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THE SANDIA COMPUTERIZED SHOCK COMPRESSION BIBLIOGRAPHICAL DATABASE

*INSERT NO. 2*

*A searchable and updateable bibliographical database is being developed which will be designed, controlled, and evaluated by working technical experts in the field of shock-compression science. It will emphasize shock-compression properties in the stress region of a few tens of GPa and provide a broad and complete base of bibliographical information on the shock-compression behavior of materials. Through the operation of technical advisors, the database provides authoritative bibliographical and keyword data for use by both the inexperienced and expert user. In its current form, it consists of: (1) a library of journal articles, reports, books, and symposia papers in the areas of shock physics and shock mechanics, and (2) a computerized database system containing complete bibliographical information, exhaustive keyword descriptions, and author abstracts for each of the documents in the database library.*

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It is important to note that the SSC Database is being designed, controlled, and evaluated by working technical experts in the field of shock-compression science. It will provide a broad and complete base of bibliographical information on the high strain rate properties of materials and will emphasize shock-compression properties of solids in the stress region of a few tens of GPa. A group of technical advisors will assure that the database provides authoritative bibliographical and keyword data for use by both the inexperienced and expert user.

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## II. ORGANIZATION OF THE DATABASE

In its current form, the database consists of: (1) a library of journal articles, reports, books, and symposia papers in the areas of shock physics and shock mechanics, and (2) a computerized database system containing complete bibliographical information, exhaustive keyword descriptions, and author abstracts for each of the documents in the database library. The computerized database is being developed using INGRES database management software for use on a VAX computer.

*INSERT NO. 5*

*Original publication* For those documents which have two sources, the source for the hard copy in the library is given in the source field and the second source is given in the original (or alternate) publication field. For example, for Russian articles, the English translation is given in the source field and the original Russian source is given in the original publication field. Preprints of papers given at symposia and symposium papers later published in journals are handled similarly.

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*Abstract* An abstract field contains an abstract of the paper content. Where possible, the original abstract of the paper is used. If no abstract was included by the original authors, a suitable summary is abstracted from the article by the technical reviewer assigning keywords.

*Additional information* This field is used by the technical reviewer to comment on the content of the paper with any information which might be relevant and informative to someone searching the database.

*Data summary* The data summary field can be used for additional information, such as table headings and figure captions.

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## IV. COMPUTERIZED SEARCH OF THE DATABASE

In principle, all fields in the database are searchable. Generally, though, searchable fields would be authors and acknowledgements, affiliations, and the technical keywords. Searches combining several fields would tend to focus the search and limit unwanted finds. For example, searches of a specific author's name and a period of time could be made by combining a search of the author field and the submission date field (or the Paper ID field). Likewise, a combination of keyword fields could become very specific. The user will eventually have the opportunity to search the database via a "user friendly," menu-driven CRT display inquiry system, with an option to print the information on relevant reports retrieved by the database. An example of the information in a retrieved document was shown earlier in Fig. 1.

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## V. ACKNOWLEDGEMENTS

This work performed at Sandia National Laboratories supported by the U. S. Department of Energy under Contract Number DE-AC04-76DP00789. The authors would also like to acknowledge W. Herrmann and L. W. ~~Dansin~~ Davison, Sandia National Laboratories, for providing the motivation and support for this work.

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# THE SANDIA COMPUTERIZED SHOCK COMPRESSION DATABASE

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*A searchable and updateable database is being developed which will be designed, controlled, and evaluated by working technical experts in the field of shock-compression science. The database is expected to serve as an authoritative source for both shock technology and shock-compression studies. Initially, it will emphasize shock-compression properties in the stress region of a few tens of GPa. The database has as its long range objective a readily available source of evaluated and unevaluated technical data for incorporation into computer codes. In the short range, it will provide a broad and complete base of bibliographical information on the shock-compression behavior of materials. Through the operation of technical advisors at the Sandia National Laboratories, this database will be able to provide authoritative, selected data for use by the casual user and more detailed data and bibliographic material for the expert user. In its current form, the database consists of: (1) a library of journal articles, reports, books, and symposia papers in the areas of shock physics and shock mechanics, and (2) a computerized database system containing complete biographical information, exhaustive keyword descriptions, and author abstracts for each of the documents in the database library.*

