USE OF A RELATIONAL DATABASE TO MANAGE INFORMATION FROM THERMALHYDRAULIC EXPERIMENTS

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ABSTRACT

Several thermalhydraulic experimental test programs are being performed under the direction of the CANDU Owners Group, including experiments performed in a full-elevation, multiple-channel representation of a CANDU primary heat transport system (RD-14M). A very large amount of experimental data and information is generated by this program. This paper describes the use of a relational database, in the PC-DOS environment, using the FoxPro database management system, to store and facilitate access to information related to the RD-14M test facility. Several databases have been set up to collectively describe the experimental facility configuration, the loop instrumentation history, the configuration for individual tests, the test conditions, and the referencing of documentation produced from the experimental program. The database is employed in conjunction with data display software to assist in the analysis of the experimental data.

1.0 INTRODUCTION

The aim of the CANDU* Safety Thermalhyraulics Research Program is to contribute to the continued improvement of our fundamental and technical understanding of CANDU heat transport system component and integrated thermalhydraulic behaviour under postulated accident and upset conditions [1]. Integrated experiments have been conducted in single channel per pass pressurized-water loops to improve our understanding of the phenomena governing the behaviour of the primary heat transport system (PHTS) under postulated accident and upset conditions [2]. The RD-14M facility [3] was built to examine the integrated effects of a multichannel-per-pass geometry on these phenomena. Other experimental programs exist to investigate the behaviour of

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* CANDU (CANada Deuterium Uranium) is a registered trademark of AECL.

components representative of those found in a CANDU reactor [4,5]. Information generated from these programs is being used to improve and validate thermalhydraulic computer codes developed to analyse the behaviour of CANDU systems [6,7].

The experimental data and information that has been generated for the CANDU Owner's Group (COG) from these test facilities is currently stored in diverse locations, such as magnetic tapes, data reports containing many plots, drawings, papers, and experimental logbooks. Users of this data and information have found it cumbersome to access and utilize, making analysis of the tests tedious and time consuming.

This paper describes the use of a relational database to store and facilitate access to all pertinent information (including some key experimental data) related to the RD-14M experimental program. Both general and specific information about the facility and tests are stored in the relational database, including test-specific information (initial conditions, test setup, etc.), instrument lists, instrument histories, loop configuration histories, memoranda, and publications. This database provides users with a convenient, common access to a comprehensive package of information describing RD-14M, and the experiments performed in RD-14M.

2.0 RELATIONAL DATABASES

A database is a collection of information that is stored, manipulated, and retrieved by a database management system (DBMS). There are three main types of database models: relational, network, and hierarchy [8,9]. The relational type of database was chosen for this work and is discussed in this paper.

The main advantages of the relational database model are its simplicity and data independence. The user is presented with a simple data model and does not need to know the details of storage structure and access strategy.

A relational database can be represented as a two-dimensional table, with the columns being the fields (categories of information) and the rows being the records of the database. Two or more databases can be related to one another by one or more common fields. For example, two databases could be searched and records could be retrieved from each in which a particular field had identical entries in both databases.

2.1 Selection of DBMS

The relational database described here is being developed and implemented with the commercial FoxPro PC-DOS DBMS (Fox Holdings, Inc.). FoxPro was chosen for its versatility, user-friendliness, and speed.

While many database operations can be performed using the FoxPro menu system, FoxPro's power can only be fully utilized through its programming language of commands and functions. Programs can be developed as standalone routines or can be incorporated in a customized menu to allow easy access to pre-programmed procedures and commands.

Several FoxPro database features have been found to be useful: easy implementation of changes to the database structure, i.e., add/delete/modify fields of a database; the capability to update database records in a number of ways, i.e., add/delete/modify records in a database; and the capability to display database records in a number of ways, e.g., default or custom displays. FoxPro also has a "memo" field type, that can store any amount of information (limited only by computer disk space), making it very useful to store text files within a database.

There are several non-database features within FoxPro that are also worth mentioning: the option to use the mouse and/or the keyboard; the capability to execute DOS commands interactively; a very useful file manager; and a windows management system that allows windows to be moved, sized, popped (brought to the front of the display), hidden (removed from the display but still active in memory), or closed (removed from memory) easily.

These features make FoxPro easy to use and powerful for both the developers and the end-users.

