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The TVO/VTT Material Database

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ABSTRACT

To make fitness, safety and lifetime related assessments for piping and equipment, the amount of necessary input data is considerable. At the same time it is essential that the data is reliable, up-to-date, well traceable and easy to obtain. Often the information that is necessary for a specific project has to be collected in a very short time.

Material data from material testing is often structurized in a different way than data from a material standard or a handbook. As material testing has been done for a long time already and the collection and storage has developed over all these years data may even be gathered in obscure places and may, especially after a longer period of time, be difficult to reproduce or impossible to directly analyse. For future purposes it is important to store the data in such a way that the same requirements as mentioned in the previous section are fulfilled.

With a growing importance of parameter studies and probabilistic analysis it is more and more important to have the input data to the analyses in a flexible and readily available digital format.

In order to accommodate the requirements that arise from the above a dedicated material database was developed using ACCESS [8] and Visual Basic [9] as the main tools that includes material data that may be dependent on more than one parameter simultaneously, is accompanied by source reference information and has references to similar materials. Further it shall fulfil the following requirements:

* It shall be a systematical archive of information.
* It shall be a reliable data source. A reliability level shall be given to all data.
* All data must be accompanied by a source reference.
* I shall be easy to check data from the database.
* It shall be easy to access the data in the database.
* It shall be possible to make an alphanumerical input file for an application program using data from the database.
* It shall be possible to write data from an output file of an application program back into the database.

The material database is part of the TVO Pipeline Analysis and Monitoring System that consists of geometry, material, loading, result and reference document databases [7]. The whole system is being developed by both TVO and VTT and is primarily intended to facilitate the analyses of piping and equipment and the generation of associated documentation.

This paper outlines the contents and capabilities of the material database.

KEYWORDS: database system and material.

GENERAL INFORMATION WITH REGARD TO THE SYSTEM

The system presently under development is meant to contain all material properties necessary as input to associated programs as well as those properties that shall be post processed and analysed further in order to obtain new material properties. In the future even some of the more common statistical analysis methods may be included into the application. For a start only properties related to the TVO OL1 and OL2 units and to the material testing of VTT Industrial Systems will be entered into the system. All data in the system will be accompanied by the necessary information with regard to its reference document(s), dates, version and validity. In case of pure test data a source reference may be problematic, but the tests related to the data shall be sufficiently identified.

Also the original material test results related to specific plant items may be entered into the system and coupled to the item under consideration as additional information. In this way it will also be possible to, from a material property point of view, keep an "as-designed/standard" version and an "as-built/measured" version.

In case a material property source reference is declared invalid within the document database, the system will "know" that the related properties are not fully reliable anymore. It is very important that subsequent analysis, like fatigue and fracture analysis, uses up-to-date and reliable input.

The system is built up of one stand-alone database and integrated program modules and is connected to at least the document database. Thus, the material database can be used for it's own purpose without the TVO Pipeline Analysis and Monitoring System having to be completed or in use.

The material database MATDBS

The material properties are gathered in a database called MATDBS. At the moment the material database undergoes a complete revision. A typical view of the new program interface display is shown in Figure 1. As can be seen, many different material properties, if necessary as function of a second, third or more variables, can be saved. In addition, the source reference of the information is input as a link to the document database, see next section. This is necessary to document the data in the application that is using it and easily cross check the data.

Note that the material identification that is coupled to the geometry of the TVO Pipeline Analysis and Monitoring System has to be chosen from the material database and as such cannot be freely chosen. Either an existing material has to be chosen or a new material has to be first introduced into the material database and then chosen. This in fact shows another basic principle in the database development project where data may only occur once and user are helped/forced to use sound data. A possibility will be incorporated to calculate either with standard values or with alternative ones, for instance measured values.

