

## FEATURES OF A SINDA/FLUINT MODEL OF A LIQUID OXYGEN SUPPLY LINE

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**TOPICS**

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1. OBJECTIVES
2. WHICH SINDA
3. LIQUID OXYGEN (LOX) SUPPLY LINE
4. FEATURES
5. PROGRAM LISTING

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**1. OBJECTIVES**

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This paper describes the modeling features used in a steady-state heat transfer problem using SINDA/FLUINT. The problem modeled is a 125 feet long, 3 inch diameter pipe, filled with liquid Oxygen flow driven by a given pressure gradient. The pipe is fully insulated in five sections. Three sections of 1 inch thick spray-on foam and two sections of vacuum jacket.

The model evaluates friction, turns losses and convection heat transfer between the fluid and the pipe wall. There is conduction through the foam insulation with temperature dependent thermal conductivity. The vacuum space is model with radiation and gas molecular conduction, if present, in the annular gap. Heat is transferred between the outer surface and surrounding ambient by natural convection and radiation; and, by axial conduction along the pipe and through the vacuum jacket spacers and welded seal flanges.

The model makes extensive use of SINDA/FLUINT basic capabilities such as the GEN option for nodes and conductors (to generate groups of nodes or conductors), the SiV option (to generate single, temperature varying conductors), the SIM option (for multiple, temperature varying conductors) and the M HX macros for fluids (to generate strings of lumps, paths and ties representing a diabatic duct). It calls subroutine CONTRN (returns the relative location in the G-array of a network conductor, given an actual conductor number) enabling an extensive manipulation of conductor (calculation an assignment of their values) with DO loops.

Models like this illustrate to the new and even to the old SINDA/FLUINT user, features of the program that are not so obvious or known, and that are extremely handy when trying to take advantage of both, the automation of the DATA headers and make surgical modifications to specific parameters of the thermal or fluid elements in the OPERATIONS portion of the model.

# 1. OBJECTIVES (CONT)

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1. SHARE SINDA/FLUINT EXPERIENCES WITH OTHER CODE USERS AT TFAWS
2. APPLY TO PRACTICAL PROBLEMS IN THE ENGINEERING FIELD
3. ESTABLISH AN INDUSTRY SOURCE OF TRICKS AND SHORT CUTS FOR USERS OF SINDA/FLUINT
4. ADDRESS SPECIALIZED TECHNIQUES NOT COVERED OR NOT SO OBVIOUS IN THE MANUAL
5. PROVIDE FEEDBACK TO CODE DEVELOPER FOR FUTURE IMPROVEMENTS

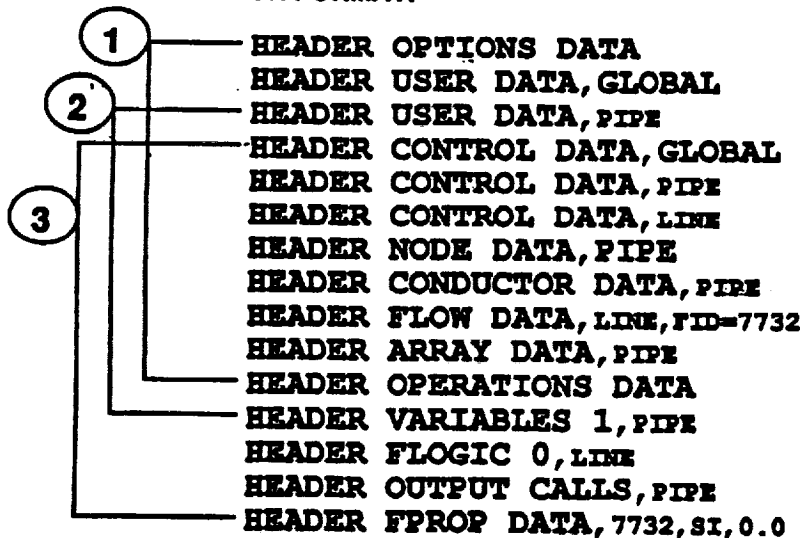
# 2. WHICH SINDA

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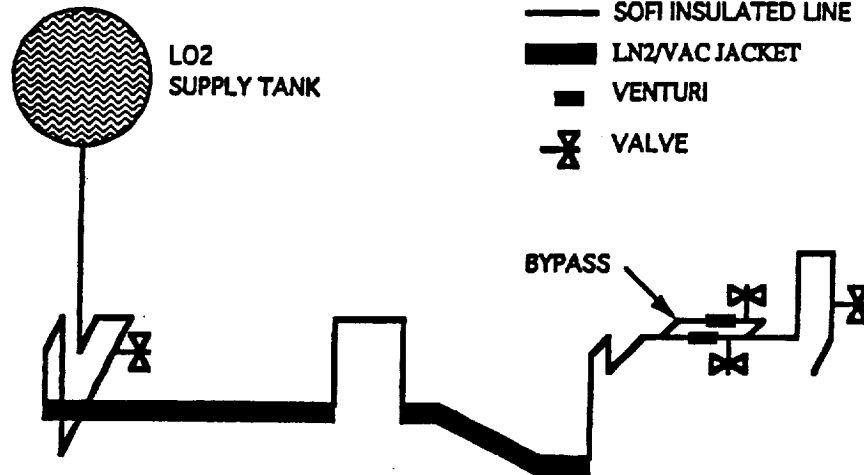
## 1. SINDA/FLUINT VERSION 2.5

SYSTEMS IMPROVED NUMERICAL DIFFERENCING ANALYZER  
AND FLUID INTEGRATOR, VERSION 2.5 DEVELOPED BY MARTIN MARIETTA  
ASTRONAUTICS GROUP, DENVER, COLORADO UNDER CONTRACT NAS9-18411.

## 2. PRESENTATION FORMAT:



### 3. LOX SUPPLY LINE



#### LOX LINE HARDWARE

##### LINE

Type 304L CRES 3 SS circular pipe schedule 80  
 Length 225 ft  
 Bypass length 14 ft  
 Diameter (ID) 2.9"  
 Wall thickness 0.3"

##### COMPONENTS

90° elbows (qty 22)  
 45° elbows (qty 2)  
 Tees (qty 2)  
 Venturies (qty 2)

