Mechanical Engineering Department

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Technical Abstracts for the Period January—June 1985

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University of California • Livermore, California • 94550

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Preface

Twice a year the Lawrence Livermore National Laboratory (LLNL) Mechanical Engineering (ME) Department publishes Technical Abstracts to inform readers of the broad range of technical activities in the Department, and to promote an exchange of ideas. This report covers the period January through June 1985 and contains 116 abstracts. Details of the work covered by an abstract may be obtained by contacting the author(s).

Each abstract is identified by a report number. Most abstracts are taken from a published document: a Laboratory report, journal article, or meeting paper. However, some abstracts in this report are the sole extent of the published work and, therefore, do not represent the contents of any other, larger work. Some abstracts have received additional editing to meet specific requirements of the present document.

The abstracts are arranged alphabetically by first-listed author. For consecutive abstracts having the same first-listed author, the abstracts are arranged by report number. "ABS" stands for "abstract" and "SUM" stands for "summary."

Three indexes are provided: key word, author name, and report number. Each abstract entry is identified by a letter/number indexing term; the letter matches the surname of the abstract's first-listed author, and the number is the sequential order of the abstract within the letter grouping.

General information about the current role and activities of each of the Department's seven divisions is given in an appendix. Further information about a division's work may be obtained from the division leader, whose name is given at the end of each divisional summary.

Howard Woo
Technical Editor

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Abstracts

A1

UCID-20350
NUREG/CR-4179, Vol. 1
(315 pages)

H.F. Alesso, T.J. Altenbach, P.G. Prassinis,
D.A. Lappa, C.Y. Kimura, C.J. Patenaude,
J.J. Sacks,* B.C. Ashmore,* D.C. Fromme,*
M.V. Hershberger,* C.F. Smith†
and W.J. Williams‡

*Digraph Matrix Analysis for Systems Interactions at
Indian Point Unit 3, Volume 1: Main Report*

Prepared for the U.S. Nuclear Regulatory
Commission

Key Words: Digraph matrix analysis, nuclear
power plants, risk assessment,
systems interactions

Studies of the events at Three Mile Island-2, Browns Ferry-3, and Crystal River-3 have indicated that complex systems interactions can occur as a result of dependent failures. Methods for identifying these intersystem dependencies have been limited. As a result, the U.S. Nuclear Regulatory Commission (NRC) is pursuing a program to define methodologies that will characterize the spatial and functional coupling of nuclear power plant systems.

At present, the NRC is considering two methodologies for system interaction studies. One approach is the expansion of the fault tree analysis portion of probabilistic risk assessments (PRA) by putting additional emphasis on dependence analysis techniques. The second approach is based on graph-theoretic methods utilizing a conditioned matrix representation of logic diagrams called digraph matrix analysis (DMA). This risk assessment technique is applied in conjunction with an event tree analysis identification of accident sequences or system combinations.

This report documents DMA methodology and the analysis of the Indian Point Plant, Unit 3, for adverse systems interactions using DMA. The primary objective of the study was to compare the effectiveness of DMA in finding systems interactions. To this end, a parallel study was funded at Brookhaven National Laboratory (BNL). The results of this study and the BNL

study will then be compared by the NRC to the results of a similar study performed by the Power Authority of the State of New York. A secondary objective of this study was to determine systems interactions in selected combinations of safety systems at Indian Point-3.

*Analytic Information Processing, Inc., Danville, California, now out of business

†Science Applications, Inc., Pleasanton, California, name now changed to Science Applications International Corp. (SAIC).

B1

UCRL-90580, Rev. 1
(54 pages)

D.J. Benson and J.O. Hallquist

*A Simple Rigid Body Algorithm for Structural
Dynamics Programs*

Prepared for the *International Journal for
Numerical Methods in Engineering*

Key Words: Dynamic structural analysis,
impact analysis

The analysis of low velocity impacts is necessary for designing everything from safe automobiles to safe shipping casks for nuclear material. However, the cost of impact analysis must be further reduced before impact analysis becomes a routine design tool. One approach replaces the mesh outside of the impact zone with a rigid body.

Structural dynamics and the rigid body dynamics of mechanisms are commonly regarded as two distinct fields both theoretically and in computational practice despite their common foundation in Newton's Second Law. The central reason for this perception is that Newton's Second Law is rarely used directly in computations.

One unfortunate consequence in both fields is that ideas developed in one area are often ignored in the other field. Another consequence is that many problems of importance are not adequately addressed by either field because they do not fit neatly into a single category. When hydrodynamics researchers realized years ago that pure

Eulerian and Lagrangian codes could not solve all of their problems, they unified the viewpoints mathematically and produced codes using both descriptions. Our goals are similar with respect to structural dynamics and rigid body dynamics.

In this paper, structural dynamics and rigid body dynamics are reviewed and reunited by deriving the weak form of Lagrange's equation with quasi-coordinates and showing that the classical formulations in the two fields are readily derived from it. Furthermore, a formulation for efficiently handling problems with aspects of both structural and rigid body dynamics is presented.

B2

UCRL-92218
(8 pages)

D.J. Benson, J.O. Hallquist, and D.W. Stillman

DYNA3D, INGRID, and TAURUS—An Integrated, Interactive Software System for Crashworthiness Engineering

Prepared for the 1985 ASME Computers in Engineering Conference, Boston, Massachusetts, August 4-8, 1985

Key Words: Crashworthiness analysis, DYNA3D (computer program), INGRID (computer program), TAURUS (computer program)

Crashworthiness engineering has always been a high priority at LLNL because of its role in the safe transport of radioactive material for the nuclear power industry and the military. As a result, the authors have developed an integrated, interactive set of finite element programs for crashworthiness analysis.

The heart of the system is DYNA3D, an explicit, fully vectorized, large deformation structural dynamics code. To generate the large and complex data files for DYNA3D, INGRID, a general purpose mesh generator, is used. With its efficient hidden line algorithms and many options for specifying geometry, INGRID also doubles as a geometric modeler. TAURUS, an interactive post processor, is used to display DYNA3D output. In addition to the standard functions, TAURUS generates interactive color displays on eight-color video screens by plotting color bands superimposed on the mesh, which indicate the value of the state variables.

In this paper, the basic methodologies of the programs are presented along with several crashworthiness calculations.

B3

UCID-20421, Vol. 1
(616 pages)

D.L. Bernreuter, J.B. Savy, R.W. Mensing, J.C. Chen, and B.C. Davis

Seismic Hazard Characterization of the Eastern United States, Volume 1: Methodology and Results for Ten Sites

Key Words: Methodology, Seismic Hazard Characterization Project, seismic risk analysis

The Eastern United States Seismic Hazard Characterization (SHC) Project is the outgrowth of an earlier study performed as part of the U.S. Nuclear Regulatory Commission's (NRC) Systematic Evaluation Program (SEP). The objectives of the SHC Project are: (1) to develop a seismic hazard characterization methodology for the region east of the Rocky Mountains, and (2) to apply the methodology to ten sites to assist the NRC staff in their assessment of the implications in the clarification of the U.S. Geological Survey (USGS) position on the 1886 Charleston earthquake.

As in the SEP, the fundamental characteristic of the methodology used in the SHC Project is in using opinions of panels of experts for all the input data. The most important improvement over the methodology used in the SEP leads to an estimate of the distribution of the hazard rather than just point estimates. An important aspect of eliciting expert opinion consists in holding feedback meetings in order to fine tune the methodology and the input data. Estimates of the hazard peak ground acceleration and spectral velocity at ten representative sites are discussed including a sensitivity analysis and a comparison with the SEP results at four sites. The methodology and the data were analyzed by a panel of experts in a formal peer review process to identify the weak points in the analysis and to recommend improvements.

The results were also compared with results obtained by using other methodologies such as

the "Historical" method and other zonation and seismicity data provided by USGS. The method developed in this project leads to stable results in good agreement with other methods.

Volume 2 contains all of the questionnaires and reports provided to our panels.

B4

UCID-20421, Vol. 2
(364 pages)

**D.L. Bernreuter, J.B. Savy, R.W. Mensing,
J.C. Chen, and B.C. Davis**

Seismic Hazard Characterization of the Eastern United States, Volume 2: Questionnaires

Key Words: Seismic Hazard Characterization Project, seismic risk analysis

This volume contains the information given to the two panels of experts: the Seismicity Panel and the Ground Motion Model Panel. Included are copies of the six questionnaires sent to the panel members.

The detailed responses to questionnaires Q1-Q4 are not given in this volume since they were not final; the detailed description of these responses is given in our interim report. Questionnaire Q6, which is the feedback questionnaire to the Ground Motion Panel, contains a complete summary of the responses to the previous questionnaire to the Ground Motion Panel.

The final set of responses, as they were used in the analysis, is presented in detail in Volume 1, of this report, which presents the methodology and results of the Seismic Hazard Characterization Project.

B5

UCRL-92433, Rev. 1
(8 pages)

M.O. Bishop, L.C. Smith, and D.F. Edwards

Slumping of Neutral Density Glass

Prepared for Fusion

Key Words: Density, glass, laser radiation shields Nova

The glassblowing laboratory at LLNL was recently requested to fabricate a number of

cylinders from a neutral-density glass. These cylinders serve as laser radiation shields in the diagnostics section of the LLNL Nova fusion laser system. The smaller cylinder surrounds a calorimeter cup and absorbs stray light striking the back and sides of the calorimeter. Both shield applications required a durable volume absorbing material such as the neutral density glass rather than an anodized metallic surface, which would be vaporized by the incident laser radiation. This vaporized metal could then deposit on optical surfaces seriously degrading their performance.

Discussion with one manufacturer indicated that the filter glasses were not easily reshaped under heat. In this paper, we briefly describe a slumping method we have discovered and have successfully applied to natural density glasses from two manufacturers. The yield for the polished pieces has been nearly 100% and about 80% for the matte pieces.

B6

UCRL-92746-ABS
(1 page)

R.L. Brady

Current Status in Development of Averaging Laser Strainometer and Testing System

Prepared for the Fourth IMOG Testing Seminar, Miamisburg, Ohio, June 19, 1985

Key Words: Lasers, strain gages

The advent of a new method of sweeping a laser beam to accurately measure a shadow image offers the ability to track fiducial positions on a remotely located specimen during compressive deformation.

A new commercial low-power, continuous-wave laser system designed for metrological applications is being applied to the testing of a delicate, brittle, notch-sensitive hygroscopic material requiring dry box enclosure. An integrated testing system is being developed to provide remote strain sensing of minimum, maximum, and average surface strains on the cylindrical portion of a compression specimen. The system additionally provides the means to compensate for bending strains observed in pre-test alignment evaluation. The results of the development of the testing fixture to date are discussed.

B7**UCRL-92542-ABS**
(1 page)**G.L. Brandt, M.O. Calderon,
and V.L. Williamson***Computer Aided Design on the Tandem Mirror
Experiment-Upgrade (TMX-U)*Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985

Key Words: Computer-aided design, TMX-U

The Tandem Mirror Experiment-Upgrade (TMX-U) at LLNL has been using a computer aided design (CAD) graphics system to enhance its design capabilities since November of 1984. Three-dimensional models of the TMX-U magnet set, neutral beams, plasma, and the containment vessel have been modeled on the system. These models are used for location interrogation, diagnostic placement, interference checking, finite element modeling, and visualization of complex shapes generated on mainframe computers. Four other fusion laboratories have purchased this same CAD system. The sites are linked together to allow for the exchange of design files and the transfer of physics and engineering data.

This paper gives examples of how the CAD system has been used to solve design and engineering problems for TMX-U. In addition, future usage of the system is examined.

B8**UCRL-92544-ABS**
(1 page)**C.A. Brooksby, S.L. Allen, L.R. Pedrotti,
T.C. Simonen, B.E. Wood, and W. Hsu****A Halo Recycler for the Tandem Mirror Experiment-
Upgrade (TMX-U)*Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985

Key Words: Design, halo, TMX-U

The halo recycler is a mechanical device on the Tandem Mirror Experiment-Upgrade (TMX-U) that is designed to increase the density at the plasma edge, providing enhanced shielding of the core plasma from background neutrals. Each recycler body consists of coaxial annular cylinders and a surrounding plenum that closely follow the plasma and halo edges in the transition region of TMX-U. The chambers are provided with gas feed and pressure measurement systems as well as Langmuir probes. This paper describes the design, fabrication, and installation of these devices.

*Sandia National Laboratories, Livermore,
California.

B9**UCRL-92545-ABS**
(1 page)**C.A. Brooksby, M.O. Calderon, W.F. Cummins,
S.W. Ferguson, and V.L. Williamson***Ion Cyclotron Resonant Heating (ICRH) Slot
Antenna for the Tandem Mirror Experiment-Upgrade
(TMX-U)*Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985Key Words: Cyclotron resonance, ion sources,
plasma heating, TMX-U

The ion cyclotron resonant heating (ICRH) slot antenna is an integral part of the ion and electron plasma heating system in the center cell region of the Tandem Mirror Experiment-Upgrade (TMX-U). The antenna is a slotted, hollow tube that completely surrounds and conforms to the plasma shape in the east end of the center cell region. It has been consistently operated to the present maximum transmitter output of 280 kW.

This paper presents the mechanical design and arrangement of the antenna, feeds, feedthroughs, and matching network for the slot antenna.

B10

UCRL-92546-ABS
(1 page)

C.A. Brooksby, S.W. Ferguson, A.W. Molvik,
and J. Barter*

*Ion Cyclotron Resonant Heating (ICRH)
2 x 170 deg Loop Antenna for the Tandem Mirror
Experiment-Upgrade (TMX-U)*

Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985

Key Words: Cyclotron resonance, ion sources,
plasma heating, TMX-U

This paper reviews the mechanical design and improvements that have taken place on the loop-type ion cyclotron resonant heating (ICRH) antenna that is located in the center cell region of Tandem Mirror Experiment-Upgrade (TMX-U).

The new ICRH loop antenna consists of two kidney shaped antennas that each subtend an arc of approximately 170 deg around the plasma. Each kidney-shaped element is comprised of three turns. The system now operates reliably with peak rf voltages of 40 kV at 2-4 MHz, up to 200 kW.

*TRW, Redondo Beach, California.

B11

UCRL-92682
(9 pages)

J.B. Bryan and D.L. Carter

*Single-Point Diamond Crushing of Zerodur with
In-Situ Polishing and Metrology on a Diamond
Turning Machine*

Prepared for the Glancing Incident Optics
Fabrication Workshop, Annapolis, Maryland,
April 1, 1985

Key Words: Diamond turning, optical glass,
single-point machining, Zerodur

Large, complicated, aspherical optical elements
of glass are presently used in many astronomical

devices, both on land and in space. At LLNL, we are currently making near-arc second quality mirrors which will be used in the EUV Explorer Satellite. The next generation of grazing incidence telescopes will need arc-second resolution. For optimum stability and accuracy, the substrate must be a glass/ceramic material such as Zerodur. These families of optics are difficult to fabricate from glass by conventional methods because of the imprecise metrology available to guide the polishing from the rough blank to the point where precise interferometric metrology can be applied. We feel that the fabrication of these mirrors can best be achieved by applying precision machining techniques and precision machines for figuring and finishing low-expansion glasses such as Zerodur. In this paper, we present a brief description of the machining, finishing, and metrology techniques.

C1

UCRL-92549-ABS
(1 page)

M.O. Calderon and H.H. Bell, Jr.

