



CLIPSOL

HEATING FLOOR MODEL Type 100

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This component models the heat transfer in a heating floor. To reduce simulation time, a convolution method is used. Using a pre-processor program (plancher.Exe), Response Factors are calculated with an ADI finite differences method. Then, these series are reduced to obtain Conductive Transfer Functions (CTF). Only, one type100 can be used per simulation.

This type is usually connected to type19 or type56.

1.

héliotechniques

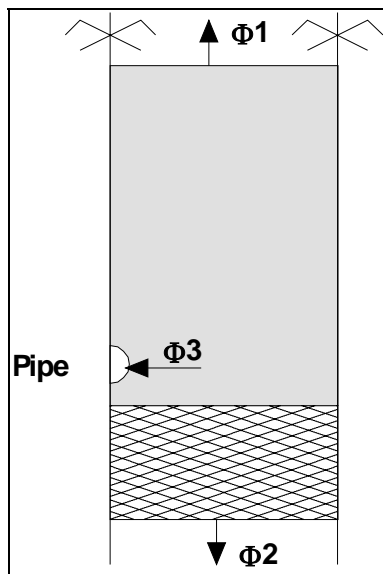
Introduction

This model was developed at the University of Savoie in 1990 by Philippe Papillon and Gilbert Achard to simulate Direct Solar Floor combisystems [1].

In order to reduce time calculation for the simulation and to be consistent with simulation of buildings tools (TRNSYS), we decided to use convolutive method instead of Finite Differences.

2. Physical Model

2.1. Conduction in the floor



Hypothesis :

- We use a constant fluid temperature which is the mean temperature between the input and the output temperature.
- The convective heat transfer coefficient for $\Phi1$ and $\Phi2$ are constant.
- We make the assumption that there is no special conduction on the border of the heating floor panel
- The thermophysical properties of materials are constant.

With these hypothesis, the floor heating system is simplified to a 2-dimensionnal problem, and only one section of the floor is studied (Figure 1).

Figure 1 : Representative cross section of the heating floor

The three heating floor density of energy can be expressed as :

$$\Phi_i(t = n\delta) = \sum_{j=1}^3 \left(\sum_{k=0}^{\infty} W_{ij,k} T_j(t = (n-k)\delta) \right)$$

where $W_{ij,k}$ are the response factor of the heating floor at surface i due to a temperature sollicitation in j at time $t=(n-k)\delta$.

The six response factors series (W_{11} , $W_{12} = W_{21}$, $W_{13} = W_{31}$, W_{22} , $W_{23} = W_{32}$, W_{33}) are first calculated by a finite differences method.

Response Factors series are infinite, but one can observed, than $W_{ij,k} = q \cdot W_{ij,k+1}$ when k is greater than k_1 , and the ratio q is called "common ratio". With this observation, we can calculate the Conduction Transfer Function ("CTF") of first order and

$$\Phi_i(t = n\delta) = \sum_{j=1}^3 \left(\sum_{k=0}^{k_1} N_{ij,k} T_j(t = (n-k)\delta) \right) + q \Phi_i(t = (n-1)\delta)$$

In some case, we can calculate CTF of second and third order, and the final expression is :

$$\Phi_i(t = n\partial) = \sum_{j=1}^3 \left(\sum_{k=0}^{km} N_{ij,k}^{(m)} T_j(t = (n-k)\partial) \right) + \sum_{k=1}^m (-1)^{k+1} D_k^{(m)} \Phi_i(t = (n-k)\partial)$$

with

D type CTF		N type CTF	
k=0	$D_0^{(m)} = 1$	k=0	$N_0^{(m)} = N_0^{(m-1)} = W_0$
0<k<m-1	$D_k^{(m)} = D_k^{(m-1)} + q^{(m)} D_{k-1}^{(m-1)}$	0<k<km	$N_k^{(m)} = N_k^{(m-1)} + q^{(m)} N_{k-1}^{(m-1)}$
k=m	$D_m^{(m)} = q^{(m)} D_{m-1}^{(m-1)}$ avec $D_k^{(0)}$		avec $N_k^{(0)} = W_k$

2.2. Thermal coupling

2.2.1. With the floor

2.2.1.1. Link with Type 19

$$\Phi_1 = h_{eq1} (Teq1 - TS1)$$

where Teq1 is the equivalent temperature (optional output of Type 19).

