# An Overview of the *hAEdb* Database

Version of September 2008

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## 1. Introduction

This document presents an overview of the current status of the *hAEdb-2* development. It gives a short explanation of the functioning of the system, presents the web based client access tool, and describes the database and the CFD repository, specifying the requirements to input data from which the IXV CFD repository is constructed. A schematic view of the *hAEdb* client-server setup is displayed in the figure below:

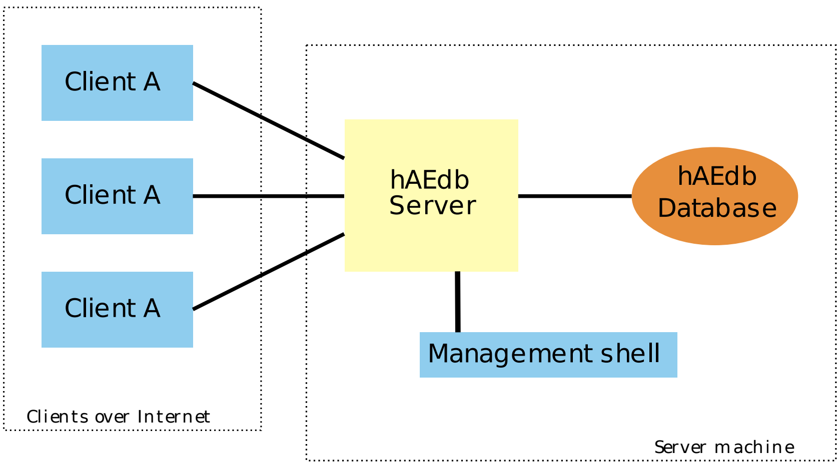


**Figure 1. Schematic view of hAEdb client-server setup**

The *Server* consists of a collection of programs driven by an Apache Web Server. These programs access the database under the control of one or more *Clients*.

*Clients* are either web based data extraction and viewing programs (see Section 2, "The Web Based Client Tool") or server management programs, i.e. programs for maintaining the *hAEdb-2* database.

The *hAEdb-2* database is a storage area containing the IXV CFD data repository and all the necessary auxiliary data necessary for running the server. The IXV CFD data repository contains the original unaltered data of the contributors. These data can be accessed and extracted on request. However, for performance reasons, the *hAEdb-2* server works with an internal data structure based on the MemCom data management system. These data are processed in batch mode by the baspl++ post-processing engine.

## 2. The Web Based Client Tool

The web based client tool is the data extraction and viewing system which is accessed by *hAEdb* users. In the current version (September 2008) the most important functions are implemented:

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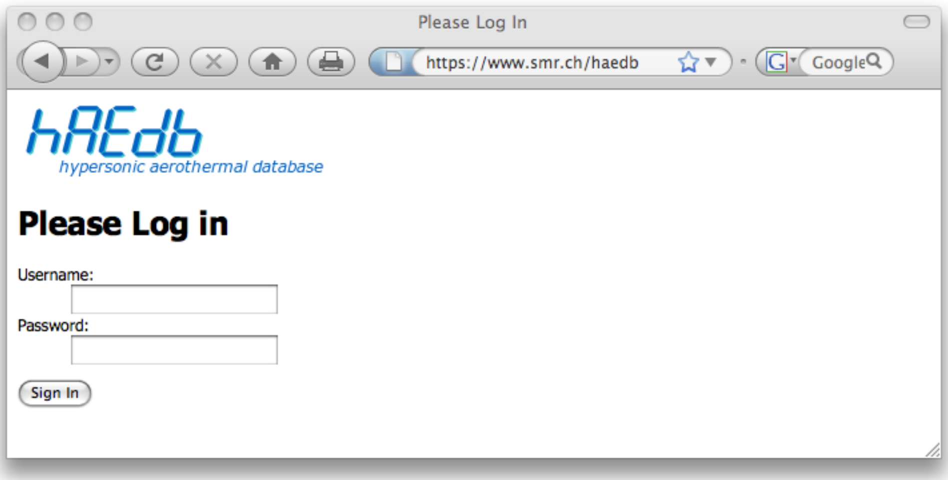
- Search and selection of models,
- Retrieval of model data,
- Edition of extraction and display settings,
- 3D surface plot with scalar variables,
- Graphs of variables on wall.

The web based client tool offers three distinct functions, i.e. *Selection*, *Settings*, and *Results*. The *Selection* comprises filter on models, selection of individual models, and non-graphical inspection of model data. *Settings* comprise specification of extraction and display settings for each post-processing method. The *Results* section comprises on the fly computation and display of results for each post-processing method.

The web based client tool is accessed by means of an Internet browser, such as Firefox™, Safari™, or Explorer™ through a HTTPS (secure Hypertext Transfer Protocol over Secure Socket Layer) connection to the server. Example login screen for logging in to the SMR HTTPS server:




Once logged in, the default *Selection* page appears. Note that the selection and the settings are per-user, i.e. each user has a view of the database and the results independently of other users.

