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**Vortex-Induced Vibration Analysis  
Marine Riser Software**

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**User’s Manual  
DOS Version 8.4**

Preface and Copyright

This program package includes VIVA version 8.4 and VIVARRAY version 8.3, which have been re-structured to be an open-access code with the option to use a standard database or a user-specified hydrodynamic database. A three-dimensional incoming current can be specified. The present manual replaces all previous versions (versions 8 and earlier). There are two preparatory programs: *risprep-v8.f* and *ris6-v8.f* for VIVA, which handles a single riser; and two preparatory programs *risprep-vv81.f* and *ris6-vv81.f* for VIVARRAY, which handles two interfering risers, the front (F) and rear (R) risers. There are two programs: *viva-v84.f* for a single riser and *vivarray-vv83.f* for two risers.

The programs described herein have been tested using experimental data and other numerical results. Modifications, however, may be deemed necessary in the future, as experimental and numerical verification continues, which will be communicated in writing to all users. Any problems should be communicated in writing to:

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The copyright of the programs remains with Drs. Michael Triantafyllou and George Triantafyllou. Duplication or distribution of the computer codes, in any form, is not permissible without written permission. The use and interpretation of the results of the programs remains the exclusive responsibility of the user.

August 2015

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# Introduction

VIVA and VIVARRAY are software analysis tools created to study vortex-induced vibrations (VIV) in marine riser applications. The programs are based on an extensive database of VIV experimental results conducted by Professor Michael Triantafyllou at Massachusetts Institute of Technology (MIT) on smooth cylinders, straked cylinders and riser-like sections (modeling choke & kill lines). The software allows three-dimensional analyses of both rigid drilling risers and SCR or lazy-wave risers in current profiles specified by the user. VIVA is for a single riser and VIVARRAY is for two interfering risers, one designated as the front (F) riser and another as the rear (R) riser, subjected to an oncoming variable current.

This manual covers the file structure and analysis procedure in Section 2, coordinate systems and conventions in Section 3, required input in Section 4, and program output in Section 5. Several example problems are described in Section 6.

Updates in Version 8.4 include:

* A new multi-frequency algorithm is implemented that makes VIVA better suited for sheared current profiles as measured in the field, especially the Gulf of Mexico (GoM) current profiles;
* A new fatigue subroutine has been prepared that allows the user to specify single or two-slope fatigue curves, which can be different for each segment of the riser (not applicable to VIVARRAY yet);
* The user can choose between modal damping (damping increases with mode number), or constant damping (all modes have the same damping) for a single riser or two interfering risers. The choice is made in the file *conditions.in* or *conditionsF/R.in* (no need for the separate file *damping\_type.in*;
* The multi-mode option is standard, so no choice is needed in *conditions.in* or *conditionsF/R.in*;
* The output file *summ.out* for single riser and *summF/R.out* for two risers has been streamlined to provide both single and multi-frequency data;
* A change that is important only for those using other software to prepare the input for VIVA, there is no need for VIVA to read the file *rispre.in* or *rispreF/R,in*, the data must be appended at the end of *dyn-n.dat* or *dyn-nF/R.dat*;
* For externally specified modes, the curvature natural modes are also needed, in addition to the displacement modes;
* Use a new high Reynolds number database (change in file *no\_files.in*);
* Predict high harmonic stresses and calculate fatigue life based on first and third harmonic (need standard input files *free.in* and *forced.in*, which are provided as part of VIVA and VIVARRAY); and
* VIVA can be configured to calculate inline vortex-induced vibrations. It must be noted that it will not calculate the combined inline and cross-flow responses, only the inline responses and the fatigue damage. The database used is *basic\_bare-inline* instead of *basic\_bare.db*, an example is included in the installation package.

# File Structure & Analysis Procedure

The software package includes VIVA version 8.4 and VIVARRAY version 8.3, which are set up in a modular format. The programs must be run sequentially in order to create the necessary intermediate files for input to the next module. The run order for VIVA is *risprep-v8.exe*, *ris6-v8.exe*, and finally *viva-v84.exe*, and the run order for VIVARRAY is *risprep-vv81.exe*, *ris6-vv81.exe*, and finally *vivarray-vv83.exe*. Two batch files, *RunVIVA.bat* and *RunVIVARRAY.bat*, have been created to aid users with these procedures. After all user-input files for a specific project have been created, the user should type **RunVIVA** for a single riser or **RunVIVARRAY** for two risers at the DOS prompt to begin the analysis, or double click the icon of *RunVIVA.bat* or *RunVIVARRAY.bat* in *Windows Explorer*. Table 2.1 provides a schematic chart of the required input files and the running sequence for a complete single riser VIV analysis. The required input files and the running sequence for a two riser VIV analysis are similar and are described in Table 2.2.

The user must define the problem with input files describing the riser configuration, current profile, fatigue curves, boundary conditions, etc. These files are then used in conjunction with the database files from the experimental test results to complete a VIV analysis run. Output is then generated in files as listed in Table 2.1 and Table 2.2.

Table 2.1 VIVA File Structure and Analysis Procedure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Input Files  Prepared by User | Input Files from Previous Step | Standard  Database | Programs  *RUNVIVA.bat* | Output Files |
| *rispre.in* |  |  | *risprep-v8.exe* | *risout.dat*  *risout.out* |
| *risdyn-n.in*  *vivo-n.in*1 | *risout.dat* |  | *ris6-v8.exe* | *dyn-n.dat*  *dynout.out* |
| *no\_files.in*  *conditions.in*  *risfat.in*  *freq.in*1  *mode\_us.in*1  *curv\_us.in*1  *visc-def.in*1  *hydro-data*2 | *dyn-n.dat* | *basic\_bare.db*  *out1.db*  *out2.db*  *out3.db*  *out4.db*  *out5.db*  *out6.db*  *out7.db*  *basic\_bare-hr.db*  *out\_s.db*  *free.in*3  *force.in* 3  *basic\_bare-inline*4  *basic\_bare-sche5*  *basic\_bare-076*  *basic\_bare-146*  *out\_hr.in7* | *viva-v84.exe* | *bend.out*  *bend\_mm.out*  *cdrag.out*  *cdrag\_mm.out*  *clv\_dom.out*  *fat.out* (*fat1.out*)  *fat\_h3.out* (*fat1\_h3.out*)  *fat-mono.out*  *fat-mono\_h3.out*  *fat-multi.out*  *fat-multi\_h3.out*  *freq.out*  *out.out*  *out\_mm.out*  *strain.out*  *strain\_mm.out*  *summ.out* (*summ1.out*)  *summ\_mm.out* (*summ1\_mm.out*)  *summary.out* |

Table 2.2 VIVARRAY File Structure and Analysis Procedure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Input Files  Prepared by User | Input Files from Previous Step | Standard  Database | Programs  *RUNVIVA.bat* | Output Files |
| *rispreF* / *R.in* |  |  | *risprep-vv81.exe* | *risoutF* / *R.dat*  *risoutF* / *R.out* |
| *risdyn-nF* / *R.in*  *vivo-nF* / *R.in*1 | *risoutF* / *R.dat* |  | *ris6-vv81.exe* | *dyn-nF* / *R.dat*  *dynoutF* / *R.out* |
| *no\_files.in*  *conditionsF* / *R.in*  *risfatF* / *R.in*  *freqF* / *R.in*1  *mode\_usF* / *R.in*1  *curv\_usF* / *R.in*1  *visc-defF* / *R.in*1  *hydro-data*2 | *dyn-nF* / *R.dat* | *basic\_bare.db*  *out1.db*  *out2.db*  *out3.db*  *out4.db*  *out5.db*  *out6.db*  *out7.db*  *basic\_bare-hr.db*  *out\_s.db*  *free.in*3  *force.in* 3 | *vivarray-vv83.exe* | *bendF* / *R.out*  *bend\_mmF* / *R.out*  *cdragF* / *R.out*  *cdrag\_mmF* / *R.out*  *clv\_dom F / R.out*  *fatF* / *R.out* (*fat1F* / *R.out*)  *fat\_h3F* / *R.out* (*fat1\_h3F* / *R.out*)  *fat-monoF* / *R.out*  *fat-mono\_h3F* / *R.out*  *fat-multiF* / *R.out*  *fat-multi\_h3F* / *R.out*  *freqF* / *R.out*  *outF* / *R.out*  *out\_mmF* / *R.out*  *strainF* / *R.out*  *strain\_mmF* / *R.out*  *summ.outF* / *R* (*summ1F* / *R.out*)  *summ\_mmF* / *R.out* (*summ1\_mmF* / *R.out*)  *summaryF* / *R.out* |

Notes:

1. Optional input files.
2. *hydro-data* refers to the entire hydrodynamic database, which is user specified, except for a single file, *basic\_bare.db*, which is the fallback database (bare cylinder data). The number of files and name are all specified in the input file *no\_files.in*.
3. Additional database files for providing high-harmonic data.
4. New database file for in-line VIV responses.
5. New database file for high Reynold’s number cases in the GoM sheared current profiles.
6. New database files for the GoM sheared current profiles with subcritical Reynold’s number. The file *basic\_bare-07* is less conservative than *basic\_bare-14*.
7. New database file for high Reynold’s number cases.

**Additional Notes on the Program Use:**

1. Number of Points for Calculations: Note that up to 6001 equidistant points may be used for numerical calculations. Make sure that at least three points are included in each segment, particularly in cases where small segments are used, like when representing a flexible joint. It is best to reduce the number of segments, if needed, to ensure adequate resolution. Consult with M. Triantafyllou for further advice.
2. Maximum Number of Point for Calculations: If familiar with FORTRAN language, you can increase the maximum number of points up to 6001.
3. Running Time: When VIVA calculates natural frequencies and modes, the execution time depends on the third power of the number of points used. For example, doubling the number of points means 8-times longer running time. When the natural frequencies are input externally (calculated by a different software, such as a finite element code), then the time of execution is almost linearly varying with the number of points. Hence, if you run the program for several velocity profiles but with the same top tension and the other material properties, it is best to run it once in the beginning with internally calculated frequencies and modes, and then store the results to use them as input for the remaining cases, as externally input modes. This will reduce the running time greatly, especially when a large number of points is needed.
4. Basic Hydrodynamic Database to Use: The program always requires a standard database for a smooth cylinder (for other riser sections consult the manual, but note that the smooth cylinder database must always be present and specified in *no\_files.in*). The file *basic\_bare.db* is the standard file for subcritical Reynolds numbers, accounting for in-line motion effects. It is a conservative approach, always assuming the worst case scenario for the effect of in-line motion. It has been extensively tested against uniform and linearly sheared profiles in subcritical Reynolds number. The file *basic\_bare-07* has been tested with GoM sheared profiles and is less conservative than *basic\_bare-14* for subcritical Reynold numbers. The *basic\_bare-hr.db* is a conservative high Reynolds number file. The file *basic\_bare-sche* has been tested for high Reynolds number cases in the GoM sheared profiles.
5. Riser-Soil Interaction: You can model the riser-soil interaction by specifying a number of distributed linear springs and linear dashpots.