2.2.1.2. Link with Type 56

$$\Phi_1 = h_{eq1} (Teq1 - TS1) = \Phi_{conv1} + \Phi_{radGLO1} - Ssi = \Phi_{comb} - Ssi$$

where Φ_{comb} is the combined convective and radiative (long wave) energy flux to other surfaces (optional output of Type 56)

Ssi is the solar radiation gain for the wall (optional output of Type 56)

TS1 is the surface temperature (optional output of Type56)

Teq1 is then calculated in Type100 as

$$Teq1 = TS1 - \frac{(\Phi_{comb} - Ssi)}{heq}$$

2.2.2. With the ceiling

2.2.2.1. Link with Type 19

$$\Phi_2 = h_{eq2} (Teq2 - TS2)$$

where Teq2 is the equivalent temperature (optional output of Type 19).

2.2.2.2. Link with Type 56

$$\Phi_2 = h_{eq2} (Teq2 - TS2) = \Phi_{conv2} + \Phi_{radGLO2} - Ssi = \Phi_{comb} - Ssi$$

where Φ_{comb} is the combined convective and radiative (long wave) energy flux to other surfaces (optional output of Type 56)

Ssi is the solar radiation gain for the wall (optional output of Type 56)

TS1 is the surface temperature (optional output of Type56)

Teq2 is then calculated in Type100 as

$$Teq2 = TS2 - \frac{(\Phi_{comb} - Ssi)}{heq}$$

2.2.3.

With the fluid

$$\Phi_3 = NNAPPE \cdot K \cdot L \left(T_3 - \frac{T_{in} + T_{out}}{2} \right) = \dot{m} C_p (T_{out} - T_{in})$$

where NNAPPE is the total number of parallel loop,
K is the total conductance between the fluid and the external surface of the pipe
L is the pipe's length of one loop,
Tin and Tout are respectively the fluid input and output temperature,
m is the flowrate.

3. Type 100

3.1. Parameters

1	LUP	Logical Unit for file containing the CTF and data for the heating floor	
2	SURF	Heating Floor Area	(m ²)
3	LTUBE	Total length of pipes embedded in the heating floor	(m)
4	NNAPPE	Number of independant heating loop for the area	
5	TETA(1)	Temperature of the Fluid 1	(°C)
6	TETA(2)	Temperature of the Fluid 2	(°C)
7	RHO(1)	Volumic Mass of the Fluid at TETA(1)	(kg/m ³)
8	RHO(2)	Volumic Mass of the Fluid at TETA(2)	(kg/m ³)
9	CP(1)	Specific Heat of the Fluid at TETA(1)	(J/kg.K)
10	CP(2)	Specific Heat of the Fluid at TETA(2)	(J/kg.K)
11	VIS(1)	Dynamic Viscosity of the Fluid at TETA(1)	(kg/m.s)
12	VIS(2)	Dynamic Viscosity of the Fluid at TETA(2)	(kg/m.s)
13	COND(1)	Conductivity of the Fluid at TETA(1)	(W/m.K)
14	COND(2)	Conductivity of the Fluid at TETA(2)	(W/m.K)
15	DIAME	External Diameter of the Pipe	(m)
16	DIAMI	Internal Diameter of the Pipe	(m)
17	CONT	Conductivity of the Pipe	(W/m.K)
18	UPTYPE	= 19 : Connection of the floor with Type19 = 56 : Connection of the floor with Type56	
19	DNTYPE	= 19 : Connection of the ceiling with Type19 = 56 : Connection of the ceiling with Type56	