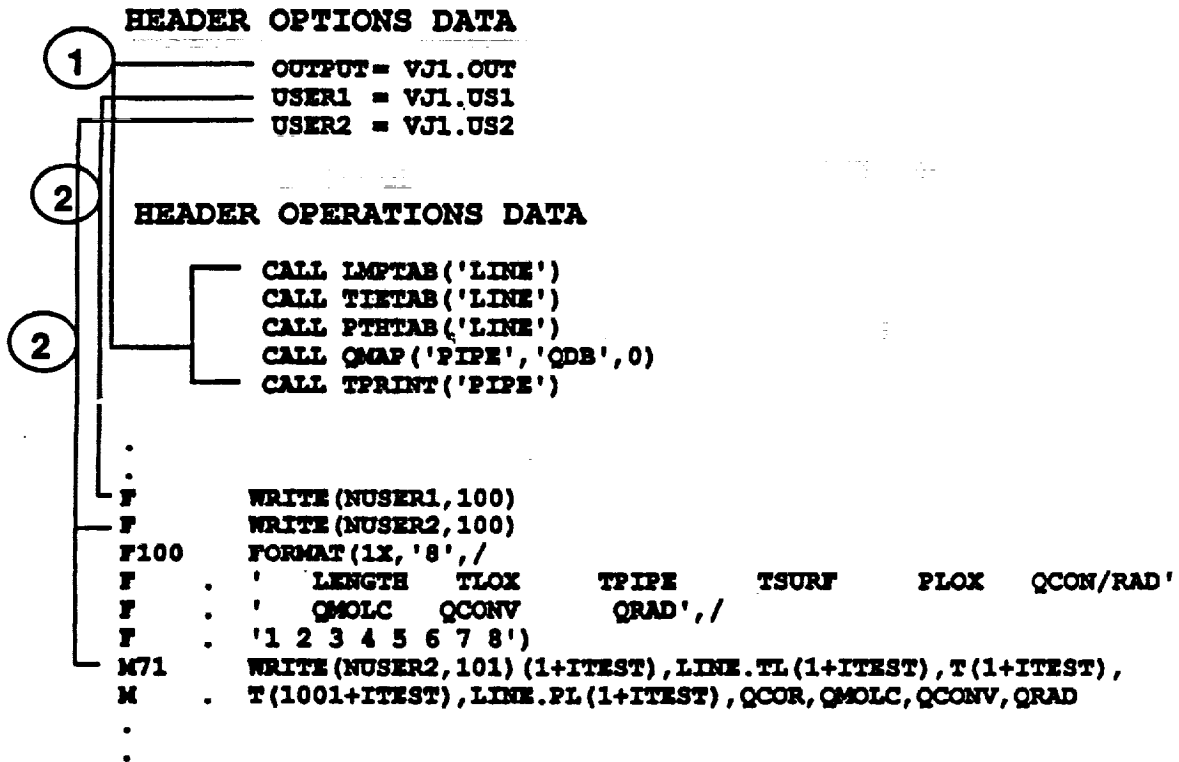
##### LN2/VACUUM JACKET

Length (long) 73 ft (from foot 42 to foot 114)  
 Length (short) 27 ft (from foot 138 to foot 164)  
 Diameter (OD) 6.625"  
 Wall thickness 0.143"  
 Annular gap 2.857"  
 End caps thickness 0.25"  
 11 sliding spacers (contact area=6.0"x0.50" and 6.0"x0.25", 1.43" tall)  
 4 45° (circular) spacers (contact area 2.1"x0.25", 1.05" tall)

##### FOAM INSULATION

Type BX-250 SOFI  
 Thickness 1"  
 Length 41 ft (from foot 1 to foot 41)  
     23 ft (from foot 115 to foot 137)  
     61 ft (from foot 165 to foot 225)  
     14 ft (bypass from foot 1 to foot 14)  
 Thermal Conductivity  $k=0.00259+0.031696(T^{\circ}R)$  Btu/Hr-ft-°F

## 4. FEATURES



### 1. OUTPUT

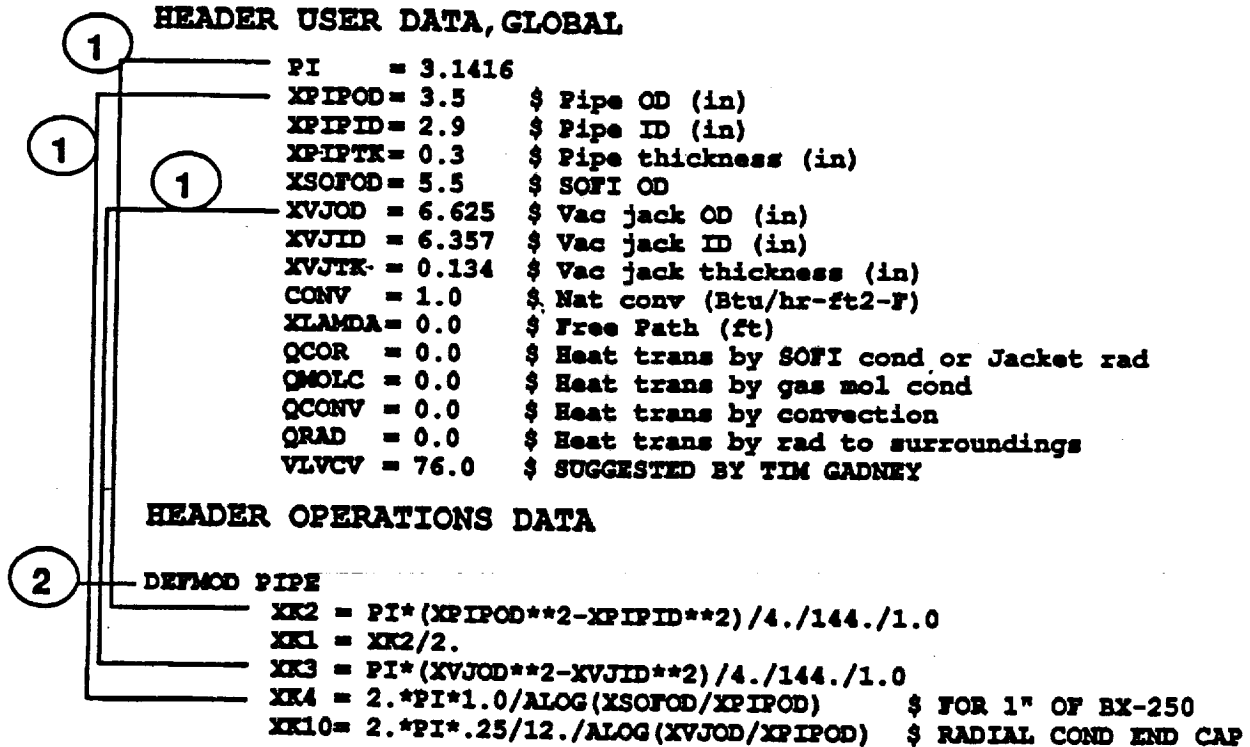
PROCESSOR PRINT FILE NAME. CAN BE ANY NAME. THIS IS WHERE THE OUTPUT FROM CALLS TO FLOMAP, TPRINT, PRPMAP, ETC. GOES TO AUTOMATICALLY.

### 2. USER1, USER2

USER AUXILIARY FILE NAMES. CAN BE ANY NAME. TO PRINT TO THEM USE THE WRITE (NUSER1, 100) TO PRINT FOR EXAMPLE TO USER1 FILE USING FORMAT 100.

WRITE (NUSER2, 100) TO PRINT FOR EXAMPLE TO USER2 FILE USING FORMAT 100.

## 4. FEATURES (CONT)



1. THIS IS A HANDY WAY TO DEFINE PI OR ANY OTHER NAME VARIABLE. WATCH FOR PROGRAM RESERVED VARIABLES NAMES SUCH AS G100 (CONDUCTOR 100). VARIABLES ATEST THROUGH ZTEST ARE AVAILABLE BY DEFAULT AND DO NOT HAVE TO BE EXPLICITLY SET.
2. AFTER ENTERING DEFMOD PIPE, YOU CAN ENTER G'S, T'S, ETC. IN THE HEADER OPERATIONS DATA BLOCK WITHOUT THE SUB-MODEL NAME IN FRONT OF IT.  
(EX: ENTER G101=10.0 INSTEAD OF PIPE.G101=10.0).