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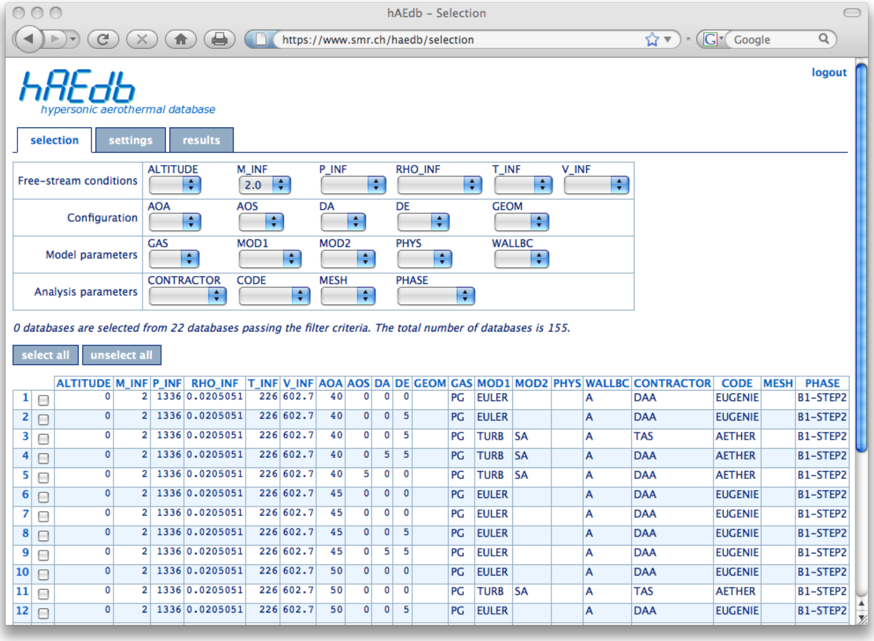
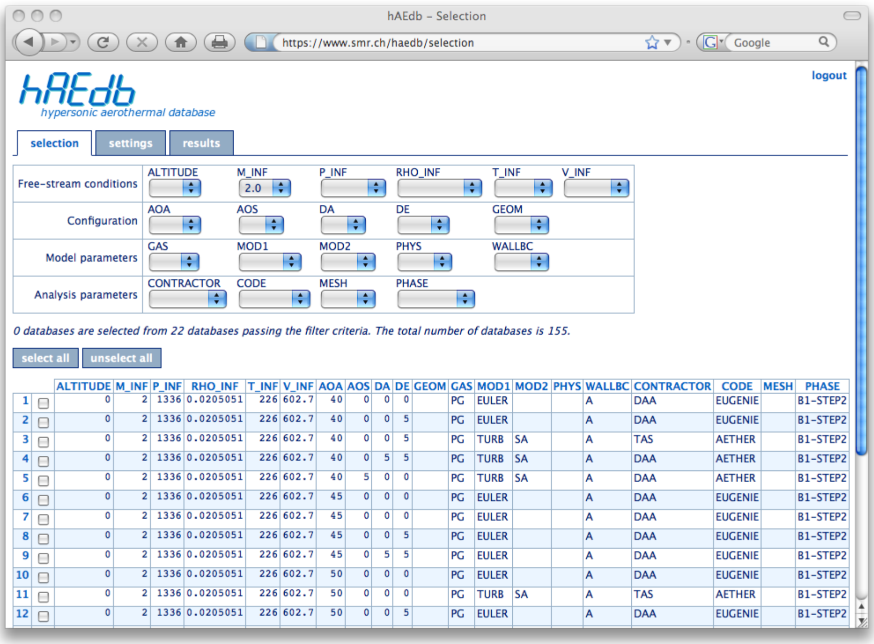



## 2.1. The *Selection* Page

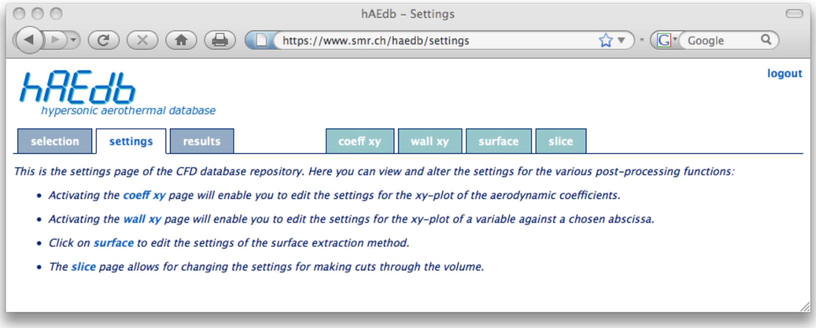
The *Selection* page allows for specifying selection criteria based on the keywords (see Section 4.3, "The keyword file keys.txt"). *Results* are always based on the selected models



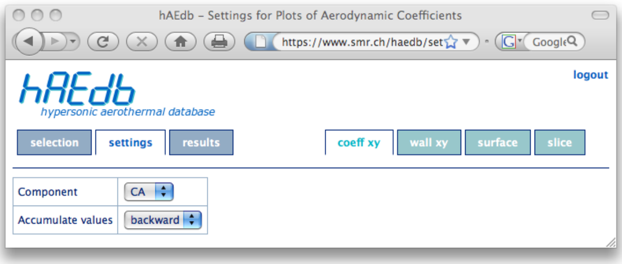

The tab bar in the above figure is the navigation bar. Below is filter area where selection criteria are specified. Note that the filter area is data-sensitive, i.e. for each criterion only data which actually exists on the database are displayed in the menu. Finally, the extraction table displays all candidate modes for the selection. Check boxes allow for retaining specific models from the proposed selection.

## 2.2. The *Settings* Pages

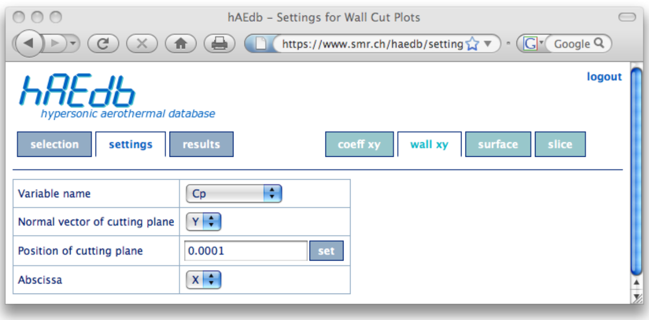
Selecting the *Settings* tab from the tab bar displays the *Settings* menu (text is self-explanatory):




Settings are selected from the right tab bar. The *coeff xy* settings page allows for specifying settings for the display of the aerodynamic coefficients.