# Coordinate Systems and Conventions

## Coordinate Systems

### Global coordinate system

The global orthogonal system (*OXYZ*) (Figure 3.1) has the origin, *O*, fixed on the bottom end of the riser or the front riser in the two riser case. Usually this is the touchdown point, but in some occasions when springs and dampers are used to model the riser/soil interaction, it can be an arbitrary point of the riser lying on the floor.

The *X* axis is pointing vertically upwards. The *Y* and *Z* axes can be arbitrary in principle. For example, the *Y* axis can be chosen as the one pointing “downstream”. This has absolute meaning only when the current is unidirectional; then the *Y* component is nonzero, while the *Z* component is zero.

### Local coordinate system

When the riser is inclined, we specify a local coordinate system (*oxyz*) at each point of the riser. The direction *x* is tangential to the local riser configuration (when the riser is vertical *x* coincides with *X*). The *y* and *z* coordinates are defined according to the case considered. When the riser is vertical *y* coincides with *Y* and *z* with *Z*. Figure 3.1 depicts a special case with the riser in the *XOY* plane. Figure 3.2 shows a more general case, where the *y* axis is defined to parallel the *XOY* plane

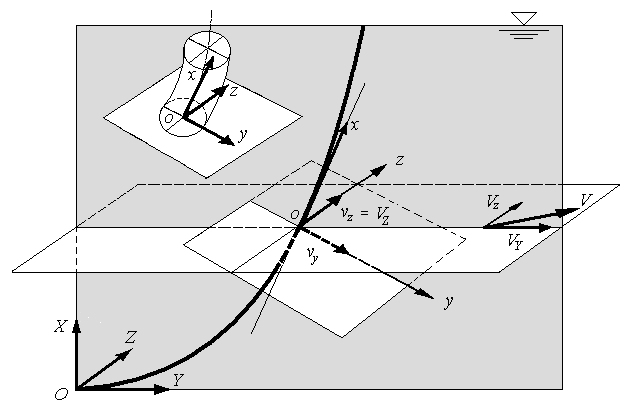


Figure 3.1 Coordinate System

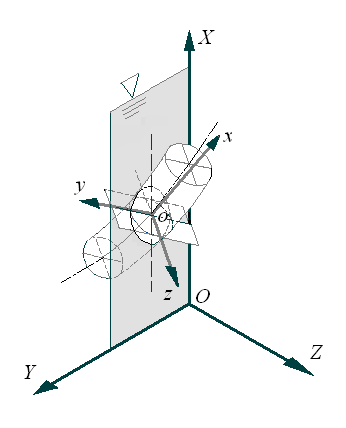


Figure 3.2 Local Coordinate System

## Current Decomposition

The program requires two current components to be specified at each point. We distinguish three cases of increasing complexity:

### Vertical, straight-rigid riser

For this case, the local system (*xyz*) coincides with the global system (*XYZ*), hence specify the current along two perpendicular horizontal directions, one along the *Y* axis and the other along the *Z* axis. It is advisable to consider the *y* direction as the “downstream” direction and the *z* direction as the “transverse” direction, although in principle it does not make any difference.

The simplest case is for a unidirectional current. Then you specify the nonzero current velocity along the *y* axis, and set the *z* component equal to zero.

### Curved riser, static configuration co-planar (two-dimensional)

When the riser is curved but the static configuration is contained within a plane, then one must specify the velocity components in a plane perpendicular to the local riser axis.

There are still three cases to distinguish:

1. The static configuration is contained within the *x*o*y* plane. Then the *z* component of the velocity remains the same as the *Z* component of the current, while the *y* component of the current is equal to the *Y* component times the cosine of the inclination angle (zero inclination angles means vertical riser). See Figure 3.1.
2. The static configuration is contained within the *x*o*z* plane. Then the *y* component of the velocity remains the same as the *Y* component of the current, while the *z* component is equal to the *Z* component times the cosine of the inclination angle (zero inclination angles means vertical riser).
3. The static configuration is not contained in the *xoy* plane nor the *xoz* plane. Rotate the coordinate system so you fall under case (1) or (2) above.

In summary, we consider the riser curvature to lie entirely within either the *XOY* plane or the *XOZ* plane.

### Curved riser, static configuration three-dimensional

The program is not strictly valid for this case, because the decomposition of the riser response into two perpendicular planes, even within the linear regime, is not valid. One may argue that the coupling terms are small and proceed with providing the velocity components along perpendicular directions.

Now we define at each point of the riser a plane perpendicular to the local riser centerline configuration (plane *yoz* as shown in Figure 3.2). The *x* axis is tangent to the riser configuration and two Euler angles are needed for its precise definition. To avoid having to deal with internal calculations with Euler angles, we ask the user to specify the current velocity components along the local *y* and *z* directions. The *z* direction is defined as the intersection of the *XOZ* plane and the plane *yoz* normal to the riser. The *y* direction is defined as perpendicular to the axis *z*, contained within the normal plane *ABC*. The system must be right-handed, so the choice of *y* is determined by the consideration that if the riser is vertical *y* must coincide with *Y*.

# Data Preparation and Input Files

## *rispre.in*, *rispreF.in* and *rispreR.in*

*Rispre.in* is the input file to *risprep-v8.exe*, and *rispreF.in* and *rispreR.in* are the input files to *risprep-vv81.exe* for the front and rear riser, respectively. The riser space-out, mass properties, segment characteristics, and type, rigid riser or SCR riser, are specified in these files according to Table 4.14.1. An example is included below:

Table 4.1 Format of *rispre.in*, *rispreF.in* and *rispreR.in*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line | Name | Description | Remarks | |
| 1 | FILENAME | Output File Name - User Specified | Enclosed in ' ', 6 characters long, e.g. ‘RISOUT’ | |
| 2 | NSEGM | Number of Segments in Riser | Maximum 1,200 | |
| Repeat 3-13 for each riser segment (I = 1 to NSEGM), starting from the bottom end of the riser towards the top end | | | | |
| 3 | RLEN(I) | Length of Segment [m] |  | |
| 4 | RMAS(I)1 | Mass per Length [kg/m], | Include riser pipe and content, auxiliary line pipe and content, and buoyancy module, etc. | |
| 5 | AMAS(I)1 | Added Mass per Length [kg/m] | ≈ cross-sectional area × density of water | |
| 6 | WEIGH(I)1 | Weight in Water per Length [N/m] | Include riser pipe and content, auxiliary line pipe and content, and buoyancy module, etc. | |
| 7 | DI(I) | Drag Diameter [m] | Normally the buoyancy module diameter, or the outer diameter of bare joints | |
| 8 | DIP(I), THICK(I) | Pipe Diameter [m], Wall Thickness [m] | Both on the same line separated by a space/tab | |
| 9 | E(I) | Bending Stiffness, *EI* [N-m2] | Effective bending stiffness that may include contribution from auxiliary lines | |
| 10 | NTYPE2 | Riser Surface Type | 7: fitted with strakes | 8: fitted with fairings |
| 1: otherwise |  |
| 11 | HTD(I)3 | Strake Height to Diameter Ratio | Only when NTYPE=7, otherwise omit this line. ICHAR(I) = 1 | |
| 12 | THIC(I), CHORD(I) | Fairing Thickness [m], Fairing Chord Length [m] | Only when NTYPE=8, otherwise omit this line. Input on the same line. ICHAR(I) = 1 | |
| 13 | ICHAR(I)4 | Riser Cross Section Type | Using Standard VIVA Database  1: smooth cylinder  2: Vetco riser 0 deg  3: Vetco riser 30 deg  4: Vetco riser 60 deg  5: Vetco riser 90 deg  6: Vetco riser 120 deg  7: Vetco riser 150 deg (see Figure 4.1)  8: staggered buoyant-bare (Default 1:3 ratio, with buoyancy module diameter on Line 7)  9. high-Re data from VIVA JIP  10 straked riser (3 strakes with *h*/*D* = 0.2 and *P*/*D* = 17). NTYPE = 1 | |
| 14 | ICHOICE5 | Riser Type | 1: Rigid riser  2: SCR or lazy-wave riser  (with additional input in *vivo-n*; or *vivo-nF* and *vivo-nR* files) | |

0°

90°

Local Current

Current

Figure 4.1 VETCO Riser Section

Notes:

1. Metric units are used in this program. The following are two riser joint examples to explain how to prepare and convert joint data from English units.