## 4. FEATURES (CONT)

### HEADER CONTROL DATA, GLOBAL

UID = ENG  
ABSZRO = -459.67  
PATMOS = 0.0  
SIGMA = 1.0  
NLOOPS = 500

### HEADER FPROP DATA, 7732, SI, 0.0

RGAS = 8314.34/31.9988  
TCRIT = 154.6 :  
PCRIT = 5.04E6  
ST = 0.0132  
TMIN = 70.0

### HEADER NODE DATA, PIPE

-1000, -297.0, 0.0  
-2000, -315.0, 0.0  
-3000, 70.0, 0.0

\$ CRYO TANK  
\$ LN2 JACKET  
\$ AMBIENT

#### 1. UID

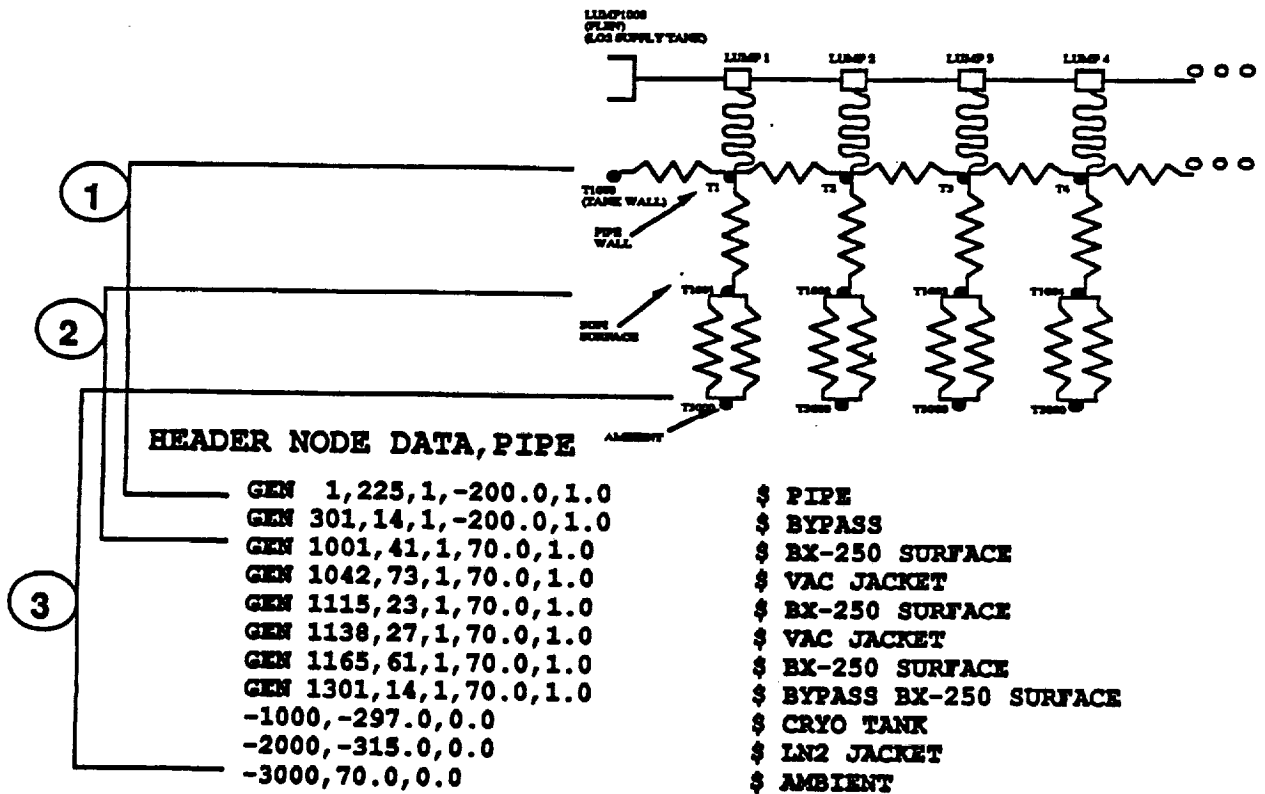
UNIT SYSTEM IDENTIFIER. NOTICE THAT THE LOX LINE PROBLEM IS IN ENG UNITS, WHILE THE FLUID PROPERTIES IN THE HEADER FPROP DATA ARE GIVEN IN SI UNITS.

#### 2. ABSZRO

VALUE OF ABSOLUTE ZERO IN USER'S TEMPERATURE UNITS

ABSZRO = -460.0 ALLOWS USE OF TEMPERATURE IN °F INSTEAD OF °R.

## 4. FEATURES (CONT)



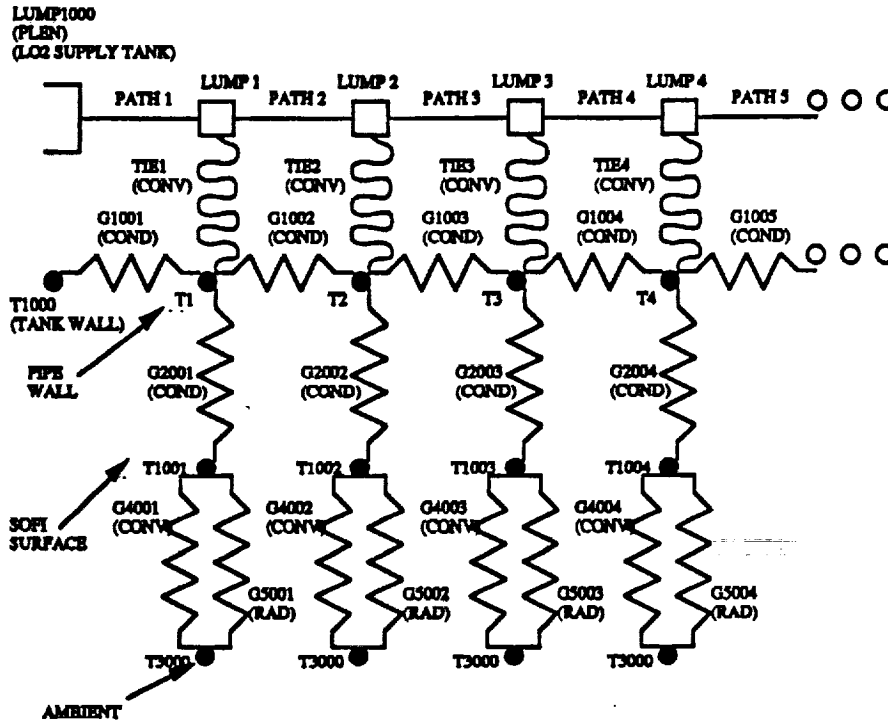
### 1. GEN

THIS SINGLE LINE GENERATES 225 DIFFUSION NODES, STARTING WITH NODE 1, IN INCREMENTS OF 1, INITIALLY AT -200°F, WITH A CAPACITANCE VALUE OF 1.0, TO REPRESENT THE LINE. THE CAPACITANCE VALUE IS IMMATERIAL SINCE THIS IS A STEADY STATE MODEL. NODES WILL BE NAMED 1, 2, 3, ETC.

2. THIS SINGLE LINE GENERATES 41 DIFFUSION NODES, STARTING WITH NODE 1001, IN INCREMENTS OF 1, INITIALLY AT 70°F, WITH A CAPACITANCE VALUE OF 1.0, TO REPRESENT THE SOFI SURFACE. NODES WILL BE NAMED 1001, 1002, 1003, ETC.

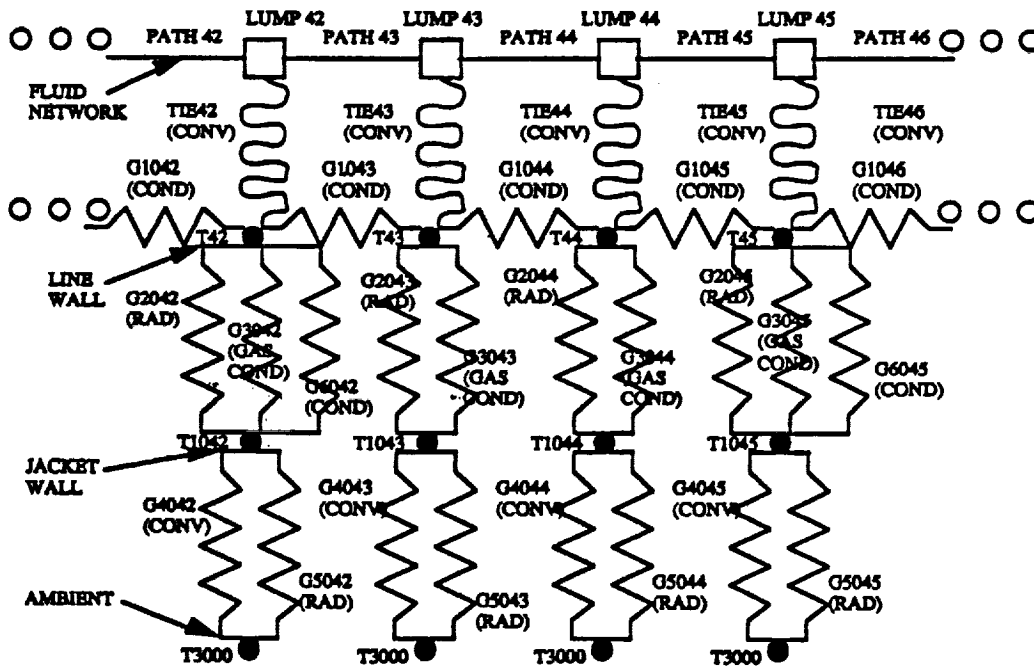
3. THIS SINGLE LINE GENERATES 1 BOUNDARY NODE 2000 (INDICATED BY THE NEGATIVE SIGN), AT 70°F, TO REPRESENT AMBIENT TEMPERATURE. THE VALUE OF CAPACITANCE IN A BOUNDARY NODE IS MEANINGLESS.

