Welcome to SIMFLEX Pipe Stress Analysis Studio

This help file contains operation instruction and brief descriptions of the input data.

The details of the input KEYWORDS are shown on <Help> <KeyWords> menu.

This help file and the keywords file can be printed by clicking the <Print HelpFile> button on the <Help> menu.

1. OPERATION INSTRUCTION

In this Studio, everything you need for doing a good pipe stress analysis is located just one Click away.

To start the program, you have to click <Start> button on the <File> menu to specify the file name for the input data. After you have specified the input data file name, the program will assign also the names for output report and plot data. The output file name has an extension .OUT, while the plot file name has .PLT. as extension.

The input data is prepared with windows NOTEPAD program in SIMFLEX Studio. You can prepare the data using any text editor outside the SIMFLEX Studio, but you can only use NotePad with the Studio. This also means, you can also use other text editors in the Studio, but you have to installed it in the same folder as the program, and rename it to "NotePad.exe'.

The input data has to be prepared using only the text mode of a text editor or word processor. All the fancy format characters are not allowed. The tab is not allowed either. Everything is strictly TEXT. Also remember that each line can only input a maximum of 78 characters.

The following is the rough diagram showing the operation of the program :

```
      -----------------------
      !  Prepare Input Data !  Click <Function> <Input-Data>
      -----------------------  or, use any text editor outside the Studio
              !
      -----------------------
      !  Check the data     !  Click <Function> <Check-Data>
      -----------------------
              !
              !   ----------------------
              ! ->! Draw Overall Iso   !  Click <Function> <Plot-Iso>
              !   ----------------------
              !
              !   ----------------------
              ! ->! Draw Segmental Iso !  Click <Function> <Detailed-Iso>
              !   ----------------------
              !
     ------------------------
     !  Analyze the System  !  Click <Function> <Analyze>
     ------------------------
              !
```

```
     -----------------------------
     !  View Results Graphically !  Click <Function> <View-Result>
     -----------------------------
              !
     -----------------------------
     !  Print or View Results    !  Click <Function> <Report>
     !  in tabular text form     !
     -----------------------------
```

Each operation is basically done by an independent program. When you finish one operation, you have to click <File> <Exit> to exit that particular program before you can initiate another functional operation.

The following are details of each function :

```
*************************************************************************
*** For some computers, after the <Function> button is clicked, it will
*** show the Function Heading on the task bar (bottom line of the acreen)
*** but will not open the window. You have to click the heading on the
*** task bar to open the function window
*************************************************************************
```

Input-Data : SIMFLEX adopts Component Oriented Keyword Freeformat Input scheme that not only simplify the input but also allow easy check on the data. The data for a typical piping system all appears on one screen. A complex valve station, for instance, can be described by one single line of data. See Section 2 on this help for details.

For analysts who are new with the program, there is a set of model data which appears on screen to guide you to code a typical system. The model data appears verytime a new data file is requested.

Check_data : The input data are first checked for any error before being sent for analysis. In this data checking phase, two screen of message will be given. The top screen records the operation status, while the bottom screen gives the operation message. This botton screen list the input data echo together with any error messge that may be given to the data. This bottom screen can also be printed for reference, by clicking <File> <Print> button.

The data has to be free of error before the analysis can be performed. However, in most of the casess, the isometric drawing can still be generated even with some data errors. This isometric drawing shall be helpful for correcting the data.

To correct the data, you have to go back to the Input-Data phase.

Overall-Iso : The isometric complete with support symbol, piping component symbols, and valves and fittings is ploted on the screen and printed to a printer. The system can be rotatated in eight (8) different angles, and any local area can be zoomed for deatail.

It is always recommended to print out the isometric to check against the actual, or expected, layout of the system.

Segmental-Iso : The piping system can be divided into multiple segments according to the input sequence. This is the typical method used by piping designers to prepare the stress iso and also fabrication iso. Since the system is divided into segments, it is not required to zoom any local area. Nevertheless, the system can be rotated in eight different angles.

Analysis : After all data are free of errors, you can click <Function> <Analyze> to analyze the piping system. In this phase of operation, again two screens will appear. The top screen shows the operation status, and the bottom screen shows the message. It is always recommended to glance through both screens to make sure that no unusual message is given.

View-Result : The analysis results can be viewed graphically for a quick idea of the situation. The program offers deformed shape and stress profile isometric graph for each load case. These deformed shape and stress profile can be rotated and zoomed as usual.

The most important feature of the program is the Code Stress Compliance Chart. In this chart, sustained stress, occasional stress and expansion stress for every point in the system are charted in comparison with the allowable stresses. A system having several hundred points can have the stress results all shown in one page is really very convenient.

