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Online Access to and Data Analysis Tools for Experiments in Building and Fire Science. Final Report

John P. Woycheese
Venkatesh Raghavan
Mihyun Kim
Felix Geller

*Worcester Polytechnic Institute
Fire Protection Engineering
100 Institute Rd.
Worcester, MA 01609*

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Building and Fire Research Laboratory
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Gaithersburg, MD 20899-8664*

By
John P. Woycheese
Venkatesh Raghavan
Mihyun Kim
Felix Geller

Worcester Polytechnic Institute
Fire Protection Engineering
100 Institute Rd.
Worcester, MA 01609

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U.S. Department of Commerce
Carlos M. Gutierrez, Secretary

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William Jeffrey, Director

Notice

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**John P. Woycheese
Venkatesh Raghavan
Mihyun Kim
Felix Geller**

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Worcester Polytechnic Institute
Fire Protection Engineering
100, Institute Road,
Worcester, MA, 01609
Phone: 508-831-6778
Fax: 508-831-5862

Table of Contents

	<u>Page</u>
Introduction.....	1
Target Audience.....	2
Research Effort	3
Experiment Database for Fire Science (EDaFS)	3
Data Architecture	4
Current Resources and Implementation.....	5
Fire and Building Educational Resource Collection (FABERC)	7
Tools	12
Conclusions.....	14
Future Work.....	15
References.....	16
Appendices.....	A-1
Appendix A: EDaFS Database Architecture 0.9	A-1
Appendix B: User's Guide for EDaFS	B-1
Appendix C: Adding Events to the FABERC Calendar	C-1

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Final Report

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Introduction

Scientists, engineers, and students have computational tools [1-3] to aid them in their efforts to model and understand fire events. These users, however, must rely on personal judgment to determine appropriate material properties for theoretical analyses and computer models, given the difficulty in obtaining validated inputs for combustion and material properties. In addition, unavailability of, or lack of confidence in, data ranges for these model inputs precludes sensitivity analyses, which would enable users to generate more complete results and to verify their assumptions. Members of the fire science community would benefit from an on-line compendium, including experimental data and tools, information about various concepts or procedures, and multimedia content like videos, photographs, and reports. The pervasiveness of the Web enables access by people from diverse locales, while allowing similar, but geographically remote, audiences to share their knowledge.

A number of disparate, individual efforts provide material about fire-science-related topics [4-20] and there have been a number of studies documenting these electronic resources for the fire field [4-7]. BFRL/NIST provides the primary on-line libraries for fire protection engineering [8]. The references provided thereby are largely bibliographic in nature [9], although BFRL-generated documents (in Acrobat Portable Document Format files), modeling software programs, and some limited data are available. The latter is not predominantly web-based [10], but specific data plots, brief descriptions of facility and experimental caliber, and links to project reports and data files are available through the Fire Data Management System [10-13], via the web and CD-ROM. The National Fire Protection Association provides electronic access to the *National Fire Codes*, along with a collection of fire investigation and other fire-related reports [14], has developed an electronic version of the Fire Protection Handbook [15], and has released a CD-ROM containing the SFPE Handbook of Fire Protection Engineering [16]. The Institute for Research in Construction (IRC) has a publications database [17] that is updated weekly. The Fire Safety Engineering Group at the University of Greenwich [18] has a few animated

simulations on their web site; this appears to be a showcase of current and past research, rather than a reference library. These and other collections, such as Firewise [19], which provides information on urban/wildland intermix fire concepts, would benefit from accessibility through a centralized search interface. Furthermore, the U.S. Fire Administration is studying the feasibility of establishing a national fire service archive, named Heritage Hall [20], to document and preserve the history of the fire-fighting profession in fire service technology and techniques, fire prevention, emergency medical services, hazmat, rescue, etc. Although these resources provide pertinent and useful information to those who know of them, none provides a centralized collection of material addressing the needs of the above audiences.

Target Audience

The building and fire science research community encompasses many disciplines, interests, and professions: from consultants to government officials to instructors and students of all ages. The audience includes practicing fire engineers, architects and building code officials; fire service personnel, including those in fire marshals' offices who work with code enforcement and investigation; researchers developing materials systems for furniture, interior finishes, FRP composites, etc.; and high school science teachers, undergraduate and graduate professors, and students interested in fire. The multidisciplinary base ensures that educators in more traditional disciplines also require fire-based content. Examples abound: spalling of concrete exposed to fire is a concern for civil engineers; changes in strengths of materials at elevated temperatures may affect calculations of mechanical engineers; and combustion characteristics and properties are of interest to chemical engineers and chemists.

Although the research community is the primary audience for the materials to be made available through this project, fire is a topic that fascinates and affects the general public. The collapse of the World Trade Center towers, hastened, at least, by multi-floor conflagrations initiated when aircraft struck and penetrated the buildings, has heightened public awareness of the need for appropriate evaluation and mitigation of fire dangers [21-23]. The more recent tragedies at the Eptome Club in Chicago and The Station in Rhode Island [24-25] have kept egress and fire concerns in the public consciousness and conscience. Societal losses owing to wildland/urban intermix fires [26-28], such as those in New Mexico and Colorado during the summer of 2002, further illustrate the broad implications of fire research. The creation of a

portal for pertinent experimental and pedagogical information offers, therefore, both tangible and intangible potential benefits to society at large. Access to and availability of more and better material, especially with regards to confidence levels in experimental data, may prove important to both the general public and members of the fire science community. As an example, the animations illustrating possible causes of the collapse of the World Trade Center [23] provided clear and concise information on a complex topic in a manner that is comprehensible to the layman. A cohesive, fundamentally sound source of material about building and fire science may have a broader audience than is immediately obvious.

Research Effort

There were three primary thrusts for this effort, each of which was comprised of multiple components. First and foremost was the development of the Experiment Database for Fire Science (EDaFS, pronounced “edifice”), which was designed to be an extensive, on-line repository of experiment data, including descriptions of the collection process or experimental procedure and associated videos, photographs, and reports. EDaFS provides both a structure for the storage of experiment data and multimedia and a web-based interface for the exploration of that information. Data consumers can search for appropriate experiments and then, using a prototypical Java® interface, view and download instrument data and files of interest.

The second area investigated under this grant was related to the creation of a portal for building and fire science that encompassed a broader topical reach than experimental data and materials. In particular, the project team created metadata for documents and materials for inclusion in a NIST collection under the Fire and Building Educational Resource Collection (FABERC, pronounced “Fabric”).

Finally, several phenomenological and visual tools were developed to enhance interpretation and analysis of experimental data. The result was an interface that enables users to view up to three videos concurrently while simultaneously displaying instrument data in real time.

Experiment Database for Fire Science (EDaFS)

The Experiment Database for Fire Science, or EDaFS, defines a data structure for accessing and managing experiments conducted by the fire science community and implements that architecture in a database that is accessible via the Web. In addition to instrument data for a

given experiment, EDaFS provides for the storage of documentation, photographs, video clips, and other related materials in a single location in a cohesive, logical manner. Recent developments in database design enable more comprehensive access to data, enabling queries that span many tables (e.g. multiple experiments or experiment groups) and data types, queries that cannot be achieved in the file-based structure for fire data, the Fire Data Management System (FDMS 2.0) [29-30]. The EDaFS architecture is based on a commercial database system, ORACLE 10g, which supports multimedia files such as photographs, video clips, and large documents; furthermore, EDaFS has been extended to enable data export and import via an extensible markup language (XML) format for flexibility.

Data Architecture

A schematic of the EDaFS structure can be found in Figure 1. Fire tests that are part of a series of experiments are linked using test collections, which can, in turn, be part of other test collections. Individual fire tests (or experiments) form the foundation of the information stored in EDaFS. Tabular references designate test methodologies, instrumentation, involved personnel and organizations, test facilities, and product descriptions, where appropriate, for each fire test. This table also contains a reference to a text-based file that stores readings from the instruments, in engineering units; specifics for instrument location, type, and characteristics are provided in a separate table.

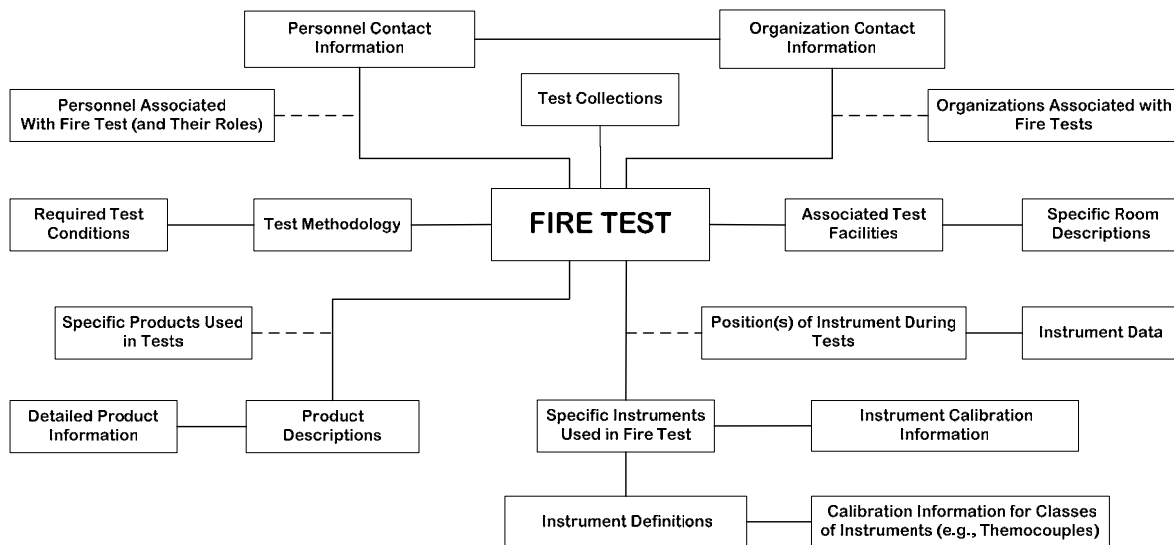


Figure 1: Basic EDaFS architecture, indicating the type of information that is stored and the relationships between these broad categories. Dashed lines indicate a compound relationship; e.g., multiple positions might be required for a given instrument in a particular fire test.

Appendix A documents the underlying structure of the database that forms the core of EDaFS, including logical views of each table and its relationship to other tables in the architecture. Data stored in EDaFS includes a subset of required fields for every fire test, such as test title, description, owner, and data, which provides a minimum level of information. In addition, the structure can store more specific information, including contact information for people involved in specific tests, specifics of experimental methodologies, and reports and other associated documentation.

Current Resources and Implementation

Over 150 experiments have been added to EDaFS from four distinct test series: the NIST Home Smoke Alarm Tests [31], the International Study of the Sublethal Effects of Fire Smoke on Survivability and Health (SEFS) [32], a re-enactment of the Station Nightclub Fire [24-25], and Room/Corner Fire Calibration Data of Screening Specimens for Marine Composites [33]. Some of the experiments include access to images and documentation and final reports associated with the tests in addition to instrument readings, descriptions, and locations.

Users can search the collection using a Web browser by visiting the EDaFS Web site [34]. (Instructions for use have been provided in Appendix B and are also available through the Web site.) The search engine page is shown in Figure 2. Users can establish conditions, such as a word or phrase in the title of one or more fire tests, for desired experiments in the EDaFS database. The results of this search are provided in a list; up to ten of these items can be selected for later visualization. In addition, individual results can be examined by clicking on a hyperlinked test title, which opens a window (see Figure 3) that provides detailed information about the selected test and links to a data visualization tool and to files associated with the test.

A Java®-based interface, shown in Figure 4, enables users to select and graph data from particular instruments while providing specific information – such as location, engineering units, and type – for the instruments, themselves. The top portion of the visualization tool provides a graph of data selected by the user from the fire tests selected from the search page. Users can compare data from similar instruments across multiple experiments, different instruments within the same experiment, or any combination. For comparison of instruments with different units, data can be plotted in up to four ordinate scales. By clicking and dragging on the graph – creating a box from upper left to lower right – users can magnify the view of the current data set.

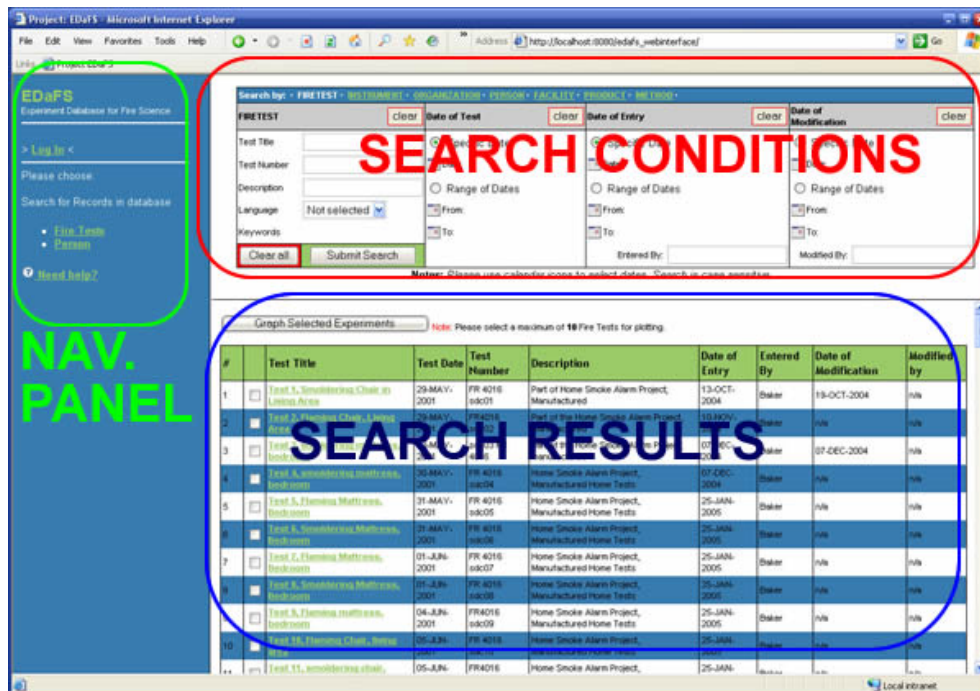


Figure 2: An image of the EDaFS search page. The Navigation Panel enables users to search for specific fire tests or personnel associated with the tests. Users can modify the Search Conditions Panel to set conditions for data inquiries, the results of which are provided in the Search Results Panel.

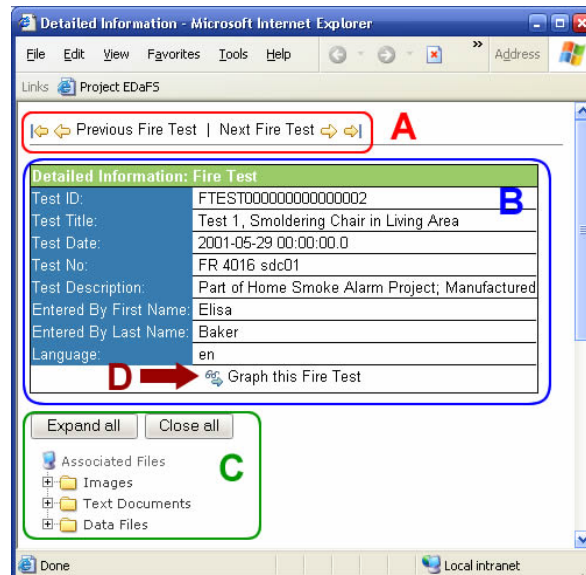


Figure 3: Detailed information about a specific fire test. The arrows (A) allow you to navigate through the set of fire tests that the latest search returned. The outer most arrows jump to the first (leftmost arrow) or last (rightmost arrow) fire test, respectively, while the inner arrows shift by one test backward or forward. The table (B) provides details about the current test. A folder tree (C) shows all files that are associated with the current fire test and the icon and “Graph this Fire Test” text (D) link to a new window that includes a Java Applet to plot data from the current fire test.

Users can also save selected data into a comma-separated file or an XML format; alternatively, a complete dataset in comma-separated value (or FDMS, where available) format can be downloaded.

A list of available test collections, individual fire tests, and their associated instruments is provided in a tree-based format (shown to the bottom left in Figure 4). When a particular item, such as a fire test, is selected, details (e.g., a description) are provided in the right of Figure 4. Selecting instruments causes the associated data to be downloaded and graphed. (Selecting an instrument a second time will remove the data from the graph.) Links to associated files are also presented in a tree-based structure, collected into Images, Text Documents, and Data Files (visible in the bottom right of Figure 4). Selecting any of these items will open a new window, in which the file will be displayed.

Originally, this grant was intended to develop a means to evaluate experiment data with regards to repeatability and confidence. Early in the first year, however, it became clear from input from the community that a wider selection of experimental data was both necessary and desirable to evaluate the effectiveness of the EDaFS architecture. As a result, an investigation into data confidence was postponed and the number of catalogued experiments was increased.

Fire and Building Educational Resource Collection (FABERC)

The broad vision for the Fire and Building Educational Resource Collection (FABERC) [35], illustrated in Figure 5, involves a central portal for searching available material in Fire Science, supported by databases, digital collections, and other digital libraries (DLs) that may serve as more narrow foci for specific areas within the field. This overarching structure enables users to find information of varying depths (e.g., appropriate for the fire scientist interested in specific fire tests and the student trying to comprehend broader concepts), differing topics – that required by an insurance adjuster is likely to differ substantially from the needs of the aforementioned fire scientist – and disparate content (e.g., video clips of fire tests for visualization, documents specifying how a test is to be conducted, and animations of appropriate concepts).

Rather than store the video clips, images, and other items directly, which could lead to copyright infringement issues, FABERC contains information about each item (metadata) and a link to the object on the owner's server, a format that facilitates cost recovery by contributors, if desired, as they control access to their content. The metadata includes a description of the contents of the object, information about the multimedia object (e.g., resolution of a video clip), and an evaluation of the educational purpose and educational level needed to comprehend the contents. In addition, parent/child and sibling relationships between similar items have been

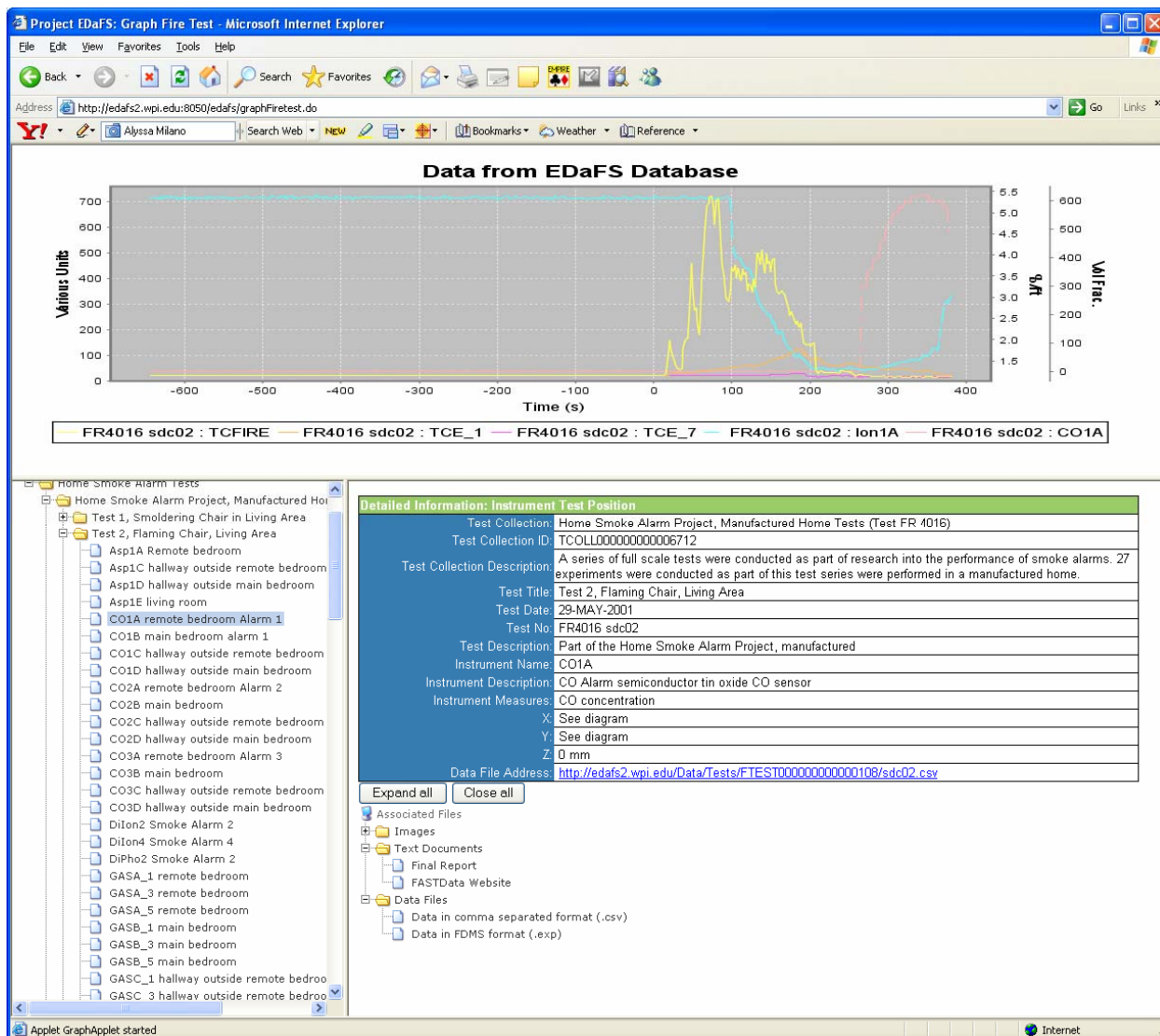


Figure 4: Web-based data visualization and exportation program for EDaFS. The top portion of the image shows a graph of data from thermocouples (temperature, in °C), an ionization detector (obscuration, in %/ft), and a carbon monoxide detector (volume fraction). To the bottom left is a list of available test collections, individual fire tests, and their associated instruments in a tree-based format. The bottom right of the image provides detailed information about the currently selected instrument (in this case, the carbon monoxide detector) and the associated fire test and test collection. Links to associated files are also provided, collected into Images, Text Documents, and Data Files.

recorded, which enables users to locate materials related to the items they view. A detail page for a specific item is provided in Figure 6. Users can find specific items via a simple search box or they can browse by collection (see Figure 7). New additions to any FABERC collection are highlighted in a “News and Information” box on the web site.

FABERC also includes an events calendar (see Figure 8), which allows users to search for and view information about seminars, symposia, calls for papers, and other items of interest to the community. Hyperlinks from the calendar lead to pages, such as that shown in Figure 9, with detailed information about the specific event. Typically, a hyperlink from this page leads to the host's Web page for the event.

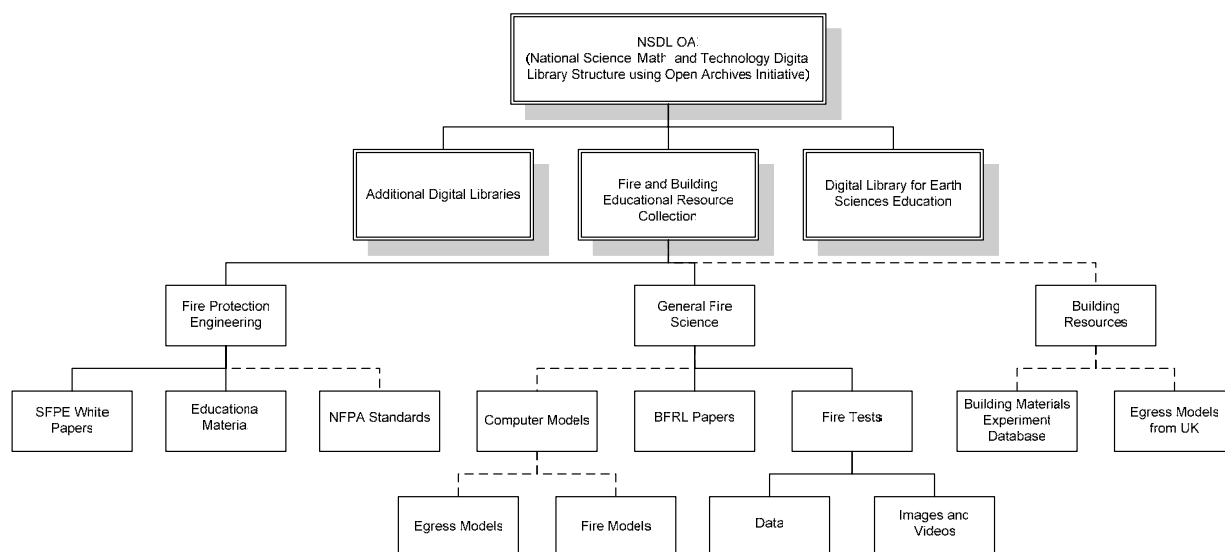


Figure 5: Hierarchy of digital libraries, showing the relationship between the Fire and Building Educational Resource Collection (FABERC) and the National Science, Math, and Technology Digital Library (NSDL). FABERC currently contains a number of collections in fire protection engineering and general fire sciences; dashed lines (e.g., to the building resources area) indicate areas of future growth.

FABERC is housed under the National Science, Math, and Technology Digital Library (NSDL), which serves as the overarching collection for a large number of digital libraries, many of which were funded by the National Science Foundation. Part of the development of FABERC was funded under the NSDL initiative through NSF, including the creation of the data structure and web interface. The current NIST grant, however, funded the creation of collections for FABERC.

Two collections were created under this grant for inclusion in the FABERC digital library: the Experiment Database for Fire Science (EDaFS) and the NIST/BFRL Multimedia Collection. The content for the EDaFS collection was detailed in the previous section. FABERC currently provides a link to the search page for EDaFS, although future updates will create metadata in FABERC for all fire tests and multimedia objects available through EDaFS.