A new feature that will be incorporated in the material database is the ability to save test data in an efficient way. This immediately incurs that the bookkeeping burden is taken away from the researcher and he or she can concentrate on research. Due to the fact that the data from any of the databases of the system can be exported into a alphanumerical file it will be possible to make files for postprocessing of measurement results. Later on it will be investigated whether some statistical analysis that is related to the test data can even be efficiently incorporated in the material database.
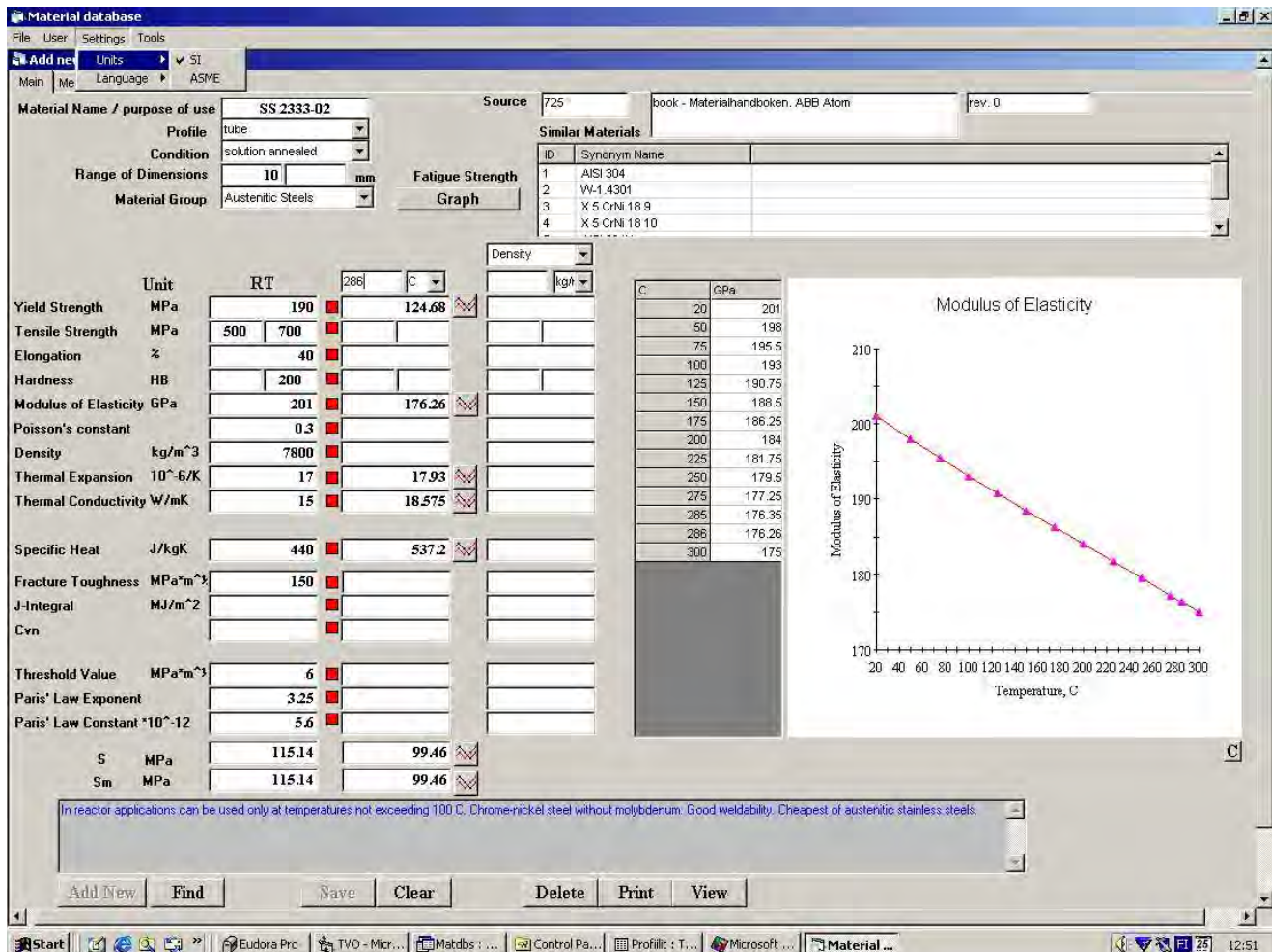