3.0 IMPLEMENTATION OF RELATIONAL DATABASE FOR RD-14M

3.1 RD-14M Facility

RD-14M is a multichannel-per-pass pressurized-water test facility with many of the essential geometric and physical characteristics of a typical CANDU PHTS (see Figure 1). The major components (heated sections, headers, steam generators, pumps, etc.) are arranged in a symmetrical "figure-of-eight" geometry and maintain a 1:1 vertical scaling with a typical CANDU reactor. The facility has ten horizontal heated sections (five per pass), each containing seven electrically heated fuel element simulators (FES). The facility is instrumented extensively to record various parameters such as temperature, pressure, volumetric flow, and void fraction.

An extensive experimental program is ongoing to investigate thermalhydraulic behaviour expected to occur in a CANDU reactor under normal and abnormal conditions. Experiments conducted in RD-14M will improve our understanding of the behaviour of multichannel systems, and will be used to validate thermalhydraulic computer codes which are used to aid thermalhydraulics analyses.

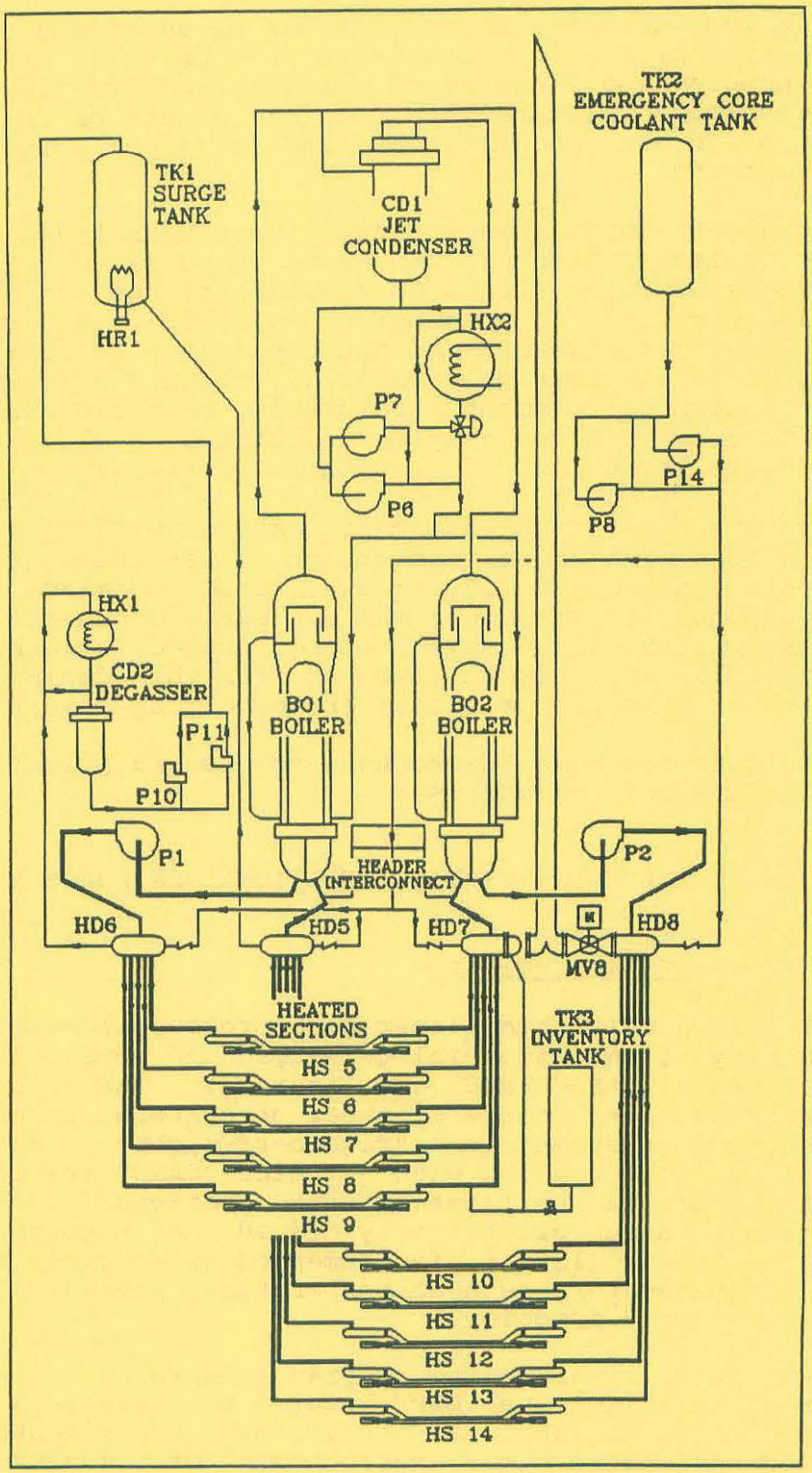

FIGURE 1: SCHEMATIC OF THE RD-14M FACILITY

3.2 RD-14M Databases

A relational database has been developed to manage information from the RD-14M experimental facility. The database consists of several "separate but related" databases that collectively describe the configuration of the experimental facility, the history of the loop instrumentation, the configuration for each individual test, the test conditions, and the referencing of documentation produced from the experimental program. Experimental data are not stored in the database, except for some key observations, such as maximum FES temperature. Experimental data can be accessed by other means such as data display software.

