FAST-BREEDER-POWER REACTOR RECORDS IN THE INIS DATABASE

- A Bibliometric Study -

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Abstract

This report presents a statistical analysis of more than 19,700 records of publications concerned with research and technology in the field of fast breeder power fission reactors which are included in the INIS Bibliographic Database for the period from 1970 to 1999. The main objectives of this bibliometric study were: to make an inventory of the fast breeder power reactor related records in the INIS Database; to provide statistics and scientific indicators for the INIS users, namely science managers, researchers, engineers, operators, scientific editors and publishers, decision-makers in the field of fast breeder power reactors related subjects; to extract other useful information from the INIS Bibliographic Database about articles published in fast breeder reactors research and technology.
The quantitative data in this report are obtained for various properties of relevant INIS records such as year of publication, secondary subject categories, countries of publication, language, publication types, literary types, etc.

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Records related to Fast-Breeder-Power Reactors in the INIS Database

Fission reactor research and technology is one of the most important subjects in the scope of the INIS database. Literature in fission reactor categories covers the following topics:

1. reactor theory, reactor physics calculation, in-pile experiments verifying reactor theory and calculations, computations of in-reactor processes;
2. design, construction, fabrication and performance (mechanical integrity, structural analysis, reliability, fracture mechanics) of reactor components and accessories, including cooling systems, coolants, shielding, pressure vessels, loading machines;
3. design, fabrication and performance of fuel pellets, fuel elements and fuel assemblies, fuel loading procedures;
4. fuel fabrication plants (regardless of the type of fuel elements produced), including technical aspects of safety, decommissioning and dismantling;
5. systems for control and surveillance of reactors and nuclear power plants, including alarm systems, automatic shutdown systems, and automatic initiation of protective systems or actions;
6. elements of reactor and nuclear power plants control systems, including drive units, control rods, safety rods and incorporated instrumentation;
7. reactor and reactor plant computerised control systems;
8. man-machine interaction problems in reactor control;
9. technical aspects of safety;
10. design, construction, performance, operation, decommissioning and dismantling of specific reactor types and related nuclear power plants as energy sources for electricity generation and other applications including fuel elements, components and accessories, but not control systems;
11. technical aspects of safety;
12. real accidents

Each record in the INIS Database is assigned a primary subject category (C1) according to the above mentioned fields of interest. Records related to fission reactors research and technology in INIS Database are assigned the following subject categories:

E2000 - FISSION REACTORS (GENERAL)
- E2100 - Reactor Theory and Calculation
- E2200 - Reactor Components and Accessories
- E2300 - Reactor Fuels
- E2400 - Reactor Control Systems

A specific sub-category is assigned to literature related to subjects 10-l2 according to reactor type:

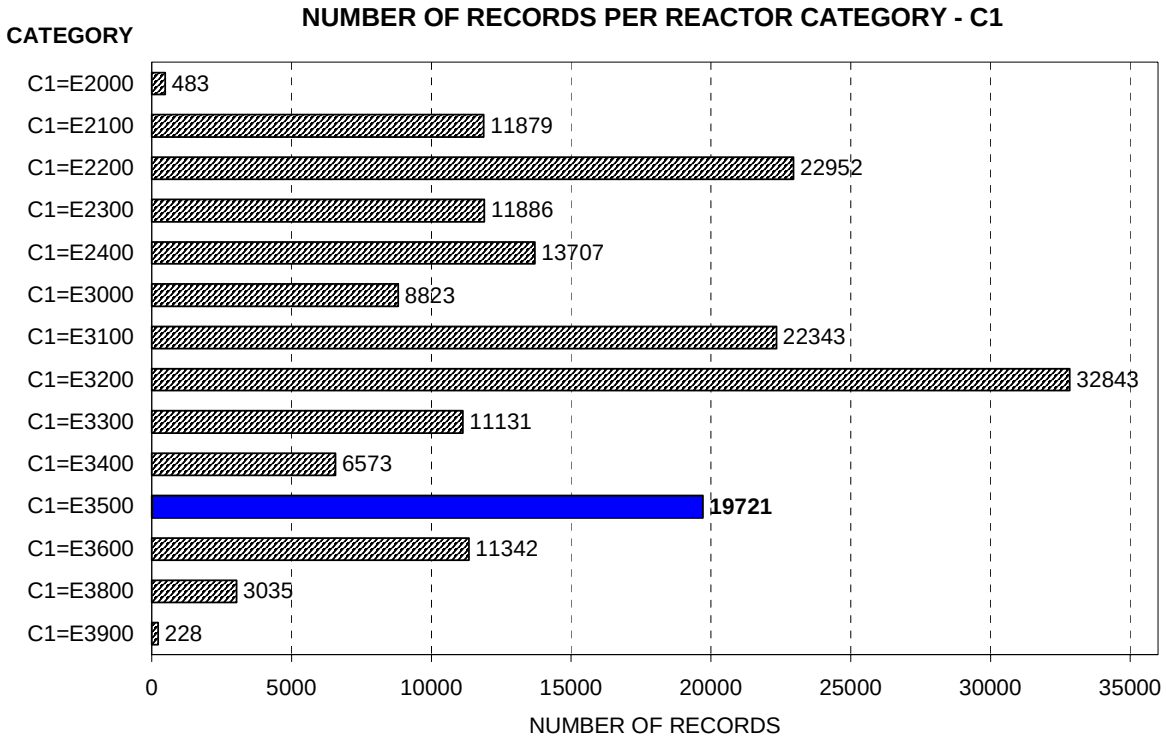
E3000 - SPECIFIC FISSION REACTOR TYPES AND THEIR ASSOCIATED PLANTS
- E3100 - Power Reactors, Non-Breeding, Light Water Moderated, Boiling Water Cooled (BWR, etc., types)
- E3200 - Power Reactors, Non-Breeding, Light Water Moderated, Non-Boiling Water Cooled (PWR, etc., types)

E3300 - Power Reactors, Non-Breeding, Graphite Moderated (GCR, AGR, HTGR, etc., types)
E3400 - Power Reactors, Non-Breeding, Heavy Water or Otherwise Moderated or Unmoderated
E3500 - Power Reactors, Breeding
E3600 - Research, Test, Training, Production, Irradiation and Materials Testing Reactors
E3800 - Mobile, Propulsion, Transportable and Package Reactors
E3900 - Process Heat Reactors

This analysis deals with records in the Power Reactors, Breeding category (E3500) and covers the period from 1970 till the end of 1999. It includes all items which have been published and input into the INIS Database till the end of 1999. The INIS Database is published on CD-ROM by the INIS Secretariat. It comprises seven archival discs covering the period from 1970 through 1996 and one current disc. The last CD taken into account for the present analysis was labelled "1997-1999/12". This is the last volume with the mentioned subject categories which have been replaced by a new common INIS and ETDE subject categorization scheme in January 2000.

In time dependence analysis, records published before 1975 were not included, since records collected during the start-up period of the INIS Database from 1970-1974, suffer from incomplete literature coverage. The following 25 years, from 1975-1999, were considered as relevant for this analysis, although records input in 1998 and 1999 must be considered as incomplete, due to the lead-in time for the database. The data presented in graphs related to the year 1998 and 1999 are, in fact, extrapolated according to the average time lag for records input into the INIS Database.

Figure 1



In December 1999, the total number of records in the INIS Database was 2,143,963 of which 181,525 records fall into reactor categories (these are the records having one of the mentioned reactor categories as their primary category). The total number of records in the Power Reactors, Breeding primary category (C1=E3500) is 19,721. This means that about 8.5% of the records in INIS Database are in fission reactor categories. About 11% of records in fission reactor categories are related to fast-breeder power reactors. This means that about 1% of the total number of records in INIS Database are in the Power Reactors, Breeding category (Figure 1). The share of records in other non-breeding power reactor categories (E3100, E3200, E3300, E3400) of the total number of records in reactor categories is 40%, i.e. about 3.5% of the INIS Database.

One should take into account the small number of fast breeder power reactors in operation or under construction. On 31. December 1998 there were 4 fast breeder power reactors in operation out of 434 power reactors in total, i.e. only 0.9%. They were producing 0.3% of total power (MWe). According to the same source (*Nuclear Power Reactors in the World, April 1999 edition, Reference data Series No. 2, IAEA, Vienna 1999)* the number of fast breeder power reactors under construction was 2, i.e. 6% in total number of power reactors under construction. Comparison of these figures with the respective number of records in the INIS database, shows the significance of subjects related to research and technology related to fast breeder power reactors.