Report : The analysis reports all given in tabular form with units and descriptions properly labeled.

The report can be processed in two ways, continuous, and partial items. The continuous report is available only for printing. It can be printed in any page ranges. The partial items are viewed first on screen. You can then print it if needed.

2. BRIEF DESCRIPTION OF INPUT DATA

The following discusses some basic ideas of input data structure, input procedure, input protocol and keywords, and a sample data file. These are just general ideas. The User's Manual should be consulted for detailed and complete discussions of the capabilities and features.

2.1 Input Data Structure

Input to SIMFLEX consists of lines of texts organized according to the following structure.

```
 ---------------  At least one line of Heading is needed to identify the
 I   HEADING   I  system being analyzed. As many lines as needed can be
 ---------------  entered. The first two lines are printed on each page of
        I         the output report.
        !
 ---------------  After the Heading, at least one line of program options
```

```
  I   OPTION    I  needs to be specified. The options are entered with
  ---------------  OPTION, ......
         I
         !
  ---------------  After the Option, the pipe data are described with
  I    SPIPEn   I  headers SPIPE1, SPIPE2,...., etc. to specify the first set
  ---------------  and second set of pipe data, and so forth. Each pipe can
         I         have more than one line of data.
         !
  ---------------  After the pipe data are the main geometrical data
  I  GEOMETRY   I  describing the situations surrounding each node point. The
  ---------------  data starts with the node number followed by the
         I         descriptions like  25, X=3.1, Z=-3.1, STY, .....
         !
  ---------------  If the rotating equipment load compliance report is needed,
  I  ROTATING   I  the information about the rotating equipment is given in
  I  EQUIPMENT  I  here. The information starts with the header ROT,... for
  ---------------  each equipment.
         I
         !
  ---------------
  I     END     I  An END line is required to conclude the input data file.
  ---------------
```

2.2 Input Procedure

This section uses the piping system described by the model data MDLDATA.SFX as an example to discuss the general procedure of preparing the input data. The model data is the one copied to your input file when you first start a new file name.

a) Define the Piping System : This includes determinations of the scope of the system, pipe material specification, operating conditions, and other special requirements. An isometric sketch has to be prepared.

   (Please run the program starting with any new input data file name. You can then print an isometric drawing from the program for this discussion)

b) Assign Data Points : The first thing you do on this sketch is to assign data points for the system to be analyzed. These points serve in a way similar to our house numbers with which the mail or information can be addressed. Because of the advanced scheme used by SIMFLEX, the node points required are kept to minimum. The following points are required to fully describe a piping system.

   * Terminal Points : ---------------- 5, 25, 60

   * Bend Tangent Intersection Points : 20, 53

   * Branch Intersection Points : ----- 15

   * Key Flange Face Points : --------- 50

   * Support and Restraint Points : --- 10, 55

   * Other points where response information is needed.

These are the minimum points that are required to fully define the geometry of the system. In other words, if any of the point is omitted, the system will not be described sufficiently.

c) Boundary Conditions : It is obvious that the analysis result is only as good as the data. This is even more true in the specification of the boundary conditions. For insatnce, a system with a rigid anchor will create a very different analysis result than the one with a vessel connection. The necessity of accurate boundary condition is also one of the main difficulties in the implementation of direct CAD interface. The following are some of the items need to be considered.

* Stiffness (or Spring Constant) of the Terminal Points: Very often the piping is just cut-off arbitrarily at a covenient point where a mathematical anchor is placed for the analysis. This, of course, is not correct by disregarding the flexibility of the cut_off point. The same thing is true for assuming a rigid vessel connection. Because of the significant flexibility exists at the vessel connection, the analysis will not be accurate if it is assumed as a rigid anchor. The situations at support and restraint locations also have to be investigated. If the support structure is very flexible, then its flexibility has to be included in the analysis.

* Anchor and Support Displacements: The terminal points and support points are normally connected to an equipment which moves during operation due to thermal expansion of the equipment. Earthquake and wind can also cause some movements. These movements have to be determined and included in the analysis.