Events and Deadlines

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May 21	22	23	24	25	26	27
28	29	30	31	June 1 Call for Papers on Vehicle Fires Cobo Center	2	3
4 NFPA World Safety Conference & Exposition® Orange County Convention Center	5 NFPA World Safety Conference & Exposition® Orange County Convention Center	6 NFPA World Safety Conference & Exposition® Orange County Convention Center	7 NFPA World Safety Conference & Exposition® Orange County Convention Center	8 NFPA World Safety Conference & Exposition® Orange County Convention Center	9	10
11	12	13	14 6th International Conference on Performance-Based Codes and Fire Safety Design Methods Waseda University: International Conference Hall	15 6th International Conference on Performance-Based Codes and Fire Safety Design Methods Waseda University: International Conference Hall	16 6th International Conference on Performance-Based Codes and Fire Safety Design Methods Waseda University: International Conference Hall	17

May 21-Jun 17 | [Jun 18-Jul 15](#) | [Jul 16-Aug 12](#) | [Aug 13-Sep 9](#) | [Sep 10-Oct 7](#) | [Oct 8-Nov 4](#) | [Nov 5-Dec 2](#) | [Dec 3-Dec 30](#) | [Dec 31-Jan 27](#) | [Jan 28-Feb 24](#) | [Feb 25-Mar 24](#) | [Mar 25-Apr 21](#) | [Apr 22-May 19](#) | [May 20-Jun 16](#) | [Jun 17-Jul 14](#) | [Jul 15-Aug 11](#) | [Aug 12-Sep 8](#)

Date(s): -
Use the format: mm/dd/yyyy

Search for Events
Title/Description:
Topic:

Figure 8: The FABERC Events and Deadlines calendar includes calls for papers, meetings, and symposia. Officials for organizations that host such events have been asked to help maintain the calendar, although members of the general public can suggest items for inclusion.

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Phone: 781-821-6725



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[Add/Suggest Event](#) | [Edit Your Events](#)

Figure 9: The information for a specific item in the FABERC calendar can include a logo, description, location, associated costs, contact data, and a link to the event Web page.

The NIST/BFRL Multimedia Collection [36] currently references nearly 750 items, including BFRL publications and a number of video clips, model animations, and images from fire tests and simulations conducted or developed at NIST. A Java® application was created to convert text documents containing information for the documents from FireDOC [37-38] to a format that could be imported into FABERC [39]. Metadata for each video and image item was developed during this grant. In addition, video clips in the NIST/BFRL Video and Image Collection were converted to a streaming media format; both the streaming and original, downloadable video formats are available through the detail pages for each item.

Tools

For many experiments, simple data plots, video clips and images adequately illustrate the results; however, it may be beneficial in some cases to plot cross-referenced data from multiple experiments, provide combinations of temporal data plotted concurrently with (potentially multiple simultaneous) video clips, or compare video imagery with simulation results and experimental data. Although some work has been conducted to evaluate the effectiveness of virtual depictions of experiments and experimental data [40], there is a need to develop methods by which researchers in the building and fire science fields can develop and submit similar representations for a variety of test methods, conditions, and facilities. With appropriate tools, instrument locations and results from similar experiments, such as room corner tests conducted by different organizations, can be compared and analyzed; this may be of particular interest when one of the experiments is more heavily instrumented. An obvious extension of this approach will contrast modeling results with experimental data, which will aid in the evaluation of the models.

The ability to find and plot data from multiple experiments has been addressed by the search engine and user interface for the Experiment Database for Fire Science (EDaFS), which were described in the EDaFS section, above. This section will focus on a visual and phenomenological tool developed under this grant that cross-links up to three video clips, animations, or a combination of both with a graph of experimental data and a virtual reality representation of the test facility.

This application, a simple web-based interface (see Figure 10), provides near-real-time aggregation of data and images, which highlights concepts such as smoke layer depth and plume extents. The data is loaded and graphed using a Java® applet that is similar to that described above for visualization of EDaFS data. Up to three videos, loaded in Windows Media Player applets arranged horizontally across the top of a Hypertext Markup Language (HTML) document, can be loaded simultaneously. The lower left-hand corner displays one of three virtual test facilities, written using Virtual Reality Markup Language (VRML 2.0), that are currently available: an ISO room, the Station Nightclub, and a mobile home (from the NIST Home Smoke Alarm Tests). Thermocouple trees; heat, ionization and photoelectric smoke, and carbon monoxide detectors; and optical density meters can be placed in appropriate locations within the virtual facility, based on the test or tests of interest.

The left-hand video applet synchronizes the video and graph; the graph pushes current data to the virtual instruments. Thus, as the videos play (or the user moves the video's time slider), the data on the graph shifts to the left and instruments in the VR facility change color to reflect their current, instantaneous values. As shown in Figure 10, simple concepts such as the hot layer for a compartment fire can be illustrated using this format. In addition, the user can “walk” or “fly” around the virtual facility to view the instruments from different angles. If the user approaches an instrument, the specific, instantaneous value for that instrument will be displayed in a floating billboard, as seen in Figure 11. Because the format is non-specific, the program can be altered to display video clips and data from two different experiments simultaneously. A simple means to change these parameters is currently under development at Worcester Polytechnic Institute.

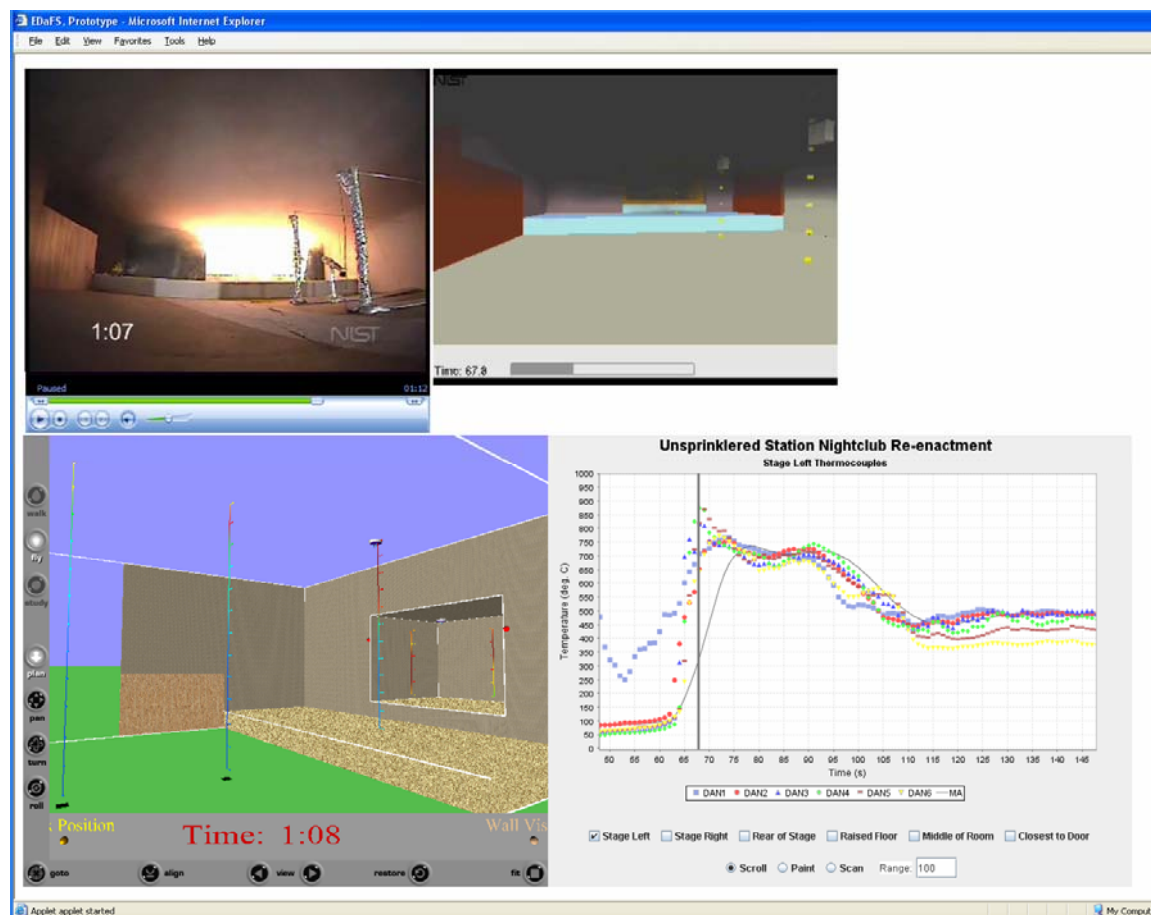


Figure 10: This application synchronizes up to three video clips (or animations) with data that is both graphed and shown in a virtual, three-dimensional environment. The user can play or pause the videos and can select a specific time of interest for further study. Using a keyboard and mouse, the user can also “walk” or “fly” around the representation of the test facility, at the lower left of the image, to examine instantaneous data in its appropriate location. The user can select the data stream or streams to be displayed in the graph at the lower right; the data shifts to the left as time progresses so that the grey vertical line represents the current values represented in the virtual facility (and in the videos).

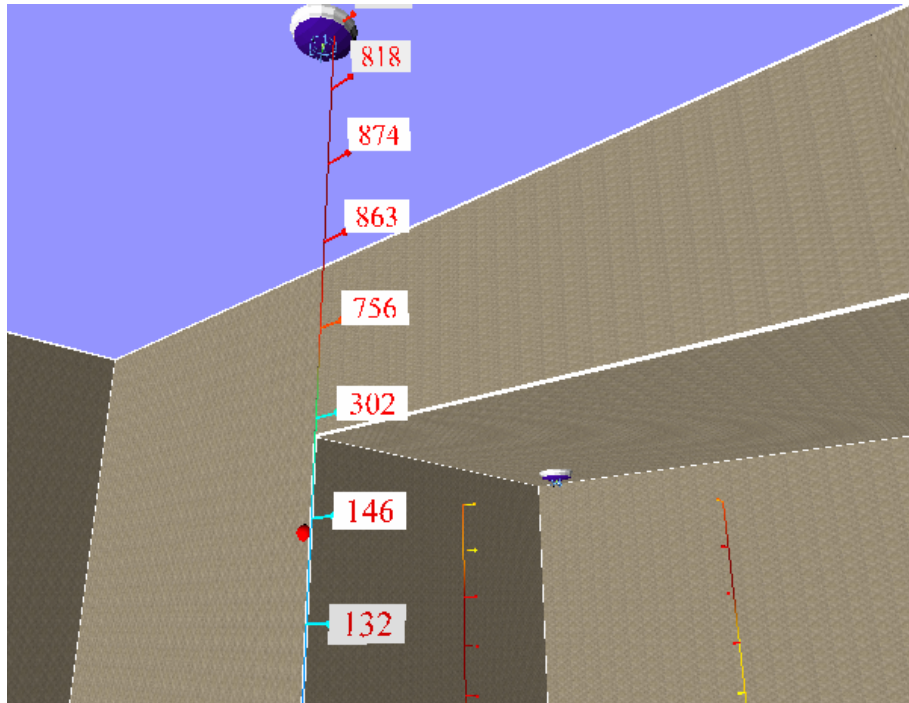


Figure 11: Close-up of a virtual reality thermocouple tree, with two more trees visible to the lower right of the image. The temperatures of individual thermocouples become visible when the user's avatar is sufficiently close to (within 1.5 m of) the thermocouple tree. The tree itself provides a visual representation of the temperature via linear interpolation of colors. Maximum (red) and minimum (blue) values can be selected; for this example, the values are 800 and 20 degrees Celsius, respectively. The two purple and white devices are heat detectors that are not linked to data in the current experiment.

Conclusions

The lack of a cohesive, fundamentally sound source of material – particularly multimedia and experimental data – for building and fire science was the impetus for this project. The creation of an on-line repository for pedagogical and scholastic materials serves a significant audience. The primary foci for this project were the development and implementation of a searchable experiment database in which fire test data, multimedia materials, and associated documentation could be stored; the collection and categorization of multimedia materials; and the creation of data visualization and manipulation tools.

During this grant period, the architecture for the Experiment Database for Fire Science (EDaFS, pronounced “edifice”) was implemented in a Web-based format that enables users to search for one or more fire tests from a collection of more than 150. A user interface was developed in which instrument readings, reports, imagery, and other assembled materials are accessible for both individual experiments and series of tests. The interface enables the user to download all or a selected portion of the data and uses the EDaFS architecture to incorporate

information about the test; instrument type, location, and characteristics; test facility; and other such metadata.

The effort to accumulate multimedia material resulted in the creation of collections under the Fire and Building Educational Resource Collection (FABERC, pronounced “fabric”), a portal and digital library for the building and fire science community. Metadata for over 700 reports, images, video clips, and other such materials was either created or converted from a bibliographic format.

Finally, several data visualization tools were developed, including a means to synchronize graphical and spatial data with up to three simultaneous video streams. Data, video, and model simulations from a re-enactment of The Station Nightclub fire, together with information on the test facility and instrumentation, were used to showcase the possibilities of this tool. Additional applications, such as a metadata conversion program and a graphical user interface and search engine, were created as part of the EDaFS and FABERC work.

This project has provided the groundwork for a working collection of multimedia and experiment data of use to students, research scientists, and practicing engineers. It is hoped that continuing efforts to expand the materials available will ensure that both FABERC and EDaFS become important tools for the building and fire science community.

Future Work

There are a number of areas that require additional effort. In particular, the format for products used in the fire tests is particularly difficult to address. The current fields may be too specific for certain types of experiments (or experimentalists), such as those involving real-world products, and too generic for others (e.g., fire investigators or chemists may require much greater detail than is currently available). Of interest from the perspective of data architecture are the types of queries that are of interest to the data consumers, as the current structure allows for storage of documents and other materials that could contain sufficient information without enabling database-wide searches for certain characteristics.

Clearly, a broader selection of experiments, data, and materials must be added to the EDaFS and FABERC collections. Now that both projects are available to the public – and have been publicized – through their respective Web interfaces, the project team expects that additional

materials will be made available by various organizations for inclusion in the databases.

Evaluation and assessment of submitted materials is a critical component for continued relevance of both projects; thus, a means to sustain such evaluations must be developed, perhaps via the adoption of this procedure by a related organization. Furthermore, a means to assign confidence levels to experimental procedures in general and to instrument data in particular has yet to be developed.

Finally, the data visualization tools should be made more generic and disconnected from the requirement of a virtual test facility. A means to create linked videos and data on demand, with and without the virtual facility, could be a powerful tool for a number of different fields. This is a fairly straightforward extension of the current work.

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Appendix A

Experiment Database for Fire Science

Database Architecture 0.9

John P. Woycheese
Venkatesh Raghavan
Mihyun Kim

August 2004



Worcester Polytechnic Institute
Fire Protection Engineering
100, Institute Road,
Worcester, MA, 01609
Phone: 508-831-6778
Fax: 508-831-5862

TABLE OF CONTENTS

	<u>Page</u>
TABLE OF CONTENTS	A-I
LIST OF FIGURES	A-II
LIST OF TABLES	A-III
1 INTRODUCTION.....	A-1
1.1 PROJECT SYNOPSIS	A-1
1.2 LOGICAL VIEW NOMENCLATURE.....	A-4
1.3 PHYSICAL VIEW NOMENCLATURE	A-5
1.4 NESTED TABLES	A-6
2 DATABASE STRUCTURE	A-7
2.1 PERSONNEL AND ORGANIZATION.....	A-7
2.1.1 <i>Logical View</i>	A-7
2.1.2 <i>Physical View</i>	A-8
2.2 FIRE TEST	A-9
2.2.1 <i>Logical View</i>	A-9
2.2.2 <i>Physical View</i>	A-12
2.3 PRODUCTS USED IN FIRE TESTS.....	A-14
2.3.1 <i>Logical View</i>	A-14
2.4 TYPES OF INSTRUMENTS	A-17
2.4.1 <i>Logical View</i>	A-17
2.4.2 <i>Physical View</i>	A-18
2.5 INSTRUMENTS FROM FIRE TESTS	A-20
2.5.1 <i>Logical View</i>	A-21
2.5.2 <i>Physical View</i>	A-22
2.6 INSTRUMENT DATA.....	A-24
2.6.1 <i>Logical view</i>	A-24
2.6.2 <i>Physical view</i>	A-26
2.7 TEST METHODS AND CONDITIONS	A-27
2.7.1 <i>Logical View</i>	A-27
2.7.2 <i>Physical View</i>	A-28
2.8 TEST ARENA	A-30
2.8.1 <i>Logical View</i>	A-30
2.8.2 <i>Physical View</i>	A-31
2.9 DOCUMENT STORAGE	A-32
3 MINIMUM REQUIREMENTS.....	A-34
4 SPECIALIZED EDAFS FORMATS	A-36
4.1 EDAFS DATA TYPES	A-36
4.2 NESTED TABLES	A-39
4.3 ORDDOC DATA TYPE	A-41
5 REFERENCES.....	A-41

LIST OF FIGURES

	<u>Page</u>
Figure 1: EDaFS Architecture	A-3
Figure 2: Logical View Nomenclature	A-4
Figure 3: Example of a Table.....	A-5
Figure 4: Example of Nested Tables.....	A-6
Figure 5: Logical View of PERSONNEL and ORGANIZATION	A-7
Figure 6: a) Data Types for PERSONNEL and ORGANIZATION b) Nested Tables	A-7
Figure 7: Logical View of FIRE_TEST.....	A-10
Figure 8: a) Required Data Types for FIRE_TEST b) Nested Tables.....	A-11
Figure 9: Logical View of PRODUCT	A-15
Figure 10: a) Data Types for PRODUCT b) Nested Tables.....	A-15
Figure 11: Logical View of INSTRUMENT_TYPE.....	A-17
Figure 12: a) Data Types for INSTRUMENT_TYPE b) Nested Tables.....	A-18
Figure 13: Logical View of INSTRUMENT	A-21
Figure 14: a) Data types for INSTRUMENT b) Nested Table.....	A-22
Figure 15: Logical View of INSTRUMENT_TEST_POSITION and INSTRUMENT_READING.....	A-25
Figure 16: a) Data Types for INSTRUMENT_TEST_POSITION and INSTRUMENT_READING b) Nested Tables.....	A-26
Figure 17: Logical View of TEST_METHOD, METHOD_CONDITION, and TEST_CONDITION.....	A-28
Figure 18: (a) Data Types for TEST_METHOD, METHOD_CONDITION, and TEST_CONDITION (b) EDaFS Nested Tables.....	A-28
Figure 19: Logical View of TEST_ARENA	A-30
Figure 20: a) Data types for TEST_ARENA b) Nested Tables.....	A-31
Figure 21: Minimum Requirements for EDaFS (Logical View).....	A-35
Figure 22: a) Data Types for Minimum Requirements for EDaFS b) Nested Tables	A-36

LIST OF TABLES

	<u>Page</u>
Table 1: ORGANIZATION	A-8
Table 2: PERSONNEL	A-9
Table 3: FIRE_TEST	A-13
Table 4: FIRE_PERSONNEL.....	A-13
Table 5: FIRE_ORGANIZATION	A-13
Table 6: TEST_COLLECTION.....	A-14
Table 7: PRODUCT.....	A-16
Table 8: PRODUCT_IN_TEST	A-16
Table 9: BASIC_INSTRUMENT_DEFINITION	A-19
Table 10: COMPOSITE_INSTRUMENT_DEFINITION	A-19
Table 11: COMPOSITE_DEFINITION_DETAIL.....	A-20
Table 12: INSTRUMENT_TYPE_CALIBRATION	A-20
Table 13: BASIC_INSTRUMENT.....	A-23
Table 14: COMPOSITE_INSTRUMENT.....	A-23
Table 15: COMPOSITE_INSTRUMENT_DETAIL	A-24
Table 16: INSTRUMENT_CALIBRATION	A-24
Table 17: INSTRUMENT_TEST_POSITION.....	A-26
Table 18: INSTRUMENT_READING.....	A-27
Table 19: TEST_METHOD.....	A-29
Table 20: METHOD_CONDITION	A-29
Table 21: TEST_CONDITION.....	A-30
Table 22: TEST_ARENA	A-32
Table 23: ROOM	A-32
Table 24: DOCUMENT.....	A-34
Table 25: TYPE_ADDRESS	A-37
Table 26: TYPE_CONTACT_INFO	A-37
Table 27: TYPE_DIMENSIONS.....	A-37
Table 28: TYPE_ERROR	A-37
Table 29: TYPE_POSITION	A-38
Table 30: TYPE_READING	A-38
Table 31: TYPE_VALUE.....	A-38
Table 32: TYPE_VIRTUAL_OBJECT	A-39
Table 33: TYPE_AUTHOR_NT	A-39
Table 34: TYPE_CHARACTERISTIC_DEFN_NT	A-39
Table 35: TYPE_CHARACTERISTIC_NT.....	A-39
Table 36: TYPE_DOCUMENTATION_NT.....	A-40
Table 37: TYPE_EVENT_NT.....	A-40
Table 38: TYPE_KEYWORD_NT.....	A-40
Table 39: TYPE_PARAMETERS_NT.....	A-40
Table 40: TYPE_PHONE_NT.....	A-40
Table 41: TYPE_SUB_PRODUCT_NT.....	A-41
Table 42: TYPE_READING_NT	A-41
Table 43: TYPE_TEST_COLLECTION_NT	A-41

Experiment Database for Fire Science

Database Architecture 0.9

John P. Woycheese, Venkatesh Raghavan, and Mihyun Kim
Worcester Polytechnic Institute

1 INTRODUCTION

Fire science is a multi-disciplinary field that combines aspects of civil, mechanical, chemical, and electrical engineering, among others. The topics range from two-phase fluid flow to combustion to structural- and material-composition issues to human response in fire. Compared to the traditional engineering disciplines, fire science is relatively new, although the benefits and liabilities of the profession are felt throughout society [1-8]. Hastened, at the least, by multi-floor conflagrations initiated when aircraft struck the buildings, the collapse of the World Trade Center towers has heightened public awareness of the need for appropriate evaluations of fire dangers [6]. Societal losses due to wildland/urban intermix fires [7, 8] further illustrate the broad implications of fire research.

A number of studies have documented electronic resources for the fire field [9-12]. At present, Building and Fire Research Laboratory (BFRL) at the National Institutes of Standards and Technology provides the primary on-line libraries for fire protection engineering [13]. The references provided thereby are largely bibliographic in nature [14], although BFRL-generated documents (in Acrobat Portable Document Format files), modeling software programs, and some limited data are available. The latter is not predominantly web-based [15], although raw data are available through the Fire Data Management System [15-18], via CD-ROM. The Fire Safety Engineering Group at the University of Greenwich [19] has a few animated simulations on its web site; this appears to be a showcase of current and past research, rather than a reference library.

A number of tools currently aid scientists and engineers in their efforts to model and understand fire events [20-22]. A major difficulty with such instruments, however, stems from the lack of complete knowledge or the unavailability of combustion and material properties. Students, research scientists, or practitioners must rely upon their own judgment to determine appropriate material properties for theoretical analyses and computer models. Furthermore, unavailability of, or lack of confidence in, information about errors related to that data precludes sensitivity analyses, which would provide more complete (or appropriate) results.

This project is intended to benefit members of the fire science community who desire a centralized, on-line compilation of experimental data, including the metadata¹ about the test methods, equipment, materials, and associated videos, photographs, and reports.

1.1 *Project Synopsis*

The Experiment Database for Fire Science, or EDaFS, currently at Version 0.9, provides a structure for accessing and managing experiments conducted by the fire science community.

¹ Metadata is any data that aids in the identification, description and location of networked electronic resources; it is, literally, data about data. Metadata for a video clip, for example, would include frame rate, resolution, and format.

EDaFS also provides for the storage of test data, documentation, photographs, video clips, and other related materials in a single location in a cohesive manner. Recent developments in database design enable more comprehensive access to data, enabling queries that span many tables (e.g. multiple experiments or experiment groups) and data types, queries that cannot be achieved in the existing file-based structure for fire data, the Fire Data Management System (FDMS 2.0). EDaFS architecture is based on a commercial database system, ORACLE 10g, and supports multimedia files, such as photographs, video clips, and large documents. Because XML is becoming the standard for data interchange over the web, EDaFS can be extended to allow access to and to query experimental data available in an XML format.

This document details the underlying structure of the database that forms the core of EDaFS. As will be discussed in later sections, this data includes a subset of required information for every fire test, such as test title, description, owner, and data. In addition, the structure can store more specific information, including contact information for people involved in specific tests, calibration curves for instruments, and reports and other associated documentation. Future documentation will focus on the user interfaces to add, search, and access information stored therein.

An overview of the database structure is provided in Figure 1. For a given fire test or series of tests, EDaFS can store information about associated people and organizations (including contact information, if desired); references to the methodology; descriptions of the physical plant at which the test(s) were conducted; details about the product or products involved in the test; and specifics about the type and placement of the experimental instrumentation, including images and video clips.

