

## **Data Retrieval and Evaluation within the Web-enabled Alloys-DB**

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### **Abstract**

JRC Petten operates a central database server for the storage of experimentally measured materials data in order to support European research projects in energy related areas. Such a central management establishes a repository of European materials property data and saves costs for capital invested in generating this data. To allow instant and controlled access to the database via the Internet a Web-enabled database application (Alloys-DB) has been developed.

Alloys-DB manages mechanical and physical properties test data and covers materials behavior at low, elevated and high temperatures for base materials and joints. Its emphasis is on data from standardised tests and on evaluation methods, which are well established and widely accepted. Such test results can be entered and stored in the database of the system where they can be accessed and handled with typical database routines and from where they can also be retrieved for data evaluation. The user is guided in an intelligent manner within the complex database structure of seven entities, more than 130 tables such as material production, heat treatment, specimen geometry, etc. and more than 1850 fields. The retrieved data can be presented in tables, charts and reports or analysed with the Alloys-DB specific evaluations methods.

This paper briefly describes the database structure and the functionality of the user interface. It also presents the technology and tools used for implementing the Web-enabled user-interface and the interactive evaluation routines.

### **1. Introduction**

Materials databases are important tools for design, construction and life-time prediction of complex components [1]. The Institute of Energy of the European Commission at Petten (JRC Petten) started developing a database for safeguarding its materials test data resulting from the in-house research some 20 years ago. Since then the database structure has constantly grown and Alloys-DB has developed from its initial mainframe version without graphical user interface, over a PC and a client/server version to the new Web-enabled interface. All current Alloys-DB applications (PC, client/server and Web-enabled) use the identical database structure simplifying data exchange between Alloys-DB partners. Alloys-DB PC stand-alone and client/server applications are commercially introduced mainly in Europe within many companies and research institutions. The database has intelligent user-guidance for data entry, data retrieval and data evaluation. Updates, upgrades and further development of Alloys-DB are agreed during annual customer meetings.

Since 2001 JRC Petten is working on the development of the Web-enabled Alloys-DB [2]. The initial motivation for developing the Web-enabled application was to provide fast access to confidential and public data sets on the Petten Server and to help ongoing European research projects and networks to administrate and distribute their data. However, the Web application now also attracts interest from current users of the client/server Alloys-DB who want to install a

web-based version for internal use on their Intranet. This eases the life of the administrator since installations at the client PC are not necessary anymore. The user just opens the browser and can directly access the database. Fast data access via the Intranet, central maintenance and easy handling makes this application very interesting for ever-growing companies with offices distributed all over the world.

Alloys-DB is integrated at JRC Petten within the ODIN portal (On-line Data Information Network), which provides access to various Web-enabled database applications for engineering, nuclear safety and document management. The applications share the ODIN hard- and software infrastructure in order to facilitate maintenance and further development.

Section 2 presents the architecture of the ODIN portal which provides the framework to Alloys-DB, section 3 describes the database structure of Alloys-DB and section 4 describes the functionality and architecture of web-enabled Alloys-DB application. Section 5 summarizes and concludes this paper.

## 2. ODIN

JRC Petten operates the Internet portal called *Online Data & Information Network* (ODIN). ODIN acts as a single point of entry for applications and information relevant to the energy research community and covers engineering databases, nuclear databases and document management applications (<http://odin.jrc.nl>). Most databases contain public and restricted data and the necessary access control is performed via a central registration and login procedure. Additionally, ODIN interfaces with external web sites and services in order to create a virtual network of centers of competence (see Figure 1).