3.2. Inputs

1	MFH	MassFlow	(kg/h)
2	TIN	Inlet Temperature of Fluid	(°C)
T19	3	TEQH	Equivalent Temperature of the Floor (°C)
T19	4	TEQB	Equivalent Temperature of the ceiling (°C)
T19	5	Specify 0,0	
T19	6	Specify 0,0	
T19	7	Specify 0,0	
T19	8	Specify 0,0	
T56	3	TSH	Temperature of the Floor (°C)
T56	4	TSB	Temperature of the ceiling (°C)
T56	5	SOLRADH	Solar Radiation on the floor (kJ/h)
T56	6	SOLRADB	Solar Radiation on the ceiling (kJ/h)
T56	7	QCOMBH	Combined heat flux for floor (kJ/h)
T56	8	QCOMBB	Combined heat flux for ceiling (kJ/h)

3.3. Outputs

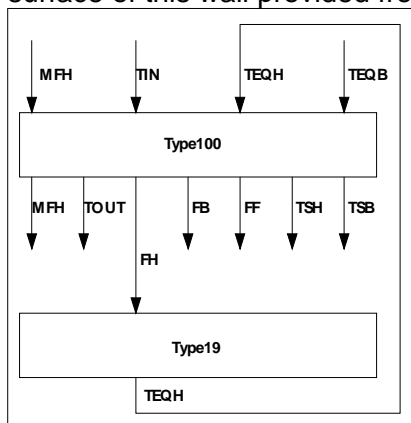
1	MFH	MassFlow	(kg/h)
2	TOUT	Outlet Temperature of Fluid	(°C)
3	FH	Heat Output through Floor	(kJ/h)
3	FB	Heat Output through Ceiling	(kJ/h)
3	FH	Heat Output from the Floor into Fluid (<0 when heating, >0 when cooling)	(kJ/h)
6	TSH	Average Mean Temperature of the Floor	(°C)
7	TSB	Average Mean Temperature of the ceiling	(°C)
8	TEQH	Equivalent Temperature of the Floor	(°C)
9	TEQB	Equivalent Temperature of the Ceiling	(°C)

3.4. Assign command

An assign command should be added in the TRNSYS deck.
For example, the command should be **ASSIGN example1.fa1 2**

4. Linking to Type19

One wall of the Building must be defined as a "NON ASHRAE Wall". The energy at the inside surface of this wall provided from Type100. This type of wall is defined by :



Parameter	Description:	
1	Surface number	1 - 15
2	Surface Type	Specify 4
3	Surface Area	Area (m ²)
4	Reflectance of inner surface for solar	[-]
5	inside convection coefficient	(kJ/m ² K)

Warning : The fifth parameter must be the same as the one used with the pre-processor.

Inputs:

1	Energy transfer into zone at the inside surface of the wall	(kJ/h)
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Figure 2 : Thermal coupling with Type19

5. Linking to Type56

5.1. Definition of the building file (*.bui)

In your building description, you have to define :

- a pure resistance wall in type56 named (for example) RESIST

Layer : Massless layer
Resistance : 0.001h.m².K/kJ

- a wall named FLOORHEATING

Only one layer : RESIST
Solar Absorptance : Front = as you want
Back = 0.0

Convective Heat Transfer Coefficient for Wall

Front : Constant : **(the value of the convective heat transfer coefficient must be the same as**

one used with the pre-processor Plancher.Exe)

the

- Back : Constant : 0.000
- the wall of the zone as :
 - Wall Type : FLOORHEATING
 - Area : the area of the floor heating
 - Category : Boundary
 - Coupling Air Flow : 0.0 kg/h
 - Boundary Temp : UserDefined = 1*TSURF(Output of Type 100) +0.0
- the necessary OUTPUT for the connection
 - ⇒ TSURF : Inside Surface Temperature (NTYPE = 17)
 - ⇒ QCOMB : Energy from the inside surface including convection to the air and long-wave radiation to other surfaces (NTYPE = 19)
 - ⇒ SOLRAD : Total Radiation absorbed at inside surface including wallgains (except long-wave radiation from other walls) (NTYPE = 21)