The number of records in fast breeder power reactor category (C1=E3500) versus year of publication is shown in Figure 2. These data are compared to the number of records in all the categories related to fission reactors and the total number of records in the INIS Database. The maximum number of records in the fast breeder reactor category input in the INIS Database are related to items published in 1984. In the following few years this number was almost constant and later it started decreasing. This trend is similar to the total number of records in fission reactor categories.

Figure 2

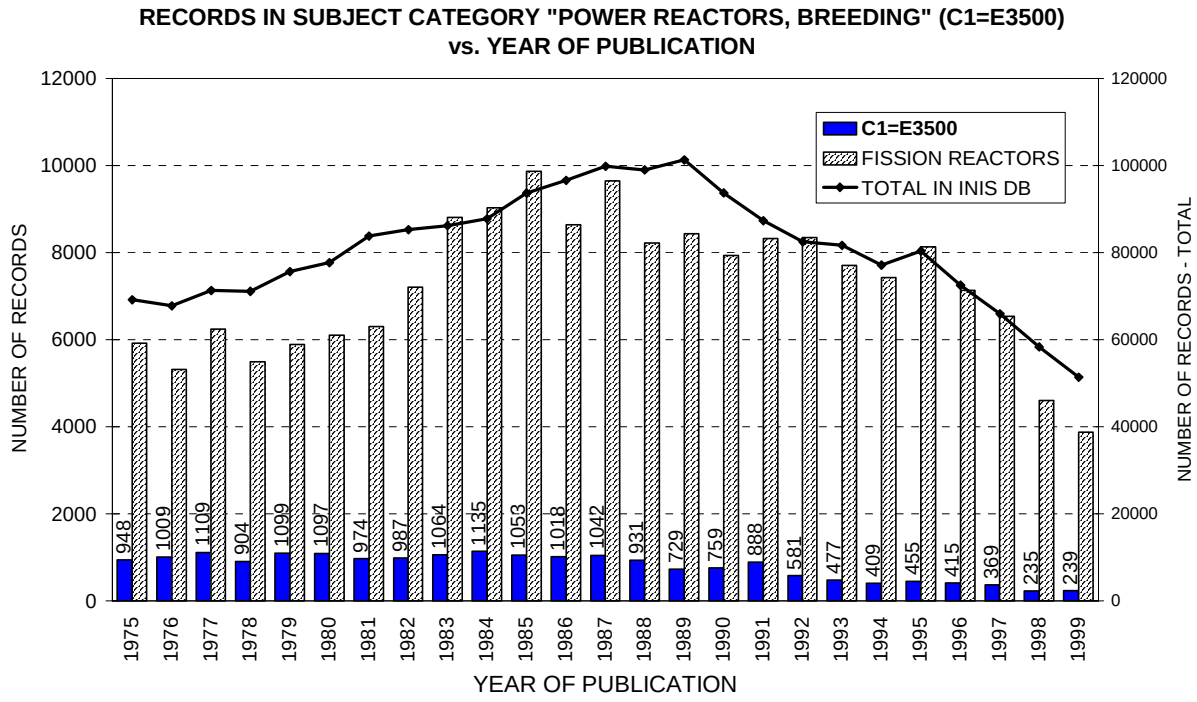


Figure 3 shows the comparison of the number of records in the fast breeder power reactor category (C1=E3500) and in non-breeding power reactor categories (E3100, E3200,E3300 and E3400) versus year of publication, and the total number of records in all the fission reactor related categories. The average yield of records in the fast breeder power reactor category versus the total number of records in power reactors (breeder and non-breeder) per year was 21%. The maximum value of this yield was attained in 1976 at 37%. It decreased gradually during the following years. This shows the time dependence of the interest in fast breeder reactor related research. Somewhat better insight into time dependence of these data, which could give information about the developments in research and technology related to breeding and non-breeding power reactors can be obtained from Figure 4. It shows the normalised time distribution of the number of records in mentioned subject categories.

Figure 3

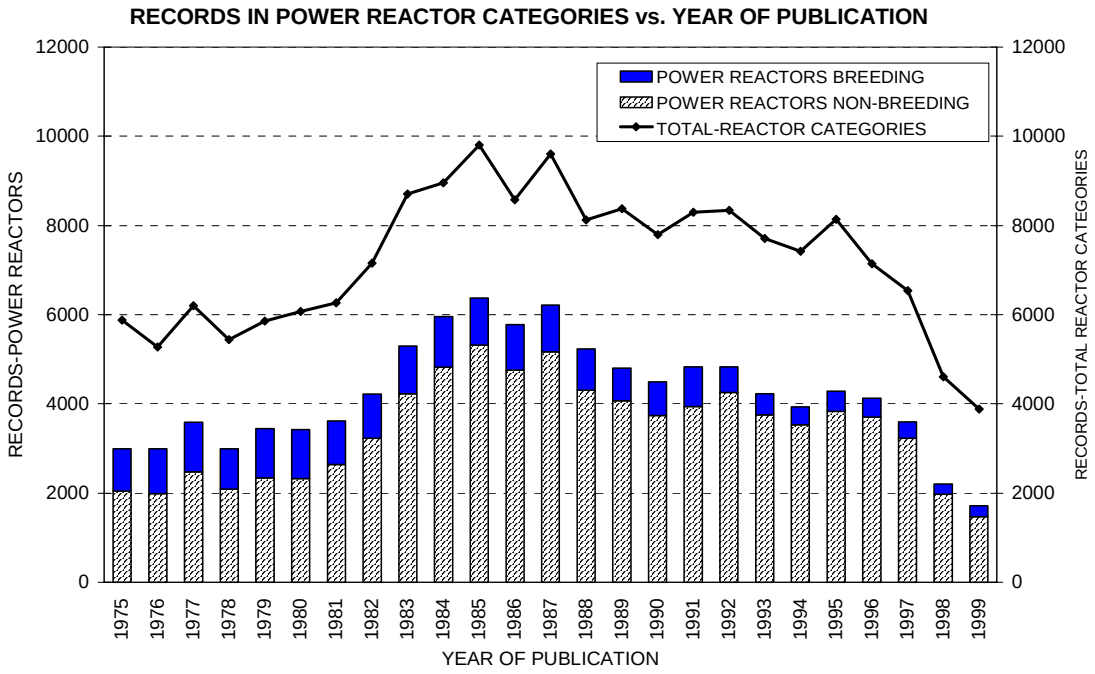
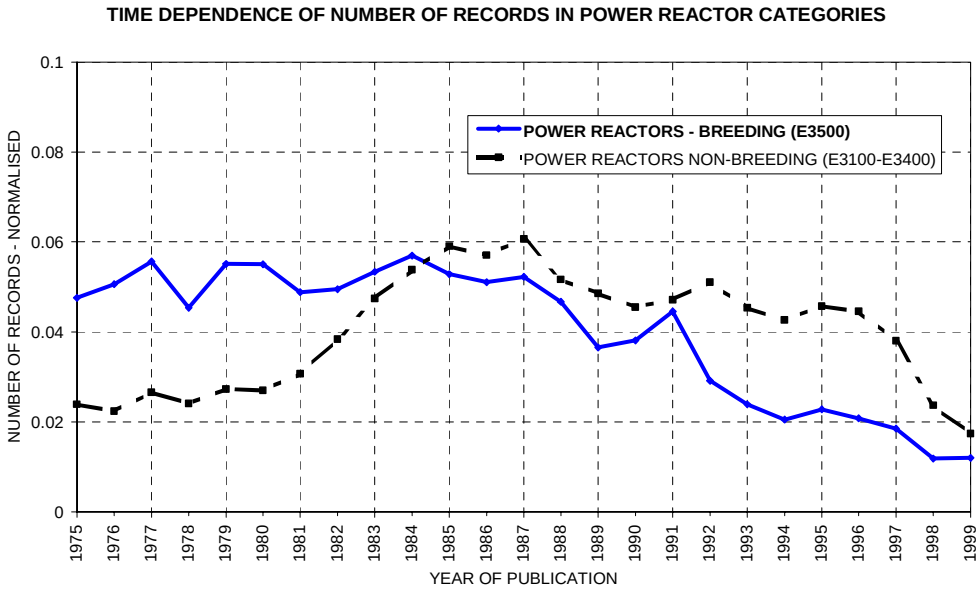


Figure 4



Primary and Secondary Subject Categories

The INIS categorization scheme allows two categorization levels in order to describe more precisely the subject of each record. Secondary subject categories are assigned frequently because of the multidisciplinary character of records in the fast breeder power reactor category. The number of records assigned the fast breeder reactor category as primary (C1) in the INIS database is 19,721, and the number of records having the fast breeder reactor category assigned as secondary (CC) amounts to 7159.

