The DOE/DOD Environmental Data Bank[1]

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Abstract

The DOE/DOD Environmental Data Bank was established in 1959 as a central location for storing weapons and equipment environments information from a variety of DOE, DOD, and industrial sources and continues to be maintained by Sandia National Laboratories. The Environmental Data Bank contains approximately 2,900 documents regarding normal and abnormal environments that describe the handling, storage, transportation, use, and general phases, which occur during the life of a weapon system. The Environmental Data Bank contains a vast assortment of resources that document crash, fire, and chemical environments resulting from aircraft, rail, ship, and truck accidents, as well as crash and thermal tests conducted on shipping containers. Also included are studies on the hazards of exposure to liquid natural gas fireballs, chemical fireballs, and hydrogen fireballs. This paper describes the DOE/DOD Environmental Data Bank system, its structure, data sources, and usage, with particular emphasis on its use for safety assessments at Sandia National Laboratories.

Introduction

The Environmental Data Bank is used by Sandia engineers as a source of information to determine the normal and abnormal environments to which a weapon system, a component, or equipment could be subjected.

For the purpose of indexing and data retrieval, the data is cataloged under two major headings, normal and abnormal environments [1]. Normal environments are those environments that will be encountered regularly. They are characterized by the high frequency of occurrence but relativity low consequence. Conversely, abnormal environments are not encountered often, and they are characterized by a low frequency of occurrence but high consequence.

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[1]This work was supported by the U.S. Department of Energy under Contract DE-ACO4-94AL85000.

All of the of the environments are also identified as either *input*, "the environment to which a system is exposed" or *response*, "the reaction of components of that system to an input." Whether the environment can be termed input or response is often dependent on the system being considered; however, the distinction is necessary to assess the occurrence.

Environmental Data Bank Operation

When test reports and published documents are acquired by the Environmental Data Bank, they are reviewed for engineering data content. Pertinent information is extracted, assigned a numerical index number, and is then archived either on aperture cards or microfiche; the data bank index is maintained as hard copy. Currently, the index is in transition to an electronic database format. Additionally, the microfilm documents are in the process of being converted to electronic media and will be archived in the DOE/DOD Environmental Data Bank database located on Sandia's Image Management System (IMS). Because it is estimated that the conversion will require two to three years, the Environmental Data Bank will operate as both a microfilm and electronic database until the conversion is completed.

Structure of the Environmental Data Bank

Environmental data can be defined as numerical or digitized descriptions of the aggregate of all external conditions and influences affecting the development and survival of systems, subsystems, and components. For efficient collection and evaluation of these data, the following 14 environment categories were established and the electronic storage and retrieval system is based upon them.

Environmental Categories

– Acceleration/time histories	– Pressure
– Acoustic noise	– Radiation
– Atmospheric contents	– Shock
– Biotic	– Temperature
– Fragmentation	– Trajectory
– Humidity	– Vibration
– Perception	– Wind

Not all environments lend themselves to normal/abnormal division. Three factors limit the number of abnormal environmental levels that require consideration:

- Some environments reach an absolute limit. Because humidity is limited by ambient temperature, for example, relative humidity cannot exceed 100 percent

- The abnormal aspects of some environments are encountered so infrequently that they are of little interest, for example, acoustic noise of an intensity to cause structural damage.
- Protection against normal environments includes protection against abnormal environments; for example, protection against entry of liquid water is effective in a cloudburst as well as during a drizzle.

For these reasons, the abnormal levels of environment are considered only for the following categories:

Environmental Categories	– Abnormal Manifestation Examples
Acceleration/time histories:	*Earthquake, vehicle collision*
Fragmentation:	*Projectile impalement, explosion, puncture*
Pressure:	*Explosion, immersion depth, crush*
Radiation:	*Lighting (direct strike)*
Shock:	*Impact (vehicle collision)*
Temperature:	*Fire*
Wind:	*Wind storm (tornado, hurricane, etc.)*

All of the environments are divided into individual use phases that occur during the life of a weapon system:

- Handling
- Storage
- Transport
- Utilization
- General

The transport and utilization phases are further subdivided into the type of carrier involved; for example, aircraft, automobile, railroad, etc.