The *wall xy* settings page define the cutting plane which will cut the wall surface, and the variable to be extracted and interpolated along the cut:




The *surface* settings page specifies the 3D surface extraction parameters, such as which part of the model to extract, the scalar fringes (flood fill) variable to be displayed, the model view, etc:

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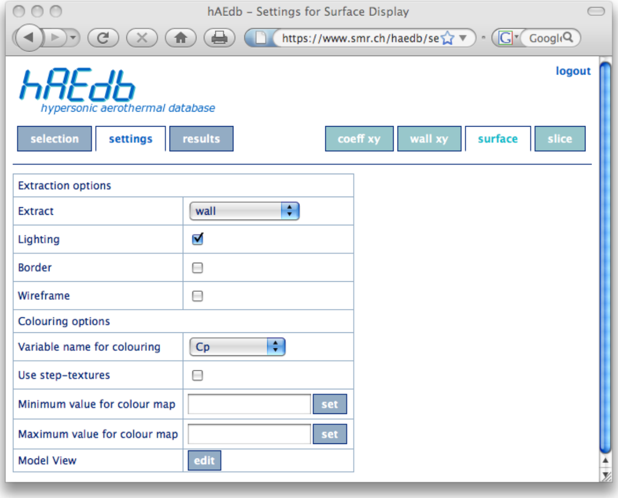
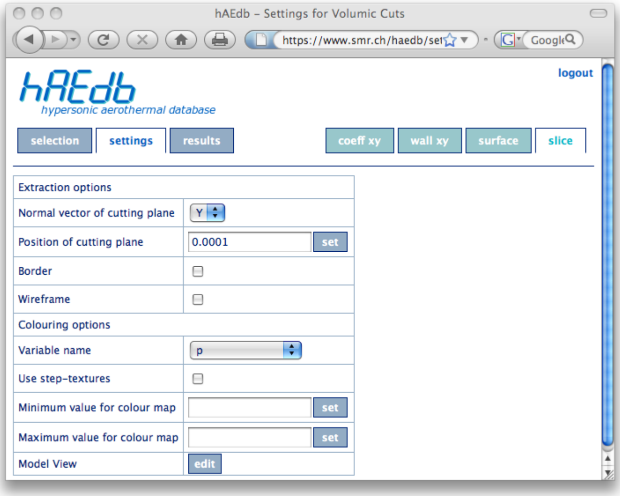
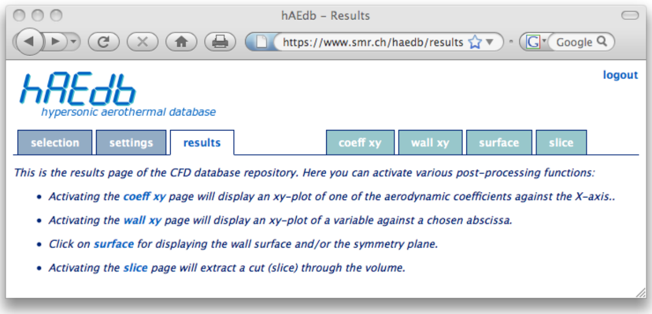



Finally, the *slice* settings page specifies the 3D cutting plane extraction parameters, such as the orientation of the cutting plane, the scalar fringes (flood fill) variable to be interpolated and displayed, the model view, etc:

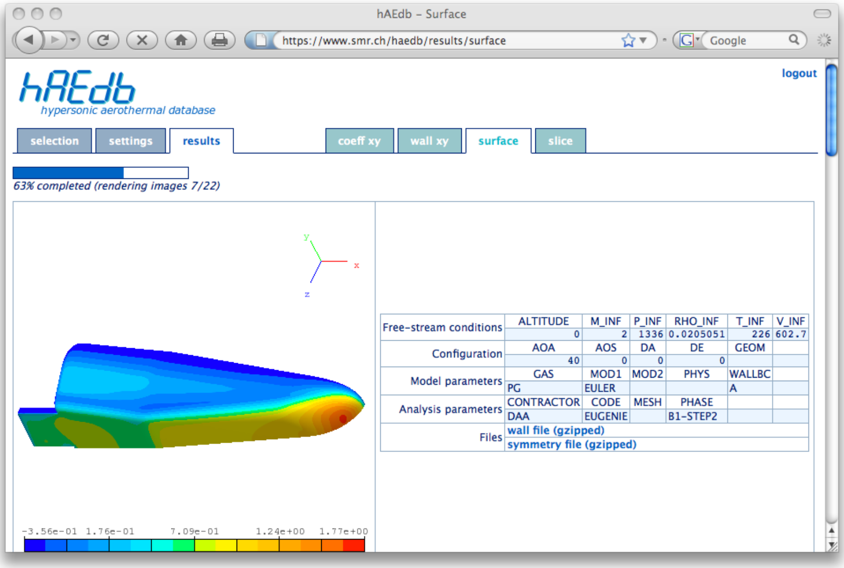



## 2.3. The *Results* Pages

Selecting the *Results* tab from the tab bar displays the *Results* menu (text is self-explanatory), allowing for applying one of the methods to the data previously selected with *Selection* page:

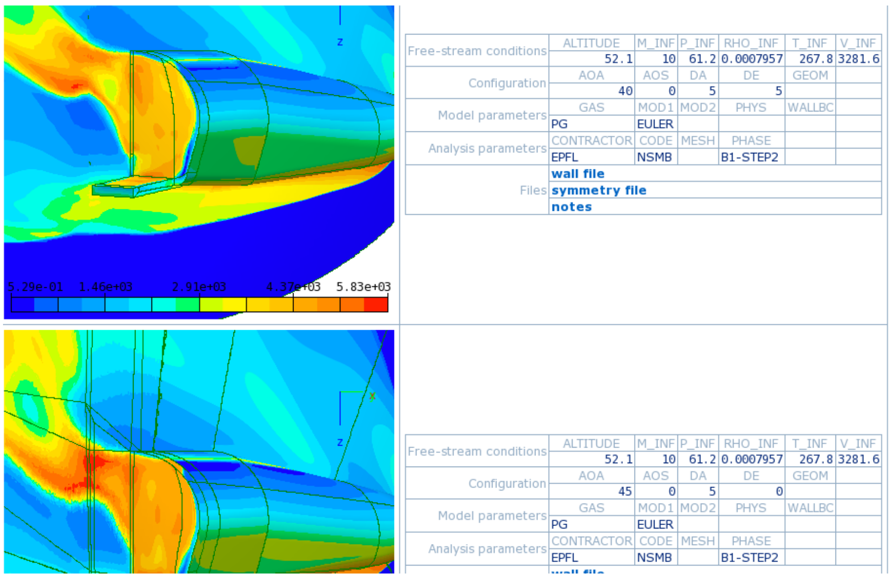


Selecting the *surface* results display page extracts the wall surface and the symmetry plane (if any) and it applies the scalar field selected by the *Settings* page. A progress bar indicating the progress of the server will appear:

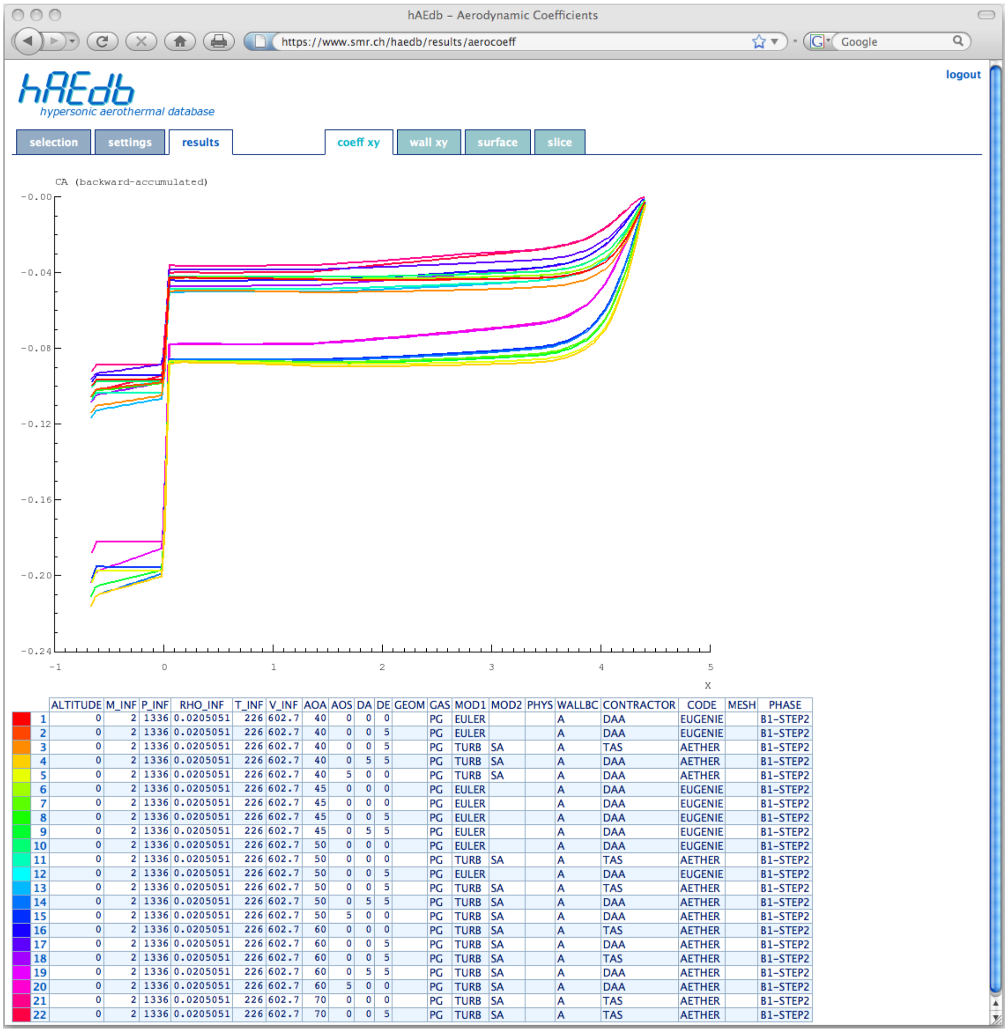



The table displayed along with the model contains the keywords of the current model and it allows for displaying and downloading of the associated result data files contained in the CFD repository.

The same display method will be applied to all models selected by the current selection. Below is an example of extracting the wall surface and the symmetry plane data of multiple models.