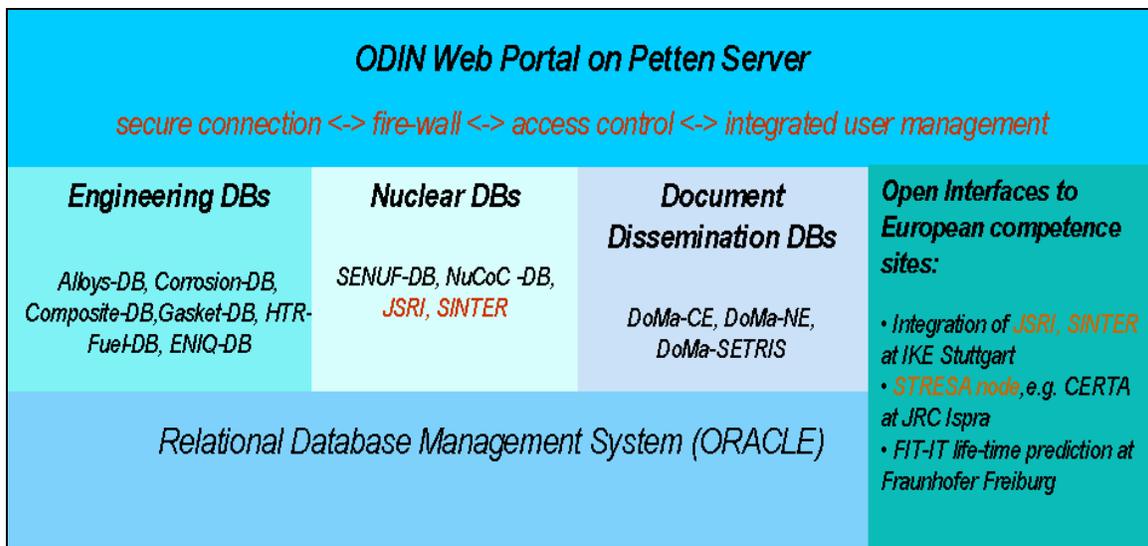


Figure 1: On-line Data Information Network – ODIN portal

ODIN provides the framework for all JRC Petten web-enabled applications. The applications share the soft- and hardware infrastructure in order to facilitate maintenance and ensure high performance and security. The technical specification of the ODIN infrastructure is listed below and is also illustrated in Figure 2.

- ORACLE as a powerful RDBMS,

- fast cabling and firewall,
- three DELL machines running a J2EE application server (Oracle10g) with Single-Sign-ON (SSO), load-balancing and the necessary redundancy to guarantee high availability,
- all Web-interfaces programmed in Java (J2EE) to increase compatibility and platform independence,
- two SUN machines as database server with high capacity Raid Arrays for the storage of data and documents

