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Nuclear Criticality Technology and Safety Project Parameter Study Database

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NUCLEAR CRITICALITY TECHNOLOGY AND SAFETY PROJECT PARAMETER STUDY DATABASE

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1.0 INTRODUCTION

A computerized, knowledge-screened, comprehensive database of the nuclear criticality safety documentation has been assembled as part of the Nuclear Criticality Technology and Safety (NCTS) Project. The database is focused on nuclear criticality parameter studies. The database has been computerized using dBASE III Plus[1] and can be used on a personal computer or a workstation. More than 1,300 documents have been reviewed by nuclear criticality specialists over the last 5 years to produce over 800 database entries. Nuclear criticality specialists will be able to access the database and retrieve information about topical parameter studies, authors, and chronology. The database places the accumulated knowledge in the nuclear criticality area over the last 50 years at the fingertips of a criticality analyst.

2.0 DESCRIPTION

The database provides an important resource to the nuclear criticality analyst in terms of background information for evaluation and planning of nuclear criticality physics experiments or analytic studies. The analyst can quickly pinpoint relevant documents containing information that may impact the neutron multiplication constants or critical masses of the experiment or study.

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[1]dBASE III Plus is a trademark of Borland International Inc.

The parameter studies selected for this database are concerned with changes in the value of the neutron multiplication constant or critical mass caused by variations in parameters such as geometry, density of materials, nuclear properties, isotopic compositions, and external conditions. These parameters are generally known within an experimental and analytical experience base, therefore permitting determination of the neutron multiplication constant or the critical mass.

This database covers 15 major topical areas for parameter studies of interest to nuclear criticality specialists. The areas were arrived at by querying the nuclear criticality community for topics and items of concern. Each of these 15 areas are further broken down into 6 parameter study subtopics. The major topical areas are:

A) *Storage of fissionable material in annular tanks.*

Process and storage tanks with and without neutron absorbers

B) *The use of fixed neutron absorbers associated with fissionable material in storage tanks.*

Cylindrical or slab tanks using fixed interior or exterior neutron absorbers

C) *The use of fixed neutron absorbers in processing equipment and facilities.*

Spent fuel storage pools, casks, storage arrays, or other process equipment

D) *Criticality analyses associated with waste recovery streams.*

Processing plants, solutions containing fissionable materials, storage tanks, loss of solutions to soil column

E) *The treatment of fissionable material gradients and diluents in criticality analyses.*

Inhomogeneous distributions of homogeneous or heterogeneous fissionable material, sediments in tanks and process equipment, materials diluting fissionable materials

F) *The impact of concrete on fissionable material systems and units.*

As a moderator, separator, reflector, container boundary - impacts due to concrete composition

G) *Impact of non-fissionable materials and elements.*

Materials added or deleted from heterogeneous or homogeneous systems

H) *Introduction of interspersed moderation in analytical studies and in actual plant or laboratory conditions.*

Sprinklers, void and other density related reactivity coefficients, water density changes, moderators other than water

I) *Fissionable material buildup in ducts, pipes, and tanks.*

Buildup of fissionable material or other materials that would make ducts, pipes, or tanks more reactive

J) *Low enriched uranium critical mass information.*

Both heterogeneous and homogeneous for up to 10 wt% enrichment

K) *Criticality of high ^{240}Pu content systems including mixed oxides.*

Solutions and heterogeneous systems - ^{240}Pu greater than 9 wt%

L) *Cross section uncertainties not only of fissionable but also if non-fissionable materials.*

Impacts of individual cross sections, intercomparison of cross section sets, cross section sensitivity studies

M) *Credit for fissionable material burnup especially for spent fuel criticality analyses.*

Due to fuel exposure, buildup and transmutation of fissionable products, depletion and buildup of fissionable material

N) *The interaction between piping and container arrays and impacts on system reactivity.*

Interaction between pipes in all geometries, interaction between pipes and container arrays, reactivity of container arrays

O) *Use of homogeneous neutron absorbers.*

Neutron absorbers in solution, also included in this are Raschig rings

For each of the major topics, the 6 subtopics are:

1) *Experimental parameter studies.*

Experimental measurements have been made measuring multiplication constants, masses, volumes, densities, and absorption levels

2) *Impact of material changes on k_{eff} or critical masses.*

Change in fissionable and nonfissionable materials in homogeneous or heterogeneous systems

3) *Variations in geometry and its impact on k_{eff} or critical masses.*

Geometry change in and between units, systems, examples - lattice pitch, tank volumes, etc.

