	.0000E+00
AHZ18AIZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00
AIZ18AJZ18	3	.1233E+01	.1233E+01	.2500E+00	.0000E+00
AJZ18AKZ18	3	.1233E+01	.2500E+00	.2500E+00	.0000E+00

An excerpt of the routine generated output mesh file is the following (the output file name is called: MESH). This output file only creates the appropriate boundary conditions; it does not make the DKM mesh file (that procedure will be discussed next). The processor altered values are in bold.

A11 1	4	1.0E+50	.2125E-01	.2125E-01	.2500E+00-.2500E+00
A21 1	5	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.5381E+00
A31 1	5	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.6143E+00
A41 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.9024E+00
A51 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.1402E+01
A61 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.1899E+01
A71 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.2393E+01
A81 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.3140E+01
A91 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.4140E+01
AA1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.5140E+01
AB1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.6140E+01
AC1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.7140E+01
AD1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.7890E+01
AE1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.8390E+01
AF1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.8890E+01
AG1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.9390E+01
AH1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.1087E+02
AI1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.1334E+02
AJ1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00-.1581E+02
AK1 1	3	1.0E+50	.2125E-01	.2125E-01	.2500E+00-.1729E+02
A12 1	4	1.0E+50	.8611E-01	.2125E-01	.1513E+01-.2500E+00
A22 1	5	.6562E-02	.0000E+00	.2125E-01	.1513E+01-.5381E+00
A32 1	5	.6562E-02	.0000E+00	.2125E-01	.1513E+01-.6143E+00
A42 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.9024E+00
A52 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.1402E+01
A62 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01-.1899E+01
A72 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01-.2393E+01
A82 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.3140E+01
A92 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.4140E+01
AA2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.5140E+01
AB2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.6140E+01
AC2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01-.7140E+01
AD2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.7890E+01
AE2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.8390E+01
AF2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.8890E+01
AG2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01-.9390E+01
AH2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01-.1087E+02
AI2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01-.1334E+02
AJ2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01-.1581E+02
AK2 1	3	1.0E+50	.8611E-01	.2125E-01	.1513E+01-.1729E+02
...					
A1Z 1	4	1.0E+50	.2125E-01	.2125E-01	.2075E+02-.2500E+00
A2Z 1	5	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.5381E+00
A3Z 1	5	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.6143E+00
A4Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.9024E+00
A5Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1402E+01
A6Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1899E+01
A7Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.2393E+01
A8Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.3140E+01
A9Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.4140E+01
AAZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.5140E+01

ABZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.6140E+01
ACZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.7140E+01
ADZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.7890E+01
AEZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.8390E+01
AFZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.8890E+01
AGZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.9390E+01
AHZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.1087E+02
AIZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.1334E+02
AJZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-	.1581E+02
AKZ 1	3	1.0E+50	.2125E-01	.2125E-01	.2075E+02-	.1729E+02
A11 2	4	1.0E+50	.4250E-01	.8500E-01	.2500E+00-	.2500E+00
A21 2	5	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.5381E+00
A31 2	5	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.6143E+00
A41 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.9024E+00
A51 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.1402E+01
A61 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.1899E+01
A71 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.2393E+01
A81 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.3140E+01
A91 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.4140E+01
AA1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.5140E+01
AB1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.6140E+01
AC1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.7140E+01
AD1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.7890E+01
AE1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.8390E+01
AF1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.8890E+01
AG1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.9390E+01
AH1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.1087E+02
AI1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.1334E+02
AJ1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-	.1581E+02
AK1 2	3	1.0E+50	.4250E-01	.8500E-01	.2500E+00-	.1729E+02
A12 2	4	1.0E+50	.1722E+00	.8500E-01	.1513E+01-	.2500E+00
A22 2	5	.1312E-01	.0000E+00	.8500E-01	.1513E+01-	.5381E+00
A32 2	5	.1312E-01	.0000E+00	.8500E-01	.1513E+01-	.6143E+00
A42 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-	.9024E+00
A52 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-	.1402E+01
A62 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01-	.1899E+01
A72 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01-	.2393E+01
A82 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-	.3140E+01
A92 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-	.4140E+01
AA2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-	.5140E+01
AB2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-	.6140E+01
AC2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-	.7140E+01
AD2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-	.7890E+01
AE2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-	.8390E+01
AF2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-	.8890E+01
AG2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-	.9390E+01
AH2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-	.1087E+02
AI2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-	.1334E+02
AJ2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-	.1581E+02
AK2 2	3	1.0E+50	.1722E+00	.8500E-01	.1513E+01-	.1729E+02
...						
AJY18	4	1.0E+50	.0000E+00	.6603E+01	.1949E+02-	.1581E+02
AKY18	4	1.0E+50	.1013E+01	.6603E+01	.1949E+02-	.1729E+02
A1Z18	4	1.0E+50	.2500E+00	.6603E+01	.2075E+02-	.2500E+00
A2Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.5381E+00
A3Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.6143E+00
A4Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.9024E+00
A5Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.1402E+01
A6Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.1899E+01
A7Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.2393E+01
A8Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.3140E+01
A9Z18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.4140E+01
AAZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.5140E+01
ABZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.6140E+01
ACZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.7140E+01
ADZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.7890E+01
AEZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.8390E+01
AFZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.8890E+01
AGZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.9390E+01
AHZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-	.1087E+02

AIZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.1334E+02
AJZ18	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02	-.1581E+02
AKZ18	4	1.0E+50	.2500E+00	.6603E+01	.2075E+02	-.1729E+02

CONNE

A11 1A11 2	10.2125E-010.4250E-01	.2500E+00	
A11 1A12 1	20.0000E+000.1013E+01	.2125E-01	.1000E+01
A11 1A21 1	30.0000E+000.3810E-01	.2125E-01	.0000E+00
A21 1A21 2	10.2125E-010.4250E-01	.3810E-01	
A21 1A22 1	20.0000E+000.1013E+01	.3239E-02	.1000E+01
A21 1A31 1	30.3810E-010.3810E-01	.2125E-01	.0000E+00
A31 1A31 2	10.2125E-010.4250E-01	.3810E-01	
A31 1A32 1	20.0000E+000.1013E+01	.3239E-02	.1000E+01
A31 1A41 1	30.3810E-010.2500E+00	.2125E-01	.0000E+00
A41 1A41 2	10.2125E-010.4250E-01	.2500E+00	
A41 1A42 1	20.0000E+000.1013E+01	.2125E-01	.1000E+01
A41 1A51 1	30.2500E+000.2500E+00	.2125E-01	.0000E+00
A51 1A51 2	10.2125E-010.4250E-01	.2500E+00	
A51 1A52 1	20.0000E+000.1013E+01	.2125E-01	.1000E+01
A51 1A61 1	30.2500E+000.2470E+00	.2125E-01	.0000E+00
A61 1A61 2	10.2125E-010.4250E-01	.2470E+00	
A61 1A62 1	20.0000E+000.1013E+01	.2100E-01	.1000E+01
A61 1A71 1	30.2470E+000.2470E+00	.2125E-01	.0000E+00
A71 1A71 2	10.2125E-010.4250E-01	.2470E+00	
A71 1A72 1	20.0000E+000.1013E+01	.2100E-01	.1000E+01
A71 1A81 1	30.2470E+000.5000E+00	.2125E-01	.0000E+00
A81 1A81 2	10.2125E-010.4250E-01	.5000E+00	
A81 1A82 1	20.0000E+000.1013E+01	.4250E-01	.1000E+01
A81 1A91 1	30.5000E+000.5000E+00	.2125E-01	.0000E+00
A91 1A91 2	10.2125E-010.4250E-01	.5000E+00	
A91 1A92 1	20.0000E+000.1013E+01	.4250E-01	.1000E+01
A91 1AA1 1	30.5000E+000.5000E+00	.2125E-01	.0000E+00
AA1 1AA1 2	10.2125E-010.4250E-01	.5000E+00	
AA1 1AA2 1	20.0000E+000.1013E+01	.4250E-01	.1000E+01

...

A5Z18A6Z18	30.2500E+000.2470E+00	.2500E+00	.0000E+00
A6Z18A7Z18	30.2470E+000.2470E+00	.2500E+00	.0000E+00
A7Z18A8Z18	30.2470E+000.5000E+00	.2500E+00	.0000E+00
A8Z18A9Z18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
A9Z18AAZ18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
AAZ18ABZ18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
ABZ18ACZ18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
ACZ18ADZ18	30.5000E+000.2500E+00	.2500E+00	.0000E+00
ADZ18AEZ18	30.2500E+000.2500E+00	.2500E+00	.0000E+00
AEZ18AFZ18	30.2500E+000.2500E+00	.2500E+00	.0000E+00
AFZ18AGZ18	30.2500E+000.2500E+00	.2500E+00	.0000E+00
AGZ18AHZ18	30.2500E+000.1233E+01	.2500E+00	.0000E+00
AHZ18AIZ18	30.1233E+010.1233E+01	.2500E+00	.0000E+00
AIZ18AJZ18	30.1233E+010.1233E+01	.2500E+00	.0000E+00
AJZ18AKZ18	30.1233E+010.0000E+00	.2500E+00	.0000E+00

The range of validity for this routine is a TOUGH2 meshmaker-generated initial primary mesh file with nx = 18, ny = 35 (direction of gravity), and nz = 20. The output results of this software routine are input into the DKM mesh generator software routine. This routine is described below as the following:

dkmmesh.f (Version 1.)

```

C
C      This processor will read the MESH file for the SHT ECM model
C      and transform it into a DKM model.  It is problem specific
C      in that it is looking for certain element indicators such
C      as specific material identifiers. Only one fracture porosity
C      will be input and used to determine the matrix and fracture
C      volumes in the ELEME
C

```

```

c      Nick Francis 03/13/98
c
c
c
c
c
c
c
c
c
c23456789012345678901234567890123456789012345678901234567890123456789012

```

```

      implicit double precision (a-h,l,o-z)
      character*5 name
      character*5 elnamem
      character*5 elnamef
      character*3 el1
      character*3 el1old
      character*3 el2
      character*3 el2old
      character*3 el
      dimension vol_i(12600)

```

```

c... Enter input data such as fracture set dimensions,
c      fractures spacing, fracture porosity
c

```

```

      write(*,*) 'What is the name of the input file?'
      read(*, '(a)') infile
      write(*,*)
      write(*,*) 'Enter the dimension N=? of fracture set'
      write(*,*) 'N=2 for 1-d, N=4 for 2-d, N=6 for 3-d'
      read(*,*) xN
      write(*,*)
      write(*,*) 'Enter the fracture spacing in meters'
      read(*,*) D
      write(*,*)

```

```

c... compute the nodal distance for the fracture-matrix connection
c... it is based on the dimensionality of the fracture set
c

```

```

      if (xN .eq. 2.) then
        con_dm = D/6.
      elseif (xN .eq. 4. ) then
        con_dm = D/8.
      elseif (xN .eq. 6.) then
        con_dm = D/10.
      else
        write(*,*) 'you have made an error'
      end if

```

```

c
c
c... read in fracture porosity
      write(*,*) 'Enter the fracture porosity'
      read(*,*) phif
      write(*,*)

```

```

c... read in the DKM fmx specification
    write(*,*) 'Select a f-m connection: c=1, krl=2, other=3'
    read(*,*) idkfm
c... open up necessary files
    open(9,file='MESH1.988',status='old')
    open(10,file=infile,status='old')
    open(13,file='dkm.mesh',status='unknown')
10    format(a5)
100   format(a3,i2,13x,i2,2E10.4,10x,3E10.4)
101   format(20x,E10.4)
102   format('M',a2,i2,10x,'roccm',2E10.4,10x,3E10.4)
103   format('F',a2,i2,10x,'roccf',2E10.4,10x,3E10.4)
112   format('M',a2,i2,10x,'heatm',2E10.4,10x,3E10.4)
113   format('F',a2,i2,10x,'heatf',2E10.4,10x,3E10.4)
122   format('M',a2,i2,10x,'inslm',2E10.4,10x,3E10.4)
123   format('F',a2,i2,10x,'inslf',2E10.4,10x,3E10.4)
132   format('M',a2,i2,10x,'tunnm',2E10.4,10x,3E10.4)
133   format('F',a2,i2,10x,'tunnf',2E10.4,10x,3E10.4)
104   format(a3,i2,a3,i2,15x,i5,4e10.4)
105   format('M',a2,i2,'M',a2,i2,15x,i5,4e10.4)
106   format('F',a2,i2,'F',a2,i2,15x,i5,4e10.4)
107   format('F',a2,i2,'M',a2,i2,15x,i5,5e10.4)

c... determines the fmx type
c
    if( idkfm .eq. 1) then

        write(*,*) 'enter the constant multiplier'
        read(*,*) const
        fmx = const

    elseif ( idkfm .eq. 2) then

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'k_rl weighted connection'
        read(*,*) ckrl
        fmx = ckrl

    else

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'other weighted connection'
        read(*,*) ckoth
        fmx = ckoth

    end if

c
c
c... store the element volumes from the original mesh
    i=1
1    read(9,10) name
    if (name .ne. 'ELEME') goto 1
32   read(9,101) vol_i(i)
    if (i .eq. 12600) then
        goto 2
    else

```

```

        i=i+1
        goto 32
    end if

c... work on the ELEME portion of the mesh first
c... begin creating the DKM mesh from the working
c    ECM mesh

2    read(10,10) name
        if (name .ne. 'ELEME') goto 2
33   read(10,100) el, ne,ma2,volx, ahtx,x,y,z
        if (el .eq. ' ') goto 555

        if (ma2 .eq. 4) then

c
c... these are the air boundary elements

c... write the matrix element
c    volxm = volx*(1.-phif)
        write(13,132) el(2:3), ne,volx,ahtx,x,y,z

c... write the fracture element

        write(13,133) el(2:3), ne,volx,ahtx,x,y,z

        elseif (ma2 .eq. 5) then

c... these are the insulation elements

c... write the matrix element
c    volxm = volx*(1.-phif)
c... use the primary volume for the matrix
        write(13,122) el(2:3), ne,volx,ahtx,x,y,z

c... write the fracture element

        volx=1.0E-05*volx
c... use an arbitrary small volume for the fracture
        write(13,123) el(2:3), ne,volx,ahtx,x,y,z

c

        elseif (ma2 .eq. 2) then

c
c.... these are the heater elements

c... write the matrix element
c    volxm = volx*(1.-phif)
c... use the primary volume for the matrix
        write(13,112) el(2:3), ne,volx,ahtx,x,y,z

c... write the fracture element

        volx=1.0E-05*volx
c... use an arbitrary small volume for the fracture
        write(13,113) el(2:3), ne,volx,ahtx,x,y,z

```

```

c          elseif (ma2 .eq. 3) then
c
c... these are rock boundary elements
c    THEY ARE dkm elements
c
c... these are rock boundary elements
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z
c... write the fracture element
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z
      else
c... This are interior rock elements
c    THEY ARE dkm elements
c
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z
c... write the fracture element
      ma2 = 7
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z
      end if
      goto 33
c.... work on the CONNE portion of the mesh next
555  read(10,10) name
      if (name .ne. 'CONNE') goto 555
      i = 1
      icheck=1
44   read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax
c... write the matrix-matrix connection
45   write(13,105) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @ areax,betax
c... write the fracture-fracture connection
      write(13,106) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @ areax,betax
      if (icheck .eq. 1) then
c... write the fracture-matrix connection
      areax = xN*vol_i(i)/D
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0

```

```

write(13,107) el1(2:3),nel,el1(2:3),nel,isot,con_df,
@   con_dm,areax,betax,fmt
  i = i+1
end if

  ellold=el1(1:3)
  el2old=el2(1:3)
  ne2old=ne2
read(10,104) el1,nel,el2,ne2,isot,d1,d2,areax,betax

  if (el1 .eq. ' ') goto 556
  if (el1 .eq. ellold) then
    icheck=2
    goto 45
  else
    icheck=1
    goto 45
  endif

556   areax = xN*vol_i(i)/D
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
write(13,107) el2old(2:3),ne2old,el2old(2:3),
@   ne2old,isot,con_df,con_dm,areax,betax,fmt

close(12)
close(13)
stop
end

```

Two input files are required to run this routine. One of the input files for dkmmesh.f is a resultant file from the software routine bdryinselem.f. Additionally, dkmmesh.f also requires the initial primary mesh file (the input file for bdryinselem.f called MESH1.988), so that it can read in the actual element volumes (recall some boundary elements were given large volumes) used to compute the interface area specified by the DKM for the matrix-fracture interface area. An excerpt of the resultant DKM mesh generated by dkmmesh.f for the TSPA-VA sensitivity study in AMR N0000 is shown below. In addition to the two large input files, the routine also calls for user input during runtime. The inputs provided during routine runtime for this particular case are the following:

```

What is the name of the input file?
MESH

```

```

Enter the dimension N=? of fracture set
N=2 for 1-d, N=4 for 2-d, N=6 for 3-d
2.

```

```

Enter the fracture spacing in meters
0.5319

```

```

Enter the fracture porosity
1.24E-04

```

```

Select a f-m connection: c=1, krl=2, other=3
1
enter the constant multiplier
8.0E-03

```

The primary input file (output file from the routine bdryinselem.f) for dkmmesh.f is file name: MESH. The heater elements (A8I 1, A9I 1, AAI 1, ABI 1, and ACI 1, all ma2 = 2) must be identified by the user by hand in the primary mesh file obtained from bdryinselem.f before it is used as input to the routine. An excerpt is shown below.

A11 1	4	1.0E+50	.2125E-01	.2125E-01	.2500E+00	.2500E+00
A21 1	5	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.5381E+00
A31 1	5	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.6143E+00
A41 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.9024E+00
A51 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.1402E+01
A61 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.1899E+01
A71 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.2393E+01
A81 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.3140E+01
A91 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.4140E+01
AA1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.5140E+01
AB1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.6140E+01
AC1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.7140E+01
AD1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.7890E+01
AE1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.8390E+01
AF1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.8890E+01
AG1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.9390E+01
AH1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.1087E+02
AI1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.1334E+02
AJ1 1	3	1.0E+50	.0000E+00	.2125E-01	.2500E+00	.1581E+02
AK1 1	3	1.0E+50	.2125E-01	.2125E-01	.2500E+00	.1729E+02
A12 1	4	1.0E+50	.8611E-01	.2125E-01	.1513E+01	.2500E+00
A22 1	5	.6562E-02	.0000E+00	.2125E-01	.1513E+01	.5381E+00
A32 1	5	.6562E-02	.0000E+00	.2125E-01	.1513E+01	.6143E+00
A42 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.9024E+00
A52 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.1402E+01
A62 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	.1899E+01
A72 1	1	.4254E-01	.0000E+00	.2125E-01	.1513E+01	.2393E+01
A82 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.3140E+01
A92 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.4140E+01
AA2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.5140E+01
AB2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.6140E+01
AC2 1	1	.8611E-01	.0000E+00	.2125E-01	.1513E+01	.7140E+01
AD2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.7890E+01
AE2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.8390E+01
AF2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.8890E+01
AG2 1	1	.4306E-01	.0000E+00	.2125E-01	.1513E+01	.9390E+01
AH2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	.1087E+02
AI2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	.1334E+02
AJ2 1	1	.2124E+00	.0000E+00	.2125E-01	.1513E+01	.1581E+02
AK2 1	3	1.0E+50	.8611E-01	.2125E-01	.1513E+01	.1729E+02
...						
A1Z 1	4	1.0E+50	.2125E-01	.2125E-01	.2075E+02	.2500E+00
A2Z 1	5	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.5381E+00
A3Z 1	5	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.6143E+00
A4Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.9024E+00
A5Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.1402E+01
A6Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.1899E+01
A7Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.2393E+01
A8Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.3140E+01
A9Z 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.4140E+01
AAZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.5140E+01
ABZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.6140E+01
ACZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.7140E+01
ADZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.7890E+01
AEZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.8390E+01
AFZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.8890E+01
AGZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02	.9390E+01

AHZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1087E+02
AI2 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1334E+02
AJZ 1	3	1.0E+50	.0000E+00	.2125E-01	.2075E+02-.1581E+02
AK2 1	3	1.0E+50	.2125E-01	.2125E-01	.2075E+02-.1729E+02
AI1 2	4	1.0E+50	.4250E-01	.8500E-01	.2500E+00-.2500E+00
A21 2	5	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.5381E+00
A31 2	5	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.6143E+00
A41 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.9024E+00
A51 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.1402E+01
A61 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.1899E+01
A71 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.2393E+01
A81 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.3140E+01
A91 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.4140E+01
AA1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.6140E+01
AB1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.7140E+01
AC1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.7890E+01
AD1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.8390E+01
AE1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.8390E+01
AF1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.8890E+01
AG1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.9390E+01
AH1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.1087E+02
AI1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.1334E+02
AJ1 2	3	1.0E+50	.0000E+00	.8500E-01	.2500E+00-.1581E+02
AK1 2	4	1.0E+50	.4250E-01	.8500E-01	.2500E+00-.1729E+02
AI2 2	5	.1312E-01	.0000E+00	.8500E-01	.1513E+01-.2500E+00
A22 2	5	.1312E-01	.0000E+00	.8500E-01	.1513E+01-.5381E+00
A32 2	5	.1312E-01	.0000E+00	.8500E-01	.1513E+01-.9024E+00
A42 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.1402E+01
A52 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.1899E+01
A62 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01-.2393E+01
A72 2	1	.8508E-01	.0000E+00	.8500E-01	.1513E+01-.3140E+01
A82 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-.4140E+01
A92 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-.5140E+01
AA2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-.6140E+01
AB2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-.7140E+01
AC2 2	1	.1722E+00	.0000E+00	.8500E-01	.1513E+01-.7890E+01
AD2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.8390E+01
AE2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.8890E+01
AF2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.9390E+01
AG2 2	1	.8611E-01	.0000E+00	.8500E-01	.1513E+01-.1087E+02
AH2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-.1334E+02
AI2 2	1	.4248E+00	.0000E+00	.8500E-01	.1513E+01-.1581E+02
AJ2 2	3	.1.0E+50	.1722E+00	.8500E-01	.1513E+01-.1729E+02
AK2 2	3	.1.0E+50	.1722E+00	.8500E-01	.1513E+01-.1729E+02

..					
AJY18	4	1.0E+50	.0000E+00	.6603E+01	.1949E+02-.1581E+02
AKY18	4	1.0E+50	.1013E+01	.6603E+01	.1949E+02-.1729E+02
AI218	4	1.0E+50	.2500E+00	.6603E+01	.2075E+02-.2500E+00
A2218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.5381E+00
A3218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.6143E+00
A4218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.9024E+00
A5218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.1402E+01
A6218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.1899E+01
A7218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.2393E+01
A8218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.3140E+01
A9218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.4140E+01
AA218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.5140E+01
AB218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.6140E+01
AC218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.7140E+01
AD218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.7890E+01
AE218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.8390E+01
AF218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.8890E+01
AG218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.9390E+01
AH218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.1087E+02
AI218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.1334E+02
AJ218	4	1.0E+50	.0000E+00	.6603E+01	.2075E+02-.1581E+02
AK218	4	1.0E+50	.2500E+00	.6603E+01	.2075E+02-.1729E+02

CONNE
 AI1 IA11 2 10.2125E-010.4250E-01 .2500E+00

A11 1A12 1	20.0000E+000.1013E+01	.2125E-01	.1000E+01
A11 1A21 1	30.0000E+000.3810E-01	.2125E-01	.0000E+00
A21 1A21 2	10.2125E-010.4250E-01	.3810E-01	
A21 1A22 1	20.0000E+000.1013E+01	.3239E-02	.1000E+01
A21 1A31 1	30.3810E-010.3810E-01	.2125E-01	.0000E+00
A31 1A31 2	10.2125E-010.4250E-01	.3810E-01	
A31 1A32 1	20.0000E+000.1013E+01	.3239E-02	.1000E+01
A31 1A41 1	30.3810E-010.2500E+00	.2125E-01	.0000E+00
A41 1A41 2	10.2125E-010.4250E-01	.2500E+00	
A41 1A42 1	20.0000E+000.1013E+01	.2125E-01	.1000E+01
A41 1A51 1	30.2500E+000.2500E+00	.2125E-01	.0000E+00
A51 1A51 2	10.2125E-010.4250E-01	.2500E+00	
A51 1A52 1	20.0000E+000.1013E+01	.2125E-01	.1000E+01
A51 1A61 1	30.2500E+000.2470E+00	.2125E-01	.0000E+00
A61 1A61 2	10.2125E-010.4250E-01	.2470E+00	
A61 1A62 1	20.0000E+000.1013E+01	.2100E-01	.1000E+01
A61 1A71 1	30.2470E+000.2470E+00	.2125E-01	.0000E+00
A71 1A71 2	10.2125E-010.4250E-01	.2470E+00	
A71 1A72 1	20.0000E+000.1013E+01	.2100E-01	.1000E+01
A71 1A81 1	30.2470E+000.5000E+00	.2125E-01	.0000E+00
A81 1A81 2	10.2125E-010.4250E-01	.5000E+00	
A81 1A82 1	20.0000E+000.1013E+01	.4250E-01	.1000E+01
A81 1A91 1	30.5000E+000.5000E+00	.2125E-01	.0000E+00
A91 1A91 2	10.2125E-010.4250E-01	.5000E+00	
A91 1A92 1	20.0000E+000.1013E+01	.4250E-01	.1000E+01
A91 1AA1 1	30.5000E+000.5000E+00	.2125E-01	.0000E+00
AA1 1AA1 2	10.2125E-010.4250E-01	.5000E+00	
AA1 1AA2 1	20.0000E+000.1013E+01	.4250E-01	.1000E+01
...			
A5Z18A6Z18	30.2500E+000.2470E+00	.2500E+00	.0000E+00
A6Z18A7Z18	30.2470E+000.2470E+00	.2500E+00	.0000E+00
A7Z18A8Z18	30.2470E+000.5000E+00	.2500E+00	.0000E+00
A8Z18A9Z18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
A9Z18AAZ18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
AAZ18ABZ18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
ABZ18ACZ18	30.5000E+000.5000E+00	.2500E+00	.0000E+00
ACZ18ADZ18	30.5000E+000.2500E+00	.2500E+00	.0000E+00
ADZ18AEZ18	30.2500E+000.2500E+00	.2500E+00	.0000E+00
AEZ18AFZ18	30.2500E+000.2500E+00	.2500E+00	.0000E+00
AFZ18AGZ18	30.2500E+000.2500E+00	.2500E+00	.0000E+00
AGZ18AHZ18	30.2500E+000.1233E+01	.2500E+00	.0000E+00
AHZ18AIZ18	30.1233E+010.1233E+01	.2500E+00	.0000E+00
AIZ18AJZ18	30.1233E+010.1233E+01	.2500E+00	.0000E+00
AJZ18AKZ18	30.1233E+010.0000E+00	.2500E+00	.0000E+00

An excerpt of the resultant DKM mesh file from the software routine is given below. This excerpted file takes the results of the routine and places them in TOUGH2.INP format, specified by hand by the user (e.g., correct placement of block headers and spaces).

ELEME	1	2	3	4	5	6	7	8
M11 1	tunnm0.1000E+510.2125E-01				0.2125E-010.2500E+00-.2500E+00			
F11 1	tunnf0.1000E+510.2125E-01				0.2125E-010.2500E+00-.2500E+00			
M21 1	inslm0.1000E+510.0000E+00				0.2125E-010.2500E+00-.5381E+00			
F21 1	inslf0.1000E+460.0000E+00				0.2125E-010.2500E+00-.5381E+00			
M31 1	inslm0.1000E+510.0000E+00				0.2125E-010.2500E+00-.6143E+00			
F31 1	inslf0.1000E+460.0000E+00				0.2125E-010.2500E+00-.6143E+00			
M41 1	roccm0.9999E+500.0000E+00				0.2125E-010.2500E+00-.9024E+00			
F41 1	roccf0.1000E+510.0000E+00				0.2125E-010.2500E+00-.9024E+00			
M51 1	roccm0.9999E+500.0000E+00				0.2125E-010.2500E+00-.1402E+01			
F51 1	roccf0.1000E+510.0000E+00				0.2125E-010.2500E+00-.1402E+01			
M61 1	roccm0.9999E+500.0000E+00				0.2125E-010.2500E+00-.1899E+01			
F61 1	roccf0.1000E+510.0000E+00				0.2125E-010.2500E+00-.1899E+01			
M71 1	roccm0.9999E+500.0000E+00				0.2125E-010.2500E+00-.2393E+01			
F71 1	roccf0.1000E+510.0000E+00				0.2125E-010.2500E+00-.2393E+01			
M81 1	roccm0.9999E+500.0000E+00				0.2125E-010.2500E+00-.3140E+01			
F81 1	roccf0.1000E+510.0000E+00				0.2125E-010.2500E+00-.3140E+01			
M91 1	roccm0.9999E+500.0000E+00				0.2125E-010.2500E+00-.4140E+01			
F91 1	roccf0.1000E+510.0000E+00				0.2125E-010.2500E+00-.4140E+01			

MA1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.5140E+01
FA1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.5140E+01
MB1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.6140E+01
FB1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.6140E+01
MC1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.7140E+01
FC1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.7140E+01
MD1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.7890E+01
FD1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.7890E+01
ME1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.8390E+01
FE1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.8390E+01
MF1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.8890E+01
FF1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.8890E+01
MG1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.9390E+01
FG1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.9390E+01
MH1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.1087E+02
FH1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.1087E+02
MI1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.1334E+02
FI1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.1334E+02
MJ1 1	roccm0.9999E+500.0000E+00	0.2125E-010.2500E+00-.1581E+02
FJ1 1	roccf0.1000E+510.0000E+00	0.2125E-010.2500E+00-.1581E+02
MK1 1	roccm0.9999E+500.2125E-01	0.2125E-010.2500E+00-.1729E+02
FK1 1	roccf0.1000E+510.2125E-01	0.2125E-010.2500E+00-.1729E+02
M12 1	tunm0.1000E+510.8611E-01	0.2125E-010.1513E+01-.2500E+00
F12 1	tunf0.1000E+510.8611E-01	0.2125E-010.1513E+01-.2500E+00
M22 1	inslm0.6562E-020.0000E+00	0.2125E-010.1513E+01-.5381E+00
F22 1	inslf0.6562E-070.0000E+00	0.2125E-010.1513E+01-.5381E+00
M32 1	inslm0.6562E-020.0000E+00	0.2125E-010.1513E+01-.6143E+00
F32 1	inslf0.6562E-070.0000E+00	0.2125E-010.1513E+01-.6143E+00
M42 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.9024E+00
F42 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.9024E+00
M52 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.1402E+01
F52 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.1402E+01
M62 1	roccm0.4253E-010.0000E+00	0.2125E-010.1513E+01-.1899E+01
F62 1	roccf0.4254E-010.0000E+00	0.2125E-010.1513E+01-.1899E+01
M72 1	roccm0.4253E-010.0000E+00	0.2125E-010.1513E+01-.2393E+01
F72 1	roccf0.4254E-010.0000E+00	0.2125E-010.1513E+01-.2393E+01
M82 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.3140E+01
F82 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.3140E+01
M92 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.4140E+01
F92 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.4140E+01
MA2 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.5140E+01
FA2 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.5140E+01
MB2 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.6140E+01
FB2 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.6140E+01
MC2 1	roccm0.8610E-010.0000E+00	0.2125E-010.1513E+01-.7140E+01
FC2 1	roccf0.8611E-010.0000E+00	0.2125E-010.1513E+01-.7890E+01
MD2 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.7890E+01
FD2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.8390E+01
ME2 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.8390E+01
FE2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.8890E+01
MF2 1	roccm0.4305E-010.0000E+00	0.2125E-010.1513E+01-.8890E+01
MG2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.9390E+01
FG2 1	roccf0.4306E-010.0000E+00	0.2125E-010.1513E+01-.9390E+01
MH2 1	roccm0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1087E+02
FH2 1	roccf0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1087E+02
MI2 1	roccm0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1334E+02
FI2 1	roccf0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1334E+02
MJ2 1	roccm0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1581E+02
FJ2 1	roccf0.2124E+000.0000E+00	0.2125E-010.1513E+01-.1581E+02
MK2 1	roccm0.9999E+500.8611E-01	0.2125E-010.1513E+01-.1729E+02
FK2 1	roccf0.1000E+510.8611E-01	0.2125E-010.1513E+01-.1729E+02
...		
M1Z 1	tunm0.1000E+510.2125E-01	0.2125E-010.2075E+02-.2500E+00
F1Z 1	tunf0.1000E+510.2125E-01	0.2125E-010.2075E+02-.2500E+00
M2Z 1	inslm0.1000E+510.0000E+00	0.2125E-010.2075E+02-.5381E+00
F2Z 1	inslf0.1000E+460.0000E+00	0.2125E-010.2075E+02-.5381E+00
M3Z 1	inslm0.1000E+510.0000E+00	0.2125E-010.2075E+02-.6143E+00
F3Z 1	inslf0.1000E+460.0000E+00	0.2125E-010.2075E+02-.6143E+00
M4Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.9024E+00

F4Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.9024E+00
M5Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1402E+01
F5Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.1402E+01
M6Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1899E+01
F6Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.1899E+01
M7Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.2393E+01
F7Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.2393E+01
M8Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.3140E+01
F8Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.3140E+01
M9Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.4140E+01
F9Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.4140E+01
MAZ 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.5140E+01
F1Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.5140E+01
M1Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.6140E+01
F2Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.6140E+01
M2Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.7140E+01
F3Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.7140E+01
M3Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.7890E+01
F4Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.7890E+01
M4Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.8390E+01
F5Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.8390E+01
M5Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.8890E+01
F6Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.8890E+01
M6Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.9390E+01
F7Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.9390E+01
M7Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1087E+02
F8Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.1087E+02
M8Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1334E+02
F9Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.1334E+02
MAZ 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1581E+02
F1Z 1	roccf0.1000E+510.0000E+00	0.2125E-010.2075E+02-.1581E+02
M1Z 1	roccm0.9999E+500.0000E+00	0.2125E-010.2075E+02-.1729E+02
F2Z 1	roccf0.1000E+510.2125E-01	0.2125E-010.2075E+02-.1729E+02
M2Z 1	tunm0.1000E+510.4250E-01	0.8500E-010.2500E+00-.2500E+00
F3Z 1	tunf0.1000E+510.4250E-01	0.8500E-010.2500E+00-.2500E+00
M3Z 1	inslm0.1000E+510.0000E+00	0.8500E-010.2500E+00-.5381E+00
F4Z 1	inslf0.1000E+460.0000E+00	0.8500E-010.2500E+00-.5381E+00
M4Z 1	inslm0.1000E+510.0000E+00	0.8500E-010.2500E+00-.6143E+00
F5Z 1	inslf0.1000E+460.0000E+00	0.8500E-010.2500E+00-.6143E+00
M5Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.9024E+00
F6Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.9024E+00
M6Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.1402E+01
F7Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.1402E+01
M7Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.1899E+01
F8Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.1899E+01
M8Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.2393E+01
F9Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.2393E+01
MAZ 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.3140E+01
F1Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.3140E+01
M1Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.4140E+01
F2Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.4140E+01
M2Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.5140E+01
F3Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.5140E+01
M3Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.6140E+01
F4Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.6140E+01
M4Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.7140E+01
F5Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.7140E+01
M5Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.7890E+01
F6Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.7890E+01
M6Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.8390E+01
F7Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.8390E+01
M7Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.8890E+01
F8Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.8890E+01
M8Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.9390E+01
F9Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.9390E+01
MAZ 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.1087E+02
F1Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.1087E+02
M1Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.1334E+02
F2Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.1334E+02
M2Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.1581E+02
F3Z 1	roccf0.1000E+510.0000E+00	0.8500E-010.2500E+00-.1581E+02
M3Z 1	roccm0.9999E+500.0000E+00	0.8500E-010.2500E+00-.1581E+02

MK1 2	roccm0.9999E+500.4250E-01	0.8500E-010.2500E+00-.1729E+02
FK1 2	roccf0.1000E+510.4250E-01	0.8500E-010.2500E+00-.1729E+02
M12 2	tunm0.1000E+510.1722E+00	0.8500E-010.1513E+01-.2500E+00
F12 2	tunnf0.1000E+510.1722E+00	0.8500E-010.1513E+01-.2500E+00
M22 2	inslm0.1312E-010.0000E+00	0.8500E-010.1513E+01-.5381E+00
F22 2	inslf0.1312E-060.0000E+00	0.8500E-010.1513E+01-.5381E+00
M32 2	inslm0.1312E-010.0000E+00	0.8500E-010.1513E+01-.6143E+00
F32 2	inslf0.1312E-060.0000E+00	0.8500E-010.1513E+01-.6143E+00
M42 2	roccm0.8610E-010.0000E+00	0.8500E-010.1513E+01-.9024E+00
F42 2	roccf0.8611E-010.0000E+00	0.8500E-010.1513E+01-.9024E+00
M52 2	roccm0.8610E-010.0000E+00	0.8500E-010.1513E+01-.1402E+01
F52 2	roccf0.8611E-010.0000E+00	0.8500E-010.1513E+01-.1402E+01
M62 2	roccm0.8507E-010.0000E+00	0.8500E-010.1513E+01-.1899E+01
F62 2	roccf0.8508E-010.0000E+00	0.8500E-010.1513E+01-.1899E+01
M72 2	roccm0.8507E-010.0000E+00	0.8500E-010.1513E+01-.2393E+01
F72 2	roccf0.8508E-010.0000E+00	0.8500E-010.1513E+01-.2393E+01
M82 2	roccm0.1722E+000.0000E+00	0.8500E-010.1513E+01-.3140E+01
F82 2	roccf0.1722E+000.0000E+00	0.8500E-010.1513E+01-.3140E+01
M92 2	roccm0.1722E+000.0000E+00	0.8500E-010.1513E+01-.4140E+01
F92 2	roccf0.1722E+000.0000E+00	0.8500E-010.1513E+01-.4140E+01
MA2 2	roccm0.1722E+000.0000E+00	0.8500E-010.1513E+01-.5140E+01
FA2 2	roccf0.1722E+000.0000E+00	0.8500E-010.1513E+01-.5140E+01
MB2 2	roccm0.1722E+000.0000E+00	0.8500E-010.1513E+01-.6140E+01
FB2 2	roccf0.1722E+000.0000E+00	0.8500E-010.1513E+01-.6140E+01
MC2 2	roccm0.1722E+000.0000E+00	0.8500E-010.1513E+01-.7140E+01
FC2 2	roccf0.1722E+000.0000E+00	0.8500E-010.1513E+01-.7140E+01
MD2 2	roccm0.8610E-010.0000E+00	0.8500E-010.1513E+01-.7890E+01
FD2 2	roccf0.8611E-010.0000E+00	0.8500E-010.1513E+01-.7890E+01
ME2 2	roccm0.8610E-010.0000E+00	0.8500E-010.1513E+01-.8390E+01
FE2 2	roccf0.8611E-010.0000E+00	0.8500E-010.1513E+01-.8390E+01
MF2 2	roccm0.8610E-010.0000E+00	0.8500E-010.1513E+01-.8890E+01
FF2 2	roccf0.8611E-010.0000E+00	0.8500E-010.1513E+01-.8890E+01
MG2 2	roccm0.8610E-010.0000E+00	0.8500E-010.1513E+01-.9390E+01
FG2 2	roccf0.8611E-010.0000E+00	0.8500E-010.1513E+01-.9390E+01
MH2 2	roccm0.4247E+000.0000E+00	0.8500E-010.1513E+01-.1087E+02
FH2 2	roccf0.4248E+000.0000E+00	0.8500E-010.1513E+01-.1087E+02
MI2 2	roccm0.4247E+000.0000E+00	0.8500E-010.1513E+01-.1334E+02
FI2 2	roccf0.4248E+000.0000E+00	0.8500E-010.1513E+01-.1334E+02
MJ2 2	roccm0.4247E+000.0000E+00	0.8500E-010.1513E+01-.1581E+02
FJ2 2	roccf0.4248E+000.0000E+00	0.8500E-010.1513E+01-.1581E+02
MK2 2	roccm0.9999E+500.1722E+00	0.8500E-010.1513E+01-.1729E+02
FK2 2	roccf0.1000E+510.1722E+00	0.8500E-010.1513E+01-.1729E+02
...		
MJV18	tunm0.1000E+510.0000E+00	0.6603E+010.1949E+02-.1581E+02
FJV18	tunnf0.1000E+510.0000E+00	0.6603E+010.1949E+02-.1581E+02
MKV18	tunm0.1000E+510.1013E+01	0.6603E+010.1949E+02-.1729E+02
FKV18	tunnf0.1000E+510.1013E+01	0.6603E+010.1949E+02-.1729E+02
M1218	tunm0.1000E+510.2500E+00	0.6603E+010.2075E+02-.2500E+00
F1218	tunnf0.1000E+510.2500E+00	0.6603E+010.2075E+02-.2500E+00
M2218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.5381E+00
F2218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.5381E+00
M3218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.6143E+00
F3218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.6143E+00
M4218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.9024E+00
F4218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.9024E+00
M5218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1402E+01
F5218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1402E+01
M6218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1899E+01
F6218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1899E+01
M7218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.2393E+01
F7218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.2393E+01
M8218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.3140E+01
F8218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.3140E+01
M9218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.4140E+01
F9218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.4140E+01
MA218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.5140E+01
FA218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.5140E+01
MB218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.6140E+01
FB218	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.6140E+01
MC218	tunm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7140E+01

FCZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7140E+01
MDZ18	tunrm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7890E+01
FDZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7890E+01
MEZ18	tunrm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8390E+01
FEZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8390E+01
MFZ18	tunrm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8890E+01
FFZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8890E+01
MGZ18	tunrm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.9390E+01
FGZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.9390E+01
MHZ18	tunrm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1087E+02
FHZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1087E+02
MIZ18	tunrm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1334E+02
FIZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1334E+02
MJZ18	tunrm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1581E+02
FJZ18	tunnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1581E+02
MKZ18	tunrm0.1000E+510.2500E+00	0.6603E+010.2075E+02-.1729E+02
FKZ18	tunnf0.1000E+510.2500E+00	0.6603E+010.2075E+02-.1729E+02

CONN-	1	2	3	4	5	6	7	8
M11 1M11 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F11 1F11 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F11 1M11 1	20.0000E+000.8865E-010.3997E-010.0000E+000.8000E-02							
M11 1M12 1	20.0000E+000.1013E+010.2125E-010.1000E+01							
F11 1F12 1	20.0000E+000.1013E+010.2125E-010.1000E+01							
M11 1M21 1	30.0000E+000.3810E-010.2125E-010.0000E+00							
F11 1F21 1	30.0000E+000.3810E-010.2125E-010.0000E+00							
M21 1M21 2	10.2125E-010.4250E-010.3810E-010.0000E+00							
F21 1F21 2	10.2125E-010.4250E-010.3810E-010.0000E+00							
M21 1M22 1	20.0000E+000.1013E+010.3239E-020.1000E+01							
F21 1F22 1	20.0000E+000.1013E+010.3239E-020.1000E+01							
M21 1M31 1	30.3810E-010.3810E-010.2125E-010.0000E+00							
F21 1F31 1	30.3810E-010.3810E-010.2125E-010.0000E+00							
M31 1M31 2	10.2125E-010.4250E-010.3810E-010.0000E+00							
F31 1F31 2	10.2125E-010.4250E-010.3810E-010.0000E+00							
F31 1M31 1	20.0000E+000.8865E-010.6088E-020.0000E+000.8000E-02							
M31 1M32 1	20.0000E+000.1013E+010.3239E-020.1000E+01							
F31 1F32 1	20.0000E+000.1013E+010.3239E-020.1000E+01							
M31 1M41 1	30.3810E-010.2500E+000.2125E-010.0000E+00							
F31 1F41 1	30.3810E-010.2500E+000.2125E-010.0000E+00							
M41 1M41 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F41 1F41 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F41 1M41 1	20.0000E+000.8865E-010.3997E-010.0000E+000.8000E-02							
M41 1M42 1	20.0000E+000.1013E+010.2125E-010.1000E+01							
F41 1F42 1	20.0000E+000.1013E+010.2125E-010.1000E+01							
M41 1M51 1	30.2500E+000.2500E+000.2125E-010.0000E+00							
F41 1F51 1	30.2500E+000.2500E+000.2125E-010.0000E+00							
M51 1M51 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F51 1F51 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F51 1M51 1	20.0000E+000.8865E-010.3997E-010.0000E+000.8000E-02							
M51 1M52 1	20.0000E+000.1013E+010.2125E-010.1000E+01							
F51 1F52 1	20.0000E+000.1013E+010.2125E-010.1000E+01							
M51 1M61 1	30.2500E+000.2470E+000.2125E-010.0000E+00							
F51 1F61 1	30.2500E+000.2470E+000.2125E-010.0000E+00							
M61 1M61 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F61 1F61 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F61 1M61 1	20.0000E+000.8865E-010.3948E-010.0000E+000.8000E-02							
M61 1M62 1	20.0000E+000.1013E+010.2100E-010.1000E+01							
F61 1F62 1	20.0000E+000.1013E+010.2100E-010.1000E+01							
M61 1M71 1	30.2470E+000.2470E+000.2125E-010.0000E+00							
F61 1F71 1	30.2470E+000.2470E+000.2125E-010.0000E+00							
M71 1M71 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F71 1F71 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F71 1M71 1	20.0000E+000.8865E-010.3948E-010.0000E+000.8000E-02							
M71 1M72 1	20.0000E+000.1013E+010.2100E-010.1000E+01							
F71 1F72 1	20.0000E+000.1013E+010.2100E-010.1000E+01							
M71 1M81 1	30.2470E+000.5000E+000.2125E-010.0000E+00							
F71 1F81 1	30.2470E+000.5000E+000.2125E-010.0000E+00							
M81 1M81 2	10.2125E-010.4250E-010.5000E+000.0000E+00							
F81 1F81 2	10.2125E-010.4250E-010.5000E+000.0000E+00							
F81 1M81 1	20.0000E+000.8865E-010.7990E-010.0000E+000.8000E-02							

```

M81 1M82 1      20. 0000E+000.1013E+010.4250E-010.1000E+01
F81 1F82 1      20. 0000E+000.1013E+010.4250E-010.1000E+01
M81 1M91 1      30. 5000E+000.5000E+000.2125E-010.0000E+00
F81 1F91 1      30. 5000E+000.5000E+000.2125E-010.0000E+00
M91 1M91 2      10. 2125E-010.4250E-010.5000E+000.0000E+00
F91 1F91 2      10. 2125E-010.4250E-010.5000E+000.0000E+00
F91 1M91 1      20. 0000E+000.8865E-010.7990E-010.0000E+000.8000E-02
M91 1M92 1      20. 0000E+000.1013E+010.4250E-010.1000E+01
F91 1F92 1      20. 0000E+000.1013E+010.4250E-010.1000E+01
M91 1MA1 1      30. 5000E+000.5000E+000.2125E-010.0000E+00
F91 1FA1 1      30. 5000E+000.5000E+000.2125E-010.0000E+00
MA1 1MA1 2      10. 2125E-010.4250E-010.5000E+000.0000E+00
FA1 1FA1 2      10. 2125E-010.4250E-010.5000E+000.0000E+00
F91 1MA1 1      20. 0000E+000.8865E-010.7990E-010.0000E+000.8000E-02
MA1 1MA2 1      20. 0000E+000.1013E+010.4250E-010.1000E+01
FA1 1FA2 1      20. 0000E+000.1013E+010.4250E-010.1000E+01

...
M5Z18M6Z18      30. 2500E+000.2470E+000.2500E+000.0000E+00
F5Z18F6Z18      30. 2500E+000.2470E+000.2500E+000.0000E+00
F5Z18M5Z18      20. 0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
M6Z18M7Z18      30. 2470E+000.2470E+000.2500E+000.0000E+00
F6Z18F7Z18      30. 2470E+000.2470E+000.2500E+000.0000E+00
F6Z18M6Z18      20. 0000E+000.8865E-010.4644E+000.0000E+000.8000E-02
M7Z18M8Z18      30. 2470E+000.5000E+000.2500E+000.0000E+00
F7Z18F8Z18      30. 2470E+000.5000E+000.2500E+000.0000E+00
F7Z18M7Z18      20. 0000E+000.8865E-010.4644E+000.0000E+000.8000E-02
M8Z18M9Z18      30. 5000E+000.5000E+000.2500E+000.0000E+00
F8Z18F9Z18      30. 5000E+000.5000E+000.2500E+000.0000E+00
F8Z18M8Z18      20. 0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
M9Z18MAZ18      30. 5000E+000.5000E+000.2500E+000.0000E+00
F9Z18FAZ18      30. 5000E+000.5000E+000.2500E+000.0000E+00
F9Z18M9Z18      20. 0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
MAZ18MBZ18      30. 5000E+000.5000E+000.2500E+000.0000E+00
FAZ18FBZ18      30. 5000E+000.5000E+000.2500E+000.0000E+00
MEZ18MCZ18      30. 5000E+000.5000E+000.2500E+000.0000E+00
FBZ18FCZ18      30. 5000E+000.5000E+000.2500E+000.0000E+00
MCZ18MDZ18      20. 0000E+000.8865E-010.9400E+000.0000E+000.8000E-02
FCZ18FDZ18      30. 5000E+000.8865E-010.9400E+000.0000E+000.8000E-02
FCZ18MCZ18      30. 2500E+000.2500E+000.2500E+000.0000E+00
MDZ18MEZ18      30. 2500E+000.2500E+000.2500E+000.0000E+00
FDZ18FEZ18      30. 2500E+000.2500E+000.2500E+000.0000E+00
FDZ18MDZ18      20. 0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MEZ18MFZ18      30. 2500E+000.2500E+000.2500E+000.0000E+00
FEZ18FFZ18      30. 2500E+000.2500E+000.2500E+000.0000E+00
FEZ18MEZ18      20. 0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MFZ18MGZ18      30. 2500E+000.2500E+000.2500E+000.0000E+00
FFZ18FGZ18      30. 2500E+000.2500E+000.2500E+000.0000E+00
FFZ18MFZ18      20. 0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MGZ18MHZ18      30. 2500E+000.1233E+010.2500E+000.0000E+00
FGZ18FHZ18      30. 2500E+000.1233E+010.2500E+000.0000E+00
FGZ18MGZ18      20. 0000E+000.8865E-010.4700E+000.0000E+000.8000E-02
MHZ18MIZ18      30. 1233E+010.1233E+010.2500E+000.0000E+00
FHZ18FIZ18      30. 1233E+010.1233E+010.2500E+000.0000E+00
FHZ18MHZ18      20. 0000E+000.8865E-010.2319E+010.0000E+000.8000E-02
MIZ18MJZ18      30. 1233E+010.1233E+010.2500E+000.0000E+00
FIZ18FIJZ18      30. 1233E+010.1233E+010.2500E+000.0000E+00
FIZ18MIZ18      20. 0000E+000.8865E-010.2319E+010.0000E+000.8000E-02
MJZ18MKZ18      30. 1233E+010.0000E+000.2500E+000.0000E+00
FJZ18FKZ18      30. 1233E+010.0000E+000.2500E+000.0000E+00
FJZ18MJZ18      20. 0000E+000.8865E-010.2319E+010.0000E+000.8000E-02
FKZ18MKZ18      20. 0000E+000.8865E-010.4700E+000.0000E+000.8000E-02

```

As stated, it is noted that the proper headers required by TOUGH2 must be inserted by the user by hand (ELEM header and one blank space then CONNE header). This excerpt is shown with the user inserted headers in the correct format for a TOUGH2 simulation. A line count is also performed to ensure that the processor processed all lines given in the primary file. The primary

mesh (the input for the processor) contains 12,600 elements and 36,110 connections. The processor output file for the ELEME portion of the mesh file contains $12,600 \times 2 = 25,200$ total elements (12,600 matrix, 12,600 fracture). The CONNE portion contains $36,110 \times 2 + 12,600 = 84,820$ total connections. These are correct so the processor is handling all lines from the primary mesh file.

The routine dkmmesh.f is also used for the median Kb sensitivity study described in the AMR N0000. The software routine used to generate this DKM mesh file is the same as above and the input file names: MESH1.988 and MESH are also the same as above. However, the routine user inputs are specified as the following:

```
What is the name of the input file?
MESH

Enter the dimension N=? of fracture set
N=2 for 1-d, N=4 for 2-d, N=6 for 3-d
2

Enter the fracture spacing in meters
0.1316

Enter the fracture porosity
3.435E-04

Select a f-m connection: c=1, krl=2, other=3
1
enter the constant multiplier
8.E-06
```

With these new user defined routine runtime inputs, the DKM mesh file for the heating median Kb simulation is generated the same as in the previous case.

The range of validity for this routine is flexible. The routine is hardwired for a model domain with 12,600 primary volume, hence this is its applicable range. However, if the following two lines are changed in the routine

```
dimension vol_i(12600)
if (i .eq. 12600) then
```

the range of validity of the routine is changed. The routine is somewhat problem specific in that the "if" statements are looking for material identifiers (ma2 =) 3 and 4 (boundary elements), 2 (heater elements), 5 (insulation elements), or 1 for the interior elements.

The active fracture implementation in the DKM mesh file required slight changes to the DKM mesh generators described above. The following software routines will be discussed and tested: dkmmeshamb_mod_1D.f, dkmmeshamb_mod.f, and dkmmesh_mod.f.

The active fracture model is implemented into the routines described above. The first routine considered is the 1-D column extractor for the active fracture model.

dkmmeshamb_mod_1D.f (Version 1.)

c

```

c      This processor will read the MESH file for the SHT ECM model
c      and transform it into a DKM model.  It is problem specific
c      in that it is looking for certain element indicators such
c      as specific material identifiers. Only one fracture porosity
c      will be input and used to determine the matrix and fracture
c      volumes in the ELEME-The ECM model has 12,600 primary volume elements
c
c      Nick Francis 03/13/98
c      modified on 9/30/99
c
c
c... this is modified for the ambient ECM mesh
c      recall that this processor is problem specific
c      but can be made general by modifying if statments
c      and format print statments
c
c
c      This will implement the LBL fracture-matrix connection area
c      TSPA-SR property set
c
c
c
c
c2345678901234567890123456789012345678901234567890123456789012

```

```

      implicit double precision (a-h,l,o-z)
      character*5 name
      character*5 elnamem
      character*5 elnamef
      character*3 el1
      character*3 ellold
      character*3 el2
      character*3 el2old
      character*3 el
      dimension vol_i(35)

```

```

c... Enter input data such as fracture set dimensions,
c      fractures spacing, fracture porosity
c
      write(*,*) 'What is the name of the input file?'
      read(*, '(a)') infile
      write(*,*)
      write(*,*) 'Enter the dimension N=? of fracture set'
      write(*,*) 'N=2 for 1-d, N=4 for 2-d, N=6 for 3-d'
      read(*,*) xN
      write(*,*)
      write(*,*) 'Enter the fracture spacing in meters'
      read(*,*) D
      write(*,*) 'Enter the fracture-matrix connection area (m^2/m^3)'
      read(*,*) afmc
      write(*,*)

c... compute the nodal distance for the fracture-matrix connection
c... it is based on the dimensionality of the fracture set
c

```

```

        if (xN .eq. 2.) then
            con_dm = D/6.
        elseif (xN .eq. 4. ) then
            con_dm = D/8.
        elseif (xN .eq. 6.) then
            con_dm = D/10.
        else
            write(*,*) 'you have made an error-not valid fracture'
        end if

c
c
c... read in fracture porosity
    write(*,*) 'Enter the fracture porosity'
    read(*,*) phif
    write(*,*)

c... read in the DKM fmx specification
    write (*,*) 'Select a f-m connection: c=1, krl=2, other=3'
    read(*,*) idkfm

c... open up necessary files
    open(9,file='MESH1.988',status='old')
    open(10,file=infile,status='old')
    open(13,file='dkm.mesh',status='unknown')
10    format(a5)
100   format(a3,i2,13x,i2,2E10.4,10x,3E10.4)
101   format(20x,E10.4)
102   format('M',a2,i2,10x,'roccm',2E10.4,10x,3E10.4)
103   format('F',a2,i2,10x,'roccf',2E10.4,10x,3E10.4)
112   format('M',a2,i2,10x,'heatm',2E10.4,10x,3E10.4)
113   format('F',a2,i2,10x,'heatf',2E10.4,10x,3E10.4)
122   format('M',a2,i2,10x,'inslm',2E10.4,10x,3E10.4)
123   format('F',a2,i2,10x,'inslf',2E10.4,10x,3E10.4)
132   format('M',a2,i2,10x,'tunnm',2E10.4,10x,3E10.4)
133   format('F',a2,i2,10x,'tunnf',2E10.4,10x,3E10.4)
142   format('M',a2,i2,10x,'rocbm',2E10.4,10x,3E10.4)
143   format('F',a2,i2,10x,'rocbf',2E10.4,10x,3E10.4)
152   format('M',a2,i2,10x,'roctm',2E10.4,10x,3E10.4)
153   format('F',a2,i2,10x,'roctf',2E10.4,10x,3E10.4)
104   format(a3,i2,a3,i2,15x,i5,4e10.4)
105   format('M',a2,i2,'M',a2,i2,15x,i5,4e10.4)
106   format('F',a2,i2,'F',a2,i2,15x,i5,4e10.4)
107   format('F',a2,i2,'M',a2,i2,15x,i5,5e10.4)

c... determines the fmx type
c
    if( idkfm .eq. 1) then

        write(*,*) 'enter the constant multiplier'
        read(*,*) const
        fmx = const

    elseif ( idkfm .eq. 2) then

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'k_rl weighted connection'
        read(*,*) ckrl

```

```

        fmx = ckrl

    else

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'other weighted connection'
        read(*,*) ckoth
        fmx = ckoth

    end if

c
c
c... store the element volumes from the original mesh
    i=1
1    read(9,10) name
    if (name .ne. 'ELEM') goto 1
32   read(9,101) vol_i(i)
    if (i .eq. 35) then
        goto 2
    else
        i=i+1
        goto 32
    end if

c... work on the ELEM portion of the mesh first
c... begin creating the DKM mesh from the working
c    ECM mesh

2    read(10,10) name
    if (name .ne. 'ELEM') goto 2
33   read(10,100) el, ne,ma2,volx, ahtx,x,y,z
    if (el .eq. ' ') goto 555

        if (ma2 .eq. 4) then

c
c... these are lower boundary rock boundary elements
c    THEY ARE dkm elements
c

c... these are rock boundary elements
c... write the matrix element
        volxm = volx*(1.-phif)
        write(13,142) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
        write(13,143) el(2:3), ne,volx,ahtx,x,y,z

c... These are used in the heating mesh processor
c
c
c... these are the air boundary elements
c
c... write the matrix element
c        volxm = volx*(1.-phif)
c        write(13,132) el(2:3), ne,volxm,ahtx,x,y,z

```

```

c
c... write the fracture element
c
c      write(13,133) el(2:3), ne,volx,ahtx,x,y,z
c
c
c      elseif (ma2 .eq. 5) then
c
c... these are the insulation elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,122) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,123) el(2:3), ne,volx,ahtx,x,y,z
c
c
c      elseif (ma2 .eq. 2) then
c
c... these are the heater elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,112) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,113) el(2:3), ne,volx,ahtx,x,y,z
c
c
c... these were used in the heating processor
c
c      elseif (ma2 .eq. 3) then
c
c
c... these are the upper rock boundary elements
c      THEY ARE dkm elements
c
c
c... these are rock boundary elements
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,152) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c      write(13,153) el(2:3), ne,volx,ahtx,x,y,z
c
c      else
c
c... This are interior rock elements
c      THEY ARE dkm elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)

```

```

        write(13,102) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
        ma2 = 7
        write(13,103) el(2:3), ne,volx,ahtx,x,y,z

        end if

        goto 33

c.... work on the CONNE portion of the mesh next

555  read(10,10) name
        if (name .ne. 'CONNE') goto 555
        i = 1
        icheck=1

44   read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

c... write the matrix-matrix connection
45   write(13,105) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
@    areax,betax
c... write the fracture-fracture connection
        write(13,106) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
@    areax,betax

        if (icheck .eq. 1) then
C... write the fracture-matrix connection
c    the connection area is modified from CKHO ASME paper to the
c    lbl connection area provided in the property sets
c
c    areax = xN*vol_i(i)/D
        areax = afmc*vol_i(i)
        con_df = 0.0
c...select isot=2 since it contains the vertical permeability
        isot=2
        betax=0.0
        write(13,107) el1(2:3),ne1,el1(2:3),ne1,isot,con_df,
@    con_dm,areax,betax,fxm
        i = i+1
        end if

        el1old=el1(1:3)
        el2old=el2(1:3)
        ne2old=ne2
        read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

        if (el1 .eq. ' ') goto 556
        if (el1 .eq. el1old) then
            icheck=2
            goto 45
        else
            icheck=1
            goto 45
        endif

```

```

c      the connection area is modified from CKHO ASME paper to the
c      lbl connection area provided in the property sets
c
c556   areax = xN*vol_i(i)/D
556   areax = afmc*vol_i(i)
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el2old(2:3),ne2old,el2old(2:3),
@      ne2old,isot,con_df,con_dm,areax,betax,fxm

      close(12)
      close(13)
      stop
      end

```

This software routine creates the ambient DKM mesh file for a 1-D column extracted from the larger 3-D SHT model domain. It is used to provide the ambient initialization of the 3-D SHT model domain top and bottom boundary conditions.