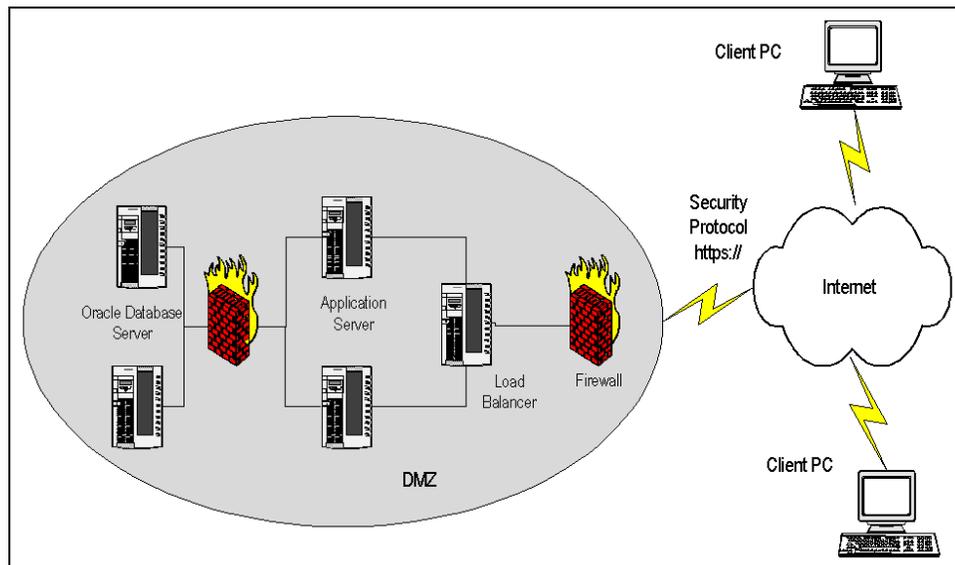


Figure 2: ODIN server arrangement at JRC Petten

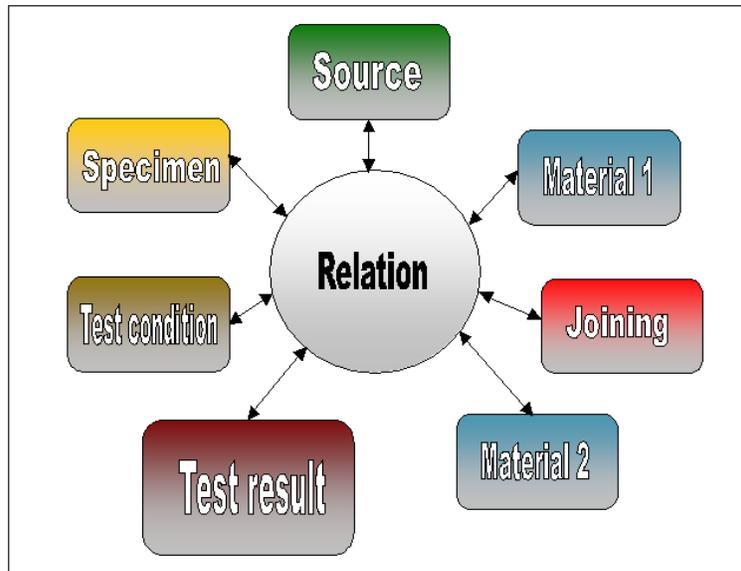
### 3. Database description and structure

The test results are reported by the laboratories in defined format and quality and are entered and stored in the database. The data can then be accessed and handled with typical database routines and can be used as input for the data evaluation routines. The materials being tested are most commonly used in components of conventional and nuclear power plants, steam and gas turbines and fuel cells.

Alloys-DB refers to such experimentally measured mechanical and physical properties data of engineering alloys. The metadata information of Alloys-DB is batch and heat related and therefore much more detailed than materials data reported in standards, e.g. the German "Key to Steel" [3]. The database structure is oriented to international material standards and recommendations. It covers the materials behaviour at low, elevated and high temperatures for base materials and joints and also includes irradiation materials testing in the field of fusion and fission and tests on thermal barrier coating for gas turbines. Its emphasis is on data from standardised tests and on evaluation methods, which are well established and widely accepted.

The data fields for base materials testing within materials databases are organised in different database tables, which belong to five logical entities: *data source*, *material*, *specimen*, *test condition* and *test result*. The entities are linked within a relation table. Dissimilar joints' testing, which is implemented within Alloys-DB, is even more complex, a *joining* and also a second *material* entity are added (see Figure 3). This *joining* entity describes the processing methods, parameters and the geometry of joints. The entity '*material*' for instance consists of twelve tables, which contain mandatory and non-mandatory fields for data entry (see Table 1). The

entity 'test result' of Alloys-DB is divided into different areas, which contain tables for storing experimentally measured mechanical (23) and thermo-physical (10) properties data, each corresponding to a particular test type. All entities contain numerical and alphanumerical character fields (customer internals), which can be used to customise the database for example with company-specific material keys. The database administrator can rename these internals according to the nomenclature of the individual company.



**Figure 3: Alloys-DB relationship containing two materials entities for dissimilar joints testing**

**Table 1: Alloys-DB tables of the material entity**

Material entity
Chemical composition
Designation & production
Characterisation
Isotropic grain size
Duplex grain size
Directionally solidified grain size
Hardness
Microstructure
Phase
Physical constants
Thermo-mechanical heat treatment
Customer internals

#### 4. Web-enabled Alloys-DB

With the emergence of the Internet and its increasing speed, it was a logical step to use web-enabled applications for data management and dissemination at JRC Petten. The first prototype of the web-enabled Alloys-DB was developed in 2001 using Oracle Portal, the current version is implemented using Java and the J2EE standard. Due to the nature of the HTML protocol the graphical interface of the web-enabled Alloys-DB is not as rich as the client/server application. Nevertheless, the current version has all the basic functionalities necessary to easily select and retrieve the desired data. Functionalities for XML-based data entry [4] and for evaluating the

data retrieved from the database are under development. Thus, the Web-enabled Alloys-DB will eventually cover the complete workflow from data entry over data retrieval up to data evaluation. Additionally it is easy to interface to existing installations of the PC and client/server versions of Alloys-DB as they share the same database structure.

