Section 2. Task 1a.1 Available Ceramic Property Data

2.1 Introduction

In the twenty years since the internet and the World Wide Web have revolutionized access to data and information, the world-wide ceramics community has created numerous online data resources covering virtually all ceramics materials and properties. Because these data resources have been created and maintained by diverse, independent organizations, locating and gaining access to a specific piece of needed data remains a challenge, even with the existence of modern search engines.

As part of this study, we performed an intensive search for ceramics data resources. The goal was not only to locate as many resources as possible, but also to characterize them with respect to content, availability, fee structure, and coverage. Our ultimate aim was to create a database of ceramic property databases that could be used by organizations as the basis for developing easier, more cohesive access to multiple data resources for users. A second aim was to understand business models used by the individual data resources in order to build recommendations of a new business model for providing single point access (a data portal) to multiple resources (see Section 4). The results of our searches follow.

2.2 Available Ceramic Property Data

The primary objective for this effort was to assess the existence of ceramic property data, focusing on those data available electronically. In this context, we define the term *ceramics* to mean any inorganic non-metal, including zeolites and minerals. While databases containing citations, abstracts, or full text information on this topic are easily found, databases containing data on ceramic properties are scarcer. There is no one single portal for such data, and ceramic property data is part of the larger materials sciences subject area which covers chemistry and engineering.

Although our focus for this effort was on electronic sources, we did examine some known print ceramic property data sources, such as those published by CRC Press, Knovel, and ASM International. We also discovered a substantial quantity of ceramic property data in journal articles that does not exist in a database. As part of our initial strategy, we gathered some background information on the topic to clarify more specifically the needed ceramic property data for the effort. We narrowed down the data forms and the types of property data needed, and then we developed a template to use in reporting the information found. Ceramic data forms/materials could include the various forms (i.e., single crystal, polycrystalline, glasses, fibers, films, composites, and coatings). Data of interest included structural, thermal, mechanical, and optical properties. Our ability to locate foreign language data resources enabled us to find many non-English data sources of ceramic property data.

The primary search for ceramic property data was performed by experienced open-source search specialists at IIa. IIa has over 25 years' experience in searching for scientific, technical, engineering, and medical information for DoD and other government agencies.

Our search strategy was to explore the known sources, such as those at NIST, the American Ceramic Society, publishers, e.g., John Wiley, Springer, and others. After exhausting the known sites, we looked at academic institutions that had strong programs in material sciences such as those at the California Institute of Technology, the Massachusetts Institute of Technology, the Georgia Institute of Technology, Iowa State University, as well as others. We utilized the library subject guides on material sciences from these institutions to discover more sources.

We also searched for ceramic property data at the Department of Energy (DOE) laboratories. At DOE's Office of Scientific and Technical Information (OSTI), we had some success in locating foreign sources using worldwidescience.org, DOE's global gateway portal that connects scientific databases and portals from over seventy-five countries and international organizations. We also used Scirus.com, a comprehensive, science-specific engine that searches over 460 million science webs. The search strategy is depicted in Figure 1. In addition to the free internet sites, we also identified commercial databases such as Knovel, Chemical Abstracts Service, ASM International, and commercial suppliers that have databases of ceramic property data.

In the course of searching for foreign ceramic data sources, we discovered that many foreign countries defer to the data from NIST. As mentioned earlier, OSTI's worldwidescience.org portal was very useful in discovering foreign sites for ceramic data. The CODATA register of materials database managers was also useful in discovering foreign sources of ceramic property data.