*Tandem Mirror Experiment-Upgrade (TMX-U)
Overview/Recent Events*

Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985

Key Words: Thermal barriers, TMX-U

Since its construction and commissioning in the winter of 1981, the Tandem Mirror Experiment-Upgrade (TMX-U) has been conducting tandem mirror thermal barrier experiments. The work following the fall of 1983, when strong plugging with thermal barriers was achieved, has been directed at controlling radial transport and forming thermal barriers with high density and Beta.

This paper describes chronologically (1) the overall engineering effort, (2) the changes and additions to the diagnostic system as they have evolved, and (3) the initial study work for a proposed TMX-U octupole-configured machine.

C2**UCIR-1540**
(32 pages)**A.H. Cassell, Technical Editor***Multiprogram Technologies of the Mechanical Engineering Department***Key Words:** Technology

The LLNL Mechanical Engineering Department has identified a number of individuals within the Department to serve as Technology Leaders in those areas that are important to the programs supported by the Department. The Technology Leaders have the primary responsibility for developing and maintaining a knowledge of the state-of-the-art in these areas. The Leaders also serve as a primary resource for the Department and the Laboratory.

This report lists each multiprogram technology and identifies its Technology Leader by LLNL Division and by name, along with a portrait photograph. A brief description and application of each multiprogram technology is given.

design requirement. Direct DEGB is defined as pipe failure caused by crack growth and instability at welded joints; indirect DEGB is defined as pipe failure due to causes other than crack growth, such as the seismically-induced failure of component supports.

This report assesses the reactor-coolant-loop piping system of west coast Westinghouse plants. There are three Westinghouse plant sites on the west coast: Trojan, Diablo Canyon 1 and 2, and San Onofre 1. These plants are considered separately from the eastern Westinghouse plants since they are situated in a more seismically active region. Trojan and Diablo Canyon are evaluated here.

The results indicate that directly induced DEGB is an unlikely event in the west coast Westinghouse plants. For the Trojan plant, leak is far more likely than a direct DEGB. Furthermore, earthquakes have very little effect on the probabilities of leak and direct DEGB. At the Diablo Canyon plant, the increase in postulated seismic levels due to reevaluation of the site to account for the Hosgri Fault has caused directly induced DEGB failure probability to be dependent on earthquake occurrences. The resulting direct DEGB failure probability is still much lower than the indirect DEGB failure probability for Diablo Canyon.

C3**UCID-19988, Vol. 4**
NUREG/CR-3660, Vol. 4
(46 pages)**D.J. Chinn, G.S. Holman, T.-Y. Lo,
and R.W. Mensing***Probability of Pipe Failure in the Reactor Coolant Loops of Westinghouse PWR Plants, Volume 4: Pipe Failure Induced by Crack Growth in West Coast Plants***Key Words:** Nuclear power plants, pipe failure, PWR, reactor coolants

The U.S. Nuclear Regulatory Commission contracted with LLNL to conduct a probabilistic assessment of the primary coolant piping of all nuclear power plants in the United States. The goal was to determine if the probability of occurrence of direct and indirect double-ended guillotine breaks (DEGB) is small enough to safely eliminate the postulation of DEGB in the

C4**UCRL-92273**
(9 pages)**T.Y. Chuang, D.L. Bernreuter, J.E. Wells,
and J.J. Johnson****Seismic Risk Assessment of a BWR: Status Report*

Prepared for the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985

Key Words: BWR, PWR, seismic risk analysis, SSMRP

The seismic risk methodology developed in the U.S. Nuclear Regulatory Commission's Seismic Safety Margins Research Program (SSMRP) was

demonstrated by its application to the Zion nuclear power plant, a pressurized water reactor (PWR). A detailed model of Zion—including systems analysis models (initiating events, event trees, and fault trees), SSI and structure models, and piping models—was developed and analyzed. The SSMRP methodology can equally be applied to a boiling water reactor (BWR). A seismic risk analysis is being performed on the LaSalle County Station nuclear power plant to: (1) demonstrate its applicability, (2) identify fundamental differences in seismic risk between a PWR and a BWR, and (3) provide a basis of comparison of seismic risk between a PWR and a BWR when analyzed with comparable methodology and assumptions.

*NTS/Structural Mechanics Associates, San Ramon, California.

C5

UCRL-92443
(26 pages)

R.C. Chun and T.Y. Chuang

Parametric Study of the Amplification Factor in the Energy Balance Method

Prepared for the American Society of Mechanical Engineers Winter Annual Meeting, Miami Beach, Florida, November 17-22, 1985

Key Words: Amplification factor, energy balance method, nuclear power plants, piping systems

This paper represents a parametric study of the amplification factor to account for rebound effects in the energy balance method used in structural analysis of nuclear power plant piping systems. Of the 66 distinct cases we chose for our parametric study, the amplification factor of 1.1 seems sufficient except in four borderline cases where the carbon steel pipes are small or have very small gaps between the pipes and the pipe whip restraints. We conclude that the amplification factor generally decreases as the parameters gap size, hinge-to-break distance, and overhang increase.

C6

UCRL-53582
(89 pages)

D.W. Coats and R.C. Murray

Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites

Key Words: DOE critical facilities, models, seismic risk analysis

Development of seismic and wind hazard models is part of a three-phase effort aimed at establishing uniform building design criteria for seismic and wind hazards at Department of Energy sites throughout the United States. In Phase 1, we gathered information on the sites and their critical facilities, including nuclear reactors, fuel-reprocessing plants, high-level waste storage and treatment facilities, and special nuclear material facilities.

In Phase 2, we initiated development of seismic and wind hazard models. The hazard models express the annual probability that the site will experience an earthquake or wind speed greater than some specified magnitude. This report summarizes the final seismic hazard models and response spectra recommended for each site and the methodology used to develop these models. Wind/tornado hazard models were published separately in UCRL-53526.

In Phase 3, it is anticipated that the Department of Energy will use the hazard models to establish uniform criteria for the design and evaluation of critical facilities.

(Main report body: 22 pages; Appendix, composed of data plots: 67 pages.)

C7

UCID-20364
(5 pages)

W. Comfort III and R. Davis*

Micro-CAE Mechanical Engineering Software Development

Key Words: Computer-aided engineering, computer software

A concept in microcomputer-aided engineering (micro-CAE) has been evolving and maturing at LLNL during the past 4 years. In harmony with

the goals of the project, several universities are participating in the development of software that will be useful both to engineering colleges and to practicing engineers. The goals of the project are to

- (1) develop, collect, and/or convert approximately 40 software packages and
- (2) transfer micro-CAE technology/software to universities.

Micro-CAE is special-purpose microcomputer graphics-augmented software for aiding engineers in modeling physical events and designing systems. The software is characterized by (1) user-system interactivenss, (2) high degree of system friendliness, and (3) heavy dependence on automatic graphics interpretation. The software will be made available to run under CP/M and MS-DOS operating systems.

Current status of the micro-CAE effort and effective implementation strategies are discussed.

*Northern Arizona University.

may choose from five standard spring materials whose strengths are modeled, within the software, as a function of wire diameter. Because static, transient, and continuously oscillating loads are considered, fatigue models for both torsion and bending are also included. The acceptable design options are chosen from 27 standard wire diameters. The user defines design constraints and parameters in response to menus and prompts displayed by SPRING.

Included in the manual are the following topics and material: method of calculation, design constraints, software and system information, executing SPRING, references, examples of results using SPRING, list of variables and constants, and SPRING program listing.

C9

UCRL-92376
(19 pages)

B.D. Cook* and G.D. Poe

Lommel Diffraction Correction for Different Size Transducers: Gaussian-Laguerre Formulation

Prepared for the *Journal of the Acoustic Society of America*

Key Words: Acoustic microscopes, diffraction, transducers

In this paper we present an alternate formulation for the diffraction correction for two coaxial, circularly symmetric piston transducers, one transmitting and one receiving. Other researchers have solved this problem for the case of the two transducers being the same size. We present a form that allows calculations when the two transducers are of different size. The answer is not exact but involves the Fresnel approximation to the diffraction integral. Previous literature denotes the solution of this approximate form as the Lommel diffraction integral. In previous papers, Cavanagh and Cook have shown the features of Gaussian-Laguerre modes are useful for calculating the fields of circular ultrasonic transducers with and without focusing. We show that it is possible to integrate over these fields, the result being a not too complex algorithm. It is now possible to extend these results to focused transducer systems. One particular goal is to model the reflection acoustic microscope.

*University of Houston, Houston, Texas.

C8

UCID-30200-83-3
(29 pages)

W.J. Comfort III

Spring: Helical Spring Design Software for Microcomputers

Key Words: Computer-aided engineering, computer software, helical springs, SPRING (computer program)

This document is a program manual for the μ CAE Program, SPRING. μ CAE (computer-aided engineering with microcomputers) is the use of special-purpose software to aid engineers in design and analysis. It is characterized by: (1) user-friendly software packages, (2) intensive user/system interaction, and (3) (usually) graphics augmentation.

SPRING has been developed for use in designing helical compression, extension, and torsion springs. It provides only those design options lying within feasible design space, which is that portion of a design space where no design constraints are violated. Design constraint definitions result from user specifications, material properties, and good design practice. The user

C10**UCRL-92093**
(5 pages)**R.H. Cornell***Experimental Investigation of Dynamic Motions of an Internal Part in an Artillery Projectile*

Prepared for the 12th Conference of Atmospheric Flight Mechanics, Snowmass, Colorado, August 19-21, 1985

Key Words: Dynamics testing, gyroscopes, projectiles

A particular developmental artillery projectile contains a partially restrained internal member (PRIM) that has the capability of limited radial and tilt movements relative to the spin axis. Present theory predicts that the PRIM should cause a reduction in spin and growth in yaw resulting in significant range loss. However, yaw growth associated with PRIM-induced instabilities were not observed during flight tests. We instituted a program of laboratory experiments to find why there was no observed PRIM effects. The first of these experiments were done with a two-degree-of-freedom gyroscope. This apparatus and resulting data are the subject of this paper.

D1**UCRL-92161**
(18 pages)**E.N.C. Dalder and J.W. Morris, Jr.***Cryogenic Structural Materials for Superconducting Magnets*

Prepared for the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985

Key Words: Construction materials, cryogenics, superconducting magnets

Superconducting magnets are used for magnetic fusion energy devices and for accelerators that are used in particle-physics research. This paper

reviews some of the variety of engineering initiatives and research activities in the United States and Japan that bear on the development of high-field superconducting-magnet technology, especially the cryogenic structural materials used for magnet cases and support structures.

D2**UCRL-92368-ABS**
(1 page)**E.N.C. Dalder, L.J. Summers, and J.R. Miller***Selection and Evaluation of Structural Alloys for Force-Cooled Superconductor Sheaths*

Prepared for the 9th International Conference on Magnet Technology, Zurich, Switzerland, September 9-13, 1985

Key Words: Cladding, superalloys, superconducting magnets

The Nb₃Sn magnets that employ force-cooled conductors present unusual materials needs because, before the wire is heat-treated to form Nb₃Sn, the sheath material must be wrapped around the wire and welded in order to make the conduit. Hence, any sheath material must have good 4-K strength and toughness after having been welded and exposed to temperatures in the range 600-800°C for up to 200 hours. This suggests use of Fe- or Ni-based superalloys that are normally aged for long times in this temperature range.

In this paper, available 4-K mechanical property data is reviewed to develop systematic yield-strength/fracture-toughness relationships for Fe- and Ni-based superalloys and their fusion welds. These data are rationalized in terms of known precipitation behavior on aging in the above temperature/time range and correlated with attempts to optimize the coefficients of thermal contraction of candidate sheath alloy and Nb₃Sn cable in cooling from the reaction temperature range to 4 K. The results are recommended composition ranges and heat-treatment schedules that will make possible: (1) attainment of maximum high-field critical current density in the conductor, and (2) structural soundness of the conduit.

D3**UCRL-53591**
(36 pages)**B.C. Davis**

Empirical Development of Ground Acceleration, Velocity, and Displacement for Accidental Explosions at J5 or the Proposed Large Altitude Rocket Cell at Arnold Engineering Development Center

Key Words: Explosions, ground motion, shock waves

The purpose of this study is to assess the effects of ground shock in the event of an accidental explosion at the proposed Large Altitude Rocket Cell or the existing J5 rocket development test cell on the Arnold Engineering Development Center (AEDC), Arnold Air Force Station, Tennessee. The results will be used by Structural Mechanics Associates, of Newport Beach, California, to provide adequate tie-down and lateral-force design requirements for structures and also design data for buried and above-ground piping and ducting.

The assessment is accomplished by reviewing existing empirical relationships for predicting ground motion from ground shock. These relationships are compared with data for surface explosions at sites with similar geology and with yields similar to expected conditions at AEDC. Empirical relationships are developed from these data and a judgment made whether to use existing empirical relationships or the relationships developed in this study.

An existing relationship (Lipner et al.) is used to predict velocity; the empirical relationships developed in the course of this study are used to predict acceleration and displacement. The ground motions are presented in table form and as contour plots. Included also is a discussion of damage criteria from blast and earthquake studies.

This report recommends using velocity rather than acceleration as an indicator of structural blast damage. It is recommended that $v = 2$ ips ($v = 0.167$ fps) be used as the damage threshold value (no major damage for $v \leq 2$ ips).

D4**UCRL-92431-ABS**
(1 page)**B.C. Davis, S.E. Grinnell, and L.I. Starrh**

Evaluation of Method for Dynamic Impact Testing of Gypsum Concrete

Prepared for the 3rd Containment Symposium, Idaho Falls, Idaho, September 10-12, 1985

Key Words: Concretes, dynamics testing, Nevada Test Site, test holes

Light-weight gypsum concrete plugs are being considered for use as part of the stemming materials put in emplacement holes at the U.S. Department of Energy's Nevada Test Site. Before use of light-weight gypsum concrete can be implemented, its behavior under dynamic loading needs to be characterized. This report describes two series of impact tests that were conducted to evaluate (1) the merits of the test and the measurement method, and (2) the material properties under dynamic loading. The results of the testing are presented as stress-strain plots from which dynamic moduli for various strains are also plotted so that an evaluation of strain energy absorption to damage is made. Strain-strain plots are presented; the slope of each is the dynamic Poisson ratio for that strain rate.

D5**UCID-19975-1**
(314 pages)**J.N. Doggett, Scientific Editor**

Fusion Poter Demonstrations I and II

Key Words: FPD, MARS, magnets

This is an interim report that presents a summary of the first phase of the Fusion Power Demonstration (FPD) design study. During this first phase, we investigated two configurations (FPD-I and FPD-II), performed detailed studies of

major components, and identified and examined critical issues. In addition to these design-specific studies, we also assembled a mirror-systems computer code to help optimize future device designs.

The two configurations that we have studied are based on the MARS magnet configuration. The FPD-I configuration employs the same magnet set used in the fiscal year 1983 FPD study, whereas the FPD-II magnets are a new, much smaller set chosen to help reduce the capital cost of the system.

As a part of the FPD study, we also identified and explored issues critical to the construction of an Engineering Test Reactor (ETR). General Dynamics and Grumman Aerospace studied two of these systems—the high-field choke coil and the halo pump/direct converter—in great detail, and their findings are presented in this report.

An additional report will be produced in the early part of 1985 at the completion of the FPD-III phase of this study.

indicated selenium thicknesses of 5.5, 12.9, 37.5, 49.8 and 74.5 μm . The control of deposition rate and of coating thickness was facilitated using a commercially available closed-loop programmable deposition controller. The x-ray transmission of the coated substrates was measured using a tritiated zirconium source. The transmissivities of the film/substrate combination are presented for the range of energies from 4 to 20 keV.