## WEB-enabled data retrieval

The user interface for web-enabled data retrieval follows the lines of the well-established client/server version, although it is slightly less sophisticated due to the limitations of the HTML protocol. Figure 4 shows the selection screen for data retrieval within the Web-enabled Alloys-DB. It allows constructing a query for a materials test according to a number of criteria: *Source*, *test type* and *material* are mandatory fields and have to be selected in sequential manner. For all selection fields the user has multiple choices except for the selection on a specific *test type* because the test results are test type specific. Data retrieval can then be continued with optional selections of *combined material* (characterizes special treatments on respectively special features of the material such as service exposed, irradiated, low carbon, etc.), *melt/batch/heat identifier*, *specimen* (type) and (test) *environment*. Finally, retrieval can be continued with optional selections on test type specific fields such as *time at rupture*, *test temperature*, *elongation* in the case of *uniaxial creep*.

The screenshot displays the 'Alloys-DB: Properties selection' web interface. On the left, a 'Progress Tracker' shows the selection steps: 1. Source identifier, 2. Test type, 3. Material, and optional selections for Combined material, Melt/batch/heat identifier, Specimen, and Environment. The central form contains the following fields and values: Source identifier: PE - COST 501 - II WP 5 C; Test type: Uniaxial creep; Material: 10 CrMo 9 10; Combined material: 10 CrMo 9 10; Melt/batch/heat identifier: (empty); Specimen: bar : cylindrical : plain; Environment: air; Test temperature (°C): 550; Operator: (empty); Minimum (or single) value: 550; Maximum: 680. Below the form, it indicates 'Total Row Count for the current query: 27' and provides buttons for 'Previous', 'Confirm', 'Reset form', and 'Generate report'. A link for 'Uniaxial creep - Test type description' is also present. The right-hand panel contains instructions for selecting test parameters and a 'Test parameter selection 1' section showing a range of values for 'Test temperature (°C)' from 550 to 680. The footer includes 'Data Management & Dissemination - JRC-Petten - The Netherlands'.

Figure 4: Data retrieval screen of the Web-enabled Alloys-DB

After the mandatory fields have been specified the *generate report* button is active allowing the user to create an overview report on the selected material tests. The report also contains links to detailed information on source (including documentation), heat treatment, chemical composition, raw data sets or numerical & graphical curve information. Furthermore the report screen allows

exporting the selected test data to MS EXCEL charts or starting routines for further evaluating the test data. A report screen for the selection of uniaxial creep test results is shown Figure 5.

Uniaxial creep : Mechanical properties

Display property data in MS Excel file format | Display curve data in MS Excel file format

Run evaluation programs

To sort the table click the appropriate column-header. To exclude rows, check the appropriate box and click **exclude** on the header!

Exclude	#	Source	Specimen	Combined material name	Combined melt batch/heat identifier	Curve/cyclic data	Test control	Test temperature (°C)	Stress (MPa)	Time at rupture (h)	Elongation at rupture (%)	Reduction of area (%)	Minimum creep rate (1/h)	Time to 1% total strain (h)	Specimen identifier	Test condition	Joining
<input type="checkbox"/>	1	4151	415130001	10 CrMo 9 10	75018	41510212	constant load	550	180	348.83	57.64	-	-	-	CFD001	415120045	-
<input type="checkbox"/>	2	4151	415130001	10 CrMo 9 10	75018	41510213	constant load	550	170	519.25	47.33	-	-	-	CFD002	415120045	-
<input type="checkbox"/>	3	4151	415130001	10 CrMo 9 10	75018	41510214	constant load	550	155	676.84	57	-	-	-	CFD003	415120045	-
<input type="checkbox"/>	4	4151	415130001	10 CrMo 9 10	75018	41510215	constant load	550	190	261.83	44.62	-	-	-	CFD004	415120045	-
<input type="checkbox"/>	5	4151	415130001	10 CrMo 9 10	75018	41510216	constant load	550	140	1618	52.56	-	-	-	CFD005	415120045	-
<input type="checkbox"/>	6	4154	415430000	10 CrMo 9 10	75018	41540201	constant load	550	170	310	22	-	-	-	S8842	415420004	-
<input type="checkbox"/>	7	4154	415430000	10 CrMo 9 10	75018	41540202	constant load	550	110	6004	41.2	-	-	-	S8843	415420005	-