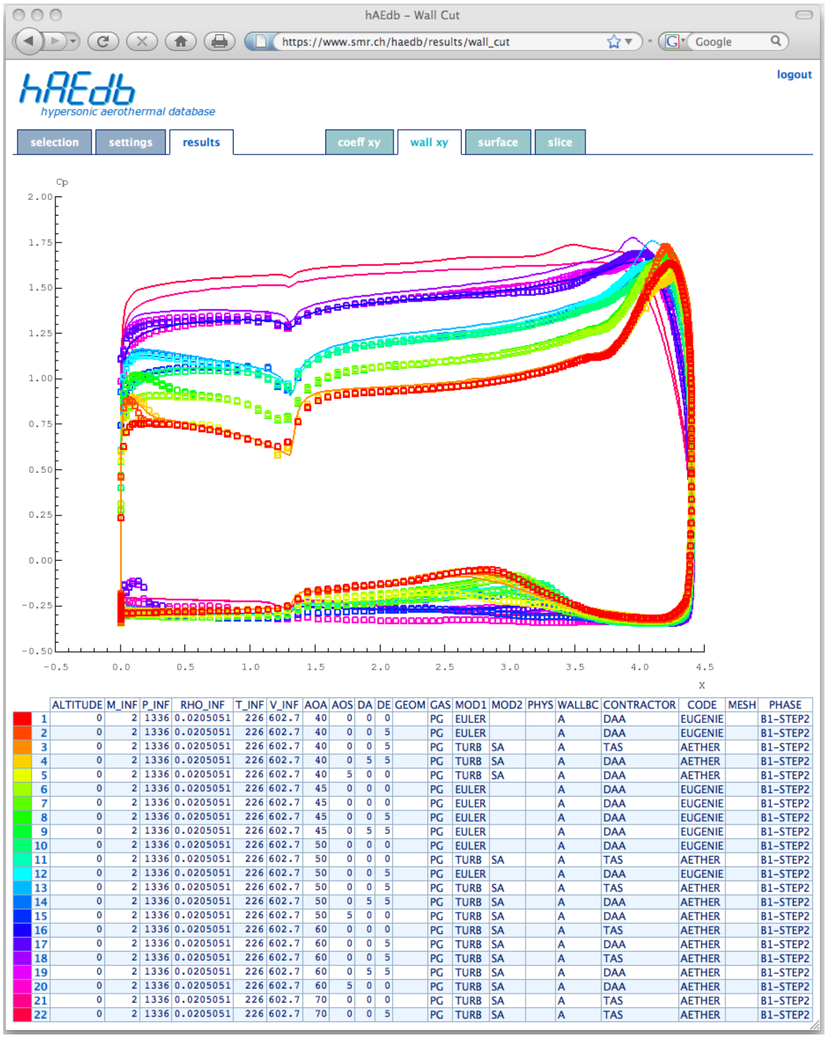



Selecting the *coeff xy* page results display page extracts the aerodynamic coefficients and displays them along the x-axis, according to the *coeff xy* settings. The example below is an extraction of the default CA for all models with $M_{\#} = 2.0$:




| | ALTITUDE | M_INF | P_INF | RHO_INF | T_INF | V_INF | AOA | AOS | DA | DE | GEOM | GAS | MOD1 | MOD2 | PHYS | WALLBC | CONTRACTOR | CODE | MESH | PHASE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 2 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 0 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 3 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 4 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 5 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 5 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 5 | 0 | 0 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 6 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 7 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 8 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 0 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 9 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 5 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 10 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 11 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 0 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 12 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 13 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 14 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 5 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 15 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 5 | 0 | 0 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 16 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 0 | 0 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 17 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 0 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 18 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 19 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 5 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 20 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 5 | 0 | 0 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 21 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 70 | 0 | 0 | 0 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 22 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 70 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |

Selecting the *wall xy* page results display page extracts a selected variable displayed along a selected axis. The example below is an extraction of the default $c_p$ along the default x-axis (as specified in the wall xy settings page) for all models with $M_{\#} = 2.0$:




| | ALTITUDE | M_INF | P_INF | RHO_INF | T_INF | V_INF | AOA | AOS | DA | DE | GEOM | GAS | MOD1 | MOD2 | PHYS | WALLBC | CONTRACTOR | CODE | MESH | PHASE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 2 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 0 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 3 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 4 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 0 | 5 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 5 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 40 | 5 | 0 | 0 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 6 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 7 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 8 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 0 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 9 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 45 | 0 | 5 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 10 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 0 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 11 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 0 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 12 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 5 | | PG | EULER | | | A | DAA | EUGENIE | | B1-STEP2 |
| 13 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 14 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 0 | 5 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 15 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 50 | 5 | 0 | 0 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 16 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 0 | 0 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 17 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 0 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 18 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 19 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 0 | 5 | 5 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 20 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 60 | 5 | 0 | 0 | | PG | TURB | SA | | A | DAA | AETHER | | B1-STEP2 |
| 21 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 70 | 0 | 0 | 0 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |
| 22 | 0 | 2 | 1336 | 0.0205051 | 226 | 602.7 | 70 | 0 | 0 | 5 | | PG | TURB | SA | | A | TAS | AETHER | | B1-STEP2 |

# 3. The Server

The *hAEdb* server is a HTTP server and must thus be accessed by any HTTP user agent , i.e. a "web browser". The server can handle multiple sessions from multiple users at the same time.

The *hAEdb* server accesses the database repository in read-only mode. Hence, modification of data from the outside is inhibited. In turn, the database repository must be prepared prior to running the *hAEdb* server. This is performed with a set of dedicated import routines which scan the database repository, locate TecPlot files and `keys.txt` files and perform consistency checks and correction of minor errors. This import procedure requires remote terminal access (via SSH, telnet, rlogin etc.) to the machine hosting the repository.

The *hAEdb* server performs on the fly post-processing to display images of 3D geometries and graphs. Originally, it was intended to create a limited number of static screen shots, to catalogue them, and to serve these screen shots upon matching requests, such as creating a screen shot for each database with a plot of the pressure variable on the surface. When the user makes a selection of databases and requests the *surface* method, the corresponding images would be sent to the user agent. However, while lightweight and very scalable, this approach would not allow for zooming and rotating of the model, which is important when working with 3D geometries (as opposed to pure 2D models). Thus, the server was designed to perform post-processing on the fly.