The primary input files are analogous to the larger SHT files already described, (just a single column taken from the bigger model). Since this is such a small primary, the initial primary mesh file (file name: MESH1.988) obtained from the meshmaker option in TOUGH2 is hand modified to give the other required input file (file name: mesh). The files are the following (in their entirety). First, the file name: MESH1.988:

ELEME			
A11 1	10.5000E+000.1000E+01	0.5000E+000.2500E+00-	.5000E+00
A12 1	10.2026E+010.4052E+01	0.5000E+000.1513E+01-	.5000E+00
A13 1	10.2026E+010.4052E+01	0.5000E+000.3539E+01-	.5000E+00
A14 1	10.2026E+010.4052E+01	0.5000E+000.5565E+01-	.5000E+00
A15 1	10.1500E+010.3000E+01	0.5000E+000.7329E+01-	.5000E+00
A16 1	10.7500E+000.1500E+01	0.5000E+000.8454E+01-	.5000E+00
A17 1	10.2000E+000.4000E+00	0.5000E+000.8929E+01-	.5000E+00
A18 1	10.2000E+000.4000E+00	0.5000E+000.9129E+01-	.5000E+00
A19 1	10.2000E+000.4000E+00	0.5000E+000.9329E+01-	.5000E+00
A1A 1	10.2000E+000.4000E+00	0.5000E+000.9529E+01-	.5000E+00
A1B 1	10.2000E+000.4000E+00	0.5000E+000.9729E+01-	.5000E+00
A1C 1	10.1250E+000.2500E+00	0.5000E+000.9891E+01-	.5000E+00
A1D 1	10.1250E+000.2500E+00	0.5000E+000.1002E+02-	.5000E+00
A1E 1	10.1250E+000.2500E+00	0.5000E+000.1014E+02-	.5000E+00
A1F 1	10.8500E-010.1700E+00	0.5000E+000.1025E+02-	.5000E+00
A1G 1	10.8500E-010.1700E+00	0.5000E+000.1033E+02-	.5000E+00
A1H 1	10.8500E-010.1700E+00	0.5000E+000.1042E+02-	.5000E+00
A1I 1	10.8500E-010.1700E+00	0.5000E+000.1050E+02-	.5000E+00
A1J 1	10.8500E-010.1700E+00	0.5000E+000.1059E+02-	.5000E+00
A1K 1	10.8500E-010.1700E+00	0.5000E+000.1067E+02-	.5000E+00
A1L 1	10.8500E-010.1700E+00	0.5000E+000.1076E+02-	.5000E+00
A1M 1	10.1250E+000.2500E+00	0.5000E+000.1086E+02-	.5000E+00
A1N 1	10.1250E+000.2500E+00	0.5000E+000.1099E+02-	.5000E+00
A1O 1	10.1250E+000.2500E+00	0.5000E+000.1111E+02-	.5000E+00
A1P 1	10.2000E+000.4000E+00	0.5000E+000.1127E+02-	.5000E+00
A1Q 1	10.2000E+000.4000E+00	0.5000E+000.1147E+02-	.5000E+00
A1R 1	10.2000E+000.4000E+00	0.5000E+000.1167E+02-	.5000E+00
A1S 1	10.2000E+000.4000E+00	0.5000E+000.1187E+02-	.5000E+00
A1T 1	10.2000E+000.4000E+00	0.5000E+000.1207E+02-	.5000E+00
A1U 1	10.7500E+000.1500E+01	0.5000E+000.1255E+02-	.5000E+00
A1V 1	10.1500E+010.3000E+01	0.5000E+000.1367E+02-	.5000E+00

AIW 1	10.2026E+010.4052E+01	0.5000E+000.1544E+02-.5000E+00
AIx 1	10.2026E+010.4052E+01	0.5000E+000.1746E+02-.5000E+00
AIY 1	10.2026E+010.4052E+01	0.5000E+000.1949E+02-.5000E+00
AIz 1	10.5000E+000.1000E+01	0.5000E+000.2075E+02-.5000E+00

CONNE		
AI1 1AI2 1	20.2500E+000.1013E+010.1000E+010.1000E+01	
AI2 1AI3 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
AI3 1AI4 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
AI4 1AI5 1	20.1013E+010.7500E+000.1000E+010.1000E+01	
AI5 1AI6 1	20.7500E+000.3750E+000.1000E+010.1000E+01	
AI6 1AI7 1	20.3750E+000.1000E+000.1000E+010.1000E+01	
AI7 1AI8 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AI8 1AI9 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AI9 1AIa 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AIa 1AIb 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AIb 1AIc 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AIc 1AId 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
AId 1AIe 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
AIe 1AIf 1	20.6250E+010.4250E+010.1000E+010.1000E+01	
AIf 1AIg 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
AIg 1AIh 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
AIh 1AIi 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
AIi 1AIj 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
AIj 1AIk 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
AIk 1AIL 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
AIL 1AIM 1	20.4250E+010.6250E+010.1000E+010.1000E+01	
AIM 1AIN 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
AIN 1AIO 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
AIO 1AIP 1	20.6250E+010.1000E+000.1000E+010.1000E+01	
AIP 1AIQ 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AIQ 1AIR 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AIR 1AIS 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AIS 1AIT 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
AIT 1AIU 1	20.1000E+000.3750E+000.1000E+010.1000E+01	
AIU 1AIV 1	20.3750E+000.7500E+000.1000E+010.1000E+01	
AIv 1AIW 1	20.7500E+000.1013E+010.1000E+010.1000E+01	
AIW 1AIX 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
AIX 1AIY 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
AIY 1AIz 1	20.1013E+010.2500E+000.1000E+010.1000E+01	

The hand modified version (file name: mesh) of this file is:

ELEME		
AI1 1	30.5000E+000.1000E+01	0.5000E+000.2500E+00-.5000E+00
AI2 1	10.2026E+010.4052E+01	0.5000E+000.1513E+01-.5000E+00
AI3 1	10.2026E+010.4052E+01	0.5000E+000.3539E+01-.5000E+00
AI4 1	10.2026E+010.4052E+01	0.5000E+000.5565E+01-.5000E+00
AI5 1	10.1500E+010.3000E+01	0.5000E+000.7329E+01-.5000E+00
AI6 1	10.7500E+000.1500E+01	0.5000E+000.8454E+01-.5000E+00
AI7 1	10.2000E+000.4000E+00	0.5000E+000.8929E+01-.5000E+00
AI8 1	10.2000E+000.4000E+00	0.5000E+000.9129E+01-.5000E+00
AI9 1	10.2000E+000.4000E+00	0.5000E+000.9329E+01-.5000E+00
AIa 1	10.2000E+000.4000E+00	0.5000E+000.9529E+01-.5000E+00
AIb 1	10.2000E+000.4000E+00	0.5000E+000.9729E+01-.5000E+00
AIc 1	10.1250E+000.2500E+00	0.5000E+000.1014E+02-.5000E+00
AId 1	10.1250E+000.2500E+00	0.5000E+000.1014E+02-.5000E+00
AIE 1	10.1250E+000.2500E+00	0.5000E+000.1025E+02-.5000E+00
AIf 1	10.8500E+010.1700E+00	0.5000E+000.1033E+02-.5000E+00
AIg 1	10.8500E+010.1700E+00	0.5000E+000.1042E+02-.5000E+00
AIH 1	10.8500E+010.1700E+00	0.5000E+000.1050E+02-.5000E+00
AII 1	10.8500E+010.1700E+00	0.5000E+000.1059E+02-.5000E+00
AIJ 1	10.8500E+010.1700E+00	0.5000E+000.1067E+02-.5000E+00
AIK 1	10.8500E+010.1700E+00	0.5000E+000.1076E+02-.5000E+00
AIL 1	10.8500E+010.1700E+00	0.5000E+000.1086E+02-.5000E+00
AIM 1	10.1250E+000.2500E+00	0.5000E+000.1099E+02-.5000E+00
AIN 1	10.1250E+000.2500E+00	0.5000E+000.1111E+02-.5000E+00
AIO 1	10.2000E+000.4000E+00	0.5000E+000.1127E+02-.5000E+00

```

A1Q 1      10.2000E+000.4000E+00      0.5000E+000.1147E+02-.5000E+00
A1R 1      10.2000E+000.4000E+00      0.5000E+000.1167E+02-.5000E+00
A1S 1      10.2000E+000.4000E+00      0.5000E+000.1187E+02-.5000E+00
A1T 1      10.2000E+000.4000E+00      0.5000E+000.1207E+02-.5000E+00
A1U 1      10.7500E+000.1500E+01      0.5000E+000.1255E+02-.5000E+00
A1V 1      10.1500E+010.3000E+01      0.5000E+000.1367E+02-.5000E+00
A1W 1      10.2026E+010.4052E+01      0.5000E+000.1544E+02-.5000E+00
A1X 1      10.2026E+010.4052E+01      0.5000E+000.1746E+02-.5000E+00
A1Y 1      10.2026E+010.4052E+01      0.5000E+000.1949E+02-.5000E+00
A1Z 1      4      1.0E+500.1000E+01      0.5000E+000.2075E+02-.5000E+00

```

```

CONNE
A11 1A12 1      20.2500E+000.1013E+010.1000E+010.1000E+010.1000E+01
A12 1A13 1      20.1013E+010.1013E+010.1000E+010.1000E+010.1000E+01
A13 1A14 1      20.1013E+010.1013E+010.1000E+010.1000E+010.1000E+01
A14 1A15 1      20.1013E+010.7500E+000.1000E+010.1000E+010.1000E+01
A15 1A16 1      20.7500E+000.3750E+000.1000E+010.1000E+010.1000E+01
A16 1A17 1      20.3750E+000.1000E+000.1000E+010.1000E+010.1000E+01
A17 1A18 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A18 1A19 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A19 1A1A 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A1A 1A1B 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A1B 1A1C 1      20.1000E+000.6250E-010.1000E+010.1000E+010.1000E+01
A1C 1A1D 1      20.6250E-010.6250E-010.1000E+010.1000E+010.1000E+01
A1D 1A1E 1      20.6250E-010.6250E-010.1000E+010.1000E+010.1000E+01
A1E 1A1F 1      20.6250E-010.4250E-010.1000E+010.1000E+010.1000E+01
A1F 1A1G 1      20.4250E-010.4250E-010.1000E+010.1000E+010.1000E+01
A1G 1A1H 1      20.4250E-010.4250E-010.1000E+010.1000E+010.1000E+01
A1H 1A1I 1      20.4250E-010.4250E-010.1000E+010.1000E+010.1000E+01
A1I 1A1J 1      20.4250E-010.4250E-010.1000E+010.1000E+010.1000E+01
A1J 1A1K 1      20.4250E-010.4250E-010.1000E+010.1000E+010.1000E+01
A1K 1A1L 1      20.4250E-010.4250E-010.1000E+010.1000E+010.1000E+01
A1L 1A1M 1      20.4250E-010.6250E-010.1000E+010.1000E+010.1000E+01
A1M 1A1N 1      20.6250E-010.6250E-010.1000E+010.1000E+010.1000E+01
A1N 1A1O 1      20.6250E-010.6250E-010.1000E+010.1000E+010.1000E+01
A1O 1A1P 1      20.6250E-010.1000E+000.1000E+010.1000E+010.1000E+01
A1P 1A1Q 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A1Q 1A1R 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A1R 1A1S 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A1S 1A1T 1      20.1000E+000.1000E+000.1000E+010.1000E+010.1000E+01
A1T 1A1U 1      20.3750E+000.7500E+000.1000E+010.1000E+010.1000E+01
A1U 1A1V 1      20.1000E+000.3750E+000.1000E+010.1000E+010.1000E+01
A1V 1A1W 1      20.7500E+000.1013E+010.1000E+010.1000E+010.1000E+01
A1W 1A1X 1      20.1013E+010.1013E+010.1000E+010.1000E+010.1000E+01
A1X 1A1Y 1      20.1013E+010.1013E+010.1000E+010.1000E+010.1000E+01
A1Y 1A1Z 1      20.1013E+010.2500E+000.1000E+010.1000E+010.1000E+01

```

The routine requires runtime input from the user. The input responses are:

What is the name of the input file?
mesh

Enter the dimension N=? of fracture set
N=2 for 1-d, N=4 for 2-d, N=6 for 3-d
2

Enter the fracture spacing in meters
0.2315
Enter the fracture-matrix connection area (m²/m³)
13.53

Enter the fracture porosity
1.E-02

Select a f-m connection: c=1, krl=2, other=3
1
enter the constant multiplier
10.41

The resultant file from the routine is the following (in its entirety):

```
M11 1 roctm0.4950E+000.1000E+01
F11 1 roctf0.5000E+000.1000E+01
M12 1 roccm0.2006E+010.4052E+01
F12 1 roccf0.2026E+010.4052E+01
M13 1 roccm0.2006E+010.4052E+01
F13 1 roccf0.2026E+010.4052E+01
M14 1 roccm0.2006E+010.4052E+01
F14 1 roccf0.2026E+010.4052E+01
M15 1 roccm0.1485E+010.3000E+01
F15 1 roccf0.1500E+010.3000E+01
M16 1 roccm0.7425E+000.1500E+01
F16 1 roccf0.7500E+000.1500E+01
M17 1 roccm0.1980E+000.4000E+00
F17 1 roccf0.2000E+000.4000E+00
M18 1 roccm0.1980E+000.4000E+00
F18 1 roccf0.2000E+000.4000E+00
M19 1 roccm0.1980E+000.4000E+00
F19 1 roccf0.2000E+000.4000E+00
M1A 1 roccm0.1980E+000.4000E+00
F1A 1 roccf0.2000E+000.4000E+00
M1B 1 roccm0.1980E+000.4000E+00
F1B 1 roccf0.2000E+000.4000E+00
M1C 1 roccm0.1237E+000.2500E+00
F1C 1 roccf0.1250E+000.2500E+00
M1D 1 roccm0.1237E+000.2500E+00
F1D 1 roccf0.1250E+000.2500E+00
M1E 1 roccm0.1237E+000.2500E+00
F1E 1 roccf0.1250E+000.2500E+00
M1F 1 roccm0.8415E-010.1700E+00
F1F 1 roccf0.8500E-010.1700E+00
M1G 1 roccm0.8415E-010.1700E+00
F1G 1 roccf0.8500E-010.1700E+00
M1H 1 roccm0.8415E-010.1700E+00
F1H 1 roccf0.8500E-010.1700E+00
M1I 1 roccm0.8415E-010.1700E+00
F1I 1 roccf0.8500E-010.1700E+00
M1J 1 roccm0.8415E-010.1700E+00
F1J 1 roccf0.8500E-010.1700E+00
M1K 1 roccm0.8415E-010.1700E+00
F1K 1 roccf0.8500E-010.1700E+00
M1L 1 roccm0.8415E-010.1700E+00
F1L 1 roccf0.8500E-010.1700E+00
M1M 1 roccm0.1237E+000.2500E+00
F1M 1 roccf0.1250E+000.2500E+00
M1N 1 roccm0.1237E+000.2500E+00
F1N 1 roccf0.1250E+000.2500E+00
M1O 1 roccm0.1237E+000.2500E+00
F1O 1 roccf0.1250E+000.2500E+00
M1P 1 roccm0.1980E+000.4000E+00
F1P 1 roccf0.2000E+000.4000E+00
M1Q 1 roccm0.1980E+000.4000E+00
F1Q 1 roccf0.2000E+000.4000E+00
M1R 1 roccm0.1980E+000.4000E+00
F1R 1 roccf0.2000E+000.4000E+00
M1S 1 roccm0.1980E+000.4000E+00
F1S 1 roccf0.2000E+000.4000E+00
M1T 1 roccm0.1980E+000.4000E+00
F1T 1 roccf0.2000E+000.4000E+00
M1U 1 roccm0.7425E+000.1500E+01
F1U 1 roccf0.7500E+000.1500E+01
M1V 1 roccm0.1485E+010.3000E+01
F1V 1 roccf0.1500E+010.3000E+01
M1W 1 roccm0.2006E+010.4052E+01
F1W 1 roccf0.2026E+010.4052E+01
M1X 1 roccm0.2006E+010.4052E+01
F1X 1 roccf0.2026E+010.4052E+01
0.5000E+000.2500E+00-.5000E+00
0.5000E+000.2500E+00-.5000E+00
0.5000E+000.1513E+01-.5000E+00
0.5000E+000.1513E+01-.5000E+00
0.5000E+000.3539E+01-.5000E+00
0.5000E+000.3539E+01-.5000E+00
0.5000E+000.5565E+01-.5000E+00
0.5000E+000.5565E+01-.5000E+00
0.5000E+000.7329E+01-.5000E+00
0.5000E+000.7329E+01-.5000E+00
0.5000E+000.8454E+01-.5000E+00
0.5000E+000.8454E+01-.5000E+00
0.5000E+000.8929E+01-.5000E+00
0.5000E+000.8929E+01-.5000E+00
0.5000E+000.9129E+01-.5000E+00
0.5000E+000.9129E+01-.5000E+00
0.5000E+000.9329E+01-.5000E+00
0.5000E+000.9329E+01-.5000E+00
0.5000E+000.9529E+01-.5000E+00
0.5000E+000.9529E+01-.5000E+00
0.5000E+000.9729E+01-.5000E+00
0.5000E+000.9729E+01-.5000E+00
0.5000E+000.9891E+01-.5000E+00
0.5000E+000.9891E+01-.5000E+00
0.5000E+000.1002E+02-.5000E+00
0.5000E+000.1002E+02-.5000E+00
0.5000E+000.1014E+02-.5000E+00
0.5000E+000.1014E+02-.5000E+00
0.5000E+000.1025E+02-.5000E+00
0.5000E+000.1025E+02-.5000E+00
0.5000E+000.1033E+02-.5000E+00
0.5000E+000.1033E+02-.5000E+00
0.5000E+000.1042E+02-.5000E+00
0.5000E+000.1042E+02-.5000E+00
0.5000E+000.1050E+02-.5000E+00
0.5000E+000.1050E+02-.5000E+00
0.5000E+000.1059E+02-.5000E+00
0.5000E+000.1059E+02-.5000E+00
0.5000E+000.1067E+02-.5000E+00
0.5000E+000.1067E+02-.5000E+00
0.5000E+000.1076E+02-.5000E+00
0.5000E+000.1076E+02-.5000E+00
0.5000E+000.1086E+02-.5000E+00
0.5000E+000.1086E+02-.5000E+00
0.5000E+000.1099E+02-.5000E+00
0.5000E+000.1099E+02-.5000E+00
0.5000E+000.1111E+02-.5000E+00
0.5000E+000.1111E+02-.5000E+00
0.5000E+000.1127E+02-.5000E+00
0.5000E+000.1127E+02-.5000E+00
0.5000E+000.1147E+02-.5000E+00
0.5000E+000.1147E+02-.5000E+00
0.5000E+000.1167E+02-.5000E+00
0.5000E+000.1167E+02-.5000E+00
0.5000E+000.1187E+02-.5000E+00
0.5000E+000.1187E+02-.5000E+00
0.5000E+000.1207E+02-.5000E+00
0.5000E+000.1207E+02-.5000E+00
0.5000E+000.1255E+02-.5000E+00
0.5000E+000.1255E+02-.5000E+00
0.5000E+000.1255E+02-.5000E+00
0.5000E+000.1367E+02-.5000E+00
0.5000E+000.1367E+02-.5000E+00
0.5000E+000.1544E+02-.5000E+00
0.5000E+000.1544E+02-.5000E+00
0.5000E+000.1746E+02-.5000E+00
0.5000E+000.1746E+02-.5000E+00
```

M1Y 1	rocCm0.2006E+010.4052E+01	0.5000E+000.1949E+02-.5000E+00
F1Y 1	rocCf0.2026E+010.4052E+01	0.5000E+000.1949E+02-.5000E+00
M1Z 1	rocBm0.9900E+500.1000E+01	0.5000E+000.2075E+02-.5000E+00
F1Z 1	rocBf0.1000E+510.1000E+01	0.5000E+000.2075E+02-.5000E+00
M11 1M12 1	20.2500E+000.1013E+010.1000E+010.1000E+01	
F11 1F12 1	20.2500E+000.1013E+010.1000E+010.1000E+01	
F11 1M11 1	20.0000E+000.3858E+010.6765E+010.0000E+000.1041E+02	
M12 1M13 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
F12 1F13 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
F12 1M12 1	20.0000E+000.3858E+010.2741E+020.0000E+000.1041E+02	
M13 1M14 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
F13 1F14 1	20.1013E+010.1013E+010.1000E+010.1000E+01	
F13 1M13 1	20.0000E+000.3858E+010.2741E+020.0000E+000.1041E+02	
M14 1M15 1	20.1013E+010.7500E+000.1000E+010.1000E+01	
F14 1F15 1	20.1013E+010.7500E+000.1000E+010.1000E+01	
F14 1M14 1	20.0000E+000.3858E+010.2741E+020.0000E+000.1041E+02	
M15 1M16 1	20.7500E+000.3750E+000.1000E+010.1000E+01	
F15 1F16 1	20.7500E+000.3750E+000.1000E+010.1000E+01	
F15 1M15 1	20.0000E+000.3858E+010.2029E+020.0000E+000.1041E+02	
M16 1M17 1	20.3750E+000.1000E+000.1000E+010.1000E+01	
F16 1F17 1	20.3750E+000.1000E+000.1000E+010.1000E+01	
F16 1M16 1	20.0000E+000.3858E+010.1015E+020.0000E+000.1041E+02	
M17 1M18 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F17 1F18 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F17 1M17 1	20.0000E+000.3858E+010.2706E+010.0000E+000.1041E+02	
M18 1M19 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F18 1F19 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F18 1M18 1	20.0000E+000.3858E+010.2706E+010.0000E+000.1041E+02	
M19 1M1A 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F19 1F1A 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F19 1M19 1	20.0000E+000.3858E+010.2706E+010.0000E+000.1041E+02	
M1A 1M1B 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F1A 1F1B 1	20.1000E+000.1000E+000.1000E+010.1000E+01	
F1A 1M1A 1	20.0000E+000.3858E+010.2706E+010.0000E+000.1041E+02	
M1B 1M1C 1	20.1000E+000.6250E+010.1000E+010.1000E+01	
F1B 1F1C 1	20.1000E+000.6250E+010.1000E+010.1000E+01	
F1B 1M1B 1	20.0000E+000.3858E+010.2706E+010.0000E+000.1041E+02	
M1C 1M1D 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
F1C 1F1D 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
F1C 1M1C 1	20.0000E+000.3858E+010.1691E+010.0000E+000.1041E+02	
M1D 1M1E 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
F1D 1F1E 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
F1D 1M1D 1	20.0000E+000.3858E+010.1691E+010.0000E+000.1041E+02	
M1E 1M1F 1	20.6250E+010.4250E+010.1000E+010.1000E+01	
F1E 1F1F 1	20.6250E+010.4250E+010.1000E+010.1000E+01	
F1E 1M1E 1	20.0000E+000.3858E+010.1691E+010.0000E+000.1041E+02	
M1F 1M1G 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1F 1F1G 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1F 1M1F 1	20.0000E+000.3858E+010.1150E+010.0000E+000.1041E+02	
M1G 1M1H 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1G 1F1H 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1G 1M1G 1	20.0000E+000.3858E+010.1150E+010.0000E+000.1041E+02	
M1H 1M1I 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1H 1F1I 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1H 1M1H 1	20.0000E+000.3858E+010.1150E+010.0000E+000.1041E+02	
M1I 1M1J 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1I 1F1J 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1I 1M1I 1	20.0000E+000.3858E+010.1150E+010.0000E+000.1041E+02	
M1J 1M1K 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1J 1F1K 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1J 1M1J 1	20.0000E+000.3858E+010.1150E+010.0000E+000.1041E+02	
M1K 1M1L 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1K 1F1L 1	20.4250E+010.4250E+010.1000E+010.1000E+01	
F1K 1M1K 1	20.0000E+000.3858E+010.1150E+010.0000E+000.1041E+02	
M1L 1M1M 1	20.4250E+010.6250E+010.1000E+010.1000E+01	
F1L 1F1M 1	20.4250E+010.6250E+010.1000E+010.1000E+01	
F1L 1M1L 1	20.0000E+000.3858E+010.1150E+010.0000E+000.1041E+02	
M1M 1M1N 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
F1M 1F1N 1	20.6250E+010.6250E+010.1000E+010.1000E+01	
F1M 1M1M 1	20.0000E+000.3858E+010.1691E+010.0000E+000.1041E+02	
M1N 1M1O 1	20.6250E+010.6250E+010.1000E+010.1000E+01	

F1N 1F1O 1	20.6250E-010.6250E-010.1000E+010.1000E+01
F1N 1M1N 1	20.0000E+000. 3858E-010.1691E+010.0000E+000.1041E+02
M1O 1M1P 1	20.6250E-010.1000E+000.1000E+010.1000E+01
F1O 1F1P 1	20.6250E-010.1000E+000.1000E+010.1000E+01
F1O 1M1O 1	20.0000E+000.3858E-010.1691E+010.0000E+000. 1041E+02
M1P 1M1Q 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1P 1F1Q 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1P 1M1P 1	20.0000E+000.3858E-010.2706E+010.0000E+000. 1041E+02
M1Q 1M1R 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1Q 1F1R 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1Q 1M1Q 1	20.0000E+000.3858E-010.2706E+010.0000E+000. 1041E+02
M1R 1M1S 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1R 1F1S 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1R 1M1R 1	20.0000E+000.3858E-010.2706E+010.0000E+000. 1041E+02
M1S 1M1T 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1S 1F1T 1	20.1000E+000.1000E+000.1000E+010.1000E+01
F1S 1M1S 1	20.0000E+000.3858E-010.2706E+010.0000E+000. 1041E+02
M1T 1M1U 1	20.1000E+000.3750E+000.1000E+010.1000E+01
F1T 1F1U 1	20.1000E+000.3750E+000.1000E+010.1000E+01
F1T 1M1T 1	20.0000E+000.3858E-010.2706E+010.0000E+000. 1041E+02
M1U 1M1V 1	20.3750E+000.7500E+000.1000E+010.1000E+01
F1U 1F1V 1	20.3750E+000.7500E+000.1000E+010.1000E+01
F1U 1M1U 1	20.0000E+000.3858E-010.1015E+020.0000E+000. 1041E+02
M1V 1M1W 1	20.7500E+000.1013E+010.1000E+010.1000E+01
F1V 1F1W 1	20.7500E+000.1013E+010.1000E+010.1000E+01
F1V 1M1V 1	20.0000E+000.3858E-010.2029E+020.0000E+000. 1041E+02
M1W 1M1X 1	20.1013E+010.1013E+010.1000E+010.1000E+01
F1W 1F1X 1	20.1013E+010.1013E+010.1000E+010.1000E+01
F1W 1M1W 1	20.0000E+000.3858E-010.2741E+020.0000E+000. 1041E+02
M1X 1M1Y 1	20.1013E+010.1013E+010.1000E+010.1000E+01
F1X 1F1Y 1	20.1013E+010.1013E+010.1000E+010.1000E+01
F1X 1M1X 1	20.0000E+000.3858E-010.2741E+020.0000E+000. 1041E+02
M1Y 1M1Z 1	20.1013E+010.2500E+000.1000E+010.1000E+01
F1Y 1F1Z 1	20.1013E+010.2500E+000.1000E+010.1000E+01
F1Y 1M1Y 1	20.0000E+000.3858E-010.2741E+020.0000E+000. 1041E+02
F1Z 1M1Z 1	20.0000E+000.3858E-010.6765E+010.0000E+000. 1041E+02

It is noted from this output result that headers required in a TOUGH2 simulation are not placed by the routine. The user must insert them by hand based on the correct format required by TOUGH2. This applies the active fracture model (AFM) in a DKM format. Since this is the case, minor modifications were required in the routines previously discussed for a standard (non-AFM) DKM. In particular, the active fracture parameter gamma and new formula for computing the interface area between matrix and fracture were implemented in this routine.

The modifications are the following:

- (1) The active fracture parameter gamma is input into the location that the fmx was previously input. The format for this input is 10 + gamma parameter (e.g., in the sample output file above, this is 10 + 0.41 = 0.1041E+02).
- (2) The matrix-fracture interaction area is computed as:

$$A = afmc \times V$$

The spot checking is as follows for elements M1N 1 and F1N 1 (created from A1N 1 located in the initial primary mesh). The gamma parameter is implemented as noted in the bold in the last column of the output file. The interface area is spot checked as the following:

$$A = 13.53 \text{ m}^2/\text{m}^3 \times 0.125 \text{ m}^3 = 1.691 \text{ m}^2$$

The connection distance is calculated as before ($D/6 = 0.2315 \text{ m}/6 = 0.03858 \text{ m}$). The routine is computing the active fracture parameters correctly. Also, check the line count. The primary mesh contains 35 volume elements. The processor generated number of volume elements is $35 \times 2 = 70$. The primary mesh contains 34 connections. The processor generated connections are $2 \times 34 + 35 = 103$. The line count is correct as well. Therefore, the processor is reading each line in the primary mesh. The 3-D ambient and heating DKM mesh generators for the AFM apply each of the routine processes applied in the software routines previously discussed. Since this is the case, an abbreviated spot check is performed for the remaining mesh generators.

dkmmeshamb_mod.f (Version 2.)

Since the AFM version of the ambient initialization uses the steady state solutions from the 1-D equilibrations that result from the routine just described, the top boundary is fixed in the larger 3-D ambient initializations. The routine is the following:

```

c
c      This processor will read the MESH file for the SHT ECM model
c      and transform it into a DKM model.  It is problem specific
c      in that it is looking for certain element indicators such
c      as specific material identifiers. Only one fracture porosity
c      will be input and used to determine the matrix and fracture
c      volumes in the ELEME-The ECM model has 12,600 primary volume elements
c
c      Nick Francis 03/13/98
c      modified on 11/14/99
c
c
c... this is modified for the ambient ECM mesh
c      recall that this processor is problem specific
c      but can be made general by modifying if statments
c      and format print statments
c
c
c      This will implement the LBL fracture-matrix connection area
c      TSPA-SR property set
c
c
c
c
c23456789012345678901234567890123456789012345678901234567890123456789012
c
c      implicit double precision (a-h,l,o-z)
c      character*5 name
c      character*5 elnamem
c      character*5 elnamef
c      character*3 el1
c      character*3 el1old
c      character*3 el2
c      character*3 el2old
c      character*3 el
c      dimension vol_i(12600)
c
c... Enter input data such as fracture set dimensions,

```

```

c   fractures spacing, fracture porosity
c
write(*,*) 'What is the name of the input file?'
read(*, '(a)') infile
write(*,*)
write(*,*) 'Enter the dimension N=? of fracture set'
write(*,*) 'N=2 for 1-d, N=4 for 2-d, N=6 for 3-d'
read(*,*) xN
write(*,*)
write(*,*) 'Enter the fracture spacing in meters'
read(*,*) D
write(*,*) 'Enter the fracture-matrix connection area (m^2/m^3)'
read(*,*) afmc
write(*,*)

c... compute the nodal distance for the fracture-matrix connection
c... it is based on the dimensionality of the fracture set
c
      if (xN .eq. 2.) then
        con_dm = D/6.
      elseif (xN .eq. 4. ) then
        con_dm = D/8.
      elseif (xN .eq. 6.) then
        con_dm = D/10.
      else
        write(*,*) 'you have made an error-not valid fracture'
      end if

c
c
c... read in fracture porosity
write(*,*) 'Enter the fracture porosity'
read(*,*) phif
write(*,*)

c... read in the DKM fmx specification
write(*,*) 'Select a f-m connection: c=1, krl=2, other=3'
read(*,*) idkfm

c... open up necessary files
open(9,file='MESH1.988',status='old')
open(10,file=infile,status='old')
open(13,file='dkm.mesh',status='unknown')

10  format(a5)
100 format(a3,i2,13x,i2,2E10.4,10x,3E10.4)
101 format(20x,E10.4)
102 format('M',a2,i2,10x,'roccm',2E10.4,10x,3E10.4)
103 format('F',a2,i2,10x,'roccf',2E10.4,10x,3E10.4)
112 format('M',a2,i2,10x,'heatm',2E10.4,10x,3E10.4)
113 format('F',a2,i2,10x,'heatf',2E10.4,10x,3E10.4)
122 format('M',a2,i2,10x,'inslm',2E10.4,10x,3E10.4)
123 format('F',a2,i2,10x,'inslf',2E10.4,10x,3E10.4)
132 format('M',a2,i2,10x,'tunnm',2E10.4,10x,3E10.4)
133 format('F',a2,i2,10x,'tunnf',2E10.4,10x,3E10.4)
142 format('M',a2,i2,10x,'rocbm',2E10.4,10x,3E10.4)
143 format('F',a2,i2,10x,'rocbf',2E10.4,10x,3E10.4)
152 format('M',a2,i2,10x,'roctm',2E10.4,10x,3E10.4)

```

```

153  format('F',a2,i2,10x,'roctf',2E10.4,10x,3E10.4)
104  format(a3,i2,a3,i2,15x,i5,4e10.4)
105  format('M',a2,i2,'M',a2,i2,15x,i5,4e10.4)
106  format('F',a2,i2,'F',a2,i2,15x,i5,4e10.4)
107  format('F',a2,i2,'M',a2,i2,15x,i5,5e10.4)

c... determines the fmx type
c
    if( idkfm .eq. 1) then

        write(*,*) 'enter the constant multiplier'
        read(*,*) const
        fmx = const

    elseif ( idkfm .eq. 2) then

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'k_rl weighted connection'
        read(*,*) ckrl
        fmx = ckrl

    else

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'other weighted connection'
        read(*,*) ckoth
        fmx = ckoth

    end if

c
c
c... store the element volumes from the original mesh
    i=1
1   read(9,10) name
    if (name .ne. 'ELEM') goto 1
32  read(9,101) vol_i(i)
    if (i .eq. 12600) then
        goto 22
    else
        i=i+1
        goto 32
    end if

c... work on the ELEM portion of the mesh first
c... begin creating the DKM mesh from the working
c   ECM mesh

22  write(*,*) 'Enter a factor multiplier for fracture volume'
    read(*,*) connew

2   read(10,10) name
    if (name .ne. 'ELEM') goto 2
33  read(10,100) el, ne,ma2,volx, ahtx,x,y,z
    if (el .eq. ' ') goto 555

    if (ma2 .eq. 4) then

```

```

c
c... these are lower boundary rock boundary elements
c    THEY ARE dkm elements
c

c... these are rock boundary elements
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,142) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      volx = volx*connew
      write(13,143) el(2:3), ne,volx,ahtx,x,y,z

c... These are used in the heating mesh processor
c
c
c... these are the air boundary elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,132) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,133) el(2:3), ne,volx,ahtx,x,y,z
c
c
c      elseif (ma2 .eq. 5) then
c
c... these are the insulation elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,122) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,123) el(2:3), ne,volx,ahtx,x,y,z
c
c
c
c      elseif (ma2 .eq. 2) then
c
c... these are the heater elements
c
c... write the matrix element
c      volxm = volx*(1.-phif)
c      write(13,112) el(2:3), ne,volxm,ahtx,x,y,z
c
c... write the fracture element
c
c      write(13,113) el(2:3), ne,volx,ahtx,x,y,z
c
c
c... these were used in the heating processor

```

```

        elseif (ma2 .eq. 3) then

c
c... these are the upper rock boundary elements
c    THEY ARE dkm elements
c

c... these are rock boundary elements
c... write the matrix element
      volx=1.0E+50
      volxm = volx*(1.-phif)
      write(13,152) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      volx=volx*connew
      write(13,153) el(2:3), ne,volx,ahtx,x,y,z

      else

c... This are interior rock elements
c    THEY ARE dkm elements
c
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      volx=volx*connew
      ma2 = 7
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z

      end if

      goto 33

c.... work on the CONNE portion of the mesh next

555  read(10,10) name
      if (name .ne. 'CONNE') goto 555
      i = 1
      icheck=1

44   read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

c... write the matrix-matrix connection
45   write(13,105) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @ areax,betax
c... write the fracture-fracture connection
      write(13,106) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @ areax,betax

      if (icheck .eq. 1) then
c... write the fracture-matrix connection
c    the connection area is modified from CKHO ASME paper to the

```

```

c      lbl connection area provided in the property sets
c
c      areax = xN*vol_i(i)/D
c      areax = afmc*vol_i(i)
c      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el1(2:3),nel,el1(2:3),nel,isot,con_df,
@      con_dm,areax,betax,fmx
      i = i+1
      end if

      ellold=el1(1:3)
      el2old=el2(1:3)
      ne2old=ne2
      read(10,104) el1,nel,el2,ne2,isot,d1,d2,areax,betax

      if (el1 .eq. ' ') goto 556
      if (el1 .eq. ellold) then
        icheck=2
        goto 45
      else
        icheck=1
        goto 45
      endif

c      the connection area is modified from CKHO ASME paper to the
c      lbl connection area provided in the property sets
c
c556  areax = xN*vol_i(i)/D
556   areax = afmc*vol_i(i)
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el2old(2:3),ne2old,el2old(2:3),
@      ne2old,isot,con_df,con_dm,areax,betax,fmx

      close(12)
      close(13)
      stop
      end

```

The input files for this routine include the initial primary mesh file called: MESH1.988, the amb.f routine generated file named mesh, and the user data input during runtime. The user input during routine runtime is:

What is the name of the input file?
 mesh

Enter the dimension N=? of fracture set
 N=2 for 1-d, N=4 for 2-d, N=6 for 3-d
 2

```

Enter the fracture spacing in meters
0.2315
Enter the fracture-matrix connection area (m^2/m^3)
13.53

Enter the fracture porosity
1.E-02

Select a f-m connection: c=1, krl=2, other=3
1
enter the constant multiplier
10.41

```

The resulting output from this routine is written in TOUGH2 format (recall, headers and space input are by the user by hand). It is noted that the line of code in the routine that prompts:

```

22  write(*,*) 'Enter a factor multiplier for fracture volume'
    read(*,*) connew

```

the user should respond with 1.0. An excerpt of the routine generated results are the following.

```

ELEMEN-----1-----2-----3-----4-----5-----6-----7-----8
M11 1      roctm0.9900E+500.2125E-01      0.2125E-010.2500E+00-.2500E+00
F11 1      roctf0.1000E+510.2125E-01      0.2125E-010.2500E+00-.2500E+00
M21 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.5381E+00
F21 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.5381E+00
M31 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.6143E+00
F31 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.6143E+00
M41 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.9024E+00
F41 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.9024E+00
M51 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.1402E+01
F51 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.1402E+01
M61 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.1899E+01
F61 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.1899E+01
M71 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.2393E+01
F71 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.2393E+01
M81 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.3140E+01
F81 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.3140E+01
M91 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.4140E+01
F91 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.4140E+01
MA1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.5140E+01
FA1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.5140E+01
MB1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.6140E+01
FB1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.6140E+01
MC1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.7140E+01
FC1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.7140E+01
MD1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.7890E+01
FD1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.7890E+01
ME1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.8390E+01
FE1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.8390E+01
MF1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.8890E+01
GF1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.8890E+01
MG1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.9390E+01
FG1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.9390E+01
MH1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.1087E+02
FH1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.1087E+02
MI1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.1334E+02
FI1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.1334E+02
MJ1 1      roctm0.9900E+500.0000E+00      0.2125E-010.2500E+00-.1581E+02
FJ1 1      roctf0.1000E+510.0000E+00      0.2125E-010.2500E+00-.1581E+02
MK1 1      roctm0.9900E+500.2125E-01      0.2125E-010.2500E+00-.1729E+02
FK1 1      roctf0.1000E+510.2125E-01      0.2125E-010.2500E+00-.1729E+02
ML2 1      rocccm0.4263E-010.8611E-01      0.2125E-010.1513E+01-.2500E+00
FL2 1      rocccf0.4306E-010.8611E-01      0.2125E-010.1513E+01-.2500E+00
M22 1      rocccm0.6496E-020.0000E+00      0.2125E-010.1513E+01-.5381E+00
F22 1      rocccf0.6562E-020.0000E+00      0.2125E-010.1513E+01-.5381E+00
M32 1      rocccm0.6496E-020.0000E+00      0.2125E-010.1513E+01-.6143E+00

```

F32 1 roccf0.6562E-020.0000E+00
 M42 1 roccm0.4263E-010.0000E+00
 F42 1 roccf0.4306E-010.0000E+00
 M52 1 roccm0.4263E-010.0000E+00
 F52 1 roccf0.4306E-010.0000E+00
 M62 1 roccm0.4211E-010.0000E+00
 F62 1 roccf0.4254E-010.0000E+00
 M72 1 roccm0.4211E-010.0000E+00
 F72 1 roccf0.4254E-010.0000E+00
 M82 1 roccm0.8525E-010.0000E+00
 F82 1 roccf0.8611E-010.0000E+00
 M92 1 roccm0.8525E-010.0000E+00
 F92 1 roccf0.8611E-010.0000E+00
 MA2 1 roccm0.8525E-010.0000E+00
 FA2 1 roccf0.8611E-010.0000E+00

...
 MJY18 roccm0.2474E+010.0000E+00
 FJY18 roccf0.2499E+010.0000E+00
 MKY18 roccm0.5014E+000.1013E+01
 PKY18 roccf0.5065E+000.1013E+01
 M1Z18 roccbm0.9900E+500.2500E+00
 F1Z18 roccbf0.1000E+510.2500E+00
 M2Z18 roccbm0.9900E+500.0000E+00
 F2Z18 roccbf0.1000E+510.0000E+00
 M3Z18 roccbm0.9900E+500.0000E+00
 F3Z18 roccbf0.1000E+510.0000E+00
 M4Z18 roccbm0.9900E+500.0000E+00
 F4Z18 roccbf0.1000E+510.0000E+00
 M5Z18 roccbm0.9900E+500.0000E+00
 F5Z18 roccbf0.1000E+510.0000E+00
 M6Z18 roccbm0.9900E+500.0000E+00
 F6Z18 roccbf0.1000E+510.0000E+00
 M7Z18 roccbm0.9900E+500.0000E+00
 F7Z18 roccbf0.1000E+510.0000E+00
 M8Z18 roccbm0.9900E+500.0000E+00
 F8Z18 roccbf0.1000E+510.0000E+00
 M9Z18 roccbm0.9900E+500.0000E+00
 F9Z18 roccbf0.1000E+510.0000E+00
 MAZ18 roccbm0.9900E+500.0000E+00
 FAZ18 roccbf0.1000E+510.0000E+00
 MBZ18 roccbm0.9900E+500.0000E+00
 FBZ18 roccbf0.1000E+510.0000E+00
 MCZ18 roccbm0.9900E+500.0000E+00
 FCZ18 roccbf0.1000E+510.0000E+00
 MDZ18 roccbm0.9900E+500.0000E+00
 Fdz18 roccbf0.1000E+510.0000E+00
 MEZ18 roccbm0.9900E+500.0000E+00
 Ffz18 roccbf0.1000E+510.0000E+00
 MFZ18 roccbm0.9900E+500.0000E+00
 Ffz18 roccbf0.1000E+510.0000E+00
 MGZ18 roccbm0.9900E+500.0000E+00
 Fgz18 roccbf0.1000E+510.0000E+00
 MHZ18 roccbm0.9900E+500.0000E+00
 FhZ18 roccbf0.1000E+510.0000E+00
 MIZ18 roccbm0.9900E+500.0000E+00
 FHz18 roccbf0.1000E+510.0000E+00
 MJZ18 roccbm0.9900E+500.0000E+00
 FJZ18 roccbf0.1000E+510.0000E+00
 MKZ18 roccbm0.9900E+500.2500E+00
 FKZ18 roccbf0.1000E+510.2500E+00

CONNE
 M11 1M11 2 10.2125E-010.4250E-010.2500E+000.0000E+00
 F11 1F11 2 10.2125E-010.4250E-010.2500E+000.0000E+00
 F11 1M11 1 20.0000E+000.3858E-010.1438E+000.0000E+000.1041E+02
 M11 1M12 1 20.2500E+000.1013E+010.2125E-010.1000E+01
 F11 1F12 1 20.2500E+000.1013E+010.2125E-010.1000E+01
 M11 1M21 1 30.2500E+000.3810E-010.2125E-010.0000E+00
 F11 1F21 1 30.2500E+000.3810E-010.2125E-010.0000E+00
 M21 1M21 2 10.2125E-010.4250E-010.3810E-010.0000E+00

0.2125E-010.1513E+01-.6143E+00
 0.2125E-010.1513E+01-.9024E+00
 0.2125E-010.1513E+01-.9024E+00
 0.2125E-010.1513E+01-.1402E+01
 0.2125E-010.1513E+01-.1402E+01
 0.2125E-010.1513E+01-.1899E+01
 0.2125E-010.1513E+01-.1899E+01
 0.2125E-010.1513E+01-.2393E+01
 0.2125E-010.1513E+01-.2393E+01
 0.2125E-010.1513E+01-.3140E+01
 0.2125E-010.1513E+01-.3140E+01
 0.2125E-010.1513E+01-.4140E+01
 0.2125E-010.1513E+01-.4140E+01
 0.2125E-010.1513E+01-.5140E+01
 0.2125E-010.1513E+01-.5140E+01
 0.2125E-010.1513E+01-.5140E+01
 0.6603E+010.1949E+02-.1581E+02
 0.6603E+010.1949E+02-.1581E+02
 0.6603E+010.1949E+02-.1729E+02
 0.6603E+010.1949E+02-.1729E+02
 0.6603E+010.2075E+02-.2500E+00
 0.6603E+010.2075E+02-.2500E+00
 0.6603E+010.2075E+02-.5381E+00
 0.6603E+010.2075E+02-.5381E+00
 0.6603E+010.2075E+02-.6143E+00
 0.6603E+010.2075E+02-.6143E+00
 0.6603E+010.2075E+02-.9024E+00
 0.6603E+010.2075E+02-.9024E+00
 0.6603E+010.2075E+02-.1402E+01
 0.6603E+010.2075E+02-.1402E+01
 0.6603E+010.2075E+02-.1899E+01
 0.6603E+010.2075E+02-.1899E+01
 0.6603E+010.2075E+02-.2393E+01
 0.6603E+010.2075E+02-.2393E+01
 0.6603E+010.2075E+02-.3140E+01
 0.6603E+010.2075E+02-.3140E+01
 0.6603E+010.2075E+02-.4140E+01
 0.6603E+010.2075E+02-.4140E+01
 0.6603E+010.2075E+02-.5140E+01
 0.6603E+010.2075E+02-.5140E+01
 0.6603E+010.2075E+02-.7140E+01
 0.6603E+010.2075E+02-.7140E+01
 0.6603E+010.2075E+02-.7890E+01
 0.6603E+010.2075E+02-.7890E+01
 0.6603E+010.2075E+02-.8390E+01
 0.6603E+010.2075E+02-.8390E+01
 0.6603E+010.2075E+02-.8890E+01
 0.6603E+010.2075E+02-.8890E+01
 0.6603E+010.2075E+02-.9390E+01
 0.6603E+010.2075E+02-.9390E+01
 0.6603E+010.2075E+02-.1087E+02
 0.6603E+010.2075E+02-.1087E+02
 0.6603E+010.2075E+02-.1334E+02
 0.6603E+010.2075E+02-.1334E+02
 0.6603E+010.2075E+02-.1581E+02
 0.6603E+010.2075E+02-.1581E+02
 0.6603E+010.2075E+02-.1729E+02
 0.6603E+010.2075E+02-.1729E+02
 0.6603E+010.2075E+02-.1729E+02

F21 1F21 2 10.2125E-010.4250E-010.3810E-010.0000E+00
F21 1M21 1 20.0000E+000.3858E-010.2191E-010.0000E+000.1041E+02
M21 1M22 1 20.2500E+000.1013E+010.3239E-020.1000E+01
F21 1F22 1 20.2500E+000.1013E+010.3239E-020.1000E+01
M21 1M31 1 30.3810E-010.3810E-010.2125E-010.0000E+00
F21 1F31 1 30.3810E-010.3810E-010.2125E-010.0000E+00
M31 1M31 2 10.2125E-010.4250E-010.3810E-010.0000E+00
F31 1F31 2 10.2125E-010.4250E-010.3810E-010.0000E+00
F31 1M31 1 20.0000E+000.3858E-010.2191E-010.0000E+000.1041E+02
M31 1M32 1 20.2500E+000.1013E+010.3239E-020.1000E+01
F31 1F32 1 20.2500E+000.1013E+010.3239E-020.1000E+01
M31 1M41 1 30.3810E-010.2500E+000.2125E-010.0000E+00
F31 1F41 1 30.3810E-010.2500E+000.2125E-010.0000E+00
M41 1M41 2 10.2125E-010.4250E-010.2500E+000.0000E+00
F41 1F41 2 10.2125E-010.4250E-010.2500E+000.0000E+00
F41 1F51 1 20.0000E+000.3858E-010.1438E+000.0000E+000.1041E+02
F41 1M41 1 20.2500E+000.1013E+010.2125E-010.1000E+01
F41 1F42 1 20.2500E+000.1013E+010.2125E-010.1000E+01
M41 1M51 1 30.2500E+000.2500E+000.2125E-010.0000E+00
F41 1F51 1 30.2500E+000.2500E+000.2125E-010.0000E+00
M51 1M51 2 10.2125E-010.4250E-010.2500E+000.0000E+00
F51 1F51 2 10.2125E-010.4250E-010.2500E+000.0000E+00
F51 1M51 1 20.0000E+000.3858E-010.1438E+000.0000E+000.1041E+02
M51 1M52 1 20.2500E+000.1013E+010.2125E-010.1000E+01
F51 1F52 1 20.2500E+000.1013E+010.2125E-010.1000E+01
M51 1M61 1 30.2500E+000.2470E+000.2125E-010.0000E+00
F51 1F61 1 30.2500E+000.2470E+000.2125E-010.0000E+00
M61 1M61 2 10.2125E-010.4250E-010.2470E+000.0000E+00
F61 1F61 2 10.2125E-010.4250E-010.2470E+000.0000E+00
F61 1M61 1 20.0000E+000.3858E-010.1421E+000.0000E+000.1041E+02
M61 1M62 1 20.2500E+000.1013E+010.2100E-010.1000E+01
F61 1F62 1 20.2500E+000.1013E+010.2100E-010.1000E+01
M61 1M71 1 30.2470E+000.2470E+000.2125E-010.0000E+00
F61 1F71 1 30.2470E+000.2470E+000.2125E-010.0000E+00
M71 1M71 2 10.2125E-010.4250E-010.2470E+000.0000E+00
F71 1F71 2 10.2125E-010.4250E-010.2470E+000.0000E+00
M71 1M72 1 20.0000E+000.3858E-010.1421E+000.0000E+000.1041E+02
F71 1F72 1 20.2500E+000.1013E+010.2100E-010.1000E+01
M71 1M81 1 20.2500E+000.1013E+010.2100E-010.1000E+01
F71 1F81 1 30.2470E+000.5000E+000.2125E-010.0000E+00
30.2470E+000.5000E+000.2125E-010.0000E+00

...
F22 1M22 1 20.0000E+000.3858E-010.8878E-010.0000E+000.1041E+02
M22 1M23 1 20.1013E+010.1013E+010.3239E-020.1000E+01
F22 1F23 1 20.1013E+010.1013E+010.3239E-020.1000E+01
M22 1M32 1 30.3810E-010.3810E-010.8611E-010.0000E+00
F22 1F32 1 30.3810E-010.3810E-010.8611E-010.0000E+00
M32 1M32 2 10.2125E-010.4250E-010.1544E+000.0000E+00
F32 1F32 2 10.2125E-010.4250E-010.1544E+000.0000E+00
F32 1M32 1 20.0000E+000.3858E-010.8878E-010.0000E+000.1041E+02
M32 1M33 1 20.1013E+010.1013E+010.3239E-020.1000E+01
F32 1F33 1 20.1013E+010.1013E+010.3239E-020.1000E+01
M32 1M42 1 30.3810E-010.2500E+000.8611E-010.0000E+00
F32 1F42 1 30.3810E-010.2500E+000.8611E-010.0000E+00
M42 1M42 2 10.2125E-010.4250E-010.1013E+010.0000E+00
F42 1F42 2 10.2125E-010.4250E-010.1013E+010.0000E+00
F42 1M42 1 20.0000E+000.3858E-010.5826E+000.0000E+000.1041E+02
M42 1M43 1 20.1013E+010.1013E+010.2125E-010.1000E+01
F42 1F43 1 20.1013E+010.1013E+010.2125E-010.1000E+01
M42 1M52 1 30.2500E+000.2500E+000.8611E-010.0000E+00
F42 1F52 1 30.2500E+000.2500E+000.8611E-010.0000E+00
M52 1M52 2 10.2125E-010.4250E-010.1013E+010.0000E+00
F52 1F52 2 10.2125E-010.4250E-010.1013E+010.0000E+00
F52 1M52 1 20.0000E+000.3858E-010.5826E+000.0000E+000.1041E+02
M52 1M53 1 20.1013E+010.1013E+010.2125E-010.1000E+01
F52 1F53 1 20.1013E+010.1013E+010.2125E-010.1000E+01
M52 1M62 1 30.2500E+000.2470E+000.8611E-010.0000E+00
F52 1F62 1 30.2500E+000.2470E+000.8611E-010.0000E+00
M62 1M62 2 10.2125E-010.4250E-010.1001E+010.0000E+00
F62 1F62 2 10.2125E-010.4250E-010.1001E+010.0000E+00

F62 1M62 1	20.0000E+000.3858E-010.5756E+000.0000E+000.1041E+02
M62 1M63 1	20.1013E+010.1013E+010.2100E-010.1000E+01
F62 1F63 1	20.1013E+010.1013E+010.2100E-010.1000E+01
M62 1M72 1	30.2470E+000.2470E+000.8611E-010.0000E+00
F62 1F72 1	30.2470E+000.2470E+000.8611E-010.0000E+00
M72 1M72 2	10.2125E-010.4250E-010.1001E+010.0000E+00
F72 1F72 2	10.2125E-010.4250E-010.1001E+010.0000E+00
F72 1M72 1	20.0000E+000.3858E-010.5756E+000.0000E+000.1041E+02
...	
FGZ18MGZ18	20.0000E+000.3858E-010.1691E+010.0000E+000.1041E+02
MHZ18MZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FHZ18FZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FHZ18MHZ18	20.0000E+000.3858E-010.8344E+010.0000E+000.1041E+02
MIZ18MJZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FIZ18FJZ18	30.1233E+010.1233E+010.2500E+000.0000E+00
FIZ18MIZ18	20.0000E+000.3858E-010.8344E+010.0000E+000.1041E+02
MJZ18MKZ18	30.1233E+010.2500E+000.2500E+000.0000E+00
FJZ18FKZ18	30.1233E+010.2500E+000.2500E+000.0000E+00
FJZ18MJZ18	20.0000E+000.3858E-010.8344E+010.0000E+000.1041E+02
FKZ18MKZ18	20.0000E+000.3858E-010.1691E+010.0000E+000.1041E+02

The following are spot checked from the resulting output. The elements **M52 1** and **F52 1** are spot checked. Values checked are in bold.

The matrix element is computed as:

$$V_m = V_{\text{prim}} \times (1 - \text{fracture porosity}) = 0.4306\text{E-}01 \times (1 - 0.01) = 0.04263 \text{ (OK)}$$

The interface distances are computed as the following:

$$d1 = 0.0 \text{ (OK)}$$

$$d2 = D/6 = 0.2315/6 = 0.03858 \text{ m (OK)}$$

The interface areas are computed as the following:

$$A = \text{afmc} \times V_{\text{prim}} = 13.53 \times 0.4306\text{E-}01 = 0.5826 \text{ m}^2 \text{ (OK)}$$

And the gamma parameter is input as 10 + 0.41. A line check as described above was verified to be correct. The range of validity for this routine is flexible. The routine is hardwired for a model domain with 12,600 primary volume hence this is its applicable range. However, if the following two lines are changed in the routine

```
dimension vol_i(12600)
  if (i .eq. 12600) then
```

the range of validity of the routine is changed. The routine is somewhat problem specific in that the IF statements are looking for material identifiers (ma2 =) 3 and 4 (boundary elements), or 1 for the interior elements.

dkmmesh_mod.f (Version 2.)

```
c
c      This processor will read the MESH file for the SHT ECM model
c      and transform it into a DKM model. It is problem specific
```

```

c      in that it is looking for certain element indicators such
c      as specific material identifiers. Only one fracture porosity
c      will be input and used to determine the matrix and fracture
c      volumes in the ELEME
c
c      Nick Francis 03/13/98
c      modified on 9/30/99
c
c
c      This will implement the LBL fracture-matrix connection area
c      TSPA-SR property set
c
c
c
c
c2345678901234567890123456789012345678901234567890123456789012

```

```

      implicit double precision (a-h,l,o-z)
      character*5 name
      character*5 elnamem
      character*5 elnamef
      character*3 el1
      character*3 el1old
      character*3 el2
      character*3 el2old
      character*3 el
      dimension vol_i(12600)

```

```

c... Enter input data such as fracture set dimensions,
c      fractures spacing, fracture porosity
c
      write(*,*) 'What is the name of the input file?'
      read(*, '(a)') infile
      write(*,*)
      write(*,*) 'Enter the dimension N=? of fracture set'
      write(*,*) 'N=2 for 1-d, N=4 for 2-d, N=6 for 3-d'
      read(*,*) xN
      write(*,*)
      write(*,*) 'Enter the fracture spacing in meters'
      read(*,*) D
      write(*,*) 'Enter the fracture-matrix connection area (m^2/m^3)'
      read(*,*) afmc
      write(*,*)

```

```

c... compute the nodal distance for the fracture-matrix connection
c... it is based on the dimensionality of the fracture set
c

```

```

      if (xN .eq. 2.) then
        con_dm = D/6.
      elseif (xN .eq. 4. ) then
        con_dm = D/8.
      elseif (xN .eq. 6.) then
        con_dm = D/10.