Figure 1. Main display of the material database

The document database

As mentioned before the source reference of the material properties is input as a link to the document database. All documents that are related to any of the items within the TVO pipeline analysis and monitoring system will be gathered into this document database. Once a document is part of the document database, it can be logically associated to any of the other databases. In this way data in the database will always be accompanied by an exact trace to the data source. In case the database document is available in digital format even this file can be coupled to the document database and will thus be readily available from the PC. An extra option in the document database is that activities and deadlines may be associated to the documents and reports can be produced showing future activities and deadlines.

The document database contains information as to the validity of documents. Other modules of the database system can read this information and produce warnings or errors to tell that the source reference is not valid anymore.

After making the link that is described before it is possible to automatically add information with regard to the data sources to the documentation that is produced by the system. For instance the crack growth analysis that is mentioned later on is performed as a batch analysis and could automatically generate a complete report with source references.
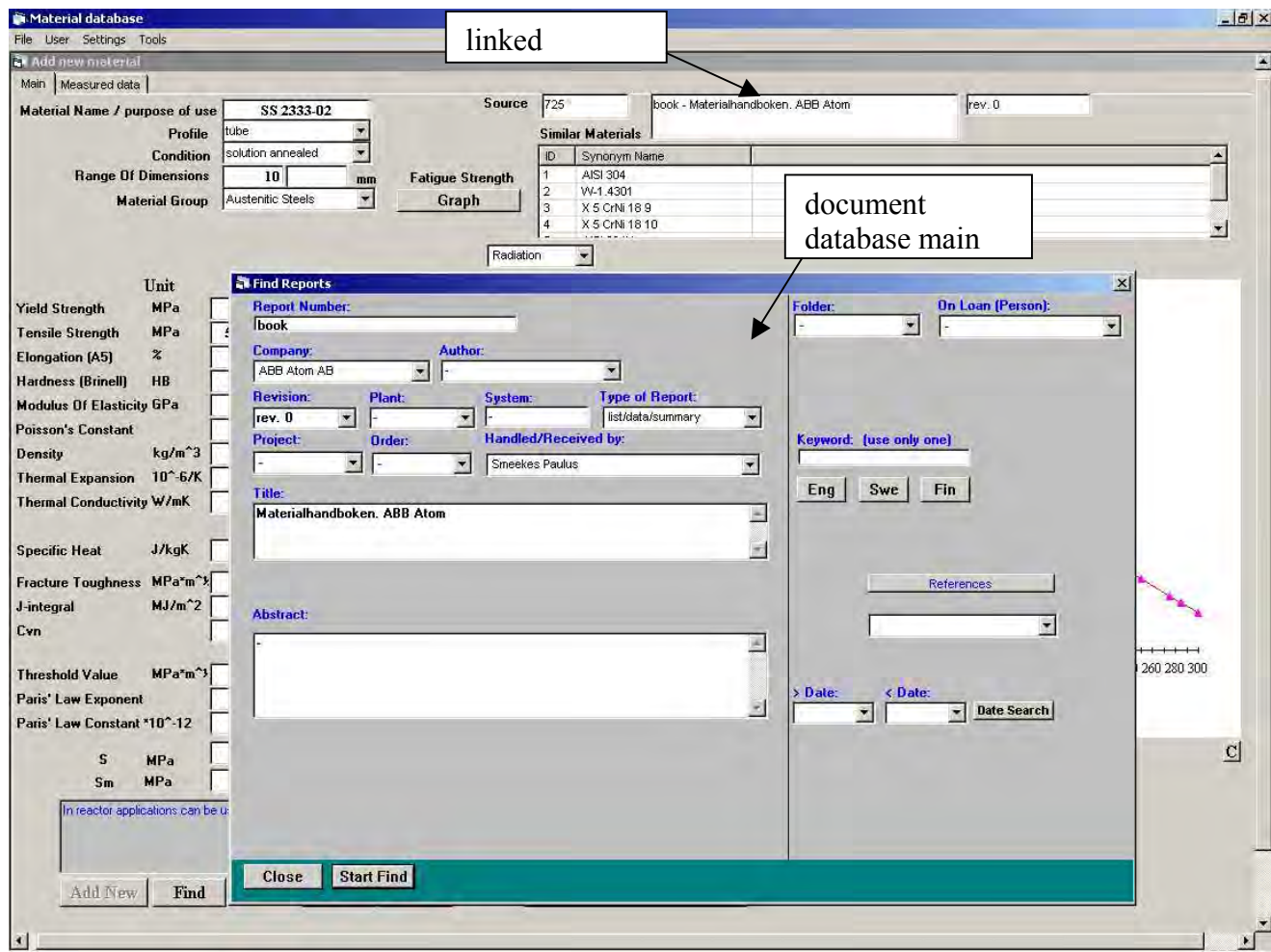