* Restraint and Guide Gaps: To allow a smooth movement of the pipe and to facilitate construction, it is a standard practice to provide some gaps at restraints and guides during construction. These construction gaps, range from 1/16 to 1/8 of an inch, do not have any significant effect on the analysis results if they are located far away from anchors or equipment connections. These gaps, therefore, can be ignored in the analysis. On the other hand, the gaps will have a very significant effect on the analysis result if they are located close to an anchor or an equipment connection. In this latter case, the gaps together with restraint spring constant have to be accurately included in the analysis.

d) Select Coordinate System : In SIMFLEX, the Y-axis has to be in the vertical direction pointing upward. This is so fixed to simplify the elevation and weight load direction. Besides the Y-axis, the other two axes are normally selected to align with North-South and East-West, or main plant orientation. It is also necessary to decide if the elevation EL is to be used in addition to X, Y, and Z. If the elevation is to be used then the elevation at the first node point has to be specified.

e) Describe the System : The whole input method is given in Section 2.3. Here only the sequence of describing the system will be discussed. You can describe the system from any point, but it is recommended to start from one of the terminal points. This starting point does not have to be an anchor. Once the starting point is selected, you can traverse the system point by point consecutively and jot down all the things encountered along the way. Again, it is recommended that a line be completely traversed before switching to another line or branch. In the model example, we start from point 5, and continue on to the other end at point 25. After the first line is completed, we switch to the other line from point 15 to point 60. It is also important to note that when describing a new branch, you have to start from a point that is already described previously.

2.3 Input Protocol and Keywords

In doing engineering analysis, it is important to ensure that the data fed into the computer is recognizable by both the computer and the people involved. Nowadays, because of the necessity of creating a user friendly environment, the importance of maintaining transparent data is very often ignored. For example, if the program is designed to essentially holding the hands of the engineer to fill in the data, the engineer may very well does not know what is going on in the analysis. This situation is even more critical to a third party who has to review the analysis. Therefore, it is important that the data has a common protocol. It should be readily recognizable by the computer, the analyst, and the reviewer.

SIMFLEX uses a set of common piping language as keywords to describe the system for analysis. For instance ANCHOR means exactly an anchor. The information is entered by the format as follows.

```
Keyword = data
```

Each piece of data, such as coordinate diemnsion and so forth, is entered with a preceding descriptive keyword like X=2.5, etc. X is the keyword describing what kind of data that follows. The equal sign is optional for data consists of only numerals. The equal sign is mandatory if the data consists of any alphabetical characters such as SHAFT=Z. Z is the data meaning in Z-axis direction. Of the keywords, only the first three (3) characters are recognized by the program. The rest of the characters are optional.

Because of the program's broad capability, the available keywords are also numerous. However, for most routine analyses, the following commonly used keywords are sufficient. The input data does not include the units which are implied by the type of data entered. In the following keywords if the data has a unit associated with, the units of corresponding measurement system are enclosed inside a pair of parentheses. The first unit is for English, the second unit for SI-metric, and the third one for gravitational metric systems.

a) Option Data (OPTION) Keywords

- CODE : Specify which code is to be based. 1, 3, 4, or 8 for ASME B31.1, B31.3, B31.4, and B31.8 respectively.
- COMPL : Request to create code stress compliance report. When COMPL is requested, T and W load cases are analyzed automatically.

- M : SI-metric unit to be used. (English is the default unit)
- MG : Gravitational-metric unit to be used.

- UNTOL : Under tolerance allowed in pipe wall thickness from manufacturing process. (%, %, %)

```
W         : Weight plus pressure (sustained) load case requested.
T         : Thermal expansion load case requested.
TW        : Thermal plus Weight plus Pressure load case (T+W) requested.

AX,AY,AZ : Earthquakes in X, Y, and Z directions respectively.(g, g, g)
WX,WY,WZ : Wind Loads in X, Y, Z directions respectively.
             (Lb/ft2, N/m2, kg/m2)

e.g.      OPTION, CODE=3, COMPL, AX=0.3, AZ=0.3, UNTOL=0
```

b) Pipe Data (SPIPEn) Keywords

```
D         : Pipe O.D. (in, mm, mm)
             (-) value means nominal size in inches.
THK=      : Pipe Thick (in, mm, mm)
             or STD, XS, XXS, S20, S30, S40,....., etc.

MATL=     : Material Name in two-character code
             CS for low carbon steel,  SS for austenic stainless steel, etc
CA        : Corrosion Allowance (in, mm, mm)

TEMP      : Temperature (deg-F, deg-C, deg-C)
P         : Design Pressure (psi, kPa, kg/cm2)

SC, SH    : Cold and Hot Allowable Stresses (Ksi, Mpa, kg/cm2)
             Needed for COMPL option.
ITHK      : Insulation Thickness (in, mm. mm)
CSG       : Content Specific Gravity (water=1.0)

e.g.      SPIPE1, D=-6, THK=S40, MATL=CS, TEMP=500, P=200, SC=20, SH=15,
                  CSG=0.67, ITHK=2.5, CA=0.05
```