Given

*ρs* = steel density = 489.02 lbm/ft3  
*ρb* = density of buoyancy module = 51.17 lbm/ft3  
*ρm* = mud density = 15 ppg = 1.8 s.g. = 112.3 lbm/ft3  
*ρw* = density of sea water = 64 lbm/ft3

75’ × 21”OD × 5/8”thk Bare Joint

Mass =  (212 – 19.752) / 144 × 489.02 = 135.86 lbm/ft = 202.6 kg/m  
Displacement =  (212 – 19.752) / 144 × 64 = 17.8 lbm/ft = 26.5 kg/m

Wet Weight = 202.6 – 26.5 = -176 kg/m = -1725 N/m

50.5”OD Buoyancy Module

Mass =  (50.52 – 212) / 144 × 51.17 = 588.7 lbm/ft = 877.6 kg/m  
Displacement =  (50.52 – 212) / 144 × 64 = 736.3 lbm/ft = 1098 kg/m

Wet Weight = 877.6 – 1098 = -220 kg/m = -2157 N/m

15 ppg Mud

Mass =  19.752 / 144 × 112.3 = 239 lbm/ft = 356.3 kg/m

Displacement =  19.752 / 144 x 64 = 136.2 lbm/ft = 203 kg/m  
Wet Weight = 356.3 – 203 = 153.3 kg/m = 1502 N/m

Added Mass of the Bare Joint

Added Mass =  212 / 144 × 64 = 154 lbm/ft = 230 kg/m

Added Mass of the Buoyant Joint

Added Mass =  50.52 / 144 × 64 = 890 lbm/ft = 1327 kg/m

Input Data for the Buoyant Joint with 15-ppg Mud

RMAS = 202.6 + 877.6 + 356.3 = 1436.4 kg/m  
AMAS = 1327 kg/m  
WEIGH = 1725 – 2157 + 1502 = 1070 N/m

Input Data for the Bare Joint with 15-ppg Mud

RMAS = 202.6 + 356.3 = 558.9 kg/m  
AMAS = 230 kg/m  
WEIGHT = 1725 + 1502 = 3227 N/m

1. NTYP=1 except when "typical strakes" or "typical fairings" are to be used – these use data from the literature, which are not very detailed – to use detailed strake data see below

NTYP=7 then typical strakes are used -- in this case add a line below the line of NTYP providing the height/diameter ratio, also specify ICHAR=1

NTYP=8 then typical fairings are used -- in this case add a line below the line of NTYP providing the thickness/diameter ratio and chord/diameter ratio, also specify ICHAR=1

1. Vortex-Suppressing Strakes:

Basic parameters for strakes are their pitch, *P*, and height, *h*. The height is measured perpendicular to the surface of the riser.

Data used in the program for standard strake configuration (NTYPE = 7) are valid for pitch to diameter ratios, *P/D*, larger than 4, up to a value of 20, preferably in the range of 5 to 8; and height to diameter ratios, *h/D*, larger than 0.05, preferably in the range of 0.06 to 0.15. The user is allowed to specify the value of the height to diameter ratio *h/D* or HTD in the program. A previous restriction of the program that no longer applies is that if more than one segment has strakes, they must all have the same height to diameter ratio.

If the strake configuration is close to the tested one (3 strakes with *h*/*D* = 0.2 and *P*/*D* = 17), I\_CHAR may be input as 10 to allow the program to use the hydrodynamic data from experiments. In this case, NTYPE must be entered as 1 with no HTD input.

1. ICHAR=1 if a standard bare cylinder is to be used -- always supply an external file *bare\_basic.db*

ICHAR=2, 3, 4, 5, 6, 7, 8 if VETCO risers (bare with 4 kill and choke lines) are to be used, 2 for an angle of attack of 0 degrees, 3 for 30 degrees, 4 for 60 degrees, 5 for 90 degrees, 6 for 120 degrees, and 7 for 150 degrees.

ICHAR=8 for staggered buoyancy-bare pipe.

ICHAR=9 for high Reynolds number data from the database “*basic\_bare-hr.db*”.

ICHAR=10 for straked riser with pitch/diameter=17, and height/diameter=25%.

1. ICHOICE=1 for straight riser

CHOICE=2 if the riser is curved or has an unusual static shape. The user must then give the static solution externally in a file called *vivo-n.in*, *vivo-nF.in* or *vivo-nR.in*

## *risdyn-n.in*, *risdyn-nF.in* and *risdyn-nR.in*

The VIVA dynamics program requires *risdyn-n.in* as input to *ris6-v8.exe*. VIVARRAY requires *risdyn-nF.in* for the front riser and *risdyn-nR.in* for the rear riser as input to *ris6-vv81.exe*. The files specify the current profile, riser top tension, and various numerical calculation parameters. Additionally, the files specify the top horizontal positions (*Y*, *Z*) in global coordinates for the front and rear risers in the VIVARRAY analyses. Table 4.2 provides the data input format.

Table 4.2 Format of *risdyn-n.in*, *risdyn-nF.in* and *risdyn-nR.in*

|  |  |  |  |
| --- | --- | --- | --- |
| Line | Name | Description | Remarks |
| 1 | FILENAME1 | Output File Name | Enclosed in ' ', 6 characters long, e.g. ‘*RISOUT*’ |
| 2 | FILENAME2 | Output File Name | Enclosed in ' ', 6 characters long, e.g. ‘*DYNOUT*’ |
| 3 | TENUP | Riser Top Tension [N] | 0 for free-standing riser |
| 4 | NP | Number of Points along riser | Points number in analysis. Minimum 200, maximum 6,001. |
| 5 | ITMAX | Maximum Iterations | Minimum 30 |
| 6 | NV | Number of Current Data | Maximum 200 |
| For each point from I = 1 to NV, repeat line 7 to specify the current profile from the top of the riser to the mudline (depth measured positive down from WL, i.e. riser portion above the water line has negative depth, see note 1 for example): | | | |
| 7 | XV(I), VY(I), VZ(I)1 | Depth [m], Velocity *Y*-Component [m/s], Velocity Z-Component [m/s] | Current velocity can be positive or negative.  For Definition of coordinate system, see Figure 3.1. |
| 8 | RHO | Water Density [kg/m3] | Typically 1025 kg/m3 |
| 9 | ZETA2 | Damping Ratio | Generally 0.01 to 0.07, see comment below |
| 10 | NO\_SPRI | Number of Intermediate Lateral Supports |  |
| For each lateral support from I = 1 to NO\_SPRI, repeat line 11 from the uppermost support to the bottom. | | | |
| 11 | X\_SPRI(I), C\_SPRI(I), B\_SPRI(I) | Distance along riser [m].  Spring constant [N/m].  Damper constant [N-sec/m]. | The distance is measured along the riser from the top end. |
| 12 | Y, Z3 | Distance of the top of the riser in the horizontal plane from the origin *O* fixed on the bottom end of the riser | *Y* and *Z* in global coordinates, only for VIVARRAY |

Notes:

1. Riser Segment above Water:

For the section of the riser above the waterline, a 0 knot current velocity must be inputted at a point **just** above the waterline and at the top of the riser. For example, a 110 m long straight-vertical riser in 100 m of water depth and a constant 1.0 m/s current profile would be entered as follows:

Depth [m] Velocity *Y* [m/s] Velocity *Z* [m/s]

-10.00 0.0 0.0  
 -0.01 0.0 0.0  
 0.00 1.0 0.0  
 100.00 1.0 0.0

1. ZETA, Structural Damping:

The user must specify the structural damping as a fraction of the critical damping of the system. Typically the damping is in the range of 0.01 to 0.07 (1% to 7% critical). Trends are as follows:

* For a uniform flow, this parameter may play a very significant role in the drag amplification and must be evaluated accurately.
* For shear flows, the role of critical damping is significantly less important.

An estimate of the importance of the structural damping can be found from the parameter *Q*:

 [4.1]

where

*St* - Strouhal Number, take 0.17  
*ρc* - density of pipe material (usually steel)  
*ρw* - density of water

*Q* is the ratio of the structural over the hydrodynamic damping, hence some general trends for the parameter are:

* If *Q* ~ 1.0 (or higher), *ζ* is very important
* If *Q* << 1.0, *ζ* does not have a large effect
* The higher the shear flows, structural damping is less important

1. *Y* and *Z* (only for VIVARRAY)

This specifies the position (*Y*, *Z*) at the top of the riser in the horizontal plane from the global origin *O* (usually *Y* is in the direction of the surface current and *Z* traverse to it). *Y* shows how far downstream the top of the riser is from the origin and *Z* how far traversed at the top. These quantities are very important for the interaction studies. This input is mandatory for the vertical risers where *vivo-n* files are not required. In the case of curved risers, the *vivo-n* files are used to specify the relevant position along the water depth, the *Y* and *Z* coordinates here will be superseded.

## *vivo-n.in, vivo-nF.in* and *vivo-nR.in* (required only for SCR / Lazy-Wave Riser option)

The SCR or lazy wave riser static configuration must be supplied by the user to *ris6-v8.exe* or *ris6-vv81.exe* when ICHOICE is inputted as 2 in file *rispre.in*, *rispreF.in*, or *rispreR.in*. For catenary risers, the portion of the riser on the ocean floor from touchdown point to the well is truncated in general, although this portion may be modeled with a series intermediate lateral supports. The file *vivo-n.in* or *vivo-nF.in* and *vivo-nR.in* should be created according to Table 4.3. A graphic depiction is given in Figure 3.1 and Figure 3.2.

Table 4.3 Format of *vivo-n.in*, *vivo-nF.in* and *vivo-nR.in* (for SCR Riser Analysis)

|  |  |  |  |
| --- | --- | --- | --- |
| Line | Name | Description | Remarks |
| 1 | NPP, DEPTH1 | Number of Points, Water Depth [m] | The *point* here is referred to the input points in this file, and can be different with NP in *RISDYN-N.in* |
| For each point from I = 1 to NPP, repeat the following data from the top of the riser and going down. See Figure 3.1. | | | |
| I+1 | SX1(I) | Distance along the Riser to point I [m] | 0 means point I is at the bottom end and the top point has SX1(I) equal to the total modeled length of the riser. |
| TEX(I) | Axial Static Tension [N] |  |
| DTEX(I)2 | Change in Static Tension [N/m] | Negative when riser wet weight > 0, can be estimated with Equations 4.2 to 4.4 |
| XXX(I)3 | Vertical Distance [m] | Measured from the bottom end, and always positive. |
| YYX(I)4 | Horizontal Distance along *Y* [m] | Measured in global coordinate |
| ZZX(I)4 | Horizontal Distance along *Z* [m] | Measured in global coordinate |
| VELEY(I)5 | Current Velocity along *y* axis [m/s] | Normal current component |
| VELEZ(I)5 | Current velocity along *z* axis [m/s] | Normal current component |
| URIST(I)6 | Riser Velocity in *XY* plane [m/s] | Dummy parameter, not used in program |
| VRIST(I)6 | Riser Velocity in *XZ* plane [m/s] | Dummy parameter, not used in program |

Notes:

1. For catenary risers, the portion of the riser lying on the floor shall be truncated in general. With the introduction of intermediate lateral support, the grounded portion may be modeled as lateral supports.
2. Numerical estimate for DTEX can be calculated with Equations 4.2 to 4.4 as follows:

For *i* = 2, 3, … (NPP-1),  [4.2]

For *i* = 1,  [4.3]

For *i* = NPP,  [4.4]

1. The vertical coordinate at every riser point, I, in the global coordinate system.
2. Although they are not used in VIVA, they are essential, however, to VIVARRAY. They are the horizontal coordinates at every riser point, I, in the global coordinate system.
3. When the riser contains large curvatures, one must specify the velocity components on a plane perpendicular to the local axis of the riser. In previous VIVA versions this was done internally to the program, but in a three-dimensional shape this is impossible, since there are two Euler angles needed. Hence the user must make sure to input the two components of velocity in a plane perpendicular to the local riser configuration.
4. URIST(I) and VRIST(I) are riser self-velocities and are omitted in the current version.