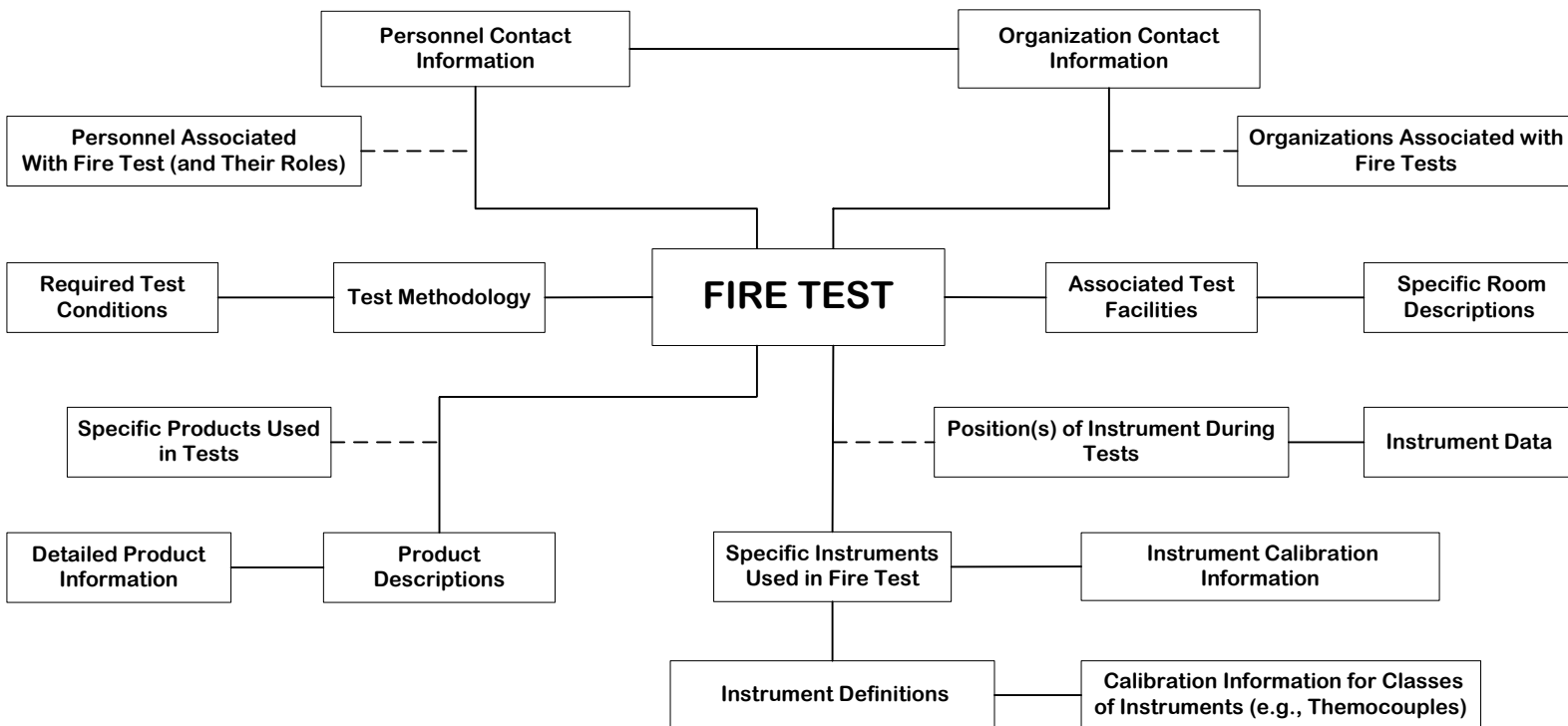


Figure 1: EDaFS Architecture

1.2 Logical View Nomenclature

The logical view nomenclature is shown in Figure 2.

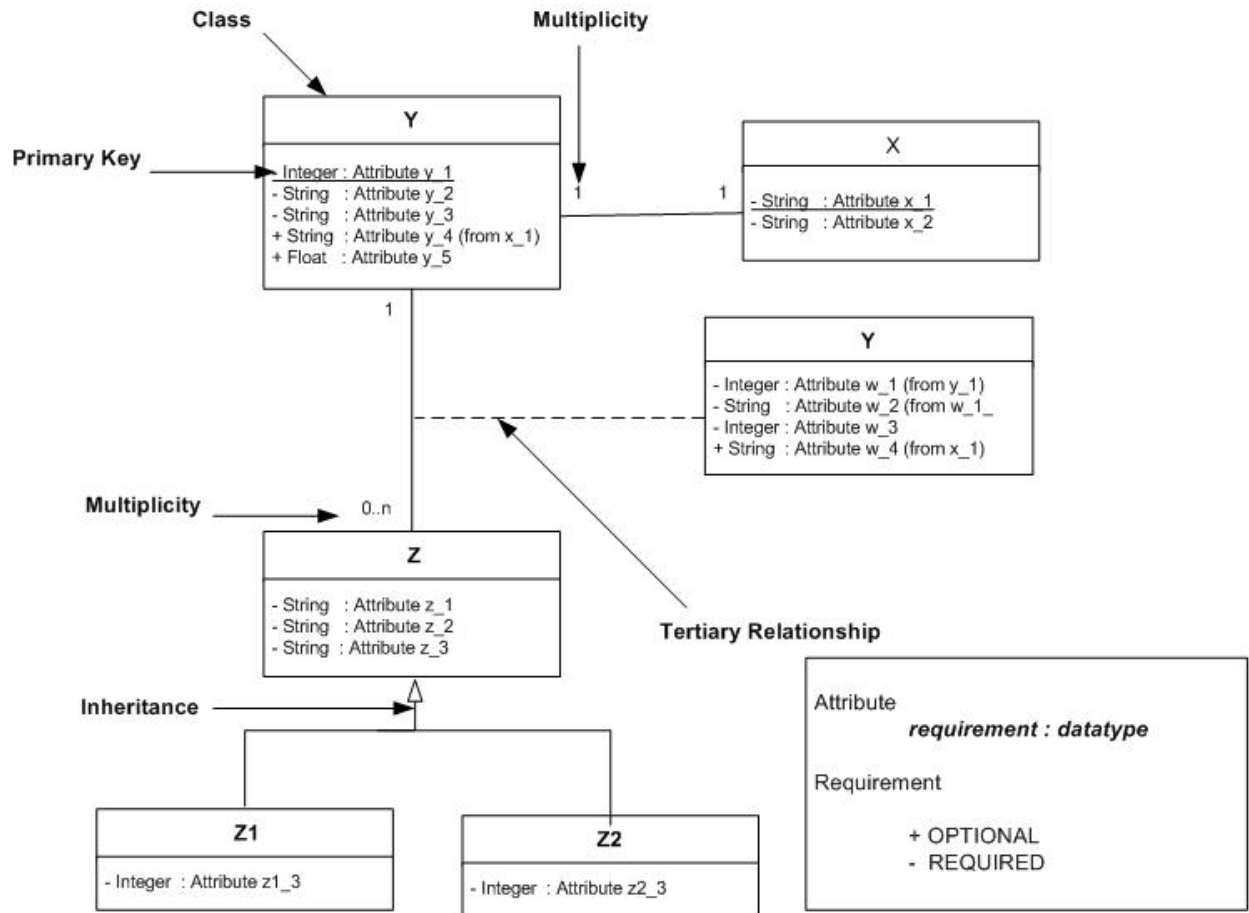


Figure 2: Logical View Nomenclature

CLASS: A table, type or view of data. The information is stored as attributes or fields, having the format:

< requirement : datatype attribute_name >

where **requirement** indicates whether a particular field is compulsory (denoted by '-') or optional (denoted by '+') and is followed by the **datatype** (e.g. string, integer, float, etc) and the **attribute name**. An instance of a class is known as an object or a record. For example, NIST fire test (SC10) is an instance (particular example) of a fire test.

PRIMARY KEY: The unique identifier for an object. The attribute of the class that is used as primary key is underlined.

RELATIONSHIP: The links between different classes. Relationships can be of the following types:

1. **INHERITANCE:** Common characteristics of different classes can be grouped, e.g. Class Z1 and Class Z2 have common characteristics that are stored in Class Z.

2. **TERTIARY RELATIONSHIP:** A new class that stores relations between two classes, along with attributes of its own. For example, the PERSONNEL table stores contact information for people, while FIRE_TEST stores information about fire tests; there is a tertiary relationship between the two, wherein the roles of people involved in a particular fire test are recorded. (See Section 2.2, Fire Test, for more information.)

MULTIPLICITY: The number of objects of one class that are related to an object of a second class.

- 1 – 1: Each object of Class A is related to one (and only one) object of Class B
- 1 – 1..n: Each object of Class A is related to at least one and possibly more objects of Class B
- 1 – 0..n: Each object of Class A can have no related entries of Class B, but can be related to any number of such objects
- 1 – 0..1: Each object of Class A is associated with no more than one object of Class B

1.3 Physical View Nomenclature

Figure 3 illustrates the nomenclature used in the documentation for tables in EDaFS.

FIELD	TYPE	W	R	CONSTRAINTS	NOTES
ATTRIBUTE_1	Integer	20	R	PRIMARY KEY	Attribute or field that uniquely identifies the record; typically a system-generated value. NULL values are not allowed.
ATTRIBUTE_2	String	1	R	<u>CHOICE:</u> 1. 'M': Male 2. 'F': Female	The constraint limits the values of this field to either 'M' or 'F'; no other entries are allowed.
ATTRIBUTE_3	String	40	O	Foreign Key Table Z: Table Name	The attribute is constrained to values from the primary key (unless otherwise noted) of Table Z.
ATTRIBUTE_4	String	30	R	Foreign Key Table Z: Table Name OR Table Q: Other Table Name	The field is limited to primary key values from either Table Z or Table Q. The value stored in ATTRIBUTE_4 is the primary key and a short string indicating the table (e.g., "4, Z", where 4 is the primary key of Table Z pointing to the linked object)
ATTRIBUTE_5	String	10	R	UNIQUE KEY	As with PRIMARY KEY , each record must have a unique value for this attribute; here, however, NULL values are acceptable.
ATTRIBUTE_6	TYPE_XYZ	-	O		A data type that begins with TYPE_ has special characteristics that are defined in Section 4.1, EDaFS Data Types.
ATTRIBUTE_7	Float	a,b	O		This attribute has a floating decimal format, with "a" digits and "b" precision
ATTRIBUTE_N					There may be any number of attributes.

Table "Y": TABLE NAME

 Table Number Name of the Table

Figure 3: Example of a Table

FIELD: Depicts the Attribute/Column name of a table

TYPE: Specifies the data format for the attribute. Can be one of the following:

- 1. Predefined database types like String and Integer.

2. User-defined data types, such as TYPE_ADDRESS and TYPE_PHONE, where the types are defined and declared within EDaFS.

W: Indicates the number of characters (width of the field) that can be stored in a data type (e.g. ATTRIBUTE_3 is a string that can contain 40 characters per record).

R: Specifies whether an attribute is required.

R: Required –Data must be entered for this attribute.

O: Optional – Can take NULL value

CONSTRAINTS: Defines limitations on the acceptable values for an attribute.

1. Primary Key (or PK) is an attribute (i.e. column) or a combination of attributes that can uniquely identify the tuple² in the table. Primary key does not accept NULL values. The primary key of some tables has multiple attributes (e.g., ATTRIBUTE_A and ATTRIBUTE_B form the primary key, such that, for each value of ATTRIBUTE_A, there may be multiple records with different values of ATTRIBUTE_B).
2. Foreign Key is an attribute table that matches the primary key of another table (e.g., in Figure 3, ATTRIBUTE_3 is a foreign key from Table Z.)
3. Unique Key is similar to primary key but it accepts NULL values.
4. Domain Constraints describe the acceptable values for the attribute; e.g. ATTRIBUTE_2 can be only 'M' (for "Male") or 'F' (for Female).

1.4 Nested Tables

ORDBMS (Object Relational Database Management Systems) introduces the concept of collections that can be treated as a part of a single row; a *nested table* is one of the most common. Nested tables are one-dimensional, unbounded collections of elements of a particular datatype. A nested table is considered as an attribute (column) of a single tuple (row) in the main table. For example, thermocouple tree TCA has seven thermocouples (TCA_1, TCA_2, TCA_3, ...TCA_7) and thermocouple tree TCB has two thermocouples (TCB_1 and TCB_2). The following diagram shows the values of a nested table for these instruments.

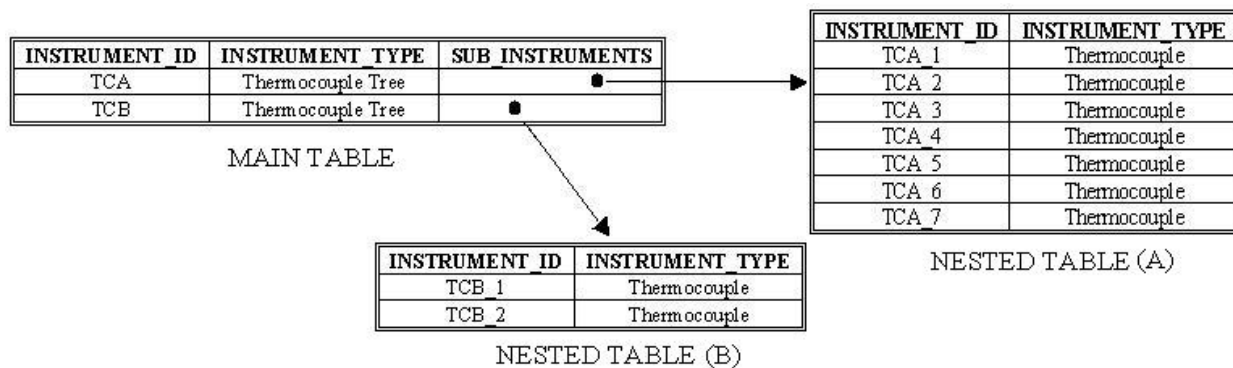


Figure 4: Example of Nested Tables

In Figure 4 NESTED TABLE (A) represents the attribute SUB_INSTRUMENTS in the first tuple of the main table (instrument tree TCA) and NESTED TABLE (B) correspond to second tuple (TCB). The example also illustrates that all nested tables for a given attribute

² Tuple – a row in a table (a.k.a. a record).

SUB_INSTRUMENTS in the table must be of the same data type, although they need not be the same value (e.g., TCA_7 could have been a Carbon Monoxide Detector).

2 DATABASE STRUCTURE

This section describes the specific structural members of the EDaFS. Although the number of tables and fields may look daunting, EDaFS is designed to store more data than many experiments will require, given that different tests provide different data. In the tables and figures below, the required and optional fields for the database are described. The required data is intended to provide a fairly complete set of information about a given fire test and its data, while also maintaining the integrity of the data entry process. Additional information can be provided to enable users to filter search results and otherwise provide a more complete picture of the fire test.

2.1 Personnel and Organization

2.1.1 Logical View

The logical view³ for fire professionals and the organization they represent is shown in Figure 5. An organization can have several departments, information for each of which – mailing address, telephone and fax number(s), and email – is stored in an ORGANIZATION relation. The names of the people involved in the fire test are stored in PERSONNEL. A system-generated identifier uniquely specifies each person. Personnel can work for different organizations at any particular time; this relation captures information about the organization and division for which the person works and in what capacity.

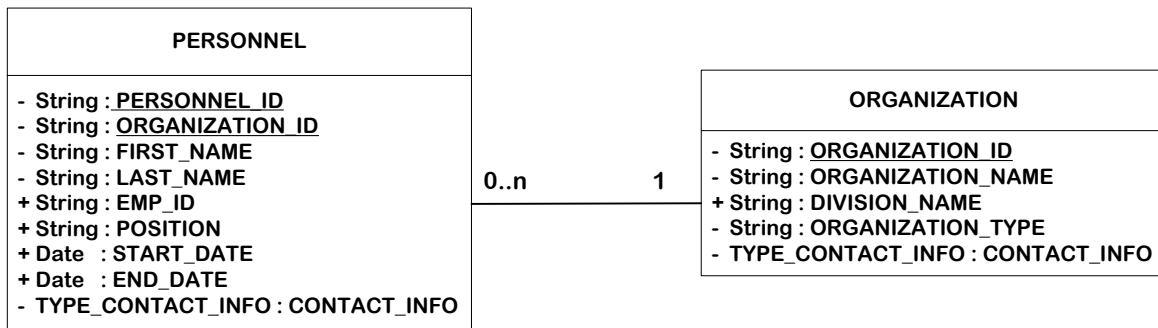


Figure 5: Logical View of PERSONNEL and ORGANIZATION

(a)

TYPE_CONTACT_INFO
+ String : EMAIL
+ TYPE_ADDRESS : ADDRESS
+ TYPE_PHONE_NT : PHONE_NUMBERS
+ String : WEBSITE

TYPE_ADDRESS
- String : DESCRIPTION
+ String : ADDRESS1
+ String : ADDRESS2
+ String : CITY
+ String : REGION
+ String : COUNTRY
+ String : ZIPCODE

(b)

TYPE_PHONE_NT
- String : DESCRIPTION
- Integer : COUNTRY_CODE
- Integer : STATE_CODE
- Integer : PHONE_NUMBER
+ Integer : EXTENSION

Figure 6: a) Data Types for PERSONNEL and ORGANIZATION b) Nested Tables

³ A visual depiction of the fields of and relationships between one or more tables in a database

2.1.2 Physical View

ORGANIZATION (Table 1) stores information about different organizations and companies – and their divisions – relevant to experiment data contained in EDaFS. These range from the laboratories in which experiments are conducted to funding agencies to manufacturers of products used in the tests. The ORGANIZATION_ID is a system-generated primary key⁴; as such, it serves as the means by which the records for this table are addressed. The ORGANIZATION_NAME, a required field, and DIVISION_NAME, not required, are self-explanatory. ORGANIZATION_TYPE is the only other required field for the table, and serves as a categorization tool. The remaining fields enable the user to store contact information for the organization, company, or agency. The fields that store the address and phone numbers are akin to embedded tables, as they store more than one piece of information per field (see Table 25 and Table 40, respectively).

FIELD	TYPE	W	R	CONSTRAINTS
ORGANIZATION_ID	String	20	R	PRIMARY KEY UNIQUE KEY
ORGANIZATION_NAME	String	40	R	
DIVISION_NAME	String	40	O	
ORGANIZATION_TYPE	String	30	R	CHOICE: 1. College & University 2. Fire Laboratory 3. Government Organization 4. National Testing Laboratory 5. Professional Organization 6. Equipment Manufacturers
CONTACT_INFO	TYPE_CONTACT_INFO	-	O	See Table 26

Table 1: ORGANIZATION

The names of people associated with fire tests, from experimentalists to data entry specialists, are stored in PERSONNEL (Table 2); Figure 5 defines the relationship between the professionals and their organizations. PERSONNEL_ID, which is system-generated, provides a unique identifier for use in other tables. The organization for which the person works is reflected in ORGANIZATION_ID, which is restricted to the values of the primary key for Table 1. The only other required information for this table is the first (FIRST_NAME) and last name (LAST_NAME) of the employee, although other data, such as the employee number or ID (from the organization), the employee's current position, the dates⁵ of employment, and contact information, can be collected. PERSONNEL stores information about professionals working for an organization (or division in an organization) who have contributed to or worked on an experiment for which data is stored EDaFS.

FIELD	TYPE	W	R	CONSTRAINTS
PERSONNEL_ID	String	20	R	Foreign Key Table 1: ORGANIZATION
ORGANIZATION_ID	String	20	R	
FIRST_NAME	String	50	R	
LAST_NAME	String	30	R	
EMP_ID	String	20	O	
POSITION	String	20	O	
START_DATE	Date	-	O	

⁴ For EDaFS, the system-generated primary keys are alphanumeric, with the first five letters reserved to represent the table name and the remaining characters denoting the specific record.

⁵ Date field formats are as follows: YYYY-MMM-DD (e.g., 2004-Jul-07)

FIELD	TYPE	W	R	CONSTRAINTS
END_DATE	Date	-	O	
CONTACT_INFO	TYPE_CONTACT_INFO	-	O	See Table 26

Table 2: PERSONNEL

2.2 Fire Test

Storage and retrieval of experiment data from fire-related tests and experiments is the primary purpose of EDaFS; to that end, there is a wealth of information that can be collected to enhance search capabilities and later analysis, beyond simple reporting of instrument type, location, and measurement. The next several sections explain the various associated tables and fields necessary to warehouse the fire test information and data.

2.2.1 Logical View

The logical view of fire tests and related tables for EDaFS is shown in Figure 8, which is somewhat complex. The expanded tables (with visible fields) are discussed in greater detail in Section 2.2.1, Physical View; other tables are described later in this document.

The FIRE_TEST table stores basic information about a specific fire test, including title, description, date of test, keywords, and information about who entered the data in EDaFS and when. Each fire test may be part of a collection of similar tests; this relationship is reflected in the TEST_COLLECTION table, which can store the collection title, the contact person or organization, keywords, and other related documentation. Note that a test collection can also contain other test collections, as may happen when a particular project includes multiple experiment sets that may be referenced separately.

While PERSONNEL and ORGANIZATION tables, respectively, store general information about people and organizations, as discussed in Section 2.1, Personnel and Organization, their associated roles for a particular fire test (e.g., technician or sponsor) is maintained in the FIRE_PERSONNEL and FIRE_ORGANIZATION tables.

The particular data types and nested tables required for these tables can be seen in a) and b) of Figure 8, and are discussed in Sections 4.1, EDaFS Data Types, and 4.2, Nested Tables, respectively.

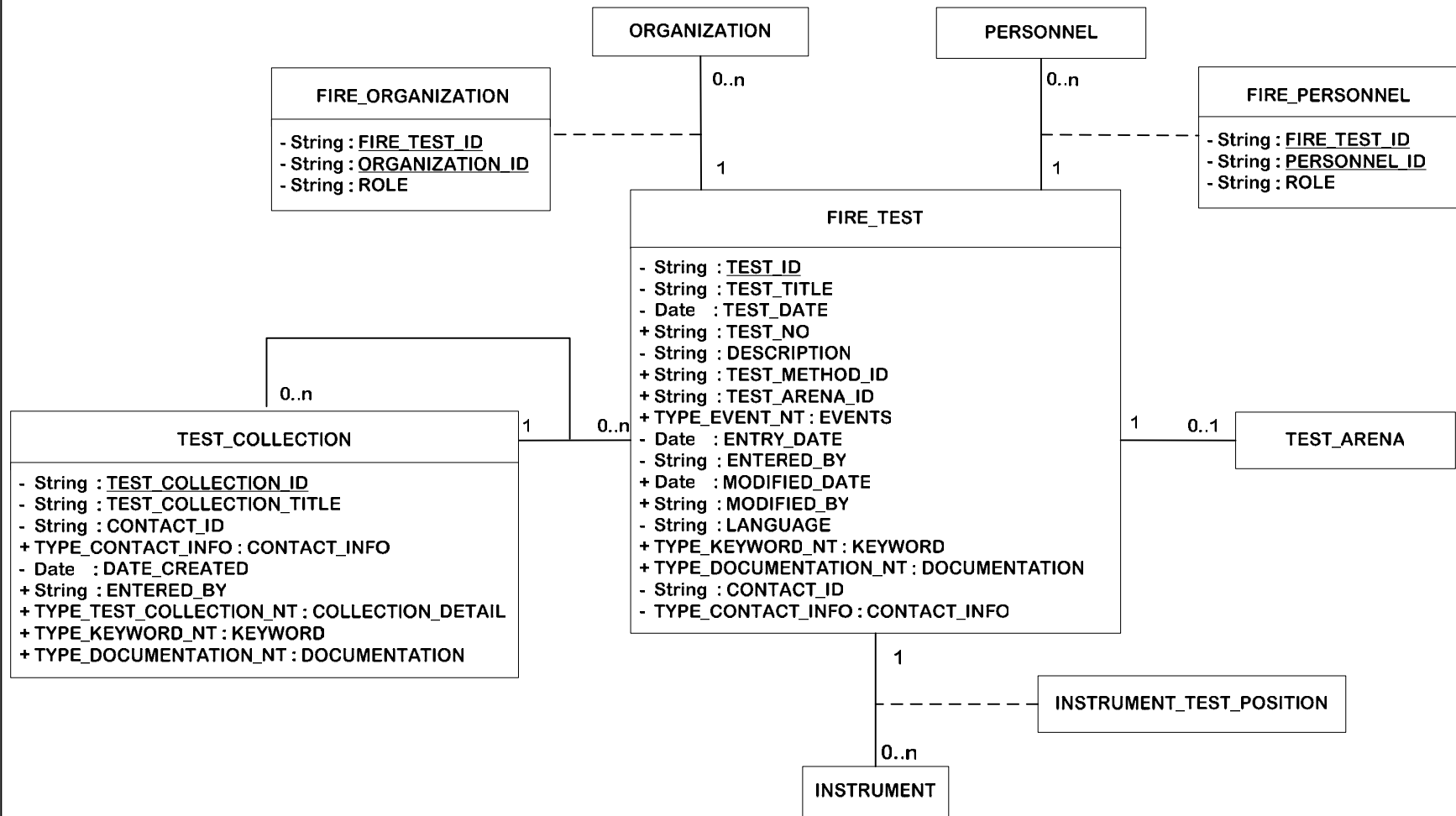
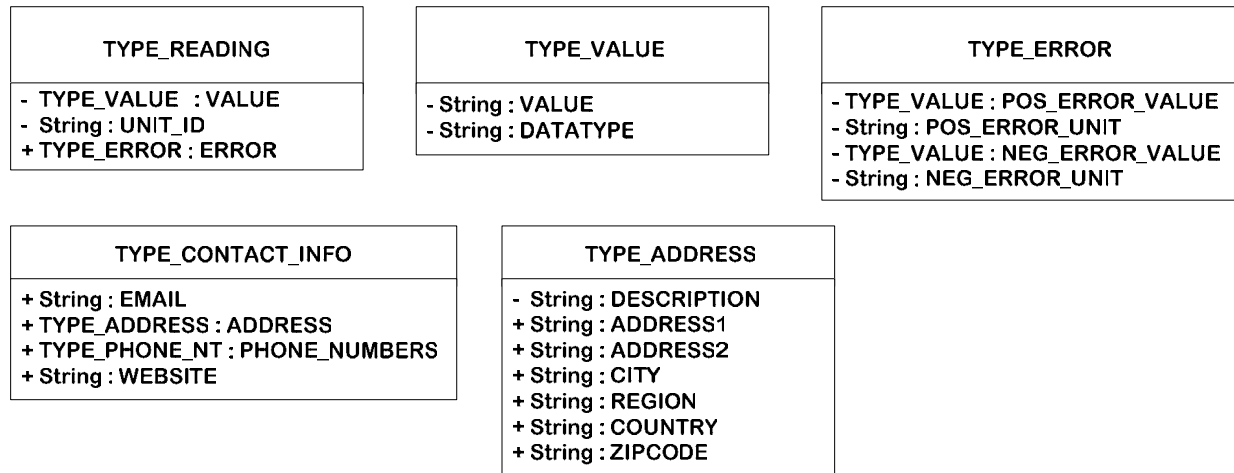


Figure 7: Logical View of FIRE_TEST



(b)

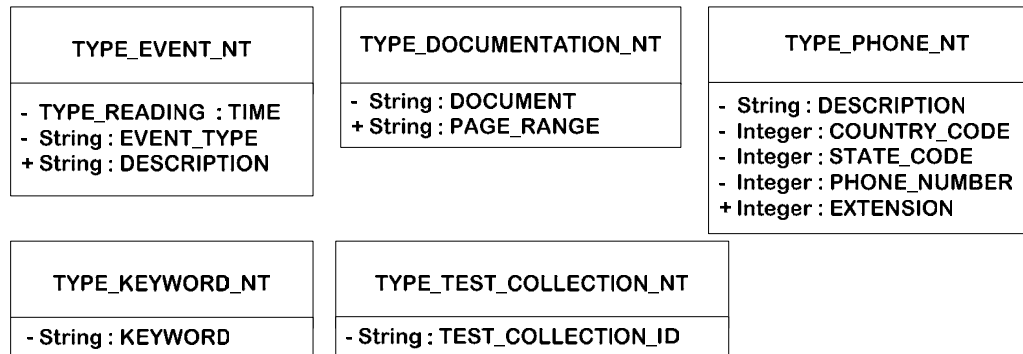


Figure 8: a) Required Data Types for FIRE_TEST b) Nested Tables

2.2.2 Physical View

All fire tests have a corresponding entry in FIRE_TEST (Table 3); this table is the lynch pin for EDaFS, as it contains information about experiments for which data is available. (Specific data is stored in other tables, as will be discussed in Section 2.6, Instrument Data.) A system-generated TEST_ID uniquely identifies each test.