## I. INTRODUCTION

In the rapidly evolving area of shock-compression science, information is being published in such voluminous amounts that workers in the field are being inundated with reports and articles. It is apparent that in the shock compression community today, there exists a need for a procedure to organize, catalogue, and store this information. Procedures are also needed for rapid location and retrieval of information applicable to an individual's current experimental, analytical, computational, or modeling efforts. A database is being developed to accomplish these tasks.

To be most useful, this database must serve the needs of two different types of individuals. First, an individual who is a newcomer to a given field will encounter problems in the collection and procurement of data. Such an individual requires a systematic procedure for scanning reports, many or most of which he may not be aware exist, for the data he requires. Second, there is the experienced veteran who has previewed, scanned, and read countless documents of interest, but then can no longer remember where he actually saw the data. This individual also requires a systematic procedure for retrieving the authors, title, etc., of the source material. Both of these types of individuals will use a database if the descriptors, identifiers, or keywords are pertinent and useful. The database under development, to be known as the Sandia Shock Compression (SSC) Database, will meet these needs.

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It is important to note that the SSC Database is being designed, controlled, and evaluated by working technical experts in the field of shock-compression science. The SSC Database will have as a long range objective a readily available source of evaluated and unevaluated technical data for incorporation into computer codes such as WONDY, CHARTD, CSQ, and TOODY. These codes are used to evaluate problems involving rapid impulsive loading for conditions in which nonlinear material properties are significant. In the short range, it will provide a broad and complete base of bibliographical information on the high strain rate properties of materials. Initially, it will emphasize shock-compression properties of solids in the stress region of a few tens of GPa.

Key to the success of the database development will be the direction and control of the Technical Operating Committee and a group of technical advisors at the Sandia National Laboratories. These individuals, responsible for the credibility and usefulness of the database, will assure that

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the database provides authoritative, selected data for use by the casual user and more detailed data and bibliographic material for the expert user.

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II. ORGANIZATION OF THE DATABASE

In its current form, the database consists of: (1) a library of journal articles, reports, books, and symposia papers in the areas of shock physics and shock mechanics, and (2) a computerized database system containing complete bibliographical information, exhaustive keyword descriptions, and author abstracts for each of the documents in the database library. The SSC library, containing a hard copy of each document in the database, will be filed in the Thermomechanical and Physical Division at the Sandia National Laboratories. The computerized database is being developed using INGRES database software and is to be housed on the VAX computer in the same division at Sandia.

The SSC Database has provisions for storing an extensive amount of information extracted from papers, reports, symposia proceedings, and books dealing with the discipline of shock-compression science. The information is presented in a logical format for the database user. It is organized into four categories: (1) paper identification, (2) bibliographic citation, (3) technical keywords, and (4) supplemental information. Each of these will be discussed briefly. A complete listing of all information currently compiled in the database for a typical article is given in Fig. 1.

### A. *IDENTIFICATION*

There are two fields associated with identification of a document. The first field is the Chronological Paper Number, which is a four digit number assigned in ascending order to each article as it is entered into the database. This number is the identifier for retrieval operations inside the database and corresponds to the storage location of a paper copy of the article in the database library. The second identifier field, the Paper ID, identifies articles in terms of the year of publication and the primary author's last name in a fashion similar to reference citations of some journals. The Paper ID has six characters: the first two characters are the last two digits of the year in which the document was published; the third character is the first letter of the primary author's last name;

and the last three characters represent a sequential assignment (as chronologically processed) of papers that year with a similar letter (e.g., 73G003 represents the third document processed into the database from the year 1973 with a primary author whose last name begins with a "G").