```

```

        else
        write(*,*) 'you have made an error-not valid fracture'
        end if

c
c
c... read in fracture porosity
        write(*,*) 'Enter the fracture porosity'
        read(*,*) phif
        write(*,*)

c... read in the DKM fmx specification
        write (*,*) 'Select a f-m connection: c=1, krl=2, other=3'
        read(*,*) idkfm
c... open up necessary files
        open(9,file='MESH1.988',status='old')
        open(10,file=infile,status='old')
        open(13,file='dkm.mesh',status='unknown')
10      format(a5)
100     format(a3,i2,13x,i2,2E10.4,10x,3E10.4)
101     format(20x,E10.4)
102     format('M',a2,i2,10x,'roccm',2E10.4,10x,3E10.4)
103     format('F',a2,i2,10x,'roccf',2E10.4,10x,3E10.4)
112     format('M',a2,i2,10x,'heatm',2E10.4,10x,3E10.4)
113     format('F',a2,i2,10x,'heatf',2E10.4,10x,3E10.4)
122     format('M',a2,i2,10x,'inslm',2E10.4,10x,3E10.4)
123     format('F',a2,i2,10x,'inslf',2E10.4,10x,3E10.4)
132     format('M',a2,i2,10x,'tunnm',2E10.4,10x,3E10.4)
133     format('F',a2,i2,10x,'tunnf',2E10.4,10x,3E10.4)
104     format(a3,i2,a3,i2,15x,i5,4e10.4)
105     format('M',a2,i2,'M',a2,i2,15x,i5,4e10.4)
106     format('F',a2,i2,'F',a2,i2,15x,i5,4e10.4)
107     format('F',a2,i2,'M',a2,i2,15x,i5,5e10.4)

c... determines the fmx type
c
        if( idkfm .eq. 1) then

        write(*,*) 'enter the constant multiplier'
        read(*,*) const
        fmx = const

        elseif ( idkfm .eq. 2) then

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'k_rl weighted connection'
        read(*,*) ckrl
        fmx = ckrl

        else

        write(*,*) 'enter a constant multiplier if needed'
        write(*,*) 'other weighted connection'
        read(*,*) ckoth
        fmx = ckoth

        end if

```

```

c
c
c... store the element volumes from the original mesh
    i=1
1    read(9,10) name
    if (name .ne. 'ELEME') goto 1
32   read(9,101) vol_i(i)
    if (i .eq. 12600) then
        goto 2
    else
        i=i+1
        goto 32
    end if

c... work on the ELEME portion of the mesh first
c... begin creating the DKM mesh from the working
c    ECM mesh

2    read(10,10) name
    if (name .ne. 'ELEME') goto 2
33   read(10,100) el, ne,ma2,volx, ahtx,x,y,z
    if (el .eq. ' ') goto 555

        if (ma2 .eq. 4) then

c
c... these are the air boundary elements

c... write the matrix element
c    volxm = volx*(1.-phif)
        write(13,132) el(2:3), ne,volx,ahtx,x,y,z

c... write the fracture element

        write(13,133) el(2:3), ne,volx,ahtx,x,y,z

        elseif (ma2 .eq. 5) then

c... these are the insulation elements

c... write the matrix element
c    volxm = volx*(1.-phif)
c... use the primary volume for the matrix
        write(13,122) el(2:3), ne,volx,ahtx,x,y,z

c... write the fracture element

        volx=1.0E-05*volx
c... use an arbitrary small volume for the fracture
        write(13,123) el(2:3), ne,volx,ahtx,x,y,z

c

        elseif (ma2 .eq. 2) then
c
c.... these are the heater elements

```

```

c... write the matrix element
c      volxm = volx*(1.-phif)
c... use the primary volume for the matrix
      write(13,112) el(2:3), ne,volx,ahtx,x,y,z

c... write the fracture element

      volx=1.0E-05*volx
c... use an arbitrary small volume for the fracture
      write(13,113) el(2:3), ne,volx,ahtx,x,y,z

c
      elseif (ma2 .eq. 3) then
c
c... these are rock boundary elements
c      THEY ARE dkm elements
c

c... these are rock boundary elements
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z

      else

c... This are interior rock elements
c      THEY ARE dkm elements
c
c... write the matrix element
      volxm = volx*(1.-phif)
      write(13,102) el(2:3), ne,volxm,ahtx,x,y,z

c... write the fracture element
      ma2 = 7
      write(13,103) el(2:3), ne,volx,ahtx,x,y,z

      end if

      goto 33

c.... work on the CONNE portion of the mesh next

555 read(10,10) name
      if (name .ne. 'CONNE') goto 555
      i = 1
      icheck=1

44 read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

c... write the matrix-matrix connection
45 write(13,105) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
@ areax,betax

```

```

c... write the fracture-fracture connection
      write(13,106) el1(2:3),ne1,el2(2:3),ne2,isot,d1,d2,
      @   areax,betax

      if (icheck .eq. 1) then
C... write the fracture-matrix connection
c    the connection area is modified from CKHO ASME paper to the
c    lbl connection area provided in the property sets
c
c      areax = xN*vol_i(i)/D
c      areax = afmc*vol_i(i)
c      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el1(2:3),ne1,el1(2:3),ne1,isot,con_df,
      @   con_dm,areax,betax,fx
      i = i+1
      end if

      el1old=el1(1:3)
      el2old=el2(1:3)
      ne2old=ne2
      read(10,104) el1,ne1,el2,ne2,isot,d1,d2,areax,betax

      if (el1 .eq. ' ') goto 556
      if (el1 .eq. el1old) then
        icheck=2
        goto 45
      else
        icheck=1
        goto 45
      endif

c    the connection area is modified from CKHO ASME paper to the
c    lbl connection area provided in the property sets
c
c556   areax = xN*vol_i(i)/D
556    areax = afmc*vol_i(i)
      con_df = 0.0
c...select isot=2 since it contains the vertical permeability
      isot=2
      betax=0.0
      write(13,107) el2old(2:3),ne2old,el2old(2:3),
      @   ne2old,isot,con_df,con_dm,areax,betax,fx

      close(12)
      close(13)
      stop
      end

```

The input files for this routine include the initial primary mesh file called: MESH1.988, the bdryinselem.f routine generated file named mesh, and the user data input during runtime. The user input during routine runtime is:

What is the name of the input file?
mesh

Enter the dimension N=? of fracture set
N=2 for 1-d, N=4 for 2-d, N=6 for 3-d
2

Enter the fracture spacing in meters
0.2315
Enter the fracture-matrix connection area (m²/m³)
13.53

Enter the fracture porosity
1.E-02

Select a f-m connection: c=1, krl=2, other=3
1
enter the constant multiplier
10.41

The primary input file (output file from the routine bdryinselem.f) for dkmmesh_mod.f is file name: MESH. The heater elements (A8I 1, A9I 1, AAI 1, ABI 1, and ACI 1, all ma2 = 2) must be identified by the user by hand in the primary mesh file obtained from bdryinselem.f before it is used as input to the routine.

The resulting output from this routine is written in TOUGH2 format (recall, headers and space input are by the user by hand).

ELEME	1	2	3	4	5	6	7	8
M11	1	tunnm0.1000E+510.2125E-01			0.2125E-010.2500E+00-.2500E+00			
F11	1	tunmf0.1000E+510.2125E-01			0.2125E-010.2500E+00-.2500E+00			
M21	1	inslm0.1000E+510.0000E+00			0.2125E-010.2500E+00-.5381E+00			
F21	1	inslf0.1000E+460.0000E+00			0.2125E-010.2500E+00-.5381E+00			
M31	1	inslm0.1000E+510.0000E+00			0.2125E-010.2500E+00-.6143E+00			
F31	1	inslf0.1000E+460.0000E+00			0.2125E-010.2500E+00-.6143E+00			
M41	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.9024E+00			
F41	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.9024E+00			
M51	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.1402E+01			
F51	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.1402E+01			
M61	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.1899E+01			
F61	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.1899E+01			
M71	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.2393E+01			
F71	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.2393E+01			
M81	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.3140E+01			
F81	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.3140E+01			
M91	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.4140E+01			
F91	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.4140E+01			
MA1	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.5140E+01			
FA1	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.5140E+01			
MB1	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.6140E+01			
FB1	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.6140E+01			
MC1	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.7140E+01			
FC1	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.7140E+01			
MD1	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.7890E+01			
FD1	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.7890E+01			
ME1	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.8390E+01			
FE1	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.8390E+01			
MF1	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.8890E+01			
FF1	1	roccf0.1000E+510.0000E+00			0.2125E-010.2500E+00-.8890E+01			
MG1	1	roccm0.9900E+500.0000E+00			0.2125E-010.2500E+00-.9390E+01			

FG1 1 roccf0.1000E+510.0000E+00
 MH1 1 roccm0.9900E+500.0000E+00
 FH1 1 roccf0.1000E+510.0000E+00
 MI1 1 roccm0.9900E+500.0000E+00
 FI1 1 roccf0.1000E+510.0000E+00
 MJ1 1 roccm0.9900E+500.0000E+00
 FJ1 1 roccf0.1000E+510.0000E+00
 MK1 1 roccm0.9900E+500.2125E-01
 FK1 1 roccf0.1000E+510.2125E-01
 M12 1 tunnm0.1000E+510.8611E-01
 F12 1 tunnf0.1000E+510.8611E-01
 M22 1 inslm0.6562E-020.0000E+00
 F22 1 inslf0.6562E-070.0000E+00
 M32 1 inslm0.6562E-020.0000E+00
 F32 1 inslf0.6562E-070.0000E+00
 M42 1 roccm0.4263E-010.0000E+00
 F42 1 roccf0.4306E-010.0000E+00
M52 1 roccm0.4263E-010.0000E+00
F52 1 roccf0.4306E-010.0000E+00
 M62 1 roccm0.4211E-010.0000E+00
 F62 1 roccf0.4254E-010.0000E+00
 M72 1 roccm0.4211E-010.0000E+00
 F72 1 roccf0.4254E-010.0000E+00
 M82 1 roccm0.8525E-010.0000E+00
 F82 1 roccf0.8611E-010.0000E+00
 M92 1 roccm0.8525E-010.0000E+00
 F92 1 roccf0.8611E-010.0000E+00
 MA2 1 roccm0.8525E-010.0000E+00
 FA2 1 roccf0.8611E-010.0000E+00

...
 M71 1 roccm0.1767E-020.0000E+00
 F71 1 roccf0.1785E-020.0000E+00
 M81 1 heatm0.3613E-020.0000E+00
 F81 1 heatf0.3613E-070.0000E+00
 M91 1 heatm0.3613E-020.0000E+00
 F91 1 heatf0.3613E-070.0000E+00
 MA1 1 heatm0.3613E-020.0000E+00
 FA1 1 heatf0.3613E-070.0000E+00
 MB1 1 heatm0.3613E-020.0000E+00
 FB1 1 heatf0.3613E-070.0000E+00
 MC1 1 heatm0.3613E-020.0000E+00
 FC1 1 heatf0.3613E-070.0000E+00
 MD1 1 roccm0.1788E-020.0000E+00
 FDI 1 roccf0.1806E-020.0000E+00

...
 MJY18 tunnm0.1000E+510.0000E+00
 FJY18 tunnf0.1000E+510.0000E+00
 MKY18 tunnm0.1000E+510.1013E+01
 FKY18 tunnf0.1000E+510.1013E+01
 M1Z18 tunnm0.1000E+510.2500E+00
 F1Z18 tunnf0.1000E+510.2500E+00
 M2Z18 tunnm0.1000E+510.0000E+00
 F2Z18 tunnf0.1000E+510.0000E+00
 M3Z18 tunnm0.1000E+510.0000E+00
 F3Z18 tunnf0.1000E+510.0000E+00
 M4Z18 tunnm0.1000E+510.0000E+00
 F4Z18 tunnf0.1000E+510.0000E+00
 M5Z18 tunnm0.1000E+510.0000E+00
 F5Z18 tunnf0.1000E+510.0000E+00
 M6Z18 tunnm0.1000E+510.0000E+00
 F6Z18 tunnf0.1000E+510.0000E+00
 M7Z18 tunnm0.1000E+510.0000E+00
 F7Z18 tunnf0.1000E+510.0000E+00
 M8Z18 tunnm0.1000E+510.0000E+00
 F8Z18 tunnf0.1000E+510.0000E+00
 M9Z18 tunnm0.1000E+510.0000E+00
 F9Z18 tunnf0.1000E+510.0000E+00
 MAZ18 tunnm0.1000E+510.0000E+00
 FAZ18 tunnf0.1000E+510.0000E+00
 MBZ18 tunnm0.1000E+510.0000E+00

0.2125E-010.2500E+00-.9390E+01
 0.2125E-010.2500E+00-.1087E+02
 0.2125E-010.2500E+00-.1087E+02
 0.2125E-010.2500E+00-.1334E+02
 0.2125E-010.2500E+00-.1334E+02
 0.2125E-010.2500E+00-.1581E+02
 0.2125E-010.2500E+00-.1581E+02
 0.2125E-010.2500E+00-.1729E+02
 0.2125E-010.2500E+00-.1729E+02
 0.2125E-010.1513E+01-.2500E+00
 0.2125E-010.1513E+01-.2500E+00
 0.2125E-010.1513E+01-.5381E+00
 0.2125E-010.1513E+01-.5381E+00
 0.2125E-010.1513E+01-.6143E+00
 0.2125E-010.1513E+01-.6143E+00
 0.2125E-010.1513E+01-.9024E+00
 0.2125E-010.1513E+01-.9024E+00
0.2125E-010.1513E+01-.1402E+01
0.2125E-010.1513E+01-.1402E+01
 0.2125E-010.1513E+01-.1899E+01
 0.2125E-010.1513E+01-.1899E+01
 0.2125E-010.1513E+01-.2393E+01
 0.2125E-010.1513E+01-.2393E+01
 0.2125E-010.1513E+01-.3140E+01
 0.2125E-010.1513E+01-.3140E+01
 0.2125E-010.1513E+01-.4140E+01
 0.2125E-010.1513E+01-.4140E+01
 0.2125E-010.1513E+01-.5140E+01
 0.2125E-010.1513E+01-.5140E+01
 0.2125E-010.1050E+02-.2393E+01
 0.2125E-010.1050E+02-.2393E+01
 0.2125E-010.1050E+02-.3140E+01
 0.2125E-010.1050E+02-.3140E+01
 0.2125E-010.1050E+02-.4140E+01
 0.2125E-010.1050E+02-.4140E+01
 0.2125E-010.1050E+02-.5140E+01
 0.2125E-010.1050E+02-.5140E+01
 0.2125E-010.1050E+02-.6140E+01
 0.2125E-010.1050E+02-.6140E+01
 0.2125E-010.1050E+02-.7140E+01
 0.2125E-010.1050E+02-.7140E+01
 0.2125E-010.1050E+02-.7890E+01
 0.2125E-010.1050E+02-.7890E+01
 0.6603E+010.1949E+02-.1581E+02
 0.6603E+010.1949E+02-.1581E+02
 0.6603E+010.1949E+02-.1729E+02
 0.6603E+010.1949E+02-.1729E+02
 0.6603E+010.2075E+02-.2500E+00
 0.6603E+010.2075E+02-.2500E+00
 0.6603E+010.2075E+02-.5381E+00
 0.6603E+010.2075E+02-.5381E+00
 0.6603E+010.2075E+02-.6143E+00
 0.6603E+010.2075E+02-.6143E+00
 0.6603E+010.2075E+02-.9024E+00
 0.6603E+010.2075E+02-.9024E+00
 0.6603E+010.2075E+02-.1402E+01
 0.6603E+010.2075E+02-.1402E+01
 0.6603E+010.2075E+02-.1899E+01
 0.6603E+010.2075E+02-.1899E+01
 0.6603E+010.2075E+02-.2393E+01
 0.6603E+010.2075E+02-.2393E+01
 0.6603E+010.2075E+02-.3140E+01
 0.6603E+010.2075E+02-.3140E+01
 0.6603E+010.2075E+02-.4140E+01
 0.6603E+010.2075E+02-.4140E+01
 0.6603E+010.2075E+02-.5140E+01
 0.6603E+010.2075E+02-.5140E+01
 0.6603E+010.2075E+02-.6140E+01

FBZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.6140E+01
MCZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7140E+01
FCZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7140E+01
MDZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7890E+01
FDZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.7890E+01
MEZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8390E+01
FEZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8390E+01
MFZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8890E+01
FFZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.8890E+01
MGZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.9390E+01
FGZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.9390E+01
MHZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1087E+02
FHZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1087E+02
MIZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1334E+02
FIZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1334E+02
MJZ18	turnnm0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1581E+02
FJZ18	turnnf0.1000E+510.0000E+00	0.6603E+010.2075E+02-.1581E+02
MKZ18	turnnm0.1000E+510.2500E+00	0.6603E+010.2075E+02-.1729E+02
FKZ18	turnnf0.1000E+510.2500E+00	0.6603E+010.2075E+02-.1729E+02

CONN	1	2	3	4	5	6	7	8
M11 1M1 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F11 1F1 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F11 1M1 1	20.0000E+000.3858E-010.1438E+000.0000E+000.1041E+02							
M11 1M1 2	20.0000E+000.1013E+010.2125E-010.1000E+01							
F11 1F1 2	20.0000E+000.1013E+010.2125E-010.1000E+01							
M11 1M2 1	30.0000E+000.3810E-010.2125E-010.0000E+00							
F11 1F2 1	30.0000E+000.3810E-010.2125E-010.0000E+00							
M21 1M2 1	10.2125E-010.4250E-010.3810E-010.0000E+00							
F21 1F2 1	10.2125E-010.4250E-010.3810E-010.0000E+00							
F21 1M2 1	20.0000E+000.3858E-010.2191E-010.0000E+000.1041E+02							
M21 1M2 2	20.0000E+000.1013E+010.3239E-020.1000E+01							
F21 1F2 2	20.0000E+000.1013E+010.3239E-020.1000E+01							
M21 1M3 1	30.3810E-010.3810E-010.2125E-010.0000E+00							
F21 1F3 1	30.3810E-010.3810E-010.2125E-010.0000E+00							
M31 1M3 2	10.2125E-010.4250E-010.3810E-010.0000E+00							
F31 1F3 2	10.2125E-010.4250E-010.3810E-010.0000E+00							
F31 1M3 1	20.0000E+000.3858E-010.2191E-010.0000E+000.1041E+02							
M31 1M3 2	20.0000E+000.1013E+010.3239E-020.1000E+01							
F31 1F3 2	20.0000E+000.1013E+010.3239E-020.1000E+01							
M31 1M4 1	30.3810E-010.2500E+000.2125E-010.0000E+00							
F31 1F4 1	30.3810E-010.2500E+000.2125E-010.0000E+00							
M41 1M4 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F41 1F4 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F41 1M4 1	20.0000E+000.3858E-010.1438E+000.0000E+000.1041E+02							
M41 1M4 2	20.0000E+000.1013E+010.2125E-010.1000E+01							
F41 1F4 2	20.0000E+000.1013E+010.2125E-010.1000E+01							
M41 1M5 1	30.2500E+000.2500E+000.2125E-010.0000E+00							
F41 1F5 1	30.2500E+000.2500E+000.2125E-010.0000E+00							
M51 1M5 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F51 1F5 2	10.2125E-010.4250E-010.2500E+000.0000E+00							
F51 1M5 1	20.0000E+000.3858E-010.1438E+000.0000E+000.1041E+02							
M51 1M5 2	20.0000E+000.1013E+010.2125E-010.1000E+01							
F51 1F5 2	20.0000E+000.1013E+010.2125E-010.1000E+01							
M51 1M6 1	30.2500E+000.2470E+000.2125E-010.0000E+00							
F51 1F6 1	30.2500E+000.2470E+000.2125E-010.0000E+00							
M61 1M6 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F61 1F6 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F61 1M6 1	20.0000E+000.3858E-010.1421E+000.0000E+000.1041E+02							
M61 1M6 2	20.0000E+000.1013E+010.2100E-010.1000E+01							
F61 1F6 2	20.0000E+000.1013E+010.2100E-010.1000E+01							
M61 1M7 1	30.2470E+000.2470E+000.2125E-010.0000E+00							
F61 1F7 1	30.2470E+000.2470E+000.2125E-010.0000E+00							
M71 1M7 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F71 1F7 2	10.2125E-010.4250E-010.2470E+000.0000E+00							
F71 1M7 1	20.0000E+000.3858E-010.1421E+000.0000E+000.1041E+02							
M71 1M7 2	20.0000E+000.1013E+010.2100E-010.1000E+01							
F71 1F7 2	20.0000E+000.1013E+010.2100E-010.1000E+01							
M71 1M8 1	30.2470E+000.5000E+000.2125E-010.0000E+00							
F71 1F8 1	30.2470E+000.5000E+000.2125E-010.0000E+00							

```

...
M22 1M22 2      10.2125E-010.4250E-010.1544E+000.0000E+00
F22 1F22 2      10.2125E-010.4250E-010.1544E+000.0000E+00
F22 1M22 1      20.0000E+000.3858E-010.8878E-010.0000E+000.1041E+02
M22 1M23 1      20.1013E+010.1013E+010.3239E-020.1000E+01
F22 1F23 1      20.1013E+010.1013E+010.3239E-020.1000E+01
M22 1M32 1      30.3810E-010.3810E-010.8611E-010.0000E+00
F22 1F32 1      30.3810E-010.3810E-010.8611E-010.0000E+00
M32 1M32 2      10.2125E-010.4250E-010.1544E+000.0000E+00
F32 1F32 2      10.2125E-010.4250E-010.1544E+000.0000E+00
M32 1M32 1      20.0000E+000.3858E-010.8878E-010.0000E+000.1041E+02
F32 1F32 1      20.1013E+010.1013E+010.3239E-020.1000E+01
M32 1M42 1      30.3810E-010.2500E+000.8611E-010.0000E+00
F32 1F42 1      30.3810E-010.2500E+000.8611E-010.0000E+00
M42 1M42 2      10.2125E-010.4250E-010.1013E+010.0000E+00
F42 1F42 2      10.2125E-010.4250E-010.1013E+010.0000E+00
F42 1M42 1      20.0000E+000.3858E-010.5826E+000.0000E+000.1041E+02
M42 1M43 1      20.1013E+010.1013E+010.2125E-010.1000E+01
F42 1F43 1      20.1013E+010.1013E+010.2125E-010.1000E+01
M42 1M52 1      30.2500E+000.2500E+000.8611E-010.0000E+00
F42 1F52 1      30.2500E+000.2500E+000.8611E-010.0000E+00
M52 1M52 2      10.2125E-010.4250E-010.1013E+010.0000E+00
F52 1F52 2      10.2125E-010.4250E-010.1013E+010.0000E+00
F52 1M52 1      20.0000E+000.3858E-010.5826E+000.0000E+000.1041E+02
M52 1M53 1      20.1013E+010.1013E+010.2125E-010.1000E+01
F52 1F53 1      20.1013E+010.1013E+010.2125E-010.1000E+01
M52 1M62 1      30.2500E+000.2470E+000.8611E-010.0000E+00
F52 1F62 1      30.2500E+000.2470E+000.8611E-010.0000E+00
M62 1M62 2      10.2125E-010.4250E-010.1001E+010.0000E+00
F62 1F62 2      10.2125E-010.4250E-010.1001E+010.0000E+00
F62 1M62 1      20.0000E+000.3858E-010.5756E+000.0000E+000.1041E+02
M62 1M63 1      20.1013E+010.1013E+010.2100E-010.1000E+01
F62 1F63 1      20.1013E+010.1013E+010.2100E-010.1000E+01
M62 1M72 1      30.2470E+000.2470E+000.8611E-010.0000E+00
F62 1F72 1      30.2470E+000.2470E+000.8611E-010.0000E+00
M72 1M72 2      10.2125E-010.4250E-010.1001E+010.0000E+00
F72 1F72 2      10.2125E-010.4250E-010.1001E+010.0000E+00

...
FGZ18MGZ18      20.0000E+000.3858E-010.1691E+010.0000E+000.1041E+02
MHZ18MIZ18      30.1233E+010.1233E+010.2500E+000.0000E+00
FHZ18FIZ18      30.1233E+010.1233E+010.2500E+000.0000E+00
FHZ18MHZ18      20.0000E+000.3858E-010.8344E+010.0000E+000.1041E+02
MIZ18MJZ18      30.1233E+010.1233E+010.2500E+000.0000E+00
FIZ18FJZ18      30.1233E+010.1233E+010.2500E+000.0000E+00
FIZ18MIZ18      20.0000E+000.3858E-010.8344E+010.0000E+000.1041E+02
MJZ18MKZ18      30.1233E+010.0000E+000.2500E+000.0000E+00
FJZ18FKZ18      30.1233E+010.0000E+000.2500E+000.0000E+00
FJZ18MJZ18      20.0000E+000.3858E-010.8344E+010.0000E+000.1041E+02
FKZ18MKZ18      20.0000E+000.3858E-010.1691E+010.0000E+000.1041E+02

```

The following are spot checked from the resulting output. The elements M52 1 and F52 1 are spot checked. Values checked are in bold.

The matrix element is computed as:

$$V_m = V_{\text{prim}} \times (1 - \text{fracture porosity}) = 0.4306E-01 \times (1 - 0.01) = 0.04263 \text{ (OK)}$$

The interface distances are computed as the following:

$$d1 = 0.0 \text{ (OK)}$$

$$d2 = D/6 = 0.2315/6 = 0.03858 \text{ m (OK)}$$

The interface areas are computed as the following:

$$A = afmc \times V_{prim} = 13.53 \times 0.4306E-01 = 0.5826 \text{ m}^2 \text{ (OK)}$$

And the gamma parameter is input as 10 + 0.41. A total line check as described above was verified to be correct for this output. The range of validity for this routine is flexible. The routine is hardwired for a model domain with 12,600 primary volume, hence this is its applicable range. However, if the following two lines are changed in the routine

```
dimension vol_i(12600)
  if (i .eq. 12600) then
```

the range of validity of the routine is changed. The routine is somewhat problem specific in that the "if" statements are looking for material identifiers (ma2 =) 3 and 4 (boundary elements), 2 (heater elements), 5 (insulation elements), or 1 for the interior elements.

A software routine was written to precondition the ambient initialization simulation results used as input for the heating runs. This routine supplies the appropriate boundary conditions in the initial conditions file needed for each of the heating runs that result from the discussions given above. It is noted that the initial conditions for the heater elements must be input by hand by the user.

icpredkm.f (Version 1.)

```
C
C
C      THIS IS USED TO PROCESS A SAVE FILE FROM THE EQUILIBRATION RUN
C      This will be used to process the boundary elements and the
c      new insulation elements at the front face and the side face.
c      This mesh has been further refined in the Z-direction MESH and
C      must have +++ at the end of the file (first three spaces)
c
c
c
c      The new file will require INCON at the top and the heater elements
c      to be modified by hand
c
C
C
C      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      character*5 name
      character*3 el
      open(unit=16,file='SAVE',status='old')
      open(unit=17,file='incon.dat',status = 'unknown')
2      read(16,5) name
5      format(a5)
      if(name.ne.'INCON') go to 2
95     read(16,100) el, ne, porx
100    format(a3,i2,10x,e15.9)
      if ( el(1:3) .eq. '+++') goto 306
      read(16,101) pg,sg10,t
101    format(3e20.13)
```

```

c
c This handles the air boundary elements. It assumes an
c RH and a tunnel temperature
c
c
      if(el(2:2) .eq. '1' .or. ne .eq. 18) then

c
c compute an air mass fraction based on T=25 and Pg
c assume RH = 100%
c
      if (el(1:1) .eq. 'M') then

porx = 1.0
rh = 1.0
Tc = 25.
pgas = pg

      call psat(pgas,rh,Tc,xair)
      write(17,100) el, ne, porx
      write(17,101) pgas,xair,Tc
      goto 95

      else

porx = 1.0
rh = 1.0
Tc = 25.
pgas = pg

      call psat(pgas,rh,Tc,xair)
      write(17,100) el, ne, porx
      write(17,101) pgas,xair,Tc
      goto 95

      end if

c
c
c This handles the insulation elements. The liquid
c saturation is re-
c set to zero.
c
c
      else if ( el(2:2) .eq. '2' .or. el(2:2) .eq. '3'
@      .or. ne .eq. 16 .or. ne .eq. 17) then

      if (el(1:1) .eq. 'M') then

porx = 0.0
pg = 1.0E+08
xair=1.0
      write(17,100) el, ne, porx

```

```

        write(17,101) pg,xair,t
        goto 95

        else

        porx = 0.0
        pg = 1.0E+08
        xair=1.0
        write(17,100) el, ne, porx
        write(17,101) pg,xair,t
        goto 95

        end if

c
c
c   handles all other elements
c
c

        else

        write(17,100) el, ne, porx
        write(17,101) pg,sg10,t
        goto 95

        end if

306   close(17)
      stop
      end

c*****
      subroutine psat(pgas,rh,t,xair)
      implicit double precision (a-h,o-z)

c...Gas constants for air and vapor
      rgas=8314.56d0
      amv=18.016d0
      ama=28.96d0
      rv=rgas/amv
      ra=rgas/ama

      call sat(t,ps)

c...Calculate partial pressure of water vapor
      pvap=rh*ps
c...Calculate partial pressure of air in gas
      pair=pgas-pvap
c...Calculate air mass fraction
      xair=1.d0/(1.d0+pvap*ra/pair/rv)

      return
      end
c*****
      SUBROUTINE SAT(T,P)
c
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)

```

```

C      COMMON/KONIT/KON,DELT,IGOOD
      DIMENSION A(9)
C      SAVE ICALL,A
      DATA A/
      A-7.691234564D0,-2.608023696D1,-1.681706546D2,6.423285504D1,
      B-1.189646225D2,4.167117320D0,2.097506760D1,1.D9,6.D0/
C
C      DATA ICALL/0/
C      ICALL=ICALL+1
C      IF(ICALL.EQ.1) WRITE(11,899)
C 899 FORMAT(6X,'SAT      1.1      10 JULY      1991',6X,
C      X'STEAM TABLE EQUATION: SATURATION PRESSURE AS FUNCTION OF',
C      X' TEMPERATURE')
C
C      IF(T.LT.1.D0.OR.T.GT.500.D0) GOTO 10
      TC=(T+273.15D0)/647.3D0
      SC=0.D0
      DO 5 J=1,5
5      SC=SC+A(J)*(1.D0-TC)**J
      PC=EXP(SC/(TC*(1.D0+A(6)*(1.D0-TC)+A(7)*(1.D0-TC)**2)))
      +- (1.D0-TC)/(A(8)*
      A(1.D0-TC)**2+A(9)))
      P=PC*2.212D7
C
      RETURN
10 IGOOD=2
      WRITE(*,1) T
      1 FORMAT(15H TEMPERATURE = ,E12.6,22H OUT OF RANGE IN SAT )
      RETURN
      END

```

An excerpt of a different (between the input SAVE file obtained from the ambient TOUGH2 initialization and the output file of this routine) file is shown below to indicate that the software routine is operating correctly.

```

1,14c1,14
< INCON -- INITIAL CONDITIONS FOR25200 ELEMENTS AT TIME 0.315360E+14
< M11 1 0.890000000E-01
< 0.8679818933622E+05 0.1007353596966E+02 0.2500000000000E+02
< F11 1 0.124000000E-03
< 0.8679882041588E+05 0.1098409324232E+02 0.2500000000000E+02
< M21 1 0.890000000E-01
< 0.8679818930932E+05 0.1007353596966E+02 0.2500000000000E+02
< F21 1 0.124000000E-03
< 0.8679882041588E+05 0.1098409325135E+02 0.2500000000000E+02
< M31 1 0.890000000E-01
< 0.8679818930931E+05 0.1007353596966E+02 0.2500000000000E+02
< F31 1 0.124000000E-03
< 0.8679882041588E+05 0.1098409325134E+02 0.2500000000000E+02
< M41 1 0.890000000E-01
---
> INCON
> M11 1 0.100000000E+01
> 0.8679818933622E+05 0.9769915871647E+00 0.2500000000000E+02
> F11 1 0.100000000E+01
> 0.8679882041588E+05 0.9769917567878E+00 0.2500000000000E+02
> M21 1 0.000000000E+00
> 0.1000000000000E+09 0.1000000000000E+01 0.2500000000000E+02
> F21 1 0.000000000E+00
> 0.1000000000000E+09 0.1000000000000E+01 0.2500000000000E+02
> M31 1 0.000000000E+00

```

```

> 0.10000000000000E+09 0.10000000000000E+01 0.25000000000000E+02
> F31 1 0.0000000000E+00
> 0.10000000000000E+09 0.10000000000000E+01 0.25000000000000E+02
> M41 1 0.8900000000E-01
16c16
< F41 1 0.124000000E-03
---
> F41 1 0.124000000E-03
18c18
< M51 1 0.890000000E-01
---
> M51 1 0.890000000E-01
20c20
< F51 1 0.124000000E-03
---
> F51 1 0.124000000E-03
22c22
< M61 1 0.890000000E-01
---
> M61 1 0.890000000E-01
24c24
< F61 1 0.124000000E-03
---
> F61 1 0.124000000E-03
26c26
< M71 1 0.890000000E-01
---
> M71 1 0.890000000E-01
...
< FFZ18 0.124000000E-03
< 0.87000000000000E+05 0.10885700000000E+02 0.25433000000000E+02
< MGZ18 0.890000000E-01
< 0.87000000000000E+05 0.10036000000000E+02 0.25433000000000E+02
< FGZ18 0.124000000E-03
< 0.87000000000000E+05 0.10885700000000E+02 0.25433000000000E+02
< MHZ18 0.890000000E-01
< 0.87000000000000E+05 0.10036000000000E+02 0.25433000000000E+02
< FHZ18 0.124000000E-03
< 0.87000000000000E+05 0.10885700000000E+02 0.25433000000000E+02
< MIZ18 0.890000000E-01
< 0.87000000000000E+05 0.10036000000000E+02 0.25433000000000E+02
< FIZ18 0.124000000E-03
< 0.87000000000000E+05 0.10885700000000E+02 0.25433000000000E+02
< MJZ18 0.890000000E-01
< 0.87000000000000E+05 0.10036000000000E+02 0.25433000000000E+02
< FJZ18 0.124000000E-03
< 0.87000000000000E+05 0.10885700000000E+02 0.25433000000000E+02
< MKZ18 0.890000000E-01
< 0.87000000000000E+05 0.10036000000000E+02 0.25433000000000E+02
< FKZ18 0.124000000E-03
< 0.87000000000000E+05 0.10885700000000E+02 0.25433000000000E+02
...
> FFZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> MGZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> FGZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> MHZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> FHZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> MIZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> FIZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> MJZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02
> FJZ18 0.100000000E+01
> 0.87000000000000E+05 0.9770457031302E+00 0.25000000000000E+02

```

```

> MKZ18      0.100000000E+01
> 0.870000000000000E+05 0.9770457031302E+00 0.250000000000000E+02
> FKZ18      0.100000000E+01
> 0.870000000000000E+05 0.9770457031302E+00 0.250000000000000E+02

```

This different result indicates that the boundary elements were correctly changed by the routine and that the interior elements (e.g., the rock elements) are unmodified by the routine. The range of validity for this software routine is a TOUGH2 meshmaker generated initial primary mesh file with $n_x = 18$, $n_y = 35$ (direction of gravity), and $n_z = 20$ (e.g., 12,600 primary elements, which translates to 25,200 DKM elements, 12,600 matrix, 12,600 fracture elements). The primary mesh file specifies the elements that are transformed from rock elements to other boundary condition elements by this initial condition preconditioning routine.

The remaining software routines take the resultant output from the TOUGH2 simulations and re-arrange it into a more convenient format for plotting purposes.

tough_extract_frac.f (Version 1.)

This routine reads the TOUGH2.OUT file for a simulation and writes the fracture temperature, liquid saturation, and pressure into column format with its x, y, z coordinate locations required by the routine Compare. The routine is the following:

```

program avsinp
c
c      this program reads fracture data from a tough2.out file
c      that contains both matrix and fracture data
c
c      modified srs.inp to write temps for all time steps
c      writes element names and array indexes to fort.29
c      writes slices to fort.32 and fort.33
c      f77 -C avsinp.f --> bound checking
c
c
c      PROGRAM TO GET DATA FROM TOUGH FILE TO MAKE EXODUSII FILE
c
c      this version only reads in 19 variables and writes 2 exo files
c
c      max x - 99
c           y - 35
c           z - 61
c
c      1      2      3      4      5      6      7
c2345678901234567890123456789012345678901234567890123456789012
c
c      implicit none
c
c      integer nel, nnds, nxc, nyc, nzc, nxnds, nynds, nznds, ncmx
c      integer maxtimes, num_elem
c      character*14 fnameexo, fnameout, fnamemesh
c      integer sandytime, sandyvar ! write temp file at this timestep
c
c!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!c
c      MAKE CHANGES HERE
c
c      parameter(nxc=18, nyc=35, nzc=20)

```

```

parameter(maxtime=35)
parameter(sandytime=3,sandyvar=3) ! 1=pressure 2=temp 3=liq sat
c

```

```

parameter(nel=nxc*nyc*nzc)
parameter(num_elem=nel)
parameter(nxnds=nxc+1, nynds=nyc+1, nznds=nzc+1)
parameter(mnds=nxnds*nynds*nznds)

```

```

integer nvars

```

```

parameter(nvars=19)

```

```

real*4 xc(nxc,nyc,nzc),yc(nxc,nyc,nzc),zc(nxc,nyc,nzc)

```

```

real*4 xctmp,yctmp,zctmp

```

```

real*4 xnds(nxnds,nynds,nznds),ynds(nxnds,nynds,nznds)

```

```

real*4 znds(nxnds,nynds,nznds)

```

```

character*22 block

```

```

character*50 block2

```

```

integer nmax,i,j,k,ctr,ctr2

```

```

real*4 n1,n2

```

```

c
real*4 pg(nel),t(nel),sg,sl(nel),pcap(nel)

```

```

real*4 pg,t,sg,sl,pcap

```

```

real*4 pg3(nxc,nyc,nzc),t3(nxc,nyc,nzc)

```

```

real*4 sl3(nxc,nyc,nzc),pcap3(nxc,nyc,nzc)

```

```

character*5 elemn1,elemn2

```

```

character*3 dummy

```

```

integer direction

```

```

real*4 dist1,dist2

```

```

real*4 xdist(nxc,nyc,nzc),ydist(nxc,nyc,nzc),zdist(nxc,nyc,nzc)

```

```

integer xidx1,yidx1,zidx1

```

```

c
flow variables

```

```

real*4 floh,floh-f,flof,flog,flo1,vell

```

```

real*4 flohx(nxc,nyc,nzc),flohy(nxc,nyc,nzc),flohz(nxc,nyc,nzc)

```

```

real*4 flogx(nxc,nyc,nzc),flogy(nxc,nyc,nzc),flogz(nxc,nyc,nzc)

```

```

real*4 flo1x(nxc,nyc,nzc),flo1y(nxc,nyc,nzc),flo1z(nxc,nyc,nzc)

```

```

real*4 velgx(nxc,nyc,nzc),velgy(nxc,nyc,nzc),velgz(nxc,nyc,nzc)

```

```

real*4 vel1x(nxc,nyc,nzc),vel1y(nxc,nyc,nzc),vel1z(nxc,nyc,nzc)

```

```

c
variables to pass to the exodus subroutine

```

```

character*(32) coord_names(3)

```

```

character*(32) var_names(nvars)

```

```

integer num_dim

```

```

integer num_nodes

```

```

integer num_elem

```

```

integer num_elem_blk

```

```

real*4 x(nnds),y(nnds),z(nnds)

```

```

integer num_elem_in_block

```

```

integer conn(8,nel)

```

```

integer ntimesteps

```

```

real*4 time_values(maxtimes),time_values_days,time_values_secs

```

```

real*4 vars(maxtimes,nvars,nel)

```

```

real*4  elem_var_vals(num_elem)

5  format(a)
   dumm=' '
   fnameexo=' '
   fnameout=' '
   fnamemesh=' '

c    write(6,*)'enter tough output file name'
c    write(6,*)'-- entering a comma will use the default TOUGH2.OUT'
c    read(5,5)fnameout
c    if (fnameout .eq. ',') fnameout='TOUGH2.OUT'
   fnameout='TOUGH2.OUT'

c    write(6,*)'enter mesh file name'
c    write(6,*)'-- entering a comma will use the default MESH'
c    read(5,5)fnamemesh
c    if (fnamemesh .eq. ',') fnamemesh='MESH'
   fnamemesh='MESH'

c    write(6,*)'enter exodus file name using 9 chars or less'
c    write(6,*)'-- entering a comma will use the default TOUGH2.EXO'
c    read(5,5)fnameexo
c    if (fnameexo .eq. ',') fnameexo='TOUGH2.EXO'
   fnameexo='TOUGH2.EXO'

c    fnameout='ecmbssl.out'
c    fnamemesh='MESH'
c    fnameexo='ecmbssl.exo'

   write(6,*)
   write(6,*)
   write(6,*)'Tough2 output file name is: ',fnameout
   write(6,*)'Mesh file name is: ',fnamemesh
   write(6,*)'Exodus file name is: ',fnameexo
   write(6,*)

   OPEN (UNIT=1,STATUS='OLD',FILE=fnamemesh)
   OPEN (UNIT=2,STATUS='OLD',FILE=fnameout)

c*****
c
c    READ INPUT
c
c*****

c    read coordinates from mesh file

   open(unit=29,status='unknown',form='formatted')

   i=1
   READ(1,10)BLOCK
10  format(a)

   do i=1,nxc

```

```

do j=1,nyc
  do k=1,nzc
c      read by matrix data
      read(1,100) elemn1, xctmp, yctmp, zctmp

      read(1,100) elemn1, xctmp, yctmp, zctmp
      yctmp=yctmp*-1
      zctmp=zctmp+.6524
      if (elemn1(1:4) .eq. 'DUMM') then      ! if elem is dumm, skip
        dumm = 'yes'
        read(1,100) elemn1, xctmp, yctmp, zctmp
      endif
      call trans(elemn1,xidx1,yidx1,zidx1)
      xc(xidx1,yidx1,zidx1)=xctmp
      yc(xidx1,yidx1,zidx1)=yctmp
      zc(xidx1,yidx1,zidx1)=zctmp

c      don't ever delete the next write
c      it is used by the elemstemp.pro

      write(29,11)xidx1,yidx1,zidx1,elemn1,
*          xctmp,yctmp,zctmp

      enddo
    enddo
  enddo
11  format(3i6,2x,a5,2x,3(e15.6,2x))

100  format(a5,45x,3e10.4)
c100  format(a22,28x,3e10.4)

      close(29)
      close(32)

c      read distances between interfaces from mesh

      do k=1,nzc
        do j=1,nyc
          do i=1,nxc
            xdists(i,j,k)=-1
            ydists(i,j,k)=-1
            zdists(i,j,k)=-1
          enddo
        enddo
      enddo

      NCMAX=0

      READ(1,10)BLOCK
      READ(1,10)BLOCK

15  format(2a5,19x,i1,3e10.4)

16  read(1,15) elemn1, elemn2, direction, dist1, dist2
      if (elemn1(1:1) .eq. '+') goto 17
ccc
c      read by matrix data

```

```

        if (elemn1(1:1) .eq. 'M') goto 16
        if (elemn1(1:1) .ne. elemn2(1:1)) goto 16
ccc
        NCMAX=NCMAX+1
        call trans(elemn1,xidx1,yidx1,zidx1)

        if (dist1 .eq. 0) then
            write(27,*) 'dist eq 0 ',elemn1,' ', elemn2,
*                      direction
            dist1=.25
        endif
        if (dist2 .eq. 0) then
            write(27,*) 'dist eq 0 ',elemn1,' ', elemn2,
*                      direction
            dist2=.25
        endif

        if (direction .eq. 1) then
            xdist(xidx1,yidx1,zidx1)=dist1
            xdist(xidx1+1,yidx1,zidx1)=dist2

        elseif (direction .eq. 2) then
            ydist(xidx1,yidx1,zidx1)=dist1
            ydist(xidx1,yidx1+1,zidx1)=dist2

        elseif (direction .eq. 3) then
            zdist(xidx1,yidx1,zidx1)=dist1
            zdist(xidx1,yidx1,zidx1+1)=dist2
        else
            print *,elemn1,elemn2,direction,dist1,dist2
        endif

        goto 16

17      continue

        close(unit=27)
        close(unit=1)

c       read data from tough

        ntimesteps=0
89      READ(2,100,END=90) BLOCK
        IF(BLOCK(1:12).NE.' TOT') GO TO 89
c       IF(BLOCK(1:12).NE.' TOTAL TIME') GO TO 89
92      continue
        ntimesteps=ntimesteps+1
        READ(2,1001) time_values(ntimesteps)
        time_values_secs=time_values(ntimesteps)
        time_values_days = time_values(ntimesteps)/60/60/24
        time_values(ntimesteps)=time_values(ntimesteps)/60/60/24/365
        print *,ntimesteps,' ',
+          time_values_secs,' s ',
+          time_values_days,' d ',
+          time_values(ntimesteps),' yrs'

1001  FORMAT(E13.4)

```

```

READ(2,10) BLOCK2
READ(2,10) BLOCK2
READ(2,10) BLOCK2
READ(2,10) BLOCK2

if (block2(19:20) .eq. 'PA') READ(2,10) BLOCK2

C
c   if there is a "DUMM" record, line count must be incremented by 1
   if (dumm .eq. 'yes') then
       nmax=nel+1
   else
c       nmax=nel
       nmax=nel*2      ! for matrix and fracture files
   endif
c   nmax=nel
   N1=1
   N2=MIN(NMAX,45)
   DO 2000 I=N1,N2
   READ(2,1006) elemn1,PG,T,SG,SL,PCAP
c   get fracture data only
   if (elemn1(1:1) .ne. 'F') goto 2000
   call trans(elemn1,xidx1,yidx1,zidx1)
   pg3(xidx1,yidx1,zidx1)=pg
   t3(xidx1,yidx1,zidx1)=t
   sl3(xidx1,yidx1,zidx1)=sl
   pcap3(xidx1,yidx1,zidx1)=pcap
   if (ntimesteps .eq. 1) write(32,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
   if (ntimesteps .eq. 2) write(33,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
   if (ntimesteps .eq. 3) write(34,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl

c1002  FORMAT(12X,4E12.4,36X,E12.4)
1006   format(1x,a5,6x,4e12.5,36x,e12.5)
2000   CONTINUE
C
2100   CONTINUE
      IF(N2.EQ.NMAX) GO TO 91
      N1=N2+1
      N2=MIN(NMAX,N1+56)
      READ(2,10) BLOCK2
      READ(2,10) BLOCK2
      if (block2(19:20) .eq. 'PA') READ(2,100) BLOCK2
      DO 2010 I=N1,N2
      READ(2,1006) elemn1,PG,T,SG,SL,PCAP
c   get fracture data only
      if (elemn1(1:1) .ne. 'F') goto 2010
      if (elemn1 .ne. 'DUMM ') then
          call trans(elemn1,xidx1,yidx1,zidx1)
          pg3(xidx1,yidx1,zidx1)=pg
          t3(xidx1,yidx1,zidx1)=t
          sl3(xidx1,yidx1,zidx1)=sl
          pcap3(xidx1,yidx1,zidx1)=pcap
c       if (ntimesteps .eq. 9) write(32,*)elemn1,
c       *       xidx1,yidx1,zidx1,pg,t,sl

      if (ntimesteps .eq. 1) write(32,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
      if (ntimesteps .eq. 2) write(33,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl

```

```

        if (ntimesteps .eq. 3) write(34,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
    endif

2010 CONTINUE
    GO TO 2100
C
91 CONTINUE

    close(32)
    close(33)
    close(34)

c    translate data arrays into exo-friendly arrays

    call exoarrs2(nxc,nyc,nzc,pg3,vars,1,nel,maxtimes,ntimesteps,
+               nvars)
    call exoarrs2(nxc,nyc,nzc,t3,vars,2,nel,maxtimes,ntimesteps,
+               nvars)
    call exoarrs2(nxc,nyc,nzc,sl3,vars,3,nel,maxtimes,ntimesteps,
+               nvars)
    call exoarrs2(nxc,nyc,nzc,pcap3,vars,4,nel,maxtimes,ntimesteps,
+               nvars)

C
c    write slice files
C

c    open(unit=32,file='slice1.dat',status='unknown',form='formatted')
c    open(unit=33,file='slice2.dat',status='unknown',form='formatted')

cc    z=-5.14

c    write(32,*) 'time=',time_values(ntimesteps)
c    do j=1,nyc
c        do i=1,nxc
c            write(32,*)xc(i,j,11),yc(i,j,11),zc(i,j,11),
c            *          t3(i,j,11),sl3(i,j,11)
c        enddo
c    enddo

cc    x=.02125

c    write(33,*) 'time=', time_values(ntimesteps)
c    do k=1,nzc
c        do j=1,nyc
c            write(33,*)xc(1,j,k),yc(1,j,k),zc(1,j,k),t3(1,j,k),sl3(1,j,k)
c        enddo
c    enddo

c    close(32)
c    close(33)

c    read flow data

300    format(a22,28x,3e10.4)
    do i=1,999999

```

```

        read(2,300,end=190) block
        if (block(11:22) .eq. 'ELEM1 ELEM2') go to 289
        if (block(1:12) .eq. ' TOTAL TIME') go to 92
    enddo

c289  READ(2,100,END=190) BLOCK
c    IF(BLOCK(11:22).NE.'ELEM1 ELEM2') GO TO 289

289  continue
    READ(2,10) BLOCK2
    READ(2,10) BLOCK2
    if (block2(35:35) .eq. 'W') READ(2,10) BLOCK2
c
    N1=1
    N2=MIN(NCMAX,53)
    DO 1600 I=N1,N2
        read(2,1003)elemn1,elemn2,floh,floh_f,flof,flog,flol,velg,vell
        call flowfields(floh,flof,flog,flol,velg,vell,
+                       flohx,flohy,flohz,
+                       flogx,flogy,flogz,flolx,floly,flolz,
+                       velgx,velgy,velgz,vellx,velly,vellz,
+                       elemn1,elemn2,nxc,nyc,nzc)
1003  format(10x,a5,2x,a5,6x,7e13.4)
c    READ(2,1003) VELG(I),VELL(I)
c1003  FORMAT(93X,2E13.5)
c1200  FORMAT(1P,6(E12.4,x))
1600  CONTINUE
c

2150  CONTINUE
    IF(N2.EQ.NCMAX) GO TO 191
    N1=N2+1
    N2=MIN(NCMAX,N1+56)
    READ(2,10) BLOCK2
    READ(2,10) BLOCK2
    if (block2(35:35) .eq. 'W') READ(2,100) BLOCK2
c    READ(2,100) BLOCK
    DO 2020 I=N1,N2
c        READ(2,1003) VELG(I),VELL(I)
        read(2,1003)elemn1,elemn2,floh,floh_f,flof,flog,flol,velg,vell
        call flowfields(floh,flof,flog,flol,velg,vell,
+                       flohx,flohy,flohz,
+                       flogx,flogy,flogz,flolx,floly,flolz,
+                       velgx,velgy,velgz,vellx,velly,vellz,
+                       elemn1,elemn2,nxc,nyc,nzc)
2020  CONTINUE
    GO TO 2150
c

191  CONTINUE
c

c    put flow fields into variables array

    call exoarrs2(nxc,nyc,nzc,flohx,vars,5,nel,maxtimes,ntimesteps,
+               nvars)
    call exoarrs2(nxc,nyc,nzc,flohy,vars,6,nel,maxtimes,ntimesteps,
+               nvars)

```

```

      call exoarrs2(nxc,nyc,nzc,flohz,vars,7,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,flogx,vars,8,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,flogy,vars,9,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,flogz,vars,10,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,flolx,vars,11,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,floly,vars,12,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,flolz,vars,13,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,velgx,vars,14,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,velgy,vars,15,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,velgz,vars,16,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,vellx,vars,17,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,velly,vars,18,nel,maxtimes,ntimesteps,
+               nvars)
      call exoarrs2(nxc,nyc,nzc,vellz,vars,19,nel,maxtimes,ntimesteps,
+               nvars)
      print *, '-----'
      go to 89 ! start reading new time step

90      continue
190     CONTINUE

      close(unit=2)
      close(unit=32)
      close(unit=33)

C*****
C
C      CREATE NODES FROM CENTERS AND DISTANCES
C
C*****

c      first layer (this is the added layer)
c      do first point (is added), then first y (is added), then rest

xnds(1,1,1)=xc(1,1,1)-xdist(1,1,1)
ynds(1,1,1)=yc(1,1,1)+ydist(1,1,1)
znds(1,1,1)=zc(1,1,1)+zdist(1,1,1)
do i=1,nxc
  xnds(i+1,1,1)=xc(i,1,1)+xdist(i,1,1)
  ynds(i+1,1,1)=yc(i,1,1)+ydist(i,1,1)
  znds(i+1,1,1)=zc(i,1,1)+zdist(i,1,1)
enddo
do j=1,nyc
  xnds(1,j+1,1)=xc(1,j,1)-xdist(1,j,1)
  ynds(1,j+1,1)=yc(1,j,1)-ydist(1,j,1)
  znds(1,j+1,1)=zc(1,j,1)+zdist(1,j,1)

```

```

      do i=1,nxc
        xnds(i+1,j+1,1)=xc(i,j,1)+xdist(i,j,1)
        ynds(i+1,j+1,1)=yc(i,j,1)-ydist(i,j,1)
        znds(i+1,j+1,1)=zc(i,j,1)+zdist(i,j,1)
      enddo
    enddo

c    x nodes - rest of layers

    do k=1,nzc
      xnds(1,1,k+1)=xc(1,1,k)-xdist(1,1,k)
      ynds(1,1,k+1)=yc(1,1,k)+ydist(1,1,k)
      znds(1,1,k+1)=zc(1,1,k)-zdist(1,1,k)
      do i=1,nxc
        xnds(i+1,1,k+1)=xc(i,1,k)+xdist(i,1,k)
        ynds(i+1,1,k+1)=yc(i,1,k)+ydist(i,1,k)
        znds(i+1,1,k+1)=zc(i,1,k)-zdist(i,1,k)
      enddo
      do j=1,nyc
        xnds(1,j+1,k+1)=xc(1,j,k)-xdist(1,j,k)
        ynds(1,j+1,k+1)=yc(1,j,k)-ydist(1,j,k)
        znds(1,j+1,k+1)=zc(1,j,k)-zdist(1,j,k)
        do i=1,nxc
          xnds(i+1,j+1,k+1)=xc(i,j,k)+xdist(i,j,k)
          ynds(i+1,j+1,k+1)=yc(i,j,k)-ydist(i,j,k)
          znds(i+1,j+1,k+1)=zc(i,j,k)-zdist(i,j,k)
        enddo
      enddo
    enddo

    if (nyc .eq. 1) then
      do k=1,nznds
        do i=1,nxnds
          ynds(i,1,k)=0
          ynds(i,2,k)=1
        enddo
      enddo
    endif

c    put nodes in 1d arrays for exodus

    ctr=0
    do k=1,nznds
      do j=1,nynds
        do i=1,nxnds
          ctr=ctr+1
          x(ctr)=xnds(i,j,k)
          y(ctr)=ynds(i,j,k)
          z(ctr)=znds(i,j,k)
        enddo
      enddo
    enddo

c*****
c
c    CREATE CONNECTIVITY LIST
c

```

```

C
C*****

      ctr=0
      ctr2=0
      do k=1,nznds-1
        ctr=nxnds*nynds*(k-1)
        do j=1,nynds-1
          do i=1,nxnds-1
            ctr=ctr+1
            ctr2=ctr2+1
            conn(5,ctr2)=ctr
            conn(6,ctr2)=conn(5,ctr2)+1
            conn(7,ctr2)=conn(6,ctr2)+nxnds
            conn(8,ctr2)=conn(5,ctr2)+nxnds
            conn(1,ctr2)=conn(5,ctr2)+(nxnds*nynds)
            conn(2,ctr2)=conn(6,ctr2)+(nxnds*nynds)
            conn(3,ctr2)=conn(7,ctr2)+(nxnds*nynds)
            conn(4,ctr2)=conn(8,ctr2)+(nxnds*nynds)
          enddo
          ctr=ctr+1
        enddo
      enddo

C*****
C
C      WRITE EXODUS FILE
C
C*****

      coord_names(1)='x'
      coord_names(2)='y'
      coord_names(3)='z'

      num_dim=3
      num_nodes=nnds
      num_elem=nel
      num_elem_blk=1
      num_elem_in_block=nel

      write pressure, temperature, liquid saturation, and cap pressure

      call wriexo1(coord_names,num_dim,num_nodes,
      +           num_elem,num_elem_blk,x,y,z,num_elem_in_block,
      +           conn,nvars,ntimesteps,time_values,vars,maxtimes,
      +           fnameexo,elem_var_vals)

      write flow variables

      call wriexo2(coord_names,num_dim,num_nodes,
      +           num_elem,num_elem_blk,x,y,z,num_elem_in_block,
      +           conn,nvars,ntimesteps,time_values,vars,maxtimes,
      +           fnameexo,elem_var_vals)

C*****
C      fort.22 - write ucd file

```

```

        open(unit=22,file='srs.inp',status='unknown',form='formatted')
        write(22,9058)'# AVS UCD File'
        write(22,9057)'#',ntimesteps
        print *, ntimesteps

9053 format(a2,35f15.10)

        write(22,9053),'# ',(time_values(j),j=1,ntimesteps)
        write(22,*)nnds,nel,' 0 ', ntimesteps, ' 0'

9057 format(a1,i3)
9058 format(a14)
9060 format(i5,3f12.6)
        do i=1,num_nodes
            write(22,9060)i,x(i),y(i),z(i)
        enddo
        do i=1,num_elem
            write(22,9059)i,(conn(j,i),j=1,8)
        enddo
9059 format(i5,' 1 hex ',8i7)

        write(22,*)ntimesteps,' 1'
        write(22,*)'temp, '

9063 format(i5,35f15.10)
        do i=1,num_elem
            write(22,9063,err=9062)i,(vars(j,2,i),j=1,ntimesteps)
        enddo

c      fort.31 - write temps for steve for input to jac3d

c      ctr=0
c      write(31,*)nel,ntimesteps
c      write(31,*)(time_values(i),i=1,ntimesteps)
c      do k=1,nzc
c          do j=1,nyc
c              do i=1,nxc
c                  ctr=ctr+1
c                  write(31,*)ctr,xc(i,j,k),yc(i,j,k),zc(i,j,k)
c              enddo
c          enddo
c      enddo

c      do i=1,nel
c          write(31,9063,err=9062)i,(vars(j,2,i),j=1,ntimesteps)
c      enddo
c      close(31)

c      fort.30 - write data for sandy

        ctr=0
        open(unit=30,file='s_frac.dat',status='unknown',form='formatted')
        do k=1,nzc
            do j=1,nyc
                do i=1,nxc
                    ctr=ctr+1

```

```

c          vars(maxtimes,nvars,nel)

          write(30,9067)xc(i,j,k),yc(i,j,k),zc(i,j,k),
*          vars(sandytime,1,ctr),    ! pressure
*          vars(sandytime,2,ctr),    ! temp
*          vars(sandytime,3,ctr)     ! liq sat
          enddo
        enddo
      enddo
    close(30)

c      print *, xc(nxc,nyc,nzc),yc(nxc,nyc,nzc),vars(3,2,ctr)
9062 close(unit=22)
      close(unit=30)

      9067 format(3f10.5,3e12.4)
c 9067 format(3f10.5,3f15.10)

*****
c      fort.23 - write nodes

      open(unit=23,file='nodes.dat',status='unknown',form='formatted')

      write(23,*)'x'
      do i=1,nxnds
        write(23,*)xnds(i,1,1)
      enddo
      write(23,*)'y'
      do i=1,nynds
        write(23,*)ynds(1,i,1)
      enddo
      write(23,*)'z'
      do i=1,nznds
        write(23,*)znds(1,1,i)
      enddo
      close(23)

c      fort.24 - write element centers

      open(unit=24,file='ctrs.dat',status='unknown',form='formatted')

      write(24,*)'x'
      do i=1,nxc
        write(24,*)xc(i,1,1)
      enddo
      write(24,*)'y'
      do i=1,nyc
        write(24,*)yc(1,i,1)
      enddo
      write(24,*)'z'
      do i=1,nzc
        write(24,*)zc(1,1,i)
      enddo
      close(24)

```

```

end
subroutine exoarrs2(nxc,nyc,nzc,tmp,vars,varsidx,nel,
+                 maxtimes,ntimesteps,nvars)

c   convert arrays into exodus array order

integer nxc, nyc, nzc, nel, varsidx, maxtimes,ntimesteps, nvars
real*4 vars(maxtimes,nvars,nel)
integer i, j, k, ctr
real*4 tmp(nxc,nyc,nzc)

ctr=0
do k=1,nzc
  do j=1,nyc
    do i=1,nxc
      ctr=ctr+1
      vars(ntimesteps,varsidx,ctr)=tmp(i,j,k)
    enddo
  enddo
enddo

end
subroutine flowfields(floh,flof,flog,flol,velg,vell,
+                   flohx,flohy,flohz,
+                   flogx,flogy,flogz,flolx,floly,flolz,
+                   velgx,velgy,velgz,vellx,velly,vellz,
+                   elemn1,elemn2,nxc,nyc,nzc)

integer nxc, nyc, nzc
real*4 floh, flof, flog, flol, velg, vell
real*4 flohx(nxc,nyc,nzc), flohy(nxc,nyc,nzc), flohz(nxc,nyc,nzc)
real*4 flogx(nxc,nyc,nzc), flogy(nxc,nyc,nzc), flogz(nxc,nyc,nzc)
real*4 flolx(nxc,nyc,nzc), floly(nxc,nyc,nzc), flolz(nxc,nyc,nzc)
real*4 velgx(nxc,nyc,nzc), velgy(nxc,nyc,nzc), velgz(nxc,nyc,nzc)
real*4 vellx(nxc,nyc,nzc), velly(nxc,nyc,nzc), vellz(nxc,nyc,nzc)
character*5 elemn1, elemn2

integer xidx1, yidx1, zidx1, xidx2, yidx2, zidx2

call trans(elemn1,xidx1,yidx1,zidx1)
call trans(elemn2,xidx2,yidx2,zidx2)
if (xidx1 .ne. xidx2) then      !flow direction is x
  flohx(xidx1,yidx1,zidx1)=floh
  flogx(xidx1,yidx1,zidx1)=flog
  flolx(xidx1,yidx1,zidx1)=flol
  velgx(xidx1,yidx1,zidx1)=velg
  vellx(xidx1,yidx1,zidx1)=vell
elseif (yidx1 .ne. yidx2) then !flow direction is y
  flohy(xidx1,yidx1,zidx1)=floh
  flogy(xidx1,yidx1,zidx1)=flog
  floly(xidx1,yidx1,zidx1)=flol
  velgy(xidx1,yidx1,zidx1)=velg
  velly(xidx1,yidx1,zidx1)=vell
elseif (zidx1 .ne. zidx2) then !flow direction is z
  flohz(xidx1,yidx1,zidx1)=floh
  flogz(xidx1,yidx1,zidx1)=flog
  flolz(xidx1,yidx1,zidx1)=flol