E1

UCRL-91561, Rev. 1
(3 pages)

E.D. Erikson, P.L. Tassano, R.H. Reiss,
and G.E. Griggs

The Deposition of Selenium Coatings on
Beryllium Foils

Prepared for Nuclear Instruments and Methods in
Physics Research

Key Words: Beryllium, coatings, metal foils,
selenium deposition

A technique for preparing selenium films on 50.8- μm -thick beryllium foils is described. The selenium was deposited in vacuum from a resistance heated evaporation source. A water-cooled enclosure was used to minimize contamination of the vacuum system and to reduce the exposure of personnel to toxic and noxious materials. Profilometry measurements of the coatings

F1

UCRL-92566-SUM
(7 pages)

R.H. Fasholz

In-House Rebuilding of Conventional Machine Tools

Prepared for the IMOG Subgroup Spring
Meeting 1985, Oakridge, Tennessee,
May 8-9, 1985

Key Words: Machine tools, production

In the laboratory and in production facilities, conventional machine tools still enjoy a prominent place as a manufacturing medium. The reason lies with the flexibility that conventional tools allow and their low cost. A problem that persists is the lack of good quality conventional machine tools. Today, many builders offer high cost computer-numerical-control equipment, while producing a small line of conventional mills or lathes as a sideline. Used machines are frequently of dubious value. But many plants still have a good stock of conventional machines ready to be put to use, leaving us with the option to rebuild those tools that are still serviceable.

Rebuilding can be accomplished in-house or through outside rebuilding contractors. At LLNL, we have used both sources. The advantages of performing in-house rebuilding are quality and cost control. One disadvantage is tying up personnel for an extended time.

This presentation traces the course of a rebuild project on a series-I Bridgeport milling machine, accomplished at LLNL from January through April 1985.

F2**UCRL-92541-ABS**
(1 page)**B. Felker, J.W. Heefner, R.R. Rubert,
and C.W. Williams***Changes and Developments in Electron Cyclotron
Resonant Heating (ECRH) on the Tandem Mirror
Experiment-Upgrade (TMX-U)*Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985**Key Words:** Cyclotron resonance, plasma
heating, TMX-U

This paper briefly describes the previously reported electron cyclotron resonant heating (ECRH) circular waveguide systems that deliver power to the Tandem Mirror Experiment-Upgrade (TMX-U) machine (see Paper 5A06, IEEE 10th Symposium on Fusion Engineering). Four of these systems helped establish electrostatic plugging in the end plugs of TMX-U. Discussed are changes to the hardware since December, 1983, that have affected operation of the 28-GHz, 200-kW pulsed gyrotron systems.

A fifth gyrotron is now being installed to power two resonant locations in the end plugs. A non-mode-preserving microwave power splitter will feed two waveguide runs that have a combined length of 11 meters. Each arm ends in a 1-meter long slot radiator that will pass 99% x-mode microwaves. The components of this system are also described.

F3**UCRL-92550-ABS**
(1 page)**B. Felker, J.F. Clauser, G.W. Coutts, B.H. Failor,
S.M. Hibbs, and E.H. Silver***X-ray Diagnostic System for the Tandem Mirror
Experiment-Upgrade (TMX-U)*Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985**Key Words:** CAMAC, TMX-U,
x-ray diagnostics

This paper describes the x-ray diagnostic system hardware on the Tandem Mirror Experiment-Upgrade (TMX-U). There are eight x-ray diagnostics used in studying the behavior of hot electrons and impurities. Three liquid-nitrogen-cooled, solid-state detectors and three sodium-iodide crystal detectors give time-resolved spectrometer data for two different energy ranges. Data from the detectors is acquired with modified commercial CAMAC hardware, while processing, display, and storage of that data is accomplished with a 32-bit desk-top computer. Two cameras are used to produce images of the x-ray intensities of the plasma. All detectors are surrounded by a double shield of 4-in.-thick lead and 8-in.-thick borated polyethylene to limit background noise generated by stray neutrons and x rays. Detailed descriptions of these diagnostics are presented.

X-ray images are produced by two different approaches. The first uses a magnetically-shielded, multistage image intensifier. The second uses a technique of exposing film to a sheet of x ray sensitive, optically fluorescent material. Details of these methods and their hardware are also presented.

F4**UCRL-90085**
(2 pages)**W.W. Feng***The Viscoelastic and Aging Characteristics of Polymer*Prepared for the International Symposium on
Non-Linear Deformation, Fracture, and Fatigue
of Polymeric Materials, Chicago, Illinois,
September 8-13, 1985**Key Words:** Aging (materials), polymers,
viscoelasticity

The theory of large elastic deformations has been developed by Rivlin and by Green and Adkins. With this theory, many finite elastic deformation problems for rubber-like materials have been solved. In reality, polymeric materials often exhibit viscoelastic and aging effects, yet very few analytical studies of these phenomena have been attempted from the continuum mechanics point of view, because the study of mechanics for polymeric materials must consider both geometric and material nonlinearities. The additional viscoelastic and aging effects make the analytical study very difficult.

In this paper, the viscoelastic effect of polymers subjected to simple extension is presented. The constitutive equation developed by Christensen is used. With two more material property functions, the constitutive equation is extended to include the aging effect of polymers. In experiments, the relaxation data for both unaged and aged specimens are obtained. Based on the formulation and test data, the viscoelastic and aging material properties are determined.

F5**UCRL-92301**
(8 pages)**W. W. Feng***Indentation of a Plane Membrane with a Rigid Paraboloid*

Prepared for the International Conference on Non-Linear Mechanics, Shanghai, China, October 28-31, 1985

Key Words: Geometry, nonlinear mechanics, paraboloids

The formulation and solution of the indentation of a rectangular nonlinear hyperelastic membrane by a rigid paraboloid is presented in this paper. The strain-energy-density function for the membrane is assumed to have the Mooney form. The total potential energy of the deformed membrane can be obtained by integration. Due to the presence of a rigid indenter, the total potential energy for a deformed membrane is subjected to an inequality constraint condition. A slack variable is introduced to convert the inequality constraint condition into an equality constraint condition. Furthermore, a substitutional method is used to eliminate one of the unknown variables. In order to solve for the remaining unknown variables, the Raleigh-Ritz method and the minimum potential energy principle are employed. The deformations of a

square membrane under various degrees of indentation are presented.

F6**UCRL-91019**
(12 pages)**L. E. Fischer***Spent Fuel Pin Temperature PC Code*

Prepared for the Waste Management '85 Meeting, Tucson, Arizona, March 24, 1985

Key Words: Pin temperatures, programs (computer), PWR, spent fuel storage

During an annual outage, a pressurized water reactor (PWR) may discharge 60 or more spent-fuel bundles into its storage pool. Most early PWRs were built to store 3 to 5 years of spent fuel in their pools, which are beginning to exceed their capacities. One method currently being developed and licensed for expanding spent-fuel storage capabilities is the dry storage of spent fuel in large casks. To reduce the probability of gross failures of fuel cladding during dry storage in casks, the fuel-pin design temperatures must be shown to remain within acceptable limits.

LLNL has developed, for the Nuclear Regulatory Commission, a personal computer (PC) code for calculating fuel-pin temperatures on the IBM PC; the code is useful in performing confirmatory analyses and comparing the results with those submitted by applicants applying for storage licenses. The code uses the Wootton-Epstein Correlation (WEC) to calculate the pin temperatures. An iterative type of solution is used to calculate the fuel-pin temperatures for specified heat fluxes and pin configurations. The WEC is based on a simplified radiative heat transfer model that replaces the fuel pin rows with equivalent concentric tubes. This paper describes the development and benchmarking of a pin-temperature computer code that is based upon the WEC concentric tube model.

F7**UCRL-92272
(10 pages)****L. E. Fischer***Fabrication Criteria for Shipping Containers Used to Transport Radioactive Materials*

Prepared for the Waste Management '85 Meeting,
Tucson, Arizona, March 24, 1985

Key Words: Fabrication, radioactive materials
handling and storage, shipping
containers

Criteria are identified for controlling the fabrication of metal components of shipping containers used for transporting radioactive materials. The criteria have been selected from the ASME Code and are based on the level of radioactive materials being transported and the nuclear safety function of the container's components. Criteria are identified for fabrication processes that are related to materials control, forming, heat treatment, examination, and acceptance testing. Implementation of criteria will ensure the structural integrity of shipping containers at levels consistent with the radioactive materials being transported.

F8**UCRL-92459
(25 pages)****L. E. Fischer, C. Y. Kimura, and M. C. Witte***An Evaluation of Current Regulations and Real Accident Conditions*

Prepared for the Waste Management '85 Meeting,
Tucson, Arizona, March 24, 1985

Key Words: Radioactive materials handling and
storage, shipping containers, spent
fuel storage, transportation safety

In 1984, a program was initiated by the U.S. Nuclear Regulatory Commission requesting LLNL to evaluate the level of protection provided by spent-fuel casks designed to current regulatory standards, if they were subjected to severe accident conditions during truck or rail transport. A two-stage screening process is used to assess the effectiveness of current standards and to evaluate the protection provided by the casks.

The first stage involves selection of loading parameters associated with real world accident scenarios and comparison with those associated with the test conditions specified in current regulatory standards. For those accident scenarios not initially screened out, the second-stage screening process involves assessment of the scenarios' probability and potential consequences in terms of the expected magnitude and characteristics of any potential radioactive source that could be released.

This paper presents the results of the evaluation performed for the hypothetical 30-foot drop onto an unyielding surface and real world impact conditions that might be experienced by a spent-fuel cask being transported by a truck.

G1**UCID-20330
NUREG/CR-4142
(307 pages)**

**A. A. Garcia, D. L. Bernreuter, T. E. McKone,
P. D. Smith, P. J. Amico,* J. W. Reed,†
M. W. McCann, Jr.,‡ P. R. Davis,‡ and
G. Apostolakis‡**

A Review of the Millstone 3 Probabilistic Safety Study

Prepared for the U.S. Nuclear Regulatory
Commission

Key Words: LWR, Millstone 3,
risk assessment

LLNL has conducted a review of the Millstone Unit-3 Probabilistic Safety Study (PSS) for the Office of Nuclear Reactor Regulation (NRR) of the Nuclear Regulatory Commission (NRC). This project is one of several in a larger NRR probabilistic risk assessment (PRA) review program in which PRAs performed and submitted to the NRC by selected light water reactor (LWR) plants in response to regulatory requests and/or requirements receive comprehensive review and evaluation.

The objective of this project was to perform a review of those Millstone-3 PSS aspects leading to the estimates of frequencies of each plant damage state and the associated uncertainty spread to determine the accuracy of these estimates. Our review covered methodology, assumptions, data, information sources, models, plant understanding, completeness of the analysis, and other areas where inconsistencies could

affect the quantitative or qualitative results. The review included a simplified reevaluation and quantification of the internal event analysis and estimates of the potential effects of changes to some external event analyses. The scope of the analysis did not include extensive reevaluation or requantification of plant damage state frequencies, nor did it include a review of the consequence analysis included in the Millstone-3 PSS.

* Applied Risk Technology Corporation.

† Jack R. Benjamin & Associates, Inc.

‡ Consultant.

G2

UCID-20316
(18 pages)

L.L. George

Files Used to Generate Figures and Tables in the Application of the SSMRP Methodology to the Seismic Risk at the Zion Nuclear Power Plant

Key Words: Files (computer), nuclear power plants, seismic risk analysis, SSMRP

This report identifies some of the files used in NUREG/CR-3428. It includes microfiche copies of the files and explains some of the differences between the files and NUREG/CR-3428.

G3

UCRL-92683-SUM
(3 pages)

L.L. George

Lotustistics: The Bootstrap

Prepared for the Reliability and Maintainability Symposium, Las Vegas, Nevada, January 21-23, 1986

Key Words: Lotustistics, bootstrap method, seismic risk analysis

The stress-strength model is $P[\text{Failure}] = P[\text{Stress} > \text{Strength}]$ where stress and strength are random variables. If the distribution param-

eters of stress or strength are estimated from sample data, then the usual estimate of component failure probability is biased. One way to avoid bias is to observe whether stress exceeds strength for each sample and compute the sample proportion of times this event occurs. This sample proportion is an unbiased estimator of component failure probability. Unfortunately, there has been no convenient, accurate estimate of the variability of the sample proportion.

In this presentation, I describe the Lotustistics Bootstrap method for obtaining an unbiased estimation of component failure probability and its variance. This method can also be used to estimate loss of load probability, damage probability due to electromagnetic pulse, and signal detection probability.

G4

UCRL-92684-SUM
(2 pages)

L.L. George

The Number of Spares Required in Combat Is Not Poisson

Prepared for the Reliability and Maintainability Symposium, Las Vegas, Nevada, January 21-23, 1986

Key Words: Combat, Poisson equation, simulation models

Logistics folklore says the number of spare parts required has the Poisson distribution. This is not true if there is attrition, even if the number of spares without attrition has the Poisson distribution. This is because units do not share operating requirements equally. (Call the things that require parts a "unit." A unit could be an aircraft, laser, truck, satellite, etc.). Some operate more than average, some less, and some are eliminated in combat. Operating requirements may not be satisfied at all due to high attrition. So under combat conditions, parts requirements are probably underestimated.

In this presentation to show mathematically the effect of attrition, I derive the mean and variance of parts requirements.

G5**UCRL-92396-ABS**
(1 page)**J. Glaser***Ambient Pressure Effects on the Sputter Particle Distribution of Insulating Materials*

Prepared for the Radiation Effects in Insulators III Meeting, University of Surrey, Guildford, United Kingdom, July 15-19, 1985

Key Words: Ion bombardment, sputtering, thermal insulation

The effect of ion bombardment on insulating materials such as alumina and glass was investigated. Changes in the electrical resistance of the substrate as a function of incoming ion energy was of particular interest. Attention was also paid to the sputter-particle distribution as a function of ambient pressure. This distribution was found to be dependent on the ion-to-substrate mass ratio. In general, the distribution follows a curve of growth, being isotropic at higher pressures. Pressures in the range of 10^{-6} to 10^{-4} torr have been used along with mass ratios in the range of 0.40 to 2.2. Samples of up to 80 cm² were subjected to a 10-cm diameter ion beam at energies of up to 6.25 KeV. Average ion currents were on the order of 1 mA/cm². Substrate temperatures while subjected to the ion beam were also monitored. From these investigations, the effects of ambient pressure on changes in surface morphology of some insulating materials under ion bombardment have been determined.

G6**UCID-20358**
(44 pages)**G. Goudreau, W. Moen, and D. Breithaupt***Evaluation of Mechanical Properties of PBXW-113 Explosive*

Key Words: Explosives, mechanical properties, NIKE2D, PBXW

A preliminary screening of the mechanical properties of PBXW-113 explosive was performed at the request of the U.S. Naval Surface Weapons Center, White Oak, Maryland. Unconfined-uniaxial-compression, constant-strain-rate

and cyclic tests were run at three intermediate strain rates and temperatures between -35 and 73°C. Hopkinson pressure bar tests in tension and compression were performed at room temperature. A standard-solid linear viscoelastic model available in most stress analysis codes was fit at one temperature and scaled to the others. A simple nonlinear viscous model available in the LLNL NIKE2D finite element code was also investigated. Further refinement of the model and more tests to identify it depend on the significance of the Navy stress analysis based on this simple model.