Note that this label is separate from the (optional) TEST_NO field, which is available for an organization-specified designation.

A user-defined title is stored in TEST_TITLE, and a more complete description of the fire test is found in DESCRIPTION. Entries for the TEST_METHOD_ID and TEST_ARENA_ID fields, both optional, are foreign keys and, thus, limited to values from their respective tables; these fields enable the user to specify a documented test methodology (such as an ASTM test) and a test structure or building utilized for the fire test.

The EVENTS field, a nested table⁶, allows the user to store multiple milestones for a given test (e.g., the time, after ignition, at which the first sprinkler operated). The entry and modification fields, which utilize information from the PERSONNEL table, maintain administrative information about those who entered the data into EDaFS. (Of the two, only the entry fields are required.)

LANGUAGE enables users to filter search results based on the language of the information and uses the ISO 639, 2-letter language codes.

KEYWORD and DOCUMENTATION are nested tables that are designed to provide additional information about the fire test. The former is a list of keywords derived from the FIREDOC vocabulary list, while the latter is a list of documents that pertain to the fire test (such as a final report).

Finally, CONTACT_ID and CONTACT_INFO fields contain details about the organization (or specific person within an organization) who should be contacted for more information about the fire test, as this information may be specific to a given fire test. Note that, unlike prior instances of a foreign key, an entry for CONTACT_ID can match the primary key of a record from either the PERSONNEL or ORGANIZATION table.

FIRE_TEST conforms to the Dublin Core standard for metadata storage, which will enable interaction between EDaFS and other digital libraries.

FIELD	TYPE	W	R	CONSTRAINTS
TEST_ID	String	20	R	PRIMARY KEY
TEST_TITLE	String	40	R	
TEST_DATE	Date	-	R	
TEST_NO	String	20	O	
DESCRIPTION	String	50	R	
TEST_METHOD_ID	String	20	O	Foreign Key Table 19: TEST_METHOD
TEST_ARENA_ID	String	20	O	Foreign Key Table 22: TEST_ARENA
EVENTS	TYPE_EVENT_NT	20	O	See Table 37
ENTRY_DATE	Date	-	R	

⁶ See Section 1.4

FIELD	TYPE	W	R	CONSTRAINTS
ENTERED_BY	String	20	R	Foreign Key Table 2: PERSONNEL
MODIFIED_DATE	Date	-	O	
MODIFIED_BY	String	20	O	Foreign Key Table 2: PERSONNEL
LANGUAGE	String	2	R	
KEYWORD	TYPE_KEYWORD_NT	-	O	See Table 38
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
CONTACT_ID	String	20	R	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
CONTACT_INFO	TYPE_CONTACT_INFO	-	O	See Table 26

Table 3: FIRE_TEST

Each fire test; as shown in Figure 8, can have a list of people (PERSONNEL) who participated in various roles. For example, one or more technicians under the guidance of one or more officers may conduct a fire test. A WRITER is person responsible for generating documentation for a particular fire test. FIRE_PERSONNEL (Table 4) stores these roles.

FIELD	TYPE	W	R	CONSTRAINTS
FIRE_TEST_ID	String	20	R	PK Foreign Key Table 3: FIRE_TEST
PERSONNEL_ID	String	20	R	
ROLE	String	10	R	<u>CHOICE:</u> 1. OFFICER 2. SPONSOR 3. TECHNICIAN 4. WRITER 5. SCIENTIST

Table 4: FIRE_PERSONNEL

Similarly, several organizations may be associated with a fire test; for example, a fire test that is funded by one organization may be conducted in the laboratory of another. FIRE_ORGANIZATION (Table 5) stores the associated organizations and their roles. The structure for this table is very similar to that for Table 4, above.

FIELD	TYPE	W	R	CONSTRAINTS
FIRE_TEST_ID	String	20	R	PK Foreign Key Table 3: FIRE_TEST
ORGANIZATION_ID	String	20	R	
ROLE	String	10	R	<u>CHOICE:</u> 1. SPONSOR 2. LABORATORY

Table 5: FIRE_ORGANIZATION

The final table to be considered in this section addresses the potential need to provide a vessel for multiple, related fire experiments, as may be desired for all tests for a given project. TEST_COLLECTION (Table 6) stores information about such collections. TEST_COLLECTION_ID is a system-generated identifier. The title

(TEST_COLLECTION_TITLE) and specific contact information (CONTACT_ID and CONTACT_INFO) for the collection is stored in this table, as is a description (DESCRIPTION).

TEST_COLLECTION has three nested tables. COLLECTION_DETAIL contains one or more associated fire test identifiers or test collection identifiers – a collection can contain other collections. KEYWORD and DOCUMENTATION fields are identical to those for Table 3, except that they apply to a series of tests, rather than a single instance.

FIELD	TYPE	W	R	CONSTRAINTS
TEST_COLLECTION_ID	String	20	R	PRIMARY KEY
TEST_COLLECTION_TITLE	String	20	R	
CONTACT_ID	String	20	R	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
CONTACT_INFO	TYPE_CONTACT_INFO	-	O	See Table 26
DESCRIPTION	String	50	R	
DATE_CREATED	Date	-	R	
ENTERED_BY	String	20	R	Foreign Key Table 2: PERSONNEL
COLLECTION_DETAIL	TYPE_TEST_COLLECTION_NT	-	O	See Table 43
KEYWORD	TYPE_KEYWORD_NT	-	O	See Table 38
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36

Table 6: TEST_COLLECTION

2.3 Products Used In Fire Tests

The PRODUCTS table reflects the materials that form the basis of many experiments. The content specified is not intended to address all possible content; additional information can be provided through the document storage capabilities of EDaFS, which enables the archival of related reports, images, and other information.

2.3.1 Logical View

PRODUCT and PRODUCT_IN_TEST are two tables associated with products and other consumables used in fire experiments. The former stores information about the composition, manufacturer, and other characteristics, while the latter records the position and other test-related material, including photographs of the matériel *in situ*. The logical view of the tables, as they relate to FIRE_TEST, is shown in Figure 9; the associated data types and nested tables are provided in Figure 10.

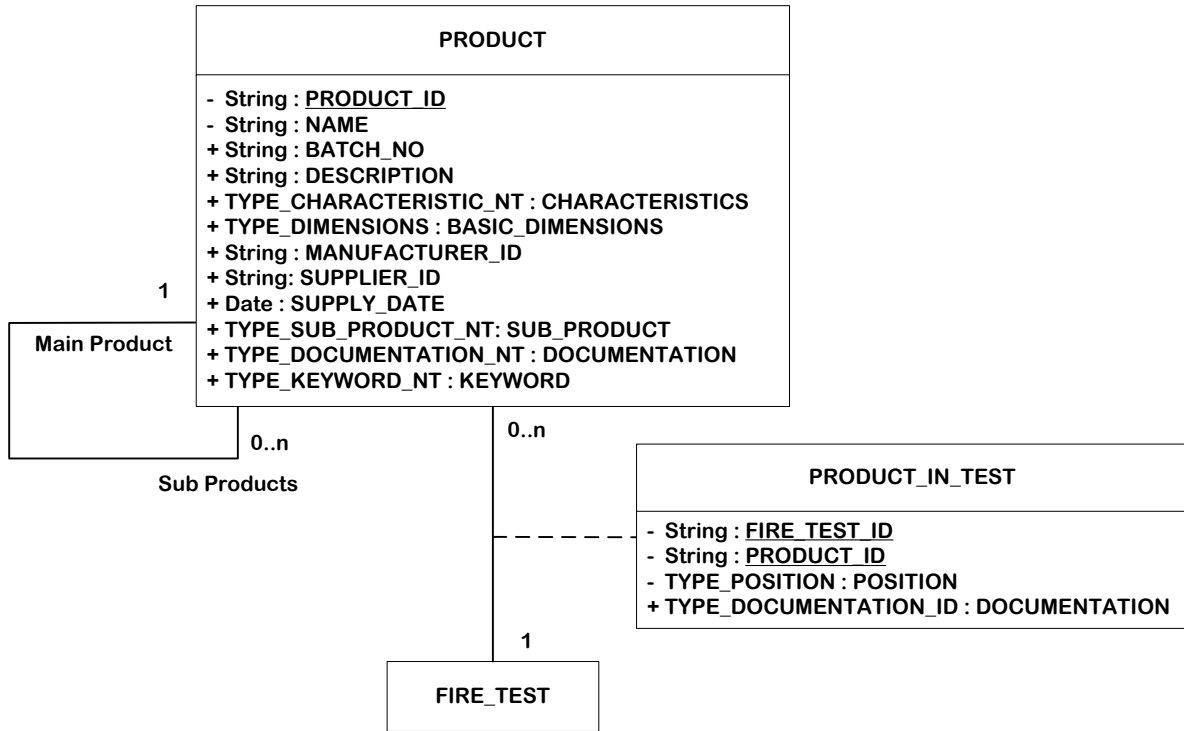
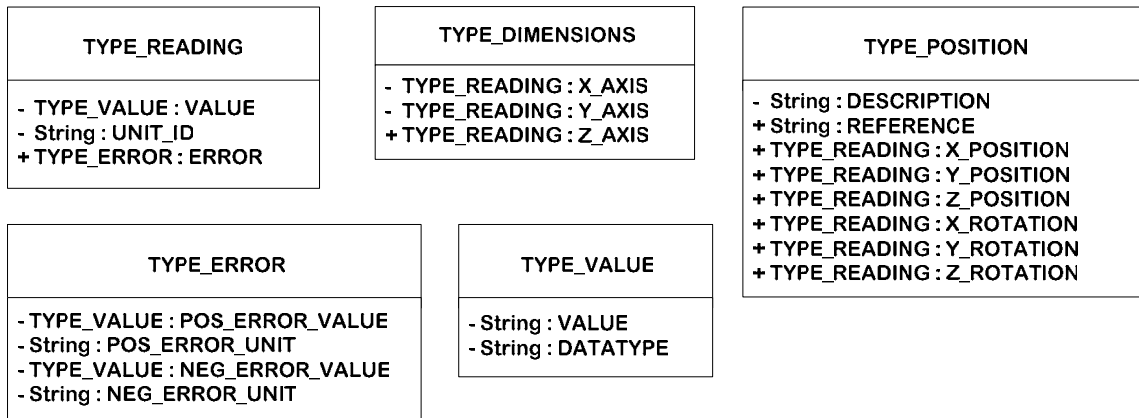


Figure 9: Logical View of PRODUCT

(a)



(b)

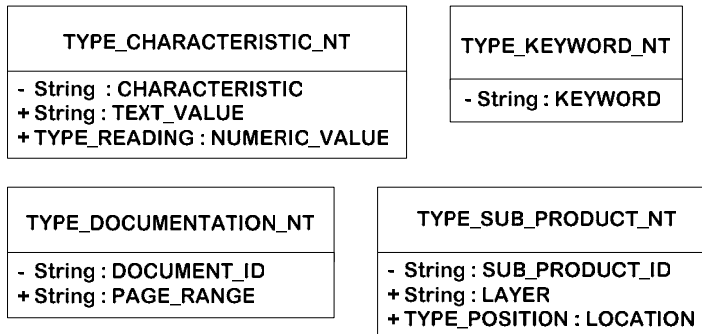


Figure 10: a) Data Types for PRODUCT b) Nested Tables.

2.3.2 Physical View

In EDaFS, “products” encompass a wide range of consumable materials necessary for fire tests: furniture, flammable liquids and gasses, and test specimens, to name a few. Each of these consumables is described in PRODUCT (Table 7).

PRODUCT_ID is a system-generated primary key, while NAME is a short, textual identifier that, with BATCH_NO, presents a unique descriptor for each product in a test series. DESCRIPTION is available for greater discourse. The CHARACTERISTICS nested table provides the means to present desired material properties in tabular form. BASIC_DIMENSIONS stores the overall dimensions of the product, if appropriate, in Cartesian coordinates. MANUFACTURER_ID, SUPPLIER_ID, and SUPPLY_DATE record information about the supply chain.

The SUB_PRODUCT nested table allows the experimentalist to decompose a product into its constituent parts and can store subjective information in LAYER and more definitive positional information in LOCATION; each sub product is a product, and so all of the information detailed above can be provided for each sub product (which can have sub products of its own).

FIELD	TYPE	W	R	CONSTRAINTS
PRODUCT_ID	String	20	R	PRIMARY KEY
NAME	String	20	R	
BATCH_NO	String	20	O	
DESCRIPTION	String	50	O	
CHARACTERISTICS	TYPE_CHARACTERISTIC_NT	-	O	See Table 35
BASIC_DIMENSIONS	TYPE_DIMENSIONS	-	O	See Table 27
MANUFACTURER_ID	String		O	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
SUPPLIER_ID	String	20	O	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
SUPPLY_DATE	Date	-	O	
SUB_PRODUCT	TYPE_SUB_PRODUCT_NT	-	O	See Table 41
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
KEYWORD	TYPE_KEYWORD_NT	-	O	See Table 38

Table 7: PRODUCT

PRODUCT_IN_TEST (Table 8) simply records the test in which a given product was used, the location, and any desired documentation.

FIELD	TYPE	W	R	CONSTRAINTS
FIRE_TEST_ID	String	20	R	PK Foreign Key Table 3: FIRE_TEST
PRODUCT_ID	String	20	R	
LOCATION	TYPE_POSITION	-	R	See Table 29
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36

Table 8: PRODUCT_IN_TEST

2.4 Types of Instruments

EDaFS makes a distinction between instrument classes, or types, and specific instances of an instrument. The former, which are addressed in this section, provide information about the characteristics of types of instruments. (The latter are described in Section 2.5.1, Logical View.) As an example, a thermocouple may be defined by a number of specific features, such as the type, shielding, bead size, and wire gauge.

EDaFS stores information about such features, for common types of instruments, in a collection of tables and can also store characteristics of grouped equipment, such as thermocouple trees or cone calorimeters; these are known, in the EDaFS lexicon, as composite instruments and can be composed of both basic and other composite instruments. For example, thermocouple trees, which are composite instruments, have one or more thermocouples, which are basic instruments.

2.4.1 Logical View

An instrument definition can either specify a particular, basic instrument or a combination of basic and composite instruments. Figure 11 shows the logical view and Figure 12 defines the associated data types and nested tables.. Each of the composite instruments stores information about the minimum and maximum allowable instruments of a given type. The instrument class can also have associated calibration data (e.g., the calibration curve for Type-K thermocouples is well known, and need not be generated for each individual thermocouple).

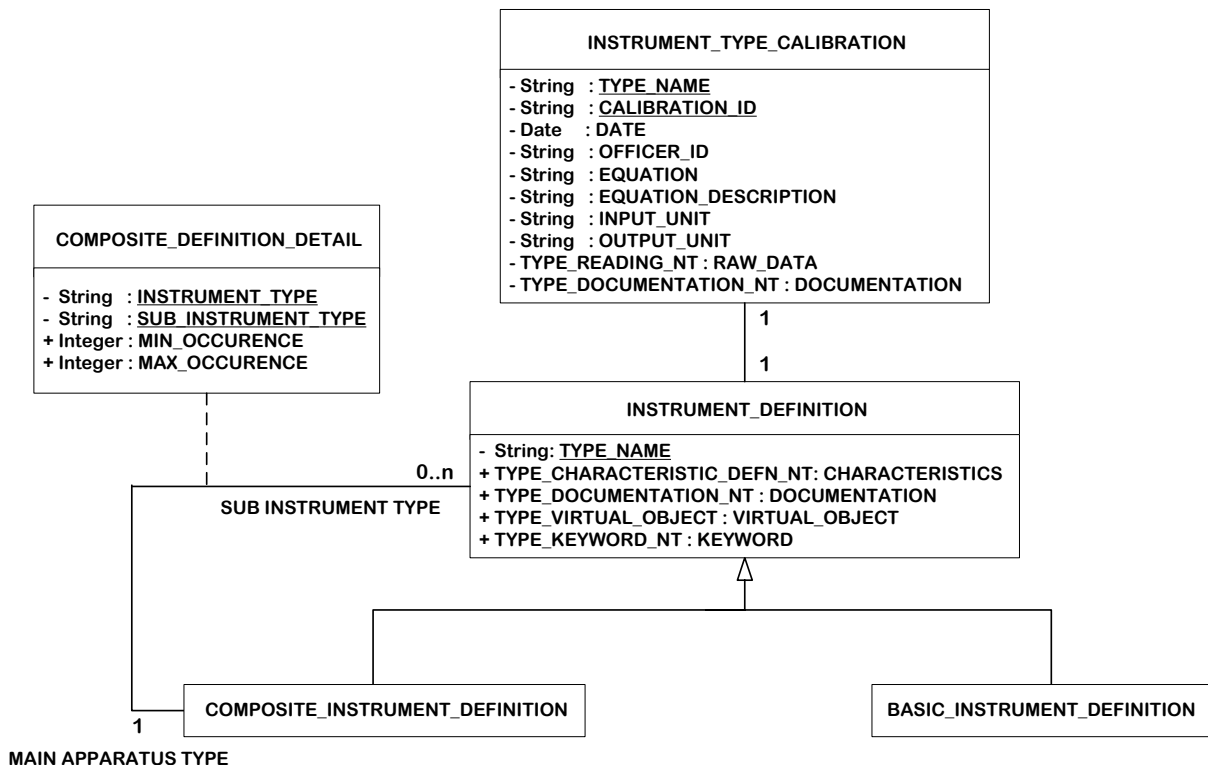


Figure 11: Logical View of INSTRUMENT_TYPE

(a)

TYPE_READING - TYPE_VALUE : VALUE - String : UNIT_ID + TYPE_ERROR : ERROR	TYPE_VALUE - String : VALUE - String : DATATYPE	TYPE_ERROR - TYPE_VALUE : POS_ERROR_VALUE - String : POS_ERROR_UNIT - TYPE_VALUE : NEG_ERROR_VALUE - String : NEG_ERROR_UNIT
TYPE_VIRTUAL_OBJECT - String : NAME - String : DESCRIPTION - String : OBJECT_TYPE + String : VERSION - LOB : OBJECT + String : AUTHOR + TYPE_CONTACT_INFO : AUTHOR_CONTACT_INFO		

(b)

<div>TYPE_CHARACTERISTIC_DEFN_NT</div> <div><div>- String : PROPERTY</div><div>- String : DESCRIPTION</div><div>+ TYPE_PARAMETERS_NT : DEFINED_PARAMETERS</div></div>	<div>TYPE_DOCUMENTATION_NT</div> <div><div>- String : DOCUMENT_ID</div><div>+ String : PAGE_RANGE</div></div>	
<div>TYPE_PARAMETERS_NT</div> <div><div>+String : TEXT_PARAMETER</div><div>+TYPE_READING : NUMERIC_PARAMETER</div></div>	<div>TYPE_READING_NT</div> <div><div>- TYPE_READING : X_AXIS</div><div>- TYPE_READING : Y_AXIS</div></div>	<div>TYPE_KEYWORD_NT</div> <div><div>- String : KEYWORD</div></div>

Figure 12: a) Data Types for INSTRUMENT_TYPE b) Nested Tables

2.4.2 Physical View

A basic instrument, as defined by EDaFS, provides a single channel of data for a given fire test, while a combination of data streams is termed a composite instrument. Instrument types are used to classify different kinds of equipment to provide searchable characteristics over different fire tests.

BASIC_INSTRUMENT_DEFINITION (Table 9) stores the name of basic instrument types in TYPE_NAME. The CHARACTERISTICS nested table stores one or more characteristics (e.g., type and shielding of a thermocouple); note that each characteristic has a name or title (PROPERTY), a DESCRIPTION, and a list of acceptable entries for each characteristic in a nested table. The nested table DEFINED_PARAMETERS stores these attributes, either in text (TEXT_PARAMETER) or as a number with units (NUMERIC_PARAMETER). For example, the thermocouple class might be defined with characteristics for “Junction” and “Wire Gauge,” which would be the PROPERTY names for the CHARACTERISTICS nested table for each of these.

The DESCRIPTION field provides a little more information (e.g., “Style of sheath tip” and “Thickness of thermocouple wires,” respectively). For “Junction,” the

DEFINED_PARAMETERS, which are of type TYPE_PARAMETERS_NT, might be “Grounded,” “Ungrounded,” and “Exposed”; these would be stored in TEXT_PARAMETER (NUMERIC_PARAMETER would be null). The DEFINED_PARAMETERS for “Wire Gauge” might be 8, 14, 20, and 24 AWG, stored in NUMERIC_PARAMETER, which is TYPE_READING, with “AWG” as the UNIT_IDS and the numbers as the VALUES.

BASIC_INSTRUMENT_DEFINITION (Table 9) also stores a nested table of documents associated with the instrument type (e.g., notes on the construction of the instrument type or manufacturer’s data sheets) in DOCUMENTATION. The VIRTUAL_OBJECT field contains information about a file that is used to provide three-dimensional renderings of the instruments. Finally, a list of descriptive keywords is maintained in the KEYWORD nested table.

FIELD	TYPE	W	R	CONSTRAINTS
TYPE_NAME	String	20	R	PRIMARY KEY
CHARACTERISTICS	TYPE_CHARACTERISTIC_DEFN_NT	-	O	See Table 34
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
VIRTUAL_OBJECT	TYPE_VIRTUAL_OBJECT	-	O	See Table 32
KEYWORD	TYPE_KEYWORD_NT	-	O	See Table 38

Table 9: BASIC_INSTRUMENT_DEFINITION

The fields for a composite instrument, COMPOSITE_INSTRUMENT_DEFINITION (Table 10), are identical to those for BASIC_INSTRUMENT_DEFINITION; the difference between the basic and composite instruments lies in the ability to link basic and composite instruments to a given composite instrument via COMPOSITE_DEFINITION_DETAIL (Table 11). This table stores the list of sub-instrument types (SUB_INSTRUMENT_TYPE) that compose a particular composite instrument (INSTRUMENT_TYPE), and allows the user to indicate acceptable minimum and maximum instances of that sub instrument. For example, a Thermocouple Tree Type will have an entry in COMPOSITE_INSTRUMENT_DEFINITION as follows: (Thermocouple Tree Type, Thermocouple Type, 1, NULL), meaning a thermocouple tree has one or more thermocouples (with no maximum), and no other sub instruments.

FIELD	TYPE	W	R	CONSTRAINTS
TYPE_NAME	String	20	R	PRIMARY KEY
CHARACTERISTICS	TYPE_CHARACTERISTIC_DEFN_NT	-	O	See Table 34
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
VIRTUAL_OBJECT	TYPE_VIRTUAL_OBJECT	-	O	See Table 32
KEYWORD	TYPE_KEYWORD_NT	-	O	See Table 38

Table 10: COMPOSITE_INSTRUMENT_DEFINITION

FIELD	TYPE	W	R	CONSTRAINTS
INSTRUMENT_TYPE	String	20	R	Foreign Key Table 11: COMPOSITE_DEFINITION_DETAIL Foreign Key Table 9: BASIC_INSTRUMENT_DEFINITION OR Table 10: COMPOSITE_INSTRUMENT_DEFINITION
SUB_INSTRUMENT_TYPE	String	20	R	

FIELD	TYPE	W	R	CONSTRAINTS
MIN_OCCURRENCE	Integer	4	O	
MAX_OCCURRENCE	Integer	4	O	

Table 11: COMPOSITE_DEFINITION_DETAIL

INSTRUMENT_TYPE_CALIBRATION (Table 12) can store one or more sets of calibration data for each instrument type.

Note that this information is valid for all instances of a given type; for calibration of a specific instrument, see the discussion in Section 2.5, Instruments from Fire Tests.

INSTRUMENT_TYPE_CALIBRATION has a primary key composed of the INSTRUMENT_TYPE and CALIBRATION_ID, which allows multiple calibration curves to be developed for each instrument type. DATE stores the date of the calibration, and OFFICER_ID contains the name of the person responsible for the calibration; for instrument types, this last field is optional, as the curves are likely developed from myriad data sources. The equation that represents the calibration curve is provided in text form in EQUATION, with a description of this equation in EQUATION_DESCRIPTION (a more lengthy description is can be stored as one of the documents in the DOCUMENTATION nested table). The units before and after calibration (i.e., the “raw” and “engineering” units) are indicated in INPUT_UNITS and OUTPUT_UNITS, respectively. Finally, the raw units themselves can be stored in the RAW_DATA nested table, which stores the time (or other independent variable) in X_AXIS and the measurement as provided by the instrument in Y_AXIS.