4) *Plant condition impacts on the k_{eff} or critical mass.*

Moderation, temperature, pressure, material accumulations, and wear and tear

5) *Upset conditions and their impacts on k_{eff} or critical mass.*

Sprinklers, flooding, fire, loss of geometry, density changes, spills, earthquakes

6) *Parameter studies using special analytical approximations.*

Buckling, solid angle, shortcut methods, and scoping tools

The letters from the major topics and the numbers from the subtopics form a matrix. During the review process of each document, the matrix

elements were determined according to the information on the document. Each database record then contains the author, title, document number, publication date, and the appropriate matrix elements. In the future, each document will also have a value index added.

There are several different data tabulation routines that allow the database user to quickly define the information needed and then retrieve a list containing the references that meet the criteria.

Table 1 shows the number of documents associated with each matrix element for the 805 documents currently in the database. There are more than 2,500 entries in the matrix for searching the database. Each document may have multiple matrix elements. Figure 1 shows the number of documents in each of the major topic categories. Figure 2 shows the distribution of documents among the subtopics. Table 2 gives an example of the results available from a search. The search was for matrix element C4, the use of fixed neutron absorbers in processing equipment and facilities where plant conditions impact the k_{eff} or critical mass. Figure 3 shows the documentation reviewed as a function of publication date.

The documentation reviewed consisted of Transactions of the American Nuclear Society, Nuclear Science and Engineering, Nuclear Technology, special national and international topical meetings on nuclear criticality safety, NUREG documentation, facility and company specific documentation, foreign documents, and academic publications. The review process is still ongoing.

Efforts are also underway to establish a link to other databases that may have abstracts for references, such as the Office of Scientific and Technical Information (OSTI) nuclear criticality database. The OSTI database will be reviewed for references not covered in the parameter study database. A link between the two databases will be established. A criticality engineer ready to embark on a parameter study can use the parameter study database to identify the pertinent publications and then request from the OSTI database abstracts on these publications. Within a few hours the engineer should know the articles pertinent to the parameter study, be aware of the people who performed the work, and have abstracts available for review. This approach represents very significant time savings, provides the needed answers, or identifies more focused directions in performing a new parameter study.

Further features to be included in the NCTS database are a quality or value index for each reference, a menu driven front end, and the capability of online graphic displays.

3.0 SUMMARY

A very useful database which addresses the most current needs for many criticality analysts has been assembled. The database can rapidly yield information on documentation covering special topics related to parameter studies. The database also serves as an excellent planning tool for helping focus large-scale studies into areas where there is a lack of experimental or analytical information. Connecting the parameter studies database to the OSTI database will enhance its usefulness by allowing users to obtain abstracts for the documentation.

Table 1. Matrix showing number of documents for each matrix element.

MAJOR TOPIC	SUBTOPIC 1	2	3	4	5	6
A	14	7	9	2	0	7
B	43	21	13	1	1	19
C	52	34	34	10	7	41
D	7	10	8	13	7	27
E	68	31	23	13	5	58
F	20	12	12	5	3	24
G	132	86	89	9	6	57
H	172	102	75	13	7	79
I	8	3	3	4	0	9
J	180	104	121	27	25	94
K	20	18	19	2	4	12
L	31	12	11	2	1	29
M	2	10	4	2	2	10
N	68	28	55	4	2	67
O	21	27	15	4	3	7

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Table 2. Results of a sample search on matrix element C4.

Document Number	Title	Author	Date Published
TRANS. AM. NUC. SOC. V.24, P231	BORATED CONCRETE USE IN THE HANFORD N REACTOR SPENT FUEL BASIN	TOFFER, H.	11/01/76
RHO-SA-30	CONCRETE AND CRITICALITY	CARTER, RD	06/01/78
UNI-SA-150	CRITICALITY CONTROL IN LARGE TANKS	TOLLEFSON DA, TOFFER H, BENJAMIN JA	05/20/85
TRANS. AM. NUC. SOC. V.41	CRITICALITY OF HIGH DENSITY, BORAL-POISONED FUEL RACKS FOR MAINE YANKEE	NAPOLITANO DG, CACCIAPOUTI	06/06/82
EGG-PHYS-5431	CRITICALITY SAFETY EVALUATION FOR SNM VESSELS IN S-CELL	BRIGGS JB, JONES RR, PUTNAM GE	05/01/81
SAND-80-1675	CRITICALITY SAFETY IN THE FEDERAL REPUBLIC OF GERMANY	KRUG H, THOMAS W	01/01/80
ORNL/TM-7403	NUCLEAR CRITICALITY SAFETY STUDIES APPLICABLE TO SPENT FUEL SHIPPING CASK DESIGNS AND SPENT FUEL STORAGE	TANG JS	11/01/80
PNL-3000-8	NUCLEAR WASTE MANAGEMENT. QUARTERLY PROGRESS REPORT, OCTOBER THROUGH DECEMBER 1980	CHIKALLA TD, POWELL JA	03/01/81
Y/DD-326	SAFETY ANALYSIS REPORT FOR PACKAGING. OAK RIDGE Y-12 PLANT MODEL DT-14A PACKAGE FOR ENRICHED URANIUM	TAYLOR RG	01/13/84
HEDL-SA-2830	SPENT FUEL STORAGE SYSTEM FOR LMFBR FUEL EXPERIMENTS	SEAY JM, GRUBER WJ	01/01/83