The appearance of records assigned with secondary subject category "fast breeder power reactors" (CC=E3500) versus primary categories in the INIS Database is shown in Figure 5. The majority (39%) of records assigned with secondary fast breeder reactor category (CC=E3500) were assigned with the primary category "Environmental aspects of nuclear installations" (C1=C5200). About 28% of records assigned with E3500 secondary category have some other fission reactors related categories assigned as primary. The distribution of primary categories for records having CC=E3500 as secondary category is shown in Figure 6-a.

More than 600 records assigned with subject category "Reactor Control Systems" (C1=E2400); are related to fast breeder power reactors (secondary category E3500). Some 372 records with primary category "Research, Test, Training, Production, Irradiation and Materials testing Reactors" (C1=E3600) have been assigned with E3500 as secondary category. The related literature is concerned with fast breeder experimental and/or research facilities. It should be mentioned that according to the IAEA Research Reactor Database (RRDB) only 5.5% of the 291 operating research reactors in the world are declared as fast breeder facilities.

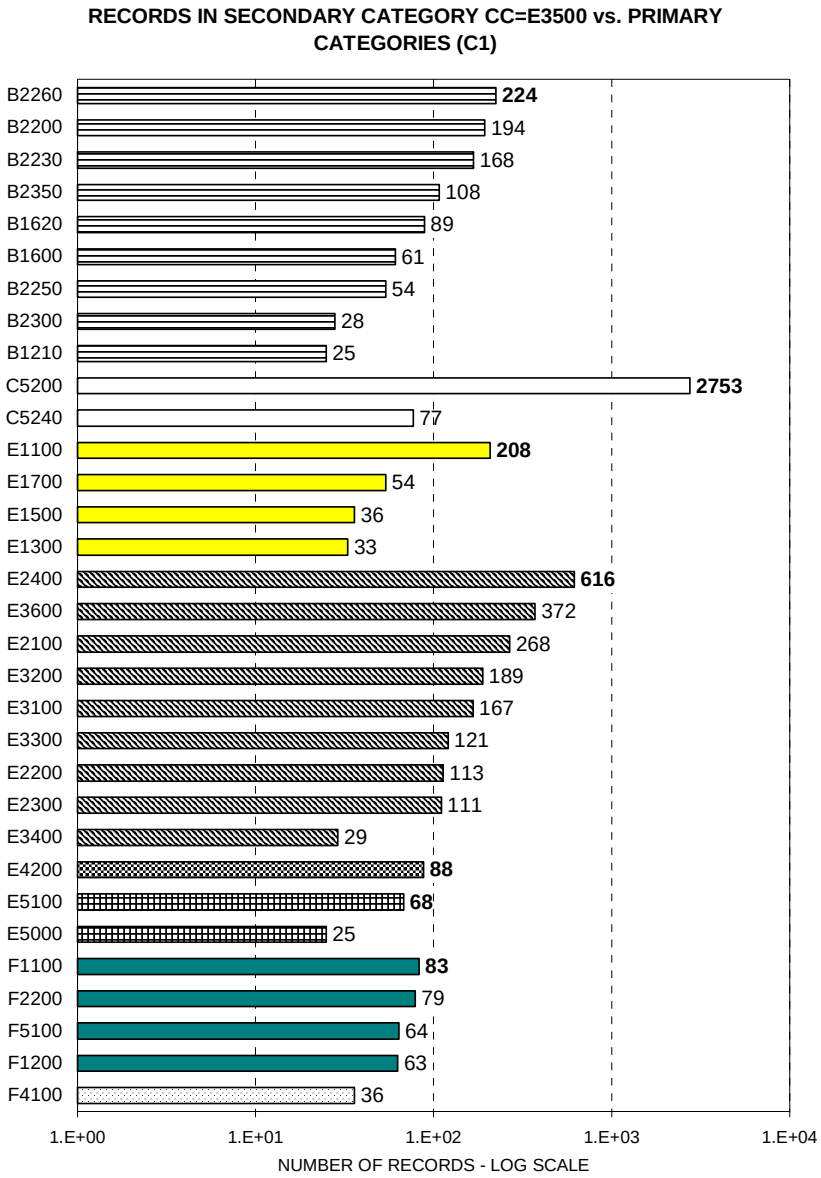
The number of records related to "Reactor Theory and Calculation" (C1=E2100), "Power Reactors, Non-Breeding, Light Water Moderated, Non-Boiling Water Cooled" (C1=E3200); "Power Reactors, Non-Breeding, Light Water Moderated, Boiling Water Cooled" (E3100); "Power Reactors, Non-Breeding, Graphite Moderated" (E3300) having CC=E3500 is not negligible. The case of categories "Reactor Components and Accessories" (E2200) and "Reactor Fuels" (E2300) is similar.

From Figure 6-b, it is seen that more than 200 records assigned with primary category "Thermodynamics and Fluid Flow" (C1=E1100) have E3500 assigned as secondary category. This is due to the fact that fast breeder power reactors are cooled by liquid metal coolant (frequently sodium) that demand special technology assessment.

The distribution of records having assigned fast breeder reactor secondary category versus the primary categories "Other aspects of nuclear and non-nuclear energy" is shown in Figure 6-c.

About 40% of the records with assigned secondary category "Fast Breeder Power Reactors" are related to primary categories in "Chemistry, materials and earth sciences". The distribution in these subject categories is shown in Figure 6-d.

Figure 5



LEGEND:

B2260 - Physical radiation effects on all metals and alloys
B2200 - Metals and Alloys
B2230 - Mechanical Properties
B2350 - Corrosion and erosion (ceramics and cermets)
B1620 - Spent fuel reprocessing
B1600 - Fission Fuels
B2250 - Corrosion and erosion (metals and alloys)
B2300 - Ceramics and cermets
B1210 - Chemical and Physico-chemical studies
C5200 - Environmental Aspects (Impact on Ecosystems) of Nuclear Installations
C5240 - Environmental Aspects of design Basis and Hypothetical Accidents at Nuclear installations
E1100 - Thermodynamics and Fluid Flow
E1700 - Materials Testing
E1500 - Handling of Radioactive Materials
E1300 - Structures and Equipment
E2400 - Reactor Control Systems
E3600 - Research , Test, Training, Production, Irradiation and Materials Testing Reactors
E2100 - Reactor Theory and Calculation
E3200 - Power Reactors, Non-Breeding, Light Water Moderated, Non-Boiling Water Cooled (PWR, etc., types)
E3100 - Power Reactors, Non-Breeding, Light Water Moderated, Boiling Water Cooled (BWR, etc., types)
E3300 - Power Reactors, Non-Breeding, Graphite Moderated (GCR, AGR, HTGR, etc., types)
E2200 - Reactor Components and Accessories
E2300 - Reactor Fuels
E3400 - Power Reactors, Non-Breeding, Heavy Water or Otherwise Moderated or Unmoderated
E4200 - Other nuclear instrumentation and Methods
E5100 - Waste Treatment
E5000 - Waste Management
F1100 - Nuclear Power Economics
F2200 - Nuclear Installations
F5100 - Nuclear Computation and Simulation
F1200 - Nuclear Fuel Cycle Economics
F4100 - Technical Aspects (Safeguards)