Electronic Structure

The electronic Environmental Data Bank uses a customized Microsoft FoxPro index database called SPEEDI II. SPEEDI II uses one, or a combination of two, of eleven search categories – Program, Phase, Condition, Environment, Method, Carrier, Subcarrier, Model, Event, and Keywords – to perform a global document search and provide a search query that contains the following document information: index number, title, classification, publication date, number of pages, an electronic-media/microfilm storage

format flag, and an abstract of the information contained in the document. This query information is used to determine whether documents must be retrieved from the electronic database or printed from microfilm. Each item's index number is then used to locate the corresponding document in the electronic database at the Image Management System (IMS), where it can be viewed or transmitted to a local personal computer. If the document has not been converted to electronic media, the index number is used to locate the microfilm aperture cards or microfiche. The information in the Environmental Data Bank is available to qualified requesters.

DOE/DOD Environmental Data Bank - Data Sources and Content

The DOE/DOD Environmental Data Bank provides engineering and experimental information concerning intensity and duration of various environments to which DOE/DOD developed systems and equipment may be exposed during storage, transporting, handling, and use. The Environmental Data Bank contains documents acquired from military agencies, government organizations, industrial groups, and various project groups at Sandia National Laboratories. The majority of these documents contain information on normal environments, but there are over 600 abnormal environment documents. Among the abnormal documents are aircraft, railroad, truck, and ship accident reports; aircraft crash test data reports; aircraft crash analysis reports; risk and safety assessment reports on severity of transportation accidents; fireball model reports on thermal hazard from hydrogen fireball, thermal hazards from propane fireballs, thermal hazards from liquefied natural gas fireballs, and skin burn hazards from chemical fireballs; risk assessment reports on transporting liquefied natural gas; climatic reports on lighting, severe winds, tornadoes, and typhoons; and earthquake reports for different parts of the world.

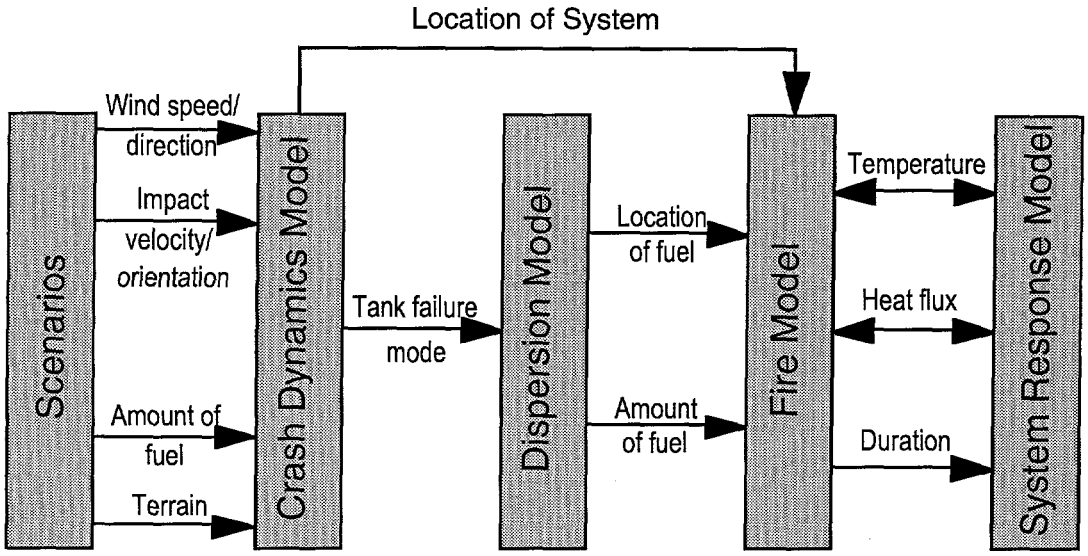
Safety Assessments

For over the past 40 years, Sandia National Laboratories has been actively engaged in research to accurately predict the response of engineered weapon systems to abnormal environments. Because these systems contain very hazardous materials, the degree of safety/risk to the public and the environment must be assessed.

Until recently, there have been two means of processing the information – by the use of historical accident data or by expert elicitation. Now, an effort at Sandia has focused on developing deterministic models to process information. Although each technique has its limitations, each can be used in support of the others. For example, a model and/or historical data can augment the insight of the experts. Similarly, historical data and expert opinion can support a model and its development.