## *no\_files.in*

*no\_files.in* lists the hydrodynamic databases to be used in VIVA or VIVARRAY. Table 4.4 provides the data input format.

Table 4.4 Format of *no\_files.in*

|  |  |  |
| --- | --- | --- |
| Line | Name | Description |
| 1 | N\_OFL1 | Number of hydrodynamic files including file *basic\_bare.db* |
| Repeat line 2 for every hydrodynamic file from I = 1 to N\_OFL | | |
| 2 | NM(I)2 | Name of the file |
| NA(I) | Number of non-dimensional frequencies to be specified in this file |
| NB(I) | Number of *Cd* values to be given for each frequency as function of *A*/*D* |

Notes:

1. The number of files is 10 for the provided *no\_files.in*, which may be changed based on the available database files.
2. The sequence is important because it must correspond with the ICHAR value given in the *rispre.in*, *rispreF.in* or *rispreR.in*. For example, ICHAR=4 means to use the fourth file in the *no\_file.in* below *out3.db*. The list below gives the “standard hydrodynamic database”:

ICHAR=1 for *basic\_bare.db* is for a bare cylinder

ICHAR=2 for *out1.db* is for a VETCO-section at 0 deg

ICHAR=3 for *out2.db* is for a VETCO-section at 30 deg

ICHAR=4 for *out3.db* is for a VETCO-section at 60 deg

ICHAR=5 for *out4.db* is for a VETCO-section at 90 deg

ICHAR=6 for *out5.db* is for a VETCO-section at 120 deg

ICHAR=7 for *out6.db* is for a VETCO-section at 150 deg

ICHAR=8 for *out7.db* is for a staggered buoyancy-bare configuration

ICHAR=9 for *basic\_bare-hr.db* is for high-RE data

ICHAR=10 for *out\_s.db* is for a straked cylinder with strakes P/D=17, h/D=-0.25

Notes: If the standard database files are used, no-files.in should be input as:

10

basic\_bare.db 36 0

out1.db 14 5

out2.db 14 5

out3.db 14 5

out4.db 14 5

out5.db 14 5

out6.db 14 5

out7.db 11 5

basic\_bare-hr.db 36 5

out\_s.db 15 4

The optional databases, as mentioned in Section 2, should be input as:

basic\_bare-sche 36 0

basic\_bare-07 36 0

basic\_bare-14 36 0

out\_hr.in 78 61

## *conditions.in*, *conditionsF.in* and *conditionsR.in*

These files specify the control variables and boundary conditions at the top and bottom of the riser for both rigid and SCR risers. There are up to seven lines of input as seen in Table 4.5.

Table 4.5 Format of *conditions.in, conditionsF.in* and *conditionsR.in*

|  |  |  |  |
| --- | --- | --- | --- |
| Line | Name | Description | Remarks |
| 1 | DEF\_CON | Control Variable | 0: by internal calculation  1: import modal frequencies only  2: import modal frequencies, modal shapes and curvatures1 |
| 2 | RNU2 | Kinematic Viscosity [m2/s] | Normally 1.114 x 10-6 m2/s for sea water  0: input through *visc-def.in* |
| 3 | I\_HIRE3, NO\_HRF | Control Variable | - I\_HIRE = 1, NO\_HRF = 1: use the old approach: re-scaling the low-Reynolds number data (default)  - I\_HIRE = 2: use the external high Reynolds number database, NO\_HRF specifies the sequential file number in *no\_files.in* corresponding to the high Reynolds database, or 9 for *out\_hr.db* |
| 4 | IBC(1)4, IBC(2)4 | Upper Boundary Condition, Lower Boundary Condition | 0: pinned connection  1: fixed end  2: end connected to an elastic rotational spring  3: free end |
| 4a5 | CUPK | Upper Rotational Spring, [1/rad-m] | See Equation 4.5, only needed when IBC(1) = 2 |
| 4b5 | CLOK | Lower Rotational Spring, [1/rad-m] | See Equation 4.5, only needed when IBC(2) = 2 |
| 5 | G\_M6 | Damping Type | 0: constant damping  1: modal damping |

Notes:

1. If DEF\_CON = 2, both the displacement and curvature natural modes are required.
2. If RNU = 0, a default value of 1.114 x 10-6 m2 /s would be used by the program. Alternatively, the user may specify the viscosities by *VISC-DEF.in* file with RNU input of zero.
3. When I\_HIRE = 1, the built-in high Reynolds number database will be used. When I\_HIRE = 2, the file number of *basic\_bare-hr.db*, or a user-specified high Reynolds number database must be specified as in *no\_files.in*.
4. A riser cannot have both upper and lower ends free.
5. Only required when the corresponding boundary condition has been specified as 2, where an end is connected to an elastic rotational spring.
6. The choice is between (a) modal damping, where if one specifies for example, 3% damping ratio, it means that each mode separately has the same modal damping ratio; or (b) constant damping where only the first mode damping is calculated and the same value of damping (not damping ratio) is used for all other modes (hence higher order modes have increasingly smaller damping ratio).

When a rotational spring (flex-joint) is chosen as the boundary condition for either top or bottom of the riser, the stiffness of the upper or lower rotational spring must be defined, respectively. The boundary condition for a riser beam at the end of the flex-joint is governed by Equation 4.5.

 or  [4.5]

where

*K* - rotational-spring constant for the flex-joint [N-m/rad]  
*E I* - bending stiffness of the riser beam [N-m2]  
*y* - lateral deflection of the riser [m]  
*S* - distance along the riser axis [m]  
*C* - stiffness input to VIVA for the flex-joint [1/m-rad], **

Notes: If the user input for K is in the unit of [N-m/deg], then

 [1/rad-m]

If the user input for K is in the unit of [lbf-ft/deg] and EI is in the unit of [lbf-ft2], then

 [1/rad-m]

## *risfat.in, risfatF.in* and *risfatR.in*

This file defines the constants A, B and stress concentration factor to be used in fatigue calculation. Results of VIV dynamic analysis are used to calculate fatigue life along the riser length for a given stress concentration factor and S-N curve. Table 4.6 provides the data input format.

The fatigue constants, A and B, of some often used fatigue curves from API RP-2A and HSE are given in Table 4.7 for IFFAT =1 or *N* = (A / *Samplitude*)B.

Table 4.6 Format of *risfat.in*, *risfatF.in* and *risfatR.in*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Line | Name | Description | Remarks | |
| 1 | IFFAT | Type of S-N Curves | 1: *N* = (A / *Samplitude*)B  2: *N* = (A / *Srange*)B  3: *N* = A / *Samplitude*B  4: *N* = A / *Srange*B  5: *N* = (A\_1 / *Samplitude*)B\_1;  *N* = (A\_2 / *Samplitude*)B\_2,  If *Samplitude* < *S\_W*  6: *N* = (A\_1*i* / *Samplitude*)B\_1*i*;  *N* = (A\_2*i* / *Samplitude*)B\_2*i*,  If *Samplitude* < *S\_Wi* | *N* number of cycles to fatigue failure  *S* VIV stress amplitude or range in N/m² or Pa  *i* the *i*th segement  Options 5 and 6 are only available for VIVA |
| 2 | A, B | Fatigue Constants | As described in S-N curve types | |
| 2a | A\_1, B\_1,  A\_2, B\_1,  S\_W, SCF | Fatigue Constants for a double slope fatigue curve | For IFFAT = 5 only | |
| 2b | A\_1*i*, B\_1*i*,  A\_2*i*, B\_1*i*,  S\_W*i*, SCF*i* | Fatigue Constants for a double slope fatigue curveof the *i*th segment | For IFFAT = 6 only, repeat line 2b for *i* = 1 to NSEGM, from bottom to top. | |
| 3 | SCF | Stress Concentration Factor | For IFFAT = 1 through 4 only | |

Table 4.7 Fatigue Constants for IFFAT = 1

|  |  |  |
| --- | --- | --- |
| Class | A (Pa) | B |
| API X | 1.3729E+09 | 4.38 |
| API X’ | 1.9115E+09 | 3.74 |
| HSE B | 2.8279E+09 | 4 |
| HSE C | 3.9197E+09 | 3.5 |
| HSE D | 5.7408E+09 | 3 |
| HSE E | 5.0773E+09 | 3 |
| HSE F | 4.2885E+09 | 3 |
| HSE F2 | 3.7639E+09 | 3 |
| HSE G | 3.1307E+09 | 3 |
| HSE W | 2.7058E+09 | 3 |
| HSE T | 5.6533E+09 | 3 |

It is assumed that each VIV mode is not in the steady state, but participates as a random process. Hence, gamma function is applied in fatigue life calculations as in the Equation 4.6 for IFFAT = 1.

 [4.6]

## *freq.in*, *freqF.in* and *freqR.in*

These files are optional if the user wishes to have them as an external input to specify the natural frequencies of the risers rather than letting it be calculated by VIVA or VIVARRAY. If DEF\_CON = 1 or DEF\_CON = 2 in the *conditions.in*, *conditionsF.in* or conditions*R.in*, then the natural frequencies of the riser should be provided sequentially in *freq.in*, *freqF.in* or *freqR.in*. Table 4.8 provides the data input format.

Table 4.8 Format of *freq.in or freqF.in or freqR.in*

|  |  |  |  |
| --- | --- | --- | --- |
| Line | Name | Description | Remarks |
| For each mode I, repeat line 1 | | | |
| 1 | I | Sequence Number | Maximum NP/71 |
| FREQ(I) | Modal Frequency [rad/sec] |  |

Notes:

1. The maximum number of frequencies, *M*, that the program will consider is up to *np\_r*/7 (one-seventh of the number of points). The minimum number is 1, but one should consider that the program predictions may be inaccurate if too few modes are specified. The program automatically finds the number *M* from the file, so there is no need to specify this number.