Figure 2. Double clicking a linked document opens the document database main display and show the most significant information related to the document

SPECIFIC CAPABILITIES OF THE MATERIAL DATABASE

Unit conversion

Within the system several unit conversion routines are available:

* A full swap between SI and ASME units. This is achieved through the main toolbar (settings/units) and illustrated in figure 1. This feature enables the user to for instance enter the numerical material property information directly from the ASME II [6] using the ASME units and continuing using this data in SI units.
* A local swap for every unit. For all variables like stress, modulus of elasticity, temperature, density etc. a set of valid units was defined. This set is shown when double clicking any of the units in the main display. After choosing a different unit this will be used for the parameter in question and for the associated graph, see figure 3.
* Through the main toolbar (tools/unit conversion) a separate unit conversion box is opened that can be used for any single valid unit conversion.
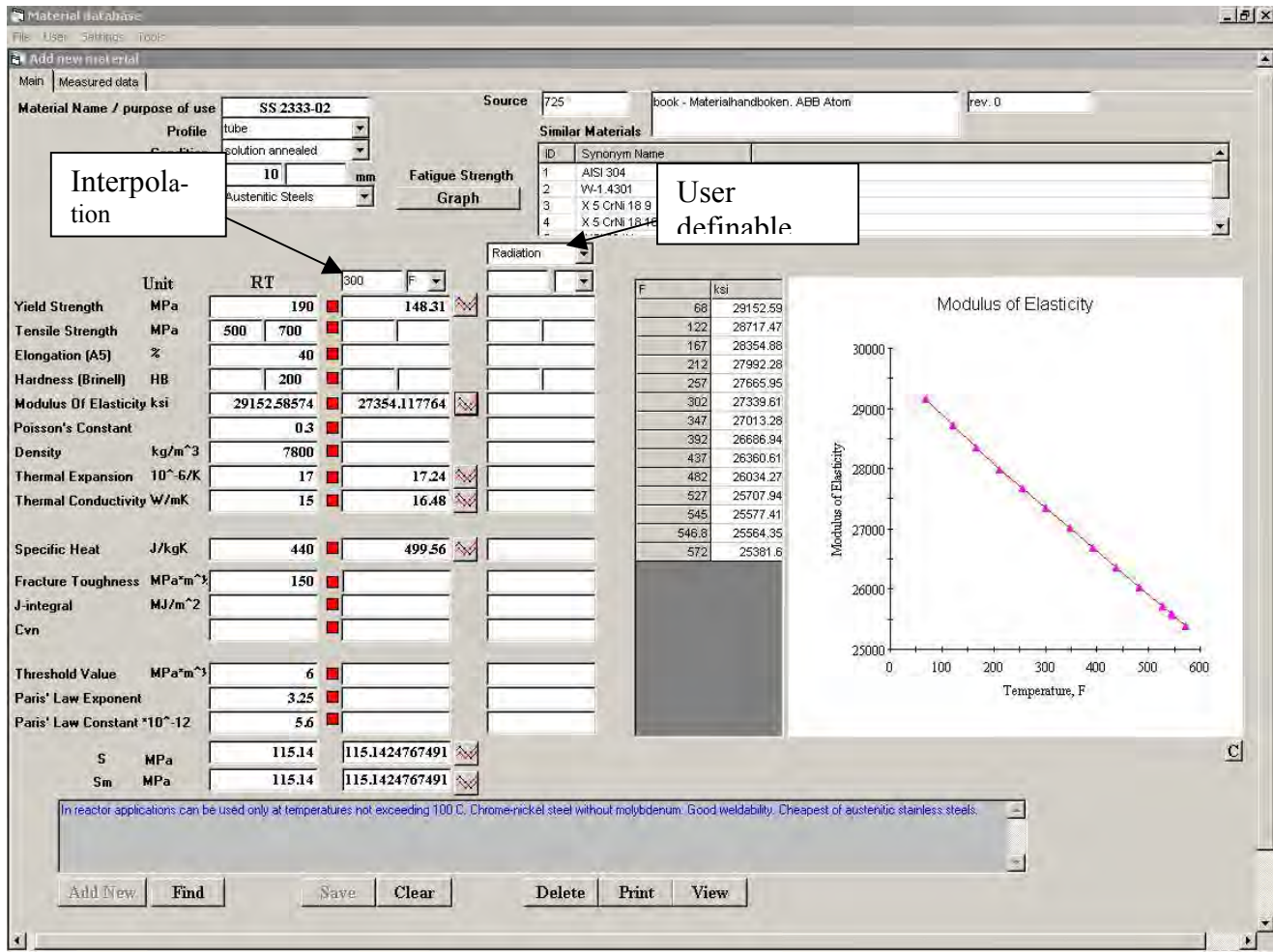