Figure 5: Report screen of the Web-enabled Alloys-DB

The evaluation routines, which can be used to evaluate the selected data are implemented as a Java applet, i.e. the programme together with the selected data is downloaded to the client PC and is then run locally as a fast and highly interactive desktop programme. Most of the test-type related evaluation programs allow fitting of mathematical models, constitutive equations, parametric expressions and regression functions to test and evaluate the result data. Within the evaluation and analysis programs it is possible to compare data sets against each other and to make simple predictions about the behaviour of the materials. Figure 6 shows a 2nd order Larson-Miller evaluation of uniaxial creep test results. The evaluation results can be saved as a MS EXCEL object.

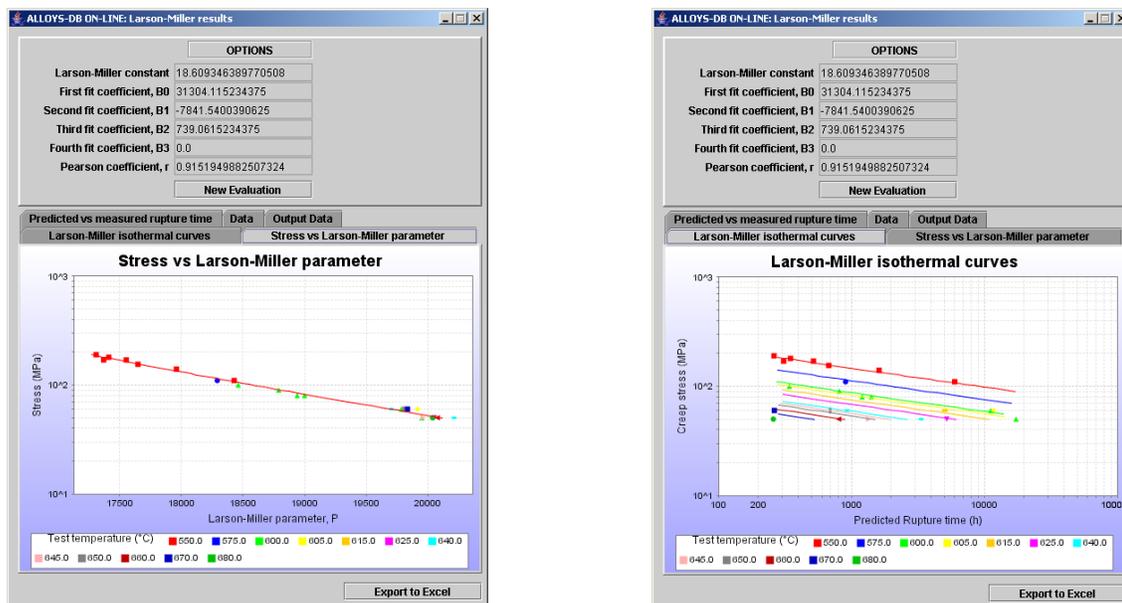


Figure 6: Data evaluation screens of the Web-enabled Alloys-DB showing the results of a Larson-Miller analysis

## Software architecture

The web-enabled Alloys-DB is implemented using Java and runs within any application server, which conforms to the J2EE standard. Therefore, it is possible to implement the complex business logic as re-usable components and at the same time stay as platform-independent as possible. The application server can be physically separated from the database server and the application communicates to the database through a standard JDBC connection facilitating the installation of a high-performance and secure hardware arrangement (see Figure 2).