## *modes\_us.in*, *modes\_usF.in* and *modes\_usR.in*

These are also optional files. They allow the user to specify the natural modes in addition to the natural frequencies. If DEF\_CON = 2 in *conditions.in*, *conditionsF.in* or *conditionsR.in*, then in addition to the natural frequencies, the natural displacement modes of the riser should be defined in the file *modes\_us.in*, *modes\_usF.in* or *modes\_usR.in*. Table 4.9 provides the data input format.

Table 4.9 Format of *modes\_us.in*, *modes\_usF.in* and *modes\_usR.in*

|  |  |  |  |
| --- | --- | --- | --- |
| Line | Name | Description | Remarks |
| For each mode I, specified in *FREQ.in*, repeat line 1 for every nodes from J = 1 to NP\_R starting from the top end | | | |
| 1 | X(J) | Axial Distance of Node J [m] | Measured from the top end |
| Y\_R(I,J) | Real Part of Displacement or Curvature at Node J [m] |  |
| Y\_I (I,J) | Imaginary Part of Displacement or Curvature at Node J [m] | Equals 0 if the modes are standing modes |

## *curv\_us.in*, *curv\_usF.in* and *curv\_usR.in*

These are also optional files. When DEF\_CON = 2 in *conditionsF.in* or *conditionsR.in*, then specify, in addition to the natural frequencies and the natural displacement modes, the natural curvature modes of each riser in the files *curv\_us.in*, *curv\_usF.in* or *curv\_usR.in*. Table 4.10 provides the data input format.

Table 4.10 Format of *curvs\_us.in*, *curvs\_usF.in* and *curvs\_usR.in*

|  |  |  |  |
| --- | --- | --- | --- |
| Line | Name | Description | Remarks |
| For each mode I, specified in *freq.in*, repeat line 1 for every nodes from J = 1 to NP\_R starting from the top end | | | |
| 1 | X(J) | Axial Distance of Node J [m] | Measured from the top end |
| Y\_R(I,J) | Real Part of Displacement or Curvature at Node J [m] |  |
| Y\_I (I,J) | Imaginary Part of Displacement or Curvature at Node J [m] | Equals 0 if the modes are standing modes |

## *visc-def.in*, *visc-defF.in* and *visc-defR.in*

If you specified a zero value in *conditions.in*, *conditionsF.in* or *conditionsR.in* for the viscosity, then you must specify the value of the viscosity (in m²/s) in *visc-def.in*, *visc-defF.in* or *visc-defR.in*, point-by-point for the riser. Table 4.11 provides the data input format.

Table 4.11 Format of *visc-def.in*, *visc-defF.in* and *visc-defR.in*

|  |  |  |  |
| --- | --- | --- | --- |
| Line | Name | Description | Remarks |
| Repeat line 1 for every nodes from I = 1 to NP\_R starting from the top end | | | |
| 1 | VISC(I) | Viscosity at Node I [m2/s] | Normally 1.114 x 10-6 m2/s for sea water |

## User-Specified Database Files for *viva-v84.exe* and *vivarray-vv83.exe*

Users may specify their own hydrodynamic databases by replacing or appending to the existing ones for the VIV calculations. Table 4.12 provides the format of these databases.

Table 4.12 Format of Hydrodynamic Database File

|  |  |  |
| --- | --- | --- |
| Line | Name | Description |
| Repeat the following lines ( 1 to [NB(I) + 1] ) for every frequency, J = 1 to NA(I) (see Table 4.4) | | |
| 1 | Frequency (J) | Non-dimensional frequency |
| Lift (J) | Lift coefficient in phase with velocity at *A*/*D* = 0 |
| Added-mass (J) | The corresponding added mass |
| First slope (J) | The first slope of the lift curve |
| Second slope (J) | The second slope of the lift curve |
| A/D (J) | The value of *A*/*D* where the slope changes |
| Repeat Line 2 for every *Cd* value, K = 1 to NB(I) (see Table 4.4) | | |
| 2 | AMD(J,K) | The value of *A*/*D* |
| CD(J,K) | The corresponding drag coefficient |

# Program output files

Every VIVA or VIVARRAY module will generate a set of output files. Some serve as input files for the consequent module, some can be used for checking the correctness of input, and the rest are the analysis results. Files of the last two categories are detailed in the following sections.

## *risprep-v8.exe* or *risprep-vv81.exe*

*risout.out* (or with the name inputted in Line 1 of *rispre.in* or *rispreR.in* and *rispreR.in*)

The user can use this file to check input data in *rispre.in* or *rispreF.in* and *rispreR.in*.

## *ris6-v8.exe* or *ris6-vv81.exe*

*dynout.out* (or with the name inputted in Line 2 of *risdyn-n.in* or *risdyn-nF.in* and *risdyn-nR.in*)

The user can use this file to check input data in *risdyn-n.in* or *risdyn-nF.in* and *risdyn-nR.in* and, if required, *vivo-n.in* or *vivo-nF.in* and *vivo-nR.in*.

## *viva-v84.exe and vivarray-vv83.exe*

* *bend.out*, *bendF.out* and *bendR.out*

These files contain the bending moment and stress response along the riser length of each excited mode. It is appropriate for plotting and provides three columns: (1) *S* coordinate, measured along the riser length from the top end (m); (2) amplitude of VIV bending moment in (N-m); and (3) amplitude of VIV bending stress in (N/m2) or (Pa).

* *bend\_mm.out*, *bend\_mmF.out* and *bend\_mmR.out*

These files contain the multi-frequency bending moment and stress response. It is appropriate for plotting and provides three columns: (1) *S* coordinate, measured along the riser length from the top end (m); (2) equivalent amplitude of VIV bending moment in (N-m); and (3) equivalent amplitude of bending stress in (N/m2) or (Pa).

* *cdrag.out*, *cdragF.out* and *cdragR.out*

These files contain the drag coefficient along the risers of each excited mode. It is appropriate for plotting and provides two columns: (1) *S* coordinate, measured along the riser length from the top end (m); and (2) drag coefficient at that point.

* *cdrag\_mm.out*, *cdrag\_mmF.out* and *cdrag\_mmR.out*

These files contain the drag coefficient for multi-frequency response. It is appropriate for plotting and provides two columns: (1) *S* coordinate, measured along the riser length from the top end (m); and (2) drag coefficient at that point.

* *clv\_dom.out* (VIVARRAY only)

This file summarizes the lift coefficients of the rear riser in the current wake of the front riser. It is appropriate for plotting and provides two columns: (1) *S* coordinate, measured along the riser length from the top end (m); and (2) lift coefficient at that point.

* *fat.out*, *fatF.out* and *fatR.out*

These files summarize the fatigue life of the risers for all the excited individual modes as well as the multi-frequency mode.

* *fat1.out; fat1F.out & fat1R.out*

These files contain the same information as files *fat.out, fatF.out* or *fatR.out*, but without notations.

* *fat\_h3.out*, *fat\_h3F.out* and *fat\_h3R.out*

These files contain the minimum single-frequency and multi-frequency fatigue life (in years) including the effect of high harmonics. This file is relatively short in length as it calculates the minimum fatigue life along the entire length for both single and multi-frequency response.

* *fat1\_h3.out*, *fat1\_h3F.out* and *fat1\_h3R.out*

These files contain the same information as file *fat\_3h.out*, *fat\_3hF.out* or *fat\_3hR.out* but without notations.

* *fat-mono.out*, *fat-monoF.out* and *fat-monoR.out*

These files provide sequentially for each excited mode the fatigue life (in year) calculated at each point along the length of the riser. It contains the following items:

1. The first line provides the number of excited modes (*INDEX*) and the number of points (*NP\_R*) at which the fatigue life is provided.
2. For each excited mode, it provides two columns of numbers: (1) *S* coordinate, measured along the riser length from the top end (m); and (2) corresponding fatigue life at the point.

* *fat-mono\_h3.out*, *fat-mono\_h3F.out* and *fat-mono\_h3R.out*

These files provide sequentially for each excited mode the fatigue life (in year) calculated at each point along the length of the riser including the effect of high harmonics. It contains the following items:

1. The first line provides the number of excited modes (*INDEX*) and the number of points (*NP\_R*) at which the fatigue life of both single and multi-frequency is provided.
2. For each excited mode, it provides two columns of numbers: (1) *S* coordinate, measured along the riser length from the top end (m); and (2) corresponding fatigue life at the point.

* *fat-multi.out*, *fat-multiF.out* and *fat-multiR.out*

These files contain the fatigue life (in year) for the multi-frequency responses, calculated at each point along the length of the riser. The file contains two columns: (1) *S* coordinate, measured along the riser length from the top end (m); and (2) corresponding fatigue life.

* *fat-multi\_h3.out*, *fat-multi\_h3F.out* and *fat-multi\_h3R.out*

These files contain the fatigue life (in year) for the multi-frequency responses, calculated at each point along the length of the riser, including the effect of high harmonics. The file contains two columns: (1) *S* coordinate, measured along the riser’s length from the top end (m); and (2) corresponding fatigue life.

* *out.out*, *outF.out* and *outR.out*

These files contain the motion responses of each excited mode. It is appropriate for plotting and provides two columns: (1) *S* coordinate, measured along the riser length from the top end; and (2) VIV amplitude at that point. All these data are in meters (m).

* *out\_mm.out*, *out\_mmF.out* and *out\_mmR.out*

These files contain the multi-frequency motion responses. It is appropriate for plotting and provides two columns: (1) *S* coordinate, measured along the riser length from the top end; and (2) equivalent VIV amplitude at that point. All these data are in meters (m).

* *freq.out*, *freqF.out* and *freqR.out*

These files contain the modal frequencies of the risers in the absence of the external current.

* *strain.out*, *strainF.out* and *strainR.out*

These files contain the bending strain along the riser length of each excited mode. It is appropriate for plotting and provides two columns: (1) *S* coordinate, measured along the riser length from the top end (m); (2) amplitude of VIV bending strain.

