The Bolting Database: An Example of a Numeric Database Application in the Nuclear Power Industry

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Abstract

The AIF/MPC Task Group on Bolting has developed a database termed BOLTS which contains a large body of data on the bolting in nuclear power plants. The data has been installed within a computer database system which permits ready access and study. The types of data and the software available for its access and analysis are described. Examples of applications to resolve issues related to plant operation are given.

1. Introduction

Tennessee Valley Authority (TVA) was one of twenty-six utilities that provided input to BOLTS, a database system developed by MRCS under the sponsorship of the Electric Power Research Institute (EPRI). The input included material property data (e.g., yield strength, ultimate tensile strength, chemical composition, hardness, Charpy impact energy, lateral expansion, etc.) obtained from certified material test reports (CMTR) on the support bolting materials. In addition, TVA sent field hardness measurements of support bolts for input into the BOLTS database.

2. Storing the Bolts Data

The information in the BOLTS database is broken down into two categories: keys and data. Keys are sets of information that help describe and differentiate between different groups of data. Data is the numerical or textual knowledge associated with a particular set of keys. For the BOLTS database, ten keys are used. These denote important metallurgical and engineering features: the source of the bolting data, the plant containing the bolt, the location within the plant, the ASTM/ASME material classification, the AISI classification, the manufacturer, the melting practice used, the failure type (if any failure was noted), a unique heat number and the data test type performed on the bolt. The data contains the results of Charpy, tensile and hardness tests, chemical analysis and general bolt descriptions, such as installation date, size, and number of bolts.

Heat treatment and miscellaneous information is also included in textual form. The database contents are shown in Table 1.

3. Database Access

Access to the data is by means of a menu-driven user interface. Use of the database is facilitated by a user manual (1), data catalogues, and by an extensive HELP facility. At the time of writing, the database is proprietary, and access is subject to EPRI approval. In the near future, MRCS expects it to be released, and to be available in a form for use on microcomputers. Prospective users should contact MRCS or EPRI (Dr. T.U. Marston).

4. Database Software

In normal database operations, ease of use has primary importance. One of BOLTS strengths is that the database contains an expansive, three-level software interface that buffers the user from the raw data. (See Figure 1.) This software provides for the menu-driven requests, the help facilities, and the many options for extracting, printing, and plotting the data.

In addition, statistical analysis is well supported, permitting correlations and regressions to be developed. Figure 2 illustrates a typical application, showing in histogram form a summary of the distribution of all of the Rockwell hardness data contained in the database.

5. Application of the Database

The database has been accessed by utilities to aid in scoping the bolting issues and in the resolution of various plant-specific problems. For example, a hardness survey of support bolting was conducted by TVA to provide a "random data point" to substantiate conclusions being reached at Consumers Power Company's Midland plant on the material variability of low alloy quenched and tempered bolting. In addition, TVA has been able to resolve questions regarding the integrity of the bolting materials at its Watts Bar and Bellefonte nuclear plants using the bolting data stored in the BOLTS database.

At Watts Bar, the low-alloy quenched and tempered support bolting materials' resistance to stress corrosion cracking was assessed. Random sampling field hardness measurements were taken of the support bolts and the results were sent to MRCS for installation in the database. The bolting hardness data, catalogued and stored in the database, was then analyzed by TVA using the statistical software developed by MRCS for the BOLTS database. Each heat of material was analyzed and the mean and standard deviation were computed using the BOLT EXTRACT Program. The plotting capabilities of the BOLT EXTRACT Program were used to construct histograms of each heat of material. Confidence bounds for each heat were calculated and compared to the material specification hardness requirements. If the confidence bounds for a specific heat fell within the material specification hardness requirements, the material was considered to be resistant to stress corrosion cracking and fit for service.

At Bellefonte, a non-conformance report was written addressing the concern of ultra-high strength reactor coolant system support bolting material (150 ksi minimum yield strength, specified) being susceptible to stress corrosion cracking. A decision was made to review the certified material test reports of each heat of material against a screening criteria adopted by the AIF/MPC Task Group on Bolting. CMTR information for all support bolting materials had previously been tabulated and sent to MRCS. A review of the various materials used for support bolting applications identified SA540 Grade B24 Class 1 bolting material as the only material with a specified yield strength of greater than or equal to 150 ksi.