```

```

        velgz(xidx1,yidx1,zidx1)=velg
        vellz(xidx1,yidx1,zidx1)=vell
    endif
end
subroutine trans(en,xidx1,yidx1,zidx1)

```

c translate element name into array indices

```

character*5 en
integer xidx1, yidx1, zidx1

if (en(2:2) .eq. '1') then
    zidx1=1
elseif (en(2:2) .eq. '2') then
    zidx1=2
elseif (en(2:2) .eq. '3') then
    zidx1=3
elseif (en(2:2) .eq. '4') then
    zidx1=4
elseif (en(2:2) .eq. '5') then
    zidx1=5
elseif (en(2:2) .eq. '6') then
    zidx1=6
elseif (en(2:2) .eq. '7') then
    zidx1=7
elseif (en(2:2) .eq. '8') then
    zidx1=8
elseif (en(2:2) .eq. '9') then
    zidx1=9
elseif (en(2:2) .eq. 'A') then
    zidx1=10
elseif (en(2:2) .eq. 'B') then
    zidx1=11
elseif (en(2:2) .eq. 'C') then
    zidx1=12
elseif (en(2:2) .eq. 'D') then
    zidx1=13
elseif (en(2:2) .eq. 'E') then
    zidx1=14
elseif (en(2:2) .eq. 'F') then
    zidx1=15
elseif (en(2:2) .eq. 'G') then
    zidx1=16
elseif (en(2:2) .eq. 'H') then
    zidx1=17
elseif (en(2:2) .eq. 'I') then
    zidx1=18
elseif (en(2:2) .eq. 'J') then
    zidx1=19
elseif (en(2:2) .eq. 'K') then
    zidx1=20
elseif (en(2:2) .eq. 'L') then
    zidx1=21
elseif (en(2:2) .eq. 'M') then
    zidx1=22
elseif (en(2:2) .eq. 'N') then
    zidx1=23

```

```

elseif (en(2:2) .eq. 'O') then
  zidx1=24
elseif (en(2:2) .eq. 'P') then
  zidx1=25
elseif (en(2:2) .eq. 'Q') then
  zidx1=26
elseif (en(2:2) .eq. 'R') then
  zidx1=27
elseif (en(2:2) .eq. 'S') then
  zidx1=28
elseif (en(2:2) .eq. 'T') then
  zidx1=29
elseif (en(2:2) .eq. 'U') then
  zidx1=30
elseif (en(2:2) .eq. 'V') then
  zidx1=31
elseif (en(2:2) .eq. 'W') then
  zidx1=32
elseif (en(2:2) .eq. 'X') then
  zidx1=33
elseif (en(2:2) .eq. 'Y') then
  zidx1=34
elseif (en(2:2) .eq. 'Z') then
  zidx1=35
else
  print *, 'trans error -- z --',en,'-- '
endif

if (en(1:1) .eq. 'B') zidx1=zidx1+35

if (en(3:3) .eq. '1') then
  yidx1=1
elseif (en(3:3) .eq. '2') then
  yidx1=2
elseif (en(3:3) .eq. '3') then
  yidx1=3
elseif (en(3:3) .eq. '4') then
  yidx1=4
elseif (en(3:3) .eq. '5') then
  yidx1=5
elseif (en(3:3) .eq. '6') then
  yidx1=6
elseif (en(3:3) .eq. '7') then
  yidx1=7
elseif (en(3:3) .eq. '8') then
  yidx1=8
elseif (en(3:3) .eq. '9') then
  yidx1=9
elseif (en(3:3) .eq. 'A') then
  yidx1=10
elseif (en(3:3) .eq. 'B') then
  yidx1=11
elseif (en(3:3) .eq. 'C') then
  yidx1=12
elseif (en(3:3) .eq. 'D') then
  yidx1=13
elseif (en(3:3) .eq. 'E') then

```

```

        yidx1=14
    elseif (en(3:3) .eq. 'F') then
        yidx1=15
    elseif (en(3:3) .eq. 'G') then
        yidx1=16
    elseif (en(3:3) .eq. 'H') then
        yidx1=17
    elseif (en(3:3) .eq. 'I') then
        yidx1=18
    elseif (en(3:3) .eq. 'J') then
        yidx1=19
    elseif (en(3:3) .eq. 'K') then
        yidx1=20
    elseif (en(3:3) .eq. 'L') then
        yidx1=21
    elseif (en(3:3) .eq. 'M') then
        yidx1=22
    elseif (en(3:3) .eq. 'N') then
        yidx1=23
    elseif (en(3:3) .eq. 'O') then
        yidx1=24
    elseif (en(3:3) .eq. 'P') then
        yidx1=25
    elseif (en(3:3) .eq. 'Q') then
        yidx1=26
    elseif (en(3:3) .eq. 'R') then
        yidx1=27
    elseif (en(3:3) .eq. 'S') then
        yidx1=28
    elseif (en(3:3) .eq. 'T') then
        yidx1=29
    elseif (en(3:3) .eq. 'U') then
        yidx1=30
    elseif (en(3:3) .eq. 'V') then
        yidx1=31
    elseif (en(3:3) .eq. 'W') then
        yidx1=32
    elseif (en(3:3) .eq. 'X') then
        yidx1=33
    elseif (en(3:3) .eq. 'Y') then
        yidx1=34
    elseif (en(3:3) .eq. 'Z') then
        yidx1=35
    else
        print *, 'trans error -- y --',en,'-- '
    endif

    read(en(4:5), '(i4)')xidx1

end

cvv      subroutine wriexol(coord_names,num_dim,num_nodes,
cvv      +                  num_elem,num_elem_blk,x,y,z,num_elem_in_block,
cvv      +                  conn,nvars,ntimesteps,time_values,vars,maxtimes,
cvv      +                  fnameexo,elem_var_vals)

cvv      implicit none

```

```

cvv      include 'exodusII.inc'

cvv      character*(MXSTLN) coord_names(3)
cvv      character*(MXSTLN) var_names(4)
cvv      integer num_dim
cvv      integer num_nodes
cvv      integer num_elem
cvv      integer num_elem_blk
cvv      real*4  x(num_nodes), y(num_nodes), z(num_nodes)
cvv      integer num_elem_in_block
cvv      integer conn(8,num_elem)
cvv      integer nvars
cvv      integer ntimesteps
cvv      real*4  time_values(maxtimes)
cvv      real*4  vars(maxtimes,nvars,num_elem)
cvv      integer maxtimes
cvv      real*4  elem_var_vals(num_elem)

cvv      integer num_node_sets, num_side_sets, idx

cvv      integer cpu_word_size, io_word_size
cvv      character*(MXSTLN) cname
cvv      character*14 fnameexo
cvv      character*(MXLNLN) exottl
cvv      integer nvarswri

cvv      integer i, m, k, iii, ierr, exoid

cvv      cpu_word_size=0
cvv      io_word_size=0
cvv      nvarswri=4

cvv      var_names(1)='pressure'
cvv      var_names(2)='temperature'
cvv      var_names(3)='liquid saturation'
cvv      var_names(4)='capillary pressure'

cvv      exottl='tough stuff'

cvv      print *, ' '
cvv      print *, 'writing first exodus ...'

c      create exodus II file

cvv      exoid=excre(fnameexo,exclob,cpu_word_size,io_word_size,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exoid'

c      initialize file with parameters

c      num_dim=
c      num_nodes=
c      num_elem=
c      num_elem_blk=
cvv      num_node_sets=0
cvv      num_side_sets=0

```

```

cvv      call expini(exoid,exottl,num_dim,num_nodes,num_elem,
cvv      +          num_elem_blk,num_node_sets,num_side_sets,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expini'

c        write nodal coordinates values and names to database

cvv      call expcor(exoid,x,y,z,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcor'

c        coord_names

cvv      call expcon(exoid,coord_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcon'

c        write element block parameters

cvv      cname='HEX'
cvv      do i=1,num_elem_blk
cvv          call expelb(exoid,i,cname,num_elem_in_block,8,0,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelb ... ',i
cvv      enddo

c        write element connectivity

cvv      do i=1,num_elem_blk
cvv          call expelc(exoid,i,conn,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelc'
cvv      enddo

c        write number of element variables

cvv      call expvp(exoid,'e',nvarswri,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expelc'

c        write element variable names

cvv      call expvan(exoid,'e',nvarswri,var_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expvan'

c        write data for each time step

cvv      do iii=1,ntimesteps

c          write time value

cvv          call exptim(exoid,iii,time_values(iii),ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error exptim...',time_values(iii)

c          write element variables

cvv          do k=1,nvarswri
cvv              idx=0
cvv              do m=1,num_elem_in_block
cvv                  idx=idx+1
cvv                  elem_var_vals(idx)=vars(iii,k,m)
cvv              enddo

```

```

cvv          call expev(exoid,iii,k,1,num_elem_in_block,
cvv          +          elem_var_vals,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expev ... ',
cvv          +          time_values(iii)
cvv          enddo

c          update file

cvv          call exupda(exoid,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error exupda'

cvv          enddo

c          close file

cvv          call exclos(exoid,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error exclos'

cvv          return
cvv          end

cvv          subroutine wriexo2(coord_names,num_dim,num_nodes,
cvv          +                  num_elem,num_elem_blk,x,y,z,num_elem_in_block,
cvv          +                  conn,nvars,ntimesteps,time_values,vars,maxtimes,
cvv          +                  fnameexo,elem_var_vals)

cvv          implicit none
cvv          include 'exodusII.inc'
cvv
cvv          character*(MXSTLN) coord_names(3)
cvv          character*(MXSTLN) var_names(15)
cvv          integer num_dim
cvv          integer num_nodes
cvv          integer num_elem
cvv          integer num_elem_blk
cvv          real*4 x(num_nodes), y(num_nodes), z(num_nodes)
cvv          integer num_elem_in_block
cvv          integer conn(8,num_elem)
cvv          integer nvars
cvv          integer ntimesteps
cvv          real*4 time_values(maxtimes)
cvv          real*4 vars(maxtimes,nvars,num_elem)
cvv          integer maxtimes
cvv          real*4 elem_var_vals(num_elem)

cvv          integer num_node_sets, num_side_sets, idx

cvv          integer cpu_word_size, io_word_size
cvv          character*(MXSTLN) cname
cvv          character*14 fnameexo
cvv          character*(MXLNLN) exottl
cvv          integer nvarswri
cvv          real*4 aaa

cvv          integer i, m, j, k, iii, ierr, exoid

```

```

cvv      cpu_word_size=0
cvv      io_word_size=0
cvv      nvarswri=15

cvv      do i=1,15
cvv          var_names(i)=
cvv      enddo

cvv      var_names(1)='heat flow, x'
cvv      var_names(2)='heat flow, y'
cvv      var_names(3)='heat flow, z'
cvv      var_names(4)='gas phase flow, x'
cvv      var_names(5)='gas phase flow, y'
cvv      var_names(6)='gas phase flow, z'
cvv      var_names(7)='liq phase flow, x'
cvv      var_names(8)='liq phase flow, y'
cvv      var_names(9)='liq phase flow, z'
cvv      var_names(10)='gas flow vel, x'
cvv      var_names(11)='gas flow vel, y'
cvv      var_names(12)='gas flow vel, z'
cvv      var_names(13)='liq flow vel,x'
cvv      var_names(14)='liq flow vel,y'
cvv      var_names(15)='liq flow vel,z'

cvv      exottl='tough stuff'

cvv      print *, 'writing second exodus ...'

c      create exodus II file

cvv      i=index(fnameexo, ' ')
cvv      fnameexo(i:i+1)='.f'

cvv      exoid=excre(fnameexo,exclob,cpu_word_size,io_word_size,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exoid'

c      initialize file with parameters

cvv      num_node_sets=0
cvv      num_side_sets=0

cvv      call expini(exoid,exottl,num_dim,num_nodes,num_elem,
cvv      +          num_elem_blk,num_node_sets,num_side_sets,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expini'

c      write nodal coordinates values and names to database

cvv      call expcor(exoid,x,y,z,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcor'

c      coord_names

cvv      call expcon(exoid,coord_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcon'

c      write element block parameters

```

```

cvv      cname='HEX'
cvv      do i=1,num_elem_blk
cvv          call expelb(exoid,i,cname,num_elem_in_block,8,0,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelb ... ',i
cvv      enddo

c        write element connectivity

cvv      do i=1,num_elem_blk
cvv          call expelc(exoid,i,conn,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelc'
cvv      enddo

c        write number of element variables

cvv      call expvp(exoid,'e',nvarswri,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expelc'

c        write element variable names

cvv      call expvan(exoid,'e',nvarswri,var_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expvan'

c        write data for each time step

cvv      do iii=1,ntimesteps

c          write time value

cvv          call exptim(exoid,iii,time_values(iii),ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error exptim...',time_values(iii)

c          write element variables

cvv          j=0
cvv          do k=5,19
cvv              idx=0
cvv              do m=1,num_elem_in_block
cvv                  idx=idx+1
cvv                  elem_var_vals(idx)=vars(iii,k,m)
cvv              enddo
cvv              j=j+1
cvv              call expev(exoid,iii,j,1,num_elem_in_block,
cvv          +              elem_var_vals,ierr)
cvv              if (ierr .ne. 0) write(6,*) 'error expev ... ',
cvv          +              time_values(iii)
cvv          enddo

c          update file

cvv          call exupda(exoid,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error exupda'

cvv      enddo

c        close file

```

```

cvv      call exclos(exoid,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exclos'

cvv      return
cvv      end

```

This processor has been checked for all cases considered in this AMR: drift scale property set for TSPA-SR, and the sensitivity studies TSPA-VA and median Kb. The spot check results (routine result file vs. TOUGH2.OUT) are the following for element **FAB 1** (a fracture element):

At 56, 114, 182, and 273 simulated days for the DS property set results:

Time (days)	56	114	182	273
Temperature (°C)	92.17	99.89	106.4	110.6
Liquid Saturation	0.1718	0.0	0.0	0.0
Pressure (Pa)	0.8693×10^5	0.8712×10^5	0.8709×10^5	0.8716×10^5

These are identical to TOUGH2.OUT results as checked by visual inspection.

At 56, 114, 182, and 273 simulated days for the TSPA-VA property set results:

Time (days)	56	114	182	273
Temperature (°C)	95.67	95.74	96.59	103.7
Liquid Saturation	0.1385	0.06447	0.0	0.0
Pressure (Pa)	0.8691×10^5	0.8694×10^5	0.8795×10^5	0.8695×10^5

These are identical to TOUGH2.OUT results as checked by visual inspection.

At 56, 114, and 182 simulated days for the median Kb property set results:

Time (days)	56	114	182
Temperature (°C)	95.68	100.8	108.4
Liquid Saturation	0.1503	0.0	0.0
Pressure (Pa)	0.8775×10^5	0.8998×10^5	0.8974×10^5

These are identical to TOUGH2.OUT results as checked by visual inspection. The matrix extraction is also verified.

tough_extract_mtrx.f (Version 1.)

This routine reads the TOUGH2.OUT file for a simulation and writes the matrix temperature, liquid saturation, and pressure into column format with its x, y, z coordinate locations required by the routine Compare. The software routine is the following:

```

program avsinp

```

```

c
c   this program reads matrix data from a tough2.out file
c   that contains both matrix and fracture data
c
c   modified srs.inp to write temps for all time steps
c   writes element names and array indexes to fort.29
c   writes slices to fort.32 and fort.33
c   f77 -C avsinp.f --> bound checking
c
C
C   PROGRAM TO GET DATA FROM TOUGH FILE TO MAKE EXODUSII FILE
C
c   this version only reads in 19 variables and writes 2 exo files
c
c   max x - 99
c       y - 35
c       z - 61
c
c           1           2           3           4           5           6           7
c23456789012345678901234567890123456789012345678901234567890123456789012
c
c   implicit none
c
c   integer nel, nnds, nxc, nyc, nzc, nxnds, nynds, nznds, ncmx
c   integer maxtimes, num_elem
c   character*14 fnameexo, fnameout, fnamemesh
c   integer sandytime, sandyvar ! write temp file at this timestep
c!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!c
c
c   parameter(nxc=18, nyc=35, nzc=20)
c   parameter(maxtimes=35)
c   parameter(sandytime=11,sandyvar=3) ! 1=pressure 2=temp 3=liq sat
c!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!c
c
c   parameter(nel=nxc*nyc*nzc)
c   parameter(num_elem=nel)
c   parameter(nxnds=nxc+1, nynds=nyc+1, nznds=nzc+1)
c   parameter(nnds=nxnds*nynds*nznds)
c
c   integer nvars
c   parameter(nvars=19)
c   real*4 xc(nxc,nyc,nzc), yc(nxc,nyc,nzc), zc(nxc,nyc,nzc)
c   real*4 xctmp,yctmp,zctmp
c   real*4 xnds(nxnds,nynds,nznds), ynds(nxnds,nynds,nznds)
c   real*4 znds(nxnds,nynds,nznds)
c   character*22 block
c   character*50 block2
c   integer nmax, i, j, k, ctr, ctr2
c   real*4 n1, n2
c
c   real*4 pg(nel), t(nel), sg, sl(nel), pcap(nel)
c   real*4 pg, t, sg, sl, pcap
c   real*4 pg3(nxc,nyc,nzc), t3(nxc,nyc,nzc)
c   real*4 sl3(nxc,nyc,nzc), pcap3(nxc,nyc,nzc)

```

```

character*5 elemn1, elemn2
character*3 dumm
integer direction
real*4 dist1, dist2
real*4 xdist(nxc,nyc,nzc), ydist(nxc,nyc,nzc), zdist(nxc,nyc,nzc)
integer xidx1,yidx1,zidx1

c   flow variables

real*4 floh, floh_f, flog, flog, flol, velg, vell
real*4 flohx(nxc,nyc,nzc), flohy(nxc,nyc,nzc), flohz(nxc,nyc,nzc)
real*4 flogx(nxc,nyc,nzc), flogy(nxc,nyc,nzc), flogz(nxc,nyc,nzc)
real*4 flolx(nxc,nyc,nzc), floly(nxc,nyc,nzc), flolz(nxc,nyc,nzc)
real*4 velgx(nxc,nyc,nzc), velgy(nxc,nyc,nzc), velgz(nxc,nyc,nzc)
real*4 vellx(nxc,nyc,nzc), velly(nxc,nyc,nzc), vellz(nxc,nyc,nzc)

c   variables to pass to the exodus subroutine

character*(32) coord_names(3)
c   character*(32) var_names(nvars)
integer num_dim
integer num_nodes
c   integer num_elem
integer num_elem_blk
real*4 x(nnds), y(nnds), z(nnds)
integer num_elem_in_block
integer conn(8,nel)
integer ntimesteps
real*4 time_values(maxtimes)
real*4 vars(maxtimes,nvars,nel)
real*4 elem_var_vals(num_elem)

5   format(a)
dumm=' '
fnameexo=' '
fnameout=' '
fnamemesh=' '

c   write(6,*) 'enter tough output file name'
c   write(6,*) '-- entering a comma will use the default TOUGH2.OUT'
c   read(5,5) fnameout
c   if (fnameout .eq. ',') fnameout='TOUGH2.OUT'
fnameout='TOUGH2.OUT'

c   write(6,*) 'enter mesh file name'
c   write(6,*) '-- entering a comma will use the default MESH'
c   read(5,5) fnamemesh
c   if (fnamemesh .eq. ',') fnamemesh='MESH'
fnamemesh='MESH'

c   write(6,*) 'enter exodus file name using 9 chars or less'
c   write(6,*) '-- entering a comma will use the default TOUGH2.EXO'
c   read(5,5) fnameexo
c   if (fnameexo .eq. ',') fnameexo='TOUGH2.EXO'
fnameexo='TOUGH2.EXO'

```

```

c      fnameout='ecmbsl.out'
c      fnamemesh='MESH'
c      fnameexo='ecmbsl.exo'

write(6,*)
write(6,*)
write(6,*)'Tough2 output file name is: ',fnameout
write(6,*)'Mesh file name is: ',fnamemesh
write(6,*)'Exodus file name is: ',fnameexo
write(6,*)

OPEN (UNIT=1,STATUS='OLD',FILE=fnamemesh)
OPEN (UNIT=2,STATUS='OLD',FILE=fnameout)

c*****
c
c      READ INPUT
c
c*****

c      read coordinates from mesh file

      open(unit=29,status='unknown',form='formatted')

      i=1
      READ(1,10)BLOCK
10    format(a)

      do i=1,nxc
        do j=1,nyc
          do k=1,nzc
            read(1,100) elemn1, xctmp, yctmp, zctmp
            yctmp=yctmp*-1
            zctmp=zctmp+.6524
            if (elemn1(1:4) .eq. 'DUMM') then      ! if elem is dumm, skip
              dumm = 'yes'
              read(1,100) elemn1, xctmp, yctmp, zctmp
            endif
            call trans(elemn1,xidx1,yidx1,zidx1)
            xc(xidx1,yidx1,zidx1)=xctmp
            yc(xidx1,yidx1,zidx1)=yctmp
            zc(xidx1,yidx1,zidx1)=zctmp

c            don't ever delete the next write
c            it is used by the elemstemp.pro

            write(29,11)xidx1,yidx1,zidx1,elemn1,
*              xctmp,yctmp,zctmp

c            read by fracture data
            read(1,100) elemn1, xctmp, yctmp, zctmp
          enddo
        enddo
      enddo
11    format(3i6,2x,a5,2x,3(e15.6,2x))

```

```

100  format(a5,45x,3e10.4)
c100  format(a22,28x,3e10.4)

      close(29)
      close(32)

c      read distances between interfaces from mesh

      do k=1,nzc
        do j=1,nyc
          do i=1,nxc
            xdist(i,j,k)=-1
            ydist(i,j,k)=-1
            zdist(i,j,k)=-1
          enddo
        enddo
      enddo

      NCMAX=0

      READ(1,10)BLOCK
      READ(1,10)BLOCK

15    format(2a5,19x,i1,3e10.4)

16    read(1,15) elemn1, elemn2, direction, dist1, dist2
      if (elemn1(1:1) .eq. '+') goto 17
ccc
c      read by fracture data
      if (elemn1(1:1) .eq. 'F') goto 16
      if (elemn1(1:1) .ne. elemn2(1:1)) goto 16
ccc
      NCMAX=NCMAX+1
      call trans(elemn1,xidx1,yidx1,zidx1)

      if (dist1 .eq. 0) then
        write(27,*) 'dist eq 0 ',elemn1,' ', elemn2,
*                  direction
        dist1=.25
      endif
      if (dist2 .eq. 0) then
        write(27,*) 'dist eq 0 ',elemn1,' ', elemn2,
*                  direction
        dist2=.25
      endif

      if (direction .eq. 1) then
        xdist(xidx1,yidx1,zidx1)=dist1
        xdist(xidx1+1,yidx1,zidx1)=dist2

      elseif (direction .eq. 2) then
        ydist(xidx1,yidx1,zidx1)=dist1
        ydist(xidx1,yidx1+1,zidx1)=dist2

      elseif (direction .eq. 3) then
        zdist(xidx1,yidx1,zidx1)=dist1

```

```

        zdist(xidx1,yidx1,zidx1+1)=dist2
    else
        print *,elemn1,elemn2,direction,dist1,dist2
    endif

    goto 16

17    continue

    close(unit=27)
    close(unit=1)

c    read data from tough

    ntimesteps=0
89    READ(2,100,END=90) BLOCK
    IF(BLOCK(1:12).NE.' TOT') GO TO 89
c    IF(BLOCK(1:12).NE.' TOTAL TIME') GO TO 89
92    continue
    ntimesteps=ntimesteps+1
    READ(2,1001) time_values(ntimesteps)
    time_values(ntimesteps)=time_values(ntimesteps)/60/60/24/365
    print *, 'reading ',time_values(ntimesteps),' years'

1001  FORMAT(E13.4)
    READ(2,10) BLOCK2
    READ(2,10) BLOCK2
    READ(2,10) BLOCK2
    READ(2,10) BLOCK2

    if (block2(19:20) .eq. 'PA') READ(2,10) BLOCK2

C
c    if there is a "DUMM" record, line count must be incremented by 1
    if (dumm .eq. 'yes') then
        nmax=nel+1
    else
c        nmax=nel
        nmax=nel*2      ! for matrix and fracture files
    endif
c    nmax=nel
    N1=1
    N2=MIN(NMAX,45)
    DO 2000 I=N1,N2
        READ(2,1006) elemn1,PG,T,SG,SL,PCAP
c    read by fracture data
        if (elemn1(1:1) .ne. 'M') goto 2000
        call trans(elemn1,xidx1,yidx1,zidx1)
        pg3(xidx1,yidx1,zidx1)=pg
        t3(xidx1,yidx1,zidx1)=t
        sl3(xidx1,yidx1,zidx1)=sl
        pcap3(xidx1,yidx1,zidx1)=pcap
c        if (ntimesteps .eq. 1) write(32,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
c        if (ntimesteps .eq. 2) write(33,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
c        if (ntimesteps .eq. 3) write(34,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl

c1002  FORMAT(12X,4E12.4,36X,E12.4)

```

```

1006 format(1x,a5,6x,4e12.5,36x,e12.5)
2000 CONTINUE
C
2100 CONTINUE
      IF(N2.EQ.NMAX) GO TO 91
      N1=N2+1
      N2=MIN(NMAX,N1+56)
      READ(2,10) BLOCK2
      READ(2,10) BLOCK2
      if (block2(19:20) .eq. 'PA') READ(2,100) BLOCK2
      DO 2010 I=N1,N2
      READ(2,1006) elemn1,PG,T,SG,SL,PCAP
c      read by fracture data
      if (elemn1(1:1) .ne. 'M') goto 2010
      if (elemn1 .ne. 'DUMM ') then
        call trans(elemn1,xidx1,yidx1,zidx1)
        pg3(xidx1,yidx1,zidx1)=pg
        t3(xidx1,yidx1,zidx1)=t
        sl3(xidx1,yidx1,zidx1)=sl
        pcap3(xidx1,yidx1,zidx1)=pcap
c        if (ntimesteps .eq. 9) write(32,*)elemn1,
c        *      xidx1,yidx1,zidx1,pg,t,sl
c        if (ntimesteps .eq. 1) write(32,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
c        if (ntimesteps .eq. 2) write(33,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl
c        if (ntimesteps .eq. 3) write(34,*)elemn1,xidx1,yidx1,zidx1,pg,t,sl

      endif

2010 CONTINUE
      GO TO 2100
C
91 CONTINUE

      close(32)
      close(33)
      close(34)

c      translate data arrays into exo-friendly arrays

      call exoarrs2(nxc,nyc,nzc,pg3,vars,1,nel,maxtimes,ntimesteps,
+      nvars)
      call exoarrs2(nxc,nyc,nzc,t3,vars,2,nel,maxtimes,ntimesteps,
+      nvars)
      call exoarrs2(nxc,nyc,nzc,sl3,vars,3,nel,maxtimes,ntimesteps,
+      nvars)
      call exoarrs2(nxc,nyc,nzc,pcap3,vars,4,nel,maxtimes,ntimesteps,
+      nvars)

c
c      write slice files
c

c      open(unit=32,file='slice1.dat',status='unknown',form='formatted')
c      open(unit=33,file='slice2.dat',status='unknown',form='formatted')

cc      z=-5.14

```

```

c      write(32,*) 'time=',time_values(ntimesteps)
c      do j=1,nyc
c          do i=1,nxc
c              write(32,*)xc(i,j,11),yc(i,j,11),zc(i,j,11),
c              *          t3(i,j,11),sl3(i,j,11)
c          enddo
c      enddo

cc      x=.02125

c      write(33-,*) 'time=', time_values(ntimesteps)
c      do k=1,nzc
c          do j=1,nyc
c              write(33,*)xc(1,j,k),yc(1,j,k),zc(1,j,k),t3(1,j,k),sl3(1,j,k)
c          enddo
c      enddo

c      close(32)
c      close(33)

c      read flow data

300      format(a22,28x,3e10.4)
        do i=1,999999
            read(2,300,end=190) block
            if (block(11:22) .eq. 'ELEM1  ELEM2') go to 289
            if (block(1:12) .eq. '  TOTAL TIME') go to 92
        enddo

c289      READ(2,100,END=190) BLOCK
c          IF(BLOCK(11:22).NE.'ELEM1  ELEM2') GO TO 289

289      continue
        READ(2,10) BLOCK2
        READ(2,10) BLOCK2
        if (block2(35:35) .eq. 'W') READ(2,10) BLOCK2
c
c      N1=1
c      N2=MIN(NCMAX,53)
c      DO 1600 I=N1,N2
c          read(2,1003)elemn1,elemn2,floh,floh_f,flof,flog,flol,velg,vell
c          call flowfields(floh,flof,flog,flol,velg,vell,
c          +              flohx,flohy,flohz,
c          +              flogx,flogy,flogz,flolx,floly,flolz,
c          +              velgx,velgy,velgz,vellx,velly,vellz,
c          +              elemn1,elemn2,nxc,nyc,nzc)
1003      format(10x,a5,2x,a5,6x,7e13.4)
c          READ(2,1003) VELG(I),VELL(I)
c1003      FORMAT(93X,2E13.5)
c1200      FORMAT(1P,6(E12.4,x))
1600      CONTINUE
c
2150      CONTINUE
        IF(N2.EQ.NCMAX) GO TO 191
        N1=N2+1

```

```

      N2=MIN(NCMAX,N1+56)
      READ(2,10) BLOCK2
      READ(2,10) BLOCK2
      if (block2(35:35) .eq. 'W') READ(2,100) BLOCK2
c      READ(2,100) BLOCK
      DO 2020 I=N1,N2
c      READ(2,1003) VELG(I),VELL(I)
      read(2,1003)elemn1,elemn2,floh,floh_f,flof,flog,flol,velg,vell
      call flowfields(floh,flof,flog,flol,velg,vell,
+                  flohx,flohy,flohz,
+                  flogx,flogy,flogz,flolx,floly,flolz,
+                  velgx,velgy,velgz,vellx,velly,vellz,
+                  elemn1,elemn2,nxc,nyc,nzc)
2020  CONTINUE
      GO TO 2150
c
191  CONTINUE
c
c      put flow fields into variables array

      call exoarrs2(nxc,nyc,nzc,flohx,vars,5,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,flohy,vars,6,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,flohz,vars,7,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,flogx,vars,8,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,flogy,vars,9,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,flogz,vars,10,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,flolx,vars,11,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,floly,vars,12,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,flolz,vars,13,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,velgx,vars,14,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,velgy,vars,15,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,velgz,vars,16,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,vellx,vars,17,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,velly,vars,18,nel,maxtimes,ntimesteps,
+                  nvars)
      call exoarrs2(nxc,nyc,nzc,vellz,vars,19,nel,maxtimes,ntimesteps,
+                  nvars)
      print *, '-----'
      go to 89 ! start reading new time step

90  continue
190  CONTINUE

```

```

close(unit=2)
close(unit=32)
close(unit=33)

C*****
C
C   CREATE NODES FROM CENTERS AND DISTANCES
C
C*****

c   first layer (this is the added layer)
c   do first point (is added), then first y (is added), then rest

xnds(1,1,1)=xc(1,1,1)-xdist(1,1,1)
ynds(1,1,1)=yc(1,1,1)+ydist(1,1,1)
znds(1,1,1)=zc(1,1,1)+zdist(1,1,1)
do i=1,nxc
  xnds(i+1,1,1)=xc(i,1,1)+xdist(i,1,1)
  ynds(i+1,1,1)=yc(i,1,1)+ydist(i,1,1)
  znds(i+1,1,1)=zc(i,1,1)+zdist(i,1,1)
enddo
do j=1,nyc
  xnds(1,j+1,1)=xc(1,j,1)-xdist(1,j,1)
  ynds(1,j+1,1)=yc(1,j,1)-ydist(1,j,1)
  znds(1,j+1,1)=zc(1,j,1)+zdist(1,j,1)
  do i=1,nxc
    xnds(i+1,j+1,1)=xc(i,j,1)+xdist(i,j,1)
    ynds(i+1,j+1,1)=yc(i,j,1)-ydist(i,j,1)
    znds(i+1,j+1,1)=zc(i,j,1)+zdist(i,j,1)
  enddo
enddo

c   x nodes - rest of layers

do k=1,nzc
  xnds(1,1,k+1)=xc(1,1,k)-xdist(1,1,k)
  ynds(1,1,k+1)=yc(1,1,k)+ydist(1,1,k)
  znds(1,1,k+1)=zc(1,1,k)-zdist(1,1,k)
  do i=1,nxc
    xnds(i+1,1,k+1)=xc(i,1,k)+xdist(i,1,k)
    ynds(i+1,1,k+1)=yc(i,1,k)+ydist(i,1,k)
    znds(i+1,1,k+1)=zc(i,1,k)-zdist(i,1,k)
  enddo
  do j=1,nyc
    xnds(1,j+1,k+1)=xc(1,j,k)-xdist(1,j,k)
    ynds(1,j+1,k+1)=yc(1,j,k)-ydist(1,j,k)
    znds(1,j+1,k+1)=zc(1,j,k)-zdist(1,j,k)
    do i=1,nxc
      xnds(i+1,j+1,k+1)=xc(i,j,k)+xdist(i,j,k)
      ynds(i+1,j+1,k+1)=yc(i,j,k)-ydist(i,j,k)
      znds(i+1,j+1,k+1)=zc(i,j,k)-zdist(i,j,k)
    enddo
  enddo
enddo

if (nyc .eq. 1) then

```

```

        do k=1,nznds
          do i=1,nxnds
            ynds(i,1,k)=0
            ynds(i,2,k)=1
          enddo
        enddo
      endif
c      put nodes in 1d arrays for exodus

      ctr=0
      do k=1,nznds
        do j=1,nynds
          do i=1,nxnds
            ctr=ctr+1
            x(ctr)=xnds(i,j,k)
            y(ctr)=ynds(i,j,k)
            z(ctr)=znds(i,j,k)
          enddo
        enddo
      enddo

c*****
c
c      CREATE CONNECTIVITY LIST
c
c*****

      ctr=0
      ctr2=0
      do k=1,nznds-1
        ctr=nxnds*nynds*(k-1)
        do j=1,nynds-1
          do i=1,nxnds-1
            ctr=ctr+1
            ctr2=ctr2+1
            conn(5,ctr2)=ctr
            conn(6,ctr2)=conn(5,ctr2)+1
            conn(7,ctr2)=conn(6,ctr2)+nxnds
            conn(8,ctr2)=conn(5,ctr2)+nxnds
            conn(1,ctr2)=conn(5,ctr2)+(nxnds*nynds)
            conn(2,ctr2)=conn(6,ctr2)+(nxnds*nynds)
            conn(3,ctr2)=conn(7,ctr2)+(nxnds*nynds)
            conn(4,ctr2)=conn(8,ctr2)+(nxnds*nynds)
          enddo
          ctr=ctr+1
        enddo
      enddo

c*****
c
c      WRITE EXODUS FILE
c
c*****

      coord_names(1)='x'
      coord_names(2)='y'

```

```

        coord_names(3)='z'

        num_dim=3
        num_nodes=nnds
c       num_elem=nel
        num_elem_blk=1
        num_elem_in_block=nel

c       write pressure, temperature, liquid saturation, and cap pressure

c       call wriexo1(coord_names,num_dim,num_nodes,
c       +           num_elem,num_elem_blk,x,y,z,num_elem_in_block,
c       +           conn,nvars,ntimesteps,time_values,vars,maxtimes,
c       +           fnameexo,elem_var_vals)

c       write flow variables

c       call wriexo2(coord_names,num_dim,num_nodes,
c       +           num_elem,num_elem_blk,x,y,z,num_elem_in_block,
c       +           conn,nvars,ntimesteps,time_values,vars,maxtimes,
c       +           fnameexo,elem_var_vals)

c*****
c       fort.22 - write ucd file

        open(unit=22,file='srs.inp',status='unknown',form='formatted')
        write(22,9058)'# AVS UCD File'
        write(22,9057)'#',ntimesteps
        print *, ntimesteps

9053 format(a2,35f15.10)

        write(22,9053),'# ',(time_values(j),j=1,ntimesteps)
        write(22,*)nnds,nel,' 0 ', ntimesteps, ' 0'

9057 format(a1,i3)
9058 format(a14)
9060 format(i5,3f12.6)
        do i=1,num_nodes
            write(22,9060)i,x(i),y(i),z(i)
        enddo
        do i=1,num_elem
            write(22,9059)i,(conn(j,i),j=1,8)
        enddo
9059 format(i5,' 1 hex ',8i7)

        write(22,*)ntimesteps,' 1'
        write(22,*)'temp, '

9063 format(i5,35f15.10)
        do i=1,num_elem
            write(22,9063,err=9062)i,(vars(j,2,i),j=1,ntimesteps)
        enddo

c       fort.31 - write temps for steve for input to jac3d

c       ctr=0

```

```

c      write(31,*)nel,ntimesteps
c      write(31,*)(time_values(i),i=1,ntimesteps)
c      do k=1,nzc
c          do j=1,nyc
c              do i=1,nxc
c                  ctr=ctr+1
c                  write(31,*)ctr,xc(i,j,k),yc(i,j,k),zc(i,j,k)
c              enddo
c          enddo
c      enddo

c      do i=1,nel
c          write(31,9063,err=9062)i,(vars(j,2,i),j=1,ntimesteps)
c      enddo
c      close(31)

c      fort.30 - write data for sandy

ctr=0
open(unit=30,file='s_mtrx.dat',status='unknown',form='formatted')
do k=1,nzc
    do j=1,nyc
        do i=1,nxc
            ctr=ctr+1

c            vars(maxtimes,nvars,nel)

            write(30,9067)xc(i,j,k),yc(i,j,k),zc(i,j,k),
*                vars(sandytime,1,ctr),    ! pressure
*                vars(sandytime,2,ctr),    ! temp
*                vars(sandytime,3,ctr)     ! liq sat
        enddo
    enddo
enddo
close(30)

c      print *, xc(nxc,nyc,nzc),yc(nxc,nyc,nzc),vars(3,2,ctr)
9062 close(unit=22)
      close(unit=30)

9067 format(3f10.5,3e12.4)
c 9067 format(3f10.5,3f15.10)

*****
c      fort.23 - write nodes

open(unit=23,file='nodes.dat',status='unknown',form='formatted')

write(23,*)'x'
do i=1,nxnds
    write(23,*)xnds(i,1,1)
enddo
write(23,*)'y'
do i=1,nynds
    write(23,*)ynds(1,i,1)
enddo
write(23,*)'z'

```

```

do i=1,nznds
    write(23,*)znds(1,1,i)
enddo
close(23)

c    fort.24 - write element centers

open(unit=24,file='ctrs.dat',status='unknown',form='formatted')

write(24,*)'x'
do i=1,nxc
    write(24,*)xc(i,1,1)
enddo
write(24,*)'y'
do i=1,nyc
    write(24,*)yc(1,i,1)
enddo
write(24,*)'z'
do i=1,nzc
    write(24,*)zc(1,1,i)
enddo
close(24)

end
subroutine exoarrs2(nxc,nyc,nzc,tmp,vars,varsidx,nel,
+                 maxtimes,ntimesteps,nvars)

c    convert arrays into exodus array order

integer nxc, nyc, nzc, nel, varsidx, maxtimes,ntimesteps, nvars
real*4 vars(maxtimes,nvars,nel)
integer i, j, k, ctr
real*4 tmp(nxc,nyc,nzc)

ctr=0
do k=1,nzc
    do j=1,nyc
        do i=1,nxc
            ctr=ctr+1
            vars(ntimesteps,varsidx,ctr)=tmp(i,j,k)
        enddo
    enddo
enddo

end
subroutine flowfields(floh,flof,flog,flol,velg,vell,
+                   flohx,flohy,flohz,
+                   flogx,flogy,flogz,flolx,floly,flolz,
+                   velgx,velgy,velgz,vellx,vellz,vellz,
+                   elemn1,elemn2,nxc,nyc,nzc)

integer nxc, nyc, nzc
real*4 floh, flof, flog, flol, velg, vell
real*4 flohx(nxc,nyc,nzc), flohy(nxc,nyc,nzc), flohz(nxc,nyc,nzc)
real*4 flogx(nxc,nyc,nzc), flogy(nxc,nyc,nzc), flogz(nxc,nyc,nzc)
real*4 flolx(nxc,nyc,nzc), floly(nxc,nyc,nzc), flolz(nxc,nyc,nzc)

```

```

real*4 velgx(nxc,nyc,nzc), velgy(nxc,nyc,nzc), velgz(nxc,nyc,nzc)
real*4 vellx(nxc,nyc,nzc), velly(nxc,nyc,nzc), vellz(nxc,nyc,nzc)
character*5 elemn1, elemn2

```

```

integer xidx1, yidx1, zidx1, xidx2, yidx2, zidx2

```

```

call trans(elemn1,xidx1,yidx1,zidx1)
call trans(elemn2,xidx2,yidx2,zidx2)
if (xidx1 .ne. xidx2) then      !flow direction is x
    flohx(xidx1,yidx1,zidx1)=floh
    flogx(xidx1,yidx1,zidx1)=flog
    flolx(xidx1,yidx1,zidx1)=flol
    velgx(xidx1,yidx1,zidx1)=velg
    vellx(xidx1,yidx1,zidx1)=vell
elseif (yidx1 .ne. yidx2) then !flow direction is y
    flohy(xidx1,yidx1,zidx1)=floh
    flogy(xidx1,yidx1,zidx1)=flog
    floly(xidx1,yidx1,zidx1)=flol
    velgy(xidx1,yidx1,zidx1)=velg
    velly(xidx1,yidx1,zidx1)=vell
elseif (zidx1 .ne. zidx2) then !flow direction is z
    flohz(xidx1,yidx1,zidx1)=floh
    flogz(xidx1,yidx1,zidx1)=flog
    flolz(xidx1,yidx1,zidx1)=flol
    velgz(xidx1,yidx1,zidx1)=velg
    vellz(xidx1,yidx1,zidx1)=vell
endif
end
subroutine trans(en,xidx1,yidx1,zidx1)

```

c translate element name into array indices

```

character*5 en
integer xidx1, yidx1, zidx1

if (en(2:2) .eq. '1') then
    zidx1=1
elseif (en(2:2) .eq. '2') then
    zidx1=2
elseif (en(2:2) .eq. '3') then
    zidx1=3
elseif (en(2:2) .eq. '4') then
    zidx1=4
elseif (en(2:2) .eq. '5') then
    zidx1=5
elseif (en(2:2) .eq. '6') then
    zidx1=6
elseif (en(2:2) .eq. '7') then
    zidx1=7
elseif (en(2:2) .eq. '8') then
    zidx1=8
elseif (en(2:2) .eq. '9') then
    zidx1=9
elseif (en(2:2) .eq. 'A') then
    zidx1=10
elseif (en(2:2) .eq. 'B') then
    zidx1=11

```

```

elseif (en(2:2) .eq. 'C') then
    zidx1=12
elseif (en(2:2) .eq. 'D') then
    zidx1=13
elseif (en(2:2) .eq. 'E') then
    zidx1=14
elseif (en(2:2) .eq. 'F') then
    zidx1=15
elseif (en(2:2) .eq. 'G') then
    zidx1=16
elseif (en(2:2) .eq. 'H') then
    zidx1=17
elseif (en(2:2) .eq. 'I') then
    zidx1=18
o elseif (en(2:2) .eq. 'J') then
elseif (en(2:2) .eq. 'K') then
    zidx1=20
elseif (en(2:2) .eq. 'L') then
    zidx1=21
elseif (en(2:2) .eq. 'M') then
    zidx1=22
elseif (en(2:2) .eq. 'N') then
    zidx1=23
elseif (en(2:2) .eq. 'O') then
    zidx1=24
elseif (en(2:2) .eq. 'P') then
    zidx1=25
elseif (en(2:2) .eq. 'Q') then
    zidx1=26
elseif (en(2:2) .eq. 'R') then
    zidx1=27
elseif (en(2:2) .eq. 'S') then
    zidx1=28
elseif (en(2:2) .eq. 'T') then
    zidx1=29
elseif (en(2:2) .eq. 'U') then
    zidx1=30
elseif (en(2:2) .eq. 'V') then
    zidx1=31
elseif (en(2:2) .eq. 'W') then
    zidx1=32
elseif (en(2:2) .eq. 'X') then
    zidx1=33
elseif (en(2:2) .eq. 'Y') then
    zidx1=34
elseif (en(2:2) .eq. 'Z') then
    zidx1=35
else
    print *, 'trans error -- z --',en,'-- '
endif

if (en(1:1) .eq. 'B') zidx1=zidx1+35

if (en(3:3) .eq. '1') then
    yidx1=1
elseif (en(3:3) .eq. '2') then

```

```

        yidx1=2
    elseif (en(3:3) .eq. '3') then
        yidx1=3
    elseif (en(3:3) .eq. '4') then
        yidx1=4
    elseif (en(3:3) .eq. '5') then
        yidx1=5
    elseif (en(3:3) .eq. '6') then
        yidx1=6
    elseif (en(3:3) .eq. '7') then
        yidx1=7
    elseif (en(3:3) .eq. '8') then
        yidx1=8
    elseif (en(3:3) .eq. '9') then
        yidx1=9
    elseif (en(3:3) .eq. 'A') then
        yidx1=10
    elseif (en(3:3) .eq. 'B') then
        yidx1=11
    elseif (en(3:3) .eq. 'C') then
        yidx1=12
    elseif (en(3:3) .eq. 'D') then
        yidx1=13
    elseif (en(3:3) .eq. 'E') then
        yidx1=14
    elseif (en(3:3) .eq. 'F') then
        yidx1=15
    elseif (en(3:3) .eq. 'G') then
        yidx1=16
    elseif (en(3:3) .eq. 'H') then
        yidx1=17
    elseif (en(3:3) .eq. 'I') then
        yidx1=18
    elseif (en(3:3) .eq. 'J') then
        yidx1=19
    elseif (en(3:3) .eq. 'K') then
        yidx1=20
    elseif (en(3:3) .eq. 'L') then
        yidx1=21
    elseif (en(3:3) .eq. 'M') then
        yidx1=22
    elseif (en(3:3) .eq. 'N') then
        yidx1=23
    elseif (en(3:3) .eq. 'O') then
        yidx1=24
    elseif (en(3:3) .eq. 'P') then
        yidx1=25
    elseif (en(3:3) .eq. 'Q') then
        yidx1=26
    elseif (en(3:3) .eq. 'R') then
        yidx1=27
    elseif (en(3:3) .eq. 'S') then
        yidx1=28
    elseif (en(3:3) .eq. 'T') then
        yidx1=29
    elseif (en(3:3) .eq. 'U') then
        yidx1=30

```

```

elseif (en(3:3) .eq. 'V') then
    yidx1=31
elseif (en(3:3) .eq. 'W') then
    yidx1=32
elseif (en(3:3) .eq. 'X') then
    yidx1=33
elseif (en(3:3) .eq. 'Y') then
    yidx1=34
elseif (en(3:3) .eq. 'Z') then
    yidx1=35
else
    print *, 'trans error -- y --',en,'-- '
endif

read(en(4:5), '(i4)')xidx1

end

cvv      subroutine wriexo1(coord_names,num_dim,num_nodes,
cvv      +                  num_elem,num_elem_blk,x,y,z,num_elem_in_block,
cvv      +                  conn,nvars,ntimesteps,time_values,vars,maxtimes,
cvv      +                  fnameexo,elem_var_vals)

cvv      implicit none
cvv      include 'exodusII.inc'

cvv      character*(MXSTLN) coord_names(3)
cvv      character*(MXSTLN) var_names(4)
cvv      integer num_dim
cvv      integer num_nodes
cvv      integer num_elem
cvv      integer num_elem_blk
cvv      real*4 x(num_nodes), y(num_nodes), z(num_nodes)
cvv      integer num_elem_in_block
cvv      integer conn(8,num_elem)
cvv      integer nvars
cvv      integer ntimesteps
cvv      real*4 time_values(maxtimes)
cvv      real*4 vars(maxtimes,nvars,num_elem)
cvv      integer maxtimes
cvv      real*4 elem_var_vals(num_elem)

cvv      integer num_node_sets, num_side_sets, idx

cvv      integer cpu_word_size, io_word_size
cvv      character*(MXSTLN) cname
cvv      character*14 fnameexo
cvv      character*(MXLNLN) exottl
cvv      integer nvarswri

cvv      integer i, m, k, iii, ierr, exoid

cvv      cpu_word_size=0
cvv      io_word_size=0
cvv      nvarswri=4

```

```

cvv      var_names(1)='pressure'
cvv      var_names(2)='temperature'
cvv      var_names(3)='liquid saturation'
cvv      var_names(4)='capillary pressure'

cvv      exottl='tough stuff'

cvv      print *, ' '
cvv      print *, 'writing first exodus ...'

c        create exodus II file

cvv      exoid=excre(fnameexo,exclob,cpu_word_size,io_word_size,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exoid'

c        initialize file with parameters

c        num_dim=
c        num_nodes=
c        num_elem=
c        num_elem_blk=
cvv      num_node_sets=0
cvv      num_side_sets=0

cvv      call expini(exoid,exottl,num_dim,num_nodes,num_elem,
cvv      +          num_elem_blk,num_node_sets,num_side_sets,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expini'

c        write nodal coordinates values and names to database

cvv      call expcor(exoid,x,y,z,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcor'

c        coord_names

cvv      call expcon(exoid,coord_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcon'

c        write element block parameters

cvv      cname='HEX'
cvv      do i=1,num_elem_blk
cvv          call expelb(exoid,i,cname,num_elem_in_block,8,0,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelb ... ',i
cvv      enddo

c        write element connectivity

cvv      do i=1,num_elem_blk
cvv          call expelc(exoid,i,conn,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelc'
cvv      enddo

c        write number of element variables

cvv      call expvp(exoid,'e',nvarswri,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expelc'

```

```

c      write element variable names

cvv      call expvan(exoid,'e',nvarswri,var_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expvan'


c      write data for each time step

cvv      do iii=1,ntimesteps

c          write time value

cvv          call exptim(exoid,iii,time_values(iii),ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error exptim...',time_values(iii)

c          write element variables

cvv          do k=1,nvarswri
cvv              idx=0
cvv              do m=1,num_elem_in_block
cvv                  idx=idx+1
cvv                  elem_var_vals(idx)=vars(iii,k,m)
cvv              enddo

cvv          call expev(exoid,iii,k,1,num_elem_in_block,
cvv      +              elem_var_vals,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expev ... ',
cvv      +              time_values(iii)
cvv      enddo

c      update file

cvv      call exupda(exoid,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exupda'

cvv      enddo

c      close file

cvv      call exclos(exoid,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exclos'

cvv      return
cvv      end

cvv      subroutine wriexo2(coord_names,num_dim,num_nodes,
cvv      +                  num_elem,num_elem_blk,x,y,z,num_elem_in_block,
cvv      +                  conn,nvars,ntimesteps,time_values,vars,maxtimes,
cvv      +                  fnameexo,elem_var_vals)

cvv      implicit none
cvv      include 'exodusII.inc'
cvv
cvv      character*(MXSTLN) coord_names(3)
cvv      character*(MXSTLN) var_names(15)
cvv      integer num_dim

```

```

cvv      integer num_nodes
cvv      integer num_elem
cvv      integer num_elem_blk
cvv      real*4   x(num_nodes), y(num_nodes), z(num_nodes)
cvv      integer num_elem_in_block
cvv      integer conn(8,num_elem)
cvv      integer nvars
cvv      integer ntimesteps
cvv      real*4   time_values(maxtimes)
cvv      real*4   vars(maxtimes,nvars,num_elem)
cvv      integer maxtimes
cvv      real*4   elem_var_vals(num_elem)

cvv      integer num_node_sets, num_side_sets, idx

cvv      integer cpu_word_size, io_word_size
cvv      character*(MXSTLN) cname
cvv      character*14 fnameexo
cvv      character*(MXLNLN) exottl
cvv      integer nvarswri
cvv      real*4   aaa

cvv      integer i, m, j, k, iii, ierr, exoid

cvv      cpu_word_size=0
cvv      io_word_size=0
cvv      nvarswri=15

cvv      do i=1,15
cvv          var_names(i)='
cvv      enddo

cvv      var_names(1)='heat flow, x'
cvv      var_names(2)='heat flow, y'
cvv      var_names(3)='heat flow, z'
cvv      var_names(4)='gas phase flow, x'
cvv      var_names(5)='gas phase flow, y'
cvv      var_names(6)='gas phase flow, z'
cvv      var_names(7)='liq phase flow, x'
cvv      var_names(8)='liq phase flow, y'
cvv      var_names(9)='liq phase flow, z'
cvv      var_names(10)='gas flow vel, x'
cvv      var_names(11)='gas flow vel, y'
cvv      var_names(12)='gas flow vel, z'
cvv      var_names(13)='liq flow vel,x'
cvv      var_names(14)='liq flow vel,y'
cvv      var_names(15)='liq flow vel,z'

cvv      exottl='tough stuff'

cvv      print *, 'writing second exodus ...'

c      create exodus II file

cvv      i=index(fnameexo,' ')
cvv      fnameexo(i:i+1)='.f'

```

```

cvv      exoid=excre(fnameexo,exclob,cpu_word_size,io_word_size,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exoid'

c        initialize file with parameters

cvv      num_node_sets=0
cvv      num_side_sets=0

cvv      call expini(exoid,exottl,num_dim,num_nodes,num_elem,
cvv      +          num_elem_blk,num_node_sets,num_side_sets,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expini'

c        write nodal coordinates values and names to database

cvv      call expcor(exoid,x,y,z,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcor'

c        coord_names

cvv      call expcon(exoid,coord_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expcon'

c        write element block parameters

cvv      cname='HEX'
cvv      do i=1,num_elem_blk
cvv          call expelb(exoid,i,cname,num_elem_in_block,8,0,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelb ... ',i
cvv      enddo

c        write element connectivity

cvv      do i=1,num_elem_blk
cvv          call expelc(exoid,i,conn,ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error expelc'
cvv      enddo

c        write number of element variables

cvv      call expvp(exoid,'e',nvarswri,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expelc'

c        write element variable names

cvv      call expvan(exoid,'e',nvarswri,var_names,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error expvan'

c        write data for each time step

cvv      do iii=1,ntimesteps

c          write time value

cvv          call exptim(exoid,iii,time_values(iii),ierr)
cvv          if (ierr .ne. 0) write(6,*) 'error exptim...',time_values(iii)

```

```

c      write element variables

cvv      j=0
cvv      do k=5,19
cvv          idx=0
cvv          do m=1,num_elem_in_block
cvv              idx=idx+1
cvv              elem_var_vals(idx)=vars(iii,k,m)
cvv          enddo
cvv          j=j+1
cvv          call expev(exoid,iii,j,1,num_elem_in_block,
cvv      +              elem_var_vals,ierr)
cvv      +      if (ierr .ne. 0) write(6,*) 'error expev ... ',
cvv      +              time_values(iii)
cvv      enddo

c      update file

cvv      call exupda(exoid,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exupda'

cvv      enddo

c      close file

cvv      call exclos(exoid,ierr)
cvv      if (ierr .ne. 0) write(6,*) 'error exclos'

cvv      return
cvv      end

```

This processor has been checked for all cases considered in this AMR: drift scale property set for TSPA-SR, and the sensitivity studies TSPA-VA and median Kb. The spot check results (routine result file vs. TOUGH2.OUT) are the following for element **MAB 1** (a matrix element).

At 56, 114, 182, and 273 simulated days for the DS property set results:

Time (days)	56	114	182	273
Temperature (°C)	91.91	100.1	106.4	110.6
Liquid Saturation	0.8923	0.8673	0.8473	0.8303
Pressure (Pa)	0.8615×10^5	0.1032×10^6	0.1279×10^6	0.1467×10^6

These are identical to TOUGH2.OUT results as checked by visual inspection.

At 56, 114, 182, and 273 simulated days for the TSPA-VA property set results:

Time (days)	56	114	182	273
Temperature (°C)	93.51	98.21	101	105.8
Liquid Saturation	0.9410	0.8971	0.8519	0.7967
Pressure (Pa)	0.8741×10^5	0.9716×10^5	0.1062×10^6	0.125×10^6

These are identical to TOUGH2.OUT results as checked by visual inspection.

At 56, 114, and 182 simulated days for the median Kb property set results:

Time (days)	56	114	182
Temperature (°C)	95.52	101.0	108.4
Liquid Saturation	0.8714	0.7048	0.4972
Pressure (Pa)	0.8793×10^5	0.1054×10^6	0.1363×10^6

These are identical to TOUGH2.OUT results as checked by visual inspection. The matrix extraction is also verified.

The range of validity for both extraction routines is based on the primary mesh file dimensions of $n_x = 18$, $n_y = 35$, and $n_z = 20$.

Compare (Version 1.)

The routine COMPARE calculates 3 statistical measures of the difference between a measured temperature data set and a model prediction of the temperature field. The computational tasks necessary to accomplish this objective are to first interpolate the model temperatures at the gage locations, and then to calculate the root mean squared difference between the measured and predicted values, the mean difference and the absolute mean difference.

Consider gage TMA-TC-2A-7 and model `s_dsps_mtrx_273`.

According to the input file `t-median.dat`, it is located at $x=0.613$, $y=4.636$, $z=0.263$ and recorded a temperature of 124.850 on day 273.5.

The interpolation routine returns:

```
7, 0.610, 0.772, 0.0185
10, 4.488, 5.488, 0.1484
21, 0.250, 0.360, 0.1182
```

indicating that the x coordinate of the gage is located fractional distance 0.0185 in-between the 7th and 8th model x coordinates, i.e., between $x = 0.610$ and $x = 0.772$. The y coordinate of the gage is located 0.1484 fractional distance in-between the 10th and 11th model nodes in the y direction, i.e. $Y=4.488$ and $y=5.488$. The z coordinate of the gage is located 0.1182 fractional distance from model z coordinate 0.250 to z coordinate 0.360.

The eight model nodes surrounding the gage location have the following node identification numbers (i,j,k), x, y and z locations in the field coordinate system, x, y and z locations in the model coordinate system, temperature, and relative weights in each coordinate direction.

```
7, 10, 21, 0.610, 4.488, 0.250, 0.61000 -10.25000 -4.48760, 118.80, 0.982, 0.852, 0.882
7, 10, 22, 0.610, 4.488, 0.360, 0.61000 -10.14000 -4.48760, 115.20, 0.982, 0.852, 0.118
```

7, 11, 21, 0.610, 5.488, 0.250,	0.61000 -10.25000	-5.48760, 114.90, 0.982, 0.148, 0.882
7, 11, 22, 0.610, 5.488, 0.360,	0.61000 -10.14000	-5.48760, 111.30, 0.982, 0.148, 0.118
8, 10, 21, 0.772, 4.488, 0.250,	0.77250 -10.25000	-4.48760, 108.20, 0.018, 0.852, 0.882
8, 10, 22, 0.772, 4.488, 0.360,	0.77250 -10.14000	-4.48760, 105.80, 0.018, 0.852, 0.118
8, 11, 21, 0.772, 5.488, 0.250,	0.77250 -10.25000	-5.48760, 104.50, 0.018, 0.148, 0.882
8, 11, 22, 0.772, 5.488, 0.360,	0.77250 -10.14000	-5.48760, 101.90, 0.018, 0.148, 0.118

From the model temperature file, s_dsps_mtrx_273.dat, the indicated nodes have temperatures (5th column from the right):

0.61000 -10.25000	-4.48760	0.1915E+06	0.1188E+03	0.8168E+00
0.61000 -10.14000	-4.48760	0.1706E+06	0.1152E+03	0.8244E+00
0.61000 -10.25000	-5.48760	0.1696E+06	0.1149E+03	0.8245E+00
0.61000 -10.14000	-5.48760	0.1505E+06	0.1113E+03	0.8306E+00
0.77250 -10.25000	-4.48760	0.1353E+06	0.1082E+03	0.8351E+00
0.77250 -10.14000	-4.48760	0.1248E+06	0.1058E+03	0.8396E+00
0.77250 -10.25000	-5.48760	0.1194E+06	0.1045E+03	0.8429E+00
0.77250 -10.14000	-5.48760	0.1090E+06	0.1019E+03	0.8480E+00

The preceding lines were copied directly from file s_dsps_mtrx_273.dat, but are found at widely disparate locations.

The model temperatures in the output file correspond correctly with the model temperatures in the input file.