(Main body of report: 6 pages; graphs and two Appendixes, 38 pages.)

G7**UCRL-92125**
(12 pages)**S.B. Guarro***Use of Reliability Data for QA Program: Evaluation*

Prepared for the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985

Key Words: Nuclear power plants, quantitative analysis, reliability models

Possible analytical approaches for evaluation of the effectiveness of QA programs implemented in the operation of U.S. commercial nuclear power plants are discussed. These approaches may be based on key plant component performance comparisons, correlation models, or comprehensive cost-benefit evaluation frameworks. As plant availability and reliability data must be used to quantify the models, the quality of these data conditions the amount of information that can ultimately be extracted. The potential impact of uncertainties in the data must be considered carefully, especially before application of the more complex models.

H1**UCRL-92217-ABS**
(1 page)**J.O. Hallquist, G.L. Goudreau, and E.C. Flower***Application of an Implicit Finite Element Code to Two-Dimensional Problems*

Prepared for the International Symposium on
Finite Element Methods for Nonlinear Problems,
Trondheim, Norway, August 12-16, 1985

Key Words: Finite element method, NIKE2D
(computer program), two-
dimensional computations

We have applied NIKE2D—our fully vectorized implicit finite element code—to a large range of two-dimensional forging, cutting, and rolling problems. Our goals were to predict final shapes, forming loads, material damage and flow characteristics. We have validated many of our calculations with comparisons to experimental data.

In these applications, we have been motivated to substantially generalize our contact/sliding algorithms, add a general rezoning capability, and compute adiabatic heating with the goal of adding heat conduction in the near future.

In this paper we describe the recent improvements to NIKE2D that permit us to solve these problems. We also present a wide range of applications and show comparisons with experimental data.

H2

UCRL-92830
(15 pages)

J.O. Hallquist, D.J. Benson, and G.L. Goudreau

Implementation of a Modified Hughes-Liu Shell into a Fully Vectorized Explicit Finite Element Code

Prepared for the International Symposium on
Finite Element Methods for Nonlinear Problems,
Trondheim, Norway, August 12-16, 1985

Key Words: Finite element method,
Hughes-Liu shell,
nonlinear equations

Operation counts are given for our fully vectorized explicit implementation of the shell element developed by Hughes and co-workers. We have dropped reduced/selective integration in favor of reduced integration augmented by an hourglass viscosity. As a consequence, for four integration points through the thickness, execution speed is 100 μ s per surface element cycle on

the Cray-1 compared to 140 μ s for four brick elements. In addition, the explicit time step will be from four to many times larger than for brick modeling.

In this paper we briefly describe our implementation, concentrating on the details that provided us with the greatest cost reduction. First we justify our choice of one point integration. Next we describe our implementation of the Jaumann stress rate. Though equivalent to the Hughes-Liu formulation, it is somewhat more cost effective. Finally, we discuss the plane stress radial return plasticity algorithm, the shell brick interface, and the hourglass viscosity. A simple example problem is shown.

H3

UCRL-92042-SUM
(3 pages)

**C.D. Henning, B.G. Logan, W.L. Barr,
R.H. Bulmer, J.N. Doggett, R.W. Hoard,
B.M. Johnston, J.D. Lee, J.R. Miller, and
D.S. Slack**

TIBER—A Small Superconducting Tokamak Ignition Device

Prepared for the American Nuclear Society's
1985 Annual Meeting, Reno, Nevada,
June 15-20, 1985

Key Words: Ignition, superconducting magnets,
TIBER, Tokamak

A Tokamak ignition/burn experimental research (TIBER) device is being designed as the smallest superconducting ignition experiment consistent with the Department of Energy, Office of Fusion Energy, Mission II physics and engineering objectives. In order to reduce the size and cost of the Tokamak, more aggressive design assumptions were necessary. The TIBER device can not only study ignition physics, but by operating in a steady-state, current-driven mode, can also study plasma/wall interactions, helium ash removal, and numerous neutron damage effects.

In this presentation, we discuss the design and operating goals of the TIBER device.

H4**UCRL-92547-ABS**
(1 page)**S.M. Hibbs, M.R. Carter, and G.W. Coutts***Neutral Particle Time-of-Flight Analyzer for the Tandem Mirror Experiment-Upgrade (TMX-U)*

Prepared for the IEEE 11th Symposium on Fusion Engineering, Austin, Texas, November 18-22, 1985

Key Words: Neutral particles, time-of-flight analyzers, TMX-U

In this paper we describe the design and performance of a time-of-flight (TOF) analyzer recently installed on the east end cell of the Tandem Mirror Experiment-Upgrade (TMX-U). The analyzer is designed to do the following: (1) measure the velocity distribution of escaping charge exchange neutral particles with energies between 20 and 5000 electron volts, (2) enable direct determination of the thermal barrier potential when used in conjunction with the plasma potential diagnostic and the end loss ion spectrometer, and (3) measure the energy distribution of passing ions leaving the central cell and the distribution of ions trapped in the thermal barrier.

H5**UCIR-1564**
(7 pages)**D.S. Hiromoto***Elastic Properties of Various Aged APC and Halothane*

Key Words: Aging (materials), elastomers, Halthanes, stockpile, weapon systems materials

Material compatibility has long been a concern for our aging weapons stockpile. This report presents the results of the biaxial stress-relaxation and age testing of a silicon-based potting elastomer, APC 2.5, and Halthane 73-18, a cured adhesive. Both materials are found in our weapon devices and were part of a compatibility study done at the Pantex weapons assembly plant in Amarillo, Texas.

H6**UCID-20397**
(102 pages)**G.S. Holman and C.K. Chou***Assessment of Value-Impact Associated with the Elimination of Postulated Pipe Ruptures from the Design Basis for Nuclear Power Plants*

Key Words: Loss-of-coolant accident, nuclear power plants, piping systems

The U.S. Nuclear Regulatory Commission is proposing to amend the regulations that currently require that the design basis for nuclear power plants include the postulation of dynamic effects from loss-of-coolant accidents up to and including the double-ended rupture of the largest pipe in the reactor coolant system. Proposed modifications would allow analyses to serve as a sufficient basis for excluding dynamic effects—including, but not necessarily limited to, pipe whip and jet impingement—associated with specific pipe ruptures. Only dynamic effects would be affected; current design requirements for containment sizing and discharge capacity of emergency core cooling systems would remain unchanged.

This report presents a detailed analysis of value-impact associated with the proposed amendment for pressurized-water-reactor coolant loop piping and for boiling-water-reactor recirculation loop piping. The effect of extending application of the proposed rule change to other piping systems is also assessed in a less quantitative manner.

H7**UCRL-53500, Vol. 1**
NUREG/CR-3663
(64 pages)**G.S. Holman, T. Lo, and C.K. Chou***Probability of Pipe Failure in the Reactor Coolant Loops of Combustion Engineering PWR Plants, Vol. 1: Summary Report*

Prepared for the U.S. Nuclear Regulatory Commission

Key Words: Earthquakes, fractures, piping systems, probabilities, PWR

As part of its reevaluation of the double-ended guillotine break (DEGB) as a design requirement for reactor coolant piping, the U.S. Nuclear Regulatory Commission (NRC) asked LLNL to estimate the probability of occurrence of a DEGB and to assess the effect that earthquakes have on DEGB probability.

This report describes a probabilistic evaluation of reactor coolant loop piping in pressurized-water-reactor (PWR) plants having nuclear steam supply systems designed by Combustion Engineering. Two causes of pipe break were considered: pipe fracture due to the growth of cracks at welded joints ("direct" DEGB), and pipe rupture indirectly caused by failure of component supports due to an earthquake ("indirect" DEGB). The probability of direct DEGB was estimated using a probabilistic fracture mechanics model. The probability of indirect DEGB was estimated by first estimating support fragility and then convolving fragility with seismic hazard.

The results of this study indicate that the probability of a DEGB from either cause is very low for reactor coolant loop piping in these plants and that the NRC should, therefore, consider eliminating DEGB as a design basis in favor of more realistic criteria.

H8**UCRL-92303
(12 pages)****G.S. Holman, C.K. Chou, and G.E. Cummings***Equipment Fragility Testing*

Prepared for the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985

Key Words: Fragility testing, nuclear power plants, seismic risk analysis

Current probabilistic risk assessment methods for nuclear power plants utilize component fragilities that are, for the most part, based on a limited data base and engineering judgement. The seismic design of components is based on code limits and Nuclear Regulatory Commission (NRC) requirements that do not reflect the actual capacity of a component to resist failure.

In order to improve the present component fragility data base and establish component seismic design margins, the NRC has commissioned a projected three-year program to compile existing fragility data and at the same time independently perform fragility tests on selected mechanical and electrical components. This paper presents the planning and technical approach being taken by LLNL in the NRC Component Fragility Program.

H9**UCID-20213
(21 pages)****W.H. Hubbell, Jr., and D.F. Cruft***Joint Task Exercise-- 1984, a Broken Arrow Exercise*

Key Words: Accident simulation, Broken Arrow, nuclear weapons

This report describes a "Broken Arrow" exercise conducted by the United States Air Force and Lawrence Livermore National Laboratory/Sandia National Laboratory, Livermore, on June 5 and 6, 1984. The exercise featured operations at LLNL and Travis Air Force Base, California. The simulated accident began at Travis AFB when an Air Force C-141 aircraft carrying a nuclear warhead was struck by small arms fire during its approach for landing. After examining the damaged warhead container, the Department of Defense's Explosive Ordnance Disposal Team notified the Department of Energy's Joint Nuclear Accident Coordinating Center (JNACC) and requested assistance in dealing with a damaged nuclear warhead. A call from the JNACC activated the LLNL Alert Center, and the LLNL Accident Response Group was deployed to Travis AFB. The Explosive Ordnance Disposal Team and the Accident Response Group assessed the situation and made recommendations on preparing the weapon for safe shipment to the Pantex Nuclear Weapons Assembly Plant in Amarillo, Texas.

Included in the report are the planning, the general and detailed exercise scenario, a post-event evaluation, identification of problem areas, and recommendations.

J1**UCRL-15475, Sup. 1**
(64 pages)**M. Joske* and B.R. White†**

1982-1983 Equipment Loan Report: Atmospheric Boundary Layer Testing, Experimental Measurements of Heavier-Than-Air Gas Dispersion in an Atmospheric Boundary Layer

Key Words: Atmospheric dispersion,
boundary layers, gas flow,
gas metering systems

In recent years, concern has been raised over the transportation and storage of large quantities of hazardous gases, such as liquified natural gas (LNG), chlorine, and ammonia, near densely populated areas. Gases such as these, if once released into the atmosphere, are dispersed by atmospheric boundary layer flows. Hazardous conditions occur if the gases become trapped near buildings or other obstacles. Consequently, there is continuing interest in the atmospheric flow around buildings and in the dispersion of gases in the atmospheric boundary layer. The effects of buildings on the atmospheric boundary layer and on the dispersion of gases have been studied analytically, numerically, and experimentally.

This report presents the results of an experimental study of the dispersion of a heavier-than-air gas, carbon dioxide, in an atmospheric boundary layer. This study designed and developed a gas concentration measurement system to be used in conjunction with the atmospheric wind tunnel at the University of California at Davis.

Steady-state concentration measurements were made about a square 7.6-cm two-dimensional obstacle using hot-wire anemometry. A single-film aspirating probe was placed in a controlled temperature environment. Concentration profiles for several wind-tunnel centerline locations are presented. The effects of overheat ratio on probe sensitivity are discussed.

This report is the Master of Science thesis of M. Joske.

*Graduate research assistant, University of California, Davis.

†Professor/principal investigator, University of California, Davis.

K1**UCRL-92246**
(12 pages)**V.N. Karpenko and D.S. Ng**

Application of Structural-Mechanics Methods to the Design of Large Tandem-Mirror Fusion Devices (MFTF-B)

Prepared for the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985

Key Words: MFTF-B, structural analysis,
tandem-mirror fusion devices

The Mirror Fusion Test Facility (MFTF-B) is a large magnetic fusion energy experiment that will test advanced plasma-confinement concepts in tandem configuration. The MFTF-B has evolved from a minimum "B" single-cell device to a thermal-barrier tandem-mirror axicell configuration. This dramatic evolution posed the challenge of maximizing performance for existing equipment and facilities. Also, in an experimental fusion device, access constraints for plasma heating and diagnostics, combined with the complexity and variety of loads, require application of the best available, most efficient, structural-mechanics methods. Large interactive structures required an integrated analytical approach to achieve a reasonable level of overall system optimization. The Tandem Magnet Generator creates a magnet configuration for the EFFF calculation of electromagnetic-field forces that, coupled with other loads, form the input loading to magnet and vessel finite-element models. The analytical results provide the data base for detailed design of magnet, vessel, foundation, and interaction effects.

This paper presents a brief overview of the structural-system analysis and design process.

K2**UCRL-92247**
(6 pages)**V.N. Karpenko**

The Mirror Fusion Test Facility (MFTF-B)—Status

Prepared for the 6th Topical Meeting on the Technology of Fusion Energy, San Francisco, California, March 3-7, 1985

Key Words: MFTF-B development

The Mirror Fusion Test Facility (MFTF-B), now under construction at LLNL, represents more than an order-of-magnitude step up from earlier magnetic mirror experiments on the way to a future mirror fusion reactor. In fact, when the device begins operating in 1988, it will be capable of achieving plasma performance approaching scientific breakeven for D-T equivalent operation. We have taken major steps to develop MFTF-B technologies for tandem mirrors. In the machine, we will use steady-state, high-field, superconducting magnets on reactor-equivalent scales. The 30-s beam pulses, electron-cyclotron-resonant heating, and ion-cyclotron-resonant heating will also introduce near steady-state technologies into those systems.

This brief status report on the MFTF-B covers the following topics: performance goals, physical description and machine layout, magnet and vacuum vessel configuration, vacuum conditions, plasma heating, diagnostics and machine control, and technology demonstration.

This paper reports on additional work done to improve the nuclear analysis and optimize the nuclear performance of this blanket. More rigorous nuclear analysis, including the treatment of resonance self-shielding effects coupled with an optimization procedure, has resulted in improved performance of the Be/Li/Th blanket. Net U-233 breeding ratio has increased 36% (to 0.84), while at a U/Th ratio of 0.25 also, energy multiplication has increased 12% (to 2.1) compared with earlier results.

*Penn State University, State College, Pennsylvania.

L2

UCRL-92252
(6 pages)

J.D. Lee and B.R. Bandini*

Nuclear Performance Optimization of the Be/Li/Th Blanket for the Fusion Breeder

Prepared for the 6th Topical Meeting on the Technology of Fusion Energy, San Francisco, California, March 3-7, 1985

Key Words: Fusion reactor blankets, optimization, performance analysis

The conceptual design and analysis of fissile-fuel-producing blankets for fusion reactors is the principal activity of the Fusion Breeder Project. In fiscal year 1982, we developed and analyzed a conceptual design of a blanket containing Be pebbles (~50 v/o) for neutron multiplication, Li (~40 v/o) for tritium breeding and cooling, Th (~3 v/o) for U-233 breeding, and a steel structure (~7 v/o). The Th is in the form of inserts or snap rings attached to each Be pebble.

This paper reports on additional work done to improve the nuclear analysis and optimize the nuclear performance of this blanket. Net U-233 breeding ratio has increased 36% (to 0.84), while at an average U-233/Th ratio of 0.5, also average energy multiplication has increased only 12% (to 2.1) compared with earlier results.