Figure 6-a

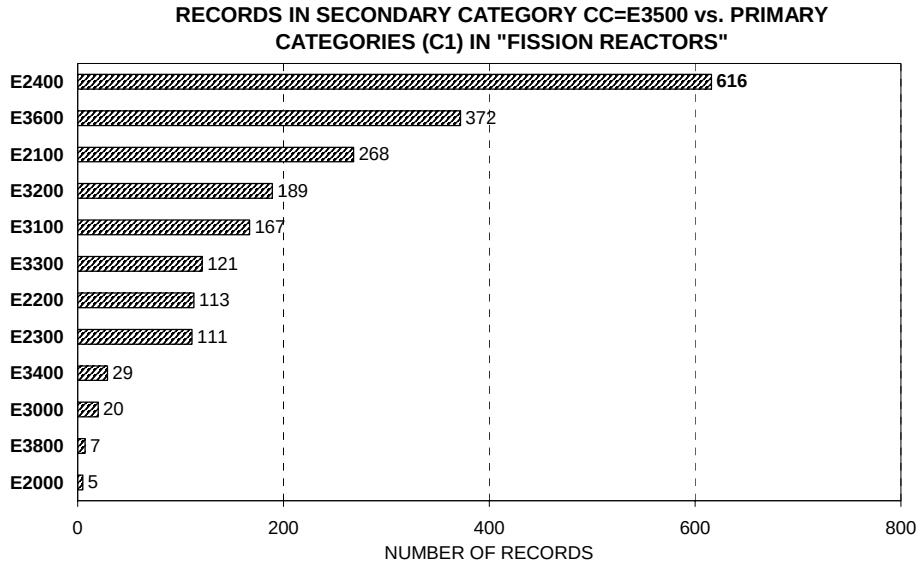


Figure 6-b

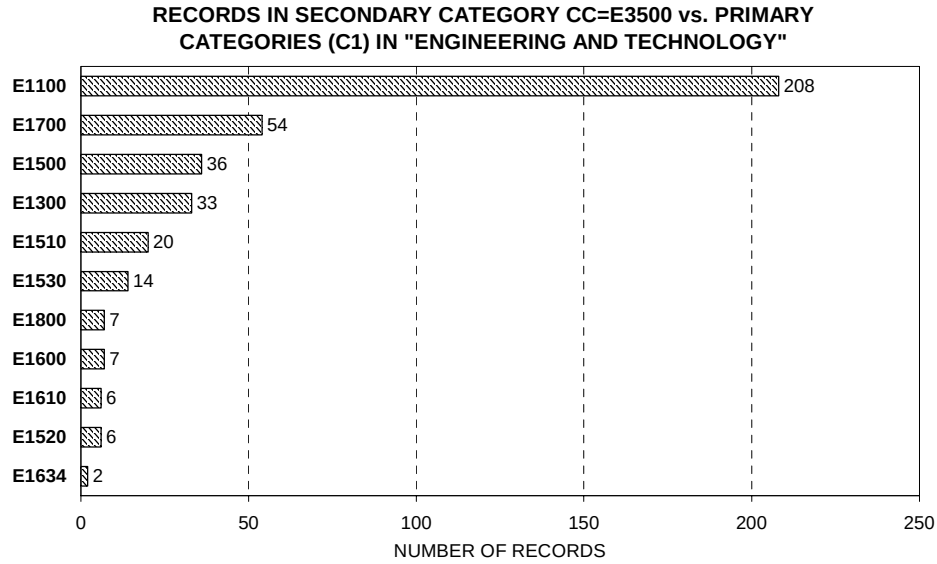


Figure 6-c

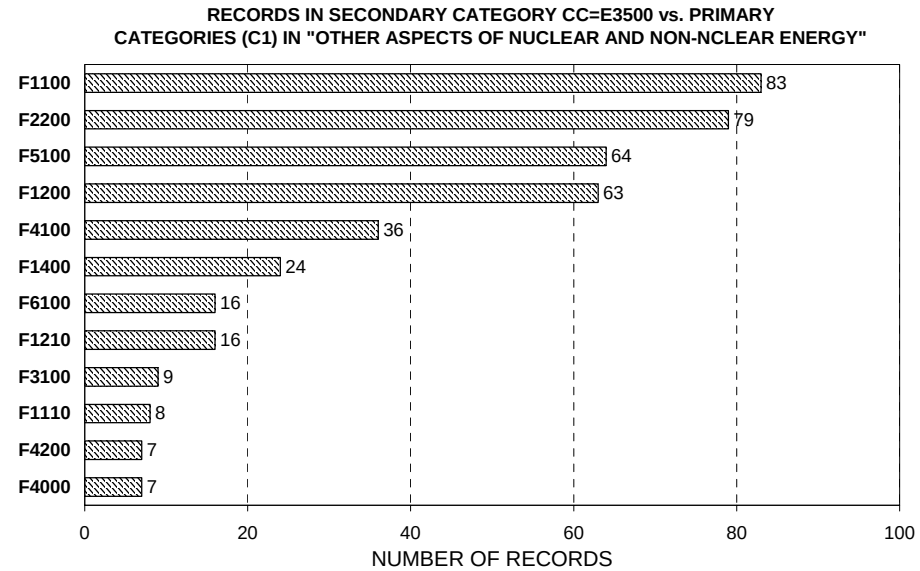
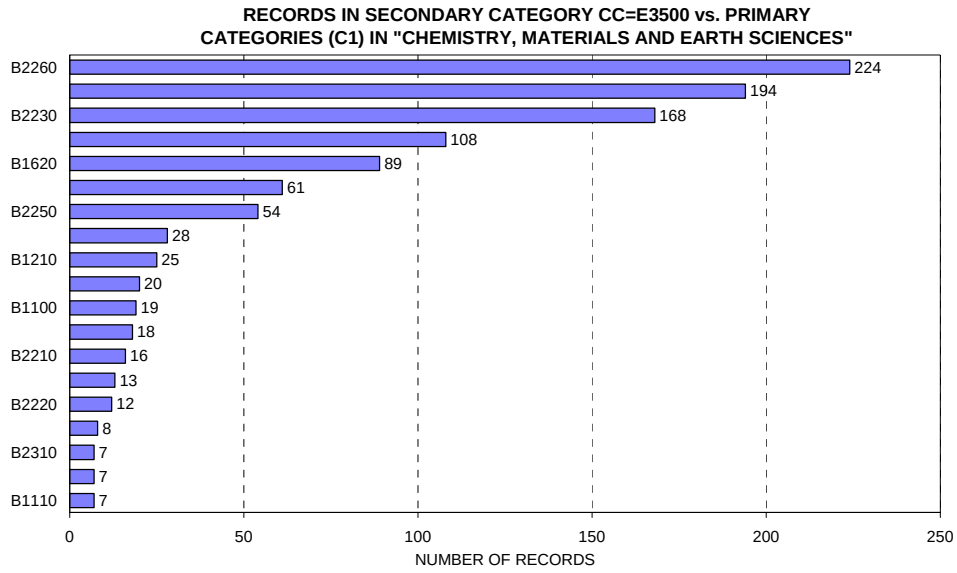
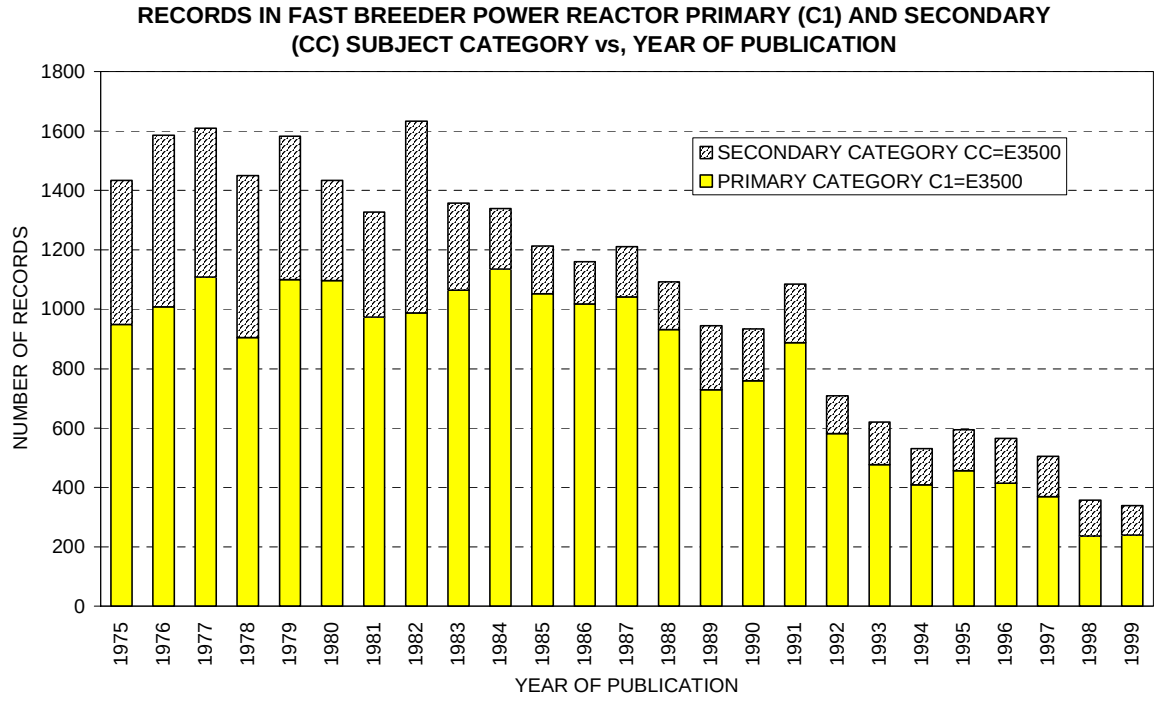


Figure 6-d



The time dependence of fast breeder power reactor records assigned both as primary and as secondary is shown in Figure 7. The average ratio of the number of records assigned with secondary (CC) versus primary (C1) fast breeder power reactor category per year is 25%. The maximum value of this ratio (40%) was attained in 1982 and a minimum showed up in 1986.