## 3.1. Server Architecture

The *hAEdb* server is composed of the following blocks:

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- The *Models*
- The Controller
- The Authentication Manager
- The Resource Manager
- The Post-Processor Backend
- The Basic Web Technology

The *Models*: On startup, the directory tree containing the CFD databases and `keys.txt` files (the database repository) is scanned. The key files are parsed and held in-memory to enable fast queries. For each user, a state is managed. Part of this state are all settings. User states are persistent for a limited time frame: The server may be shut down and then restarted while user states are preserved.

The *Controller*: Generates HTML documents as a function of the current settings and the user agent's HTTP request. For each post-processing method (like surface extraction, cut, coefficient plot etc.), a pair of dedicated controllers exist: One to manipulate the settings, and one to execute the post-processing.

The *Authentication Manager*: Is required to distinguish between different users and to restrict access to the server. The server is designed such that it can serve both HTTP and HTTPS (secure HTTP) protocols.

The *Resource Manager*: It mainly deals with temporary files and it is needed as HTTP user agents request images like those created by the backend in separate requests (the HTTP protocol cannot encapsulate multiple resources, and the HTML format does not support inlining of images). For example, when the user agent sends a request for computing a new graph, the backend creates a new (temporary) file containing the graph. The server sends back HTML which contains an URI (link) which will serve that file. When the HTTP user agent parses the HTML code, it will create a new request to retrieve that image. Upon serving that image, the server then must delete this file.

The *Post-Processor Backend*: The backend is used to create images, such as 3D geometries and graphs, from the databases. The backend is invoked as a separate process, executing the baspl++ post-processor [baspl]. This separation between server and post-processing is not only secure and more stable than an all in one design, it theoretically also allows for dedicated backend servers for improved scalability. Low-level communication between server and backend is performed via the UNIX pipe mechanism, but could be replaced by TCP. Specially-coded data encapsulation techniques permit the exchange of structured and typed data between server and backend, and the invocation of function and object methods on the backend from the server. An important issue is the handling of closed or reset HTTP connections. This occurs whenever the user hits the "stop" button of his user agent or terminates it. The server has been fitted with a specialized watchdog thread which, upon a closed or reset HTTP connection (by the user agent), will terminate the backend process. This is essential for reliable operation of the server, as lack thereof would quickly accumulate stale backend processes occupying valuable core memory.

The *Basic Web Technology*: The *hAEdb* server is implemented using the *Pylons*[1] web framework. This framework is highly customizable and, like the *hAEdb* server, written in the *Python* language.

## 3.2. Scalability

On a workstation, most - if not all - resources (memory, CPU time, etc.) can be dedicated to the person sitting in front of the machine whereas a server allows for connecting of multiple users at the same time. Hence, as soon as one user allocates many resources, the servicing of the other users requests will be delayed. In case of the *hAEdb* server, some of the on the fly post-processing tasks are demanding in memory and CPU resources. This is especially the case if (a) multiple databases are to be treated in a user's request, and (b) if the databases are medium to large models (more than 5 million of elements). Since in the current design, the post-processing backend and the *hAEdb* server itself are executing on the same machine, serving more than 5 requests at the same time may lead to very high demands on main memory. Thus, the scalability

[1] http://wiki.pylonshq.com/display/pylonsdocs/Home

of the current design is limited. This can be amended by switching to a design where the post-processing backend is hosted by a server farm which is accessed from the *hAEdb* server via a load-balancing facility. The communication protocol between server and backend is only minimally affected by such a change.

# 4. The Database and CFD Repository

By *database* we refer to a collection of data pertaining to a single computational case. This collection of data contains among others the surface and volume mesh geometries and the solution data defined on these meshes, and a `keys.txt` file containing the key/value-data uniquely identifying the database within the CFD Repository.

Since there are many different computational cases to be imported into the repository, the import process must be automatic. This means that all relevant data which serves as input must adhere to well-defined conventions such that the automatic importing tools can operate correctly.

## 4.1. Directory Names

The document *FLPP 1.2 – IXV SYS-14 - CFD Repository Database description* states that each computational case consists of a directory under which all files relevant to this case are located. Each directory containing a case is named according to a scheme containing the parameters describing the case, such as contractor, computational campaign (also referred to as phase), Mach number, etc.

For the *hAEdb*, these requirements are relaxed somewhat, as the "keys.txt" file, which must be present in each directory containing a computational case, already contains all data that is necessary to identify the case. However, each directory's name must be unique within its parent directory, and it must at least contain the name of the contractor and the computational campaign.

Thus, the *hAEdb* accepts directory names such as `EPFL_B1-STEP2`, where `EPFL` is the name of the contractor and B1-STEP2 is the computational campaign.

## 4.2. Overview of Input Files and Data Formats

The data formats adopted for the *hAEdb* database are based on those described in the document [sys014]. The input files pertaining to an analysis case are listed in the following table. The prefix `(xxx_)` may be chosen arbitrarily or omitted.

### Table 1. Imported HAEDB-2 Data Files

| File name | Status | Description |
|---|---|---|
| keys.txt | Required, format is defined | ASCII text file containing the keywords defined for the HAEDB-2, see section below. |
| (xxx_)wall.plt(.gz) | Required, format is defined | ASCII text file containing the surface result data in Tecplot form (see section below). |
| (xxx_)sym.plt(.gz) | Required, format is defined | ASCII text file containing the 'symmetry' result data in Tecplot form (see section below). |
| (xxx_)(volume).plt(.gz) | Optional, format is defined | ASCII text file containing the 'volume' result data in Tecplot form (see section below). |
| (xxx_)notes.txt(.gz) | Optional, ASCII free format | ASCII text file containing an optional additional description of the case. The text in this file must consist of the 128 original ASCII characters. Files containing other characters, such as °, µ, etc. will be rejected. Note that the optional name `xxx_` is irrelevant for HAEDB-2. |

The example directory `AST_B1-STEP2` below contains the following files

`keys.txt` Keyword file, is processed by search engine.