## 4. FEATURES (CONT)



Thermal network schematic of typical section of line with SOFI.

## 4. FEATURES (CONT)



Thermal network schematic of typical section of line with vacuum jacket



## 4. FEATURES (CONT)

```
1  HEADER CONDUCTOR DATA, PIPE
    GEN 3001,225,1, 1,1,1001,1,0.0 $ GAS MOLEC COND (SOME DUMMIES)

    HEADER VARIABLES 1, PIPE

    C-CHECK FOR GAS MOL COND
    F DO 10 ITEST=0,72
    M TTEST=(T(42+ITEST)+T(1042+ITEST))/2.+460.
      XK6=(1.4+1.)/(1.4-1.)*((32.2*1545.)/(8.*PI*28.*TTEST))**.5*1.
      XK8=PI*XPIPOD/12.*1.
    CALL CONTRN('PIPE',3042+ITEST,JTEST)
    M GLOBAL.G(JTEST)=XK6*XK7*XK8*3600./778.
      XLAMDA=3.*XK9/XK7*((PI*1545.*TTEST)/(8.*32.2*28.))**.5
    M10 IF(XLAMDA.LE.(XVJID-XPIPOD)/2./12.)GLOBAL.G(JTEST)=0.0
    C CHECK FOR GAS MOL COND
    F DO 20 ITEST=0,26
    M TTEST=(T(138+ITEST)+T(1138+ITEST))/2.+460.
      XK6=(1.4+1.)/(1.4-1.)*((32.2*1545.)/(8.*PI*28.*TTEST))**.5*1.
      XK8=PI*XPIPOD/12.*1.
    M CALL CONTRN('PIPE',3138+ITEST,JTEST)
    M GLOBAL.G(JTEST)=XK6*XK7*XK8*3600./778.
      XLAMDA=3.*XK9/XK7*((PI*1545.*TTEST)/(8.*32.2*28.))**.5
    M20 IF(XLAMDA.LE.(XVJID-XPIPOD)/2./12.)GLOBAL.G(JTEST)=0.0
```

### 1. GEN

THIS SINGLE LINE GENERATES 225 CONDUCTION CONDUCTORS, STARTING WITH CONDUCTOR NUMBER 3001, IN INCREMENTS OF 1, CONNECTING NODE 1 IN INCREMENTS OF 1, TO NODE 1001 IN INCREMENTS OF 1, WITH A CONDUCTOR VALUE OF 0.0. CONDUCTORS WILL BE NAMED 3001, 3002, 3003, ETC.

THESE CONDUCTORS REPRESENT GAS MOLECULAR CONDUCTION IN THE NEAR-VACUUM SPACE, AND THEIR VALUE ARE RE-COMPUTED (FROM 0.0) TO SOMETHING ELSE IN THE HEADER VARIABLES 1 BLOCK BASED ON SOME LOGIC PROGRAMMED THERE.

NOTICE THAT THERE ARE TWO DO LOOPS OF 73 AND 27 FOR A TOTAL OF ONLY 100 CONDUCTORS TO BE COMPUTED. THE OTHER 125 ONES WILL REMAIN AS 0.0. WHILE THEY ARE NOT NEEDED, THEY WERE LEFT THERE AS DUMMIES FOR FUTURE UTILIZATION.

## 4. FEATURES (CONT)

```

HEADER CONDUCTOR DATA, PIPE
  SIM 2001,41,1, 1,1,1001,1,A4,K4      $ BX-250 RADIAL COND
  SIM 2115,23,1,115,1,1115,1,A4,K4     $ BX-250 RADIAL COND
  SIM 2165,61,1,165,1,1165,1,A4,K4     $ BX-250 RADIAL COND
  SIM 2301,14,1,301,1,1301,1,A4,K4     $ BX-250 RADIAL COND

HEADER ARRAY DATA, PIPE
.C K SOFI BX-250
  4, -460.0, 0.00259
      800.0, 0.031696,END

HEADER OPERATIONS DATA
XR4 = 2.*PI*1.0/ALOG(XSOFOD/XRIFOD)      $ FOR 1" OF BX-250

```

### 1. SIM

TO INPUT ONE OR MORE TEMPERATURE-VARYING CONDUCTORS.

SINDA COMPUTES THE CONDUCTION CONDUCTOR  $K \cdot A/X$  BY GETTING  $K$  FROM ARRAY 4 (  $T$  VERSUS  $K$ ), AND CONSTANT  $K_4$  ( $A/X$ ) AS  $XR_4$ , COMPUTED IN THE HEADER OPERATIONS BLOCK, AND MULTIPLYING THE TWO.

### 1. CONTRN

THIS ROUTINE RETURNS THE RELATIVE LOCATION IN THE G-ARRAY OF A NETWORK CONDUCTOR, GIVEN THE ACTUAL CONDUCTOR NUMBER.

THE LOX LINE MODEL MADE EXTENSIVE USE OF THIS ROUTINE IN ORDER TO UTILIZE DO LOOPS TO RECALCULATE THE VALUES OF CONDUCTORS WITHIN SECTIONS OF THE LINE.

2. NOTICE THAT THE RADIATION CONDUCTOR CALCULATION INCLUDES  $\sigma$  ( $0.1714E-8$ ), WHILE IT IS DEFINED AS 1.0 IN THE HEADER CONTROL DATA, GLOBAL BLOCK. THE DEFAULT VALUE (IF NOT DEFINED) IS  $0.1714E-8$ .

ONE COMMON ERROR IS TO CALCULATE A CONDUCTOR WITH  $\sigma$ , BUT NOT DEFINING IT AS 1.0 IN THE HEADER CONTROL DATA BLOCK. THIS, OF COURSE, RESULTS IN A CONDUCTOR THAT IS MULTIPLIED TWICE BY  $\sigma$ .

## 4. FEATURES (CONT)

### HEADER FLOW DATA, LINE, FID=7732

```
LU DEF,          XL=0.0, PL=100.0, TL=-297.0
PA DEF,          DH=2.9/12., UPF=0.5
LU PLEN, 1000,   PL=400.0
M HX, 1, D, 1, 1, 1, PIPE.1, 1000, NSEG=11, TLENT=11., DHS=2.9/12., LU=JUNC, PA=STUBE
M HX, 2, D, 12, 12, 12, PIPE.12, 11, NSEG=1, TLENT=1., DHS=2.9/12., LU=JUNC, PA=LOSS, FK=.35
M HX, 3, D, 13, 13, 13, PIPE.13, 12, NSEG=2, TLENT=2., DHS=2.9/12., LU=JUNC, PA=STUBE
M HX, 4, D, 15, 15, 15, PIPE.15, 14, NSEG=1, TLENT=1., DHS=2.9/12., LU=JUNC, PA=LOSS, FK=.35
M HX, 5, D, 16, 16, 16, PIPE.16, 15, NSEG=2, TLENT=2., DHS=2.9/12., LU=JUNC, PA=STUBE
M HX, 6, D, 18, 18, 18, PIPE.18, 17, NSEG=1, TLENT=1., DHS=2.9/12., LU=JUNC, PA=LOSS, FK=.35
M HX, 7, D, 19, 19, 19, PIPE.19, 18, NSEG=2, TLENT=2., DHS=2.9/12., LU=JUNC, PA=STUBE
.
.
M HX, 43, D, 201, 201, 201, PIPE.201, 200, NSEG=1, TLENT=1., DHS=2.9/12., LU=JUNC, PA=LOSS, FK=
```

### HEADER FLOGIC 0, LINE

```
C CONVERT CV TO FK FOR VALVES AND VENTURIES
FK201=3.0E7*(AF201/VLVCV)**2    $ VENTURI
```

1

2

#### 1. HX MACRO

TO GENERATE A STRING OF ONE OR MORE LUMPS, PATHS AND TIES REPRESENTING A DIABATIC DUCT (HEAT EXCHANGER SEGMENT).