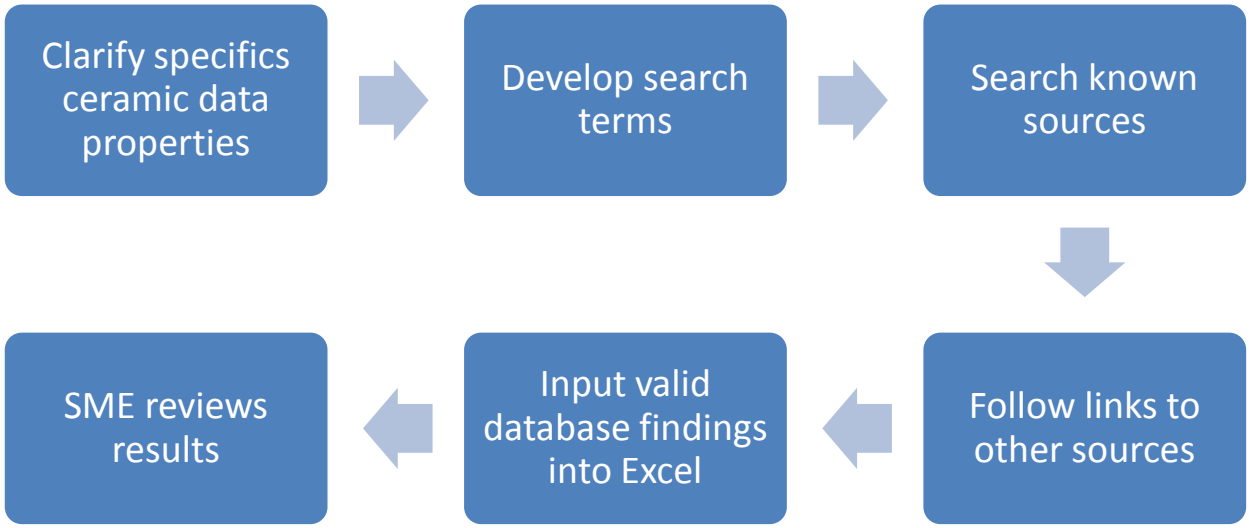

Figure 1. Schematic representation of the search strategy.

2.3 Summary of Reviewed Ceramics Data Resources

Over 100 possible ceramic property data resources were identified. Many of these contained no property data and are not included in this summary. Table 2-1 lists the ceramics data resources that do contain ceramic property data. A few of these are printed data resources or organizations with a broad mission to provide ceramic data and information. The reviewed data resources have been divided into the following categories:

- Comprehensive and General Ceramics Databases – Government and University
- Ceramic Phase Equilibria and Crystallographic Structure Databases
- Ceramic Materials Producers Databases
- Glass Databases
- Comprehensive and General Ceramics Databases - Commercial Database Providers
- Other Ceramics-related Databases
- Ceramics-related Data Publications

A brief description of each of these ceramics data resources is given in Appendix B. Where possible, we describe the extent of the data available, but for cases in which they charged a fee, we did not determine the details of the database. This list of ceramics data resources will be made available electronically to the public, as publicized in the article in the ceramics press that will be prepared.

Our general conclusions about the availability of ceramics property data are as follows.

- While considerable amounts of ceramics property data are available, no single resource is very comprehensive.
- Many of the data resources are out of date and are no longer being updated.
- Data quality indicators are lacking for most data resources.
- It is doubtful, given the effort required to locate all these data resources, that any individual ceramic scientist or engineer is aware of all or even most of these resources; this was confirmed at the E-Ceramics 2012 workshop described in Section 3.
- In aggregate, many types of properties are not adequately covered, including some fundamental types of fundamental ceramic properties.
- Performance data are incomplete, and historical coverage of these properties is lacking.
- No single point of access exists. the National Institute of Standards and Technology (U.S.) and two institutes in Japan do provide access to multiple data resources.
- Each for-fee data resource has a different fee structure: some are inexpensive and easy to subscribe to, while others are more expensive and require greater effort to subscribe.

Table 2-1. Databases and Other Data Resources Reviewed in this Report.