FIELD	TYPE	W	R	CONSTRAINTS
TYPE_NAME	String	20	R	PK Foreign Key Table 9: BASIC_INSTRUMENT_DEFINITION
CALIBRATION_ID	String	20	R	
DATE	Date		R	
OFFICER_ID	String	20	O	Foreign Key Table 2: PERSONNEL
EQUATION	String	30	R	
EQUATION_DESCRIPTION	String	50	R	
INPUT_UNITS	String	20	R	
OUTPUT_UNITS	String	20	R	
RAW_DATA	TYPE_READING_NT	-	O	See Table 42
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36

Table 12: INSTRUMENT_TYPE_CALIBRATION

2.5 Instruments from Fire Tests

An instrument, as defined by EDaFS, provides values for characteristics of equipment utilized in specific fire tests or experiments. This section parallels Section 2.4, Types of Instruments, except that the information stored herein reflects specific instances of instruments, rather than broad classes. An underlying instrument type is not a requirement, although it provides a structure that enhances search capabilities for information across multiple experiments.

2.5.1 Logical View

Each instance of a composite or basic instrument used in the fire test is captured by the logical view shown in Figure 13, with associated data types and nested tables shown in Figure 14. As with the instrument type collection, described in the previous section, an instrument can either be basic or a composite; the former provides a single data stream, while the latter collects associated basic instruments (e.g., those in a cone calorimeter) and can have multiple data streams. The position of each of these sub instruments, relative to the composite instrument, is also maintained.

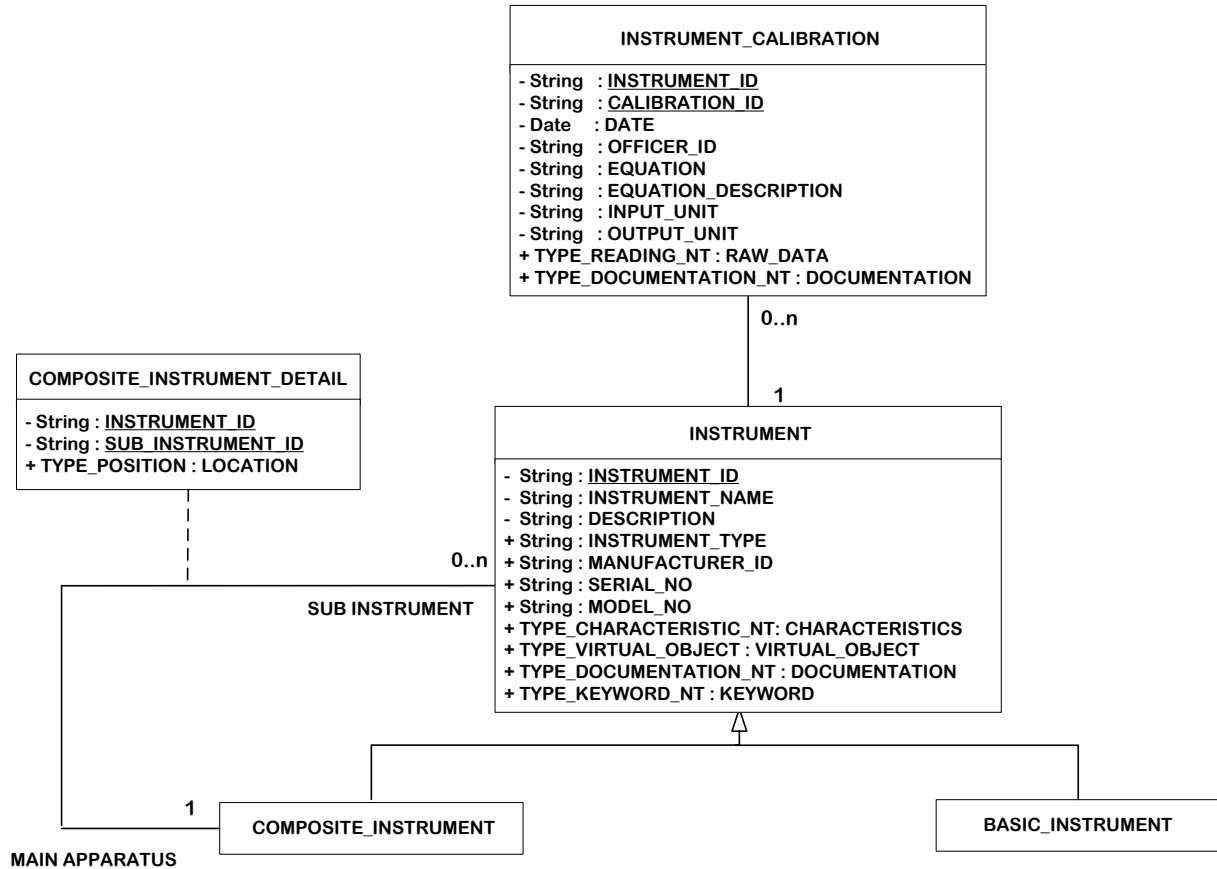


Figure 13: Logical View of INSTRUMENT

(a)

TYPE_READING - TYPE_VALUE : VALUE - String : UNIT_ID + TYPE_ERROR : ERROR	TYPE_VALUE - String : VALUE - String : DATATYPE	TYPE_ERROR - TYPE_VALUE : POS_ERROR_VALUE - String : POS_ERROR_UNIT - TYPE_VALUE : NEG_ERROR_VALUE - String : NEG_ERROR_UNIT
TYPE_POSITION - String : DESCRIPTION + String : REFERENCE + TYPE_READING : X_POSITION + TYPE_READING : Y_POSITION + TYPE_READING : Z_POSITION + TYPE_READING : X_ROTATION + TYPE_READING : Y_ROTATION + TYPE_READING : Z_ROTATION	TYPE_VIRTUAL_OBJECT - String : NAME - String : DESCRIPTION - String : OBJECT_TYPE + String : VERSION - LOB : OBJECT + String : AUTHOR + TYPE_CONTACT_INFO : AUTHOR_CONTACT_INFO	

(b)

TYPE_CHARACTERISTIC_NT - String : CHARACTERISTIC + String : TEXT_VALUE + TYPE_READING : NUMERIC_VALUE	TYPE_DOCUMENTATION_NT - String : DOCUMENT_ID + String : PAGE_RANGE	TYPE_READING_NT - TYPE_READING : X_AXIS - TYPE_READING : Y_AXIS
TYPE_KEYWORD_NT - String : KEYWORD		

Figure 14: a) Data types for INSTRUMENT b) Nested Table

2.5.2 Physical View

BASIC_INSTRUMENT (Table 13) stores information about the equipment that provides a single data stream for a given fire test. INSTRUMENT_ID is a system-generated primary key and INSTRUMENT_NAME is a user-defined label for the specific instrument. The DESCRIPTION field provides space for more details about the instrument and INSTRUMENT_TYPE is an (optional) associated class for the instrument.

MANUFACTURER_ID identifies the person or company that was responsible for the construction of the instrument. For *ad hoc* instrumentation, the technician or researcher who created the instrument is considered to be the manufacturer; for more formal equipment, the manufacturer is likely to be a company. In either case, any associated serial number or model number can be stored in the SERIAL_NO and MODEL_NO attributes, respectively. Inclusion of this information may help a user note trends from a specific instrument over multiple fire tests.

A nested table of attributes is contained in CHARACTERISTICS. This list of properties may be defined by the associated instrument type or can be user-defined; in either case, the characteristic can have a text or numerical value (see the discussion of characteristics in Section 2.4.2, Physical View). DOCUMENTATION, a nested table, can maintain design specifications,

technicians' notes, images, and other such material for future reference. KEYWORD, another nested table, provides an index for each instrument.

FIELD	TYPE	W	R	CONSTRAINTS
INSTRUMENT_ID	String	20	R	PRIMARY KEY
INSTRUMENT_NAME	String	20	R	
DESCRIPTION	String	50	R	
INSTRUMENT_TYPE	String	20	O	Foreign Key Table 9: BASIC_ INSTRUMENT_DEFINITION
MANUFACTURER_ID	String	20	O	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
SERIAL_NO	String	20	O	
MODEL_NO	String	20	O	
CHARACTERISTICS	TYPE_CHARACTERISTIC_NT	-	O	See Table 35
VIRTUAL_OBJECT	TYPE_VIRTUAL_OBJECT	-	O	See Table 32
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
KEYWORD	TYPE_KEYWORD_NT	-	O	See Table 38

Table 13: BASIC_INSTRUMENT

The fields for a composite instrument, COMPOSITE_INSTRUMENT (Table 14) are identical to those for BASIC_INSTRUMENT; the difference between the basic and composite instruments lies in the ability to link basic and composite instruments to a given composite instrument via COMPOSITE_INSTRUMENT_DETAIL (Table 15). This table stores the list of sub-instruments (SUB_INSTRUMENT_ID) that compose a particular composite instrument (INSTRUMENT_ID), and requires that the relative position of the instrument be specified. As can be seen in Figure 14(a), TYPE_POSITION, the data type of LOCATION, provides the capability of specifying the Cartesian coordinates (and rotation about the three axes) of the sub instrument relative to an indicated location on the composite instrument. Alternatively, a basic description of the location can be communicated.

FIELD	TYPE	W	R	CONSTRAINTS
INSTRUMENT_ID	String	20	R	PRIMARY KEY
INSTRUMENT_NAME	String	20	R	
DESCRIPTION	String	50	R	
INSTRUMENT_TYPE	String	20	O	Foreign Key Table 9: BASIC_ INSTRUMENT_DEFINITION
MANUFACTURER_ID	String	-	O	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
SERIAL_NO	String	20	O	
MODEL_NO	String	20	O	
CHARACTERISTICS	TYPE_CHARACTERISTIC_NT	-	O	See Table 35
VIRTUAL_OBJECT	TYPE_VIRTUAL_OBJECT	-	O	See Table 32
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
KEYWORD	TYPE_KEYWORD_NT	-	O	See Table 38

Table 14: COMPOSITE_INSTRUMENT

FIELD	TYPE	W	R		CONSTRAINTS
INSTRUMENT_ID	String	20	R	PK	Foreign Key Table 14: COMPOSITE_ INSTRUMENT
SUB_INSTRUMENT_ID	String	20	R		Foreign Key Table 14: COMPOSITE_ INSTRUMENT OR Table 13: BASIC_INSTRUMENT
LOCATION	TYPE_POSITION	-	R		See Table 29

Table 15: COMPOSITE_INSTRUMENT_DETAIL

For each specific instrument, INSTRUMENT_CALIBRATION (Table 16) can store one or more calibration curves (and sets of calibration data).

Note that this information not is valid for all instances of a given type; for calibration of a class of instruments, see the discussion in Section 2.4, Types of Instruments.

INSTRUMENT_CALIBRATION has a primary key composed of the INSTRUMENT_ID and CALIBRATION_ID, which allows multiple calibration curves to be developed for each instrument. DATE stores the date of the calibration and OFFICER_ID contains the name of the person responsible for the calibration (typically the technician).

The equation that represents the calibration curve is provided in text form in EQUATION, with a description of this equation in EQUATION_DESCRIPTION (a more lengthy description is can be stored as one of the documents in the DOCUMENTATION nested table). The units before and after calibration (i.e., the “raw” and “engineering” units) are indicated in INPUT_UNITS and OUTPUT_UNITS, respectively. Finally, the raw units themselves can be stored in the RAW_DATA nested table, which stores the time (or other independent variable) in X_AXIS and the measurement as provided by the instrument (in INPUT_UNITS) in Y_AXIS.

FIELD	TYPE	W	R		CONSTRAINTS
INSTRUMENT_ID	String	20	R	PK	Foreign Key Table 13: BASIC_INSTRUMENT
CALIBRATION_ID	String	20	R		
DATE	Date		R		
OFFICER_ID	String	20	R		Foreign Key Table 2: PERSONNEL
EQUATION	String	30	R		
EQUATION_DESCRIPTION	String	50	R		
INPUT_UNITS	String	20	R		
OUTPUT_UNITS	String	20	R		
RAW_DATA	TYPE_READING_NT	-	O		See Table 42
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O		See Table 36

Table 16: INSTRUMENT_CALIBRATION

2.6 Instrument Data

2.6.1 Logical view

Data is generated for a particular, basic instrument during a specific fire test in a discrete location. Some instruments, such as hand-held meters or cameras, may have multiple locations

for a given experiment. Figure 15 provides the logical view of the tables required to reflect these changes; Figure 16 shows the associated data types.

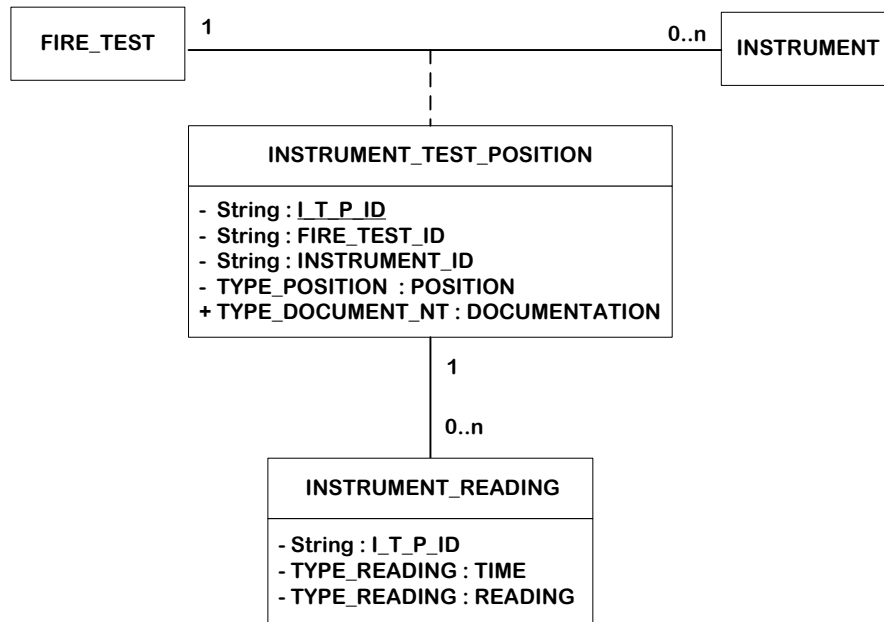


Figure 15: Logical View of INSTRUMENT_TEST_POSITION and INSTRUMENT_READING

(a)

TYPE_READING - TYPE_VALUE : VALUE - String : UNIT_ID + TYPE_ERROR : ERROR	TYPE_ERROR - TYPE_VALUE : POS_ERROR_VALUE - String : POS_ERROR_UNIT - TYPE_VALUE : NEG_ERROR_VALUE - String : NEG_ERROR_UNIT
TYPE_POSITION - String : DESCRIPTION + String : REFERENCE + TYPE_READING : X_POSITION + TYPE_READING : Y_POSITION + TYPE_READING : Z_POSITION + TYPE_READING : X_ROTATION + TYPE_READING : Y_ROTATION + TYPE_READING : Z_ROTATION	TYPE_VALUE - String : VALUE - String : DATATYPE

(b)

TYPE_DOCUMENTATION_NT
- String : DOCUMENT_ID + String : PAGE_RANGE

Figure 16: a) Data Types for INSTRUMENT_TEST_POSITION and INSTRUMENT_READING b) Nested Tables

2.6.2 Physical view

The primary key for INSTRUMENT_TEST_POSITION (Table 17), I_T_P_ID, is a system-generated value. FIRE_TEST_ID and INSTRUMENT_ID, respectively, provide the associated fire test and instrument identifiers.

Note that the latter can only be either basic instrument.

POSITION stores the particular location of the instrument during data collection, providing either Cartesian coordinates (with associated rotation) to a specified location in the test facility or a textual description, or both. Any appropriate notes or records, including images of the instrument in the given location (a generic image can be associated with the instrument in the BASIC_INSTRUMENT table, as described above), can be kept in the DOCUMENTATION nested table.

FIELD	TYPE	W	R	CONSTRAINTS
I_T_P_ID	String	20	R	PRIMARY KEY
FIRE_TEST_ID	String	20	R	Foreign Key Table 3: FIRE_TEST
INSTRUMENT_ID	String	20	R	Foreign Key Table 13: BASIC_INSTRUMENT
POSITION	TYPE_POSITION	-	R	See Table 29
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36

Table 17: INSTRUMENT_TEST_POSITION

Basic instruments provide single data streams during a fire test or experiment. INSTRUMENT_READING (Table 18) is a repository for such data from a basic instrument at a particular position in a fire test (I_T_P_ID). TIME and READING, which are TYPE_READING, store the actual data; if desired, error bars can also be associated.

FIELD	TYPE	W	R	CONSTRAINTS
I_T_P_ID	String	20	R	Foreign Key Table 17: INSTRUMENT_TEST_POSITION
TIME	TYPE_READING	-	R	See Table 30
READING	TYPE_READING	-	R	See Table 30

Table 18: INSTRUMENT_READING

2.7 Test Methods and Conditions

Test methods, in EDaFS, are the specifications under which experiments are conducted. These document the necessary equipment, associated standards, specimens, and conditions for the tests. The conditions, both intended (method) and actual (test), record the times and values of changes to the state of the experiment.

2.7.1 Logical View

The logical view for the test methods and conditions are shown in Figure 17 (with associated data types and nested tables defined in Figure 18). Each test method can be associated with any number of fire tests and can have any number of related conditions, which are prerequisite values for equipment (e.g., desired mass flow rates of propane). Each fire test can have any number of test conditions, which are the actual values in a particular experiment. There is a subtle difference between conditions and instrument data, in that conditions result from intervention in an experiment (turning of a valve), while instrument data provides the measurement of the results of these changes (measurement of the new flow rate).

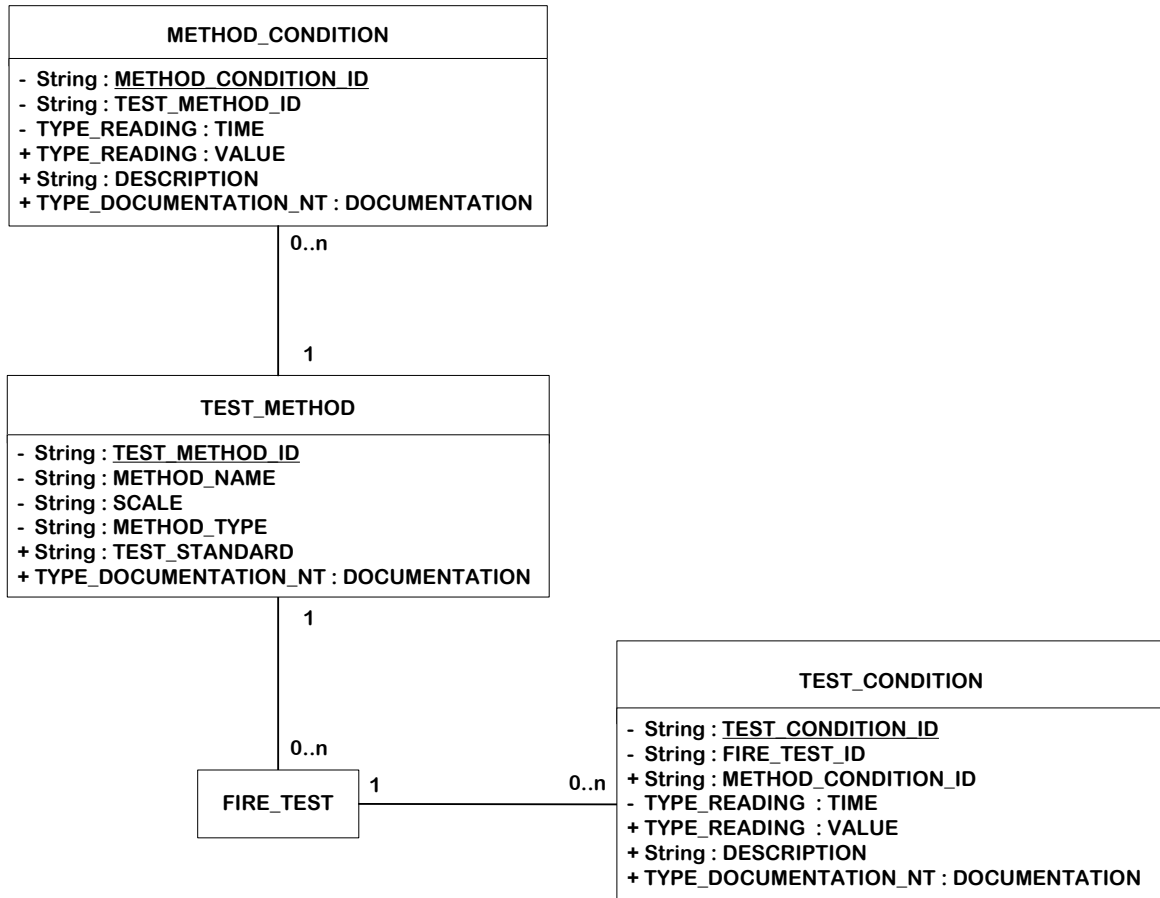
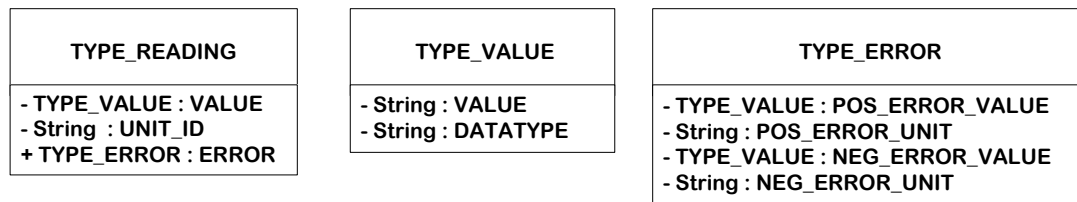


Figure 17: Logical View of TEST_METHOD, METHOD_CONDITION, and TEST_CONDITION

(a)



(b)

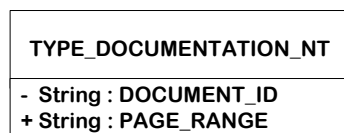


Figure 18: (a) Data Types for TEST_METHOD, METHOD_CONDITION, and TEST_CONDITION
(b) EDaFS Nested Tables

2.7.2 Physical View

EDaFS can link an experiment to a predefined test strategy, which is stored in TEST_METHOD (Table 19). Beyond the now-familiar, system-generated identifier

(TEST_METHOD_ID) and user-defined name for the method (METHOD_NAME), this table also provides a means to indicate the size of the experiment (SCALE), whether bench, intermediate, or real, and to denote the reliability of the test results (TEST_METHOD_CATEGORY). TEST_STANDARD can store the name of an associated test standard, while the DOCUMENTATION nested table holds the documents that comprise the method.

FIELD	TYPE	W	R	CONSTRAINTS
TEST_METHOD_ID	String	20	R	PRIMARY KEY
METHOD_NAME	String	20	R	
SCALE	String	30	R	<u>CHOICE:</u> 1. Bench Scale 2. Intermediate Scale 3. Real Scale
TEST_METHOD_CATEGORY	String	20	R	<u>CHOICE:</u> 1. Ad Hoc 2. Standard
TEST_STANDARD	String	40	O	
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36

Table 19: TEST_METHOD

Each test method can have multiple initial conditions and other values that may help define the test procedure. These conditions are stored in METHOD_CONDITION (Table 20). In addition to the system-generated METHOD_CONDITION_ID and a link to the appropriate test method (via TEST_METHOD_ID), the other required fields are the TIME and VALUE, at that time, of the condition characterized in CONDITION. For example, the mass flow rate for a particular test method is to be 10 g/s at $t = 0$ (start of experiment), 15 g/s at $t = 100$ s and 20 g/s at $t = 200$ s. The reason for the changes can be provided in the DESCRIPTION field, if desired, while any notes or other documentation can be stored in the DOCUMENTATION nested table.

FIELD	TYPE	W	R	CONSTRAINTS
METHOD_CONDITION_ID	String	20	R	PRIMARY KEY
TEST_METHOD_ID	String	20	R	Foreign Key Table 20: METHOD_CONDITION
CONDITION	String	40	R	
TIME	TYPE_READING	-	R	See Table 30
VALUE	TYPE_READING	-	R	See Table 30
DESCRIPTION	String	50	O	
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36

Table 20: METHOD_CONDITION

Test conditions, found in TEST_CONDITION (Table 21), are related, but may not be identical, to similar values stored in the method condition table. Again, test conditions record actions by the experimentalist, while instruments record the results of those actions. The fields in the table mirror those for METHOD_CONDITION, described above, except that the referenced table is that of the fire test (via FIRE_TEST_ID), and there is an additional (optional) link to the METHOD_CONDITION table, so that users can evaluate the similarity between the test conditions and the expected values from the method.

TEST_CONDITION does not store events, such as the time at which the first sprinkler opens; that information is stored in the EVENTS nested table of FIRE_TEST (Table 3).

FIELD	TYPE	W	R	CONSTRAINTS
TEST_CONDITION_ID	String	20	R	PRIMARY KEY
FIRE_TEST_ID	String	20	R	Foreign Key Table 3: FIRE_TEST
METHOD_CONDITION_ID	String	20	O	Foreign Key Table 20: METHOD_CONDITION
CONDITION	String	40	R	
TIME	TYPE_READING	-	R	See Table 30
VALUE	TYPE_READING	-	O	See Table 30
DESCRIPTION	String	50	O	
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36

Table 21: TEST_CONDITION

2.8 Test Arena

The test arena defines the physical location in which the fire test was conducted. No more than one arena can be associated with a particular fire test, although some large-scale tests, such as those involving ISO rooms, might define one or more rooms. In some cases, as for tests involving the cone calorimeter, there may be no test arena.

2.8.1 Logical View

Figure 19 provides the logical view for the test arena and its rooms, while Figure 20 details the necessary data types and nested tables.