Calculating the model temperature interpolated at the gage location according the snippet of code

```

for i := 0 to 1 do      for j := 0 to 1 do      for k := 0 to 1 do
begin
  tdata[2,probe[1,n]] := tdata[2,probe[1,n]] +
tmodel^[2,p[1]+i,p[2]+j,p[3]+k] * f[1,i] * f[2,j] * f[3,k];

```

produces the right result (117.603).

The output file s_dsps_mtrx_273.csv contains the correct x, y and z gage locations, measured temperature and interpolated model temperature.

TMA-TC-2A-7	0.613	4.636	0.263	0.007143	24.08	124.85	117.603	-7.247
-------------	-------	-------	-------	----------	-------	--------	---------	--------

In the section of the routine where the root mean square error, mean error, and mean absolute error are calculated, the intermediate results were written to an output file and pasted into an Excel spreadsheet. The final "hand calculations" of the required final results were calculated using standard spreadsheet functions. The results matched the calculated results exactly. The intermediate results were:

58.628891, 64.900002, 0.058824, 25.620001
71.421432, 82.320000, 0.076923, 25.020000
93.589813, 106.290001, 0.166667, 26.030001
121.594185, 130.470001, 1.000000, 28.299999
130.054932, 146.820007, 1.000000, 27.760000
138.676376, 155.850006, 0.500000, 28.299999
145.686127, 160.100006, 0.333333, 28.420000

143.041916,148.710007,0.500000,27.730000
136.213470,139.699997,1.000000,27.760000
128.757416,127.930000,0.142857,28.650000
113.239006,126.230003,0.142857,29.090000
83.380783,97.610001,0.125000,28.400000
67.837143,75.910004,0.062500,26.850000
59.548908,60.360001,0.050000,24.799999
54.318806,48.240002,0.047619,24.700001
54.636822,58.450001,0.050000,25.320000
63.976871,66.980003,0.058824,25.020000
77.936935,80.989998,0.076923,25.219999
105.883575,111.260002,0.125000,24.750000
112.267738,119.680000,0.142857,24.629999
117.603195,124.849998,0.142857,24.080000
115.335197,119.389999,0.142857,24.059999
110.691406,114.000000,0.125000,24.180000
104.869270,105.610001,0.166667,24.280001
90.946899,94.320000,0.125000,24.500000
75.193810,78.389999,0.076923,24.730000
64.226089,65.220001,0.058824,24.750000
57.642830,55.869999,0.045455,24.850000
50.988289,47.290001,0.047619,25.100000
48.041321,52.830002,0.045455,24.930000
53.121883,54.490002,0.045455,25.100000
59.266033,60.360001,0.050000,24.980000
66.000351,65.870003,0.058824,24.480000
71.624840,73.610001,0.062500,26.700001
75.751251,75.989998,0.062500,25.520000
80.261467,78.529999,0.076923,23.440001
79.791779,77.720001,0.076923,23.370001
77.743889,74.860001,0.062500,23.320000
74.220718,71.680000,0.062500,23.510000
69.931404,67.949997,0.058824,23.760000
63.819000,62.200001,0.050000,24.030001
58.303246,56.299999,0.045455,24.260000
53.962864,51.430000,0.047619,24.430000
50.949951,46.880001,0.047619,24.430000
97.196709,91.059998,0.125000,24.080000
103.930321,98.260002,0.125000,23.840000
109.859978,108.010002,0.166667,23.940001
112.281670,112.820000,0.125000,23.590000
114.016060,115.760002,0.142857,23.740000
111.147171,111.769997,0.125000,23.740000
98.252548,96.430000,0.125000,23.639999
89.000061,89.300003,0.125000,24.010000
82.211067,83.120003,0.076923,23.690001
74.060776,74.739998,0.062500,24.129999

69.133530,68.669998,0.058824,23.639999
63.645130,62.099998,0.050000,24.180000
57.332211,51.980000,0.045455,24.180000
50.200333,43.009998,0.055556,24.309999
54.236496,57.490002,0.045455,25.809999
63.273155,67.150002,0.058824,26.920000
76.623749,77.040001,0.076923,24.129999
93.882423,93.120003,0.125000,24.580000
103.641861,101.379997,0.125000,24.600000
110.029091,112.820000,0.125000,24.410000
115.346825,123.070000,0.142857,23.910000
113.547913,118.680000,0.142857,23.889999
109.181534,112.959999,0.125000,23.940001
103.434998,105.099998,0.166667,23.760000
93.112465,94.279999,0.125000,24.030001
77.043724,80.239998,0.076923,24.260000
65.431984,67.000000,0.058824,24.530001
58.340950,57.200001,0.045455,24.580000
53.670837,49.320000,0.047619,24.700001
119.052040,124.760002,0.142857,23.990000
108.736969,111.720001,0.125000,23.790001
99.702065,99.730003,0.125000,23.320000
78.931999,76.349998,0.062500,23.240000
73.067245,70.019997,0.058824,23.440001
62.640957,59.779999,0.050000,23.340000
49.326519,47.439999,0.047619,23.469999
43.231468,40.169998,0.055556,23.740000
96.877708,100.650002,0.125000,23.590000
92.190689,94.540001,0.125000,23.440001
86.886848,87.480003,0.125000,23.389999
76.634506,76.300003,0.062500,23.469999
70.684616,69.279999,0.058824,23.490000
65.533188,64.279999,0.050000,23.389999
58.325790,55.340000,0.045455,23.440001
47.761375,44.389999,0.055556,23.540001
145.873718,147.759995,0.500000,33.700001
157.967239,165.880005,0.333333,32.650002
158.337097,166.179993,0.333333,32.110001
147.662659,154.380005,0.500000,31.670000
105.034233,125.940002,0.142857,30.830000
78.433510,92.080002,0.125000,31.860001
65.018028,71.199997,0.062500,26.900000
78.914085,86.010002,0.125000,23.040001
98.333664,92.419998,0.125000,23.469999
106.185196,98.720001,0.125000,23.469999
113.075714,116.510002,0.142857,23.389999
115.555382,120.320000,0.142857,23.559999

116.678017,121.830002,0.142857,23.540001
114.919434,118.949997,0.142857,23.559999
110.994270,113.959999,0.125000,23.740000
104.103683,106.919998,0.166667,24.059999
88.855293,90.889999,0.125000,24.110001
72.324516,77.190002,0.076923,23.940001
61.781334,63.360001,0.050000,24.059999
55.631596,53.090000,0.045455,23.889999
79.456299,76.830002,0.062500,22.920000
80.459946,78.940002,0.076923,23.020000
76.432526,75.580002,0.062500,23.219999
67.112457,67.580002,0.058824,23.639999
56.377289,55.630001,0.045455,24.080000
105.614410,102.779999,0.166667,24.110001
91.949303,98.089996,0.125000,23.709999
68.981438,67.779999,0.058824,23.639999
60.557781,61.860001,0.050000,23.469999
53.872604,52.369999,0.045455,23.840000
48.770180,47.980000,0.047619,23.660000
42.606895,40.220001,0.055556,23.940001
50.737747,49.480000,0.047619,23.580000
53.235611,50.910000,0.047619,23.530001
55.856789,53.360001,0.045455,23.580000
58.429844,55.549999,0.045455,23.510000
60.808491,57.759998,0.045455,23.430000
62.812946,59.660000,0.050000,23.219999
64.213463,61.349998,0.050000,23.270000
64.880569,61.820000,0.050000,23.320000
64.790108,60.549999,0.050000,23.350000
64.512123,61.820000,0.050000,23.450001
63.391964,60.700001,0.050000,23.350000
61.685200,59.240002,0.050000,23.430000
59.545071,57.009998,0.045455,23.480000
57.208939,54.790001,0.045455,23.580000
55.120445,52.160000,0.045455,23.450001
52.825569,50.209999,0.047619,23.760000
50.293392,48.060001,0.047619,23.629999
48.044960,45.849998,0.047619,23.870001
46.712196,43.910000,0.055556,23.870001
43.873932,40.570000,0.055556,23.969999
41.993961,39.580002,0.055556,24.309999
46.304451,44.160000,0.055556,24.250000
50.524117,49.990002,0.047619,24.240000
63.204285,59.770000,0.050000,23.139999
67.722488,66.199997,0.058824,23.660000
72.642700,70.889999,0.062500,23.219999
78.154663,76.620003,0.062500,23.200001

84.555939,82.930000,0.076923,23.170000
 88.040329,86.419998,0.125000,23.200001
 90.604195,88.870003,0.125000,23.379999
 90.340782,88.739998,0.125000,23.350000
 87.558891,85.370003,0.125000,23.270000
 83.120758,80.860001,0.076923,23.320000
 77.781357,76.410004,0.062500,23.450001
 72.654442,70.419998,0.058824,23.250000
 67.712700,65.080002,0.058824,23.200001
 62.853436,60.419998,0.050000,23.200001
 59.434216,56.430000,0.045455,23.250000
 55.859848,52.939999,0.045455,23.320000
 52.148167,49.840000,0.047619,23.809999
 49.223301,46.889999,0.047619,23.709999
 47.547958,44.529999,0.055556,23.889999
 45.778816,42.410000,0.055556,24.070000
 44.082180,40.700001,0.055556,24.540001
 42.930645,40.180000,0.055556,24.290001
 47.354626,44.990002,0.055556,24.059999
 52.969513,51.509998,0.047619,24.059999
 74.825699,72.879997,0.062500,23.690001
 68.704956,66.360001,0.058824,23.629999
 63.449043,60.910000,0.050000,23.740000
 59.466850,56.410000,0.045455,23.610001
 55.500397,52.400002,0.045455,23.889999
 51.442497,48.680000,0.047619,23.740000
 48.972740,45.849998,0.047619,23.790001
 47.129097,43.240002,0.055556,23.629999
 45.301193,40.959999,0.055556,23.889999
 43.470680,39.380001,0.055556,24.049999
 79.279541,85.180000,0.125000,23.920000
 73.297432,77.830002,0.076923,23.809999
 67.445831,70.709999,0.062500,23.660000
 63.135490,64.690002,0.058824,23.709999
 59.375546,59.450001,0.050000,23.629999
 55.555367,55.310001,0.045455,23.790001
 51.733032,51.430000,0.047619,23.610001
 49.377132,48.060001,0.047619,23.610001
 47.665409,45.470001,0.047619,23.809999
 45.929813,43.130001,0.055556,23.940001
 42.411213,38.830002,0.055556,24.100000

and the code which calculated the results is

```

{now assign weights to each data point}
  weight[0] := 0; {sum of the weights}
  
```

```

    for l := 5 to 21 do for n := 1 to probe[l,0] do if
good[probe[l,n]] then
    begin
        {figure out which range the temp measurement is in}
        i := trunc(nranges*0.99999*(tdata[1,probe[l,n]]-
mintemp)/(maxtemp-mintemp))+1;
        weight[probe[l,n]] := 1.0/range[i];
        weight[0] := weight[0]+weight[probe[l,n]];
    end;

    MeanError := 0; RMSE := 0; MeanAbsError := 0;
    for l := 5 to 21 do for n := 1 to probe[l,0] do if
good[probe[l,n]] then
    begin
        j := probe[l,n];
        RMSE:= RMSE + sqr(tdata[2,j]-tdata[1,j])*weight[j];
        MeanError := MeanError + (tdata[2,j]-tdata[1,j])*weight[j];
        MeanAbsError := MeanAbsError + abs((tdata[2,j]-
tdata[1,j])/(tdata[1,j]-tdata[0,j]))*weight[j];
        if (models[nm]='s_dsps_mtrx_273.dat') then
            line
            (format('%1.6f,%1.6f,%1.6f,%1.6f',[tdata[2,j],tdata[1,j],weight[
j],tdata[0,j]]));
        end;
        RMSE:= sqrt(RMSE/weight[0]);
        MeanError:= (MeanError/weight[0]);
        MeanAbsError:= (MeanAbsError/weight[0]);

```

READ_TEMP_VS_TIME_MODELS (VERSION 1.)

This routine takes as input one of the TOUGH2 output files, which contains the temperature and saturation levels for all times at selected nodes in the model. It also takes as input the measured temperatures at all of the gage locations, one reading per day. For three of the gages, TMA-TC-4A-6, TMA-TC-5A-7, and TMA-TC-1A-7, this routine estimates the predicted temperature at the gage location at each model time step.

For validation purposes, we will consider one of the models, dsps_mean_TSPA-SR_SHT, at one time step, $t=2.36563E+07$ seconds (approximately 273.7998 days), and one of the gage locations, TMA-TC-4A-6. The following data is from a single line of the input file, dsps_mean_TSPA-SR_SHT.mod. The first number is the time step in seconds and subsequent numbers report 100 model results at a large number of nodes in the model.

2.36563E+07	2.65800E+01	3.05484E+01	3.74751E+01
5.02303E+01	6.73741E+01	7.95432E+01	8.56256E+01
9.28187E+01	9.93196E+01	1.10577E+02	1.22686E+02
1.35471E+02	1.55878E+02	1.81454E+02	2.10077E+02
2.54549E+02	2.96640E+02	2.54627E+02	2.10273E+02

1.81763E+02	1.56350E+02	1.35891E+02	1.23105E+02
1.11150E+02	1.00033E+02	9.24860E+01	8.53595E+01
7.93345E+01	6.72626E+01	5.02306E+01	3.75936E+01
3.07875E+01	2.69462E+01	2.58213E+02	2.12836E+02
1.83258E+02	1.57178E+02	1.36279E+02	1.23005E+02
1.10951E+02	9.97616E+01	9.28066E+01	8.56861E+01
7.96717E+01	6.76659E+01	5.10408E+01	3.89214E+01
2.92601E+02	2.53921E+02	2.08312E+02	1.78590E+02
1.52298E+02	1.32333E+02	1.19877E+02	1.07868E+02
9.69375E+01	9.06878E+01	8.36743E+01	7.78682E+01
6.63724E+01	5.05463E+01	3.88453E+01	2.91807E+02
2.53125E+02	2.07518E+02	1.77814E+02	1.51580E+02
1.31772E+02	1.19389E+02	1.07375E+02	9.64601E+01
8.96070E+01	8.26228E+01	7.68545E+01	6.54365E+01
4.97682E+01	3.83133E+01	8.44797E-01	8.57813E-01
8.71192E-01	8.80330E-01	8.85279E-01	8.89468E-01
8.51065E-01	8.30249E-01	7.71017E-01	2.11123E-01
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
0.00000E+00	1.06401E-01	7.49472E-01	8.29763E-01
8.51384E-01			

Item numbers 17 through 33 give the temperature at 17 nodes in the model extending straight downward from a location very near the heater. The location of the model nodes and the temperatures of those nodes at the time step specified are reported in the output file, output.csv. The relevant portions of that output file are reproduced below.

17 TEMP MAI 1	0.021	4.488	0	0.021	296.64
18 TEMP MAJ 1	0.021	4.488	-0.09	0.092	254.627
19 TEMP MAK 1	0.021	4.488	-0.17	0.171	210.273
20 TEMP MAL 1	0.021	4.488	-0.26	0.261	181.763
21 TEMP MAM 1	0.021	4.488	-0.36	0.361	156.35
22 TEMP MAN 1	0.021	4.488	-0.49	0.49	135.891
23 TEMP MAO 1	0.021	4.488	-0.61	0.61	123.105
24 TEMP MAP 1	0.021	4.488	-0.77	0.77	111.15
25 TEMP MAQ 1	0.021	4.488	-0.97	0.97	100.033
26 TEMP MAR 1	0.021	4.488	-1.17	1.17	92.486
27 TEMP MAS 1	0.021	4.488	-1.37	1.37	85.3595
28 TEMP MAT 1	0.021	4.488	-1.57	1.57	79.3345
29 TEMP MAU 1	0.021	4.488	-2.05	2.05	67.2626
30 TEMP MAV 1	0.021	4.488	-3.17	3.17	50.2306
31 TEMP MAW 1	0.021	4.488	-4.94	4.94	37.5936
32 TEMP MAX 1	0.021	4.488	-6.96	6.96	30.7875
33 TEMP MAY 1	0.021	4.488	-8.99	8.99	26.9462

Note that the temperatures are correctly reproduced from the input file.

Next, we need to calculate the interpolated temperature of the model at the radial distance of the gage location for gage TMA-TC-4A-6. This gage is located at a radial distance from the heater of 0.729 meters, as reported at the end of the output file output.csv.

Because the temperature decreases very nearly as $1/\sqrt{r}$, radial distances are first transformed into $\tilde{r} = -1/\sqrt{r}$ and linear interpolation of the temperature is performed in the transformed coordinate space using the following standard algorithm.

```
function interp (var x,y; n : word; x1 : single) : single;
    var jlo : integer;
    begin
        if x1 < get(x,1) then {extrapolate backward from first point}
            interp := get(y,1)+(x1-get(x,1))/(get(x,1)-get(x,2))*(get(y,1)-get(y,2))
        else if x1 > get(x,n) then {extrapolate from last point}
            interp := get(y,n)+(x1-get(x,n))/(get(x,n)-get(x,n-1))*(get(y,n)-get(y,n-1))
        else
            begin
                hunt (x,n,x1,jlo);
                interp := get(y,jlo)+(get(y,jlo+1)-get(y,jlo))*(x1-get(x,jlo))/(get(x,jlo+1)-get(x,jlo));
            end;
        end;
```

For example, gage TMA-TC-4A-6 is located at $r = 0.729$ or $\tilde{r} = -1.171214$. It is located between model nodes at $r = 0.6103700$ ($\tilde{r} = -1.279981$) and $r = 0.770293$ ($\tilde{r} = -1.139389$), where the model temperatures are 123.105 and 111.15, respectively. The interpolated temperature is given by

$$T = 123.105 + (111.150 - 123.105) * \frac{(-1.171214 - -1.279981)}{(-1.139389 - -1.279981)} = 113.856$$

If we look in the output file TC4A6.csv, in the column under model dsps_mean_TSPA-SR_SHT, at time step 273.7998 we find a predicted temperature at this location of 113.874. The difference between the two is a result of roundoff errors in the hand calculation.

ATTACHMENT II
ROUTINES FOR STATISTICAL REDUCTION OF THERMAL TEST NUFT
SIMULATION

ROUTINE FOR STATISTICAL REDUCTION OF THERMAL TEST NUFT SIMULATION

Routine Identification

MultiDST v1.0. This is the initial release of this routine. The routine was developed in perl v5.x and ANSI C, compiled with Sun Workshop SC4.2 cc compiler. The source code consists of the files *dstdata*, *multidst.c*, *multidst_stubs.c*, and *multidst.h*.

This routine is composed of two components—a graphical user interface in C, and a perl script. The perl script is identified as *dstdata v1.16* is executed with perl v5.x (this component performs all data manipulation). The GUI is identified as *multidst v???*, built with Sun Workshop SC4.2 cc.

Routine Purpose and Validation

The purpose of the *dstdata* script is to extract data from a local database containing results data from the drift scale test, extract corresponding data from an *ext* file, produce plots and statistical reduction of both. The purpose of the GUI is to simplify use of the underlying script, and, as it is not involved in manipulation of any of the data, it is exempt from this validation exercise.

There are several categories of tests that contribute to the validation of *dstdata*:

1. Test data extraction from database.
2. Test of data extraction from *ext* simulation file (*NUFT* output).
3. Test of the implementation of the statistical fitting algorithm.

The *dstdata* script allows for independent tests of these types via use of the intermediate one-dimensional plot output in *plotsac* format (a type of *ascii* file format).

Only a single run of *multidst* is required to generate the data needed for both test types. The input values chosen for the current test are from bore hole ESF-HD-139-RTD of the drift scale test, for day 100 after begin of test, and for comparison against *dst_AMR_ms-00.m.T.ext* which was output from *NUFT v3.0.1s*. The remainder of the interface values are left at their defaults. The intermediate results of the 1-d plot file are shown below.

```
$free
$title
Snapshot of ESF-HD-139 -- day 100
Goodness of fit ME 1.83077886366462
Goodness of fit RMSE 5.44861815555069

$xlabel
X (m)
$ylabel
Temperature (degC)
$хtype
LINEAR
$уtype
LINEAR
$хbnd          -2.209000E+01      -2.310000E+00
$уbnd          2.438033E+01      1.103936E+02
$хlegpos       0.75
$уlegpos       0.75
```

Send
 \$clab
 Drift Scale Test Data
 \$style 1
 \$symb 1
 \$location_type
 element
 \$data

-2.310000E+00	1.070923E+02
-2.610000E+00	1.004170E+02
-2.910000E+00	9.647552E+01
-3.210000E+00	9.627451E+01
-3.510000E+00	9.649810E+01
-3.810000E+00	9.650153E+01
-4.110000E+00	9.658657E+01
-4.410000E+00	9.703623E+01
-4.710000E+00	9.731010E+01
-5.010000E+00	9.810476E+01
-5.310000E+00	9.761815E+01
-5.610000E+00	9.893652E+01
-5.910000E+00	9.888971E+01
-6.210000E+00	9.882097E+01
-6.500000E+00	9.822504E+01
-6.800000E+00	9.756961E+01
-7.100000E+00	9.755582E+01
-7.400000E+00	9.757798E+01
-7.700000E+00	9.756197E+01
-8.000000E+00	9.754249E+01
-8.300000E+00	9.727423E+01
-8.600000E+00	9.691539E+01
-8.900000E+00	9.683028E+01
-9.200000E+00	9.660008E+01
-9.500000E+00	9.673367E+01
-9.800000E+00	9.663789E+01
-1.010000E+01	9.698882E+01
-1.040000E+01	9.697057E+01
-1.070000E+01	9.721291E+01
-1.100000E+01	9.717490E+01
-1.160000E+01	9.668623E+01
-1.190000E+01	9.610486E+01
-1.220000E+01	9.399352E+01
-1.250000E+01	9.232690E+01
-1.280000E+01	8.796514E+01
-1.310000E+01	8.439390E+01
-1.340000E+01	7.742752E+01
-1.370000E+01	7.392365E+01
-1.400000E+01	6.798613E+01
-1.430000E+01	6.351947E+01
-1.460000E+01	5.772922E+01
-1.490000E+01	5.409273E+01
-1.520000E+01	4.934458E+01
-1.550000E+01	4.645588E+01
-1.579000E+01	4.279303E+01
-1.609000E+01	4.065486E+01
-1.639000E+01	3.760890E+01
-1.669000E+01	3.601718E+01
-1.699000E+01	3.386448E+01
-1.729000E+01	3.267160E+01
-1.759000E+01	3.098964E+01
-1.789000E+01	3.010280E+01
-1.819000E+01	2.881125E+01
-1.849000E+01	2.822575E+01
-1.879000E+01	2.727232E+01
-1.909000E+01	2.680340E+01
-1.939000E+01	2.616070E+01
-1.969000E+01	2.586591E+01
-1.999000E+01	2.548018E+01
-2.029000E+01	2.528946E+01
-2.059000E+01	2.496642E+01
-2.089000E+01	2.482767E+01
-2.119000E+01	2.469859E+01

-2.149000E+01	2.461217E+01
-2.179000E+01	2.443685E+01
-2.209000E+01	2.438033E+01
Send	
\$clab	
NUFT Simulation Results	
\$style	1
\$symb	1
\$location_type	
element	
\$data	
-2.310000E+00	1.027230E+02
-2.610000E+00	9.745481E+01
-2.910000E+00	9.367882E+01
-3.210000E+00	9.064499E+01
-3.510000E+00	9.046567E+01
-3.810000E+00	9.052336E+01
-4.110000E+00	9.342005E+01
-4.410000E+00	9.635167E+01
-4.710000E+00	9.781509E+01
-5.010000E+00	9.926499E+01
-5.310000E+00	9.986933E+01
-5.610000E+00	1.005936E+02
-5.910000E+00	1.013052E+02
-6.210000E+00	1.016918E+02
-6.500000E+00	1.018719E+02
-6.800000E+00	1.022484E+02
-7.100000E+00	1.026315E+02
-7.400000E+00	1.032341E+02
-7.700000E+00	1.035834E+02
-8.000000E+00	1.041662E+02
-8.300000E+00	1.047993E+02
-8.600000E+00	1.063109E+02
-8.900000E+00	1.075003E+02
-9.200000E+00	1.089962E+02
-9.500000E+00	1.103751E+02
-9.800000E+00	1.103936E+02
-1.010000E+01	1.100571E+02
-1.040000E+01	1.100746E+02
-1.070000E+01	1.099686E+02
-1.100000E+01	1.088040E+02
-1.160000E+01	1.061256E+02
-1.190000E+01	1.048085E+02
-1.220000E+01	1.024447E+02
-1.250000E+01	9.986089E+01
-1.280000E+01	9.755660E+01
-1.310000E+01	9.447613E+01
-1.340000E+01	8.713717E+01
-1.370000E+01	7.971732E+01
-1.400000E+01	7.239182E+01
-1.430000E+01	6.506631E+01
-1.460000E+01	5.774081E+01
-1.490000E+01	5.038686E+01
-1.520000E+01	4.402374E+01
-1.550000E+01	4.240602E+01
-1.579000E+01	4.084223E+01
-1.609000E+01	3.921199E+01
-1.639000E+01	3.759582E+01
-1.669000E+01	3.597964E+01
-1.699000E+01	3.436416E+01
-1.729000E+01	3.274148E+01
-1.759000E+01	3.112671E+01
-1.789000E+01	2.951194E+01
-1.819000E+01	2.806818E+01
-1.849000E+01	2.773419E+01
-1.879000E+01	2.740213E+01
-1.909000E+01	2.707008E+01
-1.939000E+01	2.673802E+01
-1.969000E+01	2.640482E+01
-1.999000E+01	2.607292E+01
-2.029000E+01	2.574110E+01

-2.059000E+01	2.540919E+01
-2.089000E+01	2.507728E+01
-2.119000E+01	2.478090E+01
-2.149000E+01	2.471838E+01
-2.179000E+01	2.465586E+01
-2.209000E+01	2.459334E+01

Send

The data from the database was extracted by hand for comparison against this file. Day 100 is March 13, 1998, since the start point of the Drift Scale Test is December 3, 1997. The data from this day is shown below.

DST Data for day 100 (13 March 1998):

MDATE	MGAGE	X	Y	Z	VALUE
13-MAR-98	ESF-HD-139-TEMP7-RTD-1	-2.31	11.89	-.02	107.0923
13-MAR-98	ESF-HD-139-TEMP7-RTD-2	-2.61	11.89	-.02	100.417
13-MAR-98	ESF-HD-139-TEMP7-RTD-3	-2.91	11.89	-.01	96.47552
13-MAR-98	ESF-HD-139-TEMP7-RTD-4	-3.21	11.89	-.01	96.27451
13-MAR-98	ESF-HD-139-TEMP7-RTD-5	-3.51	11.89	-.01	96.4981
13-MAR-98	ESF-HD-139-TEMP7-RTD-6	-3.81	11.89	-.01	96.50153
13-MAR-98	ESF-HD-139-TEMP7-RTD-7	-4.11	11.9	0	96.58657
13-MAR-98	ESF-HD-139-TEMP7-RTD-8	-4.41	11.9	0	97.03623
13-MAR-98	ESF-HD-139-TEMP7-RTD-9	-4.71	11.9	0	97.3101
13-MAR-98	ESF-HD-139-TEMP7-RTD-10	-5.01	11.9	0	98.10476
13-MAR-98	ESF-HD-139-TEMP7-RTD-11	-5.31	11.9	.01	97.61815
13-MAR-98	ESF-HD-139-TEMP7-RTD-12	-5.61	11.9	.01	98.93652
13-MAR-98	ESF-HD-139-TEMP7-RTD-13	-5.91	11.9	.01	98.88971
13-MAR-98	ESF-HD-139-TEMP7-RTD-14	-6.21	11.9	.01	98.82097
13-MAR-98	ESF-HD-139-TEMP7-RTD-15	-6.5	11.9	.02	98.22504
13-MAR-98	ESF-HD-139-TEMP7-RTD-16	-6.8	11.9	.02	97.56961
13-MAR-98	ESF-HD-139-TEMP7-RTD-17	-7.1	11.9	.02	97.55582
13-MAR-98	ESF-HD-139-TEMP7-RTD-18	-7.4	11.91	.02	97.57798
13-MAR-98	ESF-HD-139-TEMP7-RTD-19	-7.7	11.91	.03	97.56197
13-MAR-98	ESF-HD-139-TEMP7-RTD-20	-8	11.91	.03	97.54249
13-MAR-98	ESF-HD-139-TEMP7-RTD-21	-8.3	11.91	.03	97.27423
13-MAR-98	ESF-HD-139-TEMP7-RTD-22	-8.6	11.91	.03	96.91539
13-MAR-98	ESF-HD-139-TEMP7-RTD-23	-8.9	11.91	.04	96.83028
13-MAR-98	ESF-HD-139-TEMP7-RTD-24	-9.2	11.91	.04	96.60008
13-MAR-98	ESF-HD-139-TEMP7-RTD-25	-9.5	11.91	.04	96.73367
13-MAR-98	ESF-HD-139-TEMP7-RTD-26	-9.8	11.91	.04	96.63789
13-MAR-98	ESF-HD-139-TEMP7-RTD-27	-10.1	11.91	.05	96.98882

MDATE	MGAGE	X	Y	Z	VALUE
13-MAR-98	ESF-HD-139-TEMP7-RTD-28	-10.4	11.92	.05	96.97057
13-MAR-98	ESF-HD-139-TEMP7-RTD-29	-10.7	11.92	.05	97.21291
13-MAR-98	ESF-HD-139-TEMP7-RTD-30	-11	11.92	.05	97.1749
13-MAR-98	ESF-HD-139-TEMP7-RTD-31	-11.3	11.92	.06	1.0000E+38
13-MAR-98	ESF-HD-139-TEMP7-RTD-32	-11.6	11.92	.06	96.68623
13-MAR-98	ESF-HD-139-TEMP7-RTD-33	-11.9	11.92	.06	96.10486
13-MAR-98	ESF-HD-139-TEMP7-RTD-34	-12.2	11.92	.06	93.99352
13-MAR-98	ESF-HD-139-TEMP7-RTD-35	-12.5	11.92	.07	92.3269
13-MAR-98	ESF-HD-139-TEMP7-RTD-36	-12.8	11.92	.07	87.96514
13-MAR-98	ESF-HD-139-TEMP7-RTD-37	-13.1	11.92	.07	84.3939
13-MAR-98	ESF-HD-139-TEMP7-RTD-38	-13.4	11.92	.07	77.42752
13-MAR-98	ESF-HD-139-TEMP7-RTD-39	-13.7	11.93	.08	73.92365
13-MAR-98	ESF-HD-139-TEMP7-RTD-40	-14	11.93	.08	67.98613
13-MAR-98	ESF-HD-139-TEMP7-RTD-41	-14.3	11.93	.08	63.51947
13-MAR-98	ESF-HD-139-TEMP7-RTD-42	-14.6	11.93	.08	57.72922
13-MAR-98	ESF-HD-139-TEMP7-RTD-43	-14.9	11.93	.09	54.09273
13-MAR-98	ESF-HD-139-TEMP7-RTD-44	-15.2	11.93	.09	49.34458
13-MAR-98	ESF-HD-139-TEMP7-RTD-45	-15.5	11.93	.09	46.45588
13-MAR-98	ESF-HD-139-TEMP7-RTD-46	-15.79	11.93	.09	42.79303
13-MAR-98	ESF-HD-139-TEMP7-RTD-47	-16.09	11.93	.1	40.65486
13-MAR-98	ESF-HD-139-TEMP7-RTD-48	-16.39	11.93	.1	37.6089
13-MAR-98	ESF-HD-139-TEMP7-RTD-49	-16.69	11.93	.1	36.01718
13-MAR-98	ESF-HD-139-TEMP7-RTD-50	-16.99	11.94	.1	33.86448

13-MAR-98	ESF-HD-139-TEMP7-RTD-51	-17.29	11.94	.11	32.6716
13-MAR-98	ESF-HD-139-TEMP7-RTD-52	-17.59	11.94	.11	30.98964
13-MAR-98	ESF-HD-139-TEMP7-RTD-53	-17.89	11.94	.11	30.1028
13-MAR-98	ESF-HD-139-TEMP7-RTD-54	-18.19	11.94	.11	28.81125

MDATE	MGAGE	X	Y	Z	VALUE
13-MAR-98	ESF-HD-139-TEMP7-RTD-55	-18.49	11.94	.12	28.22575
13-MAR-98	ESF-HD-139-TEMP7-RTD-56	-18.79	11.94	.12	27.27232
13-MAR-98	ESF-HD-139-TEMP7-RTD-57	-19.09	11.94	.12	26.8034
13-MAR-98	ESF-HD-139-TEMP7-RTD-58	-19.39	11.94	.12	26.1607
13-MAR-98	ESF-HD-139-TEMP7-RTD-59	-19.69	11.94	.13	25.86591
13-MAR-98	ESF-HD-139-TEMP7-RTD-60	-19.99	11.94	.13	25.48018
13-MAR-98	ESF-HD-139-TEMP7-RTD-61	-20.29	11.95	.13	25.28946
13-MAR-98	ESF-HD-139-TEMP7-RTD-62	-20.59	11.95	.13	24.96642
13-MAR-98	ESF-HD-139-TEMP7-RTD-63	-20.89	11.95	.13	24.82767
13-MAR-98	ESF-HD-139-TEMP7-RTD-64	-21.19	11.95	.14	24.69859
13-MAR-98	ESF-HD-139-TEMP7-RTD-65	-21.49	11.95	.14	24.61217
13-MAR-98	ESF-HD-139-TEMP7-RTD-66	-21.79	11.95	.14	24.43685
13-MAR-98	ESF-HD-139-TEMP7-RTD-67	-22.09	11.95	.14	24.38033

A manual comparison between the value column of the database data and the second column of data in the first data block in the above file confirm the data is extracted correctly from the database.

The values extracted from the *ext* file are tested via comparison with extractions performed with *xtool* v10.1. The *xtool* extractions are each performed in the direction of a single coordinate axis. In order to bracket the extraction from multidst, four *xtool* extractions are performed. Each of them are over the full range of x coordinates, holding both y and z coordinates constant. The NUFT data is referenced to the origin of the Drift Scale Test. This is a simple transformation, since the DST origin is at (293.65, 294.52, 267.61) in NUFT coordinates, and the z axis is inverted. The coordinate range is shown below:

Coordinate range:
DST Coord:
X: -2.31 -22.09
Y: 11.89 11.95
Z: -.02 .14

NUFT Coord:
X: 291.34 271.56
Y: 306.41 306.47
Z: 267.63 267.47

The resulting plot from this test is shown in Figure 1. The NUFT Simulation Results lies between the curves extracted using *xtool*. This validates the multidst data extraction from the *ext* file.

The statistical results are displayed to the terminal by the script. The results from this test case are shown below:

ME: 1.83077886366462
RMSE: 5.44861815555069
Min:24.38033 Max:107.0923
NAME:0.10435472090095

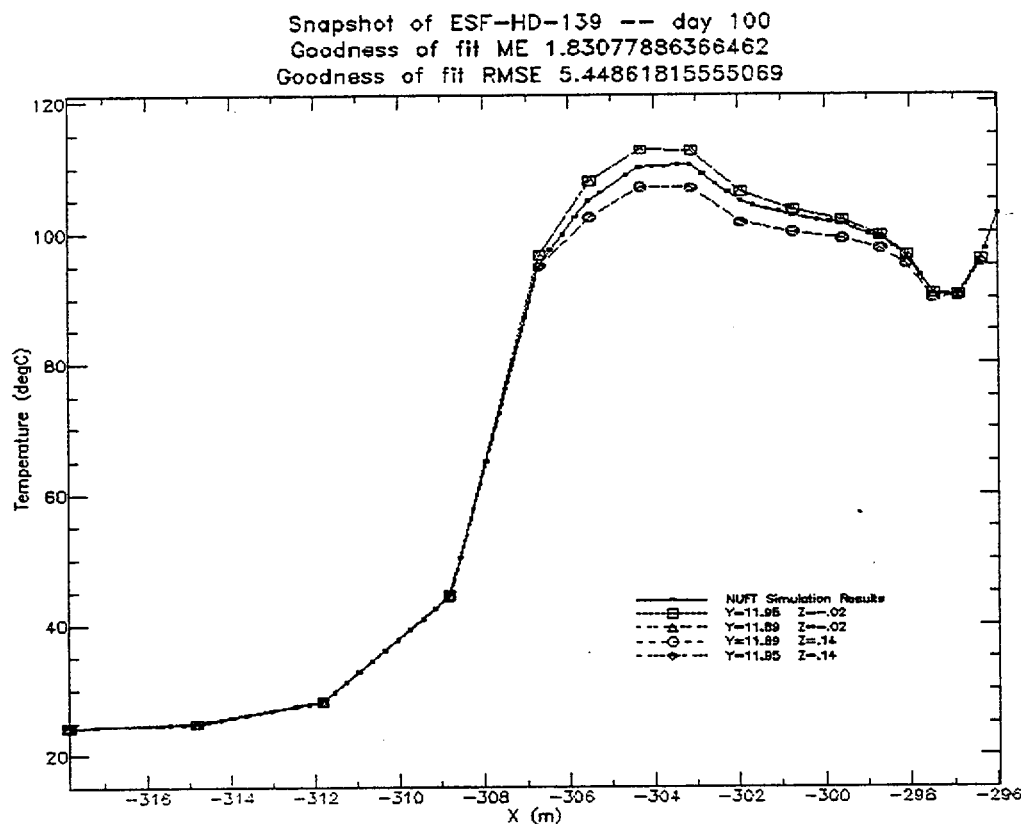


Figure 1

The formulae for the statistics above were defined outside the scope of this validation, but the intermediate steps are visible in the accompanying Excel spreadsheet. The formulae are reported below:

$$ME = \frac{\sum_i w(T_i^{meas}) (T_i^{sim} - T_i^{meas})}{\sum_i w(T_i^{meas})}$$

$$RMSE = \sqrt{\frac{\sum_i w(T_i^{meas}) (T_i^{sim} - T_i^{meas})^2}{\sum_i w(T_i^{meas})}}$$

$$NAME = \frac{\sum_i w(T_i^{meas}) \left| \frac{T_i^{sim} - T_i^{meas}}{T_i^{meas} - T_{amb}} \right|}{\sum_i w(T_i^{meas})}$$

where

T_i^{sim} represents the simulated data points

T_i^{meas} represents the field measurements

T_{amb} represents the ambient temperature without heaters (25.0 C is used here)

$w(T_i^{meas})$ represents a weighting factor based on occupancy. To compute this factor the following steps are followed:

The range of temperatures from minimum to maximum of the measured values is divided into 20 equally sized bins. We number the bins from 0 to 19, and use T_k to represent the temperature between bins numbered $k-1$ and k .

For each bin, count the number of sensors reporting a temperature in that range. This number we denote N_k .

For any given temperature T we have:

$$w(T) = \frac{1}{N_k} \ni T_k \leq T \leq T_{k+1}.$$

The computation of *NAME* differs in that the minimum allowed temperature is 5 degrees above T_{amb} , and the weighting factor is recomputed to take this into account.

The statistical data reduction is validated via an *Excel* spreadsheet. The algorithm is created as an *Excel* macro, and the results are compared against the final statistical output from multidst. The results are shown in Table 1. This test validates the statistical reduction implemented within multidst.

Table 1.

Min	24.38033
Max	107.0923
ME	1.83078
RMSE	5.44861
NAME	0.10435

Listing of dstdata script:

```
#!/usr/local/bin/perl -s

$_version = "dstdata.sh 1.16 01/25/00 17:37:11 LLNL";

$_ts_start=time;

if (defined($bg)) {
```

```

    $type='t' unless $type eq 's';
    $start="3 Dec 1997" unless $start;
} else {
    &getVal(\$type, "Extraction Type (s=snpshot, t=time history)", "t");
    &getVal(\$start, "Drift Scale Test Start Date", "3 Dec 1997");
    &getVal(\$guage, "Guage", "");
    &getVal(\$daymin, "Min days since start", "");
    &getVal(\$daymax, "Max days since start", "");
}

# using global now for quick kludge job
$doOccCut=1 if defined($filter);
$nbins=20 unless $nbins>0;

&doIt($type, $start, $guage, $daymin, $daymax, $valmin, $valmax, $nfile, $nbins, $alldata, $xwall);

$_ts_stop=time;
print "\nElapsed time: " . ($_ts_stop - $_ts_start) . "\n";

sub getVal
{
    my($var, $text, $def) = @_;
    my($inp);

    return if defined($$var);
    print "$text [$def]: ";
    $inp = <STDIN>;
    chomp $inp;
    if (defined($inp)) {
        $$var = $inp;
    } else {
        $$var = $def;
    }
}

sub doIt
{
    my($stp, $date0, $g, $d0, $d1, $v0, $v1, $nf, $bins, $all, $xthick)=@_;
    my($query, $file, $dbdata, $item, $fitres);
    my($symName);

    $|=1;
    $date0=&formatDate($date0);
    {
        $stp eq 't' && do {
            $symName="TimeHistory";
            last;
        };
        $stp eq 's' && do {
            $symName="Snapshot";
            last;
        };
        die "Unknown operation mode $stp\n";
    }

    $query=&mkSelect($date0, $g, $d0, $d1, $v0, $v1, &mkOrder($stp));
    print "SQL: $query\n" if defined($dbg);
    $file=&openSql(SQL, $query) || die "Unable to perform query\n";
    $dbdata=&{"process$symName"}(SQL);
    &closeSql(SQL);
    unlink($file) unless defined($dbg);
    &pruneDrift(\$dbdata, $xthick, $symName) if defined($xthick);

    if ($nf) {
        &getNuftData($nf, $dbdata, $symName, $d0, $d1, 'T');
    } else {
        $all=1;
    }
}

```

```

if ($symName eq 'Snapshot') {
    $fitres=&doGlobalFit($dbdata,$bins);
} else {
    foreach $item (@{$dbdata}) {
        if (&{"hasNuft$symName"}($item)) {
            $item->[4]=$nf;
            &{"testFit$symName"}($item);
        }
    }
    foreach $item (@{$dbdata}) {
        if (defined($all) || &{"hasNuft$symName"}($item)) {
            &{"output$symName"}(@{$item});
        }
    }
}

sub isInside
{
    my($c,$l)=@_;
    my($i);

    foreach $i (0..2) {
        return if $c->[$i]<$l->[$i]->[0] || $c->[$i]>$l->[$i]->[1];
    }
    return 1;
}

sub pruneDrift
{
    my($db,$cut,$type)=@_;
    my($delta)=4.43/2.0;
    my($dely)=47.5;
    my($limit)=[[-$delta-$cut,$delta+$cut],[-$cut,$dely+$cut],[-$delta-$cut,$delta+$cut]];
    my($data,$pt);

    if ($type eq "TimeHistory") {
        $data=[];
        foreach $pt (@{$db}) {
            next if isInside($pt->[3],$limit);
            push(@{$data},$pt);
        }
        $$db=$data;
    } else {
        foreach $pt (@{$db}) {
            $data=[];
            foreach $one (@{$pt->[1]}) {
                next if isInside($one->[3],$limit);
                push(@{$data},$one);
            }
            $pt->[1]=$data;
        }
    }
}

sub doGlobalFit
{
    my($dt0,$bn)=@_;
    my($fdat,$pt,$ary,$day,$g,$smin,$smax,$sinf,$sitm,$sme,$srme,$sw,$socc);
    my($i,$f,@darry,@histo,@hname,$data,$newdata,@occ,$j,$k,$Tdelt,$fname);
    my($Tamb)=25.0;
    my($dtCut)=5.0;

    $data=[];
    foreach $pt (@{$dt0}) {
        next unless defined($pt->[1]->[0]->[2]) && defined($pt->[1]->[0]->[1]);
        push(@{$data},$pt);
    }
    $fdat=&getMinMax($data);

```

```

&getOccupancy($fdat,$data,$bn);
if ($doOccCut) {
    while (($day,$sinf)=each(%{$fdat})) {
        @occ=@{$sinf->{'occ'}};
        $k=0;
        foreach $i (@occ) {
            $k+=$i;
        }
        $j=0; $i=$#occ;
        while ($i>$#occ/2 && $j<$k) {
            if ($occ[$i]==0) {
                while ($occ[$i]==0 && $i>$#occ/2) {
                    $i--;
                }
                print "Occupancy cut on day $day: old max " . $sinf->{'max'};
                $sinf->{'max'}=$sinf->{'min'}+$sinf->{'delta'}*(($i+1));
                print " new max " . $sinf->{'max'} . "\n";
                $j=2*$k;
            }
            $j+=2*$occ[$i];
            $i--
        }
    }
    &getOccupancy($fdat,$data,$bn);
}
$name=&getMinMax($data);
while (($day,$sinf)=each(%{$name})) {
    $sinf->{'min'}=$Tamb+$dtCut if $sinf->{'min'}<$Tamb+$dtCut;
}
&getOccupancy($name,$data,$bn);

foreach $pt (@{$data}) {
    $ary=$pt->[1];
    $sinf=$fdat->{$pt->[2]};
    $sinfname=$name->{$pt->[2]};
    $g=$pt->[0];
    if (!defined($sinf->{'fit'})) {
        $sinf->{'fit'}={};
        $sinf->{'fit'}->{'RMSE'}=$sinf->{'fit'}->{'ME'}=
            $sinf->{'fit'}->{'wgt'}=
            $sinf->{'fit'}->{'mabs'}=$sinf->{'fit'}->{'mnum'}=0.0;
    }
    $me=$rmse=$w=0.0;
    foreach $itm (@{$ary}) {
        next if $itm->[1]<$sinf->{'min'} || $itm->[1]>$sinf->{'max'};
        $i=($itm->[1]-$sinf->{'min'})/$sinf->{'delta'};
        $i=$bn-1 if $i>=$bn;
        $occ=$sinf->{'occ'}->[$i];
        $w+=1.0/$occ;
        $me+=$itm->[2]-$itm->[1]/$occ;
        $rmse+=$itm->[2]-$itm->[1]**2/$occ;
        $Tdelt=abs($Tamb-$itm->[1]);
        if ($Tdelt>$dtCut) {
            $i=($itm->[1]-$sinfname->{'min'})/$sinfname->{'delta'};
            $i=$bn-1 if $i>=$bn;
            $occ=$sinfname->{'occ'}->[$i];
            $sinf->{'fit'}->{'mabs'}+=abs($itm->[2]-$itm->[1])/($Tdelt*$occ);
            $sinf->{'fit'}->{'mnum'}+=1.0/$occ;
        }
    }
    if ($w) {
        $pt->[4]=[$me/$w,sqrt($rmse/$w)];
    } else {
        $pt->[4]=[0.0,-1.0];
    }
    $sinf->{'fit'}->{'RMSE'}+=$rmse;
    $sinf->{'fit'}->{'ME'}+=$me;
    $sinf->{'fit'}->{'wgt'}+=$w;
}
$i=0;
@darry=([],[],[],[]);

```

```

foreach $itm (sort {$a <=> $b} keys(%{$fdat})) {
    $sinf=$fdat->{$itm};
    $sf=$sinf->{'fit'};
    $darry[0]->[$i]=[$itm,$sf->{'ME'}/$sf->{'wgt'}};
    $darry[1]->[$i]=[$itm,sqrt($sf->{'RMSE'}/$sf->{'wgt'})];
    $darry[2]->[$i]=[$itm,$sinf->{'min'}];
    $darry[3]->[$i]=[$itm,$sinf->{'max'}];
    print "Day $itm\n";
    print " ME: ".$sf->{'ME'}/$sf->{'wgt'}."\n";
    print " RMSE: ".sqrt($sf->{'RMSE'}/$sf->{'wgt'})."\n";
    print " Min: ".$sinf->{'min'}." Max: ".$sinf->{'max'}."\n";
    print " NAME:";
    if ($sf->{'mnum'}>0.0) {
        print $sf->{'mabs'}/$sf->{'mnum'};
    } else {
        print "Num points = 0";
    }
    print "\n";
    $histo[$i]=[];
    $hname[$i]="Day $itm";
    foreach $pt (0..$bn-1) {
        $histo[$i]->[$pt]=[$sinf->{'min'}+($pt+0.5)*$sinf->{'delta'},
            $sinf->{'occ'}->[$pt]];
    }
    $i++;
}
&printSac("GoodnessOfFit.plt","NUFT Goodness of Fit to Drift Scale Test Data\n".
    "$bn Occupancy Bins for Frequency",
    \@darry,"Time (days)","Goodness of Fit",
    ["Mean Error","RMS Error","Minimum Temperature","Maximum Temperature"]);
&printSac("Occupancy.plt","Temperature Occupancy for Goodness of Fit\n",
    \@histo,"Temperature (degC)","Occupancy",\@hname);
}

sub getMinMax
{
    my($data)=@_;
    my($pt,$ary,$day,$fdat,$min,$max,$itm);

    $fdat={};
    foreach $pt (@{$data}) {
        $ary=$pt->[1];
        $day=$pt->[2];
        if (!defined($fdat->{$day})) {
            $fdat->{$day}={};
            $fdat->{$day}->{'min'}=1e38;
            $fdat->{$day}->{'max'}=-1e38;
        }
        $min=$fdat->{$day}->{'min'};
        $max=$fdat->{$day}->{'max'};
        foreach $itm (@{$ary}) {
            $min=$itm->[1] if $itm->[1]<$min;
            $max=$itm->[1] if $itm->[1]>$max;
        }
        $fdat->{$day}->{'min'}=$min;
        $fdat->{$day}->{'max'}=$max;
    }
    return $fdat;
}

sub getOccupancy
{
    my($fdat,$data,$bins)=@_;
    my($pt,$ary,$sinf,$itm,$i);

    while (($day,$sinf)=each(%{$fdat})) {
        $sinf->{'delta'}=($sinf->{'max'}-$sinf->{'min'})/$bins;
        $sinf->{'occ'}=[(0) x $bins];
    }
    foreach $pt (@{$data}) {

```

```

    Sary=$pt->[1];
    Sinf=$fdat->{$pt->[2]};
    foreach $itm (@{$Sary}) {
        next if $itm->[1]<$inf->{'min'}||$itm->[1]>$inf->{'max'};
        $i=($itm->[1]-$inf->{'min'})/$inf->{'delta'};
        $i=$bins-1 if $i>=$bins;
        $inf->{'occ'}->[$i]++;
    }
}
return $fdat;
}

```

sub getNuftData

```

{
    my($snf,$db,$sym,$d0,$d1,$var)=@_;
    my($nfile,$dblk,$time);

    print "Opening NUFT file $snf\n";
    $nfile=&openExt(NUFT,$snf);
    print "Building interpolation table...\n";
    &{"interpSetup$sym"}($db,$nfile);
    print "Interpolating NUFT data...";
    while ($dblk=&getData(NUFT)) {
        $time=$dblk->{'time'}/(3600.0*24.0);
        print "\n";
        last if $time>$d1;
        print " Time $time...";
        next if $time<$d0 ||
            $nfile->{'vnames'}->[$dblk->{'var'}] ne $var;
        print "Interpolating";
        &{"interpolate$sym"}($time,$dblk->{'data'},$db);
    }
    print "\n";
    close(NUFT);
    foreach $dblk (@{$db}) {
        undef($dblk->[4]);
    }
}

```

sub testFitTimeHistory

```

{
    my($itm)=@_;
    my($data,$nuft,$resid,$num,$i,$j);

    $data=$itm->[1];
    $nuft=$itm->[5];
    $resid=0.0;
    $num=0;
    $i=$j=0;
    do {
        while (int($data->[$i]->[0])<int($nuft->[$j]->[0])) {
            last if $i>=$#{ $data };
            $i++;
        }
        while (int($data->[$i]->[0])>int($nuft->[$j]->[0])) {
            last if $j>=$#{ $nuft };
            $j++;
        }
        if (int($data->[$i]->[0])==int($nuft->[$j]->[0])) {
            $num++;
            $resid+=$data->[$i]->[1]-$nuft->[$j]->[1]**2;
            $i++; $j++;
        }
    } while ($i<=$#{ $data } && $j<=$#{ $nuft });
    $itm->[4]->[1]=$resid/$num if $num>0;
}

```

sub testFitSnapshot

```

{

```

```

my($itm)=@_;
my($resid,$num,$pt);

$resid=0.0;
$num=0;
foreach $pt (@{$itm->[1]}) {
    $num++;
    $resid+=$pt->[1]-$pt->[2]**2;
}
$itm->[4]->[1]=$resid/$num if $num>0;
}

sub hasNuftTimeHistory
{
    my($itm)=shift;

    return defined($itm->[5]);
}

sub hasNuftSnapshot
{
    my($itm)=shift;

    return defined($itm->[1]->[0]->[2]);
}

sub interpSetupTimeHistory
{
    my($db,$nf)=@_;
    my($dat);

    foreach $dat (@{$db}) {
        print " Interpolation table for guage $dat->[0]\n";
        $dat->[4]=&nuftSetupInterp($nf,$dat->[3]);
    }
    return;
}

sub interpolateTimeHistory
{
    my($time,$data,$db)=@_;
    my($pt);

    foreach $pt (@{$db}) {
        $pt->[5]=[] unless defined $pt->[5];
        push(@{$pt->[5]}, [$time,&nuftInterpolate($pt->[4],$data)]);
    }
}

sub interpSetupSnapshot
{
    my($db,$nf)=@_;
    my($out,$i,$v,$dat);

    foreach $dat (@{$db}) {
        if (!$out{$dat->[0]}) {
            print " Interpolation table for bore $dat->[0]\n";
            $v=$out{$dat->[0]}=[];
            foreach $i (0..$#{ $dat->[1] }) {
                $v->[$i]=&nuftSetupInterp($nf,$dat->[1]->[$i]->[3]);
            }
            $dat->[4]=$out{$dat->[0]};
        }
    }
    return;
}

```

```

sub interpolateSnapshot
{
    my($time,$data,$db)=@_;
    my($pt);

    foreach $pt (@{$db}) {
        next unless int($pt->[2])==int($time);
        foreach $i (0..${$pt->[1]}) {
            $pt->[1]->[$i]->[2]&=nuftInterpolate($pt->[4]->[$i],$data);
        }
    }
}

sub interpGetBlocks
{
    my($grd,$crd)=@_;

    if ($grd->{'def'} eq 'gdef' || $grd->{'def'} eq 'nested_gdef') {
        return &interpNestedBlocks([], $grd, $crd);
    } else {
        return;
    }
}

sub interpFindBlock
{
    my($g,$c)=@_;
    my($i,$del,$v,$j,@idx,$b,$char);

    $b=0;
    $char='x';
    foreach $i (0..2) {
        $del=$g->{$char};
        $v=$c->[$i];
        foreach $j (0..${$del}) {
            if ($v<$del->[$j]) {
                $idx[$i]=$j+1;
                $b+=2**$i unless $v > ($del->[$j])/2.0;
                last;
            }
            $v--$del->[$j];
        }
        $idx[$i]=scalar(@{$del}) unless defined($idx[$i]);
        $char++;
    }
    return ([@idx],$b);
}

sub setupBlockSet
{
    my($idx,$lim,$base)=@_;
    my(@bl);

    $#bl=7;
    @d = (1) x 3;
    foreach $i (0..2) {
        $d[$i]=-1 if (2**$i) & $base;
    }
    foreach $i (0..7) {
        @n=@{$idx};
        $keep=1;
        foreach $j (0..2) {
            $n[$j]+=$d[$j] if $i & (2**$j);
            $keep=0 if $n[$j]<1 || $n[$j]>$lim->[$j];
        }
        $bl[$i]=@n if $keep;
    }
    return @bl;
}

sub interpSubGrid

```

```

{
  my($nst,$g,$sg,$c,$msk)=@_;
  my($bl,$b,$i,@o,@sc);

  @o=&getSubExtent($g,$sg->{'parovr'});
  foreach $i (0..2) {
    $msk->[$i]==0 && do {$sc[$i]=$c->[$i]-$o[$i]; next;};
    $msk->[$i]<0 && do {$sc[$i]=0.0; next;};
    $msk->[$i]>0 && do {$sc[$i]=$o[$i+3]-$o[$i]; next;};
  }
  $bl=&interpNestedBlocks([$sg->{'name'}],@{$nst}),$sg,\esc);
  foreach $b (@{$bl}) {
    next unless defined($b);
    foreach $i (0..2) {
      $b->[2]->[$i]+=$o[$i];
    }
  }
  return $bl;
}

sub interpNestedBlocks
{
  my($nst,$grd,$crd)=@_;
  my($blk,$lblk,$idx,$baseidx,$sub,@fact);
  my($i,$j,$k,$n1,$n2,$sblk,@msk);

  # get base block
  ($idx,$baseidx)=&interpFindBlock($grd,$crd);
  #setup array clipping exterior bounds
  $lblk=&setupBlockSet($idx,$grd->{'nx'},$grd->{'ny'},$grd->{'nz'}),$baseidx);
  # check for base block in subgrid
  if ($sub=&checkNestedGrid($grd,$idx)) {
    $blk=&interpSubGrid($nst,$grd,$sub,$crd,[0,0,0]);
  } else {
    $blk=[];
    # base block
    $blk->[$baseidx]=[$nst,$idx,&calcLocation($grd,$idx)];

    # primary adjacent blocks
    @fact=(2,4);
    foreach $i (0..2) {
      $j=2**$i;
      next unless defined($lblk->[$j]);
      if ($sub=&checkNestedGrid($grd,$lblk->[$j])) {
        @msk=(0) x 3;
        if ($j & $baseidx) {
          $msk[$i]=1;
        } else {
          $msk[$i]=-1;
        }
        $sblk=&interpSubGrid($nst,$grd,$sub,$crd,\@msk);
        foreach $n1 (0..1) {
          foreach $n2 (0..1) {
            $k=((~$baseidx) & $j) + $n1*$fact[0] + $n2*$fact[1];
            $blk->[$k]=$sblk->[$k] if defined($sblk->[$k]) && !defined($blk->[$k]);
          }
        }
      }
      $fact[$i]/=2;
    }

    # secondary adjacent blocks
    foreach $i (0..2) {
      $j=7-2**$i;
      next unless defined($lblk->[$j]) && (!defined($blk->[$j ^ $baseidx]) ||
        !defined($blk->[7 & ~$baseidx]));
      if ($sub=&checkNestedGrid($grd,$lblk->[$j])) {
        foreach $k (0..2) {
          if ($k==$i) {
            $msk[$k]=0;
          } elsif ((2**$k) & $baseidx) {

```

```

        $msk[$k]=1;
    } else {
        $msk[$k]=-1;
    }
}
$tblk=&interpSubGrid($nst,$grd,$sub,$crd,\@msk);
$sk = $j ^ $baseidx;
$tblk->[$k]=$tblk->[$k] if defined($tblk->[$k]) && !defined($tblk->[$k]);
$sk = 7 & ~$baseidx;
$tblk->[$k]=$tblk->[$k] if defined($tblk->[$k]) && !defined($tblk->[$k]);
}
}

# final block
$si=7 & ~$baseidx;
if (!defined($tblk->[$si]) && defined($tblk->[7])) {
    if ($sub=&checkNestedGrid($grd,$tblk->[7])) {
        foreach $sj (0..2) {
            if ($sj & $baseidx) {
                $msk[$sj]=1;
            } else {
                $msk[$sj]=-1;
            }
        }
        $tblk=&interpSubGrid($nst,$grd,$sub,$crd,\@msk);
        $tblk->[$si]=$tblk->[$si];
    }
}

foreach $i (0..7) {
    $sj=$i ^ $baseidx;
    next if defined($tblk->[$si]) || !defined($tblk->[$sj]);
    $tblk->[$si]=[$nst,$tblk->[$sj],&calcLocation($grd,$tblk->[$sj])];
}
return $tblk;
}

sub calcLocation
{
    my($g,$idx)=@_;
    my($i,$del,$k,@x,$char);

    $char='cx';
    foreach $i (0..2) {
        $del=$g->{$char};
        $k=$idx->[$i];
        if ($k<1) {
            warn "calcLocation k value $k index $i\n";
            $k=1;
        } elsif ($k>#{$del}) {
            warn "calcLocation k value $k index $i\n";
            $k=#{$del};
        }
        $x[$i]=$del->[$k];
        $char++;
    }
    return [@x];
}

sub getSubExtent
{
    ($g,$ovr)=@_;
    my($i,@v,$d,$char,$j,$k);

    $char='x';
    foreach $i (0..2) {
        $v[$i]=0;
        $d=$g->{$char};
        foreach $j (0..$ovr->[2*$i]-2) {
            $v[$i]+=$d->[$j];
        }
    }
}