*Penn State University, University Park, Pennsylvania.

L1

UCID-20166, Vol. 5
(40 pages)

J.D. Lee and B.R. Bandini*

Special Topics Reports for the Reference Tandem Mirror Fusion Breeder: Neutronic Issues and Optimization

Key Words: Fusion reactor blankets, nuclear performance

The conceptual design and analysis of fissile-fuel-producing blankets for fusion reactors is the principal activity of the Fusion Breeder Project. In fiscal year 1982, we developed and analyzed a conceptual design of a blanket containing Be pebbles (~50 v/o) for neutron multiplication, Li (~40 v/o) for tritium breeding and cooling, Th (~3 v/o) for U-233 breeding, and a steel structure (~7 v/o). The Th is in the form of inserts or snap rings attached to each Be pebble.

L3**UCRL-92640-AB5**
(1 page)**D.R. Lesuer, A. Goldberg, and J. Patt****Computer Modeling of Tank Track-Pad Elastomers*

Prepared for the 32nd Sagamore Conference,
Lake Luzerne, New York, July 22-25, 1985

Key Words: Armored vehicles, computer
modeling, elastomers

LLNL has been involved in a study of the tank track-pad failure problem for a number of years. A portion of this study has involved developing finite element models of the track shoe. Two models are being used. One is a mechanical model in which the stresses, strains, and irreversible mechanical work done in typical operating scenarios can be evaluated. The second is a thermal model in which the temperatures developed during vehicle operation are determined. These models have been used to study the influence of track design, material changes, and operating scenario on the track-pad failure problem.

We present results for three different track designs (T142, T156, and British Chieftain tracks), as well as explore the influence of pad design changes, material properties, and operating scenarios on the track-pad failure problem.

*U.S. Army Tank-Automotive Command,
Warren, Michigan.

L4**UCRL-91242**
(7 pages)**T.-Y. Lo***Failure Criteria Used in a Probabilistic Fracture
Mechanics Code*

Prepared for the 8th International Conference on
Structural Mechanics in Reactor Technology,
Brussels, Belgium, August 19-23, 1985

Key Words: Fractures in pipes, piping
systems failure

Two criteria are implemented in a piping reliability analysis code to assess the stability of crack growth in pipes. One is the critical net

section stress criterion. It is simple and convenient, but its application is limited to very ductile materials. The other is the tearing modulus stability criterion, which has a solid technical base. However, calculating the J-integral, J, and the associated tearing modulus, T, usually requires a complicated finite element method. In this piping reliability code, existing J and T solutions in tabular or formula form instead of the finite element method are used for computational efficiency. These two failure criteria are discussed and compared in terms of their effects on the estimation of pipe failure probability.

L5**UCRL-91244**
(6 pages)**T.-Y. Lo***The Selection of Minimum Earthquake Intensity in
Calculating Pipe Failure Probabilities*

Prepared for the 8th International Conference on
Structural Mechanics in Reactor Technology,
Brussels, Belgium, August 19-23, 1985

Key Words: Earthquakes, ground-motion
intensity, piping systems,
reactor safety

In a piping reliability analysis, it is sometimes necessary to specify a minimum ground motion intensity, usually the peak acceleration, below which the ground motions are not considered as earthquakes and, hence, are neglected. The calculated probability of failure of a piping system is dependent on this selected minimum earthquake intensity chosen for the analysis.

A study was conducted to determine the effects of the minimum earthquake intensity on the probability of pipe failure. The results indicated that the probability of failure of the piping system is not very sensitive to the variations of the selected minimum peak ground acceleration. However, it does have significant effects on various scenarios that make up the system failure.

This study forms the basis for selecting minimum peak ground acceleration values in calculating the leak and break probabilities of the Westinghouse and Combustion Engineering reactor coolant loop (RCL) piping systems. It is part of an ongoing research program to evaluate all RCLs in the United States using a probabilistic fracture mechanics approach.

L6**UCID-20410**
NUREG/CR-4263
(66 pages)**S.C. Lu and C.K. Chou***Reliability Analysis of Stiff Versus Flexible Piping,
Final Project Report*Prepared for the U.S. Nuclear Regulatory
Commission**Key Words:** Dynamics testing, nuclear
power plants, piping systems,
reliability analysis

The overall objective of this research project was to develop a technical basis for flexible piping designs that would improve piping reliability and minimize the use of pipe supports, snubbers, and pipe whip restraints.

A confirmatory piping reliability assessment for stiff versus flexible piping systems indicated that removing rigid supports tends, in general, to reduce thermal stress but to increase seismic stress in the pipe. As a result, piping design can be made more reliable by some reduction of rigid supports. It was demonstrated that certain piping systems with snubbers removed actually exhibit higher reliability than do those of the original design.

Proposed changes to the Regulatory Guide aimed at more flexible piping design were adopted by our study and their impact on piping design was evaluated. We concluded that these changes substantially reduce calculated piping responses and allow piping redesigns with significant reduction in number of supports and snubbers without violating ASME code requirements. Furthermore, the more flexible piping redesigns are capable of exhibiting reliability levels equal to or higher than the original stiffer design.

An investigation of the malfunction of pipe whip restraints confirmed that the malfunction introduced higher thermal stresses and tended to reduce the overall piping reliability.

Finally, support and component reliabilities were evaluated based on available fragility data. Our result indicated that the majority of supports exhibit a moderate decrease in reliability as the piping flexibility increases.

L7**UCRL-92398**
(17 pages)**S.C. Lu and C.K. Chou***Technical Considerations for Flexible Piping Design in
Nuclear Power Plants*Prepared for the American Society of Mechanical
Engineers 1985 PVP Conference and Exhibit,
New Orleans, Louisiana, June 23-26, 1985**Key Words:** Nuclear power plants, piping
systems, reliability analysis

The overall objective of this research project is to develop a technical basis for flexible piping designs that will improve piping reliability and minimize the use of pipe supports, snubbers, and pipe whip restraints. The current study was conducted to establish the necessary groundwork based on the piping reliability analysis. Highlights of the research project are presented in this paper.

M1**UCRL-92340-ABS**
(2 pages)**F.T. Marchi, R.T. Maney, K.R. Bradley,
and S.L. Thompson***Manufacture of 27 Centimeter Square KDP Crystals
for the Nova Laser*Prepared for the Conference on Applied Optics,
Cherry Hill, New Jersey, June 12-14, 1985**Key Words:** Crystal optics, KDP, Nova

Frequency conversion of the Nova laser from 1.053- μ m wavelength to the second and third harmonics is accomplished using arrays of KDP (potassium dihydrogen phosphate) crystals. There are 180 crystals, 27-cm² by 10-mm thick, used in the 10-beam Nova laser. Each beam uses 18 crystals in a 3 by 3 tandem array. KDP crystals are soft, brittle, thermally sensitive, and hygroscopic. All of these factors must be accounted for throughout the manufacturing cycle.

In this presentation, details of the fabrication process for these crystals are reviewed. Included are the processes for diamond machining, phase matching, and testing the KDP crystals for frequency conversion.

M2**UCRL-92632-ABS**
(1 page)**T.E. McKone**

The Use of Multimedia Environmental Models to Enhance the Management of Toxic Risks

Prepared for the Society for Risk Analysis
Annual Meeting, Washington D.C.,
October 7-9, 1985

Key Words: Benzene contamination,
environmental models, GEOTOX
(computer program), health
hazards, toxicology,
tritium contamination

In response to legislation such as the Toxic Substances Control Act, there is a need to simulate the environmental behavior of chemicals. A number of chemical fate models have been developed to assess the potential risks posed by chemical exposures. However, the value of the information provided by these models has not been fully explored.

We have developed a multi-media model, called GEOTOX, that describes the fate of trace elements, radionuclides, and organic chemicals. It is used to screen toxic agents based on their potential to accumulate or degrade within a geographic area. The model uses geographical, meteorological, and chemical properties to determine how a substance partitions in the environment. Concentrations are combined with exposure models and health effects data to estimate health risks.

We are now using this model to determine the value of reducing the uncertainty of input parameters. In order to illustrate and evaluate this approach, we use GEOTOX to assess uncertainty about population exposures that result from atmospheric releases of tritium and benzene. For each species, we compile a set of parameters for which the value of reducing uncertainty is high.

M3**UCRL-92647-ABS**
(1 page)**T.E. McKone**

The Use of Multimedia Environmental Models to Assess Risks from Toxic Air Emissions

Prepared for the World Clean Air Congress,
Sydney, Australia, August 22-26, 1986

Key Words: Environmental models, GEOTOX
(computer program), health
hazards, toxicology

We have developed a multimedia model, called GEOTOX, that describes the environmental fate of trace elements, radionuclides, and organic chemicals. It is used to assess toxic agents based on their potential to accumulate or degrade within a geological area. The model uses geological and meteorological properties and chemical properties to determine how a substance partitions in the environment. Concentrations are combined with exposure models and health effects data to estimate health risks. We are using these models to compare both the potential health risks of toxic chemicals and the impact of source locations, such as air, water, and soil.

This paper describes how this approach is used to assess the health risk of air-stripping contaminated groundwater and compares this to other options. Using GEOTOX, we estimate the time-varying risk to a population that resides in a water basin with a contaminated aquifer. Three scenarios are considered: (1) no cleanup, (2) air stripping, and (3) carbon filtration. In each scenario, the costs and health risks are compiled and compared for benzene, toluene, trichloroethylene, and tritium.

M4**UCRL-92784**
(30 pages)**T.E. McKone**

*Dioxin Risk Management at Times Beach, Missouri:
An Evaluation*

Prepared for *The Environmental Professional*

Key Words: Dioxin contamination; risk
management; Times Beach, MO

On February 23, 1983, the U.S. Government bought out the dioxin-contaminated community of Times Beach, Missouri, for 33-million dollars. The dioxin contamination problem is evaluated in order to determine the implicit cost-benefit ratio that was employed and to compare this with cost-benefit ratios employed for radioactive contamination. An overview on risk analysis is provided in order to lay the analytical framework for later discussions. The events that took place at Times Beach are reviewed with emphasis on those aspects that came under the category of "risk management." The historical data is used to carry out a risk assessment, based on the information that was likely to be available when the incidents at Times Beach were in the decision arena of the U.S. Environmental Protection Agency. Information derived from this assessment is used to assess the cost-benefit ratio that was implicit in the decision to buy out the community. This cost-benefit ratio is compared with that in use by the U.S. Nuclear Regulatory Commission for dealing with radioactive contamination in the nuclear fuel cycle. Consideration is given to those factors that contribute to the difference between this ratio for dioxin and that used for radionuclides. Particular attention is given to the role of uncertainty.

M5**UCID-20394**
(45 pages)**J.R. Miller***The Operation of HFTF to Test the MIT 12-T Coil***Key Words:** Coils, HFTF

The Massachusetts Institute of Technology (MIT) coil was tested in the High Field Test Facility (HFTF) to a peak field of very nearly 12 T. The accomplishment was noteworthy (1) as a demonstration of "reactor relevant" superconductors to a high magnetic field in a realistic coil environment and (2) for the operation of the HFTF in providing the necessary test conditions. This report describes the work in testing the MIT 12 T coil, with emphasis given to the test facility itself. Data specific to the MIT coil are given in appendixes.

(Main body of report: 11 pages; illustrations and two Appendixes: 34 pages.)

M6**UCRL-92343-ABS**
(1 page)**J.R. Miller***Elements of Superconducting Magnet Design Using Cable-in-Conduit Conductors Cooled by Forced Flow of HE I*

Prepared for the Cryogenic Engineering Conference, Cambridge, Massachusetts, August 12-16, 1985

Key Words: Conductivity, design, superconducting magnets

The intrinsic features of the cable-in-conduit-type conductor—which consists of a cable of many fine superconductor/stabilizer composite strands inside a strong steel sheath—can be used to good advantage in the design of superconducting magnets. In this paper, I present empirically based formulas pertinent to various important aspects of any magnet design using the cable-in-conduit conductor; the purpose of the presentation is to demonstrate the utility of this type of conductor in solving a variety of difficult design problems.

M7**UCRL-92365-ABS**
(1 page)**J.R. Miller, M.M. Steves*, and M.O. Hoenig****The Initial Filament Strain State of Cable-in-Conduit Superconductors and Its Relation to the Design of Large Bore, High Field Magnets*

Prepared for the 9th International Conference on Magnet Technology, Zurich, Switzerland, September 9-13, 1985

Key Words: Filaments, stresses, superconducting magnets

Cable-in-conduit superconductors formed by enclosing a cable of MF-Nb₃Sn/Cu composites in a strong steel sheath present a useful element for magnet design and construction. However, an important feature of this type conductor, which must be understood and accounted for in design, is the initial strain state of the superconducting

filaments that results from the differential cool-down strains of the various components of the cable-in-conduit system as it is brought from the Nb₃Sn formation temperature (~1000 K) to the operation temperature (~4 K). It is, of course, to be expected that the resultant strain depends on the proportions and thermomechanical properties of the constituent materials. However, empirical data suggest the initial strain state is also dependent upon the void fraction in the cable.

This paper surveys data currently in the literature from the standpoint of a simple model to describe the mechanical link between cable and sheath and reports new experiments devised to further clarify the situation. In addition, the use of the initial superconductor strain state as a parameter in magnet design is discussed.

*Massachusetts Institute of Technology,
Cambridge, Massachusetts.

M8

UCRL-92366-ABS
(1 page)

J.R. Miller and R.W. Hoard

Application of Cable-in-Conduit Superconductors to the Design of Extremely High-Field Solenoids for Fusion Research

Prepared for the 9th International Conference on Magnet Technology, Zurich, Switzerland, September 9-13, 1985

Key Words: Solenoids, stability,
superconductors

The next generation of machines for the mirror fusion program needs high-field barrier solenoids producing over 18 T. Later, 20 to 24 T will be required. Superconducting coils will be called upon to produce large fractions of those fields. Cable-in-conduit superconductors may have certain advantages in such applications. They have been demonstrated in small-scale tests to provide high stability margins at high current densities. The steel sheathing typical of this type of conductor may be put to good use as dis-

tributed structure to resist the high hoop loads inherent in large high-field solenoids.

In this paper, we (1) present simple, empirically based design formulas for analyzing stability, structural requirements, and protection, and (2) describe a technique for incorporating the resulting conductor designs into a high-field coil set in optimal fashion. The use of the formulas and optimization techniques are illustrated by example in a design for a coil set capable of producing 16 T at 4.2 K. The possibility of extending the design to higher fields is also discussed.

M9

UCRL-92371
(9 pages)

J.R. Miller

*Design of Aggressive Superconducting TFCX Magnet Systems**

Prepared for the 6th Topical Meeting on the Technology of Fusion Energy, San Francisco, California, March 3-7, 1985

Key Words: Design, superconducting
magnets, TFCX

An investigation of several fundamental limits of machine design indicate that a machine fitting the specifications of the Tokamak Fusion Core Experiment (TFCX) can be built with both a superconducting toroidal field (TF) coil set and a plasma major radius of less than 3.2 m. This small size is achieved by accepting a peak nuclear heat load of 50 kW·m⁻³ in the TF coil inner leg while operating at a 10-T maximum field with a current density of 35 A·mm⁻² in the winding pack. This performance, high by traditional standards, is justified based on developments in forced-flow conductor technology using Nb₃Sn composite superconductors.

In this paper, we examine the extent to which winding-pack current density can be reasonably increased and shielding decreased in the quest for a more compact and cheaper superconducting machine.