### B. *BIBLIOGRAPHIC CITATION*

There are seven fields of information associated with the bibliographic citation including: (1) authors, (2) title, (3) source, (4) original publication, (5) submission date, (6) affiliation, and (7) acknowledgements. All information normally contained in report bibliographic and reference lists is contained in one of the first three fields.

*Authors* All authors of the article are listed in the author field in the same order as in the article.

*Title* The title of the article is input exactly as found in the article.

*Source* Source field contains the publication information, that is, the information required to locate and obtain a hard copy of the document. For example: for journal articles, the source field includes the journal name, volume and issue numbers, year of publication, and page numbers; for reports, it includes publishing organization name and report number, date, and number of pages; and for symposium proceedings, it includes name of the symposium, date and location of the meeting, and the page numbers.

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*Original publication* For those documents which have two sources, the source for the hard copy in the library is given in the source field and the second source is given in the original (or alternate) publication field. For example, for Russian articles, the American translation is given in the source field and the original Russian source is given in the original publication field. Preprints of papers given at symposia and symposium papers later published in journals are handled similarly.

*Submission date* Since there is often a considerable delay in time between submission of a paper or report and its publication, the submission date field helps to identify the time when the work was initially completed.

*Affiliation* Because people often identify work with the organization instead of the individual researcher, the organizational affiliation of each of the authors is given in the affiliation field.

*Acknowledgement* Finally, an acknowledgement field is used to record the names of all persons acknowledged by the authors.

### C. *TECHNICAL KEYWORDS*

A number of computerized databases are currently available which contain documents of interest to the shock-compression community. However, it is very difficult to locate relevant documents in these general databases because of the lack of good keyword descriptors. A user of one of these general databases, then, is faced with several problems in searching the database. General descriptors become almost useless in searching for relevant documents because of the extremely large number of entries that are returned. Guessing appropriate keywords is often an art within itself, as is the proper selection of appropriate keyword combinations. The list of reports retrieved may be unacceptably long; this list requires further discrimination, typically done by using a logical "AND" with two or more keywords (all keywords must appear or else the report is rejected).

Thus, a major objective in organizing the SSC Database is the assignment of identifiers or keywords which are specific descriptors to identify the technical content of the paper. To allow for consistency in keywording, all keywording will be done by a limited number of technically trained database staff, and all keyword entries will be reviewed by experts working in the relevant technical area at Sandia.

To fully define the content and focus of each document, technical keywords have been divided into ten distinct topical areas, as shown in Fig. 1. These are:

- Special Emphasis
- Material Response
- Phenomena
- Properties
- Materials
- Experimental Method
- Experimental Results
- Theory/Model
- Computational Method
- Applications

The first five technical keyword categories, in general, describe the technical thrust of the paper, while the second set of five technical words describes the methodology or manner in which the phenomena were studied. (Note: In Fig. 1, it can be seen that there are both major descriptors and minor descriptors utilized in many of these ten fields.)

*Special emphasis* This field is used to describe the primary emphasis of each article. Six possible entries in this field are:

- Review
- Experimental Technique
- Experimental Analysis
- Theoretical
- Analytical
- Numerical

This field is also used to denote if experimental data are presented in the paper and if these data are original or referenced from other sources.

*Material Response* This field distinguishes the primary type of material response under consideration. Possible descriptor entries include:

- Mechanical
- Thermodynamic
- Electrical
- Magnetic
- Optical
- Chemical

*Phenomena* Possibly the most important keyword field of all, this field denotes the physical phenomena addressed in the article. The phenomena specifically addressed in the SSC Database will include:

- Strength
- Phase Transformation
- Spallation
- Stress-Volume
- Equation of State
- Porous Sample
- Residual Property
- Radiation
- Impact
- Stability

Once the major phenomena addressed in a paper are identified, more specific keywords (minor descriptors) are used to define the phenomena being addressed. The following lists of keywords are typical examples of this:

- Strength:
  - -- Elastic-Plastic Waves
  - -- Work Hardening
  - -- Bauschinger Effect
  - -- Release/Rarefaction
  - -- Strain-Rate Effect
  - -- Wave Attenuation
- Spallation:
  - -- Crack Coalescence
  - -- Incipient Spall
  - -- Multiple Spall
  - -- Ductile Fracture
  - -- Damage Morphology
  - -- Fragment Distribution
- Transformation:
  - -- Polymorphic
  - -- Reconstructive
  - -- Nucleation
  - -- Mixed Phase
  - -- Metastable
  - -- Recompression
- Stress-Volume:
  - -- Stress Profile
  - -- Viscoelastic
  - -- Hugoniot
  - -- Hydrodynamics
  - -- Twin Formation
  - -- Dislocation Dynamics

*Properties* Associated with the phenomena being studied are specific material properties. The major keyword headings for properties are similar to those for phenomena:

- Strength
- Phase Transformation
- Spallation
- Stress-Volume
- Equation of State
- Residual
- Thermodynamic
- Porous
- Elastic
- Rheologic

However, the minor descriptors used in conjunction with these major descriptors are different. Again, examples of these more specific keywords are as follows:

- Strength:
  - -- Hugoniot Elastic Limit
  - -- Flow Stress
  - -- Static Yield Stress
  - -- Shear Strength
- Phase Transformation:
  - -- Latent Heat
  - -- Phase Boundary
  - -- Critical Volume
  - -- P-V-T Surface
- Spallation:
  - -- Spall Stress
  - -- Fracture Energy
  - -- Crack Size
  - -- Flow Morphology
- Stress-Volume:
  - -- Stress Versus Particle Velocity
  - -- Bulk Modulus
  - -- Compliance
  - -- Release Wave
  - -- Profile

*Materials* Also of great interest to the researcher are the materials studied in the reported effort. Currently, the major descriptors are as follow:

- Metals
- Geophysical
- Polymers
- Ceramics
- Inorganics
- Organics
- Composites
- Mixtures
- Liquids
- Explosives

Specific material designations are given as minor descriptors when known. These include the following examples:

- Metals:
  - -- Aluminum (6061-T6)
  - -- Copper (OFHC)
  - -- Gold (10 Percent Porous)
- Geophysical:
  - -- Dunite (Twin Sisters)
  - -- Tuff (Mt. Helen, Porous)
  - -- Dolomite (Porous, Water Saturated)

*Experimental methods* Keywords are included in this field to describe the methods and techniques, as well as geometric constraints. The major keyword descriptors used, along with examples of minor descriptors, are as follows:

- Loading:
  - -- Explosive Flyer Plate
  - -- Rail Gun
  - -- Underground Explosion
  - -- Exploding Wire
- Geometry:
  - -- Uniaxial Stress
  - -- Biaxial Strain
  - -- Spherical
  - -- Expanding Ring

- Instrumentation:
  - -- Carbon Gage
  - -- Displacement Interferometer
  - -- Manganin Gage
  - -- Emission Spectroscopy

*Experimental results* The reported experimental results are also delineated with major and minor descriptors as follows:

- Active:
  - -- Free Surface Velocity
  - -- Wave Profile
  - -- Release Adiabat
  - -- X-Radiograph
- Passive:
  - -- Microstructure
  - -- Dislocations
  - -- Residual Strain
  - -- Chemical Analysis

*Theory/model* Some papers develop, describe, and/or use specific theories or models. Indications as to whether a paper is theoretical in nature (that is, a theory is developed) or analytical in nature (a previously developed theory is used to analyze a specific problem) are given in the special emphasis field discussed previously. In the theory/modeling field, the following major descriptors can be used:

- Elastic-Plastic
- Spallation
- Phase Transitions
- Porous
- Mixtures
- Composites
- Mechanics
- Micromechanical
- Thermodynamic
- Statistical Mechanics
- Solid State
- Radiation Transport
- Stability
- Explosive

Typical minor descriptors include:

- Elastic-Plastic:
  - -- Rigid-Plastic
  - -- Thermoelastic
  - -- $J_2$ Flow
  - -- Tresca Yield
- Spallation:
  - -- P-Minimum
  - -- Tuler-Butcher
  - -- NAG-FRAG
  - -- Statistical Fracture

*Computational methods* If computational/numerical techniques are used in the paper, then they are delineated in this field. Major descriptors and examples of minor descriptors are as follows:

- Code:
  - -- CSQ (2-D)
  - -- PISCES
  - -- MAGEE
  - -- MARBLE
- Type:
  - -- Lagrangian
  - -- Eulerian
  - -- Free Lagrangian
  - -- Hydrocode

- Method:
  - -- Finite-Difference
  - -- Boundary Element
  - -- Characteristics
  - -- Monte Carlo
- Techniques:
  - -- Implicit
  - -- Lax-Wendroff
  - -- Rezoning
  - -- Keystone Viscosity

*Applications* Particular applications for the reported research, if given in the paper, are included in this descriptor field. Typical applications descriptors include:

- Ballistic Impact
- ICF
- Metal Working
- Underground Testing
- Explosive Initiation
- Geophysics

### D. *SUPPLEMENTAL INFORMATION*

It has been found from experience that no matter how judicious the selection of keywords or identifiers, only limited information can be conveyed by this method. While a judicious selection of keywords, and a combination of keywords, can limit the articles to a manageable number, three supplemental information fields have been added to the database to supply further information on the technical content of a paper.

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*Abstract* An abstract field contains an abstract of the paper content. Where possible, the original abstract of the paper is used. If no abstract was included by the original authors, a suitable abstract is then written by the technical reviewer who is assigning the technical keywords.

*Additional information* This field is used by the technical reviewer to comment on the content of the paper with any information which might be relevant and informative to someone searching the database.

*Data summary* The data summary field provides space for table headings and figure captions. At a later date, this field could be expanded to include experimental data.

## III. DATABASE DICTIONARIES

Several dictionaries are being developed to aid in searching the SSC Database. A dictionary of keywords has been prepared and lists the acceptable set of keywords. This dictionary, including all major and minor descriptors, is the result of several iterations with a test phase of approximately fifty reports covering a wide range of technical issues in the area of shock-compression, including journal articles, articles from foreign journals, government reports, symposium presentations, and review papers. By limiting the number of keywords and making a list of these available to the individual searching the database, it is hoped that searches will be both straightforward and fruitful.

An author dictionary is also being prepared which lists alphabetically all authors in the database. This dictionary serves a number of purposes. In the process of adding new papers to the database, it is used in checking the spelling of the author's names, and it is used to check for duplicate papers already in the database. For the individual searching the database, it supplies a complete list of authors in the database and the exact spelling used.

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## IV. COMPUTERIZED SEARCH OF THE DATABASE

In principle, all fields in the database are searchable. Generally, though, searchable fields would be authors and acknowledgements, affiliations, and the technical keywords. Searches combining several fields would tend to focus the search and limit unwanted finds. For example, searches of a specific author's name and a period of time could be made by combining a search of the author field and the submission date field (or the Paper ID field). Likewise, a combination of keyword fields could become very specific.

Currently, the SSC Database can be searched using a terminal connected directly to the VAX computer in the Thermomechanical and Physical Division of the Sandia National Laboratories. The user will eventually have the opportunity to search the database via a "user friendly," menu-driven CRT display inquiry system, with an option to print the information on relevant reports retrieved by the database. An example of the information in a retrieved document was shown earlier in Fig. 1. Although searches are currently limited to terminals directly tied to the Sandia VAX, plans are being formulated for making the database available to the general public within the next several years. Anyone wanting information pertaining to this access should contact Dr. J. R. Asay or Dr. R. A. Graham of the Sandia National Laboratories.