* *strain\_mm.out*, *strain\_mmF.out* and *strain\_mmR.out*

These files contain the multi-frequency bending strain along the riser length. It is appropriate for plotting and provides two columns: (1) S coordinate, measured along the riser length from the top end (m); (2) equivalent amplitude of bending strain.

* *summ.out*, *summF.out* and *summR.out*

This file contains a brief summary of all the modes that were excited by VIV, including their frequency and amplitude.

* *summ1.out*, *summ1F.out* and *summ1R.out*

These files contain the same information as *summ.out*, *summF.out* and *summR.out* in a tabulated format. There are 4 columns: (1) mode number; (2) initial frequencies in calm water; (3) coupled frequencies; and (4) maximum VIV amplitude for that mode.

* *summ\_mm.out*, *summ\_mmF.out* and *summ\_mmR.out*

These files contain a brief summary of the multi-frequency VIV response, including the dominant and subdominant, if present, modes, their frequency and amplitude, and the maximum RMS response and its location.

* *summ1\_mm.out*, *summ1\_mmF.out* and *summ1\_mmR.out*

These files contain the same information as file *summ\_mm.out*, *summ\_mmF.out* and *summ\_mmR.out*, but without notations.

* *summary.out*, *summaryF.out* and *summaryR.out*

These files contain a summary of the modal responses, which includes (1) the mode number, (2) the frequency of response in Hz, (3) the amplitude in m, (4) the first stress harmonic amplitude in N/m2, (5) the third stress harmonic amplitude in N/m2, and (6) the probability assigned to that mode.

# example problems

To aid the user in becoming familiar with the software, several example problems are outlined in this section that cover the various riser options available during analysis, such as rigid risers in connected and disconnected modes, steel catenary risers, and free-standing risers. The standard database files are assumed for the examples hence *no\_files.in* should be input as in Section 4.4.

To run examples of single riser, copy the files from the desired example directory to the directory with VIVA programs installed and type **RunVIVA** at the DOS prompt.

To run examples of a two-riser-array, copy the files from the desired example directory to the directory with VIVARRAY programs installed and type **RunVIVARRAY** at the DOS prompt.

## Single Riser Example 1

This example is a 10,000 ft water depth rigid riser in GOMEX 3.5 knots loop current (Figure 6.1). The input files for VIVA are as follows:

* *rispre.in*

'RISOUT'

9

617.22

983.1533

245.697

6579.024

0.5524501

0.5524501 0.028575

3.235463E+08

1

2

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

320.04

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1868.492

1542.674 2540.016

1.3843

0.5524501 0.028575

3.235463E+08

1

1

868.6801

1830.216

1486.582

2714.753

1.3589

0.5524501 0.028575

3.235463E+08

1

1

22.86

983.1533

245.697

6579.024

0.5524501

0.5524501 0.028575

3.235463E+08

1

2

15.24

983.1434

245.697

6579.122

0.5524501

0.5524501 0.028575

3.235463E+08

1

2

1

* *risdyn-n.in*

'RISOUT'

'DYNOUT'

1.067573E+07

600

30

6

0 1.800555 0

91.44 1.749111 0

152.4 1.028889 0

304.8 0.5144444 0

457.2 0.2572222 0

3352.8 0.1028889 0

1025

0.01

0

* *conditions.in*

0

1.114E-06

2 9

0 0

1

* *risfat.in*

1

1.3729E+09 4.38

1.5



Top Tension = 2400 kips

Mud Density = 8.6 ppg

Figure 6.1 Example Problem 1:  
10000 ft Riser in GOMEX 3.5 kts Loop Current  
Pinned Upper and Lower Boundary Conditions

## Single Riser Example 2

This example is the above example in disconnected, or hang-off, condition (Figure 6.2). The input files for VIVA are as follows:

* *rispre.in*

'RISOUT'

10

6.4008

23583.99

673.1103

199460.4

0.9144

0.9144 0.209549993276596

2.428339E+09

1

2

617.22

983.1533

245.697

6579.024

0.5524501

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

320.04

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1868.492

1542.674

2540.016

1.3843

0.5524501 0.028575

3.235463E+08

1

1

868.6801

1830.216

1486.582

2714.753

1.3589

0.5524501 0.028575

3.235463E+08

1

1

22.86

983.1533

245.697

6579.024

0.5524501

0.5524501 0.028575

3.235463E+08

1

2

15.24

983.1434

245.697

6579.122

0.5524501

0.5524501 0.028575

3.235463E+08

1

2

1



Top Tension = 2624 kips

Mud Density = 8.6 ppg

Figure 6.2 Example Problem 2:  
10000 ft Riser in GOMEX 3.5 kts Loop Current  
Pinned Upper and Free Lower Boundary Conditions

* *risdyn-n.in*

'RISOUT'

'DYNOUT'

1.039463E+07

600

30

6

0 1.800555 0

91.44 1.749111 0

152.4 1.028889 0

304.8 0.5144444 0

457.2 0.2572222 0

3352.8 0.1028889 0

1025

0.01

0

* *conditions.in*

0

1.114E-06

2 9

0 3

1

* *risfat.in*

1

1.3729E+09 4.38

1.5

## Single Riser Example 3

This example is a 3000 ft riser in WOS 1.0 m/s current (Figure 6.3). The input files for VIVA are as follows:

* *rispre.in*

'RISOUT'

5

76.2

720.5848

229.0445

4239.197

0.5334001

0.5334001 0.015875

1.729392E+08

1

5

304.8

1219.775

960.3248

1961.964

1.0922

0.5334001 0.015875

1.729392E+08

1

1

441.96

1219.775

960.3248

1961.964

1.0922

0.5334001 0.015875

1.729392E+08

1

1

45.72

1314.422

1098.998

1529.984

1.1684

0.5334001 0.015875

1.729392E+08

1

1

76.2

874.4907

229.0445

5493.689

0.5334001

0.5334001 0.015875

1.729392E+08

1

5

1

* *risdyn-n.in*

'RISOUT'

'DYNOUT'

4448221

600

30

8

-30.48 0 0

-0.01 0 0

0 0.9980222 0

100.584 0.9414333 0

198.12 0.8179666 0

396.24 0.5813222 0

609.6 0.463 0

914.4 0.463 0

1025

0.01

0

* *conditions.in*

0

1.114E-06

2 9

0 2

1.796762E-02

1

* *risfat.in*

1

1.3729E+09 4.38

1.5



Above-Water Height = 100 ft

Top Tension = 1000 kips

Mud Density = 9 ppg

Figure 6.3 Example Problem 3:  
3000 ft Riser in WOS 1.0 m/s Current  
Pinned Upper and Flex-Joint Lower Boundary Conditions

## Single Riser Example 4

This example is a 2790 ft water depth steel catenary riser in GOMEX 3.0 knots eddy current (Figure 6.4). The input files for VIVA are as follows:

* *rispre.in*

'RISOUT'

1

1036.32

140.4619

98.19438

543.5759

0.34925

0.3048 0.0174625

3.264837E+07

1

1

2

* *risdyn-n.in*

'RISOUT'

'DYNOUT'

560475.9

400

30

9

0 1.543333 0

38.1 1.440444 0

76.2 1.183222 0

114.3 0.8745555 0

152.4 0.6173333 0

228.6 0.463 0

304.8 0.2572222 0

457.2 0.2057778 0

457.2031 0 0

1025

0.01

0



Figure 6.4 Example Problem 4:  
SCR Riser in 2790 ft Deep Water, GOMEX 3.0 kts Current  
Pinned Upper and Lower Boundary Conditions