Figure 1. Graph showing the number of documents for each major topic.

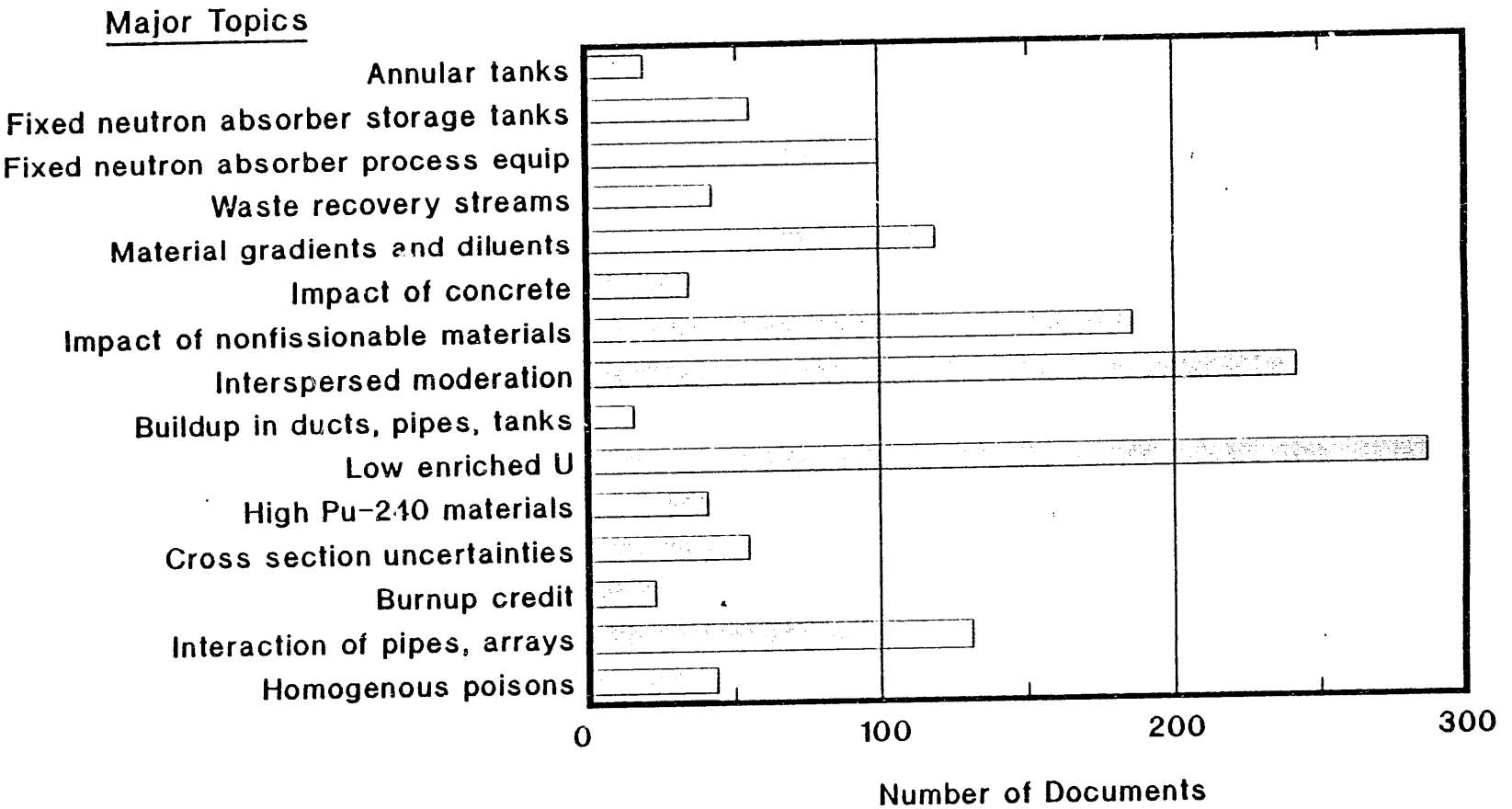

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