SOME ARE PATH PA = STUBE AND PA = LOSS TYPE OF CONNECTOR.

#### 2. IS THERE AN HX DEF LU=JUNC COMMAND TO DEFINE DEFAULTS FOR MACROS ???

#### 3. SOME OF THE LOSSES WERE SPECIFIED BY CV COEFFICIENT. THIS HANDY EQUATION, GIVEN IN THE SINDA MANUAL, CONVERT CV'S TO FK'S.

# 5. PROGRAM LISTING

## HEADER OPTIONS DATA

TITLE USTB LOX TRANSFER LINE  
OUTPUT = VJ1.OUT  
USER1 = VJ1.US1  
USER2 = VJ1.US2  
RSO = VJ1.RSI

## HEADER USER DATA, GLOBAL

PI =3.1416  
XPIPOD =3.5 \$ Pipe OD (in)  
XPIPID =2.9 \$ Pipe ID (in)  
XPIPTK =0.3 \$ Pipe thickness (in)  
XSOFOD =5.5 \$ SOFI OD  
XVJOD =6.625 \$ Vac jack OD (in)  
XVJID =6.357 \$ Vac jack ID (in)  
XVJTK =0.134 \$ Vac jack thickness (in)  
CONV =1.0 \$ Nat conv (Btu/hr-ft<sup>2</sup>-F)  
XLAMDA =0.0 \$ Free Path (ft)  
QCOR =0.0 \$ Heat trans by SOFI cond or Jacket rad  
QMOLC =0.0 \$ Heat trans by gas mol cond  
QCONV =0.0 \$ Heat trans by convection  
QRAD =0.0 \$ Heat trans by rad to surroundings  
VLVCV =76.0 \$ SUGGESTED BY TIM GADNEY

## HEADER CONTROL DATA, GLOBAL

UID = ENG  
ABSZRO = -459.67  
PATMOS = 0.0  
SIGMA = 1.0  
NLOOPS = 500

## HEADER CONTROL DATA, PIPE

EBALSA = 0.001

## HEADER CONTROL DATA, LINE

REBALF = 0.001

## HEADER NODE DATA, PIPE

C PIPE X SECTION IS  $\pi \cdot \text{od} \cdot \text{thick} / 144$  ft<sup>2</sup>, EACH SEGMENT 1 ft LONG  
GEN 1,225,1,-200.0,1.0 \$ PIPE  
GEN 301,14,1,-200.0,1.0 \$ BI-PASS  
GEN 1001,41,1,70.0,1.0 \$ BX-250 SURFACE  
GEN 1042,73,1,70.0,1.0 \$ VAC JACKET  
GEN 1115,23,1,70.0,1.0 \$ BX-250 SURFACE  
GEN 1138,27,1,70.0,1.0 \$ VAC JACKET  
GEN 1165,61,1,70.0,1.0 \$ BX-250 SURFACE  
GEN 1301,14,1,70.0,1.0 \$ BI-PASS BX-250 SURFACE  
-1000,-297.0,0.0 \$ CRYO TANK  
-2000,-315.0,0.0 \$ LN2 JACKET  
-3000,70.0,0.0 \$ AMBIENT

## HEADER CONDUCTOR DATA, PIPE

SIV 1,1000,1,A2,K1 \$ AXIAL COND TO TANK  
SIM 2,224,1,1,1,2,1,A2,K2 \$ PIPE AXIAL COND  
SIM 300,1,1,194,1,301,1,A2,K2 \$ UP PIPE-TO-BI-PASS AXIAL COND  
SIM 301,13,1,301,1,302,1,A2,K2 \$ PIPE BI-PASS AXIAL COND  
SIM 314,1,1,314,1,205,1,A2,K2 \$ LW PIPE-TO-BI-PASS AXIAL COND  
SIM 1042,72,1,1042,1,1114,1,A2,K3 \$ JACKET AXIAL COND  
SIM 1138,26,1,1138,1,1164,1,A2,K3 \$ JACKET AXIAL COND  
SIM 2001,41,1,1,1,1001,1,A4,K4 \$ BX-250 RADIAL COND  
GEN-2042,73,1,42,1,1042,1,0.0 \$ VAC JACKET RAD  
SIM 2115,23,1,115,1,1115,1,A4,K4 \$ BX-250 RADIAL COND

GEN-2138,27,1,138,1,1138,1,0.0 \$ VAC JACKET RAD  
 SIM 2165,61,1,165,1,1165,1,A4,K4 \$ BX-250 RADIAL COND  
 SIM 2301,14,1,301,1,1301,1,A4,K4 \$ BX-250 RADIAL COND  
 GEN 3001,225,1, 1,1,1001,1,0.0 \$ GAS MOLEC COND (SOME DUMMYS)  
 GEN 4001,225,1,1001,1,3000,0,0.0 \$ BX-250 & JACKET CONV TO AMB  
 GEN 4301, 14,1,1301,1,3000,0,0.0 \$ BX-250 BI-PASS CONV TO AMB  
 GEN-5001,225,1,1001,1,3000,0,0.0 \$ BX-250 & JACKET RAD TO AMB  
 GEN-5301, 14,1,1301,1,3000,0,0.0 \$ BI-PASS BX-250 RAD TO AMB

C SUPPORT CONDUCTORS

SIM 6042,1,1, 42,1,1042,1,A2,K10 \$ END CAP RADIAL COND  
 SIM 6045,1,1, 45,1,1045,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6048,1,1, 48,1,1048,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6049,1,1, 49,1,1049,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6051,1,1, 51,1,1051,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6052,1,1, 52,1,1052,1,A2,K10 \$ END CAP RADIAL COND  
 SIM 6053,1,1, 53,1,1053,1,A2,K10 \$ END CAP RADIAL COND  
 SIM 6054,1,1, 54,1,1054,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6058,1,1, 58,1,1058,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6066,1,1, 66,1,1066,1,A2,K13 \$ COND FIXED ANCHOR WING  
 SIM 9066,1,1, 66,1,3000,0,A2,K14 \$ COND FIXED ANCHOR TO GROUND  
 SIM 6073,1,1, 73,1,1073,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6075,1,1, 75,1,1075,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6077,1,1, 77,1,1077,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6081,1,1, 81,1,1081,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6085,1,1, 85,1,1085,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6093,1,1, 93,1,1093,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6097,1,1, 97,1,1097,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6099,1,1, 99,1,1099,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6101,1,1,101,1,1101,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6109,1,1,109,1,1108,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6114,1,1,114,1,1114,1,A2,K10 \$ END CAP RADIAL COND  
 SIM 6138,1,1,138,1,1138,1,A2,K10 \$ END CAP RADIAL COND  
 SIM 6145,1,1,145,1,1145,1,A2,K12 \$ COND 45 DEG SPACER  
 SIM 6147,1,1,147,1,1147,1,A2,K12 \$ COND 45 DEG SPACER  
 SIM 6151,1,1,151,1,1151,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6153,1,1,153,1,1153,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6155,1,1,155,1,1155,1,A2,K12 \$ COND 45 DEG SPACER  
 SIM 6157,1,1,157,1,1157,1,A2,K12 \$ COND 45 DEG SPACER  
 SIM 6161,1,1,161,1,1161,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6163,1,1,163,1,1163,1,A2,K11 \$ COND SLIDING SPACER  
 SIM 6164,1,1,164,1,1164,1,A2,K10 \$ END CAP RADIAL COND