Figure 7



Origin of input

During the period of 25 years, the records in the INIS database were sent by 119 Member countries or organisations, 87 countries/organisations have sent records assigned with primary fission reactor subject categories, and 47 countries/organisations contributed to the total of 19,721 records classified in "Power Reactors, Breeding" (E3500) primary category.
Records in fast breeder power reactors primary category (C1=E3500) per INIS member state/organization of input are shown in Figure 8. More detailed data are shown in Table 1. The highest contribution came from countries having the most developed nuclear programs which involve research and development in the field of fast breeder reactors technology. The comparison of records assigned E3500 primary category to total number of records in fission reactors and to total INIS Database per country of input are shown as well. The average share of E3500 records in total fission reactor records per country of input was 7%. Some figures should be noted, such as share of the fast breeder power reactor (C1=E3500) records in total reactor categories input by France (18.3%), Japan (15.1%), Italy (14.9%), Germany (14.5%). This indicates the interest in fast breeder reactor technology in the mentioned countries. Netherlands, although not a leading country in fast breeder reactor technology, is among the first ten contributors because of its developed scientific publishing activity. More than 13% of the records in fission reactor categories input by Netherlands are related to fast breeder power reactors, indicating the interest of the international community in this subject. Similar is the case of the IAEA due to the Agency's task to promote nuclear energy and co-ordinate activities in development of related technology.

Figure 8

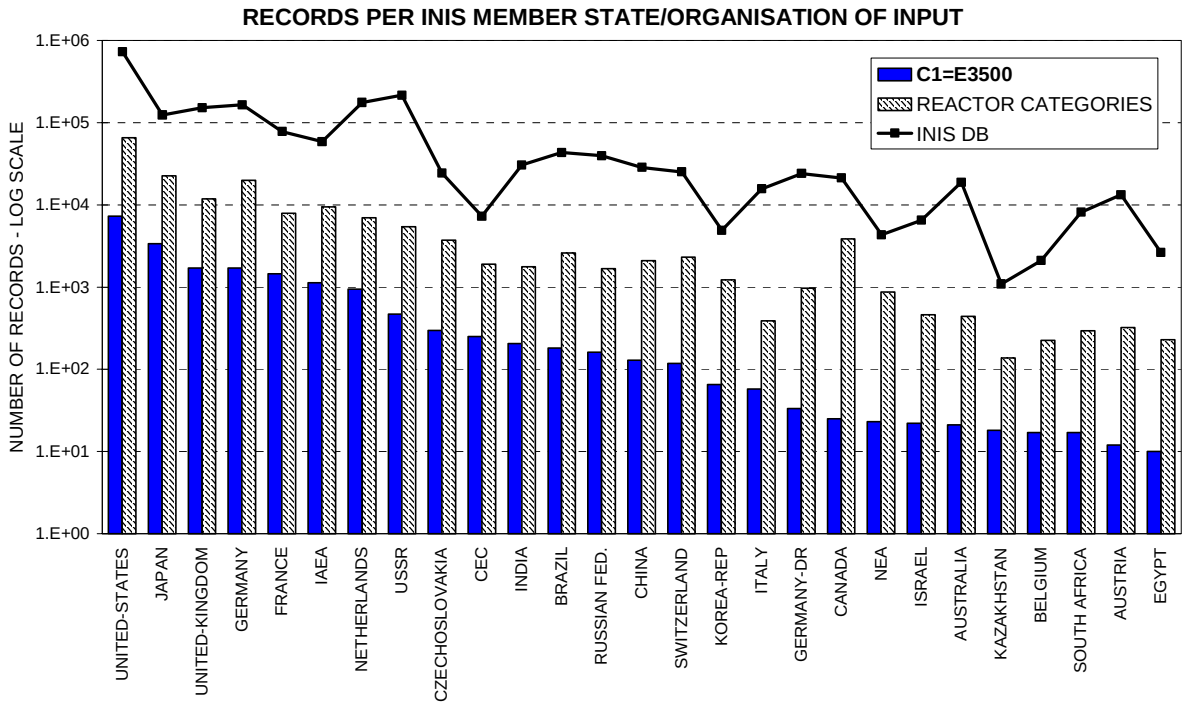
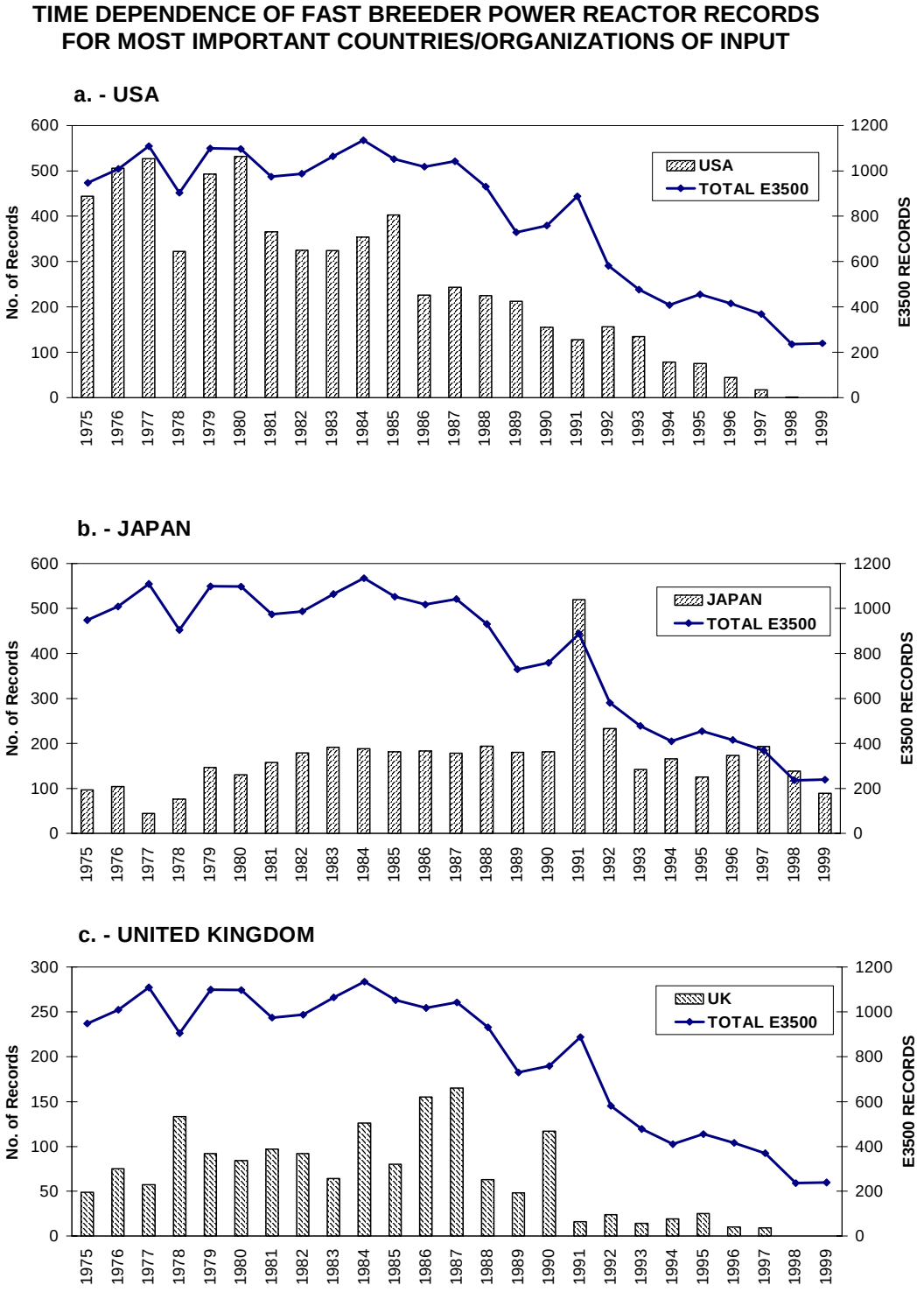