M10**UCRL-92551**
(25 pages)**J.R. Miller***Empirical Investigation of Factors Affecting the Stability of Cable-in-Conduit Superconductors*Prepared for *Cryogenics*

Key Words: Copper, stability, superconductors

Experiments investigating the stability of cable-in-conduit superconductors were performed using test conductors composed of small quadruplex cables enclosed in steel tubes. To examine the effects of a variation in stabilizer resistivity, all test conductors contained two strands of identical NbTi/Cu composite superconductor and two strands of solid copper. The grade of copper was varied for each test conductor so that a different net stabilizer resistivity existed for each conductor. When these conductors were operated outside the range of multiple stability, tests showed that their stability was negligibly affected by stabilizer resistivity; conversely, the range of operating currents for which multiple stability occurs was affected. However, the surprising result of this study is that stability is apparently affected when a large fraction of the copper stabilizer is segregated into separate cable strands. These observations are compared with other data in the literature.

M11**UCRL-53587**
NUREG/CR-4035
(39 pages)**P.B. Mohr, M.E. Mount, and M.W. Schwartz***A Highway Accident Involving Radiopharmaceuticals Near Brookhaven, Mississippi on December 3, 1983*

Prepared for the U.S. Nuclear Regulatory Commission

Key Words: Radioactive materials, transportation safety

An inquiry, assessment, and analysis were performed of a highway accident involving a rear-end collision at high speed between a passenger car and a luggage trailer in courier service transporting 84 packages, 76 of which contained radiopharmaceuticals with a total inventory of 54.774511 Ci. The accident occurred on a rural section of U.S. Highway 84 near Brookhaven, Mississippi, under conditions of light, intermittent rain showers at about 4:00 p.m. on the afternoon of December 3, 1983. The report: (1) deals with the nature and circumstances of the accident and findings of fact, (2) gives an accounting and description of the materials involved and the consequences of their exposure, and (3) gives an assessment and analysis of the mechanisms of damage and the conclusions which may be drawn from the investigation.

M12**UCRL-92681**
(47 pages)**J.W. Morris, Jr.* and E.N.C. Dalder***Cryogenic Structural Materials for High-Field Superconducting Magnets*Prepared for *Journal of Metals*

Key Words: Cryogenics, structural materials, superconducting magnets

High-field superconducting magnets are used principally for magnetic-fusion energy devices and for accelerators in particle physics research. The advances in both technologies have increased the field, size, and performance requirements of such magnets. More stringent requirements are expected in the future. The materials required include structural materials for the magnet case and for the support structure.

In this paper, we review needs and current research on structural materials for high-field superconducting magnets.

*University of California, Berkeley.

M13

UCID-20338
(151 pages)

R. C. Murray

GEMINI—A Computer Program for Two and Three Dimensional Linear Static, and Seismic Structural Analysis—CDC 7600 Version

Key Words: GEMINI (computer program), seismic analysis, structural analysis

GEMINI is a computer program developed at LLNL for the calculation of static and dynamic response of linear elastic structures by the finite element method. GEMINI has evolved from (1) SAPIV, a program developed at U.C. Berkeley, (2) SAP4, a modified and extended version of SAPIV implemented at LLNL, and (3) MODSAP, another modified and extended version of SAPIV.

Numerous user requests for extended capability, advances in element technology, and major algorithmic improvements in solution methodology occurring in the last few years have lead to the need and development of GEMINI. This program is intended to replace SAP4 at LLNL and to become the focal point here for linear static and seismic structural analysis and for future software development in the structures area.

GEMINI is written in standard FORTRAN with a modular format. It is written to allow new and complete algorithmic packages—such as equation solvers, eigenvalue routines, and modal analysis techniques—to be implemented and evaluated conveniently.

GEMINI is compatible with the LLNL CDC 7600 computers.

N1

UCIR-1535
(21 pages)

L. A. Natrass, Scientific Editor

ME Nuclear Test Program/Energy Program Highlights—1983

Key Words: Development, nuclear testing, research

This report summarizes some of the LLNL Nuclear Test Engineering Division's 1983 Technology Base and Research and Development

activities supporting the Nuclear Test Program and the Energy Program. Included are: the purpose of each activity in terms of impact on the programs, status of each activity, progress made, problems encountered or anticipated, and future directions the activity will take in 1984 and beyond.

N2

UCRL-92528-ABS
(1 page)

W. S. Neef, Jr., and B. M. Johnston

The Mechanical Configuration for a Superconducting Ignition Tokamak (TIBER)

Prepared for the IEEE 11th Symposium on Fusion Engineering, Austin, Texas, November 18-22, 1985

Key Words: Ignition, superconducting magnets, TIBER, Tokamak

LLNL is evaluating the engineering feasibility and economics of a superconducting ignition Tokamak. A satisfactory magnet arrangement has been designed. Two major operational requirements had to be satisfied: (1) the conductive heat leak to the refrigerated structure had to be minimized, and (2) assembly and maintenance of the entire experiment had to be possible with remotely operated tools. This paper discusses the mechanical structure required to react to the large magnetic forces generated.

N3

UCRL-92064-SUM
(2 pages)

D. G. Nilson

Recent Inertial Confinement Fusion Experiments at Lawrence Livermore National Laboratory

Prepared for the 1985 Annual Meeting of the American Nuclear Society, Boston, Massachusetts, June 9-14, 1985

Key Words: Inertial confinement fusion, Novette

Results are presented from recent experiments using our multi-Tera-watt (≈ 10 TW), 0.53- μm -wavelength Novette laser facility. With this high power laser, we are able to study plasmas that

have dimensions in excess of 1 mm and density gradient scale lengths greater than 0.5 mm. Experimental results from a wide variety of diagnostics—measuring target absorption, hot electron production, and signatures of various parametric instabilities—are discussed.

Most advantages pertaining to laser plasma coupling using submicron light are again seen in the Novette experiments. We have also demonstrated that at least one important parametric instability—stimulated Raman scattering—is still present in significant levels (>5%) when the density scale lengths are large enough, which could lead to difficulties as plasma sizes are further increased. Experiments using 0.26- μm light demonstrated that this instability can be suppressed in sufficiently collisional plasmas.

In order to achieve thermonuclear ignition and propagation, we must ablatively implode a deuterium-tritium (D-T) target. With the 0.53- μm light (1-nsec pulse), we have performed high density D-T experiments that produced high ablation pressures. Results are compared with previous results from similar targets fired on the 1.06- μm Shiva laser facility.

spindle error motions), it becomes difficult to accelerate and decelerate these moving elements to their proper positions.

The fast tool servo, which is a self-contained and independently operated positioning device, was designed and built to eliminate this problem by moving only the small mass of the tool bit itself. Its static and dynamic repeatability over a range of ± 50 μinches is better than 0.05 μinches . Its frequency distortion from 0 to 100 Hz is less than 1.0 μinches for peak displacements of less than 28 μinches .

*U.S. National Bureau of Standards,
Gaithersburg, Maryland.

P1**UCRL-92306**
(22 pages)**S.R. Patterson and E.B. Magrab****The Design and Testing of a Fast Tool Servo
for Diamond Turning*

Prepared for the *Journal for Precision Engineering*

Key Words: Diamond turning, fast tool servo,
machine tools

The use of feedback correction of tool position to increase the resolution and accuracy of high-precision machine tools has created the need for actuators capable of moving the machine's elements very small distances precisely. When the bandwidth of the correction signal is small, the basic moving element drivers of the machine tool often perform their function adequately. However, when the bandwidth requirement is large (as, for instance, when compensating for some

P2**UCRL-92330-ABS**
(1 page)**S.R. Patterson***Thermal Management of a Large Diamond-Turning
Machine*

Prepared for the 3rd International Precision
Engineering Seminar, Interlaken, Switzerland,
May 13-16, 1985

Key Words: Diamond-turning machinery,
LODTM, thermal analysis

A large optics diamond-turning machine (LODTM), which is a 64-in.-swing, vertical-spindle-axis precision lathe, has been constructed at LLNL. The LODTM accuracy goal of several parts in 10^8 has created the need for very careful thermal management. This requirement has been addressed with attention to three main areas: reducing the generation and flow of heat in the machine, reducing the sensitivity of the machine to changes in temperature, and rigidly controlling the environment of the machine. The principal sources of heat near the work area of the machine are the slide feed drives and spindle bearings; the measurement laser, electronics and spindle drive motor are removed from the work area of the machine and are individually temperature controlled.

The steps taken to provide thermal management of the LODTM are discussed in this paper.

P3**UCRL-92543-ABS**
(1 page)**L.R. Pedrotti, M.C. Jackson, H.H. Bell, Jr.,
J.W. Heefner, and R.L. Wong***Four Years of Magnet System Operation on the
Tandem Mirror Experiment-Upgrade (TMX-U)*

Prepared for the IEEE 11th Symposium on
Fusion Engineering, Austin, Texas,
November 18-22, 1985

Key Words: Magnets, TMX-U

During the past four years the Tandem Mirror Experiment-Upgrade (TMX-U) magnet system has operated successfully, delivering over 14,000 full-power shots. This paper (1) presents new physics criteria as it has evolved from the system and how it has affected the magnetic field design, (2) compares our operational results with previously defined criteria for current repeatability, cooling, duty cycle, forces and vacuum leak tightness, (3) details the solutions to a few operational problems including the discovery and repair of a ground fault in the east plug Ioffe, and another in an east plug C-circuit power supply, (4) includes some proposed modifications to reduce the moisture sensitivity of some of the ground fault circuits, and (5) discusses the alignment of the magnets, including a new e-beam probe similar to a device used on the Mirror Fusion Test Facility-B.

R1**UCRL-91834**
(2 pages)**R.G. Raether and E.R. Prochnow***Polishing Technique for Gadolinium Gallium Garnet*

Prepared for *Applied Optics*

Key Words: Gadolinium, gallium garnets,
optics, polishing

Reported in this note is a technique for polishing large diameter gadolinium gallium garnet

(GGG) surfaces having both high optical quality finish and figure. Koshiyama and Naitou have patented a mechanical/chemical polishing method for GGG used as substrates for epitaxial growth of magnetic thin bubble elements. The technique reported here is primarily mechanical and was developed for high damage level laser surfaces, but it should also be applicable for the bubble memory substrates.

S1**UCRL-92190**
(30 pages)**J.B. Savy, D.L. Bernreuter, and R.W. Mensing***Uncertainties in Seismic Hazard Analysis Using
Expert Opinion for the Eastern United States*

Prepared for the International ANS/ENS Topical Meeting on Probabilistic Safety Methods and Applications, San Francisco, California, February 24-March 1, 1985

Key Words: Models, probabilities,
seismic analysis

We present a comprehensive methodology to calculate the seismic hazard in the eastern United States (EUS), which uses subjective input from experts and completely quantifies the uncertainty of the results, including random and modeling uncertainty. In general, it appears that the uncertainty in the ground motion prediction was the largest, with some variation between regions (i.e., site locations) and seismicity experts. The zonations generated somewhat less uncertainty, however more erratic, and the other parameters had approximately the same amount of influence, although more uniformly distributed between experts and regions. In general, there was one to two orders of magnitude difference between the 15th and the 85th percentile curves on the probability of the exceedence. These results are consistent with other results of current analyses. It shows that the uncertainty in the seismic hazard prediction is a manageable parameter. A typical final result is shown for a hypothetical case of a site in the north central EUS.

S2**UCRL-92633-ABS**
(1 page)**J.B. Savy and D.L. Bernreuter***Sensitivity Analysis in the Hazard Calculations for the Eastern United States: Comparisons of Different Methodologies*

Prepared for the 8th European Conference on Earthquake Engineering, Lisbon, Portugal, September 7-12, 1986

Key Words: Seismic Hazard Characterization Project, seismic risk analysis, seismic sensitivity analysis

In the Seismic Hazard Characterization of the eastern United States (EUS) project for the U.S. Nuclear Regulatory Commission, we developed a methodology to rigorously quantify the hazard in the EUS. We formally distinguish between modeling and random uncertainties and propagate them in the calculations. We use subjective inputs provided individually by experts in the fields of seismicity and ground motion prediction to supplement the lacking data. The hazard model is built on the assumption of Poisson occurrence of earthquakes in space and in time, and the uncertain parameters are described by probability distributions. We investigated the sensitivity of the results to the various parameters.

The experts appear to be most sensitive to the choice of a ground motion model. It is followed in order of importance by the zonation maps and the seismicity parameters. The weighting scheme, used to combine the results associated with the various experts, did not appear to be a sensitive parameter. Our methodology, and results, were also compared with others available at this time. In particular, we compared the Monte Carlo approach with the event tree approach. We investigated the effect on the estimate of the uncertainty of considering experts' input from teams of experts instead of individuals.

S3**UCRL-92730-ABS**
(1 page)**J.B. Savy***An Application of the Use of Expert Opinion to Seismic Hazard Assessment*

Prepared for the Risk Analysis Annual Meeting, Washington, D.C., October 7-9, 1985

Key Words: Monte Carlo methods, seismic risk analysis

The purpose of the eastern United States (EUS) seismic hazard characterization project was to develop a methodology for assessing the seismic hazard in the EUS and to apply it at ten selected sites. The probability distribution of the hazard is computed by using a Monte Carlo simulation scheme where all the varying parameters (zonation, seismicity parameters, ground motion models) are defined by discrete or continuous probability density functions.

Because seismicity and ground motion data are sparse, we relied on subjective inputs. One panel of experts was dedicated to modeling the spatial and temporal distribution of earthquakes and another panel to modeling the ground motion at a site. The methodology was presented to the experts prior to eliciting their opinion through questionnaires. A feedback meeting took place between LLNL and the experts to ensure that the data provided were correctly used. The experts were asked to provide an independent opinion rather than to try to reach a consensus. In order to reflect the diversity of opinion, each expert's input was used independently to compute the hazard at the sites. The final hazard result was a weighted average using the self weights provided by the experts.

The analysis showed that the hazard results were, in general, not sensitive to large changes in the experts' self weights. Finally we analyzed the evolution of the experts' opinion in time over a period of several years during which several similar studies have been performed.

S4**UCRL-90582**
(12 pages)

**R.M. Scanlan, J.P. Zbasnik, R.W. Baldi,*
J.L. Pickering,* Y. Furuta,† M. Ikeda,† and
S. Meguro†**

Fabrication and Evaluation of a Cryostable Nb₃Sn Superconductor for the Mirror Fusion Test Facility (MFTF-B)

Prepared for the 1984 Applied Superconductivity Conference, IEEE, San Diego, California, September 9-13, 1984

Key Words: Coils, MFTF-B, superconductors

The Mirror Fusion Test Facility-B (MFTF-B) magnet system requires two 12.5-T, 36-cm bore insert coils. These coils are being constructed with a cryostable Nb_3Sn conductor manufactured by Furukawa Electric Company, Tokyo, Japan. The conductor consists of a core soldered into a cold-worked copper housing, which provides strength. The Nb_3Sn core is made by a triple extrusion bronze process. Each coil consists of 27 double pancakes and, hence, a total of 54 double pancake lengths, each 295 m long, are required. A total of 57 lengths have been made and tested.

We have made extensive tests on this conductor; these tests include critical current, ambient and 4.2 K mechanical property measurements, critical current as a function of tensile strain, and bending tolerance tests. The critical current density was found to be quite anisotropic in this conductor. The values of current density are among the highest reported for a production lot of Nb_3Sn conductor.