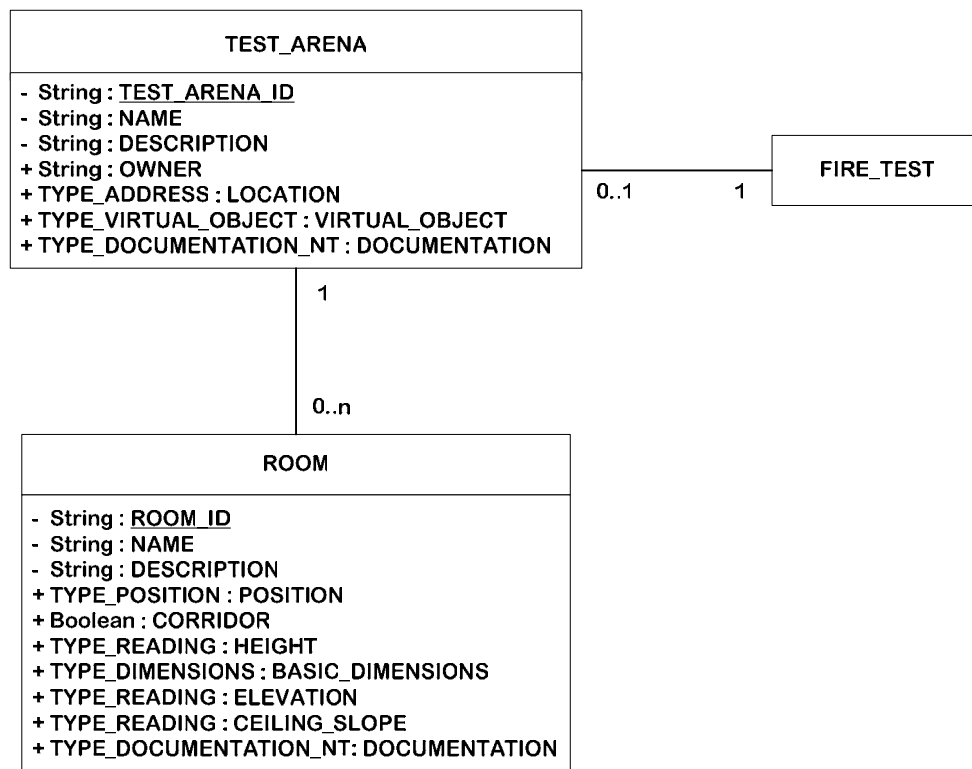


Figure 19: Logical View of TEST_ARENA

(a)

TYPE_READING - TYPE_VALUE : VALUE - String : UNIT_ID + TYPE_ERROR : ERROR	TYPE_VALUE - String : VALUE - String : DATATYPE	TYPE_ERROR - TYPE_VALUE : POS_ERROR_VALUE - String : POS_ERROR_UNIT - TYPE_VALUE : NEG_ERROR_VALUE - String : NEG_ERROR_UNIT
TYPE_ADDRESS - String : DESCRIPTION + String : ADDRESS1 + String : ADDRESS2 + String : CITY + String : REGION + String : COUNTRY + String : ZIPCODE	TYPE_VIRTUAL_OBJECT - String : NAME - String : DESCRIPTION - String : OBJECT_TYPE + String : VERSION - LOB : OBJECT + String : AUTHOR + TYPE_CONTACT_INFO : AUTHOR_CONTACT_INFO	
TYPE_POSITION - String : DESCRIPTION + String : REFERENCE + TYPE_READING : X_POSITION + TYPE_READING : Y_POSITION + TYPE_READING : Z_POSITION + TYPE_READING : X_ROTATION + TYPE_READING : Y_ROTATION + TYPE_READING : Z_ROTATION	TYPE_DIMENSIONS - TYPE_READING : X_AXIS - TYPE_READING : Y_AXIS + TYPE_READING : Z_AXIS	

(b)

TYPE_DOCUMENTATION_NT
- String : DOCUMENT_ID + String : PAGE_RANGE

Figure 20: a) Data types for TEST_ARENA b) Nested Tables

2.8.2 Physical View

Information about a test arena is stored in TEST_ARENA (Table 22). The now-familiar system-generated primary key, name, and description fields are the only required attributes for this table. In addition, information on the owner (either person or organization) and location of the arena is found in this table, as is a DOCUMENTATION nested table, which can hold images, schematics, and other such content, and a VIRTUAL_OBJECT field, which is used to contain three-dimensional, interactive software renderings of the facility.

FIELD	TYPE	W	R	CONSTRAINTS
TEST_ARENA_ID	String	20	R	PRIMARY KEY
NAME	String	40	R	
DESCRIPTION	String	50	R	
OWNER	String	20	O	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
LOCATION	String	50	O	

FIELD	TYPE	W	R	CONSTRAINTS
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
VIRTUAL_OBJECT	TYPE_VIRTUAL_OBJECT	-	O	See Table 32

Table 22: TEST_ARENA

ROOM (Table 23) contains data and descriptions for individual rooms, if any, of a test arena. POSITION specifies Cartesian coordinates and rotation for the placement of the room, relative to a location specified in one of POSITION's fields. The experimentalist can indicate whether the room is a corridor, which may be of interest to other users searching for comparable arenas. The room height (HEIGHT) and elevation (ELEVATION) can be recorded, as can the slope of the ceiling, if any. Additional information, such as the direction of the slope, can be entered in the DOCUMENTATION nested table. BASIC_DIMENSIONS stores rectangular dimensions for the room.

FIELD	TYPE	W	R	CONSTRAINTS
ROOM_ID	String	20	R	PRIMARY KEY
NAME	String	20	R	
DESCRIPTION	String	50	R	
POSITION	TYPE_POSITION	-	O	See Table 29
CORRIDOR	Boolean	-	O	
HEIGHT	TYPE_READING	-	O	See Table 30
ELEVATION	TYPE_READING	-	O	
CEILING_SLOPE	TYPE_READING	-	O	
DOCUMENTATION	TYPE_DOCUMENTATION_NT	-	O	See Table 36
BASIC_DIMENSIONS	TYPE_DIMENSIONS	-	O	See Table 27

Table 23: ROOM

2.9 Document Storage

For EDaFS, documents include all manner of content, from reports, articles, and notes to digital photographs and video clips. Information about and either digital files or links to copies of such content is stored in DOCUMENT (Table 24). The required fields enable EDaFS to share the documentation as individual elements to other digital libraries.

DOCUMENT_ID is a system-generated primary key. The TITLE and DESCRIPTION fields provide a means to store the document title and a brief description of the content. Any number of authors and editors can be included in their respective nested tables. The VOLUME and NUMBER fields are designed for bibliographies of journal articles, while the VERSION field can be used to store the edition (for books and reports) or the version number (for software and related materials). PAGES and LENGTH are similar content; the former is for page ranges in a publication, while the latter is for the total number of pages in a report or other document. PUBLICATION_LOCATION and PUBLICATION_YEAR should be self-explanatory, while PUBLISHER_ID references the publisher's entry in the PERSONNEL or ORGANIZATION table. LANGUAGE indicates the language of the document, using the ISO 639, 2-letter language codes. Any additional information can be entered in MISC_INFORMATION.

The DISCOVERABLE field indicates whether or not the document should be made available independent of the fire test. Final reports, video clips, images, and similar documents should be discoverable, but notes or content without context may not be desirable.

Note that this flag only affects discovery between EDaFS and other digital libraries; EDaFS users will be able to find documents that are not marked as discoverable.

The LEGIBILITY field is a subjective determination of the comprehensibility of a document, on a scale from 1 (very poor) to 5 (excellent).

FILE stores the digital file. The Oracle-based ORDDoc data type is discussed in detail in Section 4.3, ORDDoc Data Type; basically, this format provides specialized access to information about the object, such as the size and type. In some cases, copyright issues may prevent the inclusion of a document in EDaFS itself. In those cases, WEB_LINK can be used to cross-link between EDaFS and an online document. For either scenario, DOCUMENT_TYPE helps to classify the document, based on a list of different document categories. Finally, KEYWORDS is a nested table to help index the document.

FIELD	TYPE	W	R	CONSTRAINTS
DOCUMENT_ID	String	20	R	PRIMARY KEY
TITLE	String	50	R	
DESCRIPTION	String	50	R	
AUTHORS	TYPE_AUTHOR_NT	-	R	See Table 33
EDITORS	TYPE_AUTHOR_NT	-	O	
VOLUME	String	20	O	
NUMBER	String	20	O	
VERSION	String	20	O	
PAGES	String	20	O	
LENGTH	String	20	O	
PUBLICATION_LOCATION	TYPE_ADDRESS	-	O	See Table 25
PUBLICATION_YEAR	Integer	4	O	
PUBLISHER_ID	String	20	O	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
LANGUAGE	String	2	R	
MISC_INFORMATION	String	40	O	
DISCOVERABLE	Boolean	-	R	
LEGIBILITY	Integer	1	O	CHOICE 1. Very Poor 2. Poor 3. Fair 4. Good 5. Excellent
FILE	ORDDoc	-	O	See Section 4.3
WEB_LINK	String	75	O	

FIELD	TYPE	W	R	CONSTRAINTS
DOCUMENT_TYPE	String	35	R	<u>CHOICE:</u> 1) Still Image 2) Video Clip 3) Other 4) Text or Document a) Refereed Journal Article b) Non-refereed Article c) Conference Paper d) External Report e) Internal Report f) Presentation g) Notes h) Book i) Thesis/Dissertation j) Proposal k) Patent l) Government Publication m) Computer Program n) Software File o) Internet Document p) Online Periodical
KEYWORDS	TYPE_KEYWORDS_NT	-	R	See Table 38

Table 24: DOCUMENT

3 MINIMUM REQUIREMENTS

The previous section has detailed all of the possible information that can be stored in the EDaFS structure. In most cases, however, a subset of this total is available. This section specifies the minimum amount of data that is acceptable for inclusion of a fire test in EDaFS. Most records will be more complete. The logical view of these minimum requirements is depicted in Figure 21, with the associated data types and nested tables in Figure 22.

Note that all of the attributes of the data types are provided, whether or not they are required.

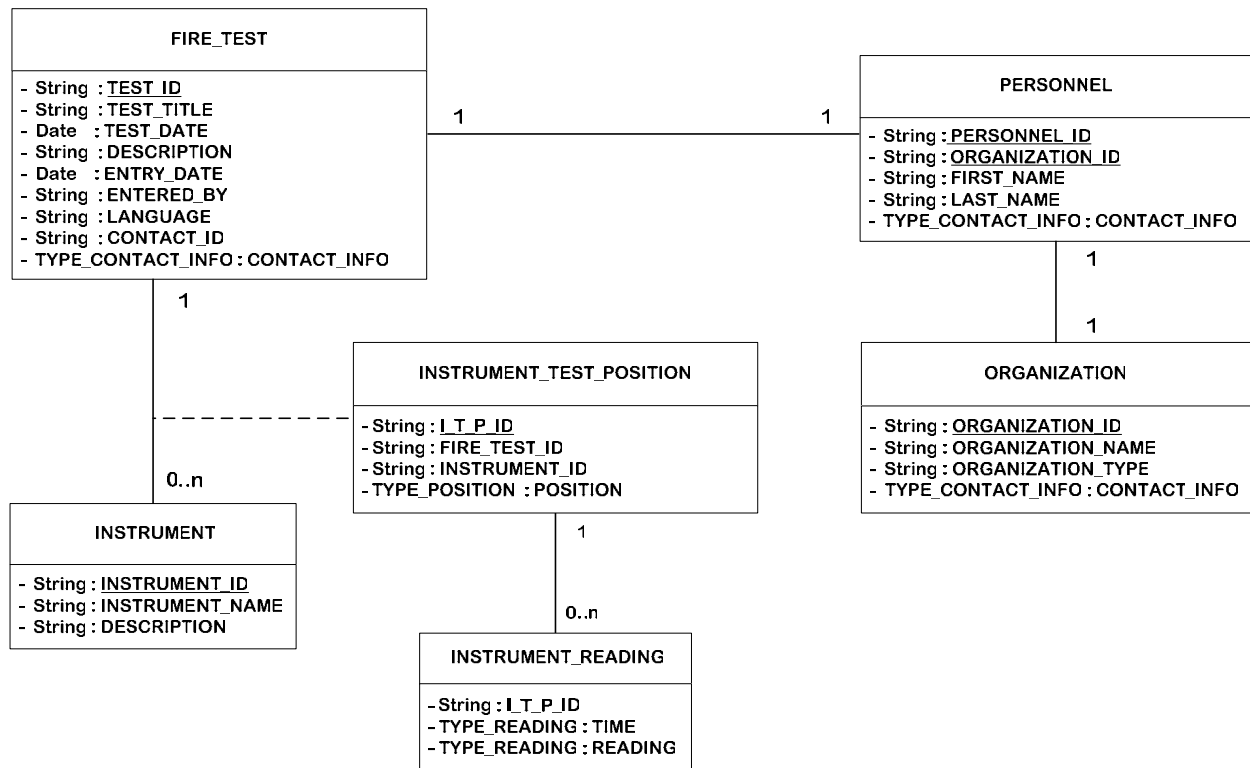


Figure 21: Minimum Requirements for EDaFS (Logical View)

(a)

<div>TYPE_CONTACT_INFO</div> <div>+ String : EMAIL + TYPE_ADDRESS : ADDRESS + TYPE_PHONE_NT : PHONE_NUMBERS + String : WEBSITE</div>	<div>TYPE_ADDRESS</div> <div>- String : DESCRIPTION + String : ADDRESS1 + String : ADDRESS2 + String : CITY + String : REGION + String : COUNTRY + String : ZIPCODE</div>	<div>TYPE_PHONE</div> <div>- Integer : COUNTRY_CODE - Integer : STATE_CODE - Integer : PHONE_NUMBER + Integer : EXTENSION</div>
<div>TYPE_READING</div> <div>- TYPE_VALUE : VALUE - String : UNIT_ID + TYPE_ERROR : ERROR</div>	<div>TYPE_VALUE</div> <div>- String : VALUE - String : DATATYPE</div>	<div>TYPE_POSITION</div> <div>- String : DESCRIPTION + String : REFERENCE + TYPE_READING : X_POSITION + TYPE_READING : Y_POSITION + TYPE_READING : Z_POSITION + TYPE_READING : X_ROTATION + TYPE_READING : Y_ROTATION + TYPE_READING : Z_ROTATION</div>
<div>TYPE_ERROR</div> <div>- TYPE_VALUE : POS_ERROR_VALUE - String : POS_ERROR_UNIT - TYPE_VALUE : NEG_ERROR_VALUE - String : NEG_ERROR_UNIT</div>		

(b)

TYPE_PHONE_NT
- String : DESCRIPTION - Integer : COUNTRY_CODE - Integer : STATE_CODE - Integer : PHONE_NUMBER + Integer : EXTENSION

Figure 22: a) Data Types for Minimum Requirements for EDaFS b) Nested Tables

4 SPECIALIZED EDaFS FORMATS

This data structure has been created for ORACLE 10g; nested tables and user-defined object types may not be available in other database programs, such as Microsoft Access. To reproduce this framework without Oracle, replace the user-defined data types – those that begin with “TYPE_” or “ORD” – with a foreign key to separate, indexed tables, one for each data type. For the nested tables, create a one-to-many relationship from the primary table to a new, non-nested table with a system-generated primary key.

4.1 EDaFS Data Types

Certain formats or field combinations are repeated in several of the tables described above. In many cases, users will not likely search these fields across multiple tables. As a result, it is preferable to utilize user-defined data types and nested tables to store the information. Data types are a standard format of data records. The basic data types supported by relational database systems are strings (text), characters, integers and other number formats; Boolean (TRUE/FALSE or YES/NO) values; and large objects, such as files. This section details the data types that have been created specifically for EDaFS.

TYPE_ADDRESS (Table 25) is fairly straightforward, and provides a means to store information about addresses for people and organizations involved in fire tests. The only required field is DESCRIPTION.

FIELD	TYPE	W	R	CONSTRAINTS
DESCRIPTION	String	50	R	
ADDRESS1	String	20	O	
ADDRESS2	String	20	O	
CITY	String	20	O	
REGION	String	20	O	
COUNTRY	String	20	O	
ZIPCODE	String	10	O	

Table 25: TYPE_ADDRESS

TYPE_CONTACT_INFO (Table 26) stores contact information: e-mail addresses (EMAIL), physical addresses (ADDRESS), any number of phone numbers (PHONE_NUMBERS) and a Uniform Resource Locator (URL) to an associated web site.

FIELD	TYPE	W	R	CONSTRAINTS
EMAIL	String	80	O	
ADDRESS	TYPE_ADDRESS	-	O	See Table 25
PHONE_NUMBERS	TYPE_PHONE_NT	-	O	See Table 40
WEBSITE	String	80	O	

Table 26: TYPE_CONTACT_INFO

TYPE_DIMENSIONS (Table 27) is intended for room size measurements and basic dimensions of products. The experimentalist can specify the values, units, and errors (if any), as desired for the three Cartesian coordinates (one of the axes is optional).

FIELD	TYPE	W	R	CONSTRAINTS
X_AXIS	TYPE_READING	-	R	See Table 30
Y_AXIS	TYPE_READING	-	R	
Z_AXIS	TYPE_READING	-	O	

Table 27: TYPE_DIMENSIONS

TYPE_ERROR (Table 28) allows the experimentalist to indicate the measured (or calculated) positive and negative error, with any desired units (including percentages).

FIELD	TYPE	W	R	CONSTRAINTS
POS_ERROR_VALUE	TYPE_VALUE	-	R	See Table 31
POS_ERROR_UNIT	String	20	R	
NEG_ERROR_VALUE	TYPE_VALUE	-	R	See Table 31
NEG_ERROR_UNIT	String	20	R	

Table 28: TYPE_ERROR

TYPE_POSITION (Table 29) stores the location of an instrument, product, or room in Cartesian coordinates. A discussion of the location, kept in DESCRIPTION, is the only required field. The reference point for the measurements is found in REFERENCE, which should also indicate the direction of the x-axis. The units for the three directional and three rotational fields are user-defined and can include error measurements, if desired.

FIELD	TYPE	W	R	CONSTRAINTS
DESCRIPTION	String	50	R	See Table 30
REFERENCE	String	50	O	
X_POSITION	TYPE_READING	-	O	
Y_POSITION	TYPE_READING	-	O	
Z_POSITION	TYPE_READING	-	O	
X_ROTATION	TYPE_READING	-	O	
Y_ROTATION	TYPE_READING	-	O	
Z_ROTATION	TYPE_READING	-	O	

Table 29: TYPE_POSITION

TYPE_READING (Table 30) links together a measurement VALUE, appropriate units (UNIT_ID), and error bound measurements (ERROR), if desired.

FIELD	TYPE	W	R	CONSTRAINTS
VALUE	TYPE_VALUE	-	R	See Table 31
UNIT_ID	String	20	R	
ERROR	TYPE_ERROR	-	O	See Table 28

Table 30: TYPE_READING

TYPE_VALUE (Table 31) enables EDaFS to keep multiple data types in a single database column. VALUE stores the actual quantity, while DATATYPE indicates the specific data type represented by the value.

Note that, for Large Objects (LOBs), VALUE stores a pointer (DOCUMENT_ID) to file and other information.

FIELD	TYPE	W	R	CONSTRAINTS
VALUE	String	20	R	Foreign Key * Table 24: DOCUMENT
DATATYPE	String	20	R	<u>CHOICE:</u> 1. Integer 2. Float 3. String 4. LOB

* Only for LOB

Table 31: TYPE_VALUE

TYPE_VIRTUAL_OBJECT (Table 32) stores information about three-dimensional, software representations of test facilities, instruments, and products. The NAME must be unique, and DESCRIPTION can be used to provide more information about the object. OBJECT_TYPE indicates the particular data format for the file, while VERSION is used to indicate the version of the associated software program necessary to view the file (not the object itself). OBJECT allows the file to be stored within the database itself, as an LOB. The AUTHOR and AUTHOR_CONTACT_INFO fields refer to the person who created the file.

FIELD	TYPE	W	R	CONSTRAINTS
NAME	String	30	R	UNIQUE KEY
DESCRIPTION	String	50	R	<u>CHOICE</u> 1. VRML 2. JAVA3D 3. X3D 4. Flash 5. Other
OBJECT_TYPE	String	10	R	

FIELD	TYPE	W	R	CONSTRAINTS
VERSION	String	10	O	
OBJECT	LOB	-	R	
AUTHOR	String	20	O	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL
AUTHOR_CONTACT_INFO	TYPE_CONTACT_INFO	-	O	

Table 32: TYPE_VIRTUAL_OBJECT

4.2 Nested Tables

Nested tables, as described in Section 1.4, Nested Tables, are one-dimensional, unbounded collections of elements of a particular data type. This section details the nested tables that are used in the EDaFS structure.

TYPE_AUTHOR_NT (Table 33) is one of the simplest, and provides a means to organize all authors and editors – either individuals or organizations – who have contributed to a given document.

FIELD	TYPE	W	R	CONSTRAINTS
AUTHOR_ID	String	20	R	Foreign Key Table 1: ORGANIZATION OR Table 2: PERSONNEL

Table 33: TYPE_AUTHOR_NT

TYPE_CHARACTERISTIC_DEFN_NT (Table 35) specifies potential properties and the acceptable values for those properties. This table holds information about instrument classes, rather than specific instruments or products. For example, “Type” may be a PROPERTY for a calorimeter, with possible parameter values of “Foil,” “Wafer,” and “Mass.” (One of these choices would be selected for an instance of a calorimeter.)

FIELD	TYPE	W	R	CONSTRAINTS
PROPERTY	String	20	R	
DESCRIPTION	String	50	R	
DEFINED_PARAMETERS	TYPE_PARAMETERS_NT	-	O	See Table 39

Table 34: TYPE_CHARACTERISTIC_DEFN_NT

TYPE_CHARACTERISTIC_NT (Table 35) is the client to TYPE_CHARACTERISTIC_DEFN_NT, and refers to both instruments and products. Characteristics, such as material properties, can be specified in CHARACTERISTIC, and either a text or numeric value can be provided. The latter case allows for declaration of units.

FIELD	TYPE	W	R	CONSTRAINTS
CHARACTERISTIC	String	20	R	
TEXT_VALUE	String	20	O	
NUMERIC_VALUE	TYPE_READING	-	O	See Table 30

Table 35: TYPE_CHARACTERISTIC_NT

TYPE_DOCUMENTATION_NT (Table 36) stores a reference to a document and, if necessary, appropriate pages within that document. PAGE_RANGE may be advantageous, as an appropriate page or chapter of a final report can be referenced in one of the calibration tables.

The use of DOCUMENT_ID reduces the number of copies of a given document stored in the database structure, as may occur for a test series (with multiple test results discussed in a single report).

FIELD	TYPE	W	R	CONSTRAINTS
DOCUMENT_ID	String	20	R	Foreign Key Table 24: DOCUMENT
PAGE_RANGE	String	20	O	

Table 36: TYPE_DOCUMENTATION_NT

TYPE_EVENT_ID (Table 37) is intended to capture events that occur during fire tests. This information is not otherwise recorded in an easily indexed location. (The information would be found in documents.)

FIELD	TYPE	W	R	CONSTRAINTS
TIME	TYPE_READING		R	See Table 30
EVENT_TYPE	String	20	R	
DESCRIPTION	String	30	O	

Table 37: TYPE_EVENT_NT

TYPE_KEYWORD_NT (Table 38) provides a collection of keywords to enhance search capabilities. The keywords are limited to the FIREDOC Vocabulary List, available from the National Institute of Standards and Technology, Building and Fire Research Laboratory.

FIELD	TYPE	W	R	CONSTRAINTS
KEYWORD	String	30	R	

Table 38: TYPE_KEYWORD_NT

TYPE_PARAMETERS_NT (Table 39) is used in conjunction with TYPE_CHARACTERISTIC_DEFN_NT (Table 35) to define acceptable values for instrument properties. The values can be either textual or numeric, but not both.

FIELD	TYPE	W	R	CONSTRAINTS
TEXT_PARAMETER	String	20	O	
NUMERIC_PARAMETER	TYPE_READING	-	O	See Table 30

Table 39: TYPE_PARAMETERS_NT

TYPE_PHONE_NT (Table 40) enables storage of multiple telephone, fax, and cell phone numbers for a given contact. The DESCRIPTION field records the kind and location of the number (e.g., "Work Cell").

FIELD	TYPE	W	R	CONSTRAINTS
DESCRIPTION	String	30	R	
COUNTRY_CODE	Integer	3	R	
STATE_CODE	Integer	3	R	
PHONE_NUMBER	Integer	10	R	
EXTENSION	String	4	O	

Table 40: TYPE_PHONE_NT

TYPE_SUB_PRODUCT_NT (Table 41) serves as a means of providing additional information about components of a product. Subjective information on the stratum of a particular element can be stored in LAYER, while LOCATION provides a more quantitative

relative position. Sub products are products in their own right and can be described with all of the fields in PRODUCT (Table 7).

FIELD	TYPE	W	R	CONSTRAINTS
SUB_PRODUCT_ID	String	30	R	Foreign Key Table 7: PRODUCT
LAYER	String	30	O	
LOCATION	TYPE_POSITION	-	O	See Table 29

Table 41: TYPE_SUB_PRODUCT_NT

TYPE_READING_NT (Table 42) records calibration data for instruments; X_AXIS is the datum from the instrument, in raw units, and Y_AXIS is the corresponding converted value, in engineering units.

FIELD	TYPE	W	R	CONSTRAINTS
X_AXIS	TYPE_READING	-	R	See Table 30
Y_AXIS	TYPE_READING	-	R	

Table 42: TYPE_READING_NT

TYPE_TEST_COLLECTION_NT (Table 43) catalogs a collection of fire tests. A test collection can also include other collections.

FIELD	TYPE	W	R	CONSTRAINTS
TEST_COLLECTION_ID	String	20	R	Foreign Key Table 6: TEST_COLLECTION OR Table 3: FIRE_TEST

Table 43: TYPE_TEST_COLLECTION_NT

4.3 ORDDoc Data Type

The EDaFS data structure is based on Oracle 10g, which has data types that have been specifically designed for multimedia files. ORDDoc can store different multimedia files, such as audio, image, video, and text files and can automatically retrieve information about the files, such as the file format and length. More information can be found in the *interMedia* documents on the Oracle web site (www.oracle.com).

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Appendix B: Experiment Database for Fire Science User's Guide for the Web Interface

John P. Woycheese, Venkatesh Raghavan, and Felix Geller
Worcester Polytechnic Institute

Introduction

This document provides instructions for the use of the Web interface to the Experiment Database for Fire Science, or EDaFS, currently at Version 0.9. EDaFS provides a structure for storing test data, documentation, photographs, video clips, and other related materials for experiments conducted by the fire science community. The Web interface to EDaFS enables users to search the database, select experiments of interest, and graph and download the data from related instruments.

