FREE-FIX User Manual

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1 Input

Input is read from the text input file "HYM_edge_file.dat" (soon to be renamed). The content of the file is described below.

1.1 Input_basics

Variable	Description
which_data	self-explanatory; for now: 0 → HYM 1 → FLOW

1.2 Input_geometry

Details about input equilibrium files. This is only meaningful for FLOW.

Variable	Description
x_size	horizontal size of input grid
z_size	vertical size of input grid
rcenter	geometric center of grid

1.3 Input_plasma

Details about target plasma equilibrium. This is only meaningful for FLOW.

Note that rcenter and rmajor differ as follows: rcenter is the geometrical center of the grid; rmajor is "R_0", the reference R value that would be used to compute functions as $F(\psi)$ in a Grad-Shafranov solver. These are going to be identical in most cases.

Variable	Description
nx	grid points in the x direction
nz	grid points in the z direction
rmajor	geometric center of plasma

1.4 Input_coils

Variable	Description
n_coils	number of coils
n_CS	number of central solenoid points/windings

For CS_data_option, option 0 is generally used. Other options have been implemented, but not maintained recently.

1.5 Input_box

Variable	Description
nbox_R	grid points in the R direction
nbox_Z	grid points in the Z direction
xbox_L	left coordinate of output box
xbox_R	right coordinate of output box
zbox_T	top coordinate of output box
zbox_B	bottom coordinate of output box

Note that nbox will soon be replaced with two independent variables for assigning the number of points in the horizontal and vertical direction.

1.6 input_HYM

This is only meaningful for HYM. This namelist contains two ratios for units. This is necessary because FREE-FIX is written in SI units.

Variable	Description
HYM_length	m / code units
HYM_current	A/m^2 / code units

1.7 Input_numerics

Variable	Description
solution_method	See detailed description in Table 1
theta_start	where to start from for points where conditions are enforced
n_fit	how many points to use for least square fit
psi_offset	how much to shift the calculated ψ
fixed_coords_option	See detailed description in Table 2

Experience shows that it is occasionally necessary to "shift" the calculated values for ψ on the boundary by a small finite amount. This can be assigned by setting the variable psi_offset to a non-zero value.

In Table 1, "exact" means that the number of equations is equal to the number of unknown coil currents; "with gradients" means that in addition to the values of ψ, the direction of $\nabla\psi$ is also assigned on plasma boundary points; "weighted" means that equations are made non-dimensional by appropriate normalizations. For the equations using $\nabla\psi$, the normalization uses the local value of $\nabla\psi$, so equations in points with shallow gradients are given a proportionally larger weight. For now, options using gradients are only available for FLOW.

Value	Description
1	exact
2	singular value decomposition (SVD) least square fit
3	linear least square fit
4	linear least square fit with gradients
5	exact with gradients
11	weighted SVD square fit
12	weighted SVD square fit with gradients

Table 1: Solution_method options.

Value	Description
1	Start from 0 (or theta_start if solution_method is 1) and insert points at constant θ distance
10	(Approximately) calculates the length of the boundary, then distributes points at equal distances. **Computationally expensive!** Does not work well if number of points is low.
11	(Approximately) calculates the length of the boundary, then distributes points at equal arc length distances.

Table 2: fixed_coords_option possible values

2 Coil Input Files

The position of the coils (except the central solenoid, see below) is specified in the file "coil_input.dat". The file contains three columns, assigning, for each coil:

1. R coordinate of coil;
2. Z coordinate of coil;
3. coil group.

The last entry tells the code if coils have the same current: coils with the same coil group will have the same current. Note that the number of coils n_coils must be equal to the number of entries in the coil_input.dat file, but the number of actual unknowns may be lower than the number of coils if some coils have the same current.

The coordinates of the central solenoid windings are assigned in the file "CS_input.dat". In a way similar to what is done for the other coils, the number of entries in this file must be equal to the value of the input variable n_CS. All central solenoid windings carry the same current.

3 Output

A few files are given as output and are detailed below.

3.1 psioftheta_out.dat

Contains the output ψ on the prescribed box **in FLOW format**, corresponding to a one-dimensional list of ψ values vs. θ values (θ is a geometric angle used by FLOW).

3.2 RZ_out.dat

Contains the output ψ on the prescribed box **in HYM format**, i.e. a list of ψ values vs. the (R,Z) coordinates on the prescribed box.

3.3 boundary_test.dat

This is a check of ψ along the **plasma** boundary; the last column is the value of the calculated ψ on the desired boundary (would be 0 for an exact solution). The first three columns are θ, R, Z (in that order). A good part of the computational cost of the code in its current form is in calculating this file, which is intended for debugging.

3.4 coils_out.dat

Contains coil currents in Ampere. The last one is the central solenoid, the others are in the order they appear in the input. For all coils except the central solenoid, the coordinates of the coils are also saved. For the central solenoid, the number of windings is returned instead.