Figure 2 shows a block diagram of the RD-14M database.

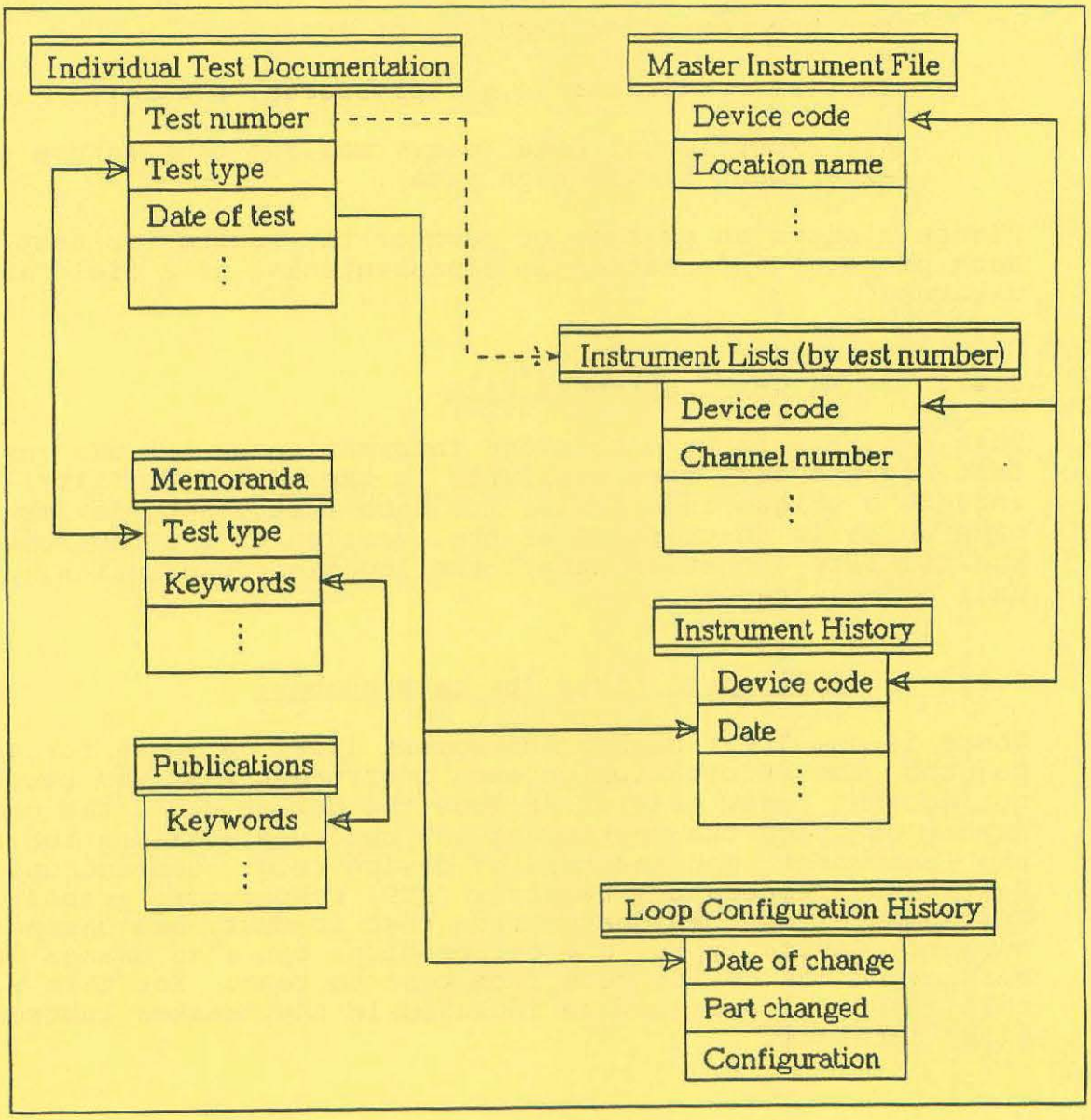

FIGURE 2: RELATIONSHIP OF RD-14M DATABASES

The various databases (e.g., Individual Test Documentation, Master Instrument File) and some of their fields (e.g., Test number, Device code) are shown, with connecting arrows to indicate fields that could be used to relate one or more databases. These databases are outlined in more detail in this section.