The following sections will address the different means by which users can search for fire tests and personnel of interest, after which the specifics of the Graphical User Interface will be described in detail.

Searching for Experiments

The Web interface offers multiple search conditions by which a user can find a specific fire test or a series of experiments. Figure 1 shows the search page, with the three main sections marked by rectangles: Search Conditions, Search Results, and Navigation Panel. Users can modify the Search Conditions Panel to set conditions for data inquiries, the results of which are provided in the Search Results Panel. The Navigation Panel allows the user to change from the search page for fire tests to that for a person involved in an experiment. The page is separated into two frames, which enables the user to adjust the relative sizes of the different sections.

Search Conditions

The current implementation allows users to search for experiments in the EDaFS Collections by Fire Test, Instrument, Organization, or Person. Later versions will expand the selection to include Facility, Product, and Method searches. Each category will be addressed separately, below; in each case, the first column is specific to the topic and the remaining three specify dates

or date ranges (see Figure 2, below). The fields in each column can be reset by clicking the appropriate "Clear" button in the upper right part of the column. Clicking the "Clear All" button (at the lower left) will empty all fields and reset the form. Note that search conditions are case-sensitive.

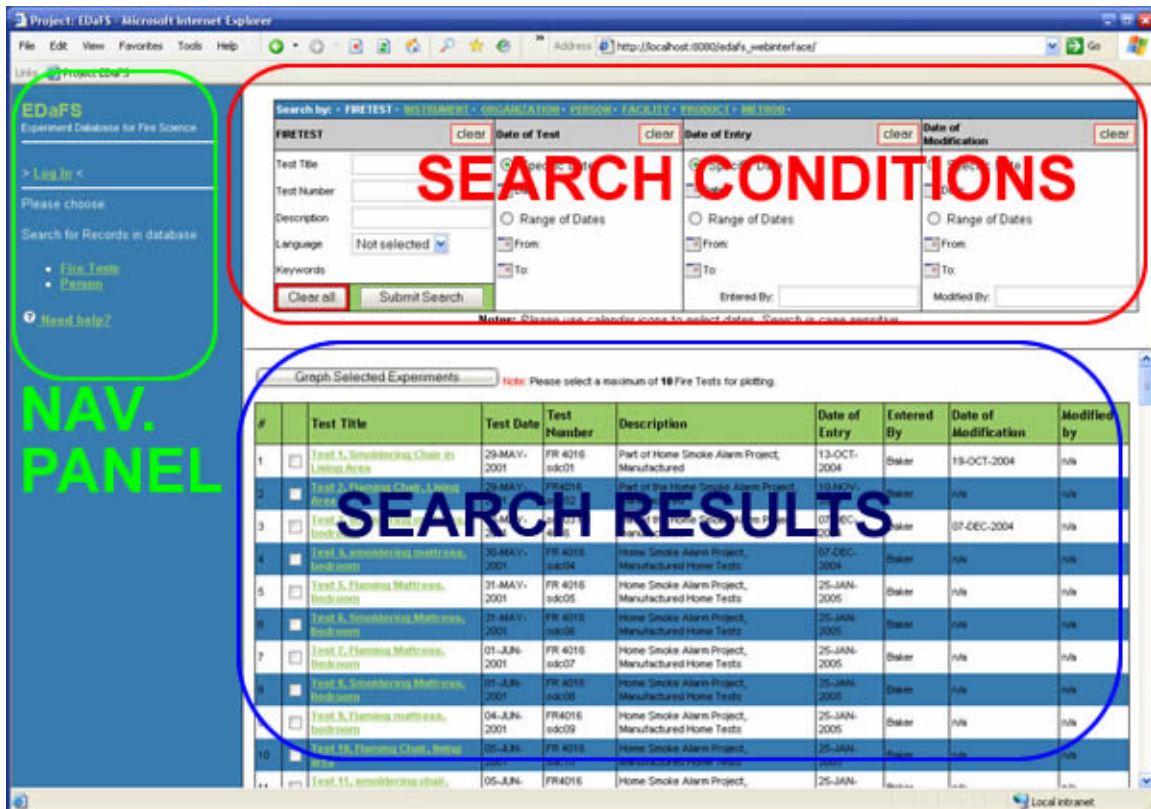


Figure 1: An image of the EDaFS search page. The Navigation Panel enables users to search for specific fire tests or personnel associated with the tests. Users can modify the Search Conditions Panel to set conditions for data inquiries, the results of which are provided in the Search Results Panel.

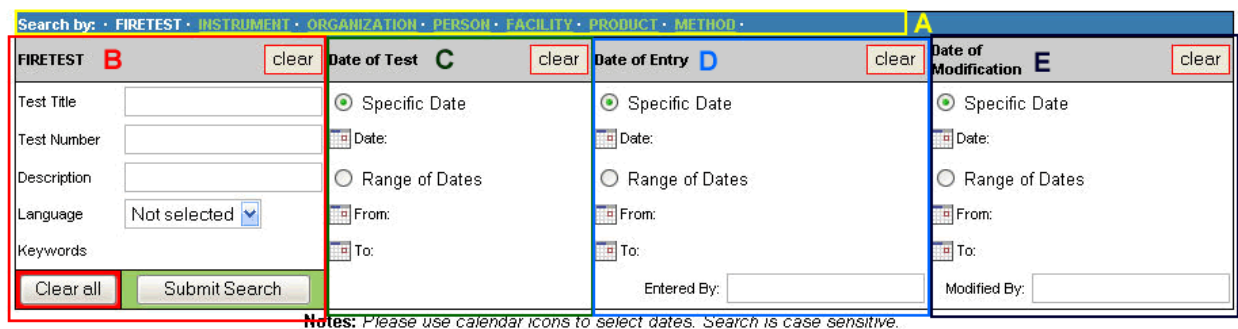


Figure 2: An image of a generic search category, indicating the different sections. The topmost area (A) provides a navigation panel for the various search conditions, which enables the user to select the category by to search for one or more fire tests. The leftmost column (B) is category-specific; in this case, for searches by fire test information. The remaining areas (C, D, and E) specify dates or ranges of dates for desired experiments by the execution date of the test, date of inclusion in the EDaFS database, and date of modification within the EDaFS database (if any), respectively.

Dates should be specified by clicking the calendar icon (📅) next to the appropriate field label to ensure that the correct format is used. Clicking on the icon will open a new window (see Figure 3), assuming the user does not have a “pop-up blocker” running, that simplifies date selection. The user selects the month from the drop-down menu on the upper left and navigates to the correct year by clicking the greater or smaller than signs next to the currently selected year. After clicking the date of choice, the window will close and the corresponding field will be populated with the selected date in the correct format.



Figure 3: Date selection pop-up tool. The drop-down box at the upper left enables the user to select a specific month, while the arrows to either side of the year (upper right) provide access to the year. Clicking on a hyperlinked number returns the selected date in the appropriate format.

Figure 4 shows the search page before any conditions have been set and Figure 5 provides an example of a search for a tests that were conducted during 2001 with results shown in the lower portion of the figure. These Search Results present tests in the database that match all of the Search Conditions. Each row contains a standard set of fields for each test: *Test Title*, *Test Date*, *Test Number*, *Description*, *Date of Entry*, *Entered By*, *Date of Modification*, and *Modified By*. (The latter two are null unless the information entered in EDaFS is modified after the initial data entry.) *Entered By* and *Modified By* display the name of the person who added the fire test to the EDaFS database or who changing information about the Fire Test, respectively. The other fields should be self explanatory. The user can open a new window that provides detailed information about a particular test by clicking on the specific, hyperlinked Test Title. The details (see Figure 6) include both metadata about the fire test and its parent collection(s) and links to files that are related to the test. The details page allows the user to browse through the results of the search via navigation buttons at the top of the window.

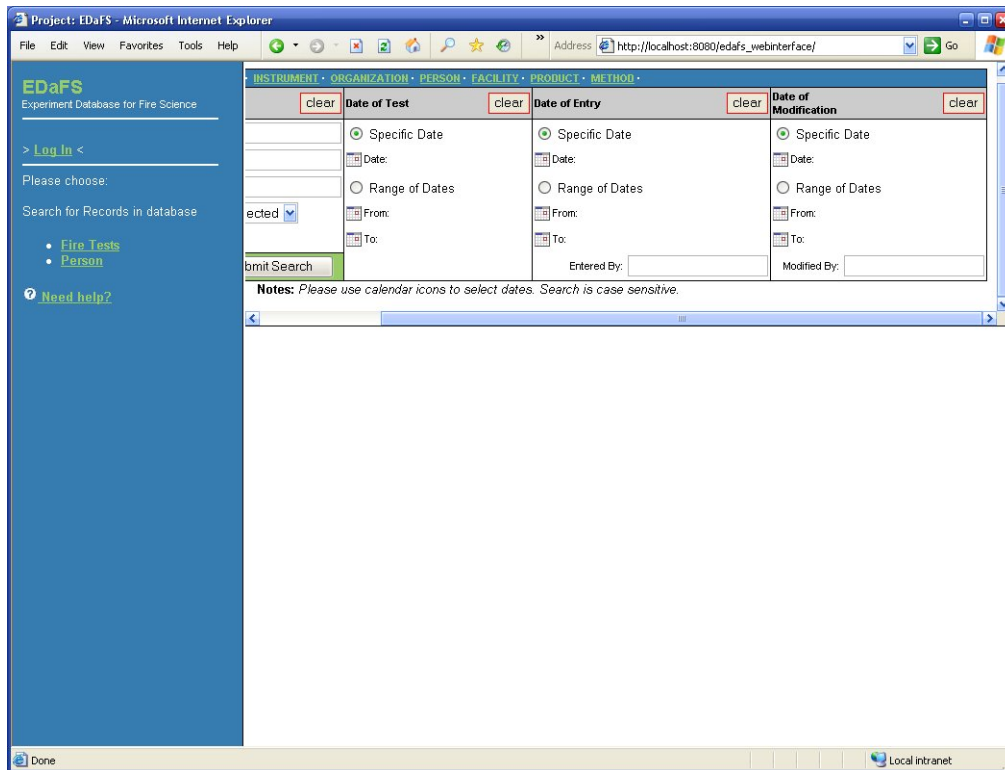


Figure 4: Blank search page, showing the blank fields and empty lower half in which results would be provided.

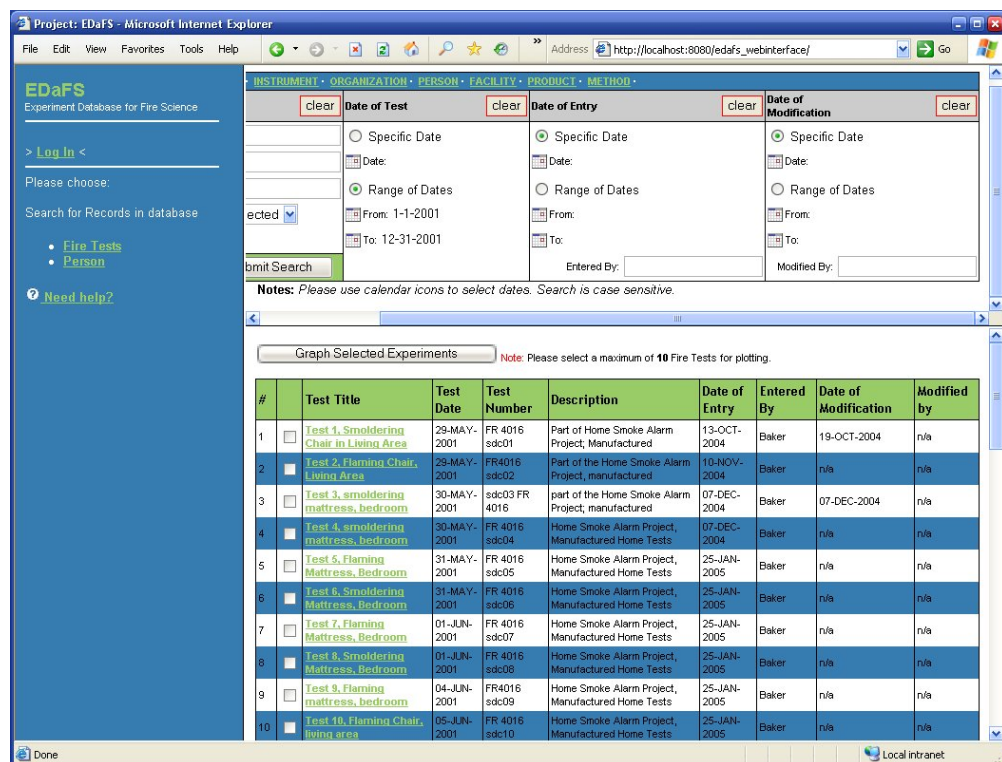


Figure 5: Search page with conditions set for experiment dates. The results, shown under the “Graph Selected Experiments” button, are for tests conducted during 2001.

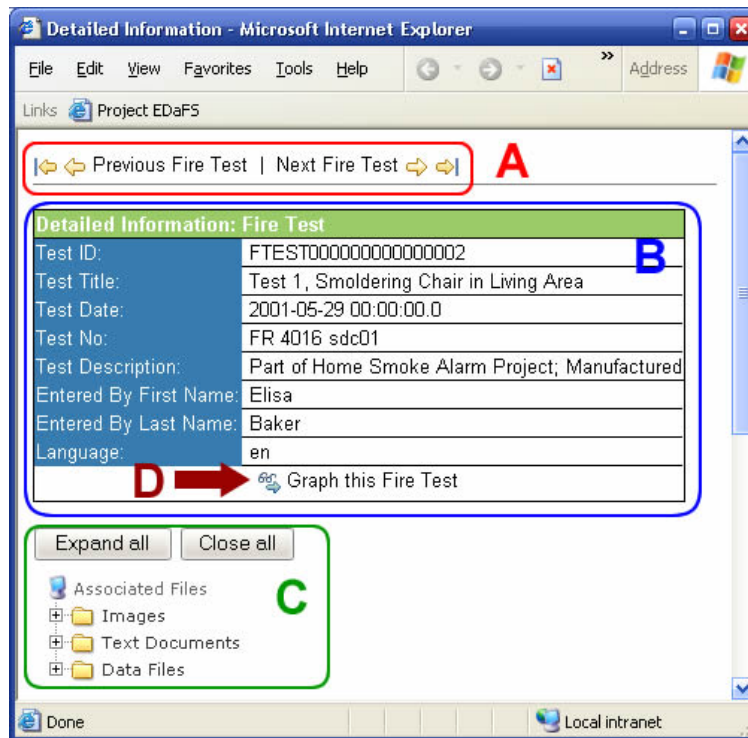



Figure 6: This is a detailed view of the metadata associated with a particular fire test. The navigation arrows at the top of the window allow the user to scroll through the current set of fire tests. The outermost arrows jump to the first (left) or last (right arrow) fire test respectively and the inner arrows move one test backward or forward. The table (B) shows more detailed information about the current test and the folder tree (C) lists all files that are associated with it. Clicking on the  icon or the “Graph this Fire Test” text will open a new window that includes a Java Applet to plot the currently selected fire test.

The checkboxes in the second column of Figure 5 can be used to select experiments having data to be plotted, up to a maximum of 10 fire tests. After choosing fire tests and clicking the “Graph Selected Experiments” button, a new window with a Graphical User Interface will open. An explanation of this window can be found in the “Graph Fire Tests” section. The fields available for the different search options (described in Part A of Figure 2), all of which return a collection of associated fire tests, are explored below.

Fire Test

Test Title	A user-defined title for each fire test
Test Number	An optional, organization-specified designation
Description	A brief report of the specific fire test
Language	A field that contains the 2-letter language codes from ISO 639, included to enables users to filter results based on the language of the information
Keywords	A collection of keywords derived from the FIREDOC vocabulary list

Instrument

There are usually multiple instruments for each fire test.

Instrument Name	A short label for the instrument
Description	A longer narrative about the specific instrument
Instrument Type	An (optional) class associated with the instrument (e.g., Type-K thermocouples)
Serial Number	An identification field that specifies a particular instrument; generally used for more complex equipment
Model Number	A secondary means of identification that classifies the instrument

Organization

Organization Name	The name of the organization related to the experiment.
Organization Type	The category of the organization related to the experiment.
Division	The division that is related to the experiment.

Person

First Name	The first name of a person associated with an experiment.
Last Name	The last name of a person associated with an experiment
Employee ID	An organization-specific identifier for someone associated with an experiment
Position	The position of the contact person within the organization for which he/she works
Email	The email address of someone of interest

Searching for a Person

The architecture for the Experiment Database for Fire Science includes a table about personnel, who can be associated with a fire test in several ways: as the data entry or modification person, as a contact for the test, or as a sponsor, official, or technician.

To find people (or more information about them), the user can use the second type of search page, which has several search conditions that can be specified (see Figure 7). The results can be ordered in ascending or descending or for each column by clicking on the respective "a" or "d" in the top row of a particular column.

By clicking the magnifying glass icon next to the "Organization" field, the user can open a new window (see Figure 8) that offers a listing of all entered organizations in alphabetical order. Selecting an organization in the new window will close the window and the Organization field of the search page will be populated.

Search for a Person

First Name:

Last Name:

Organization:

Division:

Position:

Search Results

First Name	Last Name	Email Information	Organization	Division
Elisa	Baker	elisab@wpi.edu	Worcester Polytechnic Institute	Center for Firesafety Studies
Venkatesh	Raghavan	venky@wpi.edu	Worcester Polytechnic Institute	Center for Firesafety Studies
Mihyun Esther	Kim	mhkim@wpi.edu	Worcester Polytechnic Institute	Center for Firesafety Studies
Jarrod	Alston	n/a	Worcester Polytechnic Institute	Center for Firesafety Studies
Felix	Geller	fgeller@wpi.edu	Worcester Polytechnic Institute	Center for Firesafety Studies
John	Woycheese	jpw@wpi.edu	Worcester Polytechnic Institute	Center for Firesafety Studies

Figure 7: The search page for people associated with fire tests in EDaFS

List of companies

First letter of organization's name: **W** A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Organization Name	Organization Type	Address	Webpage
NIST	Government Organization	Gaithersburg USA	http://www.bfrl.nist.gov
Worcester Polytechnic Institute	College & University	Worcester USA	www.wpi.edu/Academics/Depts/Fire/

Figure 8: A list of organizations that are either directly involved with experiments contained in EDaFS or that have personnel who are involved with the tests.

Graphing Fire Test Data

The Web Interface offers a convenient way to display information related to a fire test and to graph instrument data that is stored in the EDaFS. There are two ways to open the Graphical User Interface:

1. Select one or more fire tests by checking the boxes in their respective rows on the Fire Test Search Result page (see Figure 5 and Figure 9) and then click the "Graph Selected Experiments" button. This is the only way to select multiple fire tests.
2. Click the title of a fire test on the Fire Test Search Result page (see part C of Figure 9) and then click on the icon or "Graph this Fire Test" text of the new window (see part D of Figure 6).

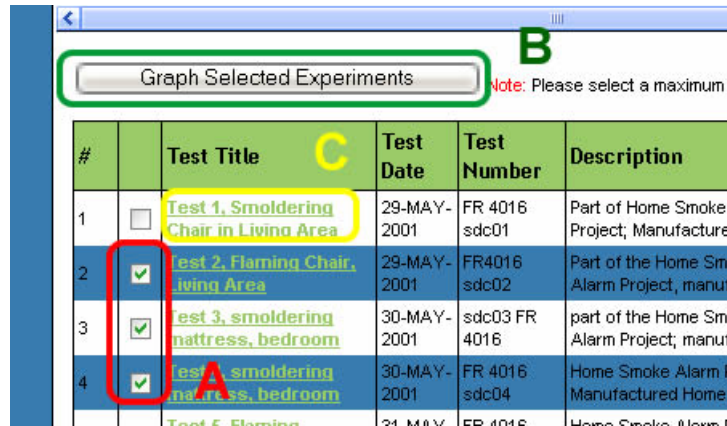


Figure 9: A visual demonstration that details how to select fire tests for visualization. Check the boxes (A) to select up to ten fire tests, then click the “Graph Selected Experiments” button (B) to open the Graphical User Interface and data visualization tool. Alternatively, users can click a fire test title to open a new window that provides more details about the test.

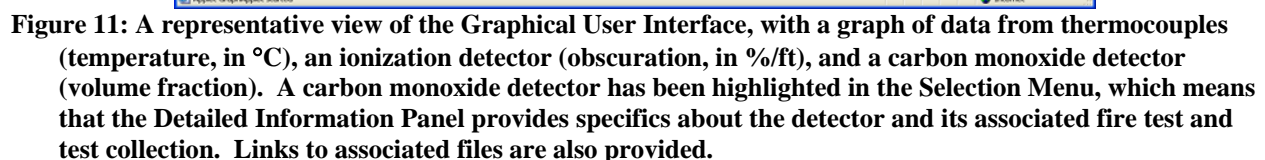
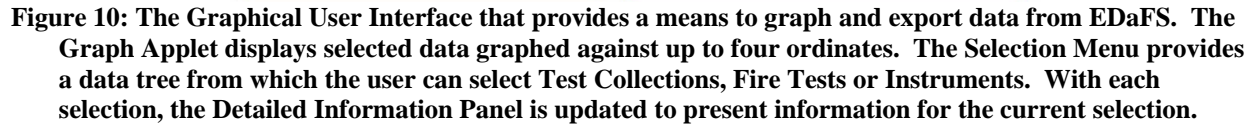
The Graphical User Interface Window

The Graphical User Interface (GUI) provides the means to interact with data and information stored in EDaFS about test collections, fire tests, and instruments and their respective data.

Figure 10 shows the different panels of the GUI: the Selection Menu, Detailed Information Panel, and Graph Applet. See Figure 11 for a representative view of the GUI in use.

Selection Menu

The Selection Menu offers a means to choose a Test Collection, Fire Test, or Instrument, which will cause the Detailed Information Panel to provide descriptive data about the selection; in addition, if an Instrument is selected, instrument data will populate the Graph Applet. Selecting an instrument twice will remove the plot from the Graph Applet. The “Expand All” button causes all branches of the Test Collection tree to be made visible; the “Close All” hides all but the topmost branches. The “View” button allows the user to have some control over the format of the Graph Applet. The “Export” button enables the user to save the data that is currently visible in the Graph Applet to a comma-separated value file with an associated XML document that contains additional information about the plot itself. See Figure 12 for more information.



Detailed Information Panel

The Detailed Information Panel shows descriptive data that is stored in EDaFS related to the Test Collection, Fire Test or Instrument this is currently selected in the Selection Menu. Null or empty fields will not be displayed. See Figure 13 for more information.

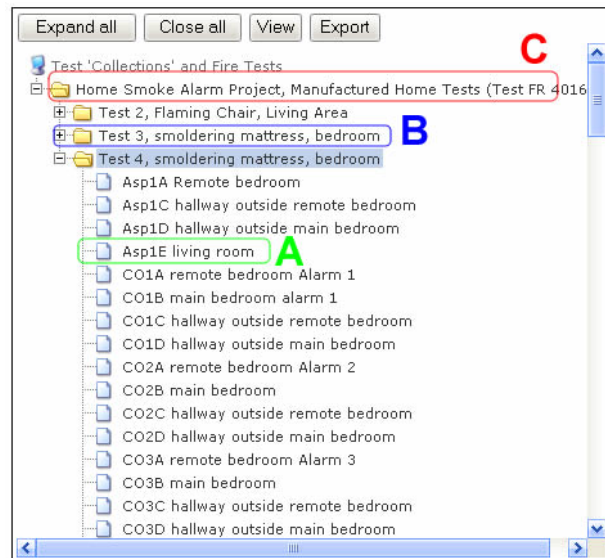


Figure 12: A closer examination of the Selection Menu of the Graphical User Interface. (A) shows an Instrument; selecting this element will populate the Detailed Information Panel with facts about the Instrument, its Fire Test, and any associated Test Collections and will cause the related instrument readings to be plotted in the Graph Applet. (B) is a Fire Test; selecting this element will populate the Detailed Information Panel with information about the Fire Test and its associated Test Collections. (C) is a Test Collection; clicking on this element will populate the Detailed Information Panel with information about the Test Collection and any associated Test Collections.

Detailed Information: Instrument Test Position	
Test Collection:	Home Smoke Alarm Project, Manufactured Home Tests (Test FR 4016)
Test Collection ID:	TCOLL000000000006712
Test Collection Description:	A series of full scale tests were conducted as part of research into the performance of smoke alarms. 27 experiments were conducted as part of this test series were performed in a manufactured home.
Test Title:	Test 2, Flaming Chair, Living Area
Test Date:	29-MAY-2001
Test No:	FR4016 sdc02
Test Description:	Part of the Home Smoke Alarm Project, manufactured
Instrument Name:	CO1A
Instrument Description:	CO Alarm semiconductor tin oxide CO sensor
Instrument Measures:	CO concentration
X:	See diagram
Y:	See diagram
Z:	0 mm
Data File Address:	http://edafs2.wpi.edu/Data/Tests/FTES00000000000108/sdc02.csv
Expand all Close all	
Associated Files	
Images	
Text Documents	
Final Report	
FASTData Website	
Data Files	
Data in comma separated format (.csv)	
Data in FDMS format (.exp)	

Figure 13: A view of the Detailed Information Panel. The top half of the panel provides specifics about the currently selected element from the Selection Menu. This information is nested, such that, when an instrument is selected, fields for the associated Fire Test and Test Collections (if any) fields will be populated. The bottom half of the panel provides a list of links to associated files, such as images, video clips, reports and documentation, and data files.