```

```

        $k=$i+3;
        $v[$k]=$v[$i];
        foreach $j ($sovr->[2*$i]-1..$sovr->[2*$i+1]-1) {
            $v[$k]+=$d->[$j];
        }
        $char++;
    }
    return @v;
}

sub checkNestedGrid
{
    my($g,$idx)=@_;
    my($s,$in,$so,$m);

    foreach $s (@{$g->{'sub'}}) {
        $in=1;
        $so=$s->{'parovr'};
        foreach $m (0..2) {
            if ($idx->[$m]<$so->[$m*2] || $idx->[$m]>$so->[$m*2+1]){
                $in=0;
                last;
            }
        }
        return $s if $in;
    }
    return;
}

sub nuftSetupInterp
{
    my($nd,$cin)=@_;
    my($c,$blkint,$blk,$m,$sum,$b,$i,$j,$bk,$vl,$df,$k,$sids,$lblk,$nst,$idx);

    $c=[293.65+$cin->[0],294.52+$cin->[1],267.61-$cin->[2]];
    # this returns an array of [nest name,[i,j,k],[x,y,z]] order xyz from 0..7
    $blkint=&interpGetBlocks($nd->{'grid'},$c) || return;
    $blk=[];
    $m=0; $sum=0.0;
    foreach $i (0..7) {
        $b=$blkint->[$i];
        next unless defined($b);
        $vl=$blk->[$m]=[[ $b->[0], $b->[1]],1.0];
        foreach $j (0..2) {
            $df=2**$j;
            $k=$i-$df if int($i/$df)%2;
            $k=$i+$df unless int($i/$df)%2;
            $bk=$blkint->[$k];
            $vl->[1]*=abs(($bk->[2]->[$j]-$c->[$j])/($bk->[2]->[$j]-$b->[2]->[$j])) if
defined($bk);
        }
        $m++;
        $sum+=$vl->[1];
    }
    foreach $b (@{$blk}) {
        # set block pattern
        $nst=@{$b->[0]->[0]};
        $idx=@{$b->[0]->[1]};
        $m=join('.', $nst, '#', $idx);
        if (!defined($lblk($m))) {
            $j='.'.join('.', $nst) if $nst;
            $k='^[^\\.]*'.$j.$nd->{'dkm'}.'#'.join('.', $idx)."$";
            $sids=&getNestedIndices($b->[0], $nd);
            if (!scalar(@{$sids})) {
                warn "No match for $k\n";
                $lblk{$m}=-1;
                next;
            }
            warn "multiple match for $k\n" if $#{$sids}>0;
            $lblk{$m}=$sids->[0];
        }
    }
}

```

```

        next if $lblk{$m}<0;
        $b->[0]=$lblk{$m};
        $b->[1]/=$sum;
    }
    return $blk;
}

sub getNestedIndices
{
    my($inf,$nfl)=@_;
    my($nst,$nam,$bl,$i);

    $nam=join(':',@{$inf->[1]});
    $bl=$nfl->{'nstblk'};
    return &getIndices('#'.$nam."\$", $nfl->{'sblk'}) unless defined($bl);
    $i=scalar(@{$inf->[0]});
    while ($i-->0) {
        $bl=$bl->{$inf->[0]->[$i]};
        if (!defined($bl)) {
            warn "Lost nest heirarchy in indices\n";
            last;
        }
    }
    if (!defined($bl)) {
        $nst='^[^\.]*';
        foreach $j (0..#{ $inf->[0] }) {
            $nst.='\'.'.$inf->[0]->[$j];
        }
        return &getIndices($nst.$nfl->{'dcm'}.'#'.$nam."\$", $nfl->{'sblk'});
    }
    return [$bl->{$nam}];
}

sub nuftInterpolate
{
    my($itp,$dat)=@_;
    my($n,$v);

    $v=0.0;
    foreach $n (@{$itp}) {
        $v+=$n->[1]*$dat->[$n->[0]];
    }
    return $v;
}

sub processTimeHistory
{
    my($sql)=shift;
    my($line,@fields,$guage,@data,$ly,@coord,$out);

    $out=[];
    print "Time History\n";
    print "Query...";
    $ly="Temperature (degC)";
    while ($line=&readSql($sql)) {
        $line=~s/^\s*//;
        @fields=split(/\s+/, $line);
        if ($guage ne $fields[0]) {
            if ($guage) {
                push(@{$out}, [$guage, [@data], $ly, [@coord]]);
            } else {
                print "Receiving\n";
            }
            @coord=($fields[3], $fields[4], $fields[5]);
            $guage=$fields[0];
            @data=();
        }
        $val=[];
        $val->[0]=$fields[1];
        $val->[1]=$fields[2];
        push(@data, $val);
    }
}

```

```

    }
    push(@{$Sout},[$Sguage,@data,$Sly,@coord]) if $Sguage;
    return $Sout;
}

sub outputTimeHistory
{
    my($g,$dat,$var,@rest)=@_;
    my(@darry,$ttl);

    $darry[0]=$dat;
    $ttl="Time History of $g\n";
    print "Output $g\n";
    if (defined($rest[2])) {
        print "        with nuft data\n";
        $darry[1]=$rest[2];
        $ttl.="Nuft Data from: $rest[1]->[0]\n";
        $ttl.="Goodness of Fit (RMS) == $rest[1]->[1]\n";
    }
    &printSac("$g.plt",$ttl,\@darry,"Time (days)",$var,
        ["Drift Scale Test Data","NUFT Simulation Results"]);
}

sub processSnapshot
{
    my($sql)=shift;
    my($line,@fields,$bore,@data,$vnam);
    my($thisbore,$day,@bfld,$snum,$out);

    $out=[];
    print "Snapshot\n";
    print "Query....";
    $vnam="Temperature (degC)";
    while ($line=&readSql($sql)) {
        $line=~s/^\s*//;
        @fields=split(/\s+/, $line);
        @bfld=split(/-/, $fields[0]);
        $snum=$bfld[$#bfld];
        $bore=$bfld[0];
        $thisbore=join('-',@bfld);
        if ($bore ne $thisbore || $day!=$fields[1]) {
            if ($bore) {
                push(@{$Sout},[$bore,@data,$day,$vnam]);
            } else {
                print "Receiving\n";
            }
            $bore=$thisbore;
            $day=$fields[1];
            @data=();
        }
        $val=[];
        $val->[1]=$fields[2];
        $val->[0]=$snum;
        $val->[3]=[$fields[3],$fields[4],$fields[5]];
        push(@data,$val);
    }
    push(@{$Sout},[$bore,@data,$day,$vnam]) if $bore;
    return $out;
}

sub outputSnapshot
{
    my($g,$dat,$day,$var,$nfit)=@_;
    my($x,$y,@delta,$i,$max,$val,@darry,$six,$ttl);

    $six=0;
    @{$dat} = sort {$a->[0] <=> $b->[0]} @{$dat};
    $beg=$dat->[0]; $end=$dat->[$#{ $dat }];
    $max=0.0;
    foreach $i (0..2) {
        $delta[$i]=abs($end->[3]->[$i]-$beg->[3]->[$i]);
    }

```

```

        $max=$delta[$i] unless $max>$delta[$i];
    }
    $max/=5.0;
    if ($delta[1]>$max) {
        $x='Y (m)';
        $y=$var;
        foreach $val (@{$dat}) {
            $val->[0]=$val->[3]->[1];
        }
    }
    } elsif ($delta[0]>$max && $delta[2]>$max) {
        $x='Distance (m)';
        $y=$var;
        foreach $val (@{$dat}) {
            $val->[0]=sqrt($val->[3]->[0]**2+$val->[3]->[2]**2);
        }
    }
    } elsif ($delta[0]>$max) {
        $x='X (m)';
        $y=$var;
        foreach $val (@{$dat}) {
            $val->[0]=$val->[3]->[0];
        }
    }
    } elsif ($delta[2]>$max) {
        $ix=1;
        $y='Z (m)';
        $x=$var;
        foreach $val (@{$dat}) {
            $val->[0]=$val->[1];
            $val->[1]=$val->[3]->[2];
        }
    }
    } else {
        $x='Distance from (0,0,0) (m)';
        $y=$var;
        foreach $val (@{$dat}) {
            $val->[0]=sqrt($val->[3]->[0]**2+$val->[3]->[1]**2+$val->[3]->[2]**2);
        }
    }
    $darry[0]=$dat;
    $ttl="Snapshot of $g -- day $day\n";
    print "Output $g $day: Axes $y vs. $x\n";
    if (defined($dat->[0]->[2])) {
        print "      with nuft data\n" if defined($darry[1]);
        $darry[1]=[];
        $ttl.="Nuft Data from: $nfit->[0]\n";
        $ttl.="Goodness of fit ME $nfit->[0]\n";
        $ttl.="Goodness of fit RMSE $nfit->[1]\n";
        $#($darry[1])=$#($dat);
        if ($ix==0) {
            foreach $i (0..$#($dat)) {
                $darry[1]->[$i]=$dat->[$i]->[0],$dat->[$i]->[2];
            }
        }
        } else {
            foreach $i (0..$#($dat)) {
                $darry[1]->[$i]=$dat->[$i]->[2],$dat->[$i]->[1];
            }
        }
    }
    }
    &printSac("$g.$day.plt",$ttl,\@darry,$x,$y,
        ["Drift Scale Test Data","NUFT Simulation Results"]);
}

sub openSql
{
    my($sql,$q)=@_;
    my($file);

    $ENV{'ORACLE_HOME'}='/usr/local/oracle/app/oracle/product/733';
    $ENV{'ORACLE_BASE'}='/usr/local/oracle/app/oracle';
    $ENV{'ORACLE_PATH'}=$ENV{'ORACLE_HOME'}. '/bin';
    $ENV{'ORACLE_TERM'}='vt100';
    $ENV{'ORACLE_SID'}='tvpl';
    $ENV{'LD_LIBRARY_PATH'}=$ENV{'LD_LIBRARY_PATH'}.'.':'. $ENV{'ORACLE_HOME'}. '/lib';
}

```

```

$ENV{'PATH'}=$ENV{'ORACLE_HOME'}.'/bin:'. $ENV{'PATH'};
$ENV{'ORA_NLS32'}=$ENV{'ORACLE_HOME'}.'/ocommon/nls/admin/data';
$ENV{'TMPDIR'}='/tmp';
$ENV{'OPENWINHOME'}='/usr/openwin';
$ENV{'TWO_TASK'}='tvpl';
$ENV{'TNS_PATH'}='/usr/local/oracle/tns';
$file="/tmp/dst$$";
open(SQLFILE,">$file.sql") || die "Cannot create sql file $!\n";
print SQLFILE "set line 300\nset pages 0\n";
print SQLFILE "set colsep ' '\nset feedback off\n";
print SQLFILE "$q;\nquit\n";
close(SQLFILE);
open($sql,"$ENV{'ORACLE_PATH'}/sqlplus shaffer/shaffer @$file|") ||
    die "Cannot start sqlplus $!\n";
while (<$sql>) {
    chomp;
    return "$file.sql" if /^PL\SQL/;
}
unlink("$file.sql") unless defined($dbg);
return;
}

sub closeSql
{
    my($sql)=shift;

    close($sql);
}

sub readSql
{
    my($sql)=shift;

    while (<$sql>) {
        chomp;
        return if /^Disconnected/;
        return $_ if $_;
    }
}

sub formatDate
{
    my($date)=shift;
    my(@m1st,@pieces,$mon,$day,$year);

    @m1st=('JAN','FEB','MAR','APR','MAY','JUN','JUL','AUG','SEP','OCT','NOV','DEV');
    @pieces=split(/[ \/, -]/,$date);
    die "Cannot parse date $date\n" unless $#pieces==2;
    if ($pieces[0]==tr/A-Za-z/A-ZA-Z/) {
        $mon=$pieces[0];
        $day=$pieces[1];
        $year=$pieces[2];
    } elsif ($pieces[1]==tr/A-Za-z/A-ZA-Z/) {
        $mon=$pieces[1];
        $day=$pieces[0];
        $year=$pieces[2];
    } else {
        $mon=$m1st[$pieces[0]-1];
        $day=$pieces[1];
        $year=$pieces[2];
    }
    $day="0$day" unless length($day)==2;
    $year+=2000 if $year<70;
    $year+=1900 if $year<100;
    return "$day-$mon-$year";
}

sub mkSelect
{
    my($dt,$g,$day0,$day1,$v0,$v1,$order)=@_;
    my($q,$dtstr);

```

```

$dtstr="mdate-to_date('$dt','dd-MON-yyyy')";
Sq="select mgage,trunc($dtstr,0),value,x,y,z \n".
    " from durham.dsttemps\n";
if ($day1) {
    if ($day0) {
        Sq.=" where $dtstr between $day0 and $day1\n";
    } else {
        Sq.=" where $dtstr between 0 and $day1\n";
    }
} else {
    if ($day0) {
        Sq.=" where $dtstr>=$day0\n";
    } else {
        Sq.=" where $dtstr>=0\n";
    }
}
Sq.=" and LTRIM(mgage) like '$g%\n' if $g;
Sq.=" and value>$v0\n" if defined($v0);
Sq.=" and value<$v1\n" if defined($v1);
Sq.=" ".Sorder if $order;
return $q;
}

sub mkOrder
{
    my($tp)=shift;

    return "order by to_char(mdate,'yyyy-mm-dd'),mgage" if $tp eq 's';
    return "order by mgage,mdate" if $tp eq 't';
}

sub printSac
{
    my($f1, $tit, $dsets, $xlab, $ylab, $clab) = @_;
    my($pt, $xmin, $xmax, $ymin, $ymax, $savFl,$dat, $i);

    open(SAC,">$f1") || do { warn "Cannot open file $f1 !"; return;};
    $savFl = select(SAC);
    print '$free'."\n".$tit."\n";
    $num= $tit~/\n/m;
    foreach ($num..2) {
        print "\n";
    }
    print '$xlab'."\n$xlab\n".$ylab."\n$ylab\n";
    print '$xtype'."\n". 'LINEAR'."\n".$ytype."\n". 'LINEAR'."\n";
    foreach $dat (@{$dsets}) {
        foreach $pt (@{$dat}) {
            if (!defined($xmax)) {
                $xmin = $xmax = $pt->[0];
                $ymin = $ymax = $pt->[1];
                next;
            }
            $xmin = $pt->[0] if $pt->[0] < $xmin;
            $xmax = $pt->[0] if $pt->[0] > $xmax;
            $ymin = $pt->[1] if $pt->[1] < $ymin;
            $ymax = $pt->[1] if $pt->[1] > $ymax;
        }
    }
    printf '$xbnd          %9E          %9E'."\n", $xmin, $xmax;
    printf '$ybnnd          %9E          %9E'."\n", $ymin, $ymax;
    print '$xlegpos  0.75'."\n".$ylegpos  0.75'."\n".$send'."\n";
    foreach $i (0..#{$dsets}) {
        $dat=$dsets->[$i];
        print '$clab'."\n$clab->[$i]\n";
        print '$style      1'."\n".$symb      1'."\n";
        print '$location_type'."\n". 'element'."\n";
        print '$data'."\n";
        foreach $pt (@{$dat}) {
            printf "          %10E          %10E\n", $pt->[0], $pt->[1];
        }
        print '$end'."\n";
    }
}

```

```

    }
    select($savFl);
    close(SAC);
}

#####
# Ext Reader
#####

sub openExt
{
    my($hndl,$fl)=@_;

    if ($fl=~ /\.ext$/ && -f $fl) {
        open($hndl,"<$fl") || die "Cannot open $fl: $!\n";
    } else {
        open($hndl,"gunzip -c $fl|") || die "Cannot open or gunzip $fl: $!\n";
    }
    return &getFileInfo($hndl);
}

#
# Pack all ext header info into one structure
sub getFileInfo
{
    my($in)=shift;
    my($info,$grd);

    $grd=&readGrid($in);
    die "Could not find grid\n" unless $grd;
    $info=&readDesc($in);
    die "Unable to parse block descriptions\n" unless $info;
    $info->{'grid'}=$grd;
    &sortNestedBlocks($info,$info->{'sblk'}) if $grd->{'def'} eq 'nested_gdef';
    return $info;
}

sub sortNestedBlocks
{
    my($ninf,$blk)=@_;
    my($lev,@part,@nest,$bl,$lst,$nlast,$i,$j);

    $lev='';
    @part=split(/\#/, $blk->[0]);
    @nest=split(/\./, $part[0]);
    $lev=$ninf->{'dkm'}='\.'. $nest[1] if $nest[1];
    $bl=$lst={};
    $nlast='';
    foreach $i (0..$#{ $blk }) {
        @part=split(/\#/, $blk->[$i]);
        @nest=split(/\./, $part[0]);
        shift(@nest);
        pop(@nest) if $lev;
        if ($nlast ne join('.',@nest)) {
            $j=@nest; $bl=$lst;
            while ($j--) {
                if (!defined($bl->{$nest[$j]})) {
                    warn "Undefined nest $bl->{$nest[$j]}\n" if $j;
                    $bl->{$nest[$j]}={};
                }
                $bl=$bl->{$nest[$j]};
            }
            $nlast=join('.',@nest);
        }
        $bl->{$part[1]}=$i;
    }
    $ninf->{'nstblk'}=$lst;
}

#
# Read a single timestep, single variable data block

```

```

sub getData
{
    my($in)=shift;
    my($out,$vidx,$data,$time);

    return if eof $in;
    $out={};
    $time=<$in>+0.0;
    $vidx=<$in>-1;
    $data=&readDataBlk($in,<$in>+0);
    $out->{'data'}=$data;
    $out->{'var'}=$vidx;
    $out->{'time'}=$time;
    return $out;
}

#
# calculate volumes for array of block indices
sub getVolumes
{
    my($blk,$grd,$idx)=@_;
    my($vols,@x,@y,@z,$i,@bijk);

    @x=@{$grd->{'x'}};
    @y=@{$grd->{'y'}};
    @z=@{$grd->{'z'}};
    $vols=[];
    foreach $i (0..${$idx}) {
        @bijk=split(/:/,(split('#',$blk->{$idx->{$i}})[1]));
        $vols->{$i}=$x[$bijk[0]-1]*$y[$bijk[1]-1]*$z[$bijk[2]-1];
        print "$blk->{$idx->{$i}} Volume: $vols->{$i}\n";
    }
    return $vols;
}

#
# Extract a list of indices into the date blocks for
# block names matching a given (RE) pattern
sub getIndices
{
    my($pat,$sb)=@_;
    my($i,$idx);

    $idx=[];
    foreach $i (0..${$sb}) {
        if ($sb->{$i} =~ /$pat/) {
            push(@{$idx},$i);
        }
    }
    return $idx;
}

#
# Read the variable and block descriptions from the file
# Information stored in hash table:
# $out->{'svar'}==ordered array of scalar variable names
# $out->{'vvar'}==ordered array of connection variable names
# $out->{'sblk'}==ordered array of block names for scalar (element) variables
# $out->{'vblk'}==ordered array of block connections for vector (connection) variables
# $out->{'vnames'}==ordered array of all variable names
sub readDesc
{
    my($in)=shift;
    my($out,$line,$num);

    $out={};
    do {
        $line=<$in>;
    } while $line =~ /^$/;
    $out->{'svar'}=&readDataBlk($in,$line+0);
    $out->{'vvar'}=&readDataBlk($in,<$in>+0);
}

```

```

    Sout->{'sblk'}=&readDataBlk($in,<$in>+0);
    Sout->{'vblk'}=&readDataBlk($in,<$in>+0);
    Sout->{'vnames'}=@{$Sout->{'svar'}},@{$Sout->{'vvar'}};
    $num=0;
    $num+=scalar(@{$Sout->{'svar'}}) if defined(@{$Sout->{'svar'}});
    $num+=scalar(@{$Sout->{'vvar'}}) if defined(@{$Sout->{'vvar'}});
    print "num variables $num\n";
    die "No variables found in file\n" unless $num;
    foreach $i (1..5*$num) {
        $line=<$in>;
    }
    return $out;
}

#
# Read one block from extfile of $num lines
# return reference to array of lines
sub readDataBlk
(
    my($in,$num)=@_;
    my($out,$i,$line);

    $out=[] if $num;
    foreach $i (1..$num) {
        $line=<$in>;
        chomp $line;
        push(@{$out}, $line);
    }
    return $out;
}

#
# Read the grid definition from the file into data area
# for rectangular ext file grid will result in
# $grd->{'type'}=='rect'
# $grd->{'nx'}=value from $nx line
#   similar from 'ny','nz'
# $grd->{'x'}=array of values from $dx block
# similar for 'y','z'
# return reference to structure
#
sub readGrid
(
    my($in)=shift;
    my($line,$grd,$def);

    $line=<$in> until $line=~s/^\$//;
    chomp($line);
    $grd={};
    $def=$grd->{'def'}=$line;
    $line=<$in>;
    chomp($line);
    $grd->{'type'}=(split(/ /,$line))[1];
    {
        $def eq 'gdef' && do {
            &readGdef($in,$grd);
            last;
        };

        $def eq 'nested_gdef' && do {
            &readNested($in,$grd);
            last;
        };

        die "Unrecognized grid type $def\n";
    }
    $line=<$in>;
    chomp($line);
    $line eq '$end_internal_grid' || die "Corrupt grid definition block\n";
    return $grd;
}

```

```

sub calcCenters
{
    my($dlt)=shift;
    my($i,$cnt,$total);

    $cnt=[];
    $total=0.0;
    foreach $i (0..${$dlt}) {
        $cnt->[$i+1]=$total+$dlt->[$i]/2.0;
        $total+=$dlt->[$i];
    }
    return $cnt;
}

sub readGdef
{
    my($in,$grd)=@_;
    my($line);
    my($cont)=3;

    while ($cont) {
        $line=<$in>;
        chomp($line);
        $line=~s/^\s*//;
        $line=~s/\s*$//;
        $line=~s/^\s*$//;
        $line=~s/^\s*$// && do {
            @tok=split(/ /,$line);
            $grd->{"n$tok[0]"}=0+$tok[1];
            next;
        };
        $line=~s/^\s*$// && do {
            $cont--;
            $grd->{$line}=&readDataBlk($in,$grd->{"n$line"});
            $grd->{"c$line"}=&calcCenters($grd->{$line});
            next;
        };
        $line=~s/^\s*$// && last;
    }
    return $grd;
}

sub readNested
{
    my($in,$grd)=@_;
    my($line,$subg,$styp);

    while ($line=<$in>) {
        chomp($line);
        $line=~s/^\s*//;
        $line=~s/\s*$//;
        $line eq '$maingrid' && do {
            $styp='main';
            next;
        };
        $line eq '$subgrid' && do {
            $subg={};
            &readNested($in,$subg);
            $grd->{'sub'}=[] unless defined($grd->{'sub'});
            push(@{$grd->{'sub'}},$subg);
            next;
        };
        $line=~s/^\s*$// && do {
            $grd->{'name'}=(split(/ /,$line))[1];
            &readGdef($in,$grd) if $styp eq 'main';
            next;
        };
        $line=~s/^\s*$// && do {
            $grd->{'parovr'}=(split(/ /,(split(/ /,$line,2))[1]));
            &readGdef($in,$grd);
            next;
        };
    }
}

```

```
    };  
    Sline eq 'Send' && last;  
  }  
  return $grd;  
}
```

QUALIFICATION OF ROCK_SUN.M

ROUTINE IDENTIFICATION

Rock_sun Version 1.0. This Matlab macro runs under Matlab Version 5.3.0.10183 (R11). The source is rock_sun.

ROUTINE PURPOSE AND VALIDATION

The purpose of rock_sun.m is to extract material property data from a pair of tables and rewrite it in NUFT material property input format. The input file pairs consist of a flow data and a thermal data file.

In order to demonstrate that rock_sun is correctly conveying material property information from the input files to the output file, it was necessary to extract information for just one sample material from one pair of input files to the corresponding output file. The file pair 1d_driftscale_lowinf_flow.prn and 1d_driftscale_lowinf_th.prn was chosen for input and the material ptn22 was chosen as the material to follow. Then, using the Unix pattern search routine, grep, lines containing data for material ptn22 were extracted from the input files and are printed below:

1d_driftscale_lowinf_flow.prn:

```
ptn22 3.27E-12 0.439 1.51E-5 0.390 0.16 1.00 1.00E-11 1.2E-2 9.39E-4 0.651
0.01 1.00 0.01 0.46 1.41
```

1d_driftscale_lowinf_th.prn:

```
ptn22 2340 1080 0.35 0.50 0.7
```

The following lines related to material ptn22 were extracted from the output file by hand:

```
(m-ptn22
  (cont-len-fac 3.623e-01) (cont-area-fac 1.410e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.312e+03) (porosity 4.390e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.080e+03)
  (tcond tcondLin (solid 3.458e-01) (liquid 4.940e-01) (gas 3.458e-01))
  (K0 3.270e-12) (K1 3.270e-12) (K2 3.270e-12)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.600e-01) (m 3.900e-01) (Smax 1.0))
      (gas krgModCorey (Srl 1.600e-01) (m 3.900e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.600e-01) (m 3.900e-01) (alpha 1.510e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
```

```

(f-ptn22
  (cont-len-fac 1.304e-02) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.808e+01) (porosity 1.200e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.080e+03)
  (tcond tcondLin (solid 4.200e-03) (liquid 6.000e-03) (gas 4.200e-03))
  (K0 1.000e-11) (K1 1.000e-11) (K2 1.000e-11)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.510e-01) (Smax 1.0) (gamma
1.000e-02))
    (gas krgModCorey (Srl 1.000e-02) (m 6.510e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.510e-01) (alpha 9.390e-04) (Smax
1.0) (gamma 1.000e-02)))
  (krMC (liquid krMCactiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
    (gas krMCactiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material

```

By visual inspection it can be seen that the quantities Cp (heat capacity), gas tortuosity, matrix and fracture porosity, matrix and fracture permeability, and the three matrix and fracture van Genuchten coefficients for material ptn22 were transferred without change into the output files. The fracture values for thermal conductivity was multiplied by the fracture porosity, .012. The matrix values for this parameter were multiplied by 1-.012. So matrix and fracture values for thermal conductivity *add up* to the values shown in the input files. The same is true for the solid densities, which come from the rock grain data. (There is only one rock of which matrix and fracture are considered fractional parts.) The active fracture terms were transferred without change to fracture gammas.

Visual inspection confirmed that the data from the input file for material ptn22 had found its way into the correct places in the output file. Rock_sun correctly transferred information from the input files to the output file.

Therefore, rock_sun provides the correct results over the range of input parameters in the input file l4c3.nft and l4c3.03v.nft.

Contents of Att.VIII

1d_driftscale_lowinf_flow.prn: first input file to rock_sun.m
1d_driftscale_lowinf_th.prn: second input file to rock_sun.m
lowinf: output from rock_sun.m
lowinfptn22.f: rock_sun.m fracture output for material ptn22 only
lowinfptn22.m: rock_sun.m matrix output for material ptn22 only
rock_sun.m: macro

Table 1. 1-D only, calibrated flow parameters for lower bound infiltration.
Calibrated parameters are shown in bold.

matrix parameters							
fracture parameters							
		permeability	porosity	van Genuchten	van Genuchten	residual	
sasatiated satu		permeability	porosity	van Genuchten	van Genuchten	residual	
sasatiated saactive		fract frequency	fracture to matrix				
Model Layer		km (m2)	fm (-)	am (1/Pa)	mm (-)	Slrm (-)	
Slsm (-)	g (-)	kf (m2)	ff (-)	af (1/Pa)	mf (-)	Slrf (-)	Slsf
(-)		f (1/m)	A (m2/m3)				
tcw11		4.63E-15	0.253	1.61E-5	0.460	0.07	
1.00		2.70E-12	2.8E-2	2.40E-3	0.598	0.01	1.00
0.25	0.92		1.56				
tcw12		8.87E-20	0.082	2.89E-5	0.241	0.19	
1.00		1.00E-10	2.0E-2	2.05E-3	0.608	0.01	1.00
0.25	1.91		13.39				
tcw13		6.61E-17	0.203	1.42E-6	0.368	0.31	
1.00		1.79E-12	1.5E-2	9.21E-4	0.600	0.01	1.00
0.25	2.79		3.77				
ptn21		1.86E-13	0.387	6.13E-5	0.165	0.23	
1.00		1.00E-11	1.1E-2	1.66E-3	0.503	0.01	1.00
0.01	0.67		1.00				
ptn22		3.27E-12	0.439	1.51E-5	0.390	0.16	
1.00		1.00E-11	1.2E-2	9.39E-4	0.651	0.01	1.00
0.01	0.46		1.41				
ptn23		4.20E-13	0.254	2.04E-6	0.387	0.08	
1.00		1.84E-13	2.5E-3	1.28E-3	0.518	0.01	1.00
0.01	0.57		1.75				
ptn24		3.94E-13	0.411	2.32E-5	0.210	0.14	
1.00		4.31E-13	1.2E-2	2.02E-3	0.594	0.01	1.00
0.01	0.46		0.34				
ptn25		2.22E-13	0.499	2.04E-5	0.296	0.06	
1.00		7.12E-13	6.2E-3	7.42E-4	0.555	0.01	1.00
0.01	0.52		1.09				
ptn26		5.43E-13	0.492	1.82E-4	0.264	0.05	
1.00		3.08E-13	3.6E-3	2.00E-4	0.401	0.01	1.00
0.01	0.97		3.56				
tsw31		6.38E-17	0.053	2.81E-5	0.317	0.22	
1.00		2.55E-11	5.5E-3	4.42E-4	0.545	0.01	1.00
0.06	2.17		3.86				
tsw32		6.28E-16	0.157	6.35E-5	0.279	0.07	
1.00		8.91E-13	9.5E-3	1.21E-3	0.603	0.01	1.00
0.23	1.12		3.21				
tsw33		1.82E-17	0.154	2.44E-5	0.248	0.12	
1.00		6.07E-13	6.6E-3	1.36E-3	0.600	0.01	1.00
0.23	0.81		4.44				
tsw34		3.50E-19	0.110	3.54E-6	0.309	0.19	
1.00		4.99E-13	1.0E-2	2.48E-4	0.515	0.01	1.00
0.23	4.32		13.54				
tsw35		1.27E-17	0.131	7.57E-6	0.187	0.12	
1.00		1.82E-12	1.1E-2	6.26E-4	0.612	0.01	1.00
0.23	3.16		9.68				
tsw36		1.19E-18	0.112	3.74E-6	0.328	0.18	
1.00		1.43E-12	1.5E-2	4.90E-4	0.540	0.01	1.00
0.23	4.02		12.31				

	tsw37	5.63E-19	0.094	3.28E-6	0.423	0.25
1.00		1.43E-12	1.5E-2	4.90E-4	0.540	1.00
0.23		4.02	12.31			
	tsw38	1.44E-18	0.037	3.72E-6	0.291	0.44
1.00		5.65E-13	1.2E-2	4.00E-4	0.603	1.00
0.23		4.36	13.34			
	tsw39	1.09E-17	0.173	2.37E-5	0.321	0.29
1.00		3.12E-13	4.6E-3	6.43E-4	0.605	1.00
0.23		0.96	2.95			
	ch1z	2.75E-20	0.288	7.26E-7	0.304	0.33
1.00		1.87E-13	1.7E-4	1.00E-3	0.611	1.00
0.12		0.04	0.11			
	ch1v	2.05E-14	0.273	9.86E-6	0.402	0.03
1.00		9.03E-13	6.9E-4	1.43E-3	0.658	1.00
0.12		0.10	0.30			
	ch2v	3.17E-13	0.345	1.91E-5	0.326	0.07
1.00		1.94E-13	8.9E-4	6.84E-4	0.544	1.00
0.12		0.14	0.43			
	ch3v	3.17E-13	0.345	1.91E-5	0.326	0.07
1.00		1.94E-13	8.9E-4	6.84E-4	0.544	1.00
0.12		0.14	0.43			
	ch4v	3.17E-13	0.345	1.91E-5	0.326	0.07
1.00		1.94E-13	8.9E-4	6.84E-4	0.544	1.00
0.12		0.14	0.43			
	ch5v	3.17E-13	0.345	1.91E-5	0.326	0.07
1.00		1.94E-13	8.9E-4	6.84E-4	0.544	1.00
0.12		0.14	0.43			
	ch2z	6.28E-18	0.331	2.44E-6	0.135	0.28
1.00		4.10E-14	4.3E-4	2.08E-4	0.613	1.00
0.12		0.14	0.43			
	ch3z	6.28E-18	0.331	2.44E-6	0.135	0.28
1.00		4.10E-14	4.3E-4	2.08E-4	0.613	1.00
0.12		0.14	0.43			
	ch4z	6.28E-18	0.331	2.44E-6	0.135	0.28
1.00		4.10E-14	4.3E-4	2.08E-4	0.613	1.00
0.12		0.14	0.43			
	ch5z	6.28E-18	0.331	2.44E-6	0.135	0.28
1.00		4.10E-14	4.3E-4	2.08E-4	0.613	1.00
0.12		0.14	0.43			
	ch6	8.20E-20	0.266	5.06E-7	0.445	0.37
1.00		1.12E-14	1.7E-4	6.10E-4	0.604	1.00
0.12		0.04	0.11			
	pp4	2.05E-18	0.325	1.83E-7	0.653	0.28
1.00		3.40E-14	4.3E-4	4.86E-4	0.635	1.00
0.12		0.14	0.43			
	pp3	1.91E-14	0.303	1.53E-5	0.355	0.10
1.00		2.23E-12	1.1E-3	5.93E-4	0.699	1.00
0.43		0.20	0.61			
	pp2	1.08E-16	0.263	2.08E-6	0.399	0.18
1.00		1.42E-13	1.1E-3	7.62E-4	0.608	1.00
0.43		0.20	0.61			
	pp1	6.52E-17	0.280	9.40E-7	0.392	0.30
1.00		7.15E-14	4.3E-4	3.90E-4	0.638	1.00
0.12		0.14	0.43			
	bf3	9.47E-15	0.115	3.75E-6	0.509	0.11
1.00		3.43E-13	1.1E-3	7.60E-4	0.611	1.00
0.43		0.20	0.61			

	bf2		1.27E-17	0.259	1.38E-7	0.568	0.18	
1.00		9.21E-15	4.3E-4	4.18E-4	0.598	0.01	1.00	
0.12		0.14	0.43					

Table 2. Thermal parameters and tortuosity factor (uncalibrated).

Model Layer	rock grain rg (kg/m ³)	rock grain Cp (J/kg K)	spdry ldry (W/m K)	conductiv lwet (W/m K)	conductiv Tortuosity t (-)
tcw11	2550	823	1.60	2.00	0.7
tcw12	2510	851	1.24	1.81	0.7
tcw13	2470	857	0.54	0.98	0.7
ptn21	2380	1040	0.50	1.07	0.7
ptn22	2340	1080	0.35	0.50	0.7
ptn23	2400	849	0.44	0.97	0.7
ptn24	2370	1020	0.46	1.02	0.7
ptn25	2260	1330	0.35	0.82	0.7
ptn26	2370	1220	0.23	0.67	0.7
tsw31	2510	834	0.37	1.00	0.7
tsw32	2550	866	1.06	1.62	0.7
tsw33	2510	882	0.79	1.68	0.7
tsw34	2530	948	1.56	2.33	0.7
tsw35	2540	900	1.20	2.02	0.7
tsw36	2560	865	1.42	1.84	0.7
tsw37	2560	865	1.42	1.84	0.7
tsw38	2360	984	1.69	2.08	0.7
tsw39	2360	984	1.69	2.08	0.7
ch1z	2310	1060	0.70	1.31	0.7
ch1v	2310	1060	0.70	1.31	0.7
ch2v	2240	1200	0.58	1.17	0.7
ch3v	2240	1200	0.58	1.17	0.7
ch4v	2240	1200	0.58	1.17	0.7
ch5v	2240	1200	0.58	1.17	0.7
ch2z	2350	1150	0.61	1.20	0.7
ch3z	2350	1150	0.61	1.20	0.7
ch4z	2350	1150	0.61	1.20	0.7
ch5z	2350	1150	0.61	1.20	0.7
ch6	2440	1170	0.73	1.35	0.7
pp4	2410	577	0.62	1.21	0.7
pp3	2580	841	0.66	1.26	0.7
pp2	2580	841	0.66	1.26	0.7
pp1	2470	635	0.72	1.33	0.7
bf3	2570	763	1.41	1.83	0.7
bf2	2410	633	0.74	1.36	0.7

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(rocktab
;;Matrix materials,
(m-tcw11
  (cont-len-fac 1.812e-01) (cont-area-fac 1.560e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.479e+03) (porosity 2.530e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.230e+02)
  (tcond tcondLin (solid 1.555e+00) (liquid 1.944e+00) (gas 1.555e+00))
  (K0 4.630e-15) (K1 4.630e-15) (K2 4.630e-15)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 7.000e-02) (m 4.600e-01) (Smax 1.0))
      (gas krgModCorey (Srl 7.000e-02) (m 4.600e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 7.000e-02) (m 4.600e-01) (alpha 1.610e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tcw12
  (cont-len-fac 8.726e-02) (cont-area-fac 1.339e+01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.460e+03) (porosity 8.200e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.510e+02)
  (tcond tcondLin (solid 1.215e+00) (liquid 1.774e+00) (gas 1.215e+00))
  (K0 8.870e-20) (K1 8.870e-20) (K2 8.870e-20)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.900e-01) (m 2.410e-01) (Smax 1.0))
      (gas krgModCorey (Srl 1.900e-01) (m 2.410e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.900e-01) (m 2.410e-01) (alpha 2.890e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tcw13
  (cont-len-fac 5.974e-02) (cont-area-fac 3.770e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.433e+03) (porosity 2.030e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.570e+02)
  (tcond tcondLin (solid 5.319e-01) (liquid 9.653e-01) (gas 5.319e-01))
  (K0 6.610e-17) (K1 6.610e-17) (K2 6.610e-17)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 3.100e-01) (m 3.680e-01) (Smax 1.0))
      (gas krgModCorey (Srl 3.100e-01) (m 3.680e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 3.100e-01) (m 3.680e-01) (alpha 1.420e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ptn21
  (cont-len-fac 2.488e-01) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.354e+03) (porosity 3.870e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.040e+03)

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(tcond tcondLin (solid 4.945e-01) (liquid 1.058e+00) (gas 4.945e-01))
(K0 1.860e-13) (K1 1.860e-13) (K2 1.860e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 2.300e-01) (m 1.650e-01) (Smax 1.0))
    (gas krgModCorey (Srl 2.300e-01) (m 1.650e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 2.300e-01) (m 1.650e-01) (alpha 6.130e-05) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ptn22
(cont-len-fac 3.623e-01) (cont-area-fac 1.410e+00)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 2.312e+03) (porosity 4.390e-01)
(Kd (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 1.080e+03)
(tcond tcondLin (solid 3.458e-01) (liquid 4.940e-01) (gas 3.458e-01))
(K0 3.270e-12) (K1 3.270e-12) (K2 3.270e-12)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.600e-01) (m 3.900e-01) (Smax 1.0))
    (gas krgModCorey (Srl 1.600e-01) (m 3.900e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.600e-01) (m 3.900e-01) (alpha 1.510e-05) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ptn23
(cont-len-fac 2.924e-01) (cont-area-fac 1.750e+00)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 2.394e+03) (porosity 2.540e-01)
(Kd (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 8.490e+02)
(tcond tcondLin (solid 4.389e-01) (liquid 9.676e-01) (gas 4.389e-01))
(K0 4.200e-13) (K1 4.200e-13) (K2 4.200e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 8.000e-02) (m 3.870e-01) (Smax 1.0))
    (gas krgModCorey (Srl 8.000e-02) (m 3.870e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 8.000e-02) (m 3.870e-01) (alpha 2.040e-06) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ptn24
(cont-len-fac 3.623e-01) (cont-area-fac 3.400e-01)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 2.342e+03) (porosity 4.110e-01)
(Kd (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 1.020e+03)
(tcond tcondLin (solid 4.545e-01) (liquid 1.008e+00) (gas 4.545e-01))
(K0 3.940e-13) (K1 3.940e-13) (K2 3.940e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.400e-01) (m 2.100e-01) (Smax 1.0))
    (gas krgModCorey (Srl 1.400e-01) (m 2.100e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.400e-01) (m 2.100e-01) (alpha 2.320e-05) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material

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(m-ptn25
  (cont-len-fac 3.205e-01) (cont-area-fac 1.090e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.246e+03) (porosity 4.990e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.330e+03)
  (tcond tcondLin (solid 3.478e-01) (liquid 8.149e-01) (gas 3.478e-01))
  (K0 2.220e-13) (K1 2.220e-13) (K2 2.220e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 6.000e-02) (m 2.960e-01) (Smax 1.0))
      (gas krgModCorey (Srl 6.000e-02) (m 2.960e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 6.000e-02) (m 2.960e-01) (alpha 2.040e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ptn26
  (cont-len-fac 1.718e-01) (cont-area-fac 3.560e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.361e+03) (porosity 4.920e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.220e+03)
  (tcond tcondLin (solid 2.292e-01) (liquid 6.676e-01) (gas 2.292e-01))
  (K0 5.430e-13) (K1 5.430e-13) (K2 5.430e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 5.000e-02) (m 2.640e-01) (Smax 1.0))
      (gas krgModCorey (Srl 5.000e-02) (m 2.640e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 5.000e-02) (m 2.640e-01) (alpha 1.820e-04) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw31
  (cont-len-fac 7.680e-02) (cont-area-fac 3.860e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.496e+03) (porosity 5.300e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.340e+02)
  (tcond tcondLin (solid 3.680e-01) (liquid 9.945e-01) (gas 3.680e-01))
  (K0 6.380e-17) (K1 6.380e-17) (K2 6.380e-17)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 2.200e-01) (m 3.170e-01) (Smax 1.0))
      (gas krgModCorey (Srl 2.200e-01) (m 3.170e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 2.200e-01) (m 3.170e-01) (alpha 2.810e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw32
  (cont-len-fac 1.488e-01) (cont-area-fac 3.210e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.526e+03) (porosity 1.570e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.660e+02)
  (tcond tcondLin (solid 1.050e+00) (liquid 1.605e+00) (gas 1.050e+00))
  (K0 6.280e-16) (K1 6.280e-16) (K2 6.280e-16)

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(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 7.000e-02) (m 2.790e-01) (Smax 1.0))
  (gas krgModCorey (Srl 7.000e-02) (m 2.790e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 7.000e-02) (m 2.790e-01) (alpha 6.350e-05) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw33
  (cont-len-fac 2.058e-01) (cont-area-fac 4.440e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.493e+03) (porosity 1.540e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.820e+02)
  (tcond tcondLin (solid 7.848e-01) (liquid 1.669e+00) (gas 7.848e-01))
  (K0 1.820e-17) (K1 1.820e-17) (K2 1.820e-17)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.200e-01) (m 2.480e-01) (Smax 1.0))
    (gas krgModCorey (Srl 1.200e-01) (m 2.480e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.200e-01) (m 2.480e-01) (alpha 2.440e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw34
  (cont-len-fac 3.858e-02) (cont-area-fac 1.354e+01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.505e+03) (porosity 1.100e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 9.480e+02)
  (tcond tcondLin (solid 1.544e+00) (liquid 2.307e+00) (gas 1.544e+00))
  (K0 3.500e-19) (K1 3.500e-19) (K2 3.500e-19)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.900e-01) (m 3.090e-01) (Smax 1.0))
    (gas krgModCorey (Srl 1.900e-01) (m 3.090e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.900e-01) (m 3.090e-01) (alpha 3.540e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw35
  (cont-len-fac 5.274e-02) (cont-area-fac 9.680e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.512e+03) (porosity 1.310e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 9.000e+02)
  (tcond tcondLin (solid 1.187e+00) (liquid 1.998e+00) (gas 1.187e+00))
  (K0 1.270e-17) (K1 1.270e-17) (K2 1.270e-17)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.200e-01) (m 1.870e-01) (Smax 1.0))
    (gas krgModCorey (Srl 1.200e-01) (m 1.870e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.200e-01) (m 1.870e-01) (alpha 7.570e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw36
  (cont-len-fac 4.146e-02) (cont-area-fac 1.231e+01)

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(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 2.522e+03) (porosity 1.120e-01)
(Kd (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 8.650e+02)
(tcond tcondLin (solid 1.399e+00) (liquid 1.812e+00) (gas 1.399e+00))
(K0 1.190e-18) (K1 1.190e-18) (K2 1.190e-18)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.800e-01) (m 3.280e-01) (Smax 1.0))
(gas krgModCorey (Srl 1.800e-01) (m 3.280e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.800e-01) (m 3.280e-01) (alpha 3.740e-06) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw37
(cont-len-fac 4.146e-02) (cont-area-fac 1.231e+01)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 2.522e+03) (porosity 9.400e-02)
(Kd (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 8.650e+02)
(tcond tcondLin (solid 1.399e+00) (liquid 1.812e+00) (gas 1.399e+00))
(K0 5.630e-19) (K1 5.630e-19) (K2 5.630e-19)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 2.500e-01) (m 4.230e-01) (Smax 1.0))
(gas krgModCorey (Srl 2.500e-01) (m 4.230e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 2.500e-01) (m 4.230e-01) (alpha 3.280e-06) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw38
(cont-len-fac 3.823e-02) (cont-area-fac 1.334e+01)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 2.332e+03) (porosity 3.700e-02)
(Kd (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 9.840e+02)
(tcond tcondLin (solid 1.670e+00) (liquid 2.055e+00) (gas 1.670e+00))
(K0 1.440e-18) (K1 1.440e-18) (K2 1.440e-18)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 4.400e-01) (m 2.910e-01) (Smax 1.0))
(gas krgModCorey (Srl 4.400e-01) (m 2.910e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 4.400e-01) (m 2.910e-01) (alpha 3.720e-06) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-tsw39
(cont-len-fac 1.736e-01) (cont-area-fac 2.950e+00)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 2.349e+03) (porosity 1.730e-01)
(Kd (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 9.840e+02)
(tcond tcondLin (solid 1.682e+00) (liquid 2.070e+00) (gas 1.682e+00))
(K0 1.090e-17) (K1 1.090e-17) (K2 1.090e-17)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 2.900e-01) (m 3.210e-01) (Smax 1.0))

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      (gas krgModCorey (Srl 2.900e-01) (m 3.210e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 2.900e-01) (m 3.210e-01) (alpha 2.370e-05) (Smax
1.0)))
    (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
  ) ;;End of the material
(m-ch1z
  (cont-len-fac 4.167e+00) (cont-area-fac 1.100e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.310e+03) (porosity 2.880e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.060e+03)
  (tcond tcondLin (solid 6.999e-01) (liquid 1.310e+00) (gas 6.999e-01))
  (K0 2.750e-20) (K1 2.750e-20) (K2 2.750e-20)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 3.300e-01) (m 3.040e-01) (Smax 1.0))
      (gas krgModCorey (Srl 3.300e-01) (m 3.040e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 3.300e-01) (m 3.040e-01) (alpha 7.260e-07) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch1v
  (cont-len-fac 1.667e+00) (cont-area-fac 3.000e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.308e+03) (porosity 2.730e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.060e+03)
  (tcond tcondLin (solid 6.995e-01) (liquid 1.309e+00) (gas 6.995e-01))
  (K0 2.050e-14) (K1 2.050e-14) (K2 2.050e-14)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 3.000e-02) (m 4.020e-01) (Smax 1.0))
      (gas krgModCorey (Srl 3.000e-02) (m 4.020e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 3.000e-02) (m 4.020e-01) (alpha 9.860e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch2v
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.238e+03) (porosity 3.450e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.200e+03)
  (tcond tcondLin (solid 5.795e-01) (liquid 1.169e+00) (gas 5.795e-01))
  (K0 3.170e-13) (K1 3.170e-13) (K2 3.170e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 7.000e-02) (m 3.260e-01) (Smax 1.0))
      (gas krgModCorey (Srl 7.000e-02) (m 3.260e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 7.000e-02) (m 3.260e-01) (alpha 1.910e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch3v
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.238e+03) (porosity 3.450e-01)

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(Kd      (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 1.200e+03)
(tcond tcondLin (solid 5.795e-01) (liquid 1.169e+00) (gas 5.795e-01))
(K0 3.170e-13) (K1 3.170e-13) (K2 3.170e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 7.000e-02) (m 3.260e-01) (Smax 1.0))
    (gas krgModCorey (Srl 7.000e-02) (m 3.260e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 7.000e-02) (m 3.260e-01) (alpha 1.910e-05) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch4v
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.238e+03) (porosity 3.450e-01)
  (Kd      (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.200e+03)
  (tcond tcondLin (solid 5.795e-01) (liquid 1.169e+00) (gas 5.795e-01))
  (K0 3.170e-13) (K1 3.170e-13) (K2 3.170e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 7.000e-02) (m 3.260e-01) (Smax 1.0))
      (gas krgModCorey (Srl 7.000e-02) (m 3.260e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 7.000e-02) (m 3.260e-01) (alpha 1.910e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch5v
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.238e+03) (porosity 3.450e-01)
  (Kd      (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.200e+03)
  (tcond tcondLin (solid 5.795e-01) (liquid 1.169e+00) (gas 5.795e-01))
  (K0 3.170e-13) (K1 3.170e-13) (K2 3.170e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 7.000e-02) (m 3.260e-01) (Smax 1.0))
      (gas krgModCorey (Srl 7.000e-02) (m 3.260e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 7.000e-02) (m 3.260e-01) (alpha 1.910e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch2z
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.349e+03) (porosity 3.310e-01)
  (Kd      (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.150e+03)
  (tcond tcondLin (solid 6.097e-01) (liquid 1.199e+00) (gas 6.097e-01))
  (K0 6.280e-18) (K1 6.280e-18) (K2 6.280e-18)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 2.800e-01) (m 1.350e-01) (Smax 1.0))
      (gas krgModCorey (Srl 2.800e-01) (m 1.350e-01) (Slmax 1.0)))

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    (pc (liquid pcVanGen (Sr 2.800e-01) (m 1.350e-01) (alpha 2.440e-06) (Smax
1.0)))
    (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch3z
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.349e+03) (porosity 3.310e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.150e+03)
  (tcond tcondLin (solid 6.097e-01) (liquid 1.199e+00) (gas 6.097e-01))
  (K0 6.280e-18) (K1 6.280e-18) (K2 6.280e-18)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 2.800e-01) (m 1.350e-01) (Smax 1.0))
      (gas krgModCorey (Srl 2.800e-01) (m 1.350e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 2.800e-01) (m 1.350e-01) (alpha 2.440e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch4z
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.349e+03) (porosity 3.310e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.150e+03)
  (tcond tcondLin (solid 6.097e-01) (liquid 1.199e+00) (gas 6.097e-01))
  (K0 6.280e-18) (K1 6.280e-18) (K2 6.280e-18)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 2.800e-01) (m 1.350e-01) (Smax 1.0))
      (gas krgModCorey (Srl 2.800e-01) (m 1.350e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 2.800e-01) (m 1.350e-01) (alpha 2.440e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch5z
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.349e+03) (porosity 3.310e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.150e+03)
  (tcond tcondLin (solid 6.097e-01) (liquid 1.199e+00) (gas 6.097e-01))
  (K0 6.280e-18) (K1 6.280e-18) (K2 6.280e-18)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 2.800e-01) (m 1.350e-01) (Smax 1.0))
      (gas krgModCorey (Srl 2.800e-01) (m 1.350e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 2.800e-01) (m 1.350e-01) (alpha 2.440e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-ch6
  (cont-len-fac 4.167e+00) (cont-area-fac 1.100e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.440e+03) (porosity 2.660e-01)
  (Kd (water 0.0) (air 0.0))

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(KdFactor (water 0.0) (air 0.0))
(Cp 1.170e+03)
(tcond tcondLin (solid 7.299e-01) (liquid 1.350e+00) (gas 7.299e-01))
(K0 8.200e-20) (K1 8.200e-20) (K2 8.200e-20)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 3.700e-01) (m 4.450e-01) (Smax 1.0))
    (gas krgModCorey (Srl 3.700e-01) (m 4.450e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 3.700e-01) (m 4.450e-01) (alpha 5.060e-07) (Smax
1.0)))
(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-pp4
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.409e+03) (porosity 3.250e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 5.770e+02)
  (tcond tcondLin (solid 6.197e-01) (liquid 1.209e+00) (gas 6.197e-01))
  (K0 2.050e-18) (K1 2.050e-18) (K2 2.050e-18)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 2.800e-01) (m 6.530e-01) (Smax 1.0))
      (gas krgModCorey (Srl 2.800e-01) (m 6.530e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 2.800e-01) (m 6.530e-01) (alpha 1.830e-07) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-pp3
  (cont-len-fac 8.333e-01) (cont-area-fac 6.100e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.577e+03) (porosity 3.030e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.410e+02)
  (tcond tcondLin (solid 6.593e-01) (liquid 1.259e+00) (gas 6.593e-01))
  (K0 1.910e-14) (K1 1.910e-14) (K2 1.910e-14)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-01) (m 3.550e-01) (Smax 1.0))
      (gas krgModCorey (Srl 1.000e-01) (m 3.550e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-01) (m 3.550e-01) (alpha 1.530e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-pp2
  (cont-len-fac 8.333e-01) (cont-area-fac 6.100e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.577e+03) (porosity 2.630e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.410e+02)
  (tcond tcondLin (solid 6.593e-01) (liquid 1.259e+00) (gas 6.593e-01))
  (K0 1.080e-16) (K1 1.080e-16) (K2 1.080e-16)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.800e-01) (m 3.990e-01) (Smax 1.0))
      (gas krgModCorey (Srl 1.800e-01) (m 3.990e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.800e-01) (m 3.990e-01) (alpha 2.080e-06) (Smax
1.0)))

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(krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-pp1
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.469e+03) (porosity 2.800e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 6.350e+02)
  (tcond tcondLin (solid 7.197e-01) (liquid 1.329e+00) (gas 7.197e-01))
  (K0 6.520e-17) (K1 6.520e-17) (K2 6.520e-17)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 3.000e-01) (m 3.920e-01) (Smax 1.0))
      (gas krgModCorey (Srl 3.000e-01) (m 3.920e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 3.000e-01) (m 3.920e-01) (alpha 9.400e-07) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-bf3
  (cont-len-fac 8.333e-01) (cont-area-fac 6.100e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.567e+03) (porosity 1.150e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 7.630e+02)
  (tcond tcondLin (solid 1.408e+00) (liquid 1.828e+00) (gas 1.408e+00))
  (K0 9.470e-15) (K1 9.470e-15) (K2 9.470e-15)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.100e-01) (m 5.090e-01) (Smax 1.0))
      (gas krgModCorey (Srl 1.100e-01) (m 5.090e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.100e-01) (m 5.090e-01) (alpha 3.750e-06) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
(m-bf2
  (cont-len-fac 1.190e+00) (cont-area-fac 4.300e-01)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.409e+03) (porosity 2.590e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 6.330e+02)
  (tcond tcondLin (solid 7.397e-01) (liquid 1.359e+00) (gas 7.397e-01))
  (K0 1.270e-17) (K1 1.270e-17) (K2 1.270e-17)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.800e-01) (m 5.680e-01) (Smax 1.0))
      (gas krgModCorey (Srl 1.800e-01) (m 5.680e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.800e-01) (m 5.680e-01) (alpha 1.380e-07) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material
;;Fracture materials
(f-tcw11
  (cont-len-fac 1.522e-02) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 7.140e+01) (porosity 2.800e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))

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(Cp 8.230e+02)
(tcond tcondLin (solid 4.480e-02) (liquid 5.600e-02) (gas 4.480e-02))
(K0 2.700e-12) (K1 2.700e-12) (K2 2.700e-12)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.000e-02) (m 5.980e-01) (Smax 1.0) (gamma 2.500e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 5.980e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.000e-02) (m 5.980e-01) (alpha 2.400e-03) (Smax 1.0)
(gamma 2.500e-01)))
(krMC (liquid krMCActiveFrac (gamma 2.500e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 2.500e-01) (Sr 0.0)))
) ;;End of the material
(f-tcw12
    (cont-len-fac 5.236e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 5.020e+01) (porosity 2.000e-02)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 8.510e+02)
    (tcond tcondLin (solid 2.480e-02) (liquid 3.620e-02) (gas 2.480e-02))
    (K0 1.000e-10) (K1 1.000e-10) (K2 1.000e-10)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.080e-01) (Smax 1.0) (gamma 2.500e-
01))
        (gas krgModCorey (Srl 1.000e-02) (m 6.080e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.080e-01) (alpha 2.050e-03) (Smax 1.0)
(gamma 2.500e-01)))
    (krMC (liquid krMCActiveFrac (gamma 2.500e-01) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 2.500e-01) (Sr 0.0)))
) ;;End of the material
(f-tcw13
    (cont-len-fac 2.688e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 3.705e+01) (porosity 1.500e-02)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 8.570e+02)
    (tcond tcondLin (solid 8.100e-03) (liquid 1.470e-02) (gas 8.100e-03))
    (K0 1.790e-12) (K1 1.790e-12) (K2 1.790e-12)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.000e-01) (Smax 1.0) (gamma 2.500e-
01))
        (gas krgModCorey (Srl 1.000e-02) (m 6.000e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.000e-01) (alpha 9.210e-04) (Smax 1.0)
(gamma 2.500e-01)))
    (krMC (liquid krMCActiveFrac (gamma 2.500e-01) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 2.500e-01) (Sr 0.0)))
) ;;End of the material
(f-ptn21
    (cont-len-fac 8.209e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 2.618e+01) (porosity 1.100e-02)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.040e+03)
    (tcond tcondLin (solid 5.500e-03) (liquid 1.177e-02) (gas 5.500e-03))
    (K0 1.000e-11) (K1 1.000e-11) (K2 1.000e-11)

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(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.000e-02) (m 5.030e-01) (Smax 1.0) (gamma 1.000e-
02))
  (gas krgModCorey (Srl 1.000e-02) (m 5.030e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.000e-02) (m 5.030e-01) (alpha 1.660e-03) (Smax 1.0)
(gamma 1.000e-02)))
(krMC (liquid krMCactiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
  (gas krMCactiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material
(f-ptn22
  (cont-len-fac 1.304e-02) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.808e+01) (porosity 1.200e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.080e+03)
  (tcond tcondLin (solid 4.200e-03) (liquid 6.000e-03) (gas 4.200e-03))
  (K0 1.000e-11) (K1 1.000e-11) (K2 1.000e-11)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.510e-01) (Smax 1.0) (gamma 1.000e-
02))
    (gas krgModCorey (Srl 1.000e-02) (m 6.510e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.510e-01) (alpha 9.390e-04) (Smax 1.0)
(gamma 1.000e-02)))
  (krMC (liquid krMCactiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
    (gas krMCactiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material
(f-ptn23
  (cont-len-fac 2.193e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 6.000e+00) (porosity 2.500e-03)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.490e+02)
  (tcond tcondLin (solid 1.100e-03) (liquid 2.425e-03) (gas 1.100e-03))
  (K0 1.840e-13) (K1 1.840e-13) (K2 1.840e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.180e-01) (Smax 1.0) (gamma 1.000e-
02))
    (gas krgModCorey (Srl 1.000e-02) (m 5.180e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.180e-01) (alpha 1.280e-03) (Smax 1.0)
(gamma 1.000e-02)))
  (krMC (liquid krMCactiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
    (gas krMCactiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material
(f-ptn24
  (cont-len-fac 1.304e-02) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.844e+01) (porosity 1.200e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.020e+03)
  (tcond tcondLin (solid 5.520e-03) (liquid 1.224e-02) (gas 5.520e-03))
  (K0 4.310e-13) (K1 4.310e-13) (K2 4.310e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.940e-01) (Smax 1.0) (gamma 1.000e-
02))

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        (gas krgModCorey (Srl 1.000e-02) (m 5.940e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.940e-01) (alpha 2.020e-03) (Smax 1.0)
    (gamma 1.000e-02)))
    (krMC (liquid krMCActiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material
(f-ptn25
    (cont-len-fac 5.962e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 1.401e+01) (porosity 6.200e-03)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.330e+03)
    (tcond tcondLin (solid 2.170e-03) (liquid 5.084e-03) (gas 2.170e-03))
    (K0 7.120e-13) (K1 7.120e-13) (K2 7.120e-13)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.550e-01) (Smax 1.0) (gamma 1.000e-
02))
        (gas krgModCorey (Srl 1.000e-02) (m 5.550e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.550e-01) (alpha 7.420e-04) (Smax 1.0)
    (gamma 1.000e-02)))
    (krMC (liquid krMCActiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material
(f-ptn26
    (cont-len-fac 1.856e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 8.532e+00) (porosity 3.600e-03)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.220e+03)
    (tcond tcondLin (solid 8.280e-04) (liquid 2.412e-03) (gas 8.280e-04))
    (K0 3.080e-13) (K1 3.080e-13) (K2 3.080e-13)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 4.010e-01) (Smax 1.0) (gamma 1.000e-
02))
        (gas krgModCorey (Srl 1.000e-02) (m 4.010e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 4.010e-01) (alpha 2.000e-04) (Smax 1.0)
    (gamma 1.000e-02)))
    (krMC (liquid krMCActiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material
(f-tsw31
    (cont-len-fac 1.267e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 1.380e+01) (porosity 5.500e-03)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 8.340e+02)
    (tcond tcondLin (solid 2.035e-03) (liquid 5.500e-03) (gas 2.035e-03))
    (K0 2.550e-11) (K1 2.550e-11) (K2 2.550e-11)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.450e-01) (Smax 1.0) (gamma 6.000e-
02))
        (gas krgModCorey (Srl 1.000e-02) (m 5.450e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.450e-01) (alpha 4.420e-04) (Smax 1.0)
    (gamma 6.000e-02)))