The application is built around the Model-View-Controller (MVC) design pattern. MVC is a widely used architectural approach for interactive applications [5]. It divides functionality among objects involved in maintaining and presenting data to minimize the degree of coupling between the objects. The MVC architecture divides applications into three layers (*Model*, *View* and *Controller*) and decouples their respective responsibilities. Each layer handles specific tasks and has specific responsibilities to the other areas.

- A *Model* represents business data and business logic or operations that govern access and modification of this business data.
- A *View* renders the contents of a model. It accesses data from the model and specifies how that data should be presented.
- A *Controller* defines application behavior. It dispatches user requests and selects views for presentation. It interprets user inputs and maps them into actions to be performed by the model. Some applications use a separate controller for each client type, because view interaction and selection often vary between client types.

Figure 7 depicts the relationships between the *Model*, *View* and *Controller* layers of an MVC application.

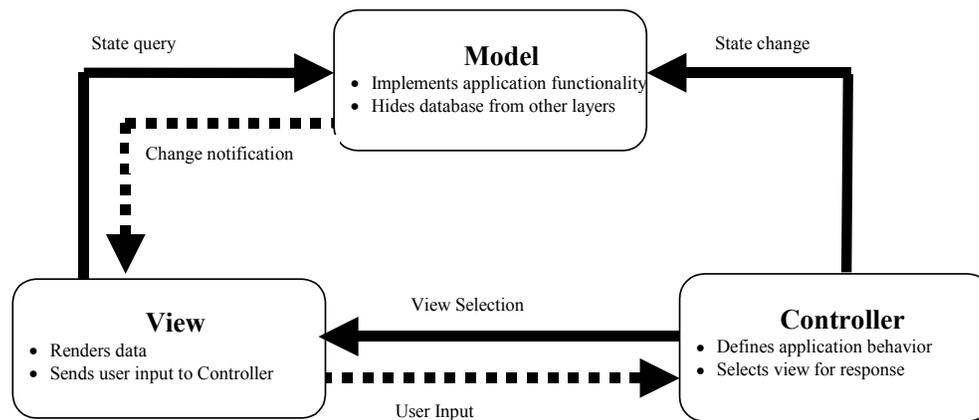


Figure 7: Model-View-Controller design pattern (MVC)

Placing business logic and presentation code in separate software layers is good design practice. The business layer provides only application functionality, with no reference to presentation. The presentation layer presents the data and input prompts to the user (or to another system), delegating application functionality to the business layer. Separating business logic from presentation has several important benefits:

- Minimizes impact of change
- Increases maintainability
- Provides client independence and code reuse
- Separates developer roles

In the case of the Alloys-DB, the separation of business logic and presentation means that the components that make up the *Model* can be re-used by a different kind of application without any modification. For example, JRC Petten currently implements a web-service, which receives the selection parameters as input and delivers the corresponding data to a consuming client in XML format using the identical software components for the *Model* as they are being used for the Alloys-DB.

## 5. Conclusions and future work

Instant availability of reliable, high-quality experimental data is extremely important for a materials engineer. Therefore, JRC Petten has been porting Alloys-DB to the Internet and it invites European R&D projects to use the web-enabled Alloys-DB for managing and conserving their confidential test data and related documentation. If agreed by the project participants, the data can be released for public access at the end of the project. By also including public data from other sources, e.g. European universities, JRC Petten aims at generating a large data pool on the Petten server, which can be exploited by the European research society for studies, expertises and training.

The web-enabled Alloys-DB is also attracting interest from industrial and research organizations that want to use the application for internal data management on their Intranet in order to have full control over the data. It is a future goal to network Alloys-DB installations at different sites thus providing a single, transparent point of access to the combined data pool. Public data can then be accessed free of charge, whereas industrial organizations can offer their data on a commercial basis.

Like any database application, Alloys-DB as well as the hard- and software infrastructure must continuously be maintained, improved and adapted to the need of the growing data management action of JRC Petten. New materials tests must be added and the database metadata structure must be referenced to latest releases of international standards. New evaluations routines and web services will be implemented and a XML-based data transfer from test machines to Alloys-DB via the Web is under development [2].

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