Table 1. Records in fast breeder power reactors primary category (C1=E3500) per INIS member state/organization of input

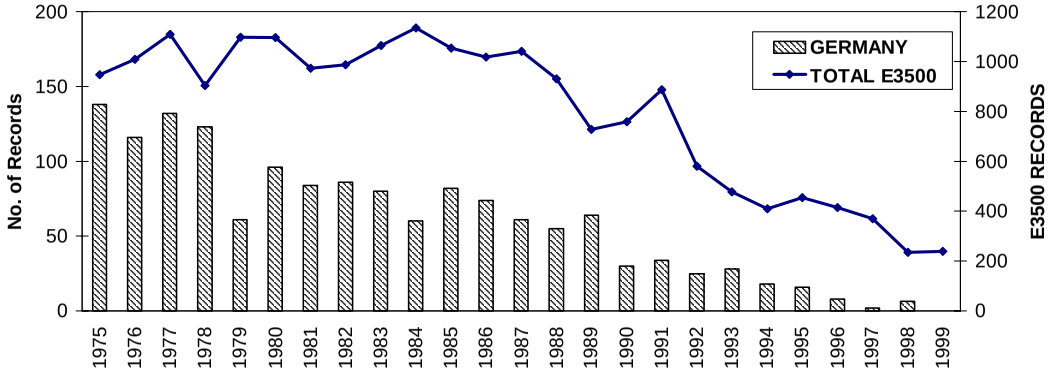
	COUNTRY/ ORGANIZATION OF INPUT	C1=E3500	SHARE IN E3500	SHARE OF E3500 IN REACTOR CAT.	SHARE OF E3500 IN INIS DB
1	UNITED STATES	7230	37%	11.0%	1.0%
2	JAPAN	3367	17%	15.1%	2.7%
3	UNITED-KINGDOM	1717	9%	8.6%	1.0%
4	GERMANY	1715	9%	14.5%	1.1%
5	FRANCE	1441	7%	18.3%	1.8%
6	IAEA	1124	6%	12.0%	1.9%
7	NETHERLANDS	938	5%	13.5%	0.5%
8	USSR	467	2%	8.6%	0.2%
9	CZECHOSLOVAKIA	298	2%	8.0%	1.2%
10	CEC	250	1%	13.2%	3.4%
11	INDIA	205	1%	11.6%	0.7%
12	BRAZIL	180	1%	6.9%	0.4%
13	RUSSIAN FEDERATION	161	1%	9.7%	0.4%
14	CHINA	128	1%	6.1%	0.5%
15	SWITZERLAND	117	1%	5.0%	0.5%
16	KOREA-REPUBLIC-OF	65	0.3%	5.3%	1.3%
17	ITALY	58	0.3%	14.9%	0.4%
18	GERMAN-DEM-REP	33	0.2%	3.4%	0.1%
19	CANADA	25	0.1%	0.6%	0.1%
20	NEA	23	0.1%	2.7%	0.5%
21	ISRAEL	22	0.1%	4.8%	0.3%
22	AUSTRALIA	21	0.1%	4.8%	0.1%
23	KAZAKHSTAN	18	0.1%	13.1%	1.6%
24	BELGIUM	17	0.1%	7.6%	0.8%
25	SOUTH-AFRICA	17	0.1%	5.8%	0.2%
26	AUSTRIA	12	0.1%	3.7%	0.1%
27	EGYPT	10	0.1%	4.3%	0.4%
28	SWEDEN	10	0.1%	1.4%	0.1%
29	ROMANIA	8	0.04%	2.2%	0.2%
30	DENMARK	7	0.04%	2.3%	0.1%
31	POLAND	7	0.04%	1.9%	0.0%
32	UKRAINE	5	0.03%	3.4%	0.1%
33	CZECH REPUBLIC	3	0.02%	0.3%	0.1%
34	HUNGARY	3	0.02%	0.4%	0.0%
35	NORWAY	3	0.02%	2.1%	0.1%
36	SPAIN	3	0.02%	0.6%	0.1%
37	ARGENTINA	2	0.01%	0.7%	0.1%
38	FINLAND	2	0.01%	0.3%	0.1%
39	BELARUS	1	0.01%	2.9%	0.1%
40	BULGARIA	1	0.01%	0.3%	0.0%
41	CERN	1	0.01%	50.0%	0.0%
42	CUBA	1	0.01%	1.1%	0.1%
43	JINR	1	0.01%	5.0%	0.0%
44	LITHUANIA	1	0.01%	1.9%	0.3%
45	PAKISTAN	1	0.01%	1.0%	0.1%
46	WEC	1	0.01%	16.7%	2.0%
47	YUGOSLAVIA	1	0.01%	0.5%	0.1%
	TOTAL	**19721**		**AVERAGE = 7%**	**AVERAGE = 0.6%**

Seven countries/organisations have sent about 90% of all records falling into fast breeder reactor category: United States (37%), Japan (17%), United Kingdom (9%), Germany (9%), France (7%), IAEA (6%), Netherlands (5). For somewhat better insight in research activities related to research and technology development in the field of fast breeder power reactors, the time dependence of number of records for the most important countries/organisations of input is shown in Figure 9 (a - f).