c) Geometrical Data Keywords

```
X,Y,Z,EL : X, Y, Z coordinate increments and Elevation. (ft, m, m)
             In English unit, ft-in-yy/xx format (2-5-1/2 for instance) can
             also be used.
BR        : Bend Radius of a bend (ft, m, m)
             Default is long radius elbow (bend radius = 1.5 time pipe dia.)

PIPE      : Pipe Number of the SPIPE set to be used.

STX,STY, : Stops in X, Y, Z directions.
STZ          Data is spring constant of the stop (Lb/in, N/mm, kg/mm)
             Default is rigid stop.

LSX,LSY, : Limit Stop Gaps (in, mm. mm). e.g. LSZ(-0.5, 0.75)
LSZ          LSX=-0.5, LSY-, LSY=0.26, etc.
SPRING    : Spring to be selected by the program.
             Can have two data entries : number of springs, and %-variation.
             SPRING=2, means two springs (trapeze).
ANCHOR    : Anchor
REL       : Release the anchor for spring design.
             This will force the spring to take entire weight, instead of
             sharing with the anchor.
```

```
DX,DY,DZ : Anchor or Support Displacement in X, Y, Z directions.
           (in, mm, mm)

TEE,FBR, : Branch Connection (FBR=pad-thick, (in, mm, mm))
WOL        WOL is weld-o-let (integral reinforced branch connection)

e.g.     10, EL=110-5, ANCH, PIPE1, DY=-0.45
         20, X=5-6, BR
```

d) Rotating Equipment (ROT) Keywords

```
COMP     : Compressor, Centrifugal API Std-617
TURB     : Turbine. (NEMA SM-23, Steam Turbine Drive)
PUMP     : Pump. (API Std-610, Centrifugal Pump)
SHAFT=   : Shaft Orientation. X, Y, or Z
NOZZ     : Nozzle Point (up to six nozzles can be specified)
           Nozzle point has to be a rigid / non-rigid interface. Inside
           equipemnt is zero weight rigid. outside is non-rigid including
           flange or valve.
NRESL    : Resolve point for combined loads
FACTOR   : Allowable load factor. Default is 1.0

e.g.     ROT, PUMP, NOZ=15, NOZ=45, NRESL=30, SHAFT=X
```

2.4 Input Example

The following model example is used for a comprehensive line by line explaination of the data.

```
SIMFLEX MODEL INPUT DATA
ABC REFINERY, S-1234 STAEM LINE .....
*******
OPTION, CODE=3, COMPL, W, T, UNTOL=12.5, WX=45, WZ=45
*******
SPIPE1, D=-8, THK=S40, MATL=CS, TEMP=500, P=300, ITHK=2, CSG=0.0
        SC=20, SH=18, CA=0.05
SPIPE2, D=-6, THK=STD, MATL=CS, TEMP=350, P=300, ITHK=2, CSG=0.0
        SC=20, SH=18, CA=0.05
*******
5,  ANCH, EL=120-5, PIPE1, DX=0.145
10, X=10, STY
15, X=5-6, TEE
20, X=5, BR
25, Z=10, ANCH, DY=0.15, DZ=0.23
*******
** 6-inch Branch
*******
50, FROM=15, Y=3-2, WNF, +FGTV, +WNF, PIPE2
53, EL=131-10-5/8, BR
55, Z=-3-2, SPRING
60, Z=-12.3, ANCHOR, DY=1.2
END
```

The data follows "Heading", "Option", "Pipe Data", "Geometry", "Rotating

Equipment" and "End" sequence.

The first two lines are "Heading" describing the piping system being analyzed. You can have as many lines of heading as you want.

In SIMFLEX data, the lines start with an asterisk (*) at the beginning are comment lines. These lines are for your own reference only. They are ignored by the program.

After the heading are "Option" data. The data starts with OPTION followed by program options to be used. The first entry is CODE=3 which means that ASME B31.3 "Chemical and Refinery" code shall be used. The program default is B31.1. COMPL requests the program to generate a code stress compliance table. W is for weight plus pressure load case, and T is for thermal expansion load case. Actually, if COMPL is requested, the program will automatically include W and T. Here we just explicitly specify them for clearness. UNTOL=12.5 means the manufacturing under tolerance is 12.5 percents which is typical for seamless pipes. This 12.5% UNTOL needs to be included in wall thickness calculations. The analysis also includes two directions of wind loads specified by WX and WZ. Each direction has the magnitude of 45 Lbs/ft2. These loads will apply on the projection area of the outer surface of the pipe including insulation. The analysis uses default English unit. If the metric unit is to be used, it has to be specified (M or MG) in this OPTION.