3.2.1 Individual Test Documentation

This database is used to store information related to each individual test. There is one record for each test, so that each entry in the test number field is unique. The type of information stored in this database is:

- Test setup (e.g., break size and location, "memo" fields for procedure and sequence of events),
- Initial conditions (e.g., pressures, powers),
- Key experimental data (e.g., maximum temperature and experiment termination data).

Figure 3 shows an example of part of the record for test T8808. Each piece of information is representative of a field in the database.

3.2.2 Master Instrument File

This database is used to store information on all the instruments that are and have been available in the RD-14M facility. Fields include a unique indentifier for each instrument (device code), a name which is descriptive of the location of the instrument in the facility (location name), the location description, and the unit of measurement.

3.2.3 Instrument Lists (by test number)

There is one "test number instrument list" database for each test to store the information on each instrument that was recorded during that test. Fields include the device code, the channel number on which the instrument was recorded, calibration range of the instrument, and the type of device (e.g., thermocouple, Resistance Temperature Detector (RTD) temperature probes). Instrument lists can change from test to test, and channel numbers, device types, and calibrations can also change with respect to the device code from test to test. For this reason, this information cannot be included in the "master instrument file" database.

Test number: T8808 Date (mm/dd/yy): 09/22/88

Test setup:

Test type:	NATCIRC
Repeat of test number:	T8805
Drain location:	HDR7
Break location:	NONE
Mode of ECI:	NONE
Primary pump status:	OFF
Surge tank status:	OFFLINE
Interconnect status/type:	NONE
Trace heating status:	ON Inlet power: 10.0 kW
	Outlet power: 11.0 kW
Decay power level:	160 kW/pass

Initial conditions:

Primary pressure: 7037.9 kPa Secondary pressure: 4493.4 kPa

HS5 power: 29.0 kW	HS10 power: 28.2 kW
HS6 power: 28.7 kW	HS11 power: 28.4 kW
HS7 power: 39.2 kW	HS12 power: 37.0 kW
HS8 power: 33.7 kW	HS13 power: 36.9 kW
HS9 power: 28.9 kW	HS14 power: 28.6 kW

Header 5 temperature: 277.1 °C	Header 7 temperature: 277.1 °C
Header 6 temperature: 251.3 °C	Header 8 temperature: 248.9 °C
Feedwater temperature: 74.3 °C	
Boiler 1 drum level: 54.7 %	Boiler 2 drum level: 57.7 %
Pump 1 discharge flow: 1.0 L/s	Pump 2 discharge flow: 1.0 L/s

Conditions at termination of test (trip data):

Trip temperature set point: 600 °C
Heated section that caused trip: 9 at 5220 s
Inventory at trip: 81.0 %

FIGURE 3: SAMPLE FROM "INDIVIDUAL TEST DOCUMENTATION" DATABASE

These instrument lists are all subsets of the list in the master instrument file as fewer than half of the available instruments are typically recorded for any given test at this time.

3.2.4 Instrument History

This database is used to store historical information about the instrumentation chronologically. This includes information on installations, removals, replacements, calibrations, and failed or faulty instrumentation.

Once this database is completed, the calibration field in the "test number instrument list" databases can be deleted because this information will be redundant. This illustrates the flexibility of the FoxPro program.

3.2.5 Loop Configuration History

This database is used to store changes to the loop hardware chronologically so that the full loop configuration or part of the loop configuration can easily be obtained at any given date. For example, a database entry would be made if a boiler tube was plugged because of leakage, as this would change the configuration of the boilers. No instrumentation history is stored in this database.

3.2.6 Memoranda and Publications

Memoranda and publication databases are used to store information about documentation related to RD-14M. A field for keywords is included in each database to facilitate searching for a particular topic.

3.2.7 Relationship of Databases

Many of the databases outlined above can be related to one another by a common field or pointer. Typical common fields for these databases are the instrument device code, test type, and date. The test number field in the "individual test documentation" database can also be used to point to the appropriate "test number instrument list" database file.