The CMTR review determined if the hardness, yield strength, ultimate tensile strength, and chemical analysis results conformed to the material specification requirements and the mils lateral expansion results exceeded 25 mils.

The BOLT EXTRACT program of the BOLTS database was used to locate all heats of SA540 Grade B24 Class 1 material. For each heat identified, the hardness, yield strength, ultimate tensile strength, chemical composition, and mils lateral expansion results were printed. These results were compared to the material specification requirements for hardness, yield strength, ultimate tensile strength, and chemical composition. The mils lateral expansion results were compared to the 25 mils minimum requirement. The results of the comparisons indicated that the material was resistant to stress corrosion cracking and fit for service.

6. Summary and Discussion

The successful application of numeric database techniques to the construction of nuclear power plants has been described. The essential elements are unambiguous identification of data (keys were used in this application), the storage of useful data, and the availability of a suitable software package.

While databases may not be a panacea, they do provide a basis for the establishment of important facts concerning material properties, permitting modeling of power plant operations, and pointing out potential areas for failure. The relatively low cost of such a technical management tool when compared to the enormous costs of failure or even unscheduled shutdown suggest that similar databases should be used to make all important data available to technical personnel. Since key decisions rest on the integrity of the data, only high quality data should be contained within a database. Fortunately, normal database management procedures provide a sophisticated quality assurance scheme to verify the validity of the data. This makes databases superior to individual collections of data.

In our experience, database development is only begun after a serious problem has emerged. This diminishes a database's effectiveness. Instead, the database should be an integral part of a plant's routine operation, where engineers can access information at a moment's notice.

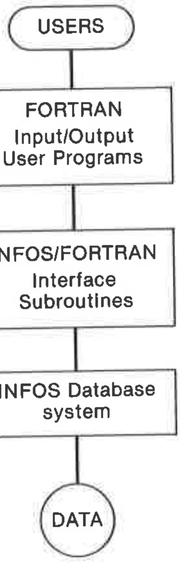
7. References

/ 1 / BOLTS Database User Manual, available from Materials Research and Computer Simulation, Inc.

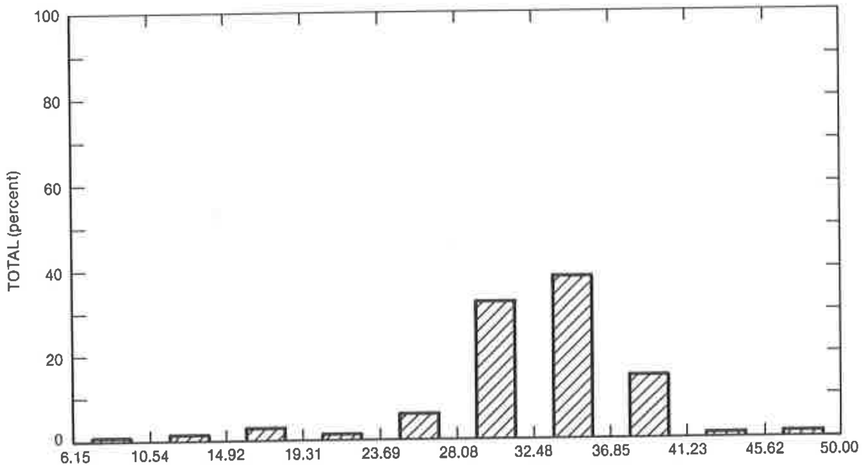
TABLE 1

LAYOUT OF BOLTS KEYS AND DATA

KEYS	DATA
1) Source 2) Location 3) Material 4) Reactor 5) Heat 6) Manufacturer 7) Failure Type 8) Melt Practice 9) Data Type 10) Steel Type	DESCRIPTION Item size, diameter, length thread size, number of bolts, years, pre-load. o Hardness: Item number, R_c, BHN o Charpy: Item number, temp, energy, LE, % crystallinity o Tensile: Item number, temp, YS, TS, RA o LEEB: TEXT o Miscellaneous Information: o Heat Treatment: CHEMISTRY o Chemistry Content:



1. Structural Breakdown of the BOLTS Database.



2. Histogram Showing the Distribution of Rockwell C Hardness Over the Database, Produced by the BOLTS EXTRACT Program.