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## V. ~~PROGRESS~~ TO DATE

There are currently 2,500 documents ~~in the~~ database after approximately thirteen ~~months of~~ effort, which has included several ~~drafts of~~ the elete

Technical Keyword Dictionary, establishing the required tables in INGRES (the particular database package being used), and entering the data. Work is just beginning on reviewing and entering the technical keywords. By May 1986, the goal is to have entered in excess of 3,000 documents with bibliographic citations and abstracts, of which approximately 1,900 of these articles will be complete with technical keywords and additional comments, primarily in the area of strength, phase transformation, and stress-volume.

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## VI. ACKNOWLEDGEMENTS

This work performed at Sandia National Laboratories supported by the U. S. Department of Energy under Contract Number DE-AC04-76DP00789.

Figure 1. Example of Database Information

| | |
|---|---|
| **Chrono Paper No.:** | 0017 |
| **Paper ID:** | 75B001 |
| **Authors:** | Bertholf, L. D., Buxton, L. D., Thorne, B. J., Byers, R. K., Stevens, A. L., and Thompson, S. L. |
| **Title:** | Damage in Steel Plates from Hypervelocity Impact. II. Numerical Results and Spall Measurement |
| **Source:** | J. Appl. Phys. 46 (9), 3776-3783 (1975) |
| **Original Publ.:** | * |
| **Submission Date:** | Feb. 24, 1975 |
| **Affiliation:** | Sandia Laboratories, Albuquerque, NM |
| **Acknowledgements:** | Bond, J. W., Shockey, D. A., Curran, D. R. and Herrmann, W. |
| **Special Emphasis:** | [numerical] |
| **Mater. Response:** | [mechanical] |
| **Phenomena:** | [phase transformation] mixed phase, polymorphic<br>[impact] cratering, spall |
| **Properties:** | [spallation] spall strength |
| **Materials:** | [metals] steel<br>[polymers] nylon |
| **Exper. Method:** | [loading] flyer plate<br>[instrumentation] visar<br>[geometry] plane strain |
| **Exper. Result:** | [active] free surface velocity<br>[residual] cross-sectional photograph |
| **Theory/Model:** | [elastic-plastic] elastic-perfectly plastic |
| **Comput. Method:** | [code] toody, csq, toorez<br>[type] lagrangian, eulerian<br>[techniques] rezone |
| **Applications** | penetration, cratering |
| **Additional Info.:** | Limited spall strength measurement. Only one isolated hypervelocity impact experiment. Numerical prediction of spall depended upon mesh size |

Figure 1. Example of Database Information (continued)

**Chrono Paper No.:** 0017

**Abstract:**

Comparisons of calculated solutions with experimental solutions with experimental results for the impact of a 9.53-mm-diam nylon sphere on a 12.7-mm-thick steel plate at 5.182 km/sec are presented. Numerical solutions are difficult to obtain with existing Eulerian codes because of the need for accurate treatment of material strength and the definition of both the material interface and the free surfaces. The large distortion of the nylon sphere and the steel near the impact crater lip also make this a difficult problem for Lagrangian codes unless frequent rezoning is used. Newly developed Eulerian and Lagrangian rezoning codes are used. They give essentially the same solution. The computation results show that in order to obtain agreement with the experiment, it is necessary to account for the alpha (bcc)==epsilon (hcp) polymorphic phase change for iron. Calculations also indicate the need to obtain experimentally the correct spall strength for the steel and a description of this measurement is included. Treatment of elastic-plastic response, a good numerical model for fracture, and a high degree of numerical resolution are also shown to be necessary in order to predict accurately the back-surface spallation observed in the experiment.

**Data Summary:**

Fig. 1 - Hugoniot states for iron (pressure vs. density).
Fig. 2 - Comparison of code calculations (Eulerian & Lagrangian) with experiment.
Fig. 3 - Effect of polymorphic phase change of iron.
Fig. 4 - Free surface velocity history of planar impact of two steel plates.
Figs. 5-6 - Comparison of code calculations with experiment.
Table 1 - Material properties used for calculations.
Table 2 - Calculated spall strengths in steel for various calculational methods.