Examples of how to access database information for a specific test number are provided below:

- To obtain the list of recorded instruments, the "individual test documentation" database can point to the appropriate "test number instrument list" database using the test number.

- To obtain information stored in the "master instrument file" database for the instruments used in the test, the "test number instrument list" database can be related to the "master instrument file" database using the device code.

- To obtain the history of the instruments used in the test, relate the "individual test documentation" database, using the date of the test, and the "test number instrument list" database, using the device code, to the "instrument history" database.

- To obtain the loop configuration on the date of the test, the "individual test documentation" database can be related to the "loop configuration history" database using the date of the test.

- To obtain a list of all memoranda related to the type of test performed, the "individual test documentation" database can be related to the "memoranda" database using the test type.

The above relations represent only a sample of the possible relations that can be used. Routines have been developed into a menu system that allow these types of relations to be recalled automatically.

3.2.8 RD-14M Database Menu System

A menu system has been developed using the FoxPro menu builder to access information stored in the RD-14M database. The concept is to provide the end-user with a convenient way of obtaining information from the databases without having a detailed knowledge of FoxPro. Some key searches and other functions have been built in to the menu system routines.

Examples of the menu selections are:

- Select a test number from a list sorted by test type, or type in the test number (this selects a record in the "individual test documentation" database). Several menu items become available, including:
  - view one of the following: test setup, initial conditions, trip data, procedure, sequence of events
  - retrieve the instrument history, as of the date of the test, for the instruments used in the test
  - retrieve the loop configuration as of the date of the test
  - list the failed/faulty instruments for the test.

- Search the "instrument history" database for the most recent set of calibrations prior to a given date.

- Search the "individual test documentation," "memoranda," or "publications" databases for records that meet a set of criteria. Custom screens have been developed for each to facilitate choosing appropriate fields to be searched.

All menu selections can be output to the screen, and most choices can be printed or output to a file.

This menu system includes the most common (but not all) routines that the users may require. Other routines will be included, as required, in future updates to this system.

3.2.9 Current Status

The RD-14M relational database structure is complete, and information is being entered into the database. It is noted that this structure may be changed in the future, if required. The first series of tests covers the natural circulation experiments. Database information being entered at this point is specific to particular tests, and does not include general facility information such as instrument history, loop configuration history, memoranda, or publications.

3.3 Data Display

Experimental data have not been included in the databases (except for some key observations), because a data display package, IsoVu (Isograph Engineering & Computing plc), is being used to help with the analysis of RD-14M experimental results [10].

Displays are created in the IsoVu "display builder," and some of the objects are given tags. These tags are used to search for data in a data file when using the data display module ("passive viewer"). IsoVu can display data in a number of ways, such as "animated" graphics and plots. "Animated" graphics includes colour modification of objects, dynamic vectors (change magnitude and/or direction - e.g., for flows), dynamic levels (e.g., for tank levels), and numeric data display. Multiple windows can be open to display more than one graphics file and/or the plot window simultaneously.

IsoVu will be used in conjunction with FoxPro in the PC-DOS environment as part of an overall program to assist in the analysis and organization of the experimental data and information.

4.0 FUTURE WORK

The RD-14M relational database will be expanded to include information from all experiments. The "instrument history," "loop configuration history," "memoranda," and "publications" databases will also be completed, and the menuing system will be updated to meet user needs.

The relational database concept will also be applied to other thermalhydraulics test facilities. These facilities include RD-14, RD-12, LASH (LArge-Scale Header), and CWIT (Cold-Water Injection Tests).

5.0 SUMMARY

A relational database has been developed that helps organize information from the RD-14M experimental facility, and provides easy access to information that would otherwise be stored in diverse locations. This project is part of an overall program to develop tools to assist in the analysis and organization of the experimental data and information.

Several "separate but related" databases are used to store the pertinent information from RD-14M. Databases are included for test specific information such as test setup, initial conditions, key experimental data and analysis results, and instrument lists. Other databases store general facility information such as a master instrument list, instrument and loop configuration histories, and documentation (memoranda and publications). Common fields that can be used to relate one or more of these databases include the test number, test type, date, and instrument device code.

The database has been implemented using the FoxPro DBMS, a powerful and easy to use package for the PC-DOS environment. A menu system was developed within FoxPro to allow end-users to access pre-programmed routines and commands to manipulate and retrieve information from the RD-14M databases.

Information from several RD-14M natural circulation tests has been entered into the database and will be expanded to include information for all tests that have been performed. The database concept will be applied to other test facilities.

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