If the list of options is longer than a line (78-characters) can accommodate, just put them in the next line or lines. However in doing so you have to make sure that each keyword and its data have to be on the same line.

The piping system uses two different sets of pipe data. The first set, represented by SPIPE1, is for the main line which is an 8 inch schedule-40 low carbon steel pipe. D normally means outside diameter in corresponding units. However, if the data is preceded with a minus (-) sign, then it means nominal pipe size in inches. D=-8 means 8 inch nominal size. This is the same as D=8.625 in English unit. THK= normally means nominal wall thickness in corresponding units, but the schedule numbers (S20, S40,..) and weight designations (STD, XS, XXS) can also be used in any of the units. The equal (=) sign after the kweyword is mandatory here. CA is the corrosion allowance. If UNTOL is not specified in OPTION, then this CA shall also include the manufacturing under tolerance. If neither UNTOL nor CA is specified, the program uses a default value of 12.5% of THK as the total allowance. CSG is the content specific gravity. Here, we specify CSG=0.0 meaning the weight of the content (steam) is negligible. CSG is defaulted to zero, so this CSG=0.0 data is optionsl. (CSG=1.0 for water).

The second set of pipe data (SPIPE2) is for the branch line which is a 6 inch low carbon steel pipe. The temperature is 300-F in this analysis. It should be noted, however, that the pipe may also operate at 500-F under certain situations. This 500-F condition can be analyzed in a separate analysis. However, a more sophiticated approach would include both situations in the same analysis so proper stress range and spring hanger range can be determined Please refer to User's Manual for data setup for analyzing multiple operating conditions. The hot allowable stress SH=18 corresponds to the 500-F maximum operating temperature.

The description of the geometry starts with point 5 which is specified as an ANCHOR. In this analysis, all three terminal points are specfied as anchors. If any of them is connected to a vessel or other type of flexible connections, it should be modified accordingly. Please refer to User's Manual on how to specify a vessel connection and others. This first point is located at elevation 120'-5". This elevation coordinate data at this first point is mandatory if you want to use elevation coordinates to describe the system. First set of pipe data is used in the beginning as called by PIPE1 (PIPE=1) entry. Please note that when a PIPEn is specified, this set of data is to be used starting from the element which ends at this point. Point 5 has a 0.145" movement in plus X-direction. This movement is normally due to expansion of the connecting equipment.

The next point is 10. There is a stop in Y-direction. The data for STY is spring constant (Stiffness) of the stop, such as STY=45000, etc. If no data is specified, it defaults to rigid (very stiff).

Point 15 is 5'-6" away from previous point, 10, in the X-direction. This is another way of specifying the coordinate in English unit. It is the same as X=5.5 feet. This point is a branch connection specified by TEE (welding tee). Other types of connection such as WOLT (weld-o-let), FBR (frbricated branch) and so forth shall be specified if appropriate.

Point 20 is a bend tangent intersection point. The X=5 distance from previous point 15, is to the tangent intersection. Since this point is not actually located at the pipe, it serves only as an input reference point. In actual analysis it is replaced by 10A and 10B located at the beginning and ending points of the bend. BR specify the Bend Radius, at the same time signifies that it is a bend intersection point. If no data is given for BR, then it defaults to a long radius elbow whose bend radius equals to 1.5 times the norminal pipe diameter. In this case BR is the same as BR=1.0 feet for 8-in pipe.

Point 25 is another terminal point specified as rigid anchor. There are movements in Y- and Z- directions. This point concludes the description of the main line.

The first point at the branch line is 50. Since the point is not connected to the point described immediatly before, a from point has to be specified. FROM=15 tells the program that the new branch starts from point 15 which must be a previuosly described point. Point 50 is located at one of the flange face which is located at 3'-2" from point 15 in Y-direction. There are one flange, one valve, and another flange connected to this point. These components are described by giving the keywords one by one in sequence. It starts with a welding neck flange WNF, followed by a flanged gate valve +FGTV, and another welding flange +WNF. The plus (+) sign preceding the keyword means that the component is located after the node point. The program will automatically determine the length and weight of the component, and include them in the analysis.

In point 55, we request the program to select a spring support. A spring support is needed, if a significant vertical displacement is expected. The program will select a spring based on the weight and displacement expected. The spring can be selected according to the catalog of the vendor specified in the OPTION. If no vendor is specified, Grinnell's catalog will be used. Also the spring is selected based on 15% allowable load variation. If other variation is desired, it should be specified. For instance, SPRING=(1, 25) means 1 spring at 25% load variation.

The example does not include rotating equipment load compliance.

Finally, an END line is required to conclude the input data.