* *vivo-n.in*

69 850.392

1035.46 560475.9 -542.6597 850.392 0 0 1.514513 0 0 0

1020.05 552113.3 -531.1013 835.2618 0 0 1.473911 0 0 0

1004.639 544106.5 -519.4116 820.1528 0 0 1.432986 0 0 0

989.2192 536099.7 -516.8723 805.0408 0 0 1.363361 0 0 0

973.8299 528181.8 -515.9528 789.9624 0 0 1.26285 0 0 0

958.4406 520219.5 -515.9528 774.8931 0 0 1.162425 0 0 0

943.0512 512301.7 -517.5436 759.842 0 0 1.043339 0 0 0

927.671 504294.9 -520.7396 744.8032 0 0 0.9235044 0 0 0

912.3 496288.1 -516.5658 729.7827 0 0 0.8123015 0 0 0

896.9288 488414.8 -513.72 714.7834 0 0 0.7128755 0 0 0

881.5609 480496.9 -515.3253 699.7934 0 0 0.613607 0 0 0

866.199 472579.1 -514.1724 684.8216 0 0 0.5752402 0 0 0

850.8492 464705.7 -510.0277 669.8834 0 0 0.5452821 0 0 0

835.4995 456921.3 -511.852 654.9512 0 0 0.515338 0 0 0

820.1711 449003.5 -519.2365 640.0526 0 0 0.4855103 0 0 0

804.8305 440996.7 -519.1927 625.1631 0 0 0.4557326 0 0 0

789.4991 433078.9 -515.1939 610.301 0 0 0.4185099 0 0 0

774.1798 425205.5 -515.5588 595.4634 0 0 0.3792276 0 0 0

758.8697 417287.7 -509.8964 580.6532 0 0 0.3400881 0 0 0

743.5596 409592.3 -508.4516 565.8613 0 0 0.3010743 0 0 0

728.2495 401718.9 -518.7695 551.1028 0 0 0.2622205 0 0 0

712.9485 393712.1 -513.3113 536.3627 0 0 0.2445061 0 0 0

697.6597 386016.7 -507.7073 521.6622 0 0 0.2393365 0 0 0

682.371 378187.8 -510.772 506.983 0 0 0.2341698 0 0 0

667.0914 370403.4 -509.619 492.3435 0 0 0.2290001 0 0 0

651.8209 362619 -508.4662 477.7314 0 0 0.2238481 0 0 0

636.5596 354879.1 -505.5474 463.1619 0 0 0.2186832 0 0 0

621.2891 347183.7 -507.0651 448.623 0 0 0.2135019 0 0 0

606.0308 339399.3 -510.2758 434.1206 0 0 0.2083551 0 0 0

590.7786 331614.9 -504.5988 419.673 0 0 0.2031889 0 0 0

575.5295 324008.5 -498.9655 405.2621 0 0 0.1980223 0 0 0

560.2894 316402 -499.2574 390.8908 0 0 0 0 0 0

545.0586 308795.6 -502.3805 376.5835 0 0 0 0 0 0

529.8308 301100.1 -502.5264 362.3219 0 0 0 0 0 0

514.6091 293493.7 -499.6077 348.1212 0 0 0 0 0 0

499.3813 285887.2 -495.5652 333.9724 0 0 0 0 0 0

484.1809 278414.2 -490.0195 319.9029 0 0 0 0 0 0

468.9714 270985.7 -490.0195 305.8912 0 0 0 0 0 0

453.771 263512.7 -493.2447 291.9619 0 0 0 0 0 0

438.5798 255995.2 -487.5385 278.1208 0 0 0 0 0 0

423.3885 248700.1 -480.2708 264.3622 0 0 0 0 0 0

408.2003 241405 -477.5271 250.6919 0 0 0 0 0 0

393.0213 234198.9 -474.8856 237.1313 0 0 0 0 0 0

377.8514 226992.8 -474.725 223.6927 0 0 0 0 0 0

362.6907 219800 -471.3539 210.373 0 0 0 0 0 0

347.5299 212700.6 -464.9034 197.1934 0 0 0 0 0 0

332.36 205699.1 -458.4821 184.151 0 0 0 0 0 0

317.2115 198799.9 -448.923 171.2823 0 0 0 0 0 0

302.069 192100.9 -445.6832 158.6027 0 0 0 0 0 0

286.9204 185299.6 -442.6331 146.1121 0 0 0 0 0 0

271.7902 178698.4 -429.5277 133.8529 0 0 0 0 0 0

256.6599 172301.9 -419.6768 121.8408 0 0 0 0 0 0

241.5296 165998.7 -413.1826 110.1029 0 0 0 0 0 0

226.4085 159802.4 -403.3463 98.67291 0 0 0 0 0 0

211.2904 153801.7 -387.0303 87.59338 0 0 0 0 0 0

196.1693 148099.1 -370.51 76.89191 0 0 0 0 0 0

181.0603 142601.1 -357.5214 66.63239 0 0 0 0 0 0

165.9606 137298.8 -341.1325 56.85132 0 0 0 0 0 0

150.8608 132299 -317.8552 47.61279 0 0 0 0 0 0

135.761 127699.5 -294.826 38.98083 0 0 0 0 0 0

120.6703 123398.1 -271.6217 31.02258 0 0 0 0 0 0

105.5797 119501.5 -245.1046 23.80188 0 0 0 0 0 0

90.48903 116000.7 -212.1078 17.41321 0 0 0 0 0 0

75.40143 113100.5 -179.038 11.90247 0 0 0 0 0 0

60.32906 110600.6 -149.281 7.373108 0 0 0 0 0 0

45.24146 108598.9 -105.9955 3.861816 0 0 0 0 0 0

30.15996 107402.3 -59.58691 1.441711 0 0 0 0 0 0

15.0815 106801.8 -26.54631 0.1432495 0 0 0 0 0 0

0 106601.6 -13.26586 0 0 0 0 0 0 0

* *conditions.in*

0

1.114E-06

2 9

0 0

1

* *risfat.in*

1

1.3729E+09 4.38

1.5

## Single Riser Example 5

This example is a 5000 ft water depth free-standing riser in Brazil current (Figure 6.5). The input files for VIVA are as follows:

* *rispre.in*

'RISOUT'

5

297.18

890.4704

245.697

5898.948

0.5524501

0.5524501 0.028575

3.235463E+08

1

5

617.22

1794.639

1571.11

1771.403

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1730.013

1571.11

1137.639

1.397

0.5524501 0.028575

3.235463E+08

1

1

228.6

1794.639

1571.11

1771.403

1.397

0.5524501 0.028575

3.235463E+08

1

1

6.096

88402.84

119664

-600241.2

12.192

0.5524501 0.028575

3.235463E+08

1

1

1

* *risdyn-n.in*

'RISOUT'

'DYNOUT'

0

600

30

7

76.2 1.006135 0

152.4 0.4372778 0

243.84 0.3189555 0

304.8 0.3189555 0

457.2 0.4475666 0

609.6 0.4012666 0

1524 0.4012666 0

1025

0.01

0

* *conditions.in*

0

1.114E-06

2 9

3 0

1

* *risfat.in*

1

1.3729E+09 4.38

1.5



Top to Waterline = 250 ft

Mud Density= 8.6 ppg

Figure 6.5 Example Problem 5:  
4750 ft Free-Standing Riser in 5000 ft WD, Brazil Current Profile  
Free Upper and Pinned Lower Boundary Condition

## Two-Riser Example 4

All input files except *risdyn-nF.in*, *risdyn-nR.in*, *vivo-nF.in* and *vivo-nR.in* are the same as the “**Single Riser Example 4**”, since both front and rear risers are identical to the riser in “**Single Riser Example 1**”.

The two risers are side-by side with a center to center distance of 2 ft. The corresponding files *risdyn-nF.in*, *risdyn-nR.in*, *vivo-nF.in* and *vivo-nR.in* are listed below.

* *risdyn-nF.in*

'RISOUT'

'DYNOUT'

560475.9

400

30

9

0 0 1.543333

38.1 0 1.440444

76.2 0 1.183222

114.3 0 0.8745555

152.4 0 0.6173333

228.6 0 0.463

304.8 0 0.2572222

457.2 0 0.2057778

457.2031 0 0

1025

0.01

0

466.7799 0

* *risdyn-nR.in*

'RISOUT'

'DYNOUT'