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(krMC (liquid krMCActiveFrac (gamma 6.000e-02) (Sr 1.000e-02))
      (gas      krMCActiveFrac (gamma 6.000e-02) (Sr 0.0)))
) ;;End of the material
(f-tsw32
  (cont-len-fac 4.241e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.422e+01) (porosity 9.500e-03)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.660e+02)
  (tcond tcondLin (solid 1.007e-02) (liquid 1.539e-02) (gas 1.007e-02))
  (K0 8.910e-13) (K1 8.910e-13) (K2 8.910e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.030e-01) (Smax 1.0) (gamma 2.300e-
01))
      (gas krgModCorey (Srl 1.000e-02) (m 6.030e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.030e-01) (alpha 1.210e-03) (Smax 1.0)
(gamma 2.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
        (gas      krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material
(f-tsw33
  (cont-len-fac 4.074e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 1.657e+01) (porosity 6.600e-03)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.820e+02)
  (tcond tcondLin (solid 5.214e-03) (liquid 1.109e-02) (gas 5.214e-03))
  (K0 6.070e-13) (K1 6.070e-13) (K2 6.070e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.000e-01) (Smax 1.0) (gamma 2.300e-
01))
      (gas krgModCorey (Srl 1.000e-02) (m 6.000e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.000e-01) (alpha 1.360e-03) (Smax 1.0)
(gamma 2.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
        (gas      krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material
(f-tsw34
  (cont-len-fac 1.157e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.530e+01) (porosity 1.000e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 9.480e+02)
  (tcond tcondLin (solid 1.560e-02) (liquid 2.330e-02) (gas 1.560e-02))
  (K0 4.990e-13) (K1 4.990e-13) (K2 4.990e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.150e-01) (Smax 1.0) (gamma 2.300e-
01))
      (gas krgModCorey (Srl 1.000e-02) (m 5.150e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.150e-01) (alpha 2.480e-04) (Smax 1.0)
(gamma 2.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
        (gas      krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material

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(f-tsw35
  (cont-len-fac 1.741e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.794e+01) (porosity 1.100e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 9.000e+02)
  (tcond tcondLin (solid 1.320e-02) (liquid 2.222e-02) (gas 1.320e-02))
  (K0 1.820e-12) (K1 1.820e-12) (K2 1.820e-12)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.120e-01) (Smax 1.0) (gamma 2.300e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.120e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.120e-01) (alpha 6.260e-04) (Smax 1.0)
(gamma 2.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material
(f-tsw36
  (cont-len-fac 1.866e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 3.840e+01) (porosity 1.500e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.650e+02)
  (tcond tcondLin (solid 2.130e-02) (liquid 2.760e-02) (gas 2.130e-02))
  (K0 1.430e-12) (K1 1.430e-12) (K2 1.430e-12)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.400e-01) (Smax 1.0) (gamma 2.300e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 5.400e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.400e-01) (alpha 4.900e-04) (Smax 1.0)
(gamma 2.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material
(f-tsw37
  (cont-len-fac 1.866e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 3.840e+01) (porosity 1.500e-02)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 8.650e+02)
  (tcond tcondLin (solid 2.130e-02) (liquid 2.760e-02) (gas 2.130e-02))
  (K0 1.430e-12) (K1 1.430e-12) (K2 1.430e-12)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.400e-01) (Smax 1.0) (gamma 2.300e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 5.400e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.400e-01) (alpha 4.900e-04) (Smax 1.0)
(gamma 2.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material
(f-tsw38
  (cont-len-fac 1.376e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))

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(solid-density 2.832e+01) (porosity 1.200e-02)
(Kd      (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 9.840e+02)
(tcond tcondLin (solid 2.028e-02) (liquid 2.496e-02) (gas 2.028e-02))
(K0 5.650e-13) (K1 5.650e-13) (K2 5.650e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.000e-02) (m 6.030e-01) (Smax 1.0) (gamma 2.300e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.030e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.000e-02) (m 6.030e-01) (alpha 4.000e-04) (Smax 1.0)
(gamma 2.300e-01)))
(krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
    (gas      krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material
(f-tsw39
(cont-len-fac 2.396e-03) (cont-area-fac 1.000e+00)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 1.086e+01) (porosity 4.600e-03)
(Kd      (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 9.840e+02)
(tcond tcondLin (solid 7.774e-03) (liquid 9.568e-03) (gas 7.774e-03))
(K0 3.120e-13) (K1 3.120e-13) (K2 3.120e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.000e-02) (m 6.050e-01) (Smax 1.0) (gamma 2.300e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.050e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.000e-02) (m 6.050e-01) (alpha 6.430e-04) (Smax 1.0)
(gamma 2.300e-01)))
(krMC (liquid krMCActiveFrac (gamma 2.300e-01) (Sr 1.000e-02))
    (gas      krMCActiveFrac (gamma 2.300e-01) (Sr 0.0)))
) ;;End of the material
(f-chlz
(cont-len-fac 2.125e-03) (cont-area-fac 1.000e+00)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 3.927e-01) (porosity 1.700e-04)
(Kd      (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))
(Cp 1.060e+03)
(tcond tcondLin (solid 1.190e-04) (liquid 2.227e-04) (gas 1.190e-04))
(K0 1.870e-13) (K1 1.870e-13) (K2 1.870e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.000e-02) (m 6.110e-01) (Smax 1.0) (gamma 1.200e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.110e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.000e-02) (m 6.110e-01) (alpha 1.000e-03) (Smax 1.0)
(gamma 1.200e-01)))
(krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
    (gas      krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-chlv
(cont-len-fac 3.450e-03) (cont-area-fac 1.000e+00)
(exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
(solid-density 1.594e+00) (porosity 6.900e-04)
(Kd      (water 0.0) (air 0.0))
(KdFactor (water 0.0) (air 0.0))

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(Cp 1.060e+03)
(tcond tcondLin (solid 4.830e-04) (liquid 9.039e-04) (gas 4.830e-04))
(K0 9.030e-13) (K1 9.030e-13) (K2 9.030e-13)
(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.000e-02) (m 6.580e-01) (Smax 1.0) (gamma 1.200e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.580e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.000e-02) (m 6.580e-01) (alpha 1.430e-03) (Smax 1.0)
(gamma 1.200e-01)))
(krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-ch2v
    (cont-len-fac 3.179e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 1.994e+00) (porosity 8.900e-04)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.200e+03)
    (tcond tcondLin (solid 5.162e-04) (liquid 1.041e-03) (gas 5.162e-04))
    (K0 1.940e-13) (K1 1.940e-13) (K2 1.940e-13)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.440e-01) (Smax 1.0) (gamma 1.200e-
01))
        (gas krgModCorey (Srl 1.000e-02) (m 5.440e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.440e-01) (alpha 6.840e-04) (Smax 1.0)
(gamma 1.200e-01)))
    (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-ch3v
    (cont-len-fac 3.179e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 1.994e+00) (porosity 8.900e-04)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.200e+03)
    (tcond tcondLin (solid 5.162e-04) (liquid 1.041e-03) (gas 5.162e-04))
    (K0 1.940e-13) (K1 1.940e-13) (K2 1.940e-13)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.440e-01) (Smax 1.0) (gamma 1.200e-
01))
        (gas krgModCorey (Srl 1.000e-02) (m 5.440e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.440e-01) (alpha 6.840e-04) (Smax 1.0)
(gamma 1.200e-01)))
    (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-ch4v
    (cont-len-fac 3.179e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 1.994e+00) (porosity 8.900e-04)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.200e+03)
    (tcond tcondLin (solid 5.162e-04) (liquid 1.041e-03) (gas 5.162e-04))
    (K0 1.940e-13) (K1 1.940e-13) (K2 1.940e-13)

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(tort (gas 7.000e-01) (liquid 0.000e+00))
(kr (liquid krlVanGen (Sr 1.000e-02) (m 5.440e-01) (Smax 1.0) (gamma 1.200e-
01))
  (gas krgModCorey (Srl 1.000e-02) (m 5.440e-01) (Slmax 1.0)))
(pc (liquid pcVanGen (Sr 1.000e-02) (m 5.440e-01) (alpha 6.840e-04) (Smax 1.0)
(gamma 1.200e-01)))
(krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
  (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-ch5v
  (cont-len-fac 3.179e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 1.994e+00) (porosity 8.900e-04)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.200e+03)
  (tcond tcondLin (solid 5.162e-04) (liquid 1.041e-03) (gas 5.162e-04))
  (K0 1.940e-13) (K1 1.940e-13) (K2 1.940e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.440e-01) (Smax 1.0) (gamma 1.200e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 5.440e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.440e-01) (alpha 6.840e-04) (Smax 1.0)
(gamma 1.200e-01)))
  (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
  ) ;;End of the material
(f-ch2z
  (cont-len-fac 1.536e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 1.010e+00) (porosity 4.300e-04)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.150e+03)
  (tcond tcondLin (solid 2.623e-04) (liquid 5.160e-04) (gas 2.623e-04))
  (K0 4.100e-14) (K1 4.100e-14) (K2 4.100e-14)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.130e-01) (Smax 1.0) (gamma 1.200e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.130e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.130e-01) (alpha 2.080e-04) (Smax 1.0)
(gamma 1.200e-01)))
  (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
  ) ;;End of the material
(f-ch3z
  (cont-len-fac 1.536e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 1.010e+00) (porosity 4.300e-04)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.150e+03)
  (tcond tcondLin (solid 2.623e-04) (liquid 5.160e-04) (gas 2.623e-04))
  (K0 4.100e-14) (K1 4.100e-14) (K2 4.100e-14)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.130e-01) (Smax 1.0) (gamma 1.200e-
01))

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        (gas krgModCorey (Srl 1.000e-02) (m 6.130e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.130e-01) (alpha 2.080e-04) (Smax 1.0)
(gamma 1.200e-01)))
    (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-ch4z
    (cont-len-fac 1.536e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 1.010e+00) (porosity 4.300e-04)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.150e+03)
    (tcond tcondLin (solid 2.623e-04) (liquid 5.160e-04) (gas 2.623e-04))
    (K0 4.100e-14) (K1 4.100e-14) (K2 4.100e-14)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.130e-01) (Smax 1.0) (gamma 1.200e-
01))
        (gas krgModCorey (Srl 1.000e-02) (m 6.130e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.130e-01) (alpha 2.080e-04) (Smax 1.0)
(gamma 1.200e-01)))
    (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-ch5z
    (cont-len-fac 1.536e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 1.010e+00) (porosity 4.300e-04)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.150e+03)
    (tcond tcondLin (solid 2.623e-04) (liquid 5.160e-04) (gas 2.623e-04))
    (K0 4.100e-14) (K1 4.100e-14) (K2 4.100e-14)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.130e-01) (Smax 1.0) (gamma 1.200e-
01))
        (gas krgModCorey (Srl 1.000e-02) (m 6.130e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.130e-01) (alpha 2.080e-04) (Smax 1.0)
(gamma 1.200e-01)))
    (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
        (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-ch6
    (cont-len-fac 2.125e-03) (cont-area-fac 1.000e+00)
    (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
    (solid-density 4.148e-01) (porosity 1.700e-04)
    (Kd (water 0.0) (air 0.0))
    (KdFactor (water 0.0) (air 0.0))
    (Cp 1.170e+03)
    (tcond tcondLin (solid 1.241e-04) (liquid 2.295e-04) (gas 1.241e-04))
    (K0 1.120e-14) (K1 1.120e-14) (K2 1.120e-14)
    (tort (gas 7.000e-01) (liquid 0.000e+00))
    (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.040e-01) (Smax 1.0) (gamma 1.200e-
01))
        (gas krgModCorey (Srl 1.000e-02) (m 6.040e-01) (Slmax 1.0)))
    (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.040e-01) (alpha 6.100e-04) (Smax 1.0)
(gamma 1.200e-01)))

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(krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
      (gas      krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-pp4
  (cont-len-fac 1.536e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 1.036e+00) (porosity 4.300e-04)
  (Kd          (water 0.0) (air 0.0))
  (KdFactor    (water 0.0) (air 0.0))
  (Cp 5.770e+02)
  (tcond tcondLin (solid 2.666e-04) (liquid 5.203e-04) (gas 2.666e-04))
  (K0 3.400e-14) (K1 3.400e-14) (K2 3.400e-14)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.350e-01) (Smax 1.0) (gamma 1.200e-
01))
      (gas krgModCorey (Srl 1.000e-02) (m 6.350e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.350e-01) (alpha 4.860e-04) (Smax 1.0)
(gamma 1.200e-01)))
  (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
        (gas      krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-pp3
  (cont-len-fac 2.750e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.838e+00) (porosity 1.100e-03)
  (Kd          (water 0.0) (air 0.0))
  (KdFactor    (water 0.0) (air 0.0))
  (Cp 8.410e+02)
  (tcond tcondLin (solid 7.260e-04) (liquid 1.386e-03) (gas 7.260e-04))
  (K0 2.230e-12) (K1 2.230e-12) (K2 2.230e-12)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.990e-01) (Smax 1.0) (gamma 4.300e-
01))
      (gas krgModCorey (Srl 1.000e-02) (m 6.990e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.990e-01) (alpha 5.930e-04) (Smax 1.0)
(gamma 4.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 4.300e-01) (Sr 1.000e-02))
        (gas      krMCActiveFrac (gamma 4.300e-01) (Sr 0.0)))
) ;;End of the material
(f-pp2
  (cont-len-fac 2.750e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.838e+00) (porosity 1.100e-03)
  (Kd          (water 0.0) (air 0.0))
  (KdFactor    (water 0.0) (air 0.0))
  (Cp 8.410e+02)
  (tcond tcondLin (solid 7.260e-04) (liquid 1.386e-03) (gas 7.260e-04))
  (K0 1.420e-13) (K1 1.420e-13) (K2 1.420e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.080e-01) (Smax 1.0) (gamma 4.300e-
01))
      (gas krgModCorey (Srl 1.000e-02) (m 6.080e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.080e-01) (alpha 7.620e-04) (Smax 1.0)
(gamma 4.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 4.300e-01) (Sr 1.000e-02))
        (gas      krMCActiveFrac (gamma 4.300e-01) (Sr 0.0)))
) ;;End of the material

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(f-pp1
  (cont-len-fac 1.536e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 1.062e+00) (porosity 4.300e-04)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 6.350e+02)
  (tcond tcondLin (solid 3.096e-04) (liquid 5.719e-04) (gas 3.096e-04))
  (K0 7.150e-14) (K1 7.150e-14) (K2 7.150e-14)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.380e-01) (Smax 1.0) (gamma 1.200e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.380e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.380e-01) (alpha 3.900e-04) (Smax 1.0)
(gamma 1.200e-01)))
  (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
(f-bf3
  (cont-len-fac 2.750e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.827e+00) (porosity 1.100e-03)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 7.630e+02)
  (tcond tcondLin (solid 1.551e-03) (liquid 2.013e-03) (gas 1.551e-03))
  (K0 3.430e-13) (K1 3.430e-13) (K2 3.430e-13)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.110e-01) (Smax 1.0) (gamma 4.300e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 6.110e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.110e-01) (alpha 7.600e-04) (Smax 1.0)
(gamma 4.300e-01)))
  (krMC (liquid krMCActiveFrac (gamma 4.300e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 4.300e-01) (Sr 0.0)))
) ;;End of the material
(f-bf2
  (cont-len-fac 1.536e-03) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 1.036e+00) (porosity 4.300e-04)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 6.330e+02)
  (tcond tcondLin (solid 3.182e-04) (liquid 5.848e-04) (gas 3.182e-04))
  (K0 9.210e-15) (K1 9.210e-15) (K2 9.210e-15)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 5.980e-01) (Smax 1.0) (gamma 1.200e-
01))
    (gas krgModCorey (Srl 1.000e-02) (m 5.980e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 5.980e-01) (alpha 4.180e-04) (Smax 1.0)
(gamma 1.200e-01)))
  (krMC (liquid krMCActiveFrac (gamma 1.200e-01) (Sr 1.000e-02))
    (gas krMCActiveFrac (gamma 1.200e-01) (Sr 0.0)))
) ;;End of the material
) ;; End of Rocktab

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(f-ptn22
  (cont-len-fac 1.304e-02) (cont-area-fac 1.000e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.808e+01) (porosity 1.200e-02)
  (Kd      (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.080e+03)
  (tcond tcondLin (solid 4.200e-03) (liquid 6.000e-03) (gas 4.200e-03))
  (K0 1.000e-11) (K1 1.000e-11) (K2 1.000e-11)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.000e-02) (m 6.510e-01) (Smax 1.0) (gamma 1.000e-
02))
      (gas krgModCorey (Srl 1.000e-02) (m 6.510e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.000e-02) (m 6.510e-01) (alpha 9.390e-04) (Smax 1.0)
(gamma 1.000e-02)))
  (krMC (liquid krMCactiveFrac (gamma 1.000e-02) (Sr 1.000e-02))
        (gas      krMCactiveFrac (gamma 1.000e-02) (Sr 0.0)))
) ;;End of the material

```

```

(m-ptn22
  (cont-len-fac 3.623e-01) (cont-area-fac 1.410e+00)
  (exfac-adv (liquid 1.000e+00) (gas 1.000e+00))
  (solid-density 2.312e+03) (porosity 4.390e-01)
  (Kd (water 0.0) (air 0.0))
  (KdFactor (water 0.0) (air 0.0))
  (Cp 1.080e+03)
  (tcond tcondLin (solid 3.458e-01) (liquid 4.940e-01) (gas 3.458e-01))
  (K0 3.270e-12) (K1 3.270e-12) (K2 3.270e-12)
  (tort (gas 7.000e-01) (liquid 0.000e+00))
  (kr (liquid krlVanGen (Sr 1.600e-01) (m 3.900e-01) (Smax 1.0))
      (gas krgModCorey (Srl 1.600e-01) (m 3.900e-01) (Slmax 1.0)))
  (pc (liquid pcVanGen (Sr 1.600e-01) (m 3.900e-01) (alpha 1.510e-05) (Smax
1.0)))
  (krMC (liquid krMCintrinsic) (gas krMCintrinsic))
) ;;End of the material

```

```

% filename:  rocktab.m
%
%   cont-len-fac=1/Nf cont-area-fac=2Nf
%   exfac-adv liq=fmx  gas=1.0

% last modified:  08/05/99, Y2K fixed

clear
format compact

% Get user input

input_file1 = input('  Input file of physical property table?  ', 's');
input_file2 = input('  Input file of thermal property table?  ', 's');

%input_file1 = 'physic.txt'
%input_file2 = 'therma.txt'

output_file = input('  What is the name of the output file?  ', 's');
%output_file = 'temp'

% Open input and output files

input_fid1 = fopen(input_file1, 'rt');
input_fid2 = fopen(input_file2, 'rt');

if (input_fid1 == -1)
    disp(' ')
    disp('Input file of physical property not available')
    disp('Execution terminating...')
    disp(' ')
    break
end
if (input_fid2 == -1)
    disp(' ')
    disp('Input file of thermal property not available')
    disp('Execution terminating...')
    disp(' ')
    break
end

output_fid = fopen(output_file, 'wr');

% Scan in comment lines and discard contents

while 1,
    comment = fscanf(input_fid1, '%s', 1);

    if (size(comment, 2) == size('(m2/m3)', 2))
        if (comment == '(m2/m3)')
            break
        end
    end
end

% Perform loop until end of file

```

```

% READ data from physical property table
i=0;
while 1,
i=i+1;
    % Scan in one line of information

    [title,count] = fscanf(input_fid1,'%s',1);

    if (count == 0)
        break
    end

    if length(title) < 5
        empt(1:5-length(title))='e';
        title0=strcat(title,empt);
    else
        title0=title;
    end
    namelength(i)=length(title);
    rockname(i,:)=title0;

    data = fscanf(input_fid1,'%f',15);
    k_m(i)      = data(1);
    phi_m(i)    = data(2);
    alpha_m(i)  = data(3);
    m_m(i)      = data(4);
    sr_m(i)     = data(5);
    smax_m(i)   = data(6);

    k_f(i)      = data(7);
    phi_f(i)    = data(8);
    alpha_f(i)  = data(9);
    m_f(i)      = data(10);
    sr_f(i)     = data(11);
    smax_f(i)   = data(12);
    gamma(i)    = data(13);
    f(i)        = data(14);
    ar(i)       = data(15);
end

% Flow length in fracure is set to half fracture width: len_f = e/2 =
phi_f/(2*f)
% where e is fracture width, phi_f fracture porosity, and f fracture
frequency.

len_f=phi_f./(2.*f);

% READ data from thermal property table
while 1,
    comment = fscanf(input_fid2,'%s',1);

    if (size(comment,2) == size('(-)',2))
        if (comment == '(-)')
            break
        end
    end
end

```

```

end

i=0;
while 1,
i=i+1;
    % Scan in one line of information

    [title,count] = fscanf(input_fid2,'%s',1);

    if (count == 0)
        break
    end

    data2 = fscanf(input_fid2,'%f',5);
    rho(i)      = data2(1);
    cp(i)       = data2(2);
    conduct_dry(i) = data2(3);
    conduct_wet(i) = data2(4);
    tort(i)     = data2(5);
end

n=length(tort);
cont_len_fac=1./(6.*f);
ffmx=1.0;
rho_f=rho.*phi_f;
rho_m=rho.*(1-phi_f);
conduct_f_wet=conduct_wet.*phi_f;
conduct_f_dry=conduct_dry.*phi_f;
conduct_m_wet=conduct_wet.*(1-phi_f);
conduct_m_dry=conduct_dry.*(1-phi_f);

% Write formatted output
fprintf(output_fid,'(rocktab\n');
% Write property of matrix materials
fprintf(output_fid,';;Matrix materials\n');
for i=1:n
    fprintf(output_fid,'(m-%s\n',rockname(i,1:namelength(i)));
    fprintf(output_fid,[' (cont-len-fac %1.3e) (cont-area-fac %1.3e)\n' ...
        ], cont_len_fac(i), ar(i));
    fprintf(output_fid,[' (exfac-adv (liquid %1.3e) (gas %1.3e)) \n'],
ffmx, ffx);
    fprintf(output_fid,[' (solid-density %1.3e) (porosity %1.3e)\n'], ...
        rho_m(i), phi_m(i));
    fprintf(output_fid,[' (Kd (water 0.0) (air 0.0))\n']);
    fprintf(output_fid,[' (KdFactor (water 0.0) (air 0.0))\n']);
    fprintf(output_fid,[' (Cp %1.3e) \n'], cp(i));
    fprintf(output_fid,[' (tcond tcondLin (solid %1.3e) (liquid %1.3e) (gas
%1.3e))\n'], ...
        conduct_m_dry(i),conduct_m_wet(i),conduct_m_dry(i));
    fprintf(output_fid,[' (K0 %1.3e) (K1 %1.3e) (K2
%1.3e)\n'],k_m(i),k_m(i),k_m(i));
    fprintf(output_fid,[' (tort (gas %1.3e) (liquid %1.3e))\n'],tort(i),
0.0);
    fprintf(output_fid,[' (kr (liquid krlVanGen (Sr %1.3e) (m %1.3e)' ...
        ' (Smax 1.0))\n'],sr_m(i),m_m(i));
    fprintf(output_fid,[' (gas krgModCorey (Srl %1.3e) (m %1.3e)' ...
        ' (Slmax 1.0))\n'], sr_m(i), m_m(i));

```

```

        fprintf(output_fid,[' (pc (liquid pcVanGen (Sr %1.3e) (m %1.3e)' ...
                                ' (alpha %1.3e) (Smax 1.0)))\n'], sr_m(i), m_m(i),
alpha_m(i));
        fprintf(output_fid,[' (krMC (liquid krMCintrinsic) (gas
krMCintrinsic))\n']);
        fprintf(output_fid,['] ;;End of the material \n']);
    end
    % Write property of fracture materials
    fprintf(output_fid,[';;Fracture materials\n']);
    for i=1:n
        fprintf(output_fid,['(f-%s\n',rockname(i,1:namelength(i))]);
        fprintf(output_fid,[' (cont-len-fac %1.3e) (cont-area-fac %1.3e)\n' ...
                                ], len_f(i), 1.0);
        fprintf(output_fid,[' (exfac-adv (liquid %1.3e) (gas %1.3e)) \n'], 1.0,
1.0);
        fprintf(output_fid,[' (solid-density %1.3e) (porosity %1.3e)\n'], ...
rho_f(i), phi_f(i));
        fprintf(output_fid,[' (Kd (water 0.0) (air 0.0))\n']);
        fprintf(output_fid,[' (KdFactor (water 0.0) (air 0.0))\n']);
        fprintf(output_fid,[' (Cp %1.3e) \n'], cp(i));
        fprintf(output_fid,[' (tcond tcondLin (solid %1.3e) (liquid %1.3e) (gas
%1.3e))\n'], ...
conduct_f_dry(i), conduct_f_wet(i),
conduct_f_dry(i));
        fprintf(output_fid,[' (K0 %1.3e) (K1 %1.3e) (K2
%1.3e)\n'],k_f(i),k_f(i),k_f(i));
        fprintf(output_fid,[' (tort (gas %1.3e) (liquid %1.3e))\n'],tort(i),
0.0);
        fprintf(output_fid,[' (kr (liquid krlVanGen (Sr %1.3e) (m %1.3e)' ...
                                ' (Smax 1.0) (gamma %1.3e))\n'],sr_f(i),m_f(i),
gamma(i));
        fprintf(output_fid,[' (gas krgModCorey (Srl %1.3e) (m %1.3e)' ...
                                ' (Slmax 1.0))\n'], sr_f(i), m_f(i));
        fprintf(output_fid,[' (pc (liquid pcVanGen (Sr %1.3e) (m %1.3e) (alpha
%1.3e) (Smax 1.0) (gamma %1.3e))\n' ...
                                ], sr_f(i), m_f(i), alpha_f(i),gamma(i));
        fprintf(output_fid,[' (krMC (liquid krMCactiveFrac (gamma %1.3e) (Sr
%1.3e)) \n' ...
                                ' (gas krMCactiveFrac (gamma %1.3e) (Sr
0.0))\n' ...
                                ], gamma(i),sr_f(i),gamma(i));
        fprintf(output_fid,['] ;;End of the material \n']);
    end

    fprintf(output_fid,['] ;; End of Rocktab');

    fclose('all');

    disp(' ')
    disp(' Congratulation! Your work is done.')
    disp(' ')

```

LBT_STATS ROUTINE

ROUTINE IDENTIFICATION

LBT_STATS Version 1.0 The source is LBT_STATS

Purpose of routine

The routine, LBT_STATS, reads a nuft output file in extool format, and temperatures measured in the Large Block, interpolates the model temperatures to field sensor locations, and calculates three goodness-of-fit statistics to compare the two temperature fields. In addition to temperature, the output file may contain other variables, such as gas pressure and liquid saturation. The calculations are repeated for six output times: 30, 100, 200, 300, 365, and 400 days. The statistical parameters calculated are the

- Root Mean Square Error (RMSE)
- Mean Error (ME), and
- Normalized Absolute Mean Error (NAME)

Application of this routine is limited to LBT quarter symmetry model used for the Thermal Test AMR (ref). Note that heating location and power in the test run are fictitious, therefore the statistics obtained from this test are not the same as for the actual simulations.

Structure

The routine performs the following tasks:

- Reads nuft output file written in extool format
- Reads the LBT measured temperature field in x-y-z format, where the origin of coordinates is the top northeastern edge of the block with x positive to the west and y positive to the south. Z is positive upward. Field distances are assumed to be supplied in feet.
- Determines the numerical grid from the nuft output
- Transforms the field data to the nuft coordinate system used in the model. The quarter symmetry model has its origin at the center of the top surface of the block, with x positive to the south and z positive downward.
- Interpolate model temperatures to field sensor locations using inverse distance cubed weighting scheme
- Call subroutines to compute the RMSE, ME, and NAME and output to the monitor

Testing method

Test procedure:

- Rerun nuft for model similar to LBT, but with the number of matrix elements reduced from 18,898 to 175
- Output a separate file with temperatures at 30 days in x-y-z format, in addition to the extool output file used in the original AMR runs.
- Pick four sensor locations and temperatures for comparison with model temperatures
- With x-y-z model results use Microsoft Excel spreadsheet to interpolate and compute model temperatures at the four sensor locations.
- Use Microsoft Excel spreadsheet to calculate the RMSE, ME, and NAME for the model temperatures compared with the field temperatures

Test files

The test files tabulated below

File name	Purpose
lbt_stats.f	Fortran source file for routine used to calculate goodness-of-fit statistics from nuft extool output and field temperatures
stats_check.f	lbt_stats.f with minor input modifications for testing
test3.m.ext	Nuft extool output from test run
test3.m.T	Nuft x-y-z output from test run
test_field	Field temperatures at four sensor locations
T_xyz_30d_F1	Excel spreadsheet showing calculation of nuft temperature interpolated at first sensor location
T_xyz_30d_F2	Excel spreadsheet showing calculation of nuft temperature interpolated at second sensor location
T_xyz_30d_F3	Excel spreadsheet showing calculation of nuft temperature interpolated at third sensor location
T_xyz_30d_F4	Excel spreadsheet showing calculation of nuft temperature interpolated at fourth sensor location
lbtstats_check	Excel spreadsheet showing calculation of RMSE, ME, and NAME for model versus field temperatures at four field locations

Results

Summary of results:

Statistical parameter	lbt_check	Spreadsheet
RMSE	10.022	10.023
ME	-3.928	-3.926
NAME	0.177	0.177

Interpolation calculations for first sensor location

x	y	z	T	d	w	w.T
0.1500	0.1000	0.3000	48.3620	2.2806	0.084303	4.077045
0.1500	0.4000	0.3000	48.3770	2.2766	0.084754	4.100142
0.1500	0.7500	0.3000	48.3960	2.3214	0.079942	3.868878
0.1500	1.1000	0.3000	48.3770	2.4165	0.070863	3.428161
0.1500	1.4000	0.3000	48.3620	2.5340	0.061458	2.97225
0.4500	0.1000	0.3000	48.3880	2.2768	0.084725	4.099651
0.4500	0.4000	0.3000	48.4070	2.2728	0.08518	4.123289
0.4500	0.7500	0.3000	48.4320	2.3176	0.080328	3.890454
0.4500	1.1000	0.3000	48.4070	2.4130	0.071179	3.44557
0.4500	1.4000	0.3000	48.3890	2.5306	0.061707	2.985955
0.7500	0.1000	0.3000	48.4060	2.3123	0.080886	3.915385
0.7500	0.4000	0.3000	48.4290	2.3083	0.081308	3.937643
0.7500	0.7500	0.3000	48.4610	2.3525	0.076812	3.722363
0.7500	1.1000	0.3000	48.4290	2.4464	0.068296	3.307516
0.7500	1.4000	0.3000	48.4060	2.5625	0.059428	2.876667
1.0500	0.1000	0.3000	48.3880	2.3852	0.073689	3.565656
1.0500	0.4000	0.3000	48.4070	2.3814	0.074049	3.584507
1.0500	0.7500	0.3000	48.4320	2.4242	0.070191	3.399506
1.0500	1.1000	0.3000	48.4070	2.5155	0.062824	3.041098
1.0500	1.4000	0.3000	48.3890	2.6286	0.055062	2.664372
1.3500	0.1000	0.3000	48.3620	2.4924	0.064586	3.123531
1.3500	0.4000	0.3000	48.3770	2.4887	0.064876	3.138494
1.3500	0.7500	0.3000	48.3960	2.5297	0.06177	2.989397
1.3500	1.1000	0.3000	48.3770	2.6173	0.055772	2.69808
1.3500	1.4000	0.3000	48.3620	2.7262	0.049356	2.38695
0.1500	0.1000	0.8500	53.1620	1.7351	0.191426	10.1766
0.1500	0.4000	0.8500	53.2420	1.7298	0.193202	10.28648
0.1500	0.7500	0.8500	53.3530	1.7883	0.174845	9.328487
0.1500	1.1000	0.8500	53.2420	1.9103	0.143458	7.637971
0.1500	1.4000	0.8500	53.1620	2.0568	0.11492	6.109382
0.4500	0.1000	0.8500	53.2930	1.7301	0.193086	10.29015
0.4500	0.4000	0.8500	53.4080	1.7248	0.194888	10.40859
0.4500	0.7500	0.8500	53.5960	1.7835	0.176271	9.447439
0.4500	1.1000	0.8500	53.4080	1.9057	0.144483	7.716532
0.4500	1.4000	0.8500	53.2930	2.0526	0.115628	6.162152
0.7500	0.1000	0.8500	53.3900	1.7765	0.178348	9.522001
0.7500	0.4000	0.8500	53.5470	1.7713	0.179926	9.634496
0.7500	0.7500	0.8500	53.8530	1.8285	0.163561	8.808277
0.7500	1.1000	0.8500	53.5470	1.9480	0.135289	7.244337
0.7500	1.4000	0.8500	53.3910	2.0919	0.109239	5.83237
1.0500	0.1000	0.8500	53.2930	1.8705	0.152796	8.142968
1.0500	0.4000	0.8500	53.4080	1.8656	0.154015	8.225622
1.0500	0.7500	0.8500	53.5960	1.9200	0.14129	7.572602
1.0500	1.1000	0.8500	53.4080	2.0340	0.118832	6.346571
1.0500	1.4000	0.8500	53.2930	2.1723	0.097557	5.19909
1.3500	0.1000	0.8500	53.1620	2.0054	0.123996	6.591866

1.3500	0.4000	0.8500	53.2420	2.0008	0.124855	6.647553
1.3500	0.7500	0.8500	53.3530	2.0516	0.115805	6.178546
1.3500	1.1000	0.8500	53.2420	2.1587	0.099409	5.292734
1.3500	1.4000	0.8500	53.1620	2.2894	0.083333	4.430161
0.1500	0.1000	1.4500	62.2000	1.1450	0.666181	41.43648
0.1500	0.4000	1.4500	62.5880	1.1369	0.680519	42.59235
0.1500	0.7500	1.4500	63.2220	1.2241	0.545167	34.46652
0.1500	1.1000	1.4500	62.5880	1.3962	0.367406	22.9952
0.1500	1.4000	1.4500	62.2000	1.5909	0.248359	15.44795
0.4500	0.1000	1.4500	62.8080	1.1374	0.679573	42.68261
0.4500	0.4000	1.4500	63.4800	1.1293	0.694398	44.08039
0.4500	0.7500	1.4500	64.8900	1.2170	0.554734	35.99672
0.4500	1.1000	1.4500	63.4800	1.3900	0.372346	23.63651
0.4500	1.4000	1.4500	62.8080	1.5854	0.250925	15.76008
0.7500	0.1000	1.4500	63.3320	1.2068	0.568929	36.0314
0.7500	0.4000	1.4500	64.4230	1.1992	0.579931	37.36092
0.7500	0.7500	1.4500	67.8530	1.2821	0.474443	32.19239
0.7500	1.1000	1.4500	64.4230	1.4474	0.329816	21.24773
0.7500	1.4000	1.4500	63.3320	1.6360	0.228392	14.46454
1.0500	0.1000	1.4500	62.8080	1.3413	0.414374	26.02602
1.0500	0.4000	1.4500	63.4800	1.3344	0.420842	26.71502
1.0500	0.7500	1.4500	64.8900	1.4095	0.357129	23.17412
1.0500	1.1000	1.4500	63.4800	1.5613	0.262764	16.68023
1.0500	1.4000	1.4500	62.8080	1.7376	0.190628	11.97296
1.3500	0.1000	1.4500	62.2000	1.5238	0.282643	17.5804
1.3500	0.4000	1.4500	62.5880	1.5177	0.286051	17.90338
1.3500	0.7500	1.4500	63.2220	1.5841	0.25157	15.90476
1.3500	1.1000	1.4500	62.5880	1.7205	0.196336	12.28826
1.3500	1.4000	1.4500	62.2000	1.8820	0.150025	9.331534
0.1500	0.1000	2.2000	74.9720	0.4460	11.27262	845.1307
0.1500	0.4000	2.2000	76.8360	0.4248	13.04811	1002.564
0.1500	0.7500	2.2000	80.6020	0.6216	4.163896	335.6184
0.1500	1.1000	2.2000	76.8360	0.9150	1.305187	100.2854
0.1500	1.4000	2.2000	74.9710	1.1911	0.591706	44.36077
0.4500	0.1000	2.2000	77.7890	0.4262	12.91901	1004.957
0.4500	0.4000	2.2000	81.8630	0.4039	15.17509	1242.278
0.4500	0.7500	2.2000	94.0650	0.6075	4.459712	419.5028
0.4500	1.1000	2.2000	81.8630	0.9056	1.346659	110.2416
0.4500	1.4000	2.2000	77.7890	1.1839	0.602682	46.88206
0.7500	0.1000	2.2000	80.7610	0.5868	4.948863	399.6752
0.7500	0.4000	2.2000	89.4010	0.5708	5.375754	480.5977
0.7500	0.7500	2.2000	120.1100	0.7293	2.57851	309.7049
0.7500	1.1000	2.2000	89.4010	0.9913	1.026449	91.76557
0.7500	1.4000	2.2000	80.7610	1.2507	0.511133	41.27959
1.0500	0.1000	2.2000	77.7890	0.8289	1.755906	136.5902
1.0500	0.4000	2.2000	81.8630	0.8177	1.829208	149.7444
1.0500	0.7500	2.2000	94.0650	0.9352	1.222757	115.0186
1.0500	1.1000	2.2000	81.8630	1.1513	0.65531	53.64562

1.0500	1.4000	2.2000	77.7890	1.3809	0.379733	29.53905
1.3500	0.1000	2.2000	74.9710	1.0999	0.751513	56.3417
1.3500	0.4000	2.2000	76.8360	1.0915	0.769067	59.09207
1.3500	0.7500	2.2000	80.6020	1.1821	0.605467	48.80182
1.3500	1.1000	2.2000	76.8360	1.3595	0.397998	30.58059
1.3500	1.4000	2.2000	74.9720	1.5588	0.26404	19.79558
0.1500	0.1000	3.0000	58.9570	0.5027	7.873668	464.2079
0.1500	0.4000	3.0000	59.2980	0.4839	8.823801	523.2338
0.1500	0.7500	3.0000	59.8450	0.6634	3.424782	204.9561
0.1500	1.1000	3.0000	59.2980	0.9440	1.18887	70.49762
0.1500	1.4000	3.0000	58.9570	1.2135	0.559601	32.9924
0.4500	0.1000	3.0000	59.4930	0.4852	8.756412	520.9452
0.4500	0.4000	3.0000	60.0720	0.4657	9.898959	594.6503
0.4500	0.7500	3.0000	61.2720	0.6503	3.636847	222.8369
0.4500	1.1000	3.0000	60.0720	0.9348	1.224311	73.54678
0.4500	1.4000	3.0000	59.4930	1.2064	0.569597	33.88706
0.7500	0.1000	3.0000	59.9460	0.6310	3.981074	238.6494
0.7500	0.4000	3.0000	60.8780	0.6161	4.275277	260.2703
0.7500	0.7500	3.0000	63.7290	0.7652	2.231696	142.2238
0.7500	1.1000	3.0000	60.8780	1.0181	0.947636	57.69019
0.7500	1.4000	3.0000	59.9460	1.2720	0.485871	29.12605
1.0500	0.1000	3.0000	59.4930	0.8607	1.568284	93.30193
1.0500	0.4000	3.0000	60.0720	0.8499	1.62885	97.84829
1.0500	0.7500	3.0000	61.2720	0.9635	1.11809	68.50758
1.0500	1.1000	3.0000	60.0720	1.1744	0.617371	37.08672
1.0500	1.4000	3.0000	59.4930	1.4003	0.364223	21.66873
1.3500	0.1000	3.0000	58.9570	1.1241	0.704065	41.50957
1.3500	0.4000	3.0000	59.2970	1.1158	0.719798	42.68189
1.3500	0.7500	3.0000	59.8450	1.2046	0.572131	34.2392
1.3500	1.1000	3.0000	59.2980	1.3791	0.381243	22.60697
1.3500	1.4000	3.0000	58.9570	1.5759	0.255513	15.06426
0.1500	0.1000	3.9000	42.7550	1.3576	0.399632	17.08626
0.1500	0.4000	3.9000	42.7840	1.3508	0.405718	17.35825
0.1500	0.7500	3.9000	42.8240	1.4250	0.34559	14.79955
0.1500	1.1000	3.9000	42.7840	1.5753	0.255809	10.94454
0.1500	1.4000	3.9000	42.7550	1.7502	0.186537	7.975394
0.4500	0.1000	3.9000	42.8040	1.3512	0.405318	17.34925
0.4500	0.4000	3.9000	42.8450	1.3444	0.411551	17.63289
0.4500	0.7500	3.9000	42.9090	1.4189	0.350049	15.02024
0.4500	1.1000	3.9000	42.8450	1.5698	0.258505	11.07563
0.4500	1.4000	3.9000	42.8040	1.7452	0.188127	8.05258
0.7500	0.1000	3.9000	42.8400	1.4102	0.356601	15.27681
0.7500	0.4000	3.9000	42.8940	1.4036	0.361631	15.51179
0.7500	0.7500	3.9000	42.9930	1.4751	0.311528	13.39354
0.7500	1.1000	3.9000	42.8940	1.6208	0.234862	10.07418
0.7500	1.4000	3.9000	42.8400	1.7912	0.173999	7.454096
1.0500	0.1000	3.9000	42.8040	1.5269	0.280932	12.025
1.0500	0.4000	3.9000	42.8450	1.5208	0.284306	12.18107

1.0500	0.7500	3.9000	42.9090	1.5871	0.25016	10.73412
1.0500	1.1000	3.9000	42.8450	1.7233	0.195402	8.37201
1.0500	1.4000	3.9000	42.8040	1.8845	0.149428	6.396121
1.3500	0.1000	3.9000	42.7550	1.6894	0.207402	8.867471
1.3500	0.4000	3.9000	42.7840	1.6839	0.209433	8.960373
1.3500	0.7500	3.9000	42.8240	1.7440	0.188526	8.073434
1.3500	1.1000	3.9000	42.7840	1.8688	0.153218	6.555267
1.3500	1.4000	3.9000	42.7550	2.0184	0.121612	5.199527
0.1500	0.1000	4.9000	34.6180	2.3474	0.077309	2.676292
0.1500	0.4000	4.9000	34.6200	2.3435	0.0777	2.689968
0.1500	0.7500	4.9000	34.6220	2.3870	0.073526	2.545602
0.1500	1.1000	4.9000	34.6200	2.4797	0.065587	2.270634
0.1500	1.4000	4.9000	34.6180	2.5943	0.057273	1.982684
0.4500	0.1000	4.9000	34.6210	2.3437	0.077674	2.689164
0.4500	0.4000	4.9000	34.6240	2.3398	0.078068	2.703026
0.4500	0.7500	4.9000	34.6270	2.3834	0.073861	2.557596
0.4500	1.1000	4.9000	34.6240	2.4762	0.065865	2.280503
0.4500	1.4000	4.9000	34.6210	2.5909	0.057494	1.990517
0.7500	0.1000	4.9000	34.6240	2.3782	0.074346	2.574173
0.7500	0.4000	4.9000	34.6260	2.3743	0.074712	2.58699
0.7500	0.7500	4.9000	34.6300	2.4173	0.070798	2.451721
0.7500	1.1000	4.9000	34.6260	2.5088	0.063327	2.192769
0.7500	1.4000	4.9000	34.6240	2.6222	0.055466	1.920442
1.0500	0.1000	4.9000	34.6210	2.4492	0.068067	2.35654
1.0500	0.4000	4.9000	34.6240	2.4454	0.068383	2.367677
1.0500	0.7500	4.9000	34.6270	2.4872	0.064996	2.250627
1.0500	1.1000	4.9000	34.6240	2.5762	0.058486	2.025017
1.0500	1.4000	4.9000	34.6210	2.6867	0.051563	1.785154
1.3500	0.1000	4.9000	34.6180	2.5537	0.060049	2.078777
1.3500	0.4000	4.9000	34.6200	2.5500	0.060305	2.087766
1.3500	0.7500	4.9000	34.6220	2.5901	0.05755	1.992489
1.3500	1.1000	4.9000	34.6190	2.6757	0.052199	1.807086
1.3500	1.4000	4.9000	34.6170	2.7823	0.046429	1.607243

SUM					142.0586	10319.35
INTERPOLATED NUFT TEMPERATURE						72.64148

x = nuft x-coordinate

y = nuft y-coordinate

z = nuft z-coordinate

d = distance from sensor location to model node

w = interpolation weight

T = model temperature

Note that weights in the sums of w.T and w are taken as zero for d > 1.0

Interpolation calculations for second sensor location

x	y	z	T	d	w	w.T
0.1500	0.1000	0.3000	48.3620	4.2121	0.013382	0.647175
0.1500	0.4000	0.3000	48.3770	4.1627	0.013863	0.670659

0.1500	0.7500	0.3000	48.3960	4.1321	0.014174	0.685972
0.1500	1.1000	0.3000	48.3770	4.1309	0.014186	0.686268
0.1500	1.4000	0.3000	48.3620	4.1535	0.013956	0.674933
0.4500	0.1000	0.3000	48.3880	4.2134	0.013369	0.646892
0.4500	0.4000	0.3000	48.4070	4.1641	0.013849	0.670406
0.4500	0.7500	0.3000	48.4320	4.1335	0.01416	0.685788
0.4500	1.1000	0.3000	48.4070	4.1323	0.014171	0.685999
0.4500	1.4000	0.3000	48.3890	4.1549	0.013942	0.674634
0.7500	0.1000	0.3000	48.4060	4.2361	0.013155	0.636801
0.7500	0.4000	0.3000	48.4290	4.1871	0.013623	0.65975
0.7500	0.7500	0.3000	48.4610	4.1566	0.013925	0.67482
0.7500	1.1000	0.3000	48.4290	4.1554	0.013936	0.674924
0.7500	1.4000	0.3000	48.4060	4.1779	0.013713	0.663794
1.0500	0.1000	0.3000	48.3880	4.2797	0.012757	0.617294
1.0500	0.4000	0.3000	48.4070	4.2312	0.013201	0.63903
1.0500	0.7500	0.3000	48.4320	4.2010	0.013488	0.653233
1.0500	1.1000	0.3000	48.4070	4.1999	0.013498	0.653417
1.0500	1.4000	0.3000	48.3890	4.2221	0.013287	0.642925
1.3500	0.1000	0.3000	48.3620	4.3437	0.012202	0.590109
1.3500	0.4000	0.3000	48.3770	4.2959	0.012614	0.61022
1.3500	0.7500	0.3000	48.3960	4.2662	0.012879	0.623303
1.3500	1.1000	0.3000	48.3770	4.2651	0.012889	0.623541
1.3500	1.4000	0.3000	48.3620	4.2869	0.012693	0.613859
0.1500	0.1000	0.8500	53.1620	3.6750	0.020148	1.071095
0.1500	0.4000	0.8500	53.2420	3.6184	0.021109	1.123867
0.1500	0.7500	0.8500	53.3530	3.5830	0.021739	1.159848
0.1500	1.1000	0.8500	53.2420	3.5817	0.021763	1.158704
0.1500	1.4000	0.8500	53.1620	3.6077	0.021296	1.132125
0.4500	0.1000	0.8500	53.2930	3.6766	0.020122	1.072362
0.4500	0.4000	0.8500	53.4080	3.6200	0.021081	1.125885
0.4500	0.7500	0.8500	53.5960	3.5847	0.02171	1.163564
0.4500	1.1000	0.8500	53.4080	3.5833	0.021734	1.160753
0.4500	1.4000	0.8500	53.2930	3.6093	0.021268	1.13341
0.7500	0.1000	0.8500	53.3900	3.7025	0.019702	1.051879
0.7500	0.4000	0.8500	53.5470	3.6463	0.020627	1.104512
0.7500	0.7500	0.8500	53.8530	3.6113	0.021233	1.143483
0.7500	1.1000	0.8500	53.5470	3.6100	0.021256	1.138214
0.7500	1.4000	0.8500	53.3910	3.6358	0.020807	1.110906
1.0500	0.1000	0.8500	53.2930	3.7524	0.018927	1.008687
1.0500	0.4000	0.8500	53.4080	3.6969	0.019792	1.057032
1.0500	0.7500	0.8500	53.5960	3.6623	0.020357	1.091072
1.0500	1.1000	0.8500	53.4080	3.6611	0.020379	1.088387
1.0500	1.4000	0.8500	53.2930	3.6865	0.01996	1.06371
1.3500	0.1000	0.8500	53.1620	3.8251	0.017867	0.949856
1.3500	0.4000	0.8500	53.2420	3.7708	0.018651	0.993036
1.3500	0.7500	0.8500	53.3530	3.7369	0.019163	1.02242
1.3500	1.1000	0.8500	53.2420	3.7356	0.019183	1.021322
1.3500	1.4000	0.8500	53.1620	3.7606	0.018803	0.999632

0.1500	0.1000	1.4500	62.2000	3.0943	0.033752	2.099399
0.1500	0.4000	1.4500	62.5880	3.0268	0.03606	2.256949
0.1500	0.7500	1.4500	63.2220	2.9845	0.037616	2.378167
0.1500	1.1000	1.4500	62.5880	2.9830	0.037676	2.358042
0.1500	1.4000	1.4500	62.2000	3.0141	0.036519	2.271459
0.4500	0.1000	1.4500	62.8080	3.0962	0.033692	2.1161
0.4500	0.4000	1.4500	63.4800	3.0287	0.035993	2.284804
0.4500	0.7500	1.4500	64.8900	2.9865	0.037543	2.436183
0.4500	1.1000	1.4500	63.4800	2.9849	0.037603	2.387011
0.4500	1.4000	1.4500	62.8080	3.0160	0.036449	2.289306
0.7500	0.1000	1.4500	63.3320	3.1270	0.032707	2.071371
0.7500	0.4000	1.4500	64.4230	3.0602	0.034894	2.247979
0.7500	0.7500	1.4500	67.8530	3.0183	0.036366	2.467519
0.7500	1.1000	1.4500	64.4230	3.0168	0.036422	2.346407
0.7500	1.4000	1.4500	63.3320	3.0476	0.035328	2.237376
1.0500	0.1000	1.4500	62.8080	3.1858	0.030927	1.942478
1.0500	0.4000	1.4500	63.4800	3.1203	0.032916	2.089507
1.0500	0.7500	1.4500	64.8900	3.0793	0.034249	2.222445
1.0500	1.1000	1.4500	63.4800	3.0778	0.0343	2.177384
1.0500	1.4000	1.4500	62.8080	3.1080	0.033309	2.092092
1.3500	0.1000	1.4500	62.2000	3.2712	0.028567	1.776889
1.3500	0.4000	1.4500	62.5880	3.2075	0.030305	1.896723
1.3500	0.7500	1.4500	63.2220	3.1676	0.031465	1.989259
1.3500	1.1000	1.4500	62.5880	3.1661	0.031509	1.972075
1.3500	1.4000	1.4500	62.2000	3.1955	0.030647	1.906271
0.1500	0.1000	2.2000	74.9720	2.3820	0.073993	5.547435
0.1500	0.4000	2.2000	76.8360	2.2936	0.082877	6.367904
0.1500	0.7500	2.2000	80.6020	2.2375	0.089273	7.195564
0.1500	1.1000	2.2000	76.8360	2.2354	0.089524	6.878686
0.1500	1.4000	2.2000	74.9710	2.2768	0.084725	6.351926
0.4500	0.1000	2.2000	77.7890	2.3844	0.073769	5.738389
0.4500	0.4000	2.2000	81.8630	2.2961	0.082605	6.7623
0.4500	0.7500	2.2000	94.0650	2.2401	0.088966	8.368541
0.4500	1.1000	2.2000	81.8630	2.2380	0.089216	7.303453
0.4500	1.4000	2.2000	77.7890	2.2794	0.084443	6.568773
0.7500	0.1000	2.2000	80.7610	2.4242	0.070192	5.668784
0.7500	0.4000	2.2000	89.4010	2.3375	0.0783	7.000104
0.7500	0.7500	2.2000	120.1100	2.2824	0.084105	10.10182
0.7500	1.1000	2.2000	89.4010	2.2804	0.084332	7.539402
0.7500	1.4000	2.2000	80.7610	2.3210	0.07998	6.459302
1.0500	0.1000	2.2000	77.7890	2.4997	0.064026	4.9805
1.0500	0.4000	2.2000	81.8630	2.4156	0.070943	5.807573
1.0500	0.7500	2.2000	94.0650	2.3624	0.075848	7.134627
1.0500	1.1000	2.2000	81.8630	2.3604	0.076039	6.224818
1.0500	1.4000	2.2000	77.7890	2.3997	0.072367	5.629321
1.3500	0.1000	2.2000	74.9710	2.6077	0.056396	4.228097
1.3500	0.4000	2.2000	76.8360	2.5272	0.061955	4.760356
1.3500	0.7500	2.2000	80.6020	2.4764	0.065849	5.307593

1.3500	1.1000	2.2000	76.8360	2.4745	0.066001	5.071235
1.3500	1.4000	2.2000	74.9720	2.5120	0.063089	4.72993
0.1500	0.1000	3.0000	58.9570	1.6591	0.218965	12.90953
0.1500	0.4000	3.0000	59.2980	1.5296	0.279439	16.57016
0.1500	0.7500	3.0000	59.8450	1.4440	0.332102	19.87462
0.1500	1.1000	3.0000	59.2980	1.4408	0.334355	19.82659
0.1500	1.4000	3.0000	58.9570	1.5043	0.293785	17.32068
0.4500	0.1000	3.0000	59.4930	1.6626	0.217598	12.94554
0.4500	0.4000	3.0000	60.0720	1.5333	0.277387	16.66322
0.4500	0.7500	3.0000	61.2720	1.4480	0.329368	20.18106
0.4500	1.1000	3.0000	60.0720	1.4448	0.331591	19.91934
0.4500	1.4000	3.0000	59.4930	1.5081	0.291556	17.34553
0.7500	0.1000	3.0000	59.9460	1.7192	0.196795	11.79705
0.7500	0.4000	3.0000	60.8780	1.5946	0.246645	15.01523
0.7500	0.7500	3.0000	63.7290	1.5127	0.288896	18.41103
0.7500	1.1000	3.0000	60.8780	1.5096	0.290681	17.69608
0.7500	1.4000	3.0000	59.9460	1.5703	0.258257	15.48146
1.0500	0.1000	3.0000	59.4930	1.8241	0.164771	9.802724
1.0500	0.4000	3.0000	60.0720	1.7071	0.201015	12.07539
1.0500	0.7500	3.0000	61.2720	1.6309	0.230532	14.12513
1.0500	1.1000	3.0000	60.0720	1.6280	0.231757	13.92208
1.0500	1.4000	3.0000	59.4930	1.6844	0.209232	12.44782
1.3500	0.1000	3.0000	58.9570	1.9694	0.130908	7.717953
1.3500	0.4000	3.0000	59.2970	1.8616	0.154995	9.190716
1.3500	0.7500	3.0000	59.8450	1.7920	0.173771	10.39934
1.3500	1.1000	3.0000	59.2980	1.7894	0.174535	10.3496
1.3500	1.4000	3.0000	58.9570	1.8409	0.160293	9.450404
0.1500	0.1000	3.9000	42.7550	0.9982	1.005449	42.98798
0.1500	0.4000	3.9000	42.7840	0.7638	2.244467	96.02728
0.1500	0.7500	3.9000	42.8240	0.5736	5.300027	226.9683
0.1500	1.1000	3.9000	42.7840	0.5653	5.53507	236.8124
0.1500	1.4000	3.9000	42.7550	0.7117	2.773797	118.5937
0.4500	0.1000	3.9000	42.8040	1.0039	0.988261	42.3015
0.4500	0.4000	3.9000	42.8450	0.7713	2.179585	93.38432
0.4500	0.7500	3.9000	42.9090	0.5835	5.033331	215.9752
0.4500	1.1000	3.9000	42.8450	0.5754	5.248727	224.8817
0.4500	1.4000	3.9000	42.8040	0.7198	2.681793	114.7915
0.7500	0.1000	3.9000	42.8400	1.0952	0.761274	32.61298
0.7500	0.4000	3.9000	42.8940	0.8868	1.433997	61.50987
0.7500	0.7500	3.9000	42.9930	0.7294	2.577081	110.7964
0.7500	1.1000	3.9000	42.8940	0.7229	2.646771	113.5306
0.7500	1.4000	3.9000	42.8400	0.8424	1.672995	71.67109
1.0500	0.1000	3.9000	42.8040	1.2534	0.507878	21.73919
1.0500	0.4000	3.9000	42.8450	1.0761	0.802586	34.38678
1.0500	0.7500	3.9000	42.9090	0.9505	1.164369	49.96192
1.0500	1.1000	3.9000	42.8450	0.9456	1.182739	50.67447
1.0500	1.4000	3.9000	42.8040	1.0398	0.889609	38.07881
1.3500	0.1000	3.9000	42.7550	1.4569	0.3234	13.82695

1.3500	0.4000	3.9000	42.7840	1.3074	0.44743	19.14286
1.3500	0.7500	3.9000	42.8240	1.2063	0.569752	24.39906
1.3500	1.1000	3.9000	42.7840	1.2024	0.575306	24.6139
1.3500	1.4000	3.9000	42.7550	1.2777	0.47937	20.49546
0.1500	0.1000	4.9000	34.6180	0.9721	1.088588	37.68474
0.1500	0.4000	4.9000	34.6200	0.7293	2.577517	89.23363
0.1500	0.7500	4.9000	34.6220	0.5268	6.838424	236.7599
0.1500	1.1000	4.9000	34.6200	0.5179	7.200314	249.2749
0.1500	1.4000	4.9000	34.6180	0.6746	3.256696	112.7403
0.4500	0.1000	4.9000	34.6210	0.9780	1.068981	37.00919
0.4500	0.4000	4.9000	34.6240	0.7372	2.495998	86.42143
0.4500	0.7500	4.9000	34.6270	0.5377	6.433756	222.7817
0.4500	1.1000	4.9000	34.6240	0.5289	6.760094	234.0615
0.4500	1.4000	4.9000	34.6210	0.6831	3.136852	108.6009
0.7500	0.1000	4.9000	34.6240	1.0715	0.812969	28.14822
0.7500	0.4000	4.9000	34.6260	0.8573	1.587024	54.95229
0.7500	0.7500	4.9000	34.6300	0.6933	3.001369	103.9374
0.7500	1.1000	4.9000	34.6260	0.6865	3.091429	107.0438
0.7500	1.4000	4.9000	34.6240	0.8113	1.872748	64.84202
1.0500	0.1000	4.9000	34.6210	1.2327	0.533863	18.48289
1.0500	0.4000	4.9000	34.6240	1.0519	0.859153	29.74733
1.0500	0.7500	4.9000	34.6270	0.9231	1.271294	44.0211
1.0500	1.1000	4.9000	34.6240	0.9180	1.292578	44.75422
1.0500	1.4000	4.9000	34.6210	1.0147	0.957043	33.1338
1.3500	0.1000	4.9000	34.6180	1.4391	0.335513	11.6148
1.3500	0.4000	4.9000	34.6200	1.2876	0.468397	16.2159
1.3500	0.7500	4.9000	34.6220	1.1848	0.601333	20.81933
1.3500	1.1000	4.9000	34.6190	1.1808	0.607411	21.02796
1.3500	1.4000	4.9000	34.6170	1.2575	0.502933	17.41003
SUM					95.65386	3662.686
INTERPOLATED NUFT TEMPERATURE						38.29104

x = nuft x-coordinate

y = nuft y-coordinate

z = nuft z-coordinate

d = distance from sensor location to model node

w = interpolation weight

T = model temperature

Note that weights in the sums of w.T and w are taken as zero for d > 1.0

Interpolation calculations for third sensor location

x	y	z	T	d	w	w.T
0.1500	0.1000	0.3000	48.3620	1.3778	0.382346	18.49104
0.1500	0.4000	0.3000	48.3770	1.3981	0.365884	17.70039
0.1500	0.7500	0.3000	48.3960	1.4994	0.296643	14.35632
0.1500	1.1000	0.3000	48.3770	1.6693	0.214965	10.39936
0.1500	1.4000	0.3000	48.3620	1.8556	0.156515	7.569365

0.4500	0.1000	0.3000	48.3880	1.4044	0.360987	17.46745
0.4500	0.4000	0.3000	48.4070	1.4244	0.346009	16.74926
0.4500	0.7500	0.3000	48.4320	1.5239	0.282548	13.68437
0.4500	1.1000	0.3000	48.4070	1.6914	0.206661	10.00383
0.4500	1.4000	0.3000	48.3890	1.8755	0.151591	7.335336
0.7500	0.1000	0.3000	48.4060	1.4922	0.300978	14.56913
0.7500	0.4000	0.3000	48.4290	1.5110	0.289871	14.03816
0.7500	0.7500	0.3000	48.4610	1.6052	0.24179	11.71737
0.7500	1.1000	0.3000	48.4290	1.7649	0.181891	8.808802
0.7500	1.4000	0.3000	48.4060	1.9420	0.136529	6.60881
1.0500	0.1000	0.3000	48.3880	1.6312	0.230404	11.14878
1.0500	0.4000	0.3000	48.4070	1.6484	0.223253	10.80699
1.0500	0.7500	0.3000	48.4320	1.7351	0.191422	9.270971
1.0500	1.1000	0.3000	48.4070	1.8839	0.149558	7.239664
1.0500	1.4000	0.3000	48.3890	2.0508	0.115943	5.610365
1.3500	0.1000	0.3000	48.3620	1.8097	0.168732	8.160217
1.3500	0.4000	0.3000	48.3770	1.8252	0.164456	7.955903
1.3500	0.7500	0.3000	48.3960	1.9039	0.144897	7.012416
1.3500	1.1000	0.3000	48.3770	2.0404	0.117717	5.694795
1.3500	1.4000	0.3000	48.3620	2.1954	0.094504	4.570401
0.1500	0.1000	0.8500	53.1620	0.8287	1.757132	93.41264
0.1500	0.4000	0.8500	53.2420	0.8621	1.560566	83.08767
0.1500	0.7500	0.8500	53.3530	1.0182	0.947361	50.54456
0.1500	1.1000	0.8500	53.2420	1.2550	0.505846	26.93224
0.1500	1.4000	0.8500	53.1620	1.4939	0.299955	15.94619
0.4500	0.1000	0.8500	53.2930	0.8723	1.506615	80.29201
0.4500	0.4000	0.8500	53.4080	0.9041	1.353088	72.26573
0.4500	0.7500	0.8500	53.5960	1.0540	0.854096	45.77612
0.4500	1.1000	0.8500	53.4080	1.2843	0.472115	25.2147
0.4500	1.4000	0.8500	53.2930	1.5185	0.285601	15.22054
0.7500	0.1000	0.8500	53.3900	1.0075	0.977817	52.20565
0.7500	0.4000	0.8500	53.5470	1.0352	0.901485	48.27182
0.7500	0.7500	0.8500	53.8530	1.1683	0.627029	33.76741
0.7500	1.1000	0.8500	53.5470	1.3797	0.380787	20.38999
0.7500	1.4000	0.8500	53.3910	1.6000	0.244142	13.03501
1.0500	0.1000	0.8500	53.2930	1.2038	0.573185	30.54677
1.0500	0.4000	0.8500	53.4080	1.2271	0.541217	28.90534
1.0500	0.7500	0.8500	53.5960	1.3413	0.414367	22.20842
1.0500	1.1000	0.8500	53.4080	1.5289	0.279793	14.94319
1.0500	1.4000	0.8500	53.2930	1.7304	0.193015	10.28633
1.3500	0.1000	0.8500	53.1620	1.4364	0.337387	17.93619
1.3500	0.4000	0.8500	53.2420	1.4560	0.323985	17.2496
1.3500	0.7500	0.8500	53.3530	1.5535	0.266729	14.23079
1.3500	1.1000	0.8500	53.2420	1.7181	0.197184	10.49849
1.3500	1.4000	0.8500	53.1620	1.8996	0.145896	7.756146
0.1500	0.1000	1.4500	62.2000	0.2347	77.3849	4813.341
0.1500	0.4000	1.4500	62.5880	0.3340	26.82726	1679.065
0.1500	0.7500	1.4500	63.2220	0.6364	3.879477	245.2683

0.1500	1.1000	1.4500	62.5880	0.9713	1.091213	68.29684
0.1500	1.4000	1.4500	62.2000	1.2649	0.494112	30.73374
0.4500	0.1000	1.4500	62.8080	0.3595	21.5262	1352.017
0.4500	0.4000	1.4500	63.4800	0.4310	12.49152	792.9618
0.4500	0.7500	1.4500	64.8900	0.6922	3.014683	195.6228
0.4500	1.1000	1.4500	63.4800	1.0088	0.97413	61.83774
0.4500	1.4000	1.4500	62.8080	1.2939	0.461646	28.99508
0.7500	0.1000	1.4500	63.3320	0.6192	4.21253	266.7879
0.7500	0.4000	1.4500	64.4230	0.6633	3.427345	220.7999
0.7500	0.7500	1.4500	67.8530	0.8564	1.592338	108.0449
0.7500	1.1000	1.4500	64.4230	1.1277	0.697233	44.91786
0.7500	1.4000	1.4500	63.3320	1.3886	0.373453	23.6515
1.0500	0.1000	1.4500	62.8080	0.9042	1.35279	84.96605
1.0500	0.4000	1.4500	63.4800	0.9349	1.223721	77.68182
1.0500	0.7500	1.4500	64.8900	1.0805	0.792703	51.43849
1.0500	1.1000	1.4500	63.4800	1.3061	0.448799	28.48973
1.0500	1.4000	1.4500	62.8080	1.5370	0.275392	17.29682
1.3500	0.1000	1.4500	62.2000	1.1965	0.583739	36.30855
1.3500	0.4000	1.4500	62.5880	1.2199	0.550803	34.47363
1.3500	0.7500	1.4500	63.2220	1.3348	0.420494	26.58448
1.3500	1.1000	1.4500	62.5880	1.5232	0.282968	17.71042
1.3500	1.4000	1.4500	62.2000	1.7253	0.194721	12.11166
0.1500	0.1000	2.2000	74.9720	0.5272	6.823526	511.5734
0.1500	0.4000	2.2000	76.8360	0.5783	5.16928	397.1868
0.1500	0.7500	2.2000	80.6020	0.7924	2.009721	161.9875
0.1500	1.1000	2.2000	76.8360	1.0800	0.793865	60.99744
0.1500	1.4000	2.2000	74.9710	1.3501	0.406312	30.46165
0.4500	0.1000	2.2000	77.7890	0.5934	4.78575	372.2787
0.4500	0.4000	2.2000	81.8630	0.6393	3.828041	313.375
0.4500	0.7500	2.2000	94.0650	0.8379	1.69986	159.8973
0.4500	1.1000	2.2000	81.8630	1.1138	0.723753	59.24859
0.4500	1.4000	2.2000	77.7890	1.3773	0.382721	29.77151
0.7500	0.1000	2.2000	80.7610	0.7786	2.118273	171.0739
0.7500	0.4000	2.2000	89.4010	0.8141	1.853185	165.6766
0.7500	0.7500	2.2000	120.1100	0.9779	1.069411	128.4469
0.7500	1.1000	2.2000	89.4010	1.2226	0.547236	48.92341
0.7500	1.4000	2.2000	80.7610	1.4667	0.31694	25.59636
1.0500	0.1000	2.2000	77.7890	1.0200	0.942258	73.29729
1.0500	0.4000	2.2000	81.8630	1.0474	0.870381	71.25199
1.0500	0.7500	2.2000	94.0650	1.1792	0.60994	57.37397
1.0500	1.1000	2.2000	81.8630	1.3888	0.373296	30.55912
1.0500	1.4000	2.2000	77.7890	1.6079	0.240556	18.71263
1.3500	0.1000	2.2000	74.9710	1.2863	0.469848	35.22498
1.3500	0.4000	2.2000	76.8360	1.3081	0.446762	34.32742
1.3500	0.7500	2.2000	80.6020	1.4158	0.352346	28.39977
1.3500	1.1000	2.2000	76.8360	1.5947	0.246592	18.94712
1.3500	1.4000	2.2000	74.9720	1.7887	0.174732	13.09997
0.1500	0.1000	3.0000	58.9570	1.3250	0.429847	25.34251

0.1500	0.4000	3.0000	59.2980	1.3462	0.409896	24.30601
0.1500	0.7500	3.0000	59.8450	1.4511	0.327272	19.5856
0.1500	1.1000	3.0000	59.2980	1.6261	0.232582	13.79166
0.1500	1.4000	3.0000	58.9570	1.8168	0.166764	9.831882
0.4500	0.1000	3.0000	59.4930	1.3527	0.403983	24.03418
0.4500	0.4000	3.0000	60.0720	1.3735	0.385964	23.18562
0.4500	0.7500	3.0000	61.2720	1.4764	0.310714	19.03807
0.4500	1.1000	3.0000	60.0720	1.6487	0.223129	13.40383
0.4500	1.4000	3.0000	59.4930	1.8371	0.161297	9.596047
0.7500	0.1000	3.0000	59.9460	1.4436	0.332383	19.92502
0.7500	0.4000	3.0000	60.8780	1.4631	0.319306	19.43869
0.7500	0.7500	3.0000	63.7290	1.5601	0.26334	16.78241
0.7500	1.1000	3.0000	60.8780	1.7241	0.195132	11.87925
0.7500	1.4000	3.0000	59.9460	1.9050	0.144652	8.671327
1.0500	0.1000	3.0000	59.4930	1.5869	0.250243	14.88773
1.0500	0.4000	3.0000	60.0720	1.6046	0.242049	14.54036
1.0500	0.7500	3.0000	61.2720	1.6936	0.20587	12.61407
1.0500	1.1000	3.0000	60.0720	1.8457	0.159044	9.554081
1.0500	1.4000	3.0000	59.4930	2.0157	0.122098	7.263989
1.3500	0.1000	3.0000	58.9570	1.7698	0.180381	10.63473
1.3500	0.4000	3.0000	59.2970	1.7857	0.175607	10.41295
1.3500	0.7500	3.0000	59.8450	1.8661	0.153885	9.209233
1.3500	1.1000	3.0000	59.2980	2.0052	0.124033	7.354897
1.3500	1.4000	3.0000	58.9570	2.1627	0.098857	5.828332
0.1500	0.1000	3.9000	42.7550	2.2245	0.090851	3.88432
0.1500	0.4000	3.9000	42.7840	2.2371	0.089316	3.821296
0.1500	0.7500	3.9000	42.8240	2.3018	0.082	3.511549
0.1500	1.1000	3.9000	42.7840	2.4159	0.070918	3.034175
0.1500	1.4000	3.9000	42.7550	2.5482	0.060439	2.58408
0.4500	0.1000	3.9000	42.8040	2.2411	0.088846	3.802959
0.4500	0.4000	3.9000	42.8450	2.2536	0.087367	3.743236
0.4500	0.7500	3.9000	42.9090	2.3178	0.080308	3.445916
0.4500	1.1000	3.9000	42.8450	2.4312	0.069588	2.981497
0.4500	1.4000	3.9000	42.8040	2.5627	0.059418	2.543345
0.7500	0.1000	3.9000	42.8400	2.2971	0.082505	3.534493
0.7500	0.4000	3.9000	42.8940	2.3093	0.081196	3.482839
0.7500	0.7500	3.9000	42.9930	2.3720	0.074928	3.221378
0.7500	1.1000	3.9000	42.8940	2.4829	0.065329	2.802235
0.7500	1.4000	3.9000	42.8400	2.6118	0.056129	2.404555
1.0500	0.1000	3.9000	42.8040	2.3897	0.073277	3.136547
1.0500	0.4000	3.9000	42.8450	2.4015	0.072202	3.093512
1.0500	0.7500	3.9000	42.9090	2.4618	0.067023	2.875874
1.0500	1.1000	3.9000	42.8450	2.5689	0.058989	2.527402
1.0500	1.4000	3.9000	42.8040	2.6936	0.051167	2.190149
1.3500	0.1000	3.9000	42.7550	2.5149	0.062867	2.687892
1.3500	0.4000	3.9000	42.7840	2.5261	0.062034	2.65406
1.3500	0.7500	3.9000	42.8240	2.5836	0.057989	2.4833
1.3500	1.1000	3.9000	42.7840	2.6857	0.051618	2.208438

1.3500	1.4000	3.9000	42.7550	2.8053	0.045296	1.936618
0.1500	0.1000	4.9000	34.6180	3.2242	0.029836	1.032856
0.1500	0.4000	4.9000	34.6200	3.2329	0.029594	1.024548
0.1500	0.7500	4.9000	34.6220	3.2780	0.02839	0.982925
0.1500	1.1000	4.9000	34.6200	3.3591	0.026383	0.913363
0.1500	1.4000	4.9000	34.6180	3.4555	0.024237	0.83903
0.4500	0.1000	4.9000	34.6210	3.2357	0.029519	1.02199
0.4500	0.4000	4.9000	34.6240	3.2444	0.029282	1.013857
0.4500	0.7500	4.9000	34.6270	3.2893	0.028099	0.972977
0.4500	1.1000	4.9000	34.6240	3.3702	0.026125	0.904537
0.4500	1.4000	4.9000	34.6210	3.4662	0.024013	0.831346
0.7500	0.1000	4.9000	34.6240	3.2747	0.028476	0.985958
0.7500	0.4000	4.9000	34.6260	3.2833	0.028253	0.978271
0.7500	0.7500	4.9000	34.6300	3.3277	0.027137	0.939754
0.7500	1.1000	4.9000	34.6260	3.4077	0.025272	0.875054
0.7500	1.4000	4.9000	34.6240	3.5027	0.02327	0.805716
1.0500	0.1000	4.9000	34.6210	3.3403	0.02683	0.928895
1.0500	0.4000	4.9000	34.6240	3.3488	0.026628	0.921961
1.0500	0.7500	4.9000	34.6270	3.3923	0.025616	0.887
1.0500	1.1000	4.9000	34.6240	3.4708	0.023918	0.828128
1.0500	1.4000	4.9000	34.6210	3.5641	0.022088	0.764698
1.3500	0.1000	4.9000	34.6180	3.4310	0.024758	0.857085
1.3500	0.4000	4.9000	34.6200	3.4393	0.024581	0.850999
1.3500	0.7500	4.9000	34.6220	3.4817	0.023694	0.820333
1.3500	1.1000	4.9000	34.6190	3.5582	0.022199	0.768495
1.3500	1.4000	4.9000	34.6170	3.6492	0.020577	0.71233

SUM					193.5584	12615.41
INTERPOLATED NUFT TEMPERATURE						65.17622

x = nuft x-coordinate

y = nuft y-coordinate

z = nuft z-coordinate

d = distance from sensor location to model node

w = interpolation weight

T = model temperature

Note that weights in the sums of w.T and w are taken as zero for d > 1.0

Interpolation calculations for fourth sensor location

x	y	z	T	d	w	w.T
0.1500	0.4000	0.3000	48.3770	2.8221	0.04449	2.152295
0.1500	0.7500	0.3000	48.3960	2.7636	0.047377	2.292876
0.1500	1.1000	0.3000	48.3770	2.7487	0.04815	2.329376
0.1500	1.4000	0.3000	48.3620	2.7713	0.046982	2.272153
0.4500	0.1000	0.3000	48.3880	2.9179	0.040254	1.947798
0.4500	0.4000	0.3000	48.4070	2.8353	0.043876	2.123896
0.4500	0.7500	0.3000	48.4320	2.7770	0.046696	2.261563
0.4500	1.1000	0.3000	48.4070	2.7622	0.04745	2.29692

0.4500	1.4000	0.3000	48.3890	2.7847	0.04631	2.240887
0.7500	0.1000	0.3000	48.4060	2.9611	0.038516	1.864416
0.7500	0.4000	0.3000	48.4290	2.8797	0.041874	2.027929
0.7500	0.7500	0.3000	48.4610	2.8224	0.044479	2.155484
0.7500	1.1000	0.3000	48.4290	2.8078	0.045174	2.187742
0.7500	1.4000	0.3000	48.4060	2.8299	0.044123	2.135813
1.0500	0.1000	0.3000	48.3880	3.0335	0.035823	1.733396
1.0500	0.4000	0.3000	48.4070	2.9541	0.038789	1.877642
1.0500	0.7500	0.3000	48.4320	2.8983	0.041075	1.989359
1.0500	1.1000	0.3000	48.4070	2.8841	0.041684	2.017796
1.0500	1.4000	0.3000	48.3890	2.9056	0.040764	1.972509
1.3500	0.1000	0.3000	48.3620	3.1331	0.032514	1.572448
1.3500	0.4000	0.3000	48.3770	3.0563	0.035027	1.694492
1.3500	0.7500	0.3000	48.3960	3.0024	0.03695	1.788222
1.3500	1.1000	0.3000	48.3770	2.9887	0.03746	1.812182
1.3500	1.4000	0.3000	48.3620	3.0095	0.036688	1.774322
0.1500	0.1000	0.8500	53.1620	2.3915	0.073109	3.886597
0.1500	0.4000	0.8500	53.2420	2.2900	0.083269	4.433394
0.1500	0.7500	0.8500	53.3530	2.2175	0.091711	4.893042
0.1500	1.1000	0.8500	53.2420	2.1989	0.094053	5.007552
0.1500	1.4000	0.8500	53.1620	2.2271	0.090527	4.812599
0.4500	0.1000	0.8500	53.2930	2.4070	0.071709	3.821606
0.4500	0.4000	0.8500	53.4080	2.3062	0.081533	4.354522
0.4500	0.7500	0.8500	53.5960	2.2341	0.089674	4.806191
0.4500	1.1000	0.8500	53.4080	2.2157	0.09193	4.909779
0.4500	1.4000	0.8500	53.2930	2.2437	0.088534	4.718245
0.7500	0.1000	0.8500	53.3900	2.4592	0.067237	3.58977
0.7500	0.4000	0.8500	53.5470	2.3606	0.076019	4.0706
0.7500	0.7500	0.8500	53.8530	2.2903	0.083237	4.48254
0.7500	1.1000	0.8500	53.5470	2.2723	0.085226	4.563621
0.7500	1.4000	0.8500	53.3910	2.2996	0.082229	4.390281
1.0500	0.1000	0.8500	53.2930	2.5460	0.060596	3.229337
1.0500	0.4000	0.8500	53.4080	2.4509	0.067928	3.6279
1.0500	0.7500	0.8500	53.5960	2.3832	0.073877	3.959532
1.0500	1.1000	0.8500	53.4080	2.3660	0.075506	4.032627
1.0500	1.4000	0.8500	53.2930	2.3922	0.073051	3.89309
1.3500	0.1000	0.8500	53.1620	2.6638	0.052902	2.812369
1.3500	0.4000	0.8500	53.2420	2.5731	0.058699	3.125254
1.3500	0.7500	0.8500	53.3530	2.5088	0.063332	3.378959
1.3500	1.1000	0.8500	53.2420	2.4924	0.06459	3.438891
1.3500	1.4000	0.8500	53.1620	2.5173	0.062692	3.332832
0.1500	0.1000	1.4500	62.2000	1.8552	0.156607	9.740962
0.1500	0.4000	1.4500	62.5880	1.7224	0.19571	12.2491
0.1500	0.7500	1.4500	63.2220	1.6247	0.233178	14.74196
0.1500	1.1000	1.4500	62.5880	1.5993	0.244477	15.30131
0.1500	1.4000	1.4500	62.2000	1.6378	0.227623	14.15816
0.4500	0.1000	1.4500	62.8080	1.8751	0.151679	9.526628
0.4500	0.4000	1.4500	63.4800	1.7438	0.188594	11.97196

0.4500	0.7500	1.4500	64.8900	1.6474	0.223685	14.51493
0.4500	1.1000	1.4500	63.4800	1.6223	0.234216	14.86806
0.4500	1.4000	1.4500	62.8080	1.6603	0.218499	13.72351
0.7500	0.1000	1.4500	63.3320	1.9417	0.136602	8.651297
0.7500	0.4000	1.4500	64.4230	1.8152	0.167199	10.77147
0.7500	0.7500	1.4500	67.8530	1.7228	0.195576	13.27045
0.7500	1.1000	1.4500	64.4230	1.6988	0.203968	13.14021
0.7500	1.4000	1.4500	63.3320	1.7351	0.191424	12.12325
1.0500	0.1000	1.4500	62.8080	2.0504	0.115999	7.285666
1.0500	0.4000	1.4500	63.4800	1.9311	0.138867	8.815268
1.0500	0.7500	1.4500	64.8900	1.8445	0.15936	10.34086
1.0500	1.1000	1.4500	63.4800	1.8221	0.165298	10.4931
1.0500	1.4000	1.4500	62.8080	1.8560	0.156401	9.823247
1.3500	0.1000	1.4500	62.2000	2.1951	0.094544	5.880625
1.3500	0.4000	1.4500	62.5880	2.0840	0.110479	6.914668
1.3500	0.7500	1.4500	63.2220	2.0041	0.124242	7.854797
1.3500	1.1000	1.4500	62.5880	1.9835	0.128144	8.020306
1.3500	1.4000	1.4500	62.2000	2.0147	0.122283	7.606002
0.1500	0.1000	2.2000	74.9720	1.2678	0.490719	36.79019
0.1500	0.4000	2.2000	76.8360	1.0640	0.830188	63.78835
0.1500	0.7500	2.2000	80.6020	0.8973	1.384224	111.5712
0.1500	1.1000	2.2000	76.8360	0.8504	1.626127	124.9451
0.1500	1.4000	2.2000	74.9710	0.9208	1.28082	96.02437
0.4500	0.1000	2.2000	77.7890	1.2967	0.458616	35.67531
0.4500	0.4000	2.2000	81.8630	1.0983	0.754818	61.79166
0.4500	0.7500	2.2000	94.0650	0.9377	1.212849	114.0866
0.4500	1.1000	2.2000	81.8630	0.8929	1.404612	114.9858
0.4500	1.4000	2.2000	77.7890	0.9602	1.129447	87.85856
0.7500	0.1000	2.2000	80.7610	1.3913	0.371323	29.98842
0.7500	0.4000	2.2000	89.4010	1.2085	0.566613	50.65574
0.7500	0.7500	2.2000	120.1100	1.0646	0.828706	99.53583
0.7500	1.1000	2.2000	89.4010	1.0254	0.927476	82.91726
0.7500	1.4000	2.2000	80.7610	1.0845	0.783918	63.31003
1.0500	0.1000	2.2000	77.7890	1.5394	0.274109	21.32266
1.0500	0.4000	2.2000	81.8630	1.3764	0.383471	31.39211
1.0500	0.7500	2.2000	94.0650	1.2520	0.509502	47.92629
1.0500	1.1000	2.2000	81.8630	1.2189	0.552246	45.20851
1.0500	1.4000	2.2000	77.7890	1.2690	0.489339	38.06522
1.3500	0.1000	2.2000	74.9710	1.7274	0.194001	14.54442
1.3500	0.4000	2.2000	76.8360	1.5839	0.251662	19.33673
1.3500	0.7500	2.2000	80.6020	1.4771	0.310305	25.01119
1.3500	1.1000	2.2000	76.8360	1.4491	0.328651	25.25224
1.3500	1.4000	2.2000	74.9720	1.4915	0.301399	22.59648
0.1500	0.1000	3.0000	58.9570	0.9437	1.189899	70.15287
0.1500	0.4000	3.0000	59.2980	0.6444	3.736522	221.5683
0.1500	0.7500	3.0000	59.8450	0.2972	38.09663	2279.893
0.1500	1.1000	3.0000	59.2980	0.0797	1974.667	117093.8
0.1500	1.4000	3.0000	58.9570	0.3621	21.06827	1242.122

0.4500	0.1000	3.0000	59.4930	0.9822	1.055365	62.78681
0.4500	0.4000	3.0000	60.0720	0.6996	2.920337	175.4305
0.4500	0.7500	3.0000	61.2720	0.4031	15.26816	935.5105
0.4500	1.1000	3.0000	60.0720	0.2837	43.77216	2629.481
0.4500	1.4000	3.0000	59.4930	0.4530	10.75386	639.7797
0.7500	0.1000	3.0000	59.9460	1.1040	0.743125	44.5474
0.7500	0.4000	3.0000	60.8780	0.8623	1.559478	94.93789
0.7500	0.7500	3.0000	63.7290	0.6455	3.718376	236.9684
0.7500	1.1000	3.0000	60.8780	0.5785	5.164975	314.4334
0.7500	1.4000	3.0000	59.9460	0.6778	3.211401	192.5107
1.0500	0.1000	3.0000	59.4930	1.2857	0.470519	27.99261
1.0500	0.4000	3.0000	60.0720	1.0853	0.782361	46.99801
1.0500	0.7500	3.0000	61.2720	0.9224	1.274255	78.07613
1.0500	1.1000	3.0000	60.0720	0.8768	1.483377	89.10945
1.0500	1.4000	3.0000	59.4930	0.9453	1.183872	70.43208
1.3500	0.1000	3.0000	58.9570	1.5057	0.292932	17.27041
1.3500	0.4000	3.0000	59.2970	1.3386	0.416886	24.72008
1.3500	0.7500	3.0000	59.8450	1.2104	0.563975	33.75108
1.3500	1.1000	3.0000	59.2980	1.1760	0.614851	36.45943
1.3500	1.4000	3.0000	58.9570	1.2279	0.540149	31.84554
0.1500	0.1000	3.9000	42.7550	1.2705	0.487621	20.84826
0.1500	0.4000	3.9000	42.7840	1.0672	0.822764	35.20114
0.1500	0.7500	3.9000	42.8240	0.9011	1.366871	58.53487
0.1500	1.1000	3.9000	42.7840	0.8544	1.603457	68.60231
0.1500	1.4000	3.9000	42.7550	0.9245	1.265565	54.10924
0.4500	0.1000	3.9000	42.8040	1.2994	0.455848	19.51213
0.4500	0.4000	3.9000	42.8450	1.1014	0.74848	32.06862
0.4500	0.7500	3.9000	42.9090	0.9413	1.198914	51.44421
0.4500	1.1000	3.9000	42.8450	0.8967	1.386833	59.41885
0.4500	1.4000	3.9000	42.8040	0.9638	1.117067	47.81494
0.7500	0.1000	3.9000	42.8400	1.3937	0.369375	15.82402
0.7500	0.4000	3.9000	42.8940	1.2113	0.562678	24.13552
0.7500	0.7500	3.9000	42.9930	1.0678	0.821303	35.3103
0.7500	1.1000	3.9000	42.8940	1.0287	0.918551	39.40032
0.7500	1.4000	3.9000	42.8400	1.0877	0.777169	33.29392
1.0500	0.1000	3.9000	42.8040	1.5416	0.272933	11.68264
1.0500	0.4000	3.9000	42.8450	1.3789	0.381416	16.34177
1.0500	0.7500	3.9000	42.9090	1.2548	0.506204	21.72073
1.0500	1.1000	3.9000	42.8450	1.2217	0.548476	23.49945
1.0500	1.4000	3.9000	42.8040	1.2717	0.486256	20.81371
1.3500	0.1000	3.9000	42.7550	1.7294	0.193339	8.266226
1.3500	0.4000	3.9000	42.7840	1.5860	0.250643	10.72349
1.3500	0.7500	3.9000	42.8240	1.4794	0.30886	13.22661
1.3500	1.1000	3.9000	42.7840	1.4514	0.327061	13.99298
1.3500	1.4000	3.9000	42.7550	1.4938	0.300022	12.82745
0.1500	0.1000	4.9000	34.6180	2.0780	0.111443	3.857935
0.1500	0.4000	4.9000	34.6200	1.9603	0.132743	4.595572
0.1500	0.7500	4.9000	34.6220	1.8751	0.151684	5.251617

0.1500	1.1000	4.9000	34.6200	1.8531	0.157148	5.440458
0.1500	1.4000	4.9000	34.6180	1.8864	0.148958	5.156632
0.4500	0.1000	4.9000	34.6210	2.0958	0.108633	3.760968
0.4500	0.4000	4.9000	34.6240	1.9792	0.128991	4.466198
0.4500	0.7500	4.9000	34.6270	1.8948	0.147009	5.090472
0.4500	1.1000	4.9000	34.6240	1.8730	0.152191	5.269468
0.4500	1.4000	4.9000	34.6210	1.9060	0.14442	4.999975
0.7500	0.1000	4.9000	34.6240	2.1556	0.099842	3.456942
0.7500	0.4000	4.9000	34.6260	2.0424	0.117383	4.064515
0.7500	0.7500	4.9000	34.6300	1.9607	0.132673	4.594478
0.7500	1.1000	4.9000	34.6260	1.9397	0.137033	4.744897
0.7500	1.4000	4.9000	34.6240	1.9716	0.13049	4.518072
1.0500	0.1000	4.9000	34.6210	2.2540	0.087322	3.023172
1.0500	0.4000	4.9000	34.6240	2.1460	0.101182	3.503321
1.0500	0.7500	4.9000	34.6270	2.0684	0.113	3.912842
1.0500	1.1000	4.9000	34.6240	2.0485	0.116327	4.027697
1.0500	1.4000	4.9000	34.6210	2.0787	0.111326	3.854225
1.3500	0.1000	4.9000	34.6180	2.3864	0.073584	2.547329
1.3500	0.4000	4.9000	34.6200	2.2846	0.08386	2.903217
1.3500	0.7500	4.9000	34.6220	2.2119	0.092405	3.199245
1.3500	1.1000	4.9000	34.6190	2.1933	0.094777	3.281078
1.3500	1.4000	4.9000	34.6170	2.2216	0.091206	3.157292

SUM					2146.1	127416.4
INTERPOLATED NUFT TEMPERATURE						59.37111

x = nuft x-coordinate

y = nuft y-coordinate

z = nuft z-coordinate

d = distance from sensor location to model node

w = interpolation weight

T = model temperature

Note that weights in the sums of w.T and w are taken as zero for d > 1.0

87.3500	72.6393	216.4047	-14.7107	0.1902
33.1300	38.2901	26.6266	5.1601	0.2231
59.8900	65.1768	27.9503	5.2868	0.1060
70.8100	59.3708	130.8553	-11.4392	0.1881

SUM	401.8369	-15.7030	0.7074
RMSD	10.0229		
MD		-3.9258	
NAME			0.1768

c

=====

c

c Program to read extool 3D LBT temperatures calculated by NUFT, and
 c temperatures measured in the block, interpolate NUFT temperatures to field