Figure 3. The units have been changed for the modulus of elasticity (see also the graph and for the temperature. Other units remain in the SI system.

Determination of S and Sm

The numerical values of S and Sm are automatically derived and displayed, see figure 3.

Parameter dependence

In the second column of the main display temperature dependant properties are displayed interpolated for the temperature input in the field above this column, see figure 3. The properties are input table-wise, like the table shown next to the graph. For out of bound temperature the properties are presently extrapolated with help of a straight line through the adjoining points. In the future the interpolation can be done with help of more sophisticated interpolation techniques.

In the third column of the main display material properties that are depending on other parameter than temperature are displayed while interpolated for the input in the field above the column, see figure 3.

Fatigue curves

In case available the applicable ASME fatigue curves can be displayed. This can be done by depressing the Graph button next to the material group, see figure 4. In the future it will be possible to couple more fatigue curves to the same material. These can be specific curves for the material in question or environment dependent fatigue curves.
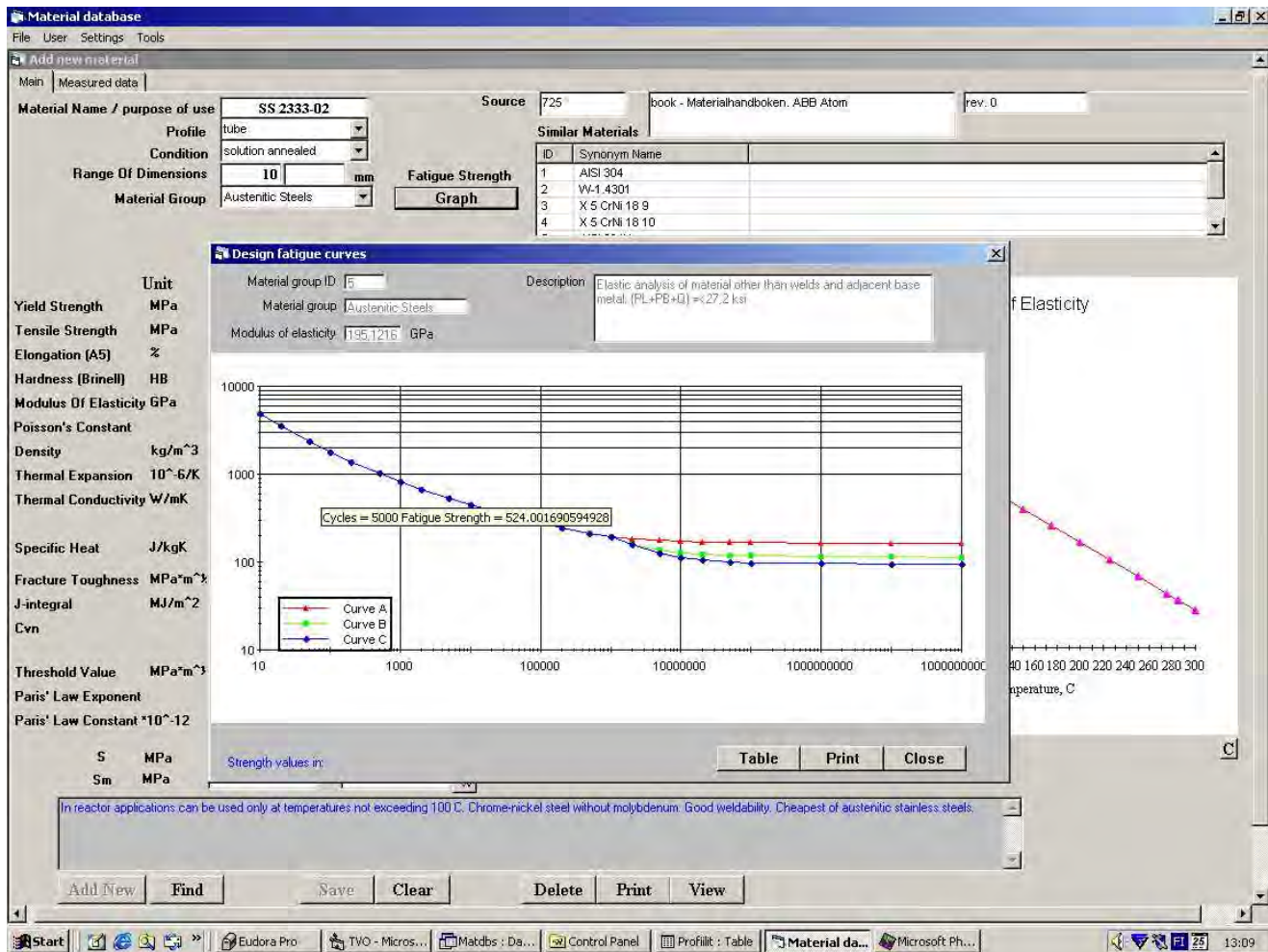

Figure 4. Clicking the graph button next to the material group will open a window with the associated ASME fatigue curve(s), in this case the fatigue strength for austenitic steels.

Synonyms and similar materials

It is possible to indicate the relation between different materials that have been entered in the database. The similar material part defines which materials are similar or equal to the main material and in how far they are equal. Directly after choosing the main material these similar materials are sorted from the database according to the default search rules and put into an order according to the default priority rules. Rules like these could be any combination of the items below:

* The material name shall be equal or a synonym.
* The profile shall be equal or not.
* The condition shall be equal or not.
* The condition shall be equal or not.
* The range of dimensions shall be fulfilled with or without a tolerance percentage.
* The material group shall be equal or not.
* The source document number, revision number, document type or company shall be equal or not.