An example of the use of numerical models to characterize an abnormal environment for a transportation accident (a crash followed by a fire) is given below [2]. The

environment and system response is defined by distinct but coupled models: the crash dynamic model, the dispersion model, the fire model, and the system response model (see figure). First, the nature of an abnormal environment is physically characterized and numerically simulated. The crash dynamic model represents the initial environmental condition, wind speed, and direction, where an assessment is made regarding the level of damage to the system (i.e., amount of damage to fuel tanks, mechanical damage to the cargo). Second, initial conditions and quantification of the level of mechanical damage are then fed to the fuel dispersion model. Third, the location of the fire and the amount of fuel available from burning is determined. Finally, the fire model then uses all of the information provided from the other models to create a hypothetical thermal environment to which the system is subjected.



Prediction of System Response to an Abnormal Environment

Historical data from the Environmental Data Bank can be used to help define and support the development and validation of the above models. The DOE/DOD Environmental Data Bank contains a variety of aircraft, truck, railroad, and ship accident reports that include the characterization of crash, impact, collision, penetration, immersion, and fire environments. The characterization of the different abnormal environments in these studies serve as the bases to characterize the dominant physics needed to develop and validate the above mentioned models. For example, aircraft high-energy and low-energy impact parameter distribution information and fuel fire duration as a function of aircraft size and on-board fuel information can be found in severities of transportation accident studies involving cargo aircraft. Safety assessment information on fireball growth rate, critical fireball size, fireball heat flux, and reaction time is available from Propane, Liquefied Natural Gas, and Liquid-Propellant fireball models. In some cases, such as the Safe Secure Trailer analysis discussed in the next topic, abnormal

environments regarding probability of occurrence can be taken directly from information found in the Environmental Data Bank.

The Environmental Data Bank as a Source of Historical Data

The Environmental Data Bank provided a valuable source of historical data in a study to determine abnormal environments for certification of the transportation of weapon systems on the Safe Secure Trailer (SST) [3]. All of the information required for analysis on this effort, which contains summaries of the maximum environmental definitions that the SST might encounter in a dynamic or static state, was found in the Environmental Data Bank. Topics that were researched include shock, vibration, thermal, humidity, atmospheric pressure, crush, immersion, fire, and lightning. The accident rate was determined, normal environments were extracted from a number of SST test data reports, and normal thermal information was extracted from reports stored in the Environmental Data Bank. Although no abnormal test data were found for the SST, the majority of the abnormal environments estimates in the resulting summary are based on statistical analysis found in transportation accident studies located within the Environmental Data Bank. Finally, estimates were made based on the probabilities and severity of motor carrier accidents and environments that are common to all types of vehicles (e.g. lightning, fire, collision, immersion).

One of the risk/safety assessment studies used to determine abnormal environments for the SST analysis summary report discussed above is a study on the severity of transportation accidents involving large packages [4]. This risk/safety assessment study combined historical data found in the Environmental Data Bank and other sources with the probabilistic risk assessment approach to prepare a report that quantitatively describes the severity of the environments that large hazardous-material containers can be expected to experience in truck and rail transportation accidents. The primary interest of this study was directed toward the type of package used to transport radioactive materials; however, the findings are not limited to this type of package but can be applied to a much larger class of shipping containers. The accident environments discussed are fire, impact, crush, puncture, and immersion. Although accident rates are discussed, accident severity is the primary emphasis of the report, which incorporates historical data and statistical models that were used in the accident severity study.

Summary and Conclusion

The DOE/DOD Environmental Data Bank has approximately 2,900 documents archiving normal and abnormal environments spanning almost 40 years. Currently the index as well as the documents are in transition from microfilm, microfiche and hard copy formats to digitized, electronic format to speed up searches, and to facilitate data retrieval. The information archived in Sandia's DOE/DOD Environmental Data Bank is invaluable in the following areas: determining the system design requirements and their associated

risk assessments, development and validation of numerical models, and finally, specifying realistic and appropriate laboratory and field tests. The probabilistic risk assessment conducted for Sandia's Safe, Secure Trailer (SST) discussed in this paper provides a clear example of how the information contained in the Environmental Data Bank can be used to quantitatively predict the severity of transportation accident environments.

References

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