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`notes.txt` Additional notes file, is not processed and can be consulted by client.
`sym.plt.gz` Symmetry data file (compressed)
`wall.plt.gz` Wall data file (compressed)
An example of the mandatory `keys.txt` file is listed below:

```
AOA=  4.0000000e+01
AOS=  0.0000000e+00
CODE="NSMB"
CONTRACTOR="AST"
DE=  0.0000000e+00
DA=  0.0000000e+00
GAS="pg"
MOD1="Euler"
MOD2="None"
STEP="B1-STEP2"
M_INF=  1.0000000e+01
P_INF=  6.5069100e+01
RHO_INF=  8.4239000e-04
T_INF=  2.6923400e+02
V_INF=  3.2895700e+03
ALTITUDE=  5.1628000e+01
```

And an example of an optional `notes.txt` file:

```
Code/algorithm:
NSMB (Navier-Stokes MultiBlock)
 -Second order Upwind scheme - Van Leer limiter
 -Implicit time integration

Mesh:
Multi block structured mesh.
number of cells: 917 883

Comments:
1-) In the "wall" file the Re_theta quantity is not computed and
the fields Cf, Cfx, Cfy, Cfz, Q, Q_tr, Q_vib, Q_diff, Epsilon,
y+, tow,  emissivity,  Re_tetha, cN2, cO2, cNO, cN, cO are
 intentionally set to zero.
2-) In the "sym" file the fields cN2, cO2, cNO, cN, cO, TvN2, TvO2,
 TvNO are intentionally set to zero.
```

## 4.3. The keyword file `keys.txt`

The purpose of the keyword file `keys.txt`[2] is to identify the model and its global parameters. All search operations are based on the keyword files. Thus, the contents of the key file must be unique. The `keyfile.txt` file has been superseded by the "keys.txt" file. The reason for this is that the "keyfile.txt", which is present for all computational cases as delivered on the DVD FLPP 1.2 – IXV SYS-14 - CFD Repository Database (data from phase B1-STEP1 and B1-STEP2), does not follow a well-defined format which can be interpreted by a computer program. Instead, it is mandatory that each computational case is accompanied by a "keys.txt" file, whose format is described in this section.

Based on the input from the document `SYS-14_IXV-ASTRIUM-TNT-033_Iss1.pdf` and the analysis of keyword files provided with the STEP1 and STEP2 results, a unified description of keywords has been defined. Each individual computational case must provide a file `keys.txt` containing keywords according to the following simple syntax:

[2]Note that the keyfile.txt file has been replaced by the keys.txt file. The reason for this is that the "keyfile.txt", which is present for all computational cases as delivered on the DVD FLPP 1.2 – IXV SYS-14 - CFD Repository Database (data from phase B1-STEP1 and B1-STEP2), does not follow a well-defined format which can be interpreted by a computer program. Instead, it is mandatory that each computational case is accompanied by a "keys.txt" file, whose format is described in this section.

```
key=value [;]
```

If more than one keyword is to be placed on one line the keywords must be separated by a semicolon. If one single keyword is defined on one line the semicolon is not needed. If the value is a character string special rules apply (see next paragraph).

The tables below describe the HAEDB-2 keywords. Note that - for easier understanding and for reasons of selection and display - the HAEDB-2 keywords have been split in groups "Free-Stream conditions" (FS), "Configuration" (CO), "Physical Model" (MO), and "Analysis" (AN). However, all keywords are equivalent, i.e. there is no keyword search hierarchy.

Keyword names are not case-sensitive, i.e. HAEDB-2 will always convert keyword names to upper case when searching for specific keyword names. However, the content (value) of the keyword is case sensitive.

- STATUS is either R (required) or O (optional). All optional keywords must provide default values as indicated in the table below.
- TYPE describes the data type. F means float (64bit float),I means integer (32bit integer), K means character. Special rules pertain to character strings:
- The UNIT attribute must be strictly respected since all dimensioned values are implicitly dimensioned. All units are SI units.

### Table 2. HAEDB-2 keywords: Free-Stream conditions (FS)

| Keyword | Status | Type | Units | Description |
|---|---|---|---|---|
| ALTITUDE | R | F | [km] | Altitude. |
| M_INF | R | F | - | Mach number at infinity. Corresponds to the M entry of the file names. |
| P_INF | R | F | [Pa] | Pressure at infinity. |
| RHO_INF | R | F | [kg/ $m^3$] | Density at infinity. |
| T_INF | R | F | [K] | Temperature at infinity. |
| V_INF | R | F | [m/s] | Velocity at infinity. |

### Table 3. HAEDB-2 keywords: Configuration (CO)

| Keyword | Status | Type | Units | Description |
|---|---|---|---|---|
| AOA | O | F | [DEG] | Angle of attack. Default value is 0. |
| AOS | O | F | [DEG] | Angle of slip. Default value is 0. |
| DE | O | F | [DEG] | Symmetrical flap deflection angle. Default value is 0. |
| DA | O | F | [DEG] | Asymmetrical flap deflection angle. Default value is 0. |
| GEOM | ? | K | - | Geometric configuration. The following values are defined (case-sensitive):*HALF*, *FULL*, others? |

### Table 4. HAEDB-2 keywords: Model parameters (MO)

| Keyword | Status | Type | Units | Description |
|---|---|---|---|---|
| GAS | R | K | - | Gas model. The following values are defined (not case-sensitive): *PG*, *EQ*, *NEQ*. |
| GEOM | ? | K | - | Geometric configuration. The following values are defined (case-sensitive): *HALF*, *FULL*, others? |