This paper describes the fabrication and evaluation of prototype and production lengths of a cryostable Nb_3Sn superconductor for use in the MFTF-B.

*General Dynamics/Convair, San Diego, California.

*Furukawa Electric Company, Ltd., Tokyo, Japan.

Mixtures of hydrogen isotopes, primarily deuterium (D_2), protium-deuterium (HD), and protium (H_2) must be pumped by the vacuum system in the Mirror Fusion Test Facility (MFTF) at LLNL. Thus, to verify the adequacy of our MFTF design, we performed experiments to measure the pumping capacity of pre-deposited argon substrates at 4.2 K for mixed hydrogen isotopes. We used argon as an adsorbent for cryopumping the isotopes and found that deuterium will displace already adsorbed protium. Thus, when we pump mixtures of the two, sufficient argon must be supplied to adsorb both species. We also found that without argon, deuterium will cryotrap protium in accord with Raoult's law.

S6

UCRL-92288-ABS
(1 page)

L.G. Seppala

Focus Lens Design for X-ray Experiments on the NOVA Laser

Prepared for the 1985 Spring Conference on Applied Optics, Cherry Hill, New Jersey, June 10-13, 1985

Key Words: Novette, optical materials, x-ray lasers.

During 1983, the Inertial Confinement Fusion Program at LLNL conducted x-ray laser experiments on the NOVETTE laser test bed. These experiments confirmed theories for a laser-pumped high-gain amplifier in the soft x-ray region. The amplifier region of the x-ray laser target, 100-microns wide by 12-mm long, was pumped by focusing each 740-mm diameter NOVETTE beam to a uniform line of these dimensions.

This paper discusses the design and optical performance of the cylinder lenses that were used to convert NOVETTE for the x-ray experiments. Based on the success of NOVETTE, cylinder lenses have been designed to allow x-ray experiments on NOVA.

S5

UCRL-92055
(5 pages)

B.J. Schumacher and W.R. Call

Cryopumping Hydrogen Isotope Mixtures in MFTF-B with and without Argon Adsorbent

Prepared for the 6th Topical Meeting on the Technology of Fusion Energy, San Francisco, California, March 3-7, 1985

Key Words: Argon, cryopumps, hydrogen isotopes, MFTF-B

S7**UCRL-92865-ABS**
(1 page)**A. B. Shapiro***LLNL Finite Element Code Overview for CAE*

Prepared for the 4th Department of Energy Workshop on Computer-Aided Engineering, Upton, New York, October 10-11, 1985

Key Words: Computer-aided engineering, finite element method, two-dimensional computations, three-dimensional computations

At LLNL we have developed and are supporting a comprehensive package of finite element analysis codes for two- and three-dimensional CAE (computer-aided engineering). These analysis codes and fully interactive pre- and post-processors have been implemented on the Cray and VAX computers.

An overview is presented of the capabilities of the following codes with application to current design problems at LLNL:

- NIKE—An implicit, finite deformation, finite element code for analyzing the static and dynamic response of solids.
- TOPAZ—An implicit, finite element heat transfer code.
- DYNA—An explicit, finite element hydrodynamic code.
- MAZE/INGRID—An interactive two- and three-dimensional preprocessor for the above finite element codes.
- ORION/TAURUS—An interactive two- and three-dimensional postprocessor for the above finite element codes.

S8**UCID-20314**
(94 pages)**L.C. Shieh, N.C. Tsai,* M.S. Yang,* and W.L. Wong****Seismic Margins and Calibration of Piping Systems*

Key Words: Nuclear power plants, piping systems, seismic risk analysis, SSMRP

In Phase I of the Seismic Safety Margins Research Program (SSMRP), an overall seismic

risk assessment methodology was developed and assembled. The application of this methodology to the seismic Probabilistic Risk Assessment (PRA) at the Zion Nuclear Power Plant was performed. However, since the application of this methodology is too time consuming and costly, particularly in the area of seismic response determination of structures and subsystems, a simplified-methods project was initiated to develop a simplified seismic risk methodology for general use. One major area of simplification was in the determination of seismic responses in Phase II for SSMRP.

This report documents:

- The method for developing piping response factors, which relate median response (best estimate) to responses calculated by selected design procedures in the nuclear power industry. The response factors were used to calibrate the design responses (piping moments and valve accelerations, etc.) to median level values.
- The investigation of differences among the selected parameters in the design procedures and the quantifying of their effect on response. The parameters include damping, modal combinations, directional combinations, stress component combinations, in-structure response spectra, etc.

*NCT Engineering, Inc., Lafayette, California.

S9**UCRL-91251**
(7 pages)**L.C. Shieh, N.C. Tsai,* M.S. Yang,* W.L. Wong****Seismic Analysis Response Factors and Design Margins of Piping Systems*

Prepared for the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985

Key Words: Nuclear power plants, piping systems, PRA, seismic risk analysis

Median response and its variability and correlation are the elements required in the calculation of component failure probability. Conservatism or nonconservatism of the seismic response of a piping system generated by the plant design procedures must be removed. LLNL under contract to the U.S. Nuclear Regulatory Com-

mission developed an overall seismic risk assessment methodology, which was applied to the seismic probabilistic risk assessment (PRA) at the Zion nuclear power plant.

In the seismic PRA, seismic response determination of structures and subsystems required thirty earthquake simulations in each direction. A multisupport time history analysis technique was employed to calculate subsystem responses. This procedure produced the best estimate seismic response of subsystems. However, it was very time consuming. In order to achieve the objective, a simplified calculational procedure of the seismic response was needed. The response factor approach was applied to serve this purpose.

The results of the study are presented.

*NCT Engineering, Inc., Lafayette, California.

S10

UCRL-92010, Rev. 1
(5 pages)

J.A. Smith and T.A. Glover

Hopkinson Bar Simulation Using DYNA2D

Prepared for the Second Symposium on the Interaction of Non-Nuclear Munitions with Structures, Miracle Mile Resort, Panama City Beach, Florida, April 15-19, 1985

Key Words: Concretes, dynamic response, DYNA2D (computer program)

A finite-element simulation of a split Hopkinson's bar (Kolsky apparatus) technique involving mortar specimens is accomplished with DYNA2D, an explicit two-dimensional finite-element code. Calculations are compared with experimental results contained in a University of Florida report, *Dynamic Response of Concrete and Concrete Structures*, and with analytic solutions of the appropriate wave propagation problem. The aim of these calculations is to demonstrate the growing accuracy with which the dynamic response of concrete can be predicted by DYNA2D as improved inputs to existing material models are developed. This report summarizes the results of the Hopkinson bar modeling.

S11

UCRL-92038
(2 pages)

R.S. Stolcis, R.T. Maney, P.P. Hed,
R. Blachman, and D.F. Edwards

Polishing Vitreous Carbon

Prepared for *Applied Optics*

Key Words: Carbon, material properties,
polishing

The physical and chemical properties of vitreous carbon (VC) make it an attractive material for low-energy grazing angle x-ray mirrors. For VC applications at our laboratory the Jentsch criterion indicates a surface roughness of less than $\sim 60 \text{ \AA}$ is required. The work of Ehrenberg indicates that far smaller irregularities give rise to an appreciable background that, for some applications, may not be acceptable. As a compromise, a polishing goal of $10\text{-\AA}$ rms roughness was set. Test data indicate a surface figure of $\lambda/10$ or better would correspond to x-ray reflectances 94% or better. Using the technique described here, we have produced sleek-free flat surfaces ranging in size from $50 \times 75 \text{ mm}$ to surfaces as large as $300 \times 63 \text{ mm}$. For each surface, a smoothness of $10 \text{ \AA}$ rms or less and a figure of $\lambda/10$ or better were obtained.

S12

UCRL-15475, Sup. 2
(164 pages)

C.J. Strataridakis* and B.R. Whitet

1983-1984 Equipment Loan Report: Atmospheric Boundary Layer Testing, Hot-Wire Anemometry Measurements of Turbulent Boundary Layer Flow Past a Two-Dimensional Obstacle

Key Words: Anemometry, boundary layers,
gas flow

Measurements of a zero-pressure-gradient turbulent boundary layer flow past a two-dimensional obstacle were made for both smooth

and rough surfaces using single and X hot-wire probes. The Reynolds number based on obstacle height and freestream velocity was about 15,302. Profiles of mean velocity, turbulent intensity, and probability density functions in two dimensions were determined. Also, Reynolds stress profiles, energy spectra, and second moments of energy spectra were obtained. From the results, evidence emerged that upstream, over, and downstream of the obstacle there were zones of recirculating flow. The flow-field was dominated by the obstacle presence, such that no distinction between smooth- and rough-surface measurements could be made.

This report is the Master of Science thesis of C.J. Strataridakis.

*Graduate research assistant, University of California, Davis.

†Professor/principal investigator, University of California, Davis.

S13**UCRL-92345-ABS
(1 page)****L.T. Summers and E.N.C. Dalder**

An Investigation of the Cryogenic Mechanical Properties of Low Thermal Expansion Superalloys

Prepared for the Cryogenics Engineering Conference and the International Cryogenic Materials Conference, Cambridge, Massachusetts, August 12-16, 1985

Key Words: Cryogenics, mechanical properties, superalloys, superconductors

A study was initiated to determine the 4-K mechanical properties of a series of low coefficient of thermal expansion (COE) alloys (Incoloy 903, 905, 909). These alloys, which are candidate materials for the forced cooled superconductor, have a COE that is typically one half that of the stainless steels presently used for this application. Alloys with COE matching that of Nb₃Sn show promise of increased conductor critical current by reduction of compressive pre-strain in the superconductor matrix. Currently, microstructural evolution, aging kinetics, and

mechanical properties of these alloys have not been adequately determined for the long reaction heat treatments of interest to superconductor fabricators. In this investigation, both tensile properties and fracture toughness at 4 K were determined for weld and base plate given a six-day heat treatment used for Nb₃Sn superconductor processing. The microstructure has been characterized and the aging kinetics determined for both the weld and base plate at extended aging times.

S14**UCRL-92346-ABS
(1 page)****L.T. Summers and J.W. Morris, Jr.***

Improvements in the Weldability of a Superconductor Sheath Material

Prepared for the Cryogenics Engineering Conference and the International Cryogenic Materials Conference, Cambridge, Massachusetts, August 12-16, 1985

Key Words: Coatings, superconductors, welds

This study investigates the effects of chemistry and heat treatment variation on the 4-K tensile properties of A-286, a candidate sheath material for forced-cooled superconductors. Currently, full utilization of A-286 and similar superalloys is limited by the welded and aged condition. The low strength is shown to be associated with the formation of precipitate free zones as a result of alloying element segregation during weld pool solidification. It has been determined that minor modifications of the weld metal chemistry by the addition of Ti reduce precipitate free zone formation, resulting in matching weld and base plate strengths at 4 K. Furthermore, nucleation of the gamma prime hardening phase has been found to be a strong function of temperature as well as composition. Modified heat treatment schedules that are amenable to superconductor fabrication have been determined that result in increased weld hardening and improved 4-K tensile properties.

*University of California, Berkeley.

S15**UCAR-10132**
(327 pages)**G. Sutton***Environmental Compliance and Cleanup: Conceptual Design Report, FY1987 Budget***Key Words:** Design, Environmental Compliance and Cleanup Program

This report: (1) describes the scope and breakdown of the planned work of LLNL's Environmental Compliance and Cleanup Program, (2) provides cost estimates and a cost breakdown for each project and major task together with the assumptions and principal cost factors, (3) provides a schedule for each major task and/or project together with a rationale for its construction and major timing constraints, (4) highlights the requirements for each of the projects (that is, the environmental limits or requirements of cleanliness, the laws or environmental regulations that have to be met, and the potential consequences of noncompliance), and (5) identifies risks and uncertainties in the environmental projects, investigations, and assessments work and outlines what can be done to minimize them.

S16**UCRL-91883, Rev. 1**
(57 pages)**S.B. Sutton, H. Brandt, and B.R. White***Atmospheric Dispersion of a Heavier-Than-Air Gas Near a Two-Dimensional Obstacle**Prepared for Boundary-Layer Meteorology***Key Words:** Atmospheric dispersion, boundary layers, gas flow

Flow over a two-dimensional obstacle and dispersion of a heavier-than-air gas near the obstacle were studied. Two species, one representing air and the other representing the heavier-than-air gas, were treated. Equations for mass and momentum conservation were cast in mass averaged form, with turbulent Reynolds stresses and mass fluxes modeled using eddy-viscosity and diffusivity hypotheses. A two-

equation k - ϵ turbulence model was used to determine the effective turbulent viscosity. Streamline curvature and buoyancy corrections were added to the basic turbulence formulation. The model equations were solved using finite difference techniques. An alternating direction implicit technique was used to solve the parabolic transport equations and a direct matrix solver was used to solve the elliptic pressure equation.

Experimental measurements were made with air flow over a 7.6- by 7.6-cm obstacle in an atmospheric boundary layer wind tunnel. The experimental results for flow over the obstacle were compared with numerical calculations to validate the numerical solution procedure. A sensitivity study on the effect of curvature correction and variation of turbulence model constants on the numerical solution was conducted.

In a second part of the study, numerical calculations were performed for the dispersion of a heavier-than-air gas in the vicinity of the two-dimensional obstacle. Characteristics of an adiabatic atmospheric boundary layer were used in these calculations.

S17**MISC-4279**
(29 pages)**C.K. Syn, T.T. Saito, J.S. Taylor, and R.R. Donaldson***Materials Properties Influence on Smoothness of Diamond-Turned Electroless Nickel**Prepared for the Workshop on Optical Fabrication and Testing, Cherry Hill, New Jersey, June 12-14, 1985***Key Words:** Diamond turning, material properties, nickel

This report consists of facsimile copies of 29 projection plates ("vugraphs"). Topics covered include: sample preparation, hardness measurement, precision engineering research lathe, cutting process, diamond tool tip geometry, x-ray diffraction analysis, effect of surface pits, surface finish (peak-to-valley and rms), diamond tool wear (rake face), correlation between surface finish and material properties, optical microscopy of diamond-tool wear, and conclusions.

S18**UCRL-91148**
(13 pages)**C.K. Syn, J.W. Dini, J.S. Taylor, G.L. Mara,
R.R. Vandervoort, and R.R. Donaldson***Influence of Phosphorus Content and Heat Treatment
on the Machinability of Electroless Nickel Deposits*Prepared for the Electroless Nickel Conference IV,
Chicago, Illinois, April 23-24, 1985**Key Words:** Coatings, machining, nickel

Precision machining, or diamond turning, is the use of a single point diamond tool on a precision lathe under very precisely controlled machine and environmental conditions to fabricate finished components. Coatings offer significant advantages for diamond turning applications inasmuch as they can be applied to lightweight substrates such as aluminum or beryllium, or to unusual substrates such as molybdenum or glass. One of the most used, frequently employed coatings for diamond turning applications is electroless nickel. On occasion, electroless nickel deposits are not diamond turnable, because, for example, tool life is shortened. This could be a function of phosphorus content, age of the solution, stress in the deposit, additives in the solution, heat treat conditions, etc. The work reported in this paper includes machinability studies on electroless nickel deposits varying in composition from 1.8 to 13% phosphorus in the as-deposited condition, and after heating at 200, 400 and 600°C.

T1**UCID-20321**
(10 pages)**C.S. Tallman***Fabrication of Copper Cooling Panels***Key Words:** Cooling systems, copper,
fabrication

The objective of this study was to investigate and recommend a brazing or welding process and procedure to join several sizes of copper tubing to copper plates. The two prime requirements were met:

- (1) Provide thermal conductivity values in the joint area comparable to that of the copper plate and copper tubing.