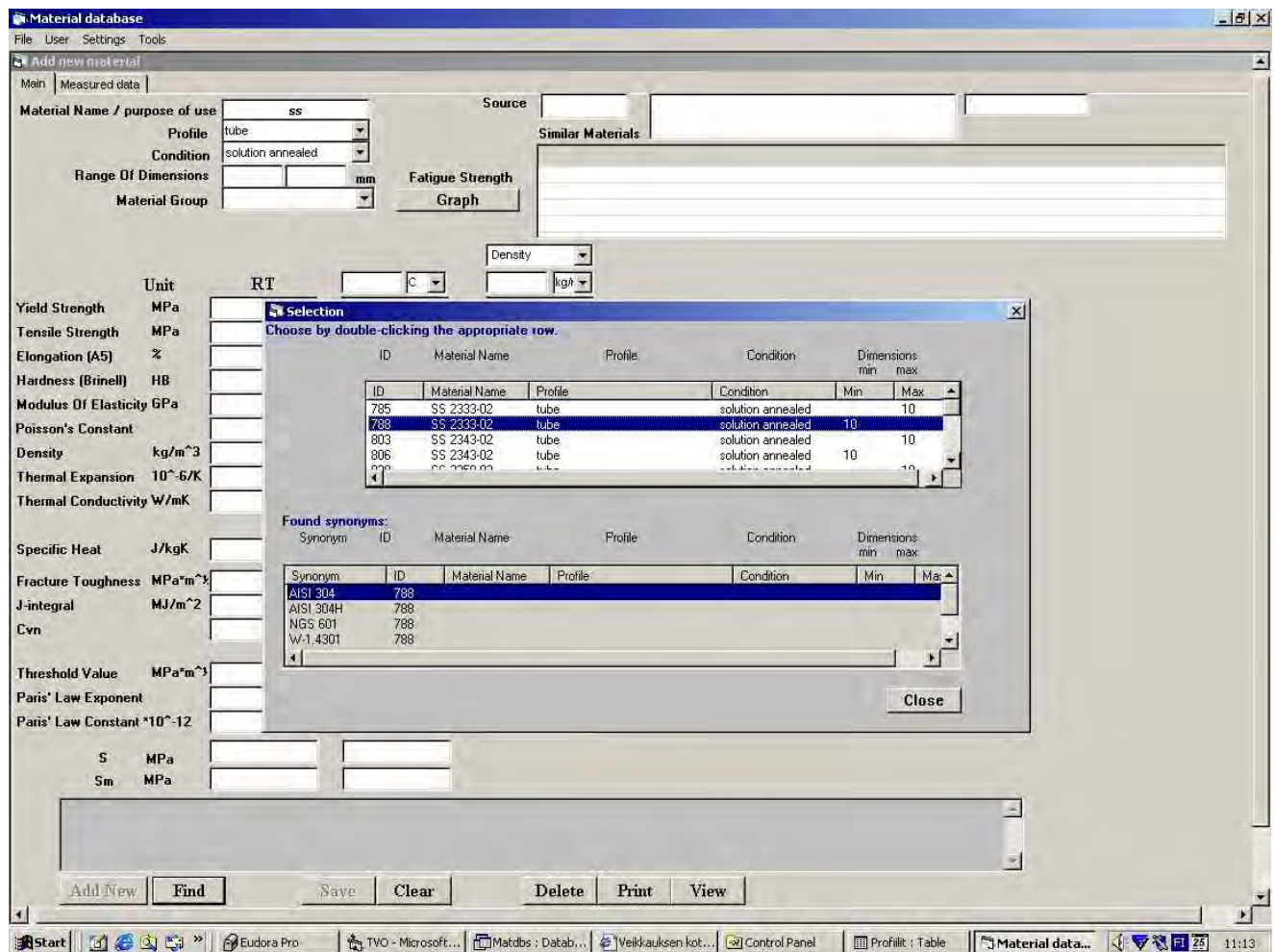The default search rules are defined by a group of experts and set by the main user.

Figure 6. Search result

Change of language

The language of the application can be changed at any moment. A new language is user definable through a language translation table. Presently four languages have been defined. As example the figure below shows the Finnish language.

Figure 5. Through the menu the language can be changed for the whole application.

Other developments

The following topics will be studied/added in the future:

* Part of or all properties on the main display will be user definable. Basically default properties will be defined for material groups, like metals, fluid/gas, plastics, rubber etc, but if necessary these can be changed with help of pull-down menus.

* Analysis capabilities will be added. The first could be the capability to display the graphs in different ways. For instance points only, connected by straight lines or some curve generation through the points or a cloud of points. This could be chosen through a pull-down menu next to the graph. The chosen curve type could be saved as an additional data-item and the associated interpolations and extrapolations could be performed accordingly.