C UNCOMMENT NEXT TWO LINES FOR LN2 CASES

C GEN 7042,73,1,42,1,2000,0,1000.0 \$ LINE TO LN2  
 C GEN 7138,27,1,138,1,2000,0,1000.0 \$ LINE TO LN2  
 C GEN 8042,73,1,2000,0,1042,1,1000.0 \$ JACKET TO LN2  
 C GEN 8138,27,1,2000,0,1138,1,1000.0 \$ JACKET TO LN2

HEADER FLOW DATA,LINE,FID=7732

LU DEF, XL=0.0,PL=100.0,TL=-297.0  
 PA DEF, DH=2.9/12.,UPF=0.5  
 LU PLEN,1000,PL=400.0

M HX,1,D, 1,1,1,PIPE.1,1000,NSEG-11,TLENT-11.,DHS-2.9/12.,LU-JUNC,PA-STUBE  
 M HX,2,D,12,12,12,PIPE.12,11,NSEG-1,TLENT-1.,DHS-2.9/12.,LU-JUNC,PA-LOSS,FK-.35  
 M HX,3,D,13,13,13,PIPE.13,12,NSEG-2,TLENT-2.,DHS-2.9/12.,LU-JUNC,PA-STUBE  
 M HX,4,D,15,15,15,PIPE.15,14,NSEG-1,TLENT-1.,DHS-2.9/12.,LU-JUNC,PA-LOSS,FK-.35  
 M HX,5,D,16,16,16,PIPE.16,15,NSEG-2,TLENT-2.,DHS-2.9/12.,LU-JUNC,PA-STUBE  
 M HX,6,D,18,18,18,PIPE.18,17,NSEG-1,TLENT-1.,DHS-2.9/12.,LU-JUNC,PA-LOSS,FK-.35  
 M HX,7,D,19,19,19,PIPE.19,18,NSEG-2,TLENT-2.,DHS-2.9/12.,LU-JUNC,PA-STUBE  
 M HX,8,D,21,21,21,PIPE.21,20,NSEG-1,TLENT-1.,DHS-2.9/12.,LU-JUNC,PA-STUBE  
 M HX,9,D,22,22,22,PIPE.22,21,NSEG-1,TLENT-1.,DHS-2.9/12.,LU-JUNC,PA-LOSS,FK=0.0  
 M HX,10,D,23,23,23,PIPE.23,22,NSEG-4,TLENT=4.,DHS-2.9/12.,LU-JUNC,PA-STUBE  
 M HX,11,D,27,27,27,PIPE.27,26,NSEG-1,TLENT=1.,DHS-2.9/12.,LU-JUNC,PA-LOSS,FK=.35  
 M HX,12,D,28,28,28,PIPE.28,27,NSEG-5,TLENT=5.,DHS-2.9/12.,LU-JUNC,PA-STUBE  
 M HX,13,D,33,33,33,PIPE.33,32,NSEG-1,TLENT=1.,DHS-2.9/12.,LU-JUNC,PA-LOSS,FK=.35

M HX, 14, D, 34, 34, 34, PIPE. 34, 33, NSEG-2, TLENT-2., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 15, D, 36, 36, 36, PIPE. 36, 35, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 16, D, 37, 37, 37, PIPE. 37, 36, NSEG-4, TLENT-4., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 17, D, 41, 41, 41, PIPE. 41, 40, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 18, D, 42, 42, 42, PIPE. 42, 41, NSEG-72, TLENT-72., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 19, D, 114, 114, 114, PIPE. 114, 113, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 20, D, 115, 115, 115, PIPE. 115, 114, NSEG-7, TLENT-7., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 21, D, 122, 122, 122, PIPE. 122, 121, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 22, D, 123, 123, 123, PIPE. 123, 122, NSEG-6, TLENT-6., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 23, D, 129, 129, 129, PIPE. 129, 128, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 24, D, 130, 130, 130, PIPE. 130, 129, NSEG-7, TLENT-7., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 25, D, 137, 137, 137, PIPE. 137, 136, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 26, D, 138, 138, 138, PIPE. 138, 137, NSEG-8, TLENT-1., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 27, D, 146, 146, 146, PIPE. 146, 145, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.19  
M HX, 28, D, 147, 147, 147, PIPE. 147, 146, NSEG-9, TLENT-9., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 29, D, 156, 156, 156, PIPE. 156, 155, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.19  
M HX, 30, D, 157, 157, 157, PIPE. 157, 156, NSEG-7, TLENT-7., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 31, D, 164, 164, 164, PIPE. 164, 163, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 32, D, 165, 165, 165, PIPE. 165, 164, NSEG-7, TLENT-7., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 33, D, 172, 172, 172, PIPE. 172, 171, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 34, D, 173, 173, 173, PIPE. 173, 172, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 35, D, 174, 174, 174, PIPE. 174, 173, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 36, D, 175, 175, 175, PIPE. 175, 174, NSEG-2, TLENT-2., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 37, D, 177, 177, 177, PIPE. 177, 176, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
  
M HX, 38, D, 178, 178, 178, PIPE. 178, 177, NSEG-10, TLENT-10., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 39, D, 188, 188, 188, PIPE. 188, 187, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
  
M HX, 40, D, 189, 189, 189, PIPE. 189, 188, NSEG-6, TLENT-6., DHS-2.9/12., LU-JUNC, PA-STUBE  
C STRAIGHT SPLIT  
M HX, 41, D, 195, 195, 195, PIPE. 195, 194, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.15  
M HX, 42, D, 196, 196, 196, PIPE. 196, 195, NSEG-5, TLENT-5., DHS-2.9/12., LU-JUNC, PA-STUBE  
C VENTURI  
M HX, 43, D, 201, 201, 201, PIPE. 201, 200, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-0.0  
C VALVE  
M HX, 44, D, 202, 202, 202, PIPE. 202, 201, NSEG-2, TLENT-2., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 45, D, 204, 204, 204, PIPE. 204, 203, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.15  
  
M HX, 46, D, 205, 205, 205, PIPE. 205, 204, NSEG-4, TLENT-4., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 47, D, 209, 209, 209, PIPE. 209, 208, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 48, D, 210, 210, 210, PIPE. 210, 209, NSEG-6, TLENT-6., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 49, D, 216, 216, 216, PIPE. 216, 215, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 50, D, 217, 217, 217, PIPE. 217, 216, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
M HX, 51, D, 218, 218, 218, PIPE. 218, 217, NSEG-3, TLENT-3., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 52, D, 221, 221, 221, PIPE. 221, 220, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 53, D, 222, 222, 222, PIPE. 222, 221, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-0.0  
M HX, 54, D, 223, 223, 223, PIPE. 223, 222, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 55, D, 224, 224, 224, PIPE. 224, 223, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
C END OF LOX LINE  
M HX, 56, C, 225, 225, 225, PIPE. 225, 224, 2000, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-STUBE  
C TURN SPLIT  
M HX, 57, D, 301, 301, 301, PIPE. 301, 194, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 58, D, 302, 302, 302, PIPE. 302, 301, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
  
M HX, 59, D, 303, 303, 303, PIPE. 303, 302, NSEG-6, TLENT-6., DHS-2.9/12., LU-JUNC, PA-STUBE  
C VENTURY  
M HX, 60, D, 309, 309, 309, PIPE. 309, 308, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-0.0  
  
M HX, 62, D, 310, 310, 310, PIPE. 310, 309, NSEG-2, TLENT-2., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 63, D, 312, 312, 312, PIPE. 312, 311, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.35  
  