560475.9

400

30

9

0 0 1.543333

38.1 0 1.440444

76.2 0 1.183222

114.3 0 0.8745555

152.4 0 0.6173333

228.6 0 0.463

304.8 0 0.2572222

457.2 0 0.2057778

457.2031 0 0

1025

0.01

0

466.7799 0.6096

* *vivo-nF.in*

69 850.392

1035.46 560475.9 -542.6597 850.392 466.7799 0 0 1.543333 0 0

1020.05 552113.3 -531.1013 835.2618 463.8157 0 0 1.502474 0 0

1004.639 544106.5 -519.4116 820.1528 460.825 0 0 1.461672 0 0

989.2192 536099.7 -516.8723 805.0408 457.7849 0 0 1.39149 0 0

973.8299 528181.8 -515.9528 789.9624 454.7064 0 0 1.289692 0 0

958.4406 520219.5 -515.9528 774.8931 451.5829 0 0 1.187955 0 0

943.0512 512301.7 -517.5436 759.842 448.4096 0 0 1.066966 0 0

927.671 504294.9 -520.7396 744.8032 445.1909 0 0 0.945129 0 0

912.3 496288.1 -516.5658 729.7827 441.9216 0 0 0.8319595 0 0

896.9288 488414.8 -513.72 714.7834 438.5999 0 0 0.7306963 0 0

881.5609 480496.9 -515.3253 699.7934 435.2267 0 0 0.6294947 0 0

866.199 472579.1 -514.1724 684.8216 431.7971 0 0 0.5906583 0 0

850.8492 464705.7 -510.0277 669.8834 428.3129 0 0 0.5604028 0 0

835.4995 456921.3 -511.852 654.9512 424.7711 0 0 0.5301597 0 0

820.1711 449003.5 -519.2365 640.0526 421.172 0 0 0.4999844 0 0

804.8305 440996.7 -519.1927 625.1631 417.5077 0 0 0.4698277 0 0

789.4991 433078.9 -515.1939 610.301 413.7803 0 0 0.4319687 0 0

774.1798 425205.5 -515.5588 595.4634 409.9862 0 0 0.3918996 0 0

758.8697 417287.7 -509.8964 580.6532 406.1244 0 0 0.3519047 0 0

743.5596 409592.3 -508.4516 565.8613 402.1903 0 0 0.3119592 0 0

728.2495 401718.9 -518.7695 551.1028 398.1813 0 0 0.2721041 0 0

712.9485 393712.1 -513.3113 536.3627 394.0948 0 0 0.2541067 0 0

697.6597 386016.7 -507.7073 521.6622 389.9319 0 0 0.2491444 0 0

682.371 378187.8 -510.772 506.983 385.6845 0 0 0.2441893 0 0

667.0914 370403.4 -509.619 492.3435 381.3527 0 0 0.2392475 0 0

651.8209 362619 -508.4662 477.7314 376.9312 0 0 0.234315 0 0

636.5596 354879.1 -505.5474 463.1619 372.4208 0 0 0.2293969 0 0

621.2891 347183.7 -507.0651 448.623 367.8086 0 0 0.2244891 0 0

606.0308 339399.3 -510.2758 434.1206 363.0936 0 0 0.2195937 0 0

590.7786 331614.9 -504.5988 419.673 358.2766 0 0 0.2147168 0 0

575.5295 324008.5 -498.9655 405.2621 353.3473 0 0 0.2098522 0 0

560.2894 316402 -499.2574 390.8908 348.3026 0 0 0 0 0

545.0586 308795.6 -502.3805 376.5835 343.1408 0 0 0 0 0

529.8308 301100.1 -502.5264 362.3219 337.8528 0 0 0 0 0

514.6091 293493.7 -499.6077 348.1212 332.4374 0 0 0 0 0

499.3813 285887.2 -495.5652 333.9724 326.8763 0 0 0 0 0

484.1809 278414.2 -490.0195 319.9029 321.1797 0 0 0 0 0

468.9714 270985.7 -490.0195 305.8912 315.3275 0 0 0 0 0

453.771 263512.7 -493.2447 291.9619 309.3199 0 0 0 0 0

438.5798 255995.2 -487.5385 278.1208 303.1483 0 0 0 0 0

423.3885 248700.1 -480.2708 264.3622 296.7979 0 0 0 0 0

408.2003 241405 -477.5271 250.6919 290.264 0 0 0 0 0

393.0213 234198.9 -474.8856 237.1313 283.5363 0 0 0 0 0

377.8514 226992.8 -474.725 223.6927 276.6068 0 0 0 0 0

362.6907 219800 -471.3539 210.373 269.4636 0 0 0 0 0

347.5299 212700.6 -464.9034 197.1934 262.0881 0 0 0 0 0

332.36 205699.1 -458.4821 184.151 254.4665 0 0 0 0 0

317.2115 198799.9 -448.923 171.2823 246.5988 0 0 0 0 0

302.069 192100.9 -445.6832 158.6027 238.4627 0 0 0 0 0

286.9204 185299.6 -442.6331 146.1121 230.0356 0 0 0 0 0

271.7902 178698.4 -429.5277 133.8529 221.3162 0 0 0 0 0

256.6599 172301.9 -419.6768 121.8408 212.2803 0 0 0 0 0

241.5296 165998.7 -413.1826 110.1029 202.9071 0 0 0 0 0

226.4085 159802.4 -403.3463 98.67291 193.1834 0 0 0 0 0

211.2904 153801.7 -387.0303 87.59338 183.0909 0 0 0 0 0

196.1693 148099.1 -370.51 76.89191 172.6078 0 0 0 0 0

181.0603 142601.1 -357.5214 66.63239 161.7265 0 0 0 0 0

165.9606 137298.8 -341.1325 56.85132 150.4315 0 0 0 0 0

150.8608 132299 -317.8552 47.61279 138.7034 0 0 0 0 0

135.761 127699.5 -294.826 38.98083 126.5356 0 0 0 0 0

120.6703 123398.1 -271.6217 31.02258 113.9328 0 0 0 0 0

105.5797 119501.5 -245.1046 23.80188 100.8917 0 0 0 0 0

90.48903 116000.7 -212.1078 17.41321 87.42795 0 0 0 0 0

75.40143 113100.5 -179.038 11.90247 73.56665 0 0 0 0 0

60.32906 110600.6 -149.281 7.373108 59.35617 0 0 0 0 0

45.24146 108598.9 -105.9955 3.861816 44.8166 0 0 0 0 0

30.15996 107402.3 -59.58691 1.441711 30.03055 0 0 0 0 0

15.0815 106801.8 -26.54631 0.1432495 15.06772 0 0 0 0 0

0 106601.6 -13.26586 0 0 0 0 0 0 0

* *vivo-nR.in*

69 850.392

1035.46 560475.9 -542.6597 850.392 466.7799 0.6096 0 1.543333 0 0

1020.05 552113.3 -531.1013 835.2618 463.8157 0.6096 0 1.502474 0 0

1004.639 544106.5 -519.4116 820.1528 460.825 0.6096 0 1.461672 0 0

989.2192 536099.7 -516.8723 805.0408 457.7849 0.6096 0 1.39149 0 0

973.8299 528181.8 -515.9528 789.9624 454.7064 0.6096 0 1.289692 0 0

958.4406 520219.5 -515.9528 774.8931 451.5829 0.6096 0 1.187955 0 0

943.0512 512301.7 -517.5436 759.842 448.4096 0.6096 0 1.066966 0 0

927.671 504294.9 -520.7396 744.8032 445.1909 0.6096 0 0.945129 0 0

912.3 496288.1 -516.5658 729.7827 441.9216 0.6096 0 0.8319595 0 0

896.9288 488414.8 -513.72 714.7834 438.5999 0.6096 0 0.7306963 0 0

881.5609 480496.9 -515.3253 699.7934 435.2267 0.6096 0 0.6294947 0 0

866.199 472579.1 -514.1724 684.8216 431.7971 0.6096 0 0.5906583 0 0

850.8492 464705.7 -510.0277 669.8834 428.3129 0.6096 0 0.5604028 0 0

835.4995 456921.3 -511.852 654.9512 424.7711 0.6096 0 0.5301597 0 0

820.1711 449003.5 -519.2365 640.0526 421.172 0.6096 0 0.4999844 0 0

804.8305 440996.7 -519.1927 625.1631 417.5077 0.6096 0 0.4698277 0 0

789.4991 433078.9 -515.1939 610.301 413.7803 0.6096 0 0.4319687 0 0

774.1798 425205.5 -515.5588 595.4634 409.9862 0.6096 0 0.3918996 0 0

758.8697 417287.7 -509.8964 580.6532 406.1244 0.6096 0 0.3519047 0 0

743.5596 409592.3 -508.4516 565.8613 402.1903 0.6096 0 0.3119592 0 0

728.2495 401718.9 -518.7695 551.1028 398.1813 0.6096 0 0.2721041 0 0

712.9485 393712.1 -513.3113 536.3627 394.0948 0.6096 0 0.2541067 0 0

697.6597 386016.7 -507.7073 521.6622 389.9319 0.6096 0 0.2491444 0 0

682.371 378187.8 -510.772 506.983 385.6845 0.6096 0 0.2441893 0 0

667.0914 370403.4 -509.619 492.3435 381.3527 0.6096 0 0.2392475 0 0

651.8209 362619 -508.4662 477.7314 376.9312 0.6096 0 0.234315 0 0

636.5596 354879.1 -505.5474 463.1619 372.4208 0.6096 0 0.2293969 0 0

621.2891 347183.7 -507.0651 448.623 367.8086 0.6096 0 0.2244891 0 0

606.0308 339399.3 -510.2758 434.1206 363.0936 0.6096 0 0.2195937 0 0

590.7786 331614.9 -504.5988 419.673 358.2766 0.6096 0 0.2147168 0 0

575.5295 324008.5 -498.9655 405.2621 353.3473 0.6096 0 0.2098522 0 0

560.2894 316402 -499.2574 390.8908 348.3026 0.6096 0 0 0 0

545.0586 308795.6 -502.3805 376.5835 343.1408 0.6096 0 0 0 0

529.8308 301100.1 -502.5264 362.3219 337.8528 0.6096 0 0 0 0

514.6091 293493.7 -499.6077 348.1212 332.4374 0.6096 0 0 0 0

499.3813 285887.2 -495.5652 333.9724 326.8763 0.6096 0 0 0 0

484.1809 278414.2 -490.0195 319.9029 321.1797 0.6096 0 0 0 0

468.9714 270985.7 -490.0195 305.8912 315.3275 0.6096 0 0 0 0

453.771 263512.7 -493.2447 291.9619 309.3199 0.6096 0 0 0 0

438.5798 255995.2 -487.5385 278.1208 303.1483 0.6096 0 0 0 0

423.3885 248700.1 -480.2708 264.3622 296.7979 0.6096 0 0 0 0

408.2003 241405 -477.5271 250.6919 290.264 0.6096 0 0 0 0

393.0213 234198.9 -474.8856 237.1313 283.5363 0.6096 0 0 0 0

377.8514 226992.8 -474.725 223.6927 276.6068 0.6096 0 0 0 0

362.6907 219800 -471.3539 210.373 269.4636 0.6096 0 0 0 0

347.5299 212700.6 -464.9034 197.1934 262.0881 0.6096 0 0 0 0

332.36 205699.1 -458.4821 184.151 254.4665 0.6096 0 0 0 0

317.2115 198799.9 -448.923 171.2823 246.5988 0.6096 0 0 0 0

302.069 192100.9 -445.6832 158.6027 238.4627 0.6096 0 0 0 0

286.9204 185299.6 -442.6331 146.1121 230.0356 0.6096 0 0 0 0

271.7902 178698.4 -429.5277 133.8529 221.3162 0.6096 0 0 0 0

256.6599 172301.9 -419.6768 121.8408 212.2803 0.6096 0 0 0 0

241.5296 165998.7 -413.1826 110.1029 202.9071 0.6096 0 0 0 0

226.4085 159802.4 -403.3463 98.67291 193.1834 0.6096 0 0 0 0

211.2904 153801.7 -387.0303 87.59338 183.0909 0.6096 0 0 0 0

196.1693 148099.1 -370.51 76.89191 172.6078 0.6096 0 0 0 0

181.0603 142601.1 -357.5214 66.63239 161.7265 0.6096 0 0 0 0

165.9606 137298.8 -341.1325 56.85132 150.4315 0.6096 0 0 0 0

150.8608 132299 -317.8552 47.61279 138.7034 0.6096 0 0 0 0

135.761 127699.5 -294.826 38.98083 126.5356 0.6096 0 0 0 0

120.6703 123398.1 -271.6217 31.02258 113.9328 0.6096 0 0 0 0

105.5797 119501.5 -245.1046 23.80188 100.8917 0.6096 0 0 0 0

90.48903 116000.7 -212.1078 17.41321 87.42795 0.6096 0 0 0 0

75.40143 113100.5 -179.038 11.90247 73.56665 0.6096 0 0 0 0

60.32906 110600.6 -149.281 7.373108 59.35617 0.6096 0 0 0 0

45.24146 108598.9 -105.9955 3.861816 44.8166 0.6096 0 0 0 0

30.15996 107402.3 -59.58691 1.441711 30.03055 0.6096 0 0 0 0

15.0815 106801.8 -26.54631 0.1432495 15.06772 0.6096 0 0 0 0

0 106601.6 -13.26586 0 0 0.6096 0 0 0 0

## Single Riser Inline VIV Example 1

This example is based on the single riser example in Section 6.1. The input files for VIVA are as follows:

* *rispre.in*

'RISOUT'

9

617.22

983.1533

245.697

6579.024

0.5524501

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

320.04

1887.917

1571.11

2451.479

1.397

0.5524501 0.028575

3.235463E+08

1

1

297.18

1868.492

1542.674 2540.016

1.3843

0.5524501 0.028575

3.235463E+08

1

1

868.6801

1830.216

1486.582

2714.753

1.3589

0.5524501 0.028575

3.235463E+08

1

1

22.86

983.1533

245.697

6579.024

0.5524501

0.5524501 0.028575

3.235463E+08

1

2

15.24

983.1434

245.697

6579.122

0.5524501

0.5524501 0.028575

3.235463E+08

1

1

1

* *risdyn-n.in*

'RISOUT'

'DYNOUT'

1.067573E+07

600

30

6

0 1.800555 0

91.44 1.749111 0

152.4 1.028889 0

304.8 0.5144444 0

457.2 0.2572222 0

3352.8 0.1028889 0

1025

0.01

0

* *conditions.in*

0

1.114E-06

1 1

0 0

1

* *risfat.in*

1

1.3729E+09 4.38

1.5

* *no\_files.in*

2 ! number of hydrodynamic files

basic\_bare-inline 41 0 ! BASIC HYDRO DATA for smooth cylinder, in-line

out\_s.db 15 4 ! file with strakes P/D=17, h/D=-0.25