5.2. Linking Type100 and Type56

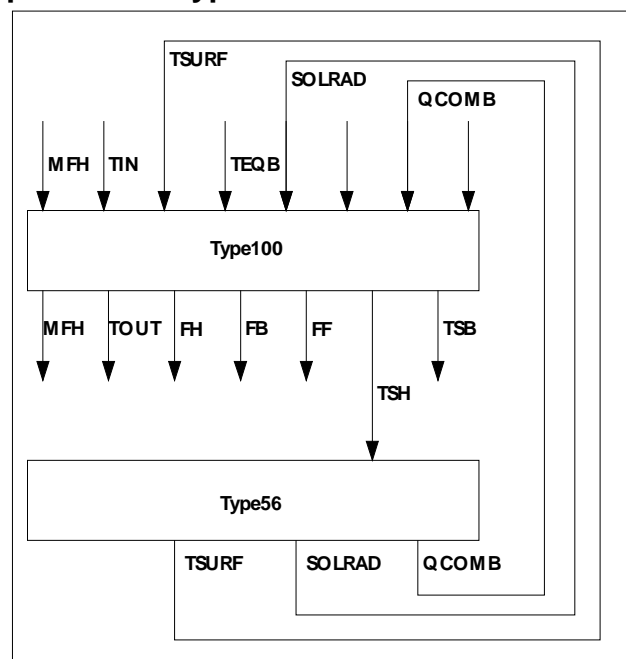
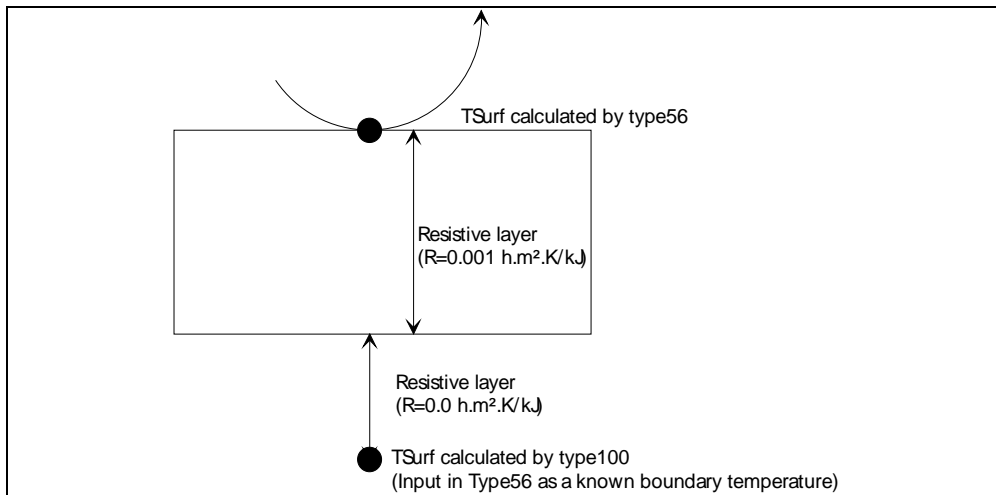


Figure 2 : Thermal coupling with Type56

5.3. Important note

We have observed some problems with this kind of connection.

In Type56, the input TSH from Type100 is the outside surface temperature of the fictive wall with only one resistance layer. In Type56, the inside surface temperature of this wall is then calculated and there is some differences in the two surface temperatures.



With the data on the figure above, the global heat transfer coefficient is $U = 1000 \text{ kJ/h.m}^2.\text{K} = 278 \text{ W/m}^2.\text{K}$. That means that a difference of 0.1°C between the two floor temperatures leads to an heating flux of 28 W/m^2 . In order to reduce this temperature difference, it is necessary to reduce the resistance of the resistive layer.

As it is not possible to reduce the resistance of the resistive layer in PREBID (problem in formatting data with cause an error in running BidWin), you have to edit you *.bui file and to decrease the resistance to 0.00001 kJ/h.m^2 and then to run BidWin.

6.

Pre Processor Plancher.Exe

The preprocessor Plancher.Exe (plancher32eng.exe) is necessary to use the Type100. This preprocessor calculates the response factors and the CTF for the designed heating floor, and stores the data used by Type100 in a file.

This preprocessor can use a file containing physical description of the heating floor or data can be typed on the screen. Example1.dat, provided with Plancher.Exe, is an example of input file for Plancher.Exe.

As the response factors are calculated with a finite differences method, small nodes shall be used in the region of high temperature gradient (close to the heating pipe).