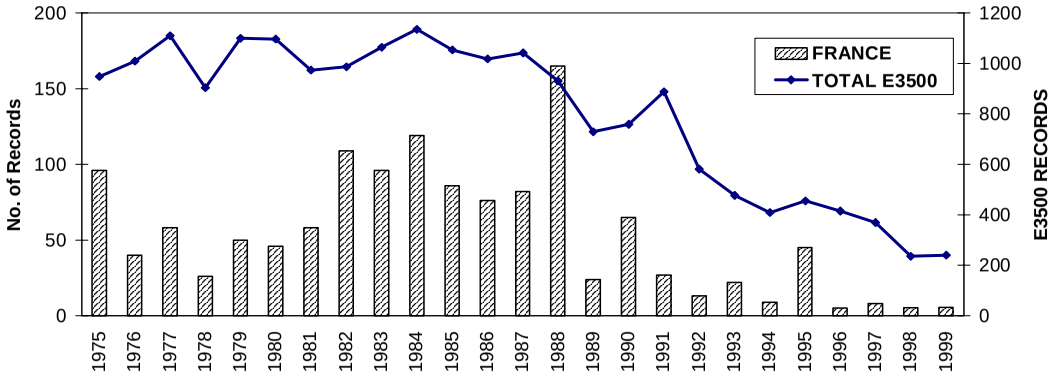
Figure 9



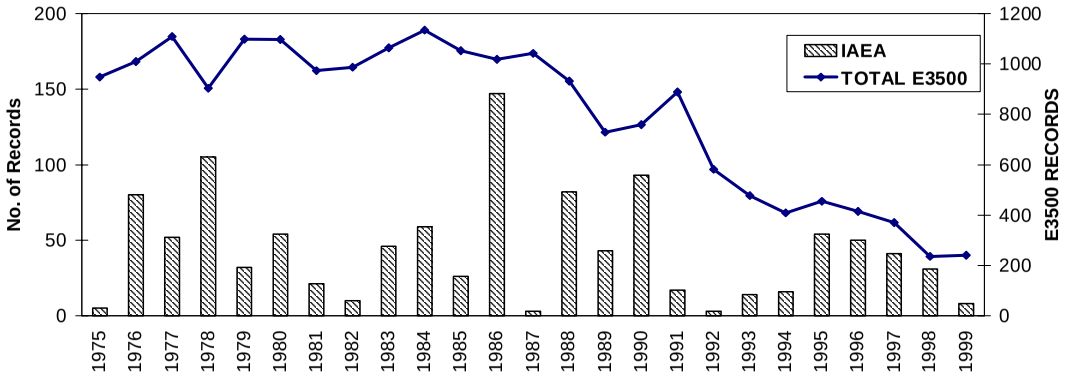
d. - GERMANY



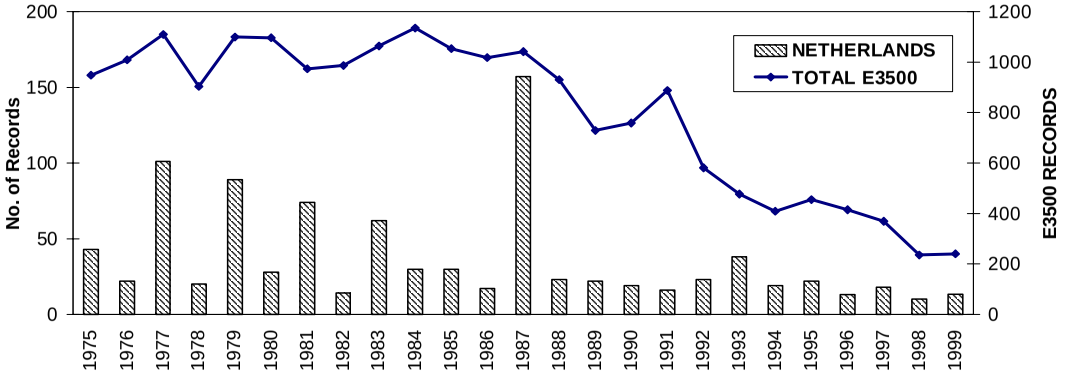
e. - FRANCE



f. - IAEA



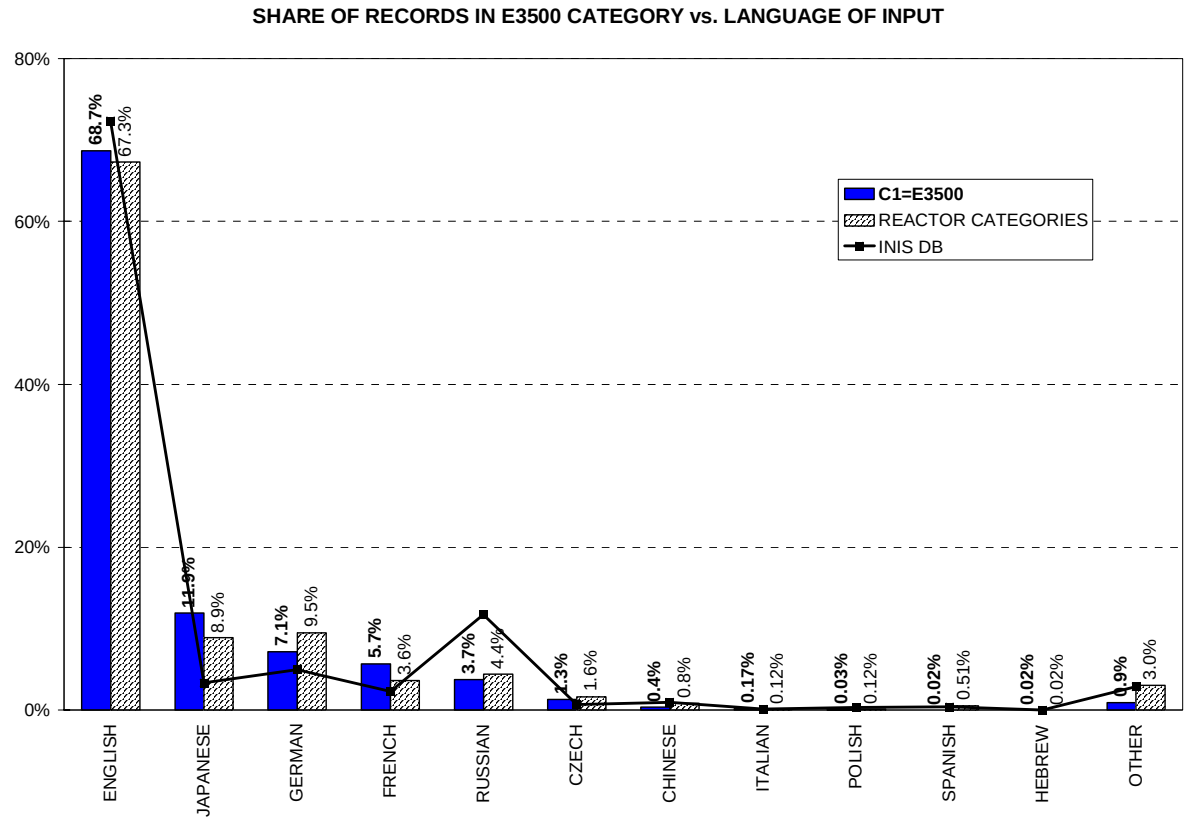
g. - NETHERLANDS



Languages

The majority of records in the fast breeder power reactor category refer to documents written in English (68.7%) which is somewhat less than the use of English language in the total INIS Database (72.3%) and slightly more than in the fission rector categories (67.3%). The share of records in fast breeder power reactors versus the most important languages used is compared to those in fission reactor categories and to the total INIS Database in Figure 10. One could conclude that the majority of authors from non-English speaking countries are submitting their publications in English, i.e. that the language of research and technology in fast breeder power reactors is English. The same conclusion is valid for the publications related to fission reactors and all other subjects in the scope of the INIS Database.

Figure 10



Publication types

Each record in the INIS Database indicates which type of publication it represents. The seven pre-defined types are: book, journal-article, report, miscellaneous (non-conventional literature), patent, computer-medium, translation and audio-visual material.

In Figure 11, the number of records in the fast breeder power reactor category is shown per publication type, and compared to the number of records related to fission reactors and the total number of records in the INIS database per publication type. The share of record types in the fast breeder power reactor category is compared to the share of records types in fission reactor categories and in the INIS Database in Figure 12. It turns out that about one third of records in the fast breeder power reactor category are journal-articles, one third are reports and 21% are books. The share of record types is similar to that in fission reactor subject categories. The share for journal-article type documents in fast breeder power reactor category as well as in fission reactor categories is less than in the INIS database, where it amounts to 55%. The difference in other categories is not so significant. One could also notice that the share of patent type records in the fast breeder power reactor category (13%) is higher than in fission reactor categories and significantly higher than in the total INIS Database.