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| Keyword | Status | Type | Units | Description |
|---|---|---|---|---|
| MOD1 | R | K | - | Flow model. The following values are defined (not case-sensitive): *EULER*, *LAM*, *TURB*, *TRANS*. |
| MOD2 | (R) | K | - | Turbulence model required if MOD1 == *turb* \| *trans*. The following values are defined (case-sensitive): *SA* (Spalart Allmaras), *KE* (k-epsilon), *KW* (k-omega Wilcox), *BL* (Baldwin Lomax). |
| PHYS | O | K | - | Short informal description of physical model used. |
| WALLBC | O | K | - | Wall boundary condition (not case-sensitive) FC = fully catalytic A = Adiabatic. |

### Table 5. HAEDB-2 keywords: Analysis parameters (AN)

| Keyword | Status | Type | Units | Description |
|---|---|---|---|---|
| CODE | R | K | - | CFD code used to produce results. The following values are defined (case-sensitive): *Aether*, *CFD++*, *Eugenie*, *H3NS*, *NSAERO*, *NSMB*, *TAU*. |
| CONTRACTOR | R | K | - | Contractor name. The following values are defined (case-sensitive): *AST* (Astrium), *CFS* (CFS Engineering), *CIRA*, *DAA* (Dassault), *DLR*, *EPFL*, *UNIROMA*, *TAS* (Thales Alenia Spazio). |
| MESH | O | K | - | Short informal description of mesh. |
| PHASE | R | K | - | Phase of computational campaign. Must be *B1-STEP1*, *B1-STEP2*, *B2*, *C1* |

The keywords described above must be placed in an ASCII text file `keys.txt` according to the following syntax

```
key=value [;]
```

If more than one keyword is to be placed on one line the keywords must be separated by a semicolon. If one single keyword is defined on one line the semicolon is not needed. The values must be specified according to the following rules:

- Data of type F (floating point) must contain the dot (.) decimal delimiter.
- Data of type K (character strings) must be enclosed in quotes '...' or double-quotes "...". If the character string extends over several lines it must be enclosed in 3 quotes (''' ... ''') or 3 double quotes (" " " ... " " ").

## 4.4. Tecplot Result Data Files

### 4.4.1. General Requirements

All TecPlot files must be delivered as ASCII files; binary TecPlot files will be rejected. The TecPlot files must conform to version 8 at least. Files may be delivered in uncompressed or compressed form, where the latter is recommended to reduce disk space usage. For compression, the use of the `gzip` utility is required. Other compression formats are not supported.

The result data files must be named according to Table 1, "Imported HAEDB-2 Data Files". For automatic identification of files delivered in compressed form, file names must end with the `.gz` suffix, which is automatically added by the `gzip` utility.

The reference axis definition shall be consistent with the IXV reference coordinate system. In addition, the formats shall be provided at a level that enables subsequent FEM structural and thermal analyses to be performed.

All result data files described in Table 1, “Imported HAEDB-2 Data Files”, i.e. the wall datafile, the symmetry plane file, and the volume data file, are imported in a single MemCom database

### 4.4.2. Surface data (file wall.plt)

Contains the surface mesh and at least the following surface quantities ('variables') at the mesh nodes:

```
x y z T_w Cp Cf Cfx Cfy Cfz Q Q_tr Q_vib Q_diff y+ emissivity Re_tetha
cN2 cO2 cNO cN cO
```

c are the mass fractions of the species.

### 4.4.3. Symmetry data (file sym.plt)

Must contain at least the following surface quantities ('variables') ) at the mesh nodes:

```
x y z cN2 cO2 cNO cN cO TvN2 TvO2 TvNO T rho p Mach enthalpy
```

### 4.4.4. Volume data (file volume.plt)

Must contain at least the following surface quantities ('variables') ) at the mesh nodes:

```
x y z u v w cN2 cO2 cNO cN cO TvN2 TvO2 TvNO T rho p Mach enthalpy
```

## 4.5. Other files

Files containing the aerodynamic coefficients are not required. Instead, aerodynamic coefficients will be computed by the importing tool during the import procedure.

## 4.6. The Data Conversion Process

As mentioned earlier, the conversion process is intended to be fully automatic.

### 4.6.1. Conversion of data from phase B1

Status: All data have been imported.

The DVD with the FLPP 1.2 – IXV SYS-14 - CFD Repository Database (data from phase B1-STEP1 and B1-STEP2) has been converted by SMR: Since it was produced before any definition of HAEDB-2 the data is not consistent with the HAEDB-2 requirements. Thus, conversion programs which take into account all 'special cases' had to be devised by SMR. Specifically, free stream conditions, and codes used in computations, had to be added by guessing them with the MOD1, STEP, and the MACH keywords.

Some problems encountered:

- Some contractors provided `.dat` files instead of .plt
- Some contractors did not adhere to directory naming conventions.
- Some contractors put input files belonging to different computational cases into the same directory.
- Keywords are missing here and there.
- Some contractors had special characters in the keyword files.

### 4.6.2. Conversion of data from phases B2 and C1

Status of 2008-09-30: Data has been received but is not in correct format. A significant amount of manual processing would be necessary to correct these errors.

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## 5. Problems and Workarounds

1. *Variable naming*: For phase B1, all TecPlot files which are available to SMR have been imported to the CFD database successfully, except for binary TecPlot files and truncated TecPlot files. However, variable naming in the TecPlot files is not always consistent with the definitions according to the [sys014] document. A tool has been developed which, when run prior to import, corrects these variable name errors in the TecPlot files. Hence, the variable names, as imported to the CFD database, are consistent.

2. *Data from phases B2 and C1, status of 2008-09-30*: Data has been received but is not in correct format. A significant amount of manual processing would be necessary to correct these errors.

# Bibliography

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