Grapher Applet

This panel contains a plot of all instrument data that has been selected. Note that every instrument that is selected will be plotted on a single graph, although the ordinates will be collected by similar units as much as possible. Figure 14 shows a graph of thermocouple, ionization detector, and carbon monoxide detector data for a particular fire test. Note that each type of instrument is plotted against a different ordinate, which enables easier comparison of the effects of the fire gasses for the different instruments. In particular, the CO detector is seen to react before, and with greater change than, the ionization detector. The thermocouples are remote from the fire, and barely register a change in temperature. Users can magnify the graph by clicking and dragging a rectangle from the upper left of the desired area to the lower right. Clicking the “View” button in the Selection Menu opens a popup window that enables the user to modify the visible data, the legend text, and the background colors of the graph.

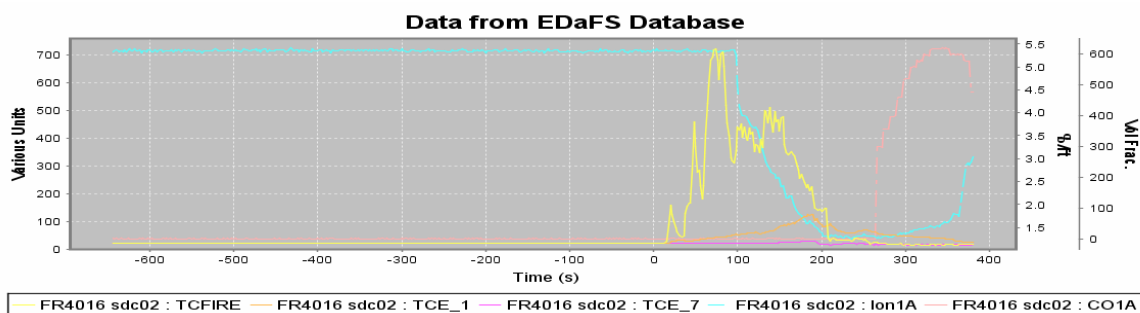


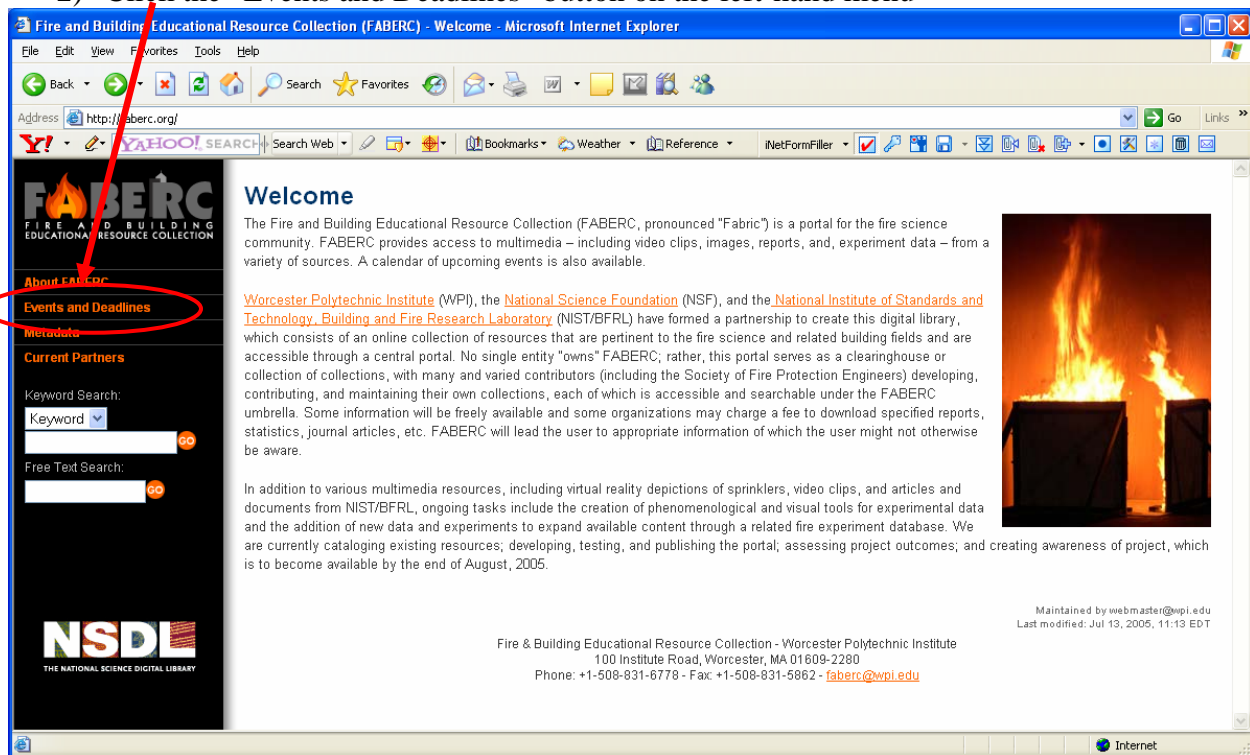
Figure 14: A view of the Grapher Applet.

Appendix C: The FABERC Calendar

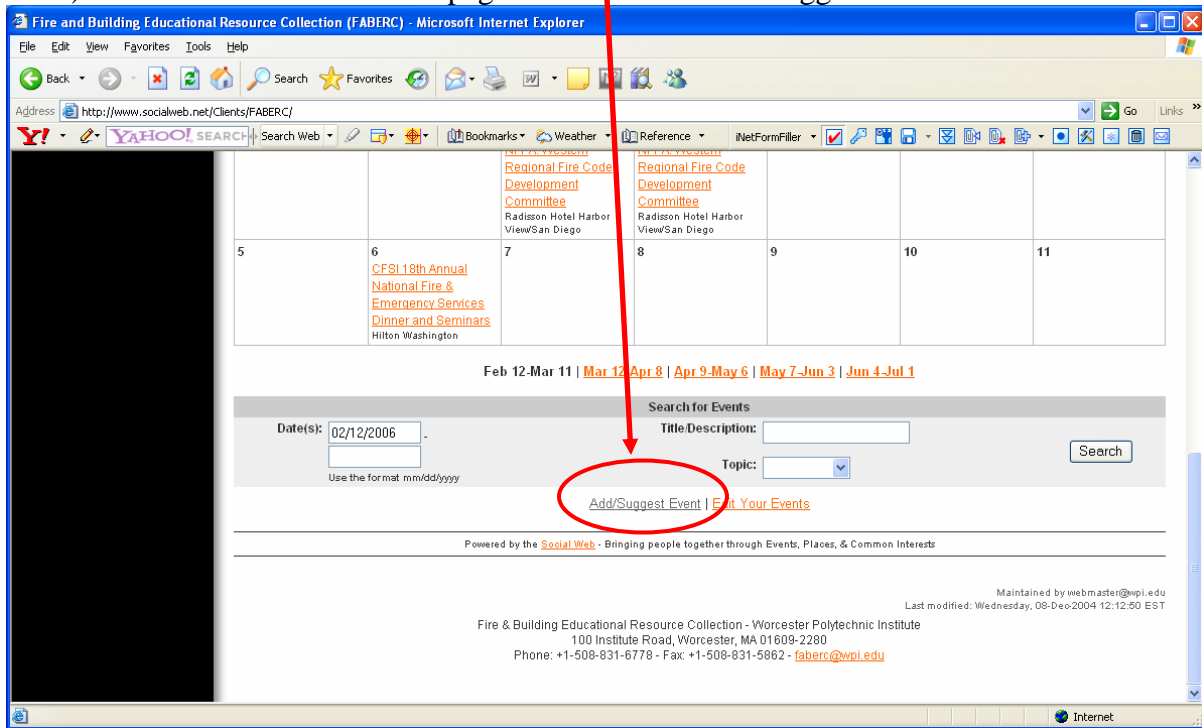
John P. Woycheese

The Fire and Building Educational Resource Collection (FABERC) Calendar provides a means to make the fire and building community aware of seminars, events, meetings, and calls for papers that are of topical interest. This calendar is part of a larger collection of events, known as the Social Web, that is available free to the public. The FABERC portion of the Social web can be accessed via the FABERC portal at www.faberc.org. Although anyone who is a member of the Social Web can suggest events, only administrators can make them visible on the FABERC Calendar. To that end, FABERC has asked certain people throughout the fire and building community to serve as administrators for their organizations, to ensure that the FABERC Calendar is as complete and up-to-date as possible. To add Events to the FABERC Calendar, as an administrator, follow these steps:

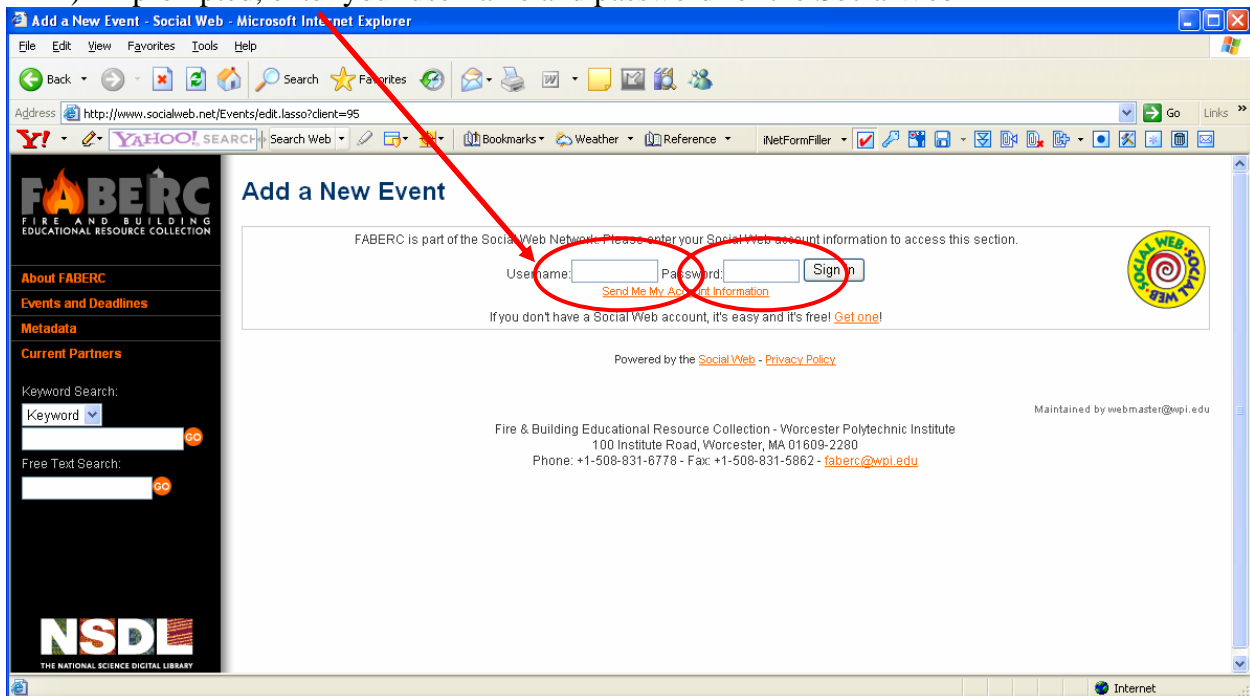
- 1) Go to <http://www.faberc.org>
- 2) Click the “Events and Deadlines” button on the left-hand menu



3) Scroll to the bottom of the page and click the “Add/Suggest Event” link



4) If prompted, enter your username and password for the SocialWeb



5) Under **Categories and Audiences**:

- a. For ***Format***, select:
 - i. “Conference” for a conference or symposium
 - ii. “Deadlines/Notices” for a Call for Papers or Abstracts
 - iii. “Class/Workshop” for an educational opportunity
 - iv. “Meeting” for a meeting (more informal gathering than a conference)
- b. ***Topic*** should be limited to “Education,” “Business,” “Politics,” or “Other” for the near term. More specific topical areas may be added in the future.
- c. Select “Adult” (and, possibly, “College”) for the ***Primary Ages*** field
- d. ***Audience Affiliation*** should be left as “Public”

The screenshot shows a web browser window titled "Add a New Event - Social Web - Microsoft Internet Explorer". The address bar shows the URL "http://www.socialweb.net/Events/edit.lasso?client=95". The page features a sidebar on the left with the FABERC logo and navigation links: "About FABERC", "Events and Deadlines", "Metadata", and "Current Partners". Below these are search fields for "Keyword Search" and "Free Text Search". The main content area is titled "Add a New Event" and includes a sub-header "Categories and Audiences". Below this, there are several form fields: "Format:" (Required) with a dropdown menu; "Topic:" (Required) with a dropdown menu; "Primary Ages:" (Required) with checkboxes for "Preschool", "Elementary", "Middle School", "High School", "College", "Adult", and "Elders", accompanied by a note to select only the intended ages; "Audience:" with a dropdown menu set to "All" and a note to select the most appropriate one; and "Audience Affiliation:" with a dropdown menu set to "Public" and a note to select a group if not for the general public.

6) Under **General Information:**

- a. Enter an appropriate **Title**, which will be displayed in the Calendar view.
 - i. Calls for Papers or Abstracts should begin with “Call for Papers: “ or “Call for Abstracts: “
 - ii. Use Title Case for the Title (i.e., do not use all caps)
- b. Add the **Date** of the event, or the date on which a multi-day event will start.
- c. For **Recurring/Multi-Day Event Options**, if the event occurs:
 - i. On a single day, select “Does not repeat”
 - ii. Over the course of a week (e.g., Monday through Thursday), select “Daily” and enter the last date in **End Date**
 - iii. Over multiple weeks, select “Weekly,” choose the days of the week on which the event takes place, and enter the last date in **End Date**
- d. Do not use the **Additional Begin Times for This Event** field.
- e. For **Place**, select the location at which the event will occur from the drop-down menu. If your location is not on the list, select “The location is not on this list”

The screenshot shows a web browser window titled "Add a New Event - Social Web - Microsoft Internet Explorer". The address bar shows "http://www.socialweb.net/Events/edit.lasso?client=95". The page has a sidebar on the left with the NSDL logo and the text "THE NATIONAL SCIENCE DIGITAL LIBRARY". The main content area is titled "General Information" and contains the following fields:

- Title:** (Required) [Text input field] a
Please do not use all capital letters for titles.
- Entered By:** jpw@faberc.org
- Date:** [Text input field] b
Begin date for multi-day events (Required) Use the format mm/dd/yyyy
- Time:** [Text input field]
Use the format xx:xx AMPM - Other formats will be converted automatically for you. Note: If the event is open ~~the same hours~~ at the place it is located in, leave these fields blank. (Example: An exhibit at a museum)
- Recurring / Multi-Day Event Options:**
 - ☒ Does not Repeat c
 - ☐ Daily
 - ☐ Weekly ☐ Sun. ☐ Mon. ☐ Tue. ☐ Wed. ☐ Thu. ☐ Fri. ☐ Sat.
- End Date:** [Text input field] d
Use the format mm/dd/yyyy
- Additional Begin Times for This Event:** (Example: movie times)
[Text input field]
End times will be calculated based on the first occurrence length. If the event starts at different time on different days, or has different lengths, enter each occurrence as a separate event.
- Place:** Building/Grounds Name: (Required) [Drop-down menu] e
Room Number Name: (If applicable)

If your location did not exist (Item 6e, above), and you selected “The location is not on this list”:

- i. Type the location name in the “Building/Grounds Name” field and click the “Search” button (Note: Hitting the “Enter” key may have no effect.)

Choose a Building/Grounds for Your Event

To save you time, see if the Social Web knows about the building or grounds where your event will be. Search for your event's location below.

- To avoid typos or multiple ways to spell the same location name, enter just the beginnings of words in the place name and avoid parts that may include punctuation.
- Places are generally listed under their full names. If you're searching for an acronym, type it out.
- Rooms are not places in the system. Search for the building the room is in instead.

Building/Grounds Name: Search

Logged in as John Woycheese - My Settings - Sign Out
Powered by the [Social Web](#) - [Privacy Policy](#)

Maintained by webmaster@wpj.edu

Fire & Building Educational Resource Collection - Worcester Polytechnic Institute
100 Institute Road, Worcester, MA 01609-2280
Phone: +1-508-831-6778 - Fax: +1-508-831-5862 - faberc@wpj.edu

- ii. Click on your location if it is listed.

Choose a Building/Grounds for Your Event

Buildings or grounds containing "San Francisco"

2 Found

If the location of this event is here, select it from this list. Otherwise search for it again using different criteria, or add a new building/grounds to the database.

Place Name	Address
San Francisco Museum of Modern Art	151 Third Street, San Francisco, CA
Sofitel San Francisco Bay	223 Twin Dolphin Drive, Redwood City, CA

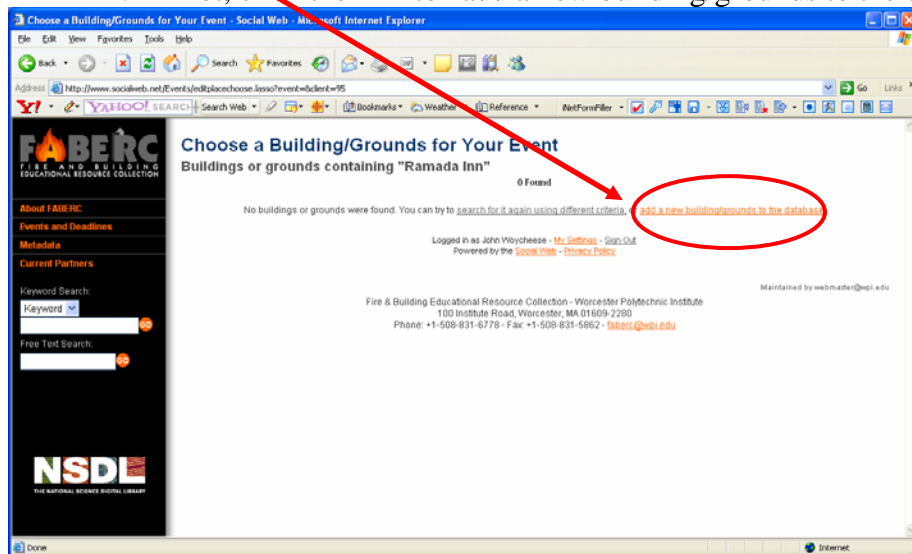
[Add a new building/grounds](#) | [Search Again](#)

Logged in as John Woycheese - My Settings - Sign Out
Powered by the [Social Web](#) - [Privacy Policy](#)

Maintained by webmaster@wpj.edu

Fire & Building Educational Resource Collection - Worcester Polytechnic Institute
100 Institute Road, Worcester, MA 01609-2280
Phone: +1-508-831-6778 - Fax: +1-508-831-5862 - faberc@wpj.edu

iii. If not, click the link to “add a new building/grounds to the database.”



- iv. On the “Add a New Place” page,
 1. Select a **Primary Category**, such as “Accommodations” or “Theaters/Halls/Arena”
 2. Enter the **Building/Grounds Name**; for a hotel in a chain, include the city name and state (if in the US) or country after slash (e.g., “Ramada Inn / San Francisco, CA”)
 3. Provide the **Address**, if known.
 4. The **Zip Code** is required. For non-US addresses, use 00000 for the present.
 5. Provide **Phone, Fax, E-mail**, and **Web Address**, if known.
 6. Scroll to the bottom of the page and click the “Add Place and Return to your Event” button.

Add a New Place

Now you can tell the Social Web as much as you know about the place where your event is going to be held. The system will remember this place so if you have other events here, you'll only have to do this once.

None of the information here should be about your event in particular.

Primary Category:

<input type="checkbox"/> Accommodations	<input type="checkbox"/> Libraries	<input type="checkbox"/> Transportation
<input type="checkbox"/> Attractions	<input type="checkbox"/> Movie Theaters	<input type="checkbox"/> Worship
<input type="checkbox"/> Bars & Pubs	<input type="checkbox"/> Museums & Galleries	<input type="checkbox"/> Cities*
<input type="checkbox"/> Coffee Houses	<input type="checkbox"/> Parks	<input type="checkbox"/> Others*
<input type="checkbox"/> Dance Clubs	<input type="checkbox"/> Restaurants	<input type="checkbox"/> Personal Residences*
<input type="checkbox"/> Farms & Orchards	<input type="checkbox"/> Schools	<input type="checkbox"/> Stores*
<input type="checkbox"/> Games & Athletics	<input type="checkbox"/> Social Clubs	<input type="checkbox"/> TV/Radio Stations*
<input type="checkbox"/> Historical Landmarks	<input type="checkbox"/> Theatres/Halls/Arenas	

Building/Grounds Name:

Do not add rooms of a building as new places.

Street Address:

Only use physical address, no PO Boxes

Do not enter City and State here. This information is determined from the ZIP below.

ZIP: [Lookup ZIP Code](#)

Phone:

Use the form 000-000-0000

Alternate Phone:

Use the form 000-000-0000

Fax:

Use the form 000-000-0000

E-mail:

Place Website:

Use the form http://www.website.com/

Logo/Photo Web Address:

Example: http://www.website.com/images/photo.jpg

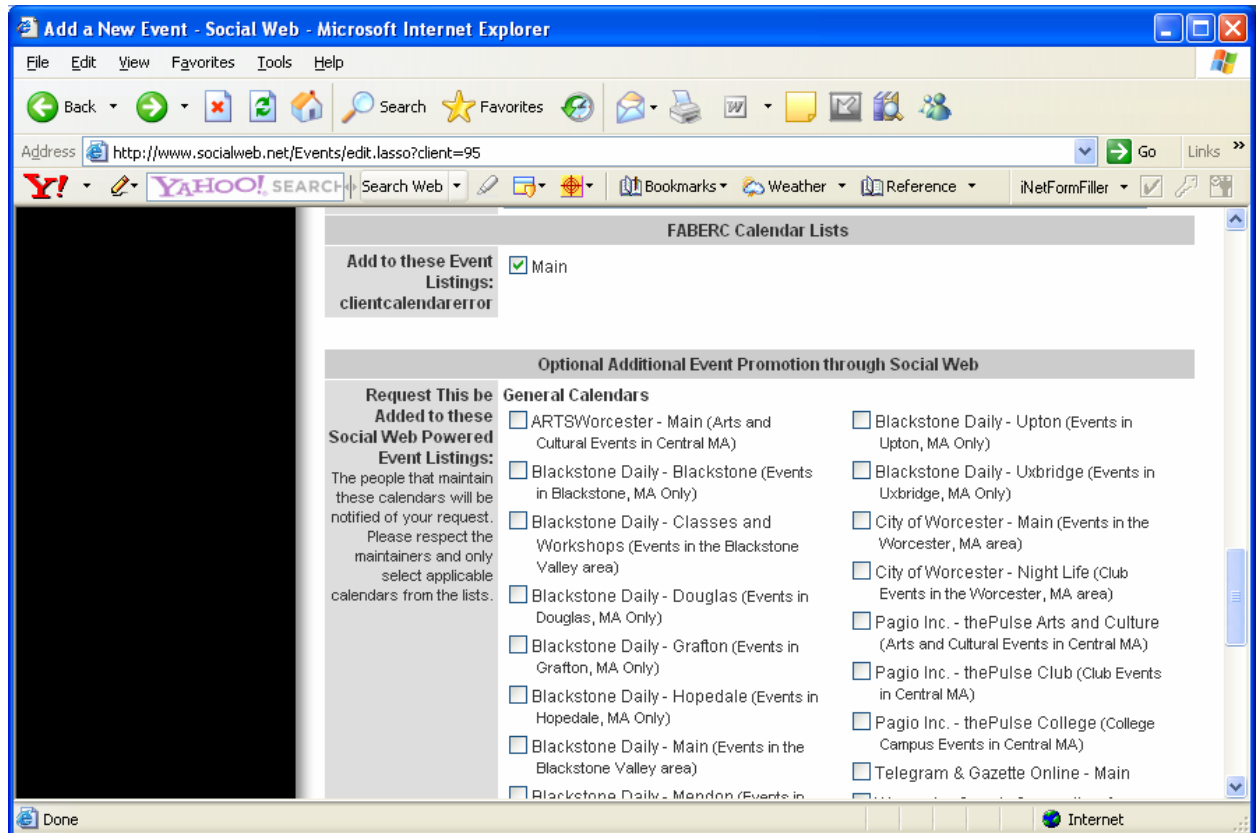
- 7) Provide as much information as possible in the “Additional Information” area. Note that the web page for the event will often have a description that can be copied to the **Event Description** field. Use the **E-mail** and **Phone Number** fields to allow viewers to contact the event sponsors directly. Unfortunately, currently only one e-mail and phone number can be provided here (although more can be entered in the free-form **Event Description** field with the description of the event), and only U.S. phone numbers can be entered at present. Note that the **Graphic Web Address** can be used to display a particular graphic (jpg, gif, etc.) on the Calendar’s details page for the event.

The screenshot shows a web browser window titled "Add a New Event - Social Web - Microsoft Internet Explorer". The address bar shows the URL "http://www.socialweb.net/Events/edit.lasso?client=95". The browser's toolbar includes buttons for Back, Forward, Stop, Reload, Home, Search, Favorites, and various application icons. Below the toolbar is a Yahoo! Search bar and a navigation menu with links to Search Web, Bookmarks, Weather, Reference, and iNetFormFiller. The main content area displays a form titled "Additional Information". The form has a left sidebar with a black background. The form fields include:

- Cost(s):** A text input field with a note: "Include member discounts, student discounts, prepayment prices, etc."
- Sponsor(s):** A text input field.
- Contact Information:** A section containing:
 - E-mail:** (If not jpw@faberc.org) A text input field. Below it, a note: "Note: By assigning a contact e-mail address, that person can also modify this event."
 - Phone Number:** A text input field. Below it, a note: "Use the format 000-000-0000x000"
- Event's Webpage:** A text input field with a note: "Use only if the event itself has its own webpage." and an example: "Example: http://www.website.com/Events/thisevent.html"
- Graphic Web Address:** A text input field with a note: "If you want a graphic to appear next to your event, enter the image's URL here." and an example: "Example: http://www.website.com/Images/photo.jpg"
- Event Description:** A large text area with a note: "Any information that has not already been entered above."

The browser's status bar at the bottom shows "Done" and "Internet".

- 8) Do not uncheck the “Main” check box under the “FABERC Calendar Lists” area
- 9) Do not check any boxes in the “Optional Additional Event Promotion through Social Web” section.



- 10) Click the “Add Event” button to add the event to the FABERC Calendar.