Figure 11

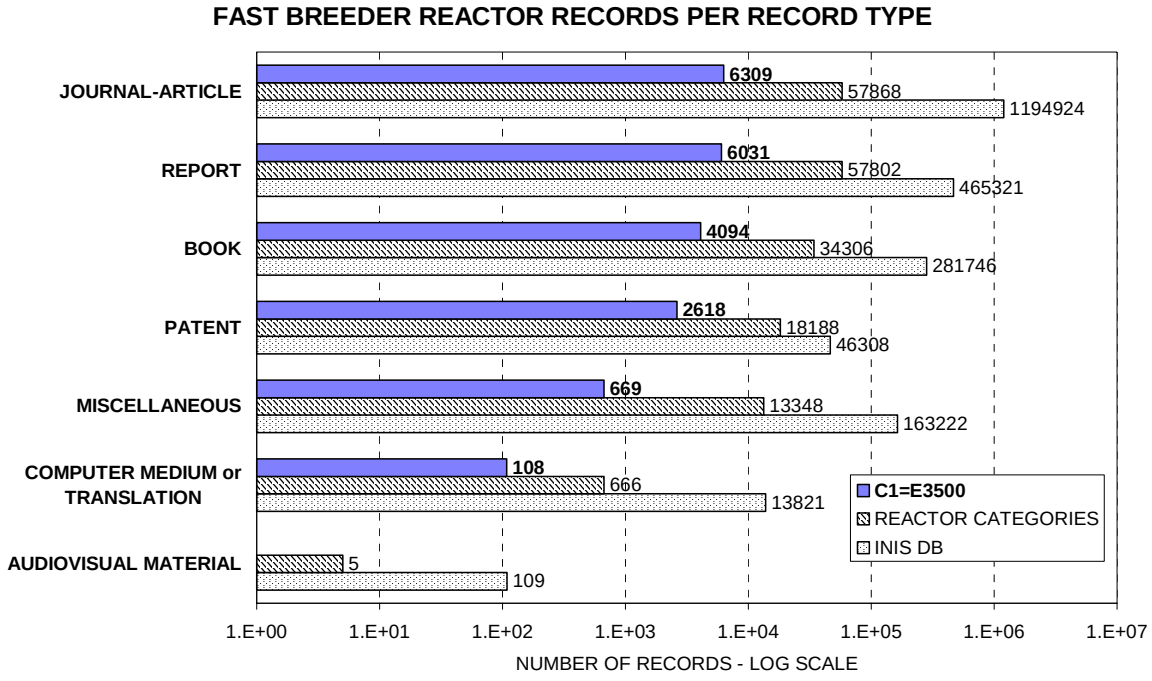
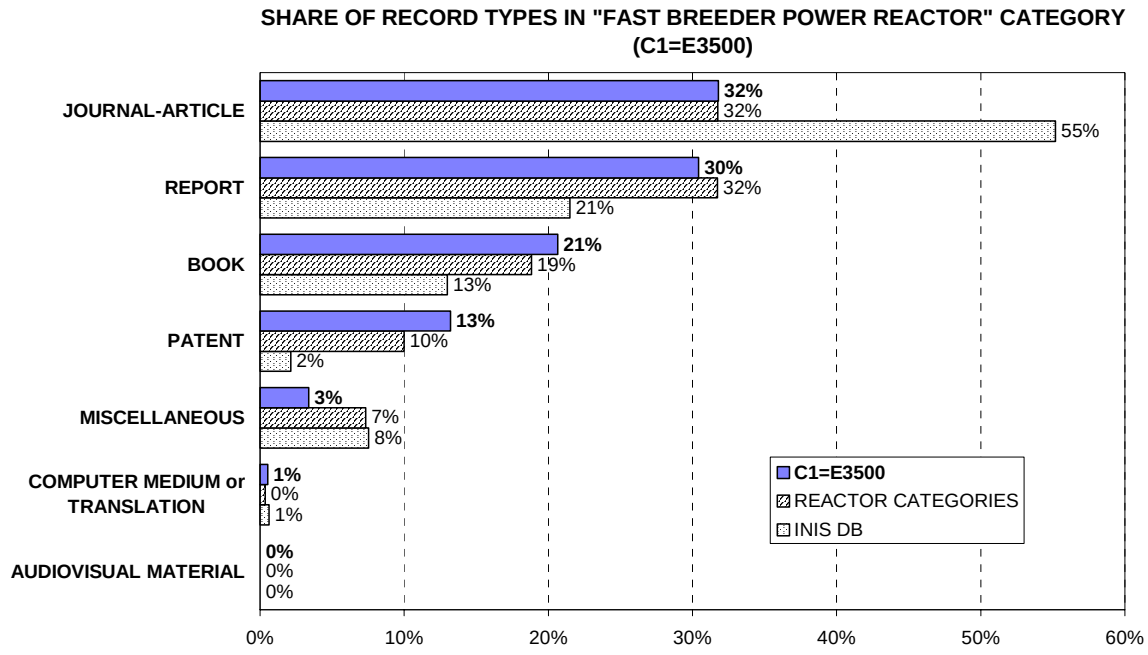


Figure 12



Literary indicators

The following 10 literary types are defined: short communication, conference, dictionary, numerical data, legal material, thesis or dissertation, computer program description, standard or specification, progress report, bibliography. The full text of non-conventional literature is usually available from INIS unless it is marked with the special literary indicator “X” (unavailable from INIS).

The number of records in the fast breeder power reactors category per literary type are shown in Figure 13 in comparison with the respective number of records per literary type in fission reactor categories and in the INIS Database.

The majority of records (63%) in the fast breeder power reactors category were published as conference publications (Figure 14). The fraction of publications in the form of microfiche and short communication is 15%. Only 4% of publications are categorised as numerical data and 2% as progress reports. Almost 10% of the records published as thesis in fission reactor categories are related to fast breeder power reactors.

Each record in the database is assigned both with a record type and a literary type. Figure 15 shows he distribution of literary types per record type for the fast breeder reactor category.

The number of book-type records, journal-article-type records and report-type records per literary type are shown in Figures 16-a, 16-b, 16-c, for the fast breeder reactor category compared with respective numbers for fission reactor records as well as the database on the whole.

Figure 13

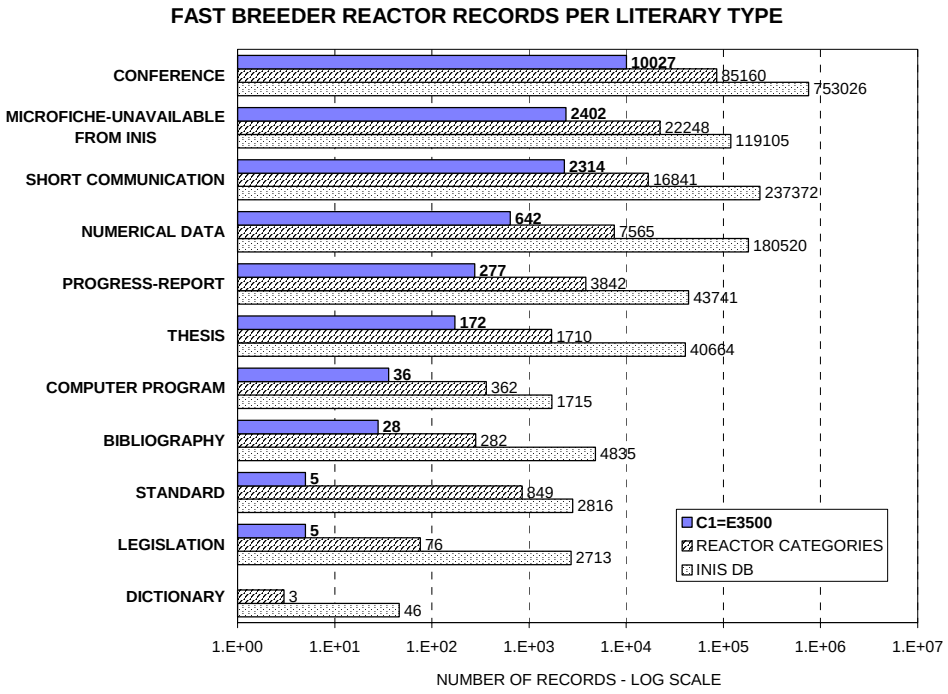


Figure 14

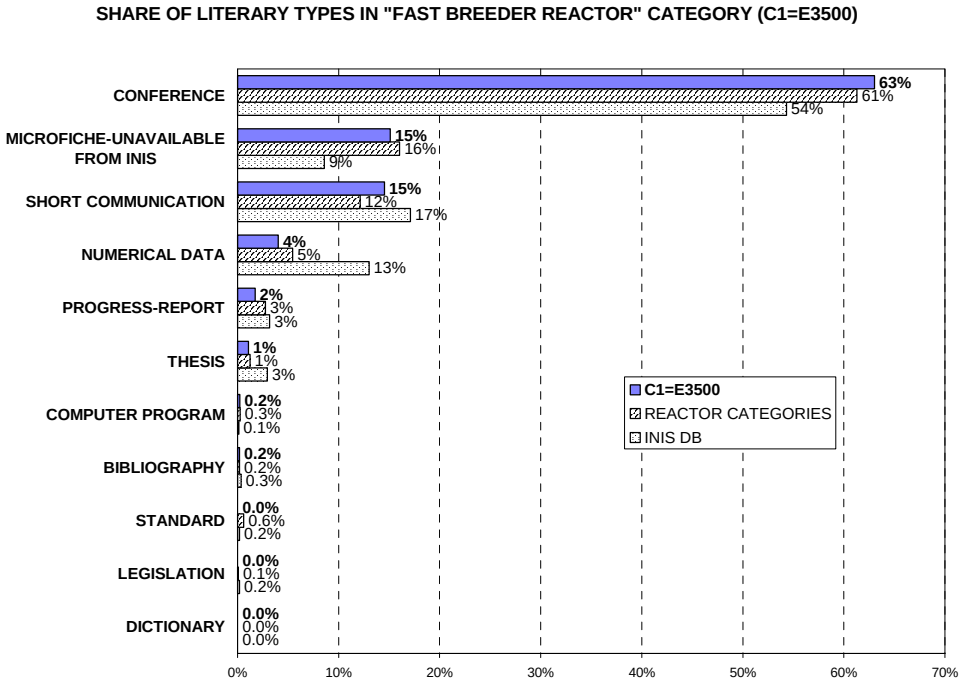