M HX, 64, D, 313, 313, 313, PIPE. 313, 312, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-STUBE  
M HX, 65, C, 314, 314, 314, PIPE. 314, 313, 204, NSEG-1, TLENT-1., DHS-2.9/12., LU-JUNC, PA-LOSS, FK-.70

LU PLEN,2000

\$ EXHAUST

HEADER ARRAY DATA,PIPE

C K FOR AISI 304L SS (BTU/HR-FT-F)

2, -400.0, 2.0  
-350.0, 4.0  
-300.0, 5.1  
-250.0, 6.0  
-150.0, 7.0  
-50.0, 8.0  
100.0, 9.0, END

C K SOFI BX-250

4, -460.0, 0.00259  
800.0, 0.031696,END

HEADER USER DATA, PIPE

1 -0.0  
2 -0.0  
3 -0.0  
4 -0.0  
5 -0.0  
6 -0.0  
7 -10.E-5\*.01934\*144. \$ IN-HG--->PSIA  
8 -0.0 \$ PIPE SURFACE AREA  
9 -.0228/3600. \$ GN2 gas visc (LBM/FT-SEC) @250 R  
10 -0.0 \$ A/X FOR RADIAL COND END CAP  
11 -0.0 \$ A/X FOR COND SLIDING SPACER  
12 -0.0 \$ A/X FOR COND 45 DEG SPACER  
13 -0.0 \$ A/X FOR COND FIXED ANCHOR WING  
14 -0.0 \$ A/X FOR COND FIXED ANCHOR TO GROUND

HEADER OPERATIONS DATA

BUILD PIPE,PIPE

DEFMOD PIPE

XK2 =  $PI*(XPIPOD**2-XPIPID**2)/4./144./1.0$   
XK1 = XK2/2.  
XK3 =  $PI*(XVJOD**2-XVJID**2)/4./144./1.0$   
XK4 =  $2.*PI*1.0/ALOG(XSOFOD/XPIPOD)$  FOR 1" OF BX-250  
XK10=  $2.*PI*.25/12./ALOG(XVJOD/XPIPOD)$  \$ RADIAL COND END CAP  
XK11=  $6.*( .25+.5)/1.43/12.$  \$ COND SLIDING SPACER  
XK12=  $4.*.25*2.1/1.05/12.$  \$ COND 45 DEG SPACER  
XK13=  $6.*.25/1.43/12.$  \$ COND FIXED ANCHOR WING  
XK14=  $8.*.5/9.56/12.$  \$ COND FIXED ANCHOR TO GROUND

F DO 10 ITEST=0,40  
M CALL CONTRN('PIPE',4001+ITEST,JTEST)  
M CALL CONTRN('PIPE',5001+ITEST,KTEST)  
C SOFI CONVECTION TO AMB  
M GLOBAL.G(JTEST)=CONV\*PI\*XSOFOD/12.\*1.0  
C SOFI RADIATION TO AMB  
M10 GLOBAL.G(KTEST)=.1714E-8\*.9\*1.\*PI\*XSOFOD/12.\*1.0

F DO 20 ITEST=0,72  
M CALL CONTRN('PIPE',2042+ITEST,JTEST)  
M CALL CONTRN('PIPE',4042+ITEST,KTEST)  
M CALL CONTRN('PIPE',5042+ITEST,LTEST)  
C VAC JACK INTERNAL RAD  
M GLOBAL.G(JTEST)=.1714E-8\*.18\*1.\*PI\*XPIPOD/12./1.0  
C VAC JACK CONV TO AMB  
M GLOBAL.G(KTEST)=CONV\*PI\*XVJOD/12.\*1.0  
C VAC JACK RAD TO AMB  
M20 GLOBAL.G(LTEST)=.1714E-8\*.90\*1.\*PI\*XVJOD/12.\*1.0

F DO 30 ITEST=0,22

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M      CALL CONTRN('PIPE',4115+ITEST,JTEST)
M      CALL CONTRN('PIPE',5115+ITEST,KTEST)
C SOFI CONVECTION TO AMB
M      GLOBAL.G(JTEST)=CONV*PI*XSOFOD/12.*1.0
C SOFI RADIATION TO AMB
M30   GLOBAL.G(KTEST)=.1714E-8*.9*1.*PI*XSOFOD/12.*1.0

F      DO 40 ITEST=0,26
M      CALL CONTRN('PIPE',2138+ITEST,JTEST)
M      CALL CONTRN('PIPE',4138+ITEST,KTEST)
M      CALL CONTRN('PIPE',5138+ITEST,LTEST)
C VAC JACK INTERNAL RAD
M      GLOBAL.G(JTEST)=.1714E-8*.18*1.*PI*XPIPOD/12./1.0
C VAC JACK CONV TO AMB
M      GLOBAL.G(KTEST)=CONV*PI*XVJOD/12.*1.0
C VAC JACK RAD TO AMB
M40   GLOBAL.G(LTEST)=.1714E-8*.9*1.*PI*XVJOD/12.*1.0

F      DO 50 ITEST=0,60
M      CALL CONTRN('PIPE',4165+ITEST,JTEST)
M      CALL CONTRN('PIPE',5165+ITEST,KTEST)
C SOFI CONVECTION TO AMB
M      GLOBAL.G(JTEST)=CONV*PI*XSOFOD/12.*1.0
C SOFI RADIATION TO AMB
M50   GLOBAL.G(KTEST)=.1714E-8*.9*1.*PI*XSOFOD/12.*1.0

F      DO 60 ITEST=0,13
M      CALL CONTRN('PIPE',4301+ITEST,JTEST)
M      CALL CONTRN('PIPE',5301+ITEST,KTEST)
C BI-PASS SOFI CONVECTION TO AMB
M      GLOBAL.G(JTEST)=CONV*PI*XSOFOD/12.*1.0
C BI-PASS SOFI RADIATION TO AMB
M60   GLOBAL.G(KTEST)=.1714E-8*.9*1.*PI*XSOFOD/12.*1.0

BUILD PIPE,LINE
      CALL FASTIC
      CALL LMPTAB('LINE')
      CALL TIETAB('LINE')
      CALL PHTTAB('LINE')
C      CALL QMAP('PIPE','QDB',0)
      CALL TPRINT('PIPE')
F      WRITE(NUSER1,100)
F      WRITE(NUSER2,100)
F100  FORMAT(1X,'8',/
F      '      LENGTH      TLOX      TPIPE      TSURF      PLOX      QCON/RAD'
F      '      ' QMOLC QCONV      QRAD',/
F      ' 1 2 3 4 5 6 7 8')

F      DO 70 ITEST=0,148
M      CALL CONTRN('PIPE',2001+ITEST,JTEST)
M      CALL CONTRN('PIPE',3001+ITEST,KTEST)
M      CALL CONTRN('PIPE',4001+ITEST,LTEST)
M      CALL CONTRN('PIPE',5001+ITEST,MTEST)
M      CALL QMETER(T(1+ITEST),T(1001+ITEST),GLOBAL.G(JTEST),QCOR)
M      IF(1+ITEST.GT.41.AND.1+ITEST.LT.114) THEN
M      CALL RDTNQS(T(1001+ITEST),T(1+ITEST),GLOBAL.G(JTEST),QCOR)
M      CALL QMETER(T(1+ITEST),T(1001+ITEST),GLOBAL.G(KTEST),QMOLC)
M      ELSE IF(1+ITEST.GT.136.AND.1+ITEST.LT.165) THEN
M      CALL RDTNQS(T(1001+ITEST),T(1+ITEST),GLOBAL.G(JTEST),QCOR)
M      CALL QMETER(T(1+ITEST),T(1001+ITEST),GLOBAL.G(KTEST),QMOLC)
F      ELSE
      QMOLC=0.0
F      END IF
M      CALL QMETER(T(1001+ITEST),T3000,GLOBAL.G(LTEST),QCONV)

```