- (2) The process must be rapid enough to ensure fast turnaround for extremely tight production schedules.

Six processes were tested and evaluated. All testing employed the same joint design and base metal (1/4-inch copper plate and 3/8-inch diameter copper tubing) that will be used in fabricating copper cooling coils. Of the processes evaluated, the gas-metal-arc welding process, using deoxidized copper filler metal, proved to have the desired operability, produced an adequate weld cross-section for heat transfer purposes, and provided the best deposition rate.

T2**UCRL-89776, Rev. 2**
(6 pages)**P.L. Tassano***Deposition of Cesium Iodide on Parylene-N Pellicles*Prepared for *Journal of Vacuum Science and
Technology***Key Words:** Cesium iodides, coatings,
deposition, parylenes

High speed streak cameras are a basic tool in x-ray diagnostics performed by LLNL. As part of the development of a director cathode for one of these cameras, a coating of cesium iodide (CsI) on thin Parylene-N pellicles had been specified. CsI was chosen for its high electron emittance properties. Attempts to obtain these coatings commercially met with little success.

This paper outlines the handling and coating techniques used to deposit CsI upon Parylene-N and compares the results of LLNL-produced foils with those of commercially available foils.

T3**UCID-20283**
(15 pages)**R.M. Trusty, M.D. Wilt, G.W. Carter, and
D.R. Lesuer***Field Measurement of Tension in a T-142 Tank Track***Key Words:** Armored vehicles, materials
testing, rubber

This paper describes a method to measure the tension developed between neighboring track

sections of a U.S. Army tank. Such information is important for input to the computer models that are being developed by the Laboratory for the U.S. Army Tank-Automotive Command, Warren, Michigan. The computer models will simulate and evaluate the thermal and mechanical response of several tank track-pad designs on different tanks during field maneuvers. Hysteresis heating in the rubber has been addressed through laboratory experimentation and is fairly well understood. The mechanical behavior, however, is not easily simulated in the laboratory and, thus, very little data is available. An important mechanical input to the rubber pad is the shear force in the pad caused by a differential tension in the steel links across the pad.

A section of track was instrumented with strain gages and mounted in a tensile testing machine. The strain gage output was then calibrated as a function of tension. The calibrated track section was mounted on the tank and connected through a hard-wire electrical tether to a portable data acquisition system. A video recording system with a clock common to the data acquisition system was used to correlate environmental inputs to tension data. Initial track pre-tension levels were measured. Data was also acquired when the tank traversed several objects, moved uphill over an obstacle, and executed pivot turns.

tank. Such information is used as input to the computer models being developed for the U.S. Army Tank-Automotive Command to simulate and evaluate the thermal and mechanical response of several tank track-pad designs on different tanks during field maneuvers.

A section of track was instrumented with strain gages and mounted in a tensile testing machine. The strain gage output was calibrated as a function of tension. The calibrated track section was mounted on the tank and connected through a hard-wire electrical tether to a portable data acquisition system. A video recording system, with a clock common to the data acquisition system, was used to correlate environmental inputs to tension data. Initial track pretension levels were measured. Data were also acquired when the tank traversed several objects, moved uphill over an obstacle, and executed pivot turns.

T4

UCRL-92050
(9 pages)

R.M. Trusty, M.D. Wilt, G.W. Carter,
and D.R. Lesuer

*Field Measurement of Tension in a T-142 Tank
Track*

*Prepared for the 1985 Spring Conference of the
Society of Experimental Mechanics, Las Vegas,
Nevada, June 9-14, 1985*

Key Words: *Armored vehicles, materials
testing, tensile strength*

This paper describes a method used to measure the tension developed between neighboring track sections of a T-142 track mounted on an M-60

V1

UCIR-1569
(4 pages)

T.M. Vercelli

*Description and Operation of the RTNS-II Target
Cooling Water Bypass System*

Key Words: *Cooling systems, neutron
targets, RTNS-II*

The RTNS-II Facility at LLNL currently uses a 50-cm diameter copper target with internal cooling channels. The target is coated with tritium-tritide on one surface and produces 14-MeV neutrons when hit with a deuteron beam. The heat produced by the deuteron beam in the target is extracted by chilled water flowing through the target cooling channels. The chilled water is supplied by a closed-loop system at the RTNS-II Facility. The water chilling system incorporates a proportionally controlled bypass valve that controls the amount of flow to the target. The chiller system puts out 30-gpm constant flow at a supply pressure up to 350 psig. If the demand to the target is less than 30 gpm, the bypass valve directs the excess flow back to a reservoir. The purpose of the bypass valve is to protect the chiller system pump from excessive back pressure.

W1**UCID-20306**
(6 pages)**W. Wakeman***Deflection Measurements of LABAN Canister Sections in Horizontal Attitude*

Key Words: Canisters, deflection measurements, LABAN (event)

EG&G personnel performed a series of horizontal deflection tests on the LABAN diagnostics canister as part of the Canister Alignment Study. Results of these tests are reported in this document, and a correlation of the results to the GEMINI finite-element model is given in a document prepared by Echo Energy Consultants, Inc.

Deflection measurements indicate that the apparent stiffness of its frames with all the diagnostics experiments installed is not significantly different from the stiffness of the bare frames.

W2**UCID-20379**
(22 pages)**H.J. Weaver, R.B. Burdick, and M.C. Abe***Dynamic Test and Model Verification of COTTAGE Device Canister*

Key Words: Canisters, COTTAGE (event), dynamics testing, modal analysis

This report describes the procedures and results of a modal test performed on the COTTAGE device canister. The test was conducted at the Nevada Test Site while the canister was suspended from a Ringer crane and located inside the construction tower. The primary purpose of this test was to verify the finite element model that was constructed to evaluate seismic and neighboring event loads on the suspended canister. In addition to model verification, the modal test also provides a means of predicting the magnitude of energy loss or damping values associated with the particular structural system.

W3**UCRL-91241**
(9 pages)**J.E. Wells and G.E. Cummings***Evolution of a Seismic Risk Assessment Technique*

Prepared for the 8th International Conference on Structural Mechanics in Reactor Technology, Brussels, Belgium, August 19-23, 1985

Key Words: Earthquakes, nuclear power plants, seismic risk analysis, SSMRP

To assist the U.S. Nuclear Regulatory Commission in its licensing evaluation role, the Seismic Safety Margins Research Program (SSMRP) was started at LLNL in 1978. Its goal was to develop tools and data bases to evaluate the probability of earthquake-caused radioactive releases from commercial nuclear power plants. The methodology was finalized in 1982 and a seismic risk assessment of the Zion Nuclear Power Plant was finished in 1983. Work continues on the study of the LaSalle Boiling Water Reactor. This paper discusses some of the effects of the assumptions made during development of the systems analysis techniques used in SSMRP in light of the results obtained on studies to date.

W4**UCRL-92328-ABS**
(1 page)**J.E. Wells***Seismic Risk Assessment as Applied to a BWR*

Prepared for the ASME Winter Annual Meeting, Miami Beach, Florida, November 17-21, 1985

Key Words: BWR, nuclear power plants, seismic risk analysis, SSMRP

The seismic risk methodology developed by the U.S. NRC Seismic Safety Margins Research Program (SSMRP) was demonstrated by its application to the Zion nuclear power plant, a pressurized water reactor (PWR). A detailed model of Zion—including systems analysis

models (initiating events, event trees, and fault trees), structure and SSI models, and piping models—was developed and analyzed. The SSMRP methodology can be applied equally to a boiling water reactor (BWR). A seismic risk assessment is being performed on the LaSalle nuclear power plant to (1) demonstrate its applicability, (2) identify fundamental differences in seismic risk between a PWR and a BWR, and (3) provide a basis of comparison of seismic risk between a PWR and a BWR when analyzed with comparable methodology and assumptions.

This paper describes the seismic risk assessment methodology and the results obtained from using this methodology to assess the LaSalle nuclear power plant.

W5**UCRL-92049-ABS**
(1 page)

S.W. Winchester and H.S. Freynik, Jr.

Protective Coating System for Bonded Resistance Sensor on Superconducting Magnets

Prepared for the 1985 Spring Conference of the Society of Experimental Mechanics, Las Vegas, Nevada, June 9-14, 1985

Key Words: Bonding, coatings, superconducting magnets

A coating system is discussed that was developed to protect strain gages and temperature sensors bonded to superconducting magnet structures. The environment varies between moisture and condensation at ambient temperatures, and high vacuum and magnetic fields at 4.2 K.

W6**UCRL-92540-ABS**
(1 page)

R.L. Wong, L.R. Pedrotti, D.E. Baldwin, S.M. Hibbs, D.N. Hill, and M.C. Jackson

The Addition of Trim Coils to the Tandem Mirror Experiment-Upgrade (TMX-U) Magnet System to Improve the Magnetic Field Mapping

Prepared for the IEEE 11th Symposium on Fusion Engineering, Austin, Texas, November 18-22, 1985

Key Words: Magnet coils, magnetic field mapping, TMX-U

The mapping of the magnetic flux bundle, from the center cell to the plasma potential control plates on the end fan of the Tandem Mirror Experiment-Upgrade (TMX-U), was improved by the addition of trim coils (12,000 amp-turns) on each side of each end fan next to the pump beam magnetic shields. The coils' axes are oriented perpendicular to the machine centerline. They made the necessary corrections to the field-line mapping, while keeping the field in the nearby pump beam magnetic shield below the saturation threshold.

This paper briefly describes the problem, the design as it evolved, and presents the results of the field testing. A brief description of the improvement in the machine performance is also included.

W7**UCRL-92548-ABS**
(1 page)

R.L. Wong, H.H. Bell, Jr., M.O. Calderon, M.C. Jackson, and L.R. Pedrotti

An Octupole Coil Configuration for the Tandem Mirror Experiment-Upgrade (TMX-U)

Prepared for the IEEE 11th Symposium on Fusion Engineering, Austin, Texas, November 18-22, 1985

Key Words: Coils, octupoles, TMX-U

The octupole plug concept offers the attractive possibility of reducing the length of the plug and transition sections in tandem mirror reactors. In the Tandem Mirror Experiment-Upgrade (TMX-U), we are designing an octupole plug/transition that will replace our current quadrupole plug/transition. The reduction in length is possible due to the more nearly circular plasma cross-section throughout the plug and transition sections. Each octupole set consists of six coils replacing the transition and plug sets in the existing TMX-U experiment. The central cell

coils will remain unchanged. Five of the coils for each of the new sets will be fabricated while one, the 6 T mirror coil, will be reused from TMX-U.

This paper will elaborate on the design configuration of the magnets, power supplies and controls. The magnet design criteria, including forces, cooling, lifetime, and ground fault voltages are presented.

W8

UCAR-10134-85
(89 pages)

H.H. Woo, Scientific Editor

Mechanical Engineering Department, Engineering Research Proposals, Fiscal Year 1985

Key Words: Proposals

This report records the 45 proposals that were formally submitted for the fiscal year 1985 Engineering Research Program in the LLNL Mechanical Engineering Department. Although only 13 proposals were funded, the remaining proposals are still of interest since they possess the potential for future action. This report is intended to provide readers an understanding of the kinds of current research interest and expertise that exist within the Mechanical Engineering Department. Key word and investigator indexes are provided.

Z1

UCRL-92005
(4 pages)

A.S. Zolnay, W.M. McDonald, P.A. Doupont, R.L. McKinney, and M.M. Lee

Axial Tomography from Digitized Real Time Radiography

Prepared for the 6th Symposium on X- and Gamma-Ray Sources and Applications Meeting, Ann Arbor, Michigan, May 21-23, 1985

Key Words: Real-time operating systems, radiography, tomography

Axial tomography from digitized real time radiographs provides a useful tool for industrial radiography and tomography. The components of this system are: x-ray source, image intensifier, video camera, video line extractor and digitizer, data storage, and reconstruction computers. With this system it is possible to view a two-dimensional x-ray image in real time at each angle of rotation and select the tomography plane of interest by choosing which video line to digitize. The digitization of a video line requires less than a second, thus, making data acquisition relatively short.

Initial results and plans for further improvements on this system are reported.

Z2

UCRL-92271, Rev. 1
(11 pages)

A.S. Zolnay

Radiation Interactions for Tomography

Prepared for Materials Evaluation

Key Words: Radiation interactions, tomography

Besides showing density contrast, there are new requirements emerging in the field of tomography: the need for spatial resolution in the micrometer range, atomic species specificity, and quantitative density discrimination. This paper addresses these questions from the perspective of a research environment that often requires state-of-the-art solutions to challenging problems. This paper considers: (1) methods for achieving a special versatility appropriate to such a research environment, (2) some practical considerations regarding charged particle and gamma radiation interactions as they apply to tomography, and (3) the very challenging problem of quantitative interpretation of tomographic results.

Appendix

Divisional Roles and Activities

The Mechanical Engineering Department is responsible for the design, analysis, fabrication, testing, and field installation of all mechanical components and systems required by Defense Systems, Lasers, Magnetic Fusion Energy, Physics, and Biomedical and Environmental Research. Similar support is provided to the Chemistry and Computation Departments.

Energy Systems Engineering Division (ESED)

This Division is engaged in a variety of work to provide mechanical engineering support to the Laser Program in three major categories: laser isotope separation (LIS), Inertial Confinement Fusion (ICF) and Advanced Lasers Development (ALD). The coordinators, designers, engineers, and technicians in ESED are involved in designing mechanical, optical, and opto-mechanical components used to build lasers, targets, extractor collectors, and diagnostics in each program. In addition, they contribute to developing the technologies needed to reach programmatic goals.

(For further information, contact J. E. Keller, Jr., Ext. 2-7582.)

Engineering Sciences Division (ESD)

This Division provides complete technical services to LLNL programs for materials characterization, engineering measurements, non-destructive evaluation, and mechanical systems design and evaluation. The Division has more than 20 separate laboratories and facilities that are organized into sections responsible for specific technological areas.

ESD also maintains the Engineering Records Center, which archives, reproduces, and distributes engineering drawings for LLNL's Mechanical, Electrical, and Plant Engineering Departments. In addition, ESD maintains two libraries containing technical references, specifications, and vendor data.

(For further information, contact J. P. Mahler, Ext. 2-8360.)

Magnetic Fusion Engineering Division (MFED)

This Division supports the LLNL physics programs in three principal areas: magnetic fusion energy (MFE) confinement experiments, MFE development and technology, and beam development. The three areas share a common technological base, although their individual goals differ greatly. Each area requires support from essentially all mechanical engineering disciplines and from specialists in normal and superconducting magnetics, cryogenic systems, vacuum systems, high-voltage components, and nucleonics.

(For further information, contact R. B. Carr, Ext. 2-6750.)

Materials Fabrication Division (MFD)

This Division is a multidisciplinary organization in the Mechanical Engineering Department and provides engineering process development and fabrication services that are not available from commercial sources. The number and diversity of LLNL research efforts make this division one of the Laboratory's largest. There are approximately 450 skilled personnel and a division inventory of more than 3,700 pieces of equipment.

With these facilities and the special capabilities of the staff, R & D and fabrication services are provided in the fields of optics, welding, vacuum process, glass, plastics, sheet metal, metal finishing, metrology, forming, inspection, and assembly, as well as conventional and numerically controlled machining of metal, high explosives, and ceramics.

(For further information, contact D. K. Fisher, Ext. 2-7643.)

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