```

c  sensor locations, and calculate goodness-of-fit statistics to compare the
c  two temperature fields. The goodness-of-fit statistics calculated are:
c      1) Root Mean Square Error (RMSE)
c      2) Mean Difference (ME), and
c      3) Normalized Absolute Mean Error (NAME).
c
c  The calculations are repeated for six output times: 30, 100, 200, 300,
c  365.25,
c  and 400 days.
c
c  Application of this routine is limited to the LBT quarter symmetry model
c  used
c  the Thermal Test AMR (Ref.)
c
c  Three cases addressed:
c      1. all sensors
c      2. sensors with T < 97 C
c      3. sensors with T >= 97 C
c
c
c  Written by:      Kenrick H. Lee
c                  December 1999
c
c
c
c
=====

c  declare variables

      real dx(100),dy(100),dz(100),x(100),y(100),z(100),tmpn(50000),
*      xf(1000),yf(1000),zf(1000),tmpf(1000),xn(50000),yn(50000),
*      zn(50000),tint(1000),timd(10),name

      double precision tim
      character lin*80,xfil(10)*15
      parameter(nx=25,ny=21,nz=58,ntim=6,
*             xmin=.03,xmax=1.47,ymin=.03,ymax=1.47,
*             zmin=.02,zmax=6.0,

c  Three cases addressed:
c      1. all sensors
c      2. sensors with T < 97 C
c      3. sensors with T >= 97 C

c  User must "uncomment out" the case being addressed

      *      tmin=10,tmax=400,
ctmp      *      tmin=10,tmax=97,
ctmp      *      tmin=97,tmax=400,

      *      ttol=1000.0,
      *      dmax=1.3,pow=3.0)

      data(timd(i), i=1,6) /30,100,200,300,365.25,400/

```

```

c      read NUFT extool output (select appropriate nuft extool file)

ctmp      open(8,file='/data28/lbt_AMR_T_00/lbt_AMR_T_00.ext')
ctmp      open(8,file='/data28/lbt_AMR_ms-01/lbt_AMR_ms-01_rest.m.ext')
ctmp      open(8,file='/data28/lbt_AMR_ms-01/ms01.ext')
ctmp      open(8,file='/data28/lbt_AMR_ds-00/lbt_AMR_ds-00.m.ext')
ctmp      open(8,file='/data28/lbt_AMR_ms-02/lbt_AMR_ms-02.m.ext')
ctmp      open(8,file='/data28/lbt_AMR_ms-02/ms02.ext')
ctmp      open(8,file='/data28/lbt_AMR_ms-00/lbt_AMR_ms-00.m.ext')

      open(9,file='rmsout')
      open(10,file='tmpcmp')

c      identify files with field temperatures at 30, 100, 200, 300, 365.25,
and 400 days

      xfil(1)='lbt_T_3_30_97'
      xfil(2)='lbt_T_6_8_97'
      xfil(3)='lbt_T_9_15_97'
      xfil(4)='lbt_T_12_24_97'
      xfil(5)='lbt_T_2_28_98'
      xfil(6)='lbt_T_4_4_98'

c      read field grid info from extool file
11      read(8,'(80a)') lin
      if(lin(1:3) .ne. '$dx') go to 11

      do 20 i=1,nx
20          read(8,*) dx(i)
      read(8,'(80a)') lin
      do 30 i=1,ny
30          read(8,*) dy(i)
      read(8,'(80a)') lin
      do 40 i=1,nz
40          read(8,*) dz(i)

c      compute coordinates of nodes
      x(1) = dx(1)/2.0
      y(1) = dy(1)/2.0
      z(1) = dz(1)/2.0
      sum = dx(1)
      do 60 i=2,nx
          x(i) = sum + dx(i)/2.0
          sum = sum + dx(i)
60      continue
      sum = dy(1)
      do 70 i=2,ny
          y(i) = sum + dy(i)/2.0
          sum = sum + dy(i)
70      continue
      sum = dz(1)
      do 80 i=2,nz
          z(i) = sum + dz(i)/2.0
          sum = sum + dz(i)
80      continue

```

```

c      loop thru output times

      do 700 ii=1,ntim

      timn = timd(ii)*86400.0

99      read(8,'(80a)',end=690) lin

      if(lin(1:10) .ne. '          2') go to 99

      backspace 8
      backspace 8
      read(8,*) tim
      low = timn - ttol
      high = timn + ttol
      read(8,*) nvar
      read(8,*) nnode

      if(tim .lt. low .or. tim .gt. high) go to 99

      nc = 0

c      read nuft temperature field at specified time
      do 200 k=1,nz
        do 160 i=1,nx
          do 140 j=1,ny
            if(.not.((i .ge. 18 .and. k .le. 38) .or.
*              (i .le. 17 .and. j .ge. 14 .and.
*              k .le. 38))) then
              nc = nc + 1
              read(8,*) tmpn(nc)

              xn(nc) = x(i)
              yn(nc) = y(j)
              zn(nc) = z(k)

              end if

140          continue
160        continue
200      continue

c      get field temperatures with corresponding coordinates and
c      convert to nuft coordinate system
      call fieldtmp(xf,yf,zf,tmpf,nf,xfil(ii))

c      call subroutine interp to calculate nuft T at field points
c      loop thru field coords and find nuft T at each point

      do 300 i=1,nf
        call interp(xf(i),yf(i),zf(i),xn,yn,zn,tmpn,nnode,dmax,pow,tmp)
        tint(i) = tmp

c      compare nuft and measured temperature fields
      write(10,600) xf(i),yf(i),zf(i),tmpf(i),tint(i)

300      continue

```

```

c      call subroutine rm to compute RMSD and MD and NAME for field and
c      nuft temperatures

```

```

      call rm(tmpf,tint,nf,tmin,tmax,rmsd,dmean,name)

```

```

c      write results to screen
      write(6,*) ' '
      write(6,*) 'Time is ',timd(ii),' days'
      write(6,*) 'RMSD is ',rmsd
      write(6,*) 'MD is ',dmean
      write(6,*) 'NAME is ',name
      write(6,*) ' '
      write(9,580) timd(ii), rmsd, dmean, name

```

```

690  continue

```

```

700  continue

```

```

500  format(t1,f9.3,2x,f9.3,2x,f9.3,2x,f9.3)

```

```

580  format(t1,'Time in days: ',f9.2,/,

```

```

      *      t1,'RMSD:          ',f10.3,/,

```

```

      *      t1,'MD:           ',f10.3,/,

```

```

      *      t1,'NAME:         ',f10.3)

```

```

600  format(t1,f8.3,2x,f8.3,2x,f8.3,2x,f8.3,f8.3)

```

```

999  stop

```

```

      end

```

```

=====
=====

```

```

c      Subroutine to compute the RMSE, ME, and NAME from model and measured
c      temperature fields

```

```

=====

```

```

      subroutine rm(dat1,dat2,npts,tmin,tmax,rmsd,dmean,norm)

```

```

      real dat1(1000),dat2(1000),norm,nsum

```

```

      parameter(tol=5.0,Tamb=10.0)

```

```

c      dat1 is standard (or field data)

```

```

      sqdif = 0.0

```

```

      dif = 0.0

```

```

      nsum = 0.0

```

```

      nnam = 0

```

```

      tlow = Tamb + tol

```

```

c      loop to sum difference and squared difference

```

```

c      omit field temps less than tmin and greater than tmax

```

```

      ncnt = 0

```

```

      do 100 i=1,npts

```

```

        if(dat1(i) .gt. tmin .and. dat1(i) .lt. tmax)then

```

```

          ncnt = ncnt + 1

```

```

          sqdif = sqdif + (dat2(i) - dat1(i))**2

```

```

          dif = dif + (dat2(i) - dat1(i))

```

```

          if(dat1(i) .ge. tlow .and. dat1(i) .lt. tmax)then

```

```

            nnam = nnam + 1

```

```

            nsum = nsum + abs((dat2(i) - dat1(i))/(dat1(i)-Tamb))
        end if
    end if
100  continue

    smean = sqdif/float(ncnt)
    dmean = dif/float(ncnt)
    rmsd = sqrt(smean)
    norm = nsum/float(nnam)
    return
end

=====
c
c      subroutine to read field temperatures and convert LBT coordinates
c      to nuft coordinates
c=====

    subroutine fieldtmp(xf,yf,zf,tmp,nc,xfil)
    parameter(con=3.2808,xmin=.03,xmax=1.47,ymin=.03,ymax=1.47,
*           zmin=.02,zmax=6.0)
    character xfil*15
    real xf(1000),yf(1000),zf(1000),tmp(1000)
    open(7,file=xfil)

    sumt = 0
    nc = 0
    do 200 i=1,1000
    read(7,*,end=999) x,y,z,t
    x = x/con
    y = y/con
    z = -1.0*z/con
    temp = x
    x = abs(1.5 - y)
    y = abs(1.5 - temp)
    if(x .gt. xmin .and. y .gt. ymin .and. z .gt. zmin
* .and. t .gt. 0 .and. x .lt. xmax .and. y .lt. ymax
* .and. z .lt. zmax )then
        sumt = sumt + t
        nc = nc + 1
        xf(nc) = x
        yf(nc) = y
        zf(nc) = z
        tmp(nc) = t
    end if
200  continue

300  format(t1,3f10.3,2x,f10.3)

cken 999  write(6,*) 'No. of points = ',nc
999  continue
cken      write(6,*) 'Average field temp = ',sumt/float(nc)
        return
        end

=====

```

```

c=====
c      Subroutine to estimate nuft model temperatures at field sensor
c      locations by interpolation using the inverse distance cubed
c      weighting method
c=====

```

```

      subroutine interp(xf,yf,zf,xn,yn,zn,tn,nnode,dmax,pow,tmp)
      real xn(1000),yn(1000),zn(1000),tn(1000)
      suminv = 0
      sumtop = 0

c      interpolate for closer values only
      do 100 i=1,nnode
          d = sqrt((xn(i) - xf)**2 + (yn(i) - yf)**2 +
*              (zn(i) - zf)**2)
          if(d .le. dmax) then
              sumtop = sumtop + tn(i)/d**pow
              suminv = suminv + 1.0/d**pow
          end if
100    continue
      tmp = sumtop/suminv

      return
      end

```

```

c=====

```

4	6	-8.42	87.35
8.00	4.00	-14.52	33.14
4.41	5.50	-5.50	59.89
8.34	5.50	-10.00	70.81

NUFT Version 3.0.1s (SUN/SOLARIS).

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Operating System: SunOS s116.es.llnl.gov 5.5.1 Generic_103640-17 sun4u sparc SUNW,Ultra-2

C Compiler: CC: WorkShop Compilers 4.2 18 Sep 1997 C++ 4.2 patch 104631-04

Fortran Compiler: f77: WorkShop Compilers 4.2 04 Mar 1997 FORTRAN 77 4.2 patch 104529-01

Run Date: Wed Mar 22 13:52:31 2000

test3 LBT, imp-DKM,3D, Active Fractures, DS data, Sl_init 0.75

```

$gdef-continua
$continuum m
$type rect
$nx 5
$ny 5
$nz 7
$order yxz
$dx
3.0000e-01
3.0000e-01
3.0000e-01
3.0000e-01

```

3.0000e-01 \$dy
2.0000e-01 \$dz
4.0000e-01
3.0000e-01
4.0000e-01
2.0000e-01
6.0000e-01
5.0000e-01
7.0000e-01
8.0000e-01
1.0000e+00
\$continuum f
\$type rect
\$nx 5
\$ny 5
\$nz 7
\$order yxz
\$dx
3.0000e-01
3.0000e-01
3.0000e-01
3.0000e-01
3.0000e-01
3.0000e-01
\$dy
2.0000e-01
4.0000e-01
3.0000e-01
2.0000e-01
\$dz
6.0000e-01
5.0000e-01
7.0000e-01
8.0000e-01
1.0000e+00
1.0000e+00
\$end
\$time
0.000000e+00
\$variable
T
\$type
xyz
\$data
175

1.5000e-01 1.0000e-01 3.0000e-01 2.4000e+01
1.5000e-01 4.0000e-01 3.0000e-01 2.4000e+01
1.5000e-01 7.5000e-01 3.0000e-01 2.4000e+01
1.5000e-01 1.1000e+00 3.0000e-01 2.4000e+01
1.5000e-01 1.4000e+00 3.0000e-01 2.4000e+01
4.5000e-01 1.0000e-01 3.0000e-01 2.4000e+01
4.5000e-01 4.0000e-01 3.0000e-01 2.4000e+01
4.5000e-01 4.0000e-01 3.0000e-01 2.4000e+01

April 2000

April 2000

1.35000e+00	4.00000e-01	3.00000e+00	2.4000e+01
1.35000e+00	7.50000e-01	3.00000e+00	2.4000e+01
1.35000e+00	1.10000e+00	3.00000e+00	2.4000e+01
1.35000e+00	1.40000e+00	3.00000e+00	2.4000e+01
1.50000e-01	1.00000e-01	3.90000e+00	2.4000e+01
1.50000e-01	4.00000e-01	3.90000e+00	2.4000e+01
1.50000e-01	7.50000e-01	3.90000e+00	2.4000e+01
1.50000e-01	1.10000e+00	3.90000e+00	2.4000e+01
1.50000e-01	1.40000e+00	3.90000e+00	2.4000e+01
4.50000e-01	1.00000e-01	3.90000e+00	2.4000e+01
4.50000e-01	4.00000e-01	3.90000e+00	2.4000e+01
4.50000e-01	7.50000e-01	3.90000e+00	2.4000e+01
4.50000e-01	1.10000e+00	3.90000e+00	2.4000e+01
4.50000e-01	1.40000e+00	3.90000e+00	2.4000e+01
7.50000e-01	1.00000e-01	3.90000e+00	2.4000e+01
7.50000e-01	4.00000e-01	3.90000e+00	2.4000e+01
7.50000e-01	7.50000e-01	3.90000e+00	2.4000e+01
7.50000e-01	1.10000e+00	3.90000e+00	2.4000e+01
7.50000e-01	1.40000e+00	3.90000e+00	2.4000e+01
1.05000e+00	1.00000e-01	3.90000e+00	2.4000e+01
1.05000e+00	4.00000e-01	3.90000e+00	2.4000e+01
1.05000e+00	7.50000e-01	3.90000e+00	2.4000e+01
1.05000e+00	1.10000e+00	3.90000e+00	2.4000e+01
1.05000e+00	1.40000e+00	3.90000e+00	2.4000e+01
1.35000e+00	1.00000e-01	3.90000e+00	2.4000e+01
1.35000e+00	4.00000e-01	3.90000e+00	2.4000e+01
1.35000e+00	7.50000e-01	3.90000e+00	2.4000e+01
1.35000e+00	1.10000e+00	3.90000e+00	2.4000e+01
1.35000e+00	1.40000e+00	3.90000e+00	2.4000e+01
1.50000e-01	1.00000e-01	4.90000e+00	2.4000e+01
1.50000e-01	4.00000e-01	4.90000e+00	2.4000e+01
1.50000e-01	7.50000e-01	4.90000e+00	2.4000e+01
1.50000e-01	1.10000e+00	4.90000e+00	2.4000e+01
1.50000e-01	1.40000e+00	4.90000e+00	2.4000e+01
4.50000e-01	1.00000e-01	4.90000e+00	2.4000e+01
4.50000e-01	4.00000e-01	4.90000e+00	2.4000e+01
4.50000e-01	7.50000e-01	4.90000e+00	2.4000e+01
4.50000e-01	1.10000e+00	4.90000e+00	2.4000e+01
4.50000e-01	1.40000e+00	4.90000e+00	2.4000e+01
7.50000e-01	1.00000e-01	4.90000e+00	2.4000e+01
7.50000e-01	4.00000e-01	4.90000e+00	2.4000e+01
7.50000e-01	7.50000e-01	4.90000e+00	2.4000e+01
7.50000e-01	1.10000e+00	4.90000e+00	2.4000e+01
7.50000e-01	1.40000e+00	4.90000e+00	2.4000e+01
1.05000e+00	1.00000e-01	4.90000e+00	2.4000e+01
1.05000e+00	4.00000e-01	4.90000e+00	2.4000e+01
1.05000e+00	7.50000e-01	4.90000e+00	2.4000e+01
1.05000e+00	1.10000e+00	4.90000e+00	2.4000e+01
1.05000e+00	1.40000e+00	4.90000e+00	2.4000e+01
1.35000e+00	1.00000e-01	4.90000e+00	2.4000e+01
1.35000e+00	4.00000e-01	4.90000e+00	2.4000e+01
1.35000e+00	7.50000e-01	4.90000e+00	2.4000e+01
1.35000e+00	1.10000e+00	4.90000e+00	2.4000e+01
1.35000e+00	1.40000e+00	4.90000e+00	2.4000e+01

\$end
 \$time
 2.592000e+06

\$variable

T

\$type

xyz

\$data

175

1.50000e-01	1.00000e-01	3.00000e-01	4.8362e+01
1.50000e-01	4.00000e-01	3.00000e-01	4.8377e+01
1.50000e-01	7.50000e-01	3.00000e-01	4.8396e+01
1.50000e-01	1.10000e+00	3.00000e-01	4.8377e+01
1.50000e-01	1.40000e+00	3.00000e-01	4.8362e+01
4.50000e-01	1.00000e-01	3.00000e-01	4.8388e+01
4.50000e-01	4.00000e-01	3.00000e-01	4.8407e+01
4.50000e-01	7.50000e-01	3.00000e-01	4.8432e+01
4.50000e-01	1.10000e+00	3.00000e-01	4.8407e+01
4.50000e-01	1.40000e+00	3.00000e-01	4.8389e+01
7.50000e-01	1.00000e-01	3.00000e-01	4.8406e+01
7.50000e-01	4.00000e-01	3.00000e-01	4.8429e+01
7.50000e-01	7.50000e-01	3.00000e-01	4.8461e+01
7.50000e-01	1.10000e+00	3.00000e-01	4.8429e+01
7.50000e-01	1.40000e+00	3.00000e-01	4.8406e+01
1.05000e+00	1.00000e-01	3.00000e-01	4.8388e+01
1.05000e+00	4.00000e-01	3.00000e-01	4.8407e+01
1.05000e+00	7.50000e-01	3.00000e-01	4.8432e+01
1.05000e+00	1.10000e+00	3.00000e-01	4.8407e+01
1.05000e+00	1.40000e+00	3.00000e-01	4.8389e+01
1.35000e+00	1.00000e-01	3.00000e-01	4.8362e+01
1.35000e+00	4.00000e-01	3.00000e-01	4.8377e+01
1.35000e+00	7.50000e-01	3.00000e-01	4.8396e+01
1.35000e+00	1.10000e+00	3.00000e-01	4.8377e+01
1.35000e+00	1.40000e+00	3.00000e-01	4.8362e+01
1.50000e-01	1.00000e-01	8.50000e-01	5.3162e+01
1.50000e-01	4.00000e-01	8.50000e-01	5.3242e+01
1.50000e-01	7.50000e-01	8.50000e-01	5.3353e+01
1.50000e-01	1.10000e+00	8.50000e-01	5.3242e+01
1.50000e-01	1.40000e+00	8.50000e-01	5.3162e+01
4.50000e-01	1.00000e-01	8.50000e-01	5.3293e+01
4.50000e-01	4.00000e-01	8.50000e-01	5.3408e+01
4.50000e-01	7.50000e-01	8.50000e-01	5.3596e+01
4.50000e-01	1.10000e+00	8.50000e-01	5.3408e+01
4.50000e-01	1.40000e+00	8.50000e-01	5.3293e+01
7.50000e-01	1.00000e-01	8.50000e-01	5.3390e+01
7.50000e-01	4.00000e-01	8.50000e-01	5.3547e+01
7.50000e-01	7.50000e-01	8.50000e-01	5.3853e+01
7.50000e-01	1.10000e+00	8.50000e-01	5.3547e+01
7.50000e-01	1.40000e+00	8.50000e-01	5.3391e+01
1.05000e+00	1.00000e-01	8.50000e-01	5.3293e+01
1.05000e+00	4.00000e-01	8.50000e-01	5.3408e+01
1.05000e+00	7.50000e-01	8.50000e-01	5.3596e+01
1.05000e+00	1.10000e+00	8.50000e-01	5.3408e+01
1.05000e+00	1.40000e+00	8.50000e-01	5.3293e+01
1.35000e+00	1.00000e-01	8.50000e-01	5.3162e+01
1.35000e+00	4.00000e-01	8.50000e-01	5.3242e+01
1.35000e+00	7.50000e-01	8.50000e-01	5.3353e+01
1.35000e+00	1.10000e+00	8.50000e-01	5.3242e+01
1.35000e+00	1.40000e+00	8.50000e-01	5.3162e+01
1.50000e-01	1.00000e-01	1.45000e+00	6.2200e+01

1.50000e-01	4.00000e-01	1.45000e+00	6.2588e+01
1.50000e-01	7.50000e-01	1.45000e+00	6.3222e+01
1.50000e-01	1.10000e+00	1.45000e+00	6.2588e+01
1.50000e-01	1.40000e+00	1.45000e+00	6.2200e+01
4.50000e-01	1.00000e-01	1.45000e+00	6.2808e+01
4.50000e-01	4.00000e-01	1.45000e+00	6.3480e+01
4.50000e-01	7.50000e-01	1.45000e+00	6.4890e+01
4.50000e-01	1.10000e+00	1.45000e+00	6.3480e+01
4.50000e-01	1.40000e+00	1.45000e+00	6.2808e+01
7.50000e-01	1.00000e-01	1.45000e+00	6.3332e+01
7.50000e-01	4.00000e-01	1.45000e+00	6.4423e+01
7.50000e-01	7.50000e-01	1.45000e+00	6.7853e+01
7.50000e-01	1.10000e+00	1.45000e+00	6.4423e+01
7.50000e-01	1.40000e+00	1.45000e+00	6.3332e+01
1.05000e+00	1.00000e-01	1.45000e+00	6.2808e+01
1.05000e+00	4.00000e-01	1.45000e+00	6.3480e+01
1.05000e+00	7.50000e-01	1.45000e+00	6.4890e+01
1.05000e+00	1.10000e+00	1.45000e+00	6.3480e+01
1.05000e+00	1.40000e+00	1.45000e+00	6.2808e+01
1.35000e+00	1.00000e-01	1.45000e+00	6.2200e+01
1.35000e+00	4.00000e-01	1.45000e+00	6.2588e+01
1.35000e+00	7.50000e-01	1.45000e+00	6.3222e+01
1.35000e+00	1.10000e+00	1.45000e+00	6.2588e+01
1.35000e+00	1.40000e+00	1.45000e+00	6.2200e+01
1.50000e-01	1.00000e-01	2.20000e+00	7.4972e+01
1.50000e-01	4.00000e-01	2.20000e+00	7.6836e+01
1.50000e-01	7.50000e-01	2.20000e+00	8.0602e+01
1.50000e-01	1.10000e+00	2.20000e+00	7.6836e+01
1.50000e-01	1.40000e+00	2.20000e+00	7.4971e+01
4.50000e-01	1.00000e-01	2.20000e+00	7.7789e+01
4.50000e-01	4.00000e-01	2.20000e+00	8.1863e+01
4.50000e-01	7.50000e-01	2.20000e+00	9.4065e+01
4.50000e-01	1.10000e+00	2.20000e+00	8.1863e+01
4.50000e-01	1.40000e+00	2.20000e+00	7.7789e+01
7.50000e-01	1.00000e-01	2.20000e+00	8.0761e+01
7.50000e-01	4.00000e-01	2.20000e+00	8.9401e+01
7.50000e-01	7.50000e-01	2.20000e+00	1.2011e+02
7.50000e-01	1.10000e+00	2.20000e+00	8.9401e+01
7.50000e-01	1.40000e+00	2.20000e+00	8.0761e+01
1.05000e+00	1.00000e-01	2.20000e+00	7.7789e+01
1.05000e+00	4.00000e-01	2.20000e+00	8.1863e+01
1.05000e+00	7.50000e-01	2.20000e+00	9.4065e+01
1.05000e+00	1.10000e+00	2.20000e+00	8.1863e+01
1.05000e+00	1.40000e+00	2.20000e+00	7.7789e+01
1.35000e+00	1.00000e-01	2.20000e+00	7.4971e+01
1.35000e+00	4.00000e-01	2.20000e+00	7.6836e+01
1.35000e+00	7.50000e-01	2.20000e+00	8.0602e+01
1.35000e+00	1.10000e+00	2.20000e+00	7.6836e+01
1.35000e+00	1.40000e+00	2.20000e+00	7.4972e+01
1.50000e-01	1.00000e-01	3.00000e+00	5.8957e+01
1.50000e-01	4.00000e-01	3.00000e+00	5.9298e+01
1.50000e-01	7.50000e-01	3.00000e+00	5.9845e+01
1.50000e-01	1.10000e+00	3.00000e+00	5.9298e+01
1.50000e-01	1.40000e+00	3.00000e+00	5.8957e+01
4.50000e-01	1.00000e-01	3.00000e+00	5.9493e+01
4.50000e-01	4.00000e-01	3.00000e+00	6.0072e+01
4.50000e-01	7.50000e-01	3.00000e+00	6.1272e+01

4.50000e-01	1.10000e+00	3.00000e+00	6.0072e+01
4.50000e-01	1.40000e+00	3.00000e+00	5.9493e+01
7.50000e-01	1.00000e-01	3.00000e+00	5.9946e+01
7.50000e-01	4.00000e-01	3.00000e+00	6.0878e+01
7.50000e-01	7.50000e-01	3.00000e+00	6.3729e+01
7.50000e-01	1.10000e+00	3.00000e+00	6.0878e+01
7.50000e-01	1.40000e+00	3.00000e+00	5.9946e+01
1.05000e+00	1.00000e-01	3.00000e+00	5.9493e+01
1.05000e+00	4.00000e-01	3.00000e+00	6.0072e+01
1.05000e+00	7.50000e-01	3.00000e+00	6.1272e+01
1.05000e+00	1.10000e+00	3.00000e+00	6.0072e+01
1.05000e+00	1.40000e+00	3.00000e+00	5.9493e+01
1.35000e+00	1.00000e-01	3.00000e+00	5.8957e+01
1.35000e+00	4.00000e-01	3.00000e+00	5.9297e+01
1.35000e+00	7.50000e-01	3.00000e+00	5.9845e+01
1.35000e+00	1.10000e+00	3.00000e+00	5.9298e+01
1.35000e+00	1.40000e+00	3.00000e+00	5.8957e+01
1.50000e-01	1.00000e-01	3.90000e+00	4.2755e+01
1.50000e-01	4.00000e-01	3.90000e+00	4.2784e+01
1.50000e-01	7.50000e-01	3.90000e+00	4.2824e+01
1.50000e-01	1.10000e+00	3.90000e+00	4.2784e+01
1.50000e-01	1.40000e+00	3.90000e+00	4.2755e+01
4.50000e-01	1.00000e-01	3.90000e+00	4.2804e+01
4.50000e-01	4.00000e-01	3.90000e+00	4.2845e+01
4.50000e-01	7.50000e-01	3.90000e+00	4.2909e+01
4.50000e-01	1.10000e+00	3.90000e+00	4.2845e+01
4.50000e-01	1.40000e+00	3.90000e+00	4.2804e+01
7.50000e-01	1.00000e-01	3.90000e+00	4.2840e+01
7.50000e-01	4.00000e-01	3.90000e+00	4.2894e+01
7.50000e-01	7.50000e-01	3.90000e+00	4.2993e+01
7.50000e-01	1.10000e+00	3.90000e+00	4.2894e+01
7.50000e-01	1.40000e+00	3.90000e+00	4.2840e+01
1.05000e+00	1.00000e-01	3.90000e+00	4.2804e+01
1.05000e+00	4.00000e-01	3.90000e+00	4.2845e+01
1.05000e+00	7.50000e-01	3.90000e+00	4.2909e+01
1.05000e+00	1.10000e+00	3.90000e+00	4.2845e+01
1.05000e+00	1.40000e+00	3.90000e+00	4.2804e+01
1.35000e+00	1.00000e-01	3.90000e+00	4.2755e+01
1.35000e+00	4.00000e-01	3.90000e+00	4.2784e+01
1.35000e+00	7.50000e-01	3.90000e+00	4.2824e+01
1.35000e+00	1.10000e+00	3.90000e+00	4.2784e+01
1.35000e+00	1.40000e+00	3.90000e+00	4.2755e+01
1.50000e-01	1.00000e-01	4.90000e+00	3.4618e+01
1.50000e-01	4.00000e-01	4.90000e+00	3.4620e+01
1.50000e-01	7.50000e-01	4.90000e+00	3.4622e+01
1.50000e-01	1.10000e+00	4.90000e+00	3.4620e+01
1.50000e-01	1.40000e+00	4.90000e+00	3.4618e+01
4.50000e-01	1.00000e-01	4.90000e+00	3.4621e+01
4.50000e-01	4.00000e-01	4.90000e+00	3.4624e+01
4.50000e-01	7.50000e-01	4.90000e+00	3.4627e+01
4.50000e-01	1.10000e+00	4.90000e+00	3.4624e+01
4.50000e-01	1.40000e+00	4.90000e+00	3.4621e+01
7.50000e-01	1.00000e-01	4.90000e+00	3.4624e+01
7.50000e-01	4.00000e-01	4.90000e+00	3.4626e+01
7.50000e-01	7.50000e-01	4.90000e+00	3.4630e+01
7.50000e-01	1.10000e+00	4.90000e+00	3.4626e+01
7.50000e-01	1.40000e+00	4.90000e+00	3.4624e+01

1.05000e+00	1.00000e-01	4.90000e+00	3.4621e+01
1.05000e+00	4.00000e-01	4.90000e+00	3.4624e+01
1.05000e+00	7.50000e-01	4.90000e+00	3.4627e+01
1.05000e+00	1.10000e+00	4.90000e+00	3.4624e+01
1.05000e+00	1.40000e+00	4.90000e+00	3.4621e+01
1.35000e+00	1.00000e-01	4.90000e+00	3.4618e+01
1.35000e+00	4.00000e-01	4.90000e+00	3.4620e+01
1.35000e+00	7.50000e-01	4.90000e+00	3.4622e+01
1.35000e+00	1.10000e+00	4.90000e+00	3.4619e+01
1.35000e+00	1.40000e+00	4.90000e+00	3.4617e+01

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