```

M      CALL RDTNQS (T3000, T (1001+ITEST), GLOBAL.G (MTEST), QRAD)
M70    WRITE (NUSER1, 101) (1+ITEST), LINE.TL (1+ITEST), T (1+ITEST),
M      . T (1001+ITEST), LINE.PL (1+ITEST), QCOR, QMOLC, QCONV, QRAD

F      DO 71 ITEST=149,224
M      CALL CONTRN ('PIPE', 2001+ITEST, JTEST)
M      CALL CONTRN ('PIPE', 3001+ITEST, KTEST)
M      CALL CONTRN ('PIPE', 4001+ITEST, LTEST)
M      CALL CONTRN ('PIPE', 5001+ITEST, MTEST)
M      CALL QMETER (T (1+ITEST), T (1001+ITEST), GLOBAL.G (JTEST), QCOR)
M      IF (1+ITEST.GT.41.AND.1+ITEST.LT.114) THEN
M      CALL RDTNQS (T (1001+ITEST), T (1+ITEST), GLOBAL.G (JTEST), QCOR)
M      CALL QMETER (T (1+ITEST), T (1001+ITEST), GLOBAL.G (KTEST), QMOLC)
M      ELSE IF (1+ITEST.GT.136.AND.1+ITEST.LT.165) THEN
M      CALL RDTNQS (T (1001+ITEST), T (1+ITEST), GLOBAL.G (JTEST), QCOR)
M      CALL QMETER (T (1+ITEST), T (1001+ITEST), GLOBAL.G (KTEST), QMOLC)
F      ELSE
M      QMOLC=0.0
F      END IF
M      CALL QMETER (T (1001+ITEST), T3000, GLOBAL.G (LTEST), QCONV)
M      CALL RDTNQS (T3000, T (1001+ITEST), GLOBAL.G (MTEST), QRAD)
M71    WRITE (NUSER2, 101) (1+ITEST), LINE.TL (1+ITEST), T (1+ITEST),
M      . T (1001+ITEST), LINE.PL (1+ITEST), QCOR, QMOLC, QCONV, QRAD

F101   FORMAT (1X, I5, 1X, 1PE9.2, 1X, 1PE9.2, 1X, 1PE9.2, 1X, 1PE9.2, 1X, 1PE9.2,
F      . 1X, 1PE9.2, 1X, 1PE9.2, 1X, 1PE9.2)

```

```

HEADER VARIABLES 1, PIPE
C CHECK FOR GAS MOL COND
F      DO 10 ITEST=0,72
M      TTEST=(T(42+ITEST)+T(1042+ITEST))/2.+460.
M      XK6=(1.4+1.)/(1.4-1.)*((32.2*1545.)/(8.*PI*28.*TTEST))**.5*1.
M      XK8=PI*XPIPOD/12.*1.
M      CALL CONTRN ('PIPE', 3042+ITEST, JTEST)
M      GLOBAL.G (JTEST)=-XK6*XK7*XK8*3600./778.
M      XLAMDA=3.*XK9/XK7*((PI*1545.*TTEST)/(8.*32.2*28.))**.5
M10    IF (XLAMDA.LE. ((XVJID-XPIPOD)/2./12.)) GLOBAL.G (JTEST)=0.0
C CHECK FOR GAS MOL COND
F      DO 20 ITEST=0,26
M      TTEST=(T(138+ITEST)+T(1138+ITEST))/2.+460.
M      XK6=(1.4+1.)/(1.4-1.)*((32.2*1545.)/(8.*PI*28.*TTEST))**.5*1.
M      XK8=PI*XPIPOD/12.*1.
M      CALL CONTRN ('PIPE', 3138+ITEST, JTEST)
M      GLOBAL.G (JTEST)=-XK6*XK7*XK8*3600./778.
M      XLAMDA=3.*XK9/XK7*((PI*1545.*TTEST)/(8.*32.2*28.))**.5
M20    IF (XLAMDA.LE. ((XVJID-XPIPOD)/2./12.)) GLOBAL.G (JTEST)=0.0

```

```

HEADER FLOGIC 0, LINE
C CONVERT CV TO FK FOR VALVES AND VENTURIES
FK22=3.0E7*(AF22/VLVCV)**2 $ VALVE
FK201=3.0E7*(AF201/VLVCV)**2 $ VENTURI
FK202=3.0E7*(AF202/VLVCV)**2 $ VALVE
FK222=3.0E7*(AF222/VLVCV)**2 $ VALVE
FK309=3.0E7*(AF309/VLVCV)**2 $ VENTURI
FK310=3.0E7*(AF310/VLVCV)**2 $ VALVE

```

```

HEADER OUTPUT CALLS, PIPE
C-----
HEADER FPROP DATA, 7732, SI, 0.0
C
C MORE COMPLETE OXYGEN TWO-PHASE (FROM 70 TO 120K, NEAR 90 K)
C VAPOR PROPERTIES ARE FOR SATURATED VAPOR
C

```

RGAS = 8314.34/31.9988

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TCRIT = 154.6
PCRIT = 5.04E6
ST = 0.0132
TMIN = 70.0
PGMAX = 1.0E6
C TGMAX = 120.0
C
C *** ALTERNATE INPUTS FOR SUPERHEATED VAPOR PROPERTIES AT 1 ATM
C THEN USE THE FOLLOWING LINES INSTEAD:
C TGMAX = 700.0
AT, VG, 80.0, 6.27E-6, 100.0, 7.68E-6, 120.0, 9.12E-6, 130.0, 9.85E-6
140.0, 10.6E-6, 155.0, 11.6E-6, 170.0, 12.7E-6, 200.0, 14.7E-6
300.0, 20.7E-6, 400.0, 25.9E-6, 500.0, 30.5E-6, 600.0, 34.7E-6
700.0, 38.5E-6
AT, KG, 100.0, 9.1E-3, 120.0, 0.0109, 130.0, 0.0119, 140.0, 0.0128
155.0, 0.0142, 170.0, 0.0156, 200.0, 0.0182, 300.0, 0.0267
400.0, 0.0342, 500.0, 0.0412, 600.0, 0.0480, 700.0, 0.0544
C *** END ALTERNATE INPUTS
C
C THE NEXT TWO LINES ARE FOR SATURATED VAPOR
CAT, VG, 80.0, 6.27E-6, 100.0, 7.72E-6, 120.0, 9.49E-6, 130.0, 1.057E-5
CAT, KG, 100.0, 9.3E-3, 120.0, 0.0124, 130.0, 0.015
C
AT, DOME, 54.34, 145.3, 242.37E3
C ELSE: 60.0, 724.9, 238.26E3
C ELSE: 70.0, 6253.0, 230.50E3
90.19, 101325.0, 213.03E3
C ELSE: 100.0, 0.254E6, 202.57E3
C ELSE: 110.0, 0.534E6, 189.69E3
C ELSE: 120.0, 1.022E6, 173.75E3
AT, KL, 80.0, 0.1623, 100.0, 0.1372, 120.0, 0.1096, 130.0, 0.0949
C 140.0, 0.0796, 150.0, 0.0610
AT, VL, 80.0, 2.57E-4, 100.0, 1.56E-4, 120.0, 1.117E-4, 130.0, 9.6E-5
C 140.0, 7.8E-5, 150.0, 5.1E-5
C
AT, CPG, 80.0, 909.8, 170.0, 909.8, 200.0, 910.2, 300.0, 918.4
400.0, 941.5, 500.0, 970.9, 600.0, 1002., 700.0, 1031.
AT, DL, 53.34, 1309., 60.0, 1282., 65.0, 1259., 70.0, 1238.,
75.0, 1214., 80.0, 1190., 85.0, 1167., 90.0, 1142.
95.0, 1116., 100.0, 1091., 105.0, 1064., 110.0, 1035.
115.0, 1006., 120.0, 973.7, 125.0, 939.8
C 130.0, 902.5, 135.0, 861.3, 140.0, 813.0, 145.0, 755.3
END OF DATA

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