Name	***Builder or Maintainer***
Comprehensive and General Ceramics Databases – Government and Universities	
Ceramic WebBook	National Institute of Standards and Technology
Network Database System for Thermophysical Property Data	National Institute of Advanced Industrial Science and Technology (AIST), Japan
Materials Project	Massachusetts Institute of Technology (MIT)
Thermal Protection Systems Expert and Material Properties Database (TPSX)	National Aeronautics and Space Administration (NASA) Ames Research Center
MATBASE	Matbase Group, Netherlands
Ceramics Summary and Design Data Files (Compendium)	University of Dayton Research Institute (UDRI)
Optical Properties of Ceramics and Ceramics Thin Films	National Institute of Advanced Industrial Science and Technology (AIST), Japan

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Name	***Builder or Maintainer***
Network Database system for Thermophysical Property Data	National Institute of Advanced Industrial Science and Technology (AIST), Japan
CCDB Glaze Database	National Institute of Advanced Industrial Science and Technology (AIST), Japan
RASMIM (Raman Spectra Database of Minerals and Inorganic Materials)	National Institute of Advanced Industrial Science and Technology (AIST), Japan
Materials Database	Japan Aerospace Exploration Agency (JAXA), Japan
Mat Navi, NIMS Materials Database	National Institute of Materials Science(NIMS), Japan
Kaye & Laby Tables of Physical and Chemical Constants	National Physical Laboratory, U.K.
Materials Properties Open Database	University of Caen Basse-Normandie, France
Mat Bank	Korea
Tribocollect	Bundesanstalt für Materialforschung und –prüfung, Berlin
Ceramic Phase Equilibria and Crystal Structure Databases	
Phase Equilibria Diagrams	National Institute of Standards and Technology and the American Ceramic Society, USA
Inorganic Crystal Structural Database (ICSD)	FIZ Karlsruhe, Germany and National Institute of Standards and Technology
Bilbao Incommensurate Structures Database	Basque University, Spain
The American Mineralogist Crystal Structure Database	Mineralogical Society of America and Mineralogical Society of Canada
WWW-MINCRYST	Institute of Experimental Mineralogy, Russian Academy of Sciences
Database of Zeolite Structures	Structure Commission, International Zeolite Association
Ceramic Materials Producers Databases (selected examples)	
Dynallox Alumina Ceramics	
Morgan Technical Ceramics	
Boston Piezo-Optics Inc.	
COORSTEK	
Du-Co Ceramics	
Accuratus	
Ceradyne	
Materials Science and Engineering, State University of New York at Stony Brook	
Properties of Piezoelectricity Ceramics	Morgan Technical Ceramics
Glass Databases	
SciGlass Property Information System	Scimatics, Newton, MA
INTERGLAD	New Glass Forum, Japan
Comprehensive and General Ceramics Databases – Commercial Database Providers	

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Name	***Builder or Maintainer***
MatWeb	MatWeb, LLC, Blacksburg VA
Thermophysical Properties of Materials Database (TMPD)	CINDAS LLC, West Lafayette IN
Microelectronic Packing Materials Database (MPMD)	CINDAS LLC, West Lafayette IN
Granta Data Series	Granta Material Intelligence, U.K.
Matereality Global Data Center	Matereality LLC, New York
JAHM Software	JAHM Software, Inc., Reading MA
Material ConneXion Online Materials Database	Material ConneXion, New York, NY
ProQquest Deep Indexing: Materials Science	ProQuest, Cambridge Information Services, Ann Arbor MI
Materials Properties Database	Makeitfrom
efunda	eFunda, Inc., Sunnyvale CA
Other Ceramics-related Data Resources	
American Ceramic Society	
ASM International	
Mindat.org	Mindat, Coulsdon, Surrey, England
Materials Digital Library Pathway (MatDL)	Kent State University, OH
Advanced Materials, Manufacturing, and Testing Information Analysis Center (AMMTIAC)	Alion Science, Rome NY
Ceramics-related Hard Copy Data Sources	
CRC Materials Science and Engineering Handbook	Ed. By J.F. Shackelford, W. Alexander, and J. S. Park
Thermal and Other Properties of Refractories	Technical Report Program No. R056
Single Crystal Elastic Constants and Calculated Aggregate Properties: A Handbook, 2nd Edition	Ed. by G. Simmons and H. Wang
Elastic Moduli Data for Polycrystalline Oxide Ceramics	Ed. by R. G. Munro
Handbook of Optical Constants of Solids II	Ed. by E. D. Palik
Data Evaluation Theory and Practice for Materials Properties: NIST Recommended Practice Guide 960-11	Ed. by R. G. Munro