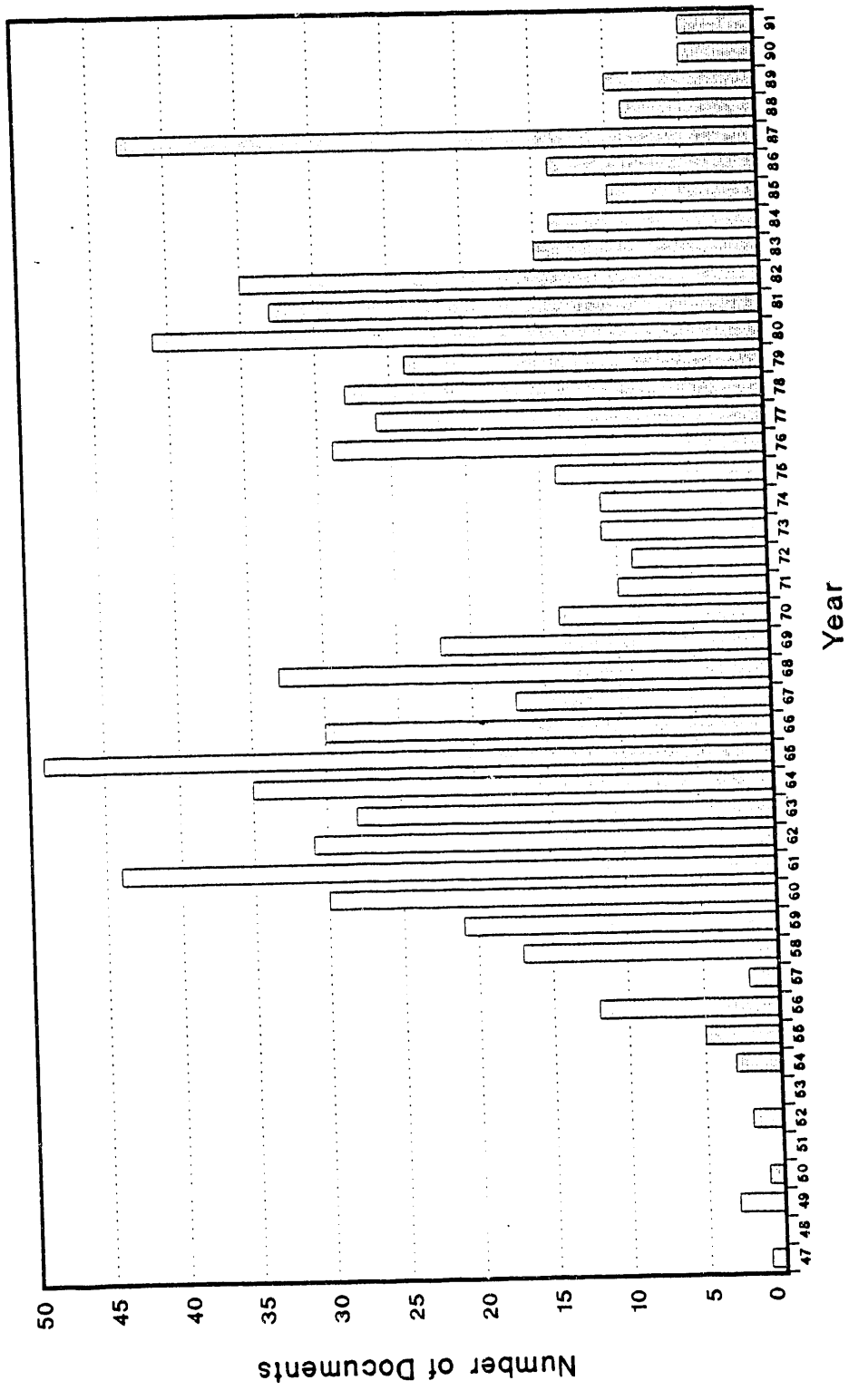
Figure 3. Graph showing yearly contribution of documents to database.



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