Because of symetries, only one part of the heating floor is used.

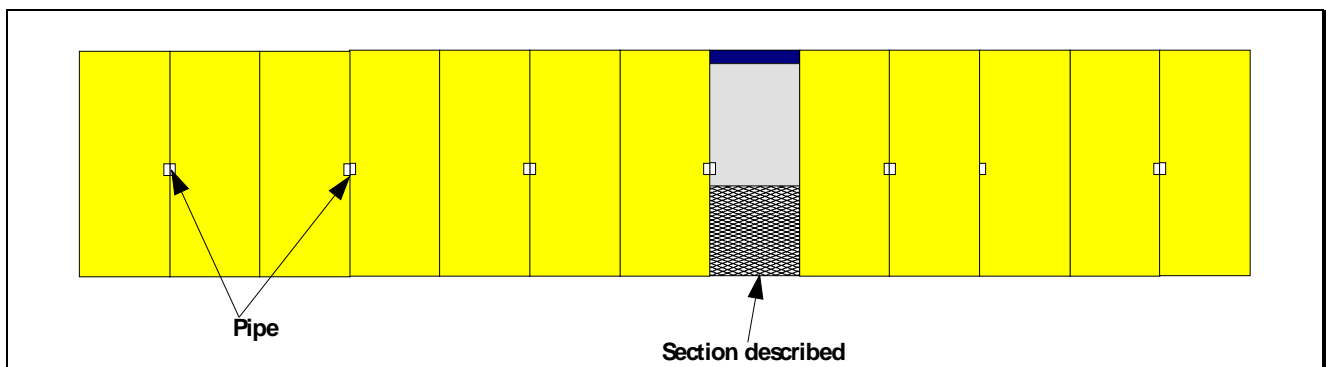


Figure 4 : Section of the heating floor

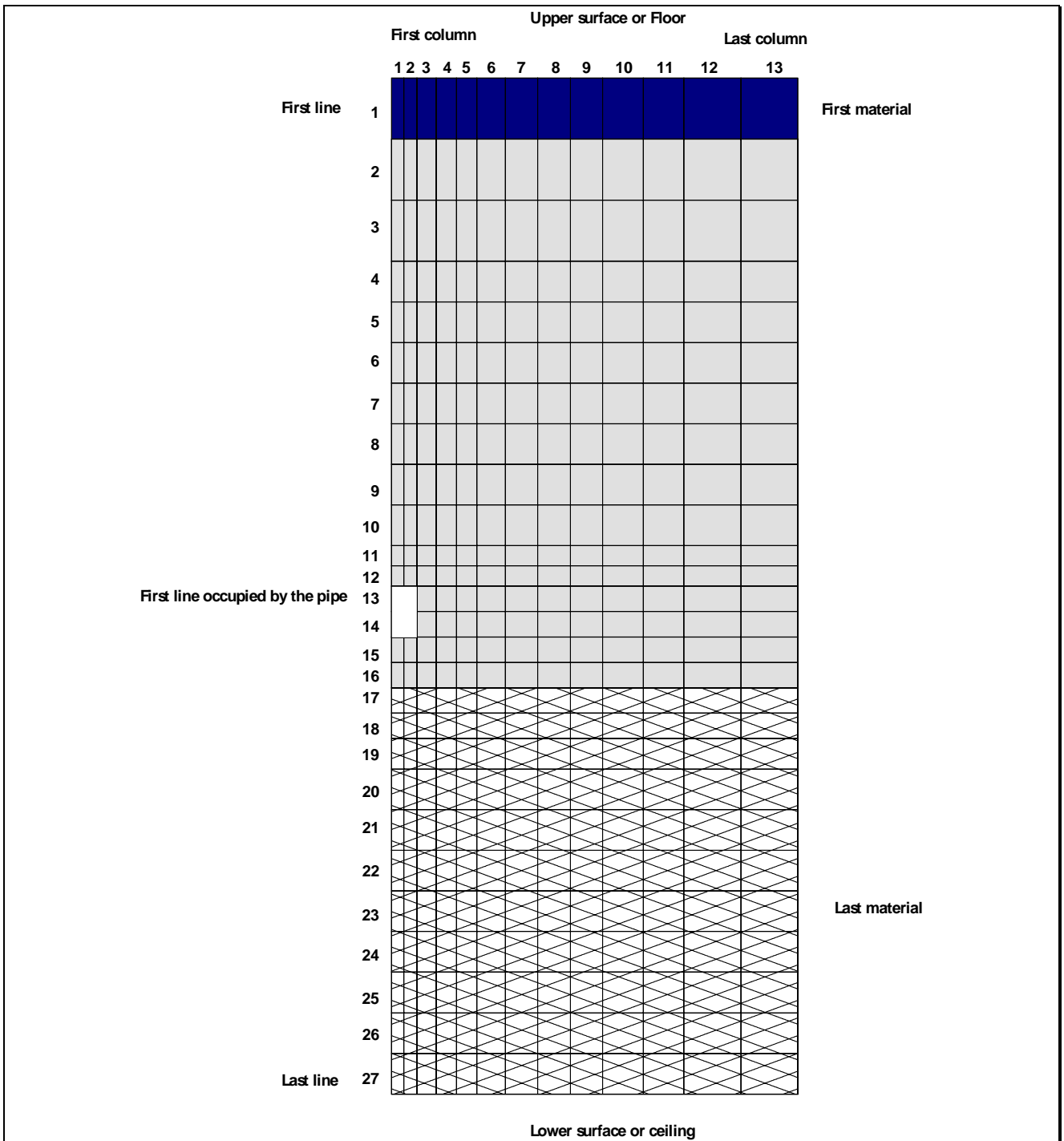


Figure 5 : Description of the representative cross section for example1

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2          Type of calculation
2          Simulation condition
1          Impulsion type
13         Columns number
.30000e+01 Width of the first column (mm)
.32500e+01 Width of the second column
.47500e+01
.50000e+01
.50000e+01
.70000e+01
.80000e+01
.80000e+01
.80000e+01
.10000e+02
.10000e+02
.14000e+02
.14000e+02          Width of the 13th column
27         Line Number
.15000e+02          Height of the first line (Upper Line)(mm)
.15000e+02          Height of the second line
.15000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.50000e+01
.50000e+01
.62500e+01
.62500e+01
.62500e+01
.62500e+01
.62500e+01
.75000e+01
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02
.10000e+02          Height of the 27th line
2          Number of columns occupied by the pipe
2          Number of lines occupied by the pipe

13         First Line occupied by the pipe
3          Number of different materials
.20000e+04 .92000e+03 .15000e+01 1 1      Description of the first material
.24500e+04 .92000e+03 .17500e+01 216
.38000e+02 .92000e+03 .30000e-011727      Description of the third material
.642e+01      Heat transfer coefficient at the upper surface (W/m2.K)
.360e+01      Heat transfer coefficient at the lower surface (W/m2.K)

1800        Timestep between two response factors (s)
1           Number of timestep for the calculation of Response Factors
60          First TimeStep of calculation (s)
216000      Total Duration of calculation (s)

```

Figure 6 : Data of "exemple1.dat" file

Type of calculation : This program calculate Response Factors (1) or Response Factors and Conduction Transfer Function (2). The main advantage of the second type of calculation is to reduce the number of coefficients. With example1, there is 121 Response Factors and only 36 CTF.

Simulation conditions : Response Factors and CTF are calculated with Surface Temperature of the floor and the ceiling (1) or with Ambient Temperature and Heat Transfer Coefficient (2). The

second type of calculation is recommended because Surface Temperature are not uniform with an heating floor.

Impulsion type : For convolutive methods, you can use two type of impulsion : triangle or ramp. With TRNSYS, use the triangle type.

For the materials, the data are :

- specific mass (kg/m^3)
- specific heat (J/kg.K)
- conductivity (W/m.K)
- first line with this material
- last line with this material

Number of timestep for the calculation of Response Factors : In order to reduce processor time, two timesteps can be used : a short one for the beginning of the simulation, and a longer one for the end. Now, with the computer we use, there is no important differences.