* Addition of statistical properties like standard deviation or distribution to the material properties. As many analyses and studies are going in the probabilistic direction this is significant information.

* The user will be enabled to change some display variables, like the amount of significant numbers shown.

* The possibility to enter properties that are dependent on more then one material, like friction and heat transfer.

* Fluids and water tables will be added as materials.

* The property display area will be divided in a standard property area, a user definable property area and an area where properties are displayed that are determined from other properties and parameters.

BOOKKEEPING AND VALIDATION

As the database is very flexible and quite complex at the same time, a good design and bookkeeping is very important. Records shall be kept for all input made. The records shall contain the following information.

* Input date and person that made it. This is recorded fully automatically.
* Reliability level of the data., input only, checked or used in actual analysis
* Source reference information enabling the user to quickly check, see figure 2.

ORGANISATION AND TIME SCHEDULE OF THE PIPELINE ANALYSIS AND MONITORING PROJECT

During the first years, TVO was the sole contributor to the project. During this period, the material database and the document database were developed, as was the base of the pipeline database. Up to this time, the interface was still alphanumerical. As test project, a pipeline geometry transfer was performed to a general purpose FEM-program. Since a few years, the project is a joint effort of TVO, VTT and FEMdata. In the project "Lifetime of pressure retaining components" [2] a practical toolbox consisting of computational and experimental tools is generated for effective condition monitoring of process piping and estimation of its remaining lifetime. In future, the use of this kind of tools will be much facilitated by connecting them to the database system. Application programs that have been coupled to the database are the piping analysis program FPIPE [4] and the MASI-PIPE crack analysis program [5]. As a part of the project, both application program systems are further extended and tailored to optimally fit the monitoring needs.

TVO Pipeline Analysis and Monitoring System developments for the near future are the finalisation of the revision of the material database, the bookkeeping and reliability features in all databases and the analysis result database that is used to gather the significant results from analyses that are performed from the databases or other sources. Feasibility studies will be performed with regard to interfaces to one-dimensional pipe flow analysis programs, CFD-programs, modal analysis and update [3], general-purpose FEM programs and true neutral files.

The previous time that the full TVO Pipeline Analysis and Monitoring System was presented was during the PLIM 2002 [10] and the next time will be at the SMiRT 2003 [7].

ACKNOWLEDGEMENTS

REFERENCES

1. Raiko, H., Lipponen, A., Smeekes, P. & Talja, H. Load-Case, and -Combination Database. SMiRT 16 Paper 1869, 2001.
2. Talja, H., Smeekes, P., Torkkeli, E., Laaksonen, J., Rostedt, J., Haapaniemi, H., Lipponen, A., Saarenheimo, A. & Solin, J. Lifetime of pressure retaining components (PUKK). Espoo: VTT Manufacturing Technology. Report VAL64-001549. 22 p. 2000.
3. Smeekes, P., Talja, H., Saarenheimo, A. & Haapaniemi, H. Numerical Simulation of Piping Vibrations Using Modal Correlation. SMiRT 16 Paper 1866, 2001.
4. FPIPE, a finite element method (FEM) based piping analysis program developed at FEMdata Oy, Finland
5. MASI-PIPE, a fracture mechanics analysis program to make quick crack growth and residual lifetime assessments for cracked piping, developed by VTT Manufacturing Technology, Finland
6. ASME BOILER AND PRESSURE VESSEL CODE, SECTION II, Materials, Part D, Properties.
7. Smeekes, P., Lipponen, A., Raiko, H. and Talja, H. The TVO Pipeline Analysis and Monitoring System. SMiRT 17 Paper D185, 2003.
8. Microsoft® Access 2000, Relational Database Management System for Windows.
9. Microsoft® Visual Basic 6.0 programming language for Windows.
10. Simola, K., Talja, H. & Smeekes, P., Use of plant specific information in life management, PLIM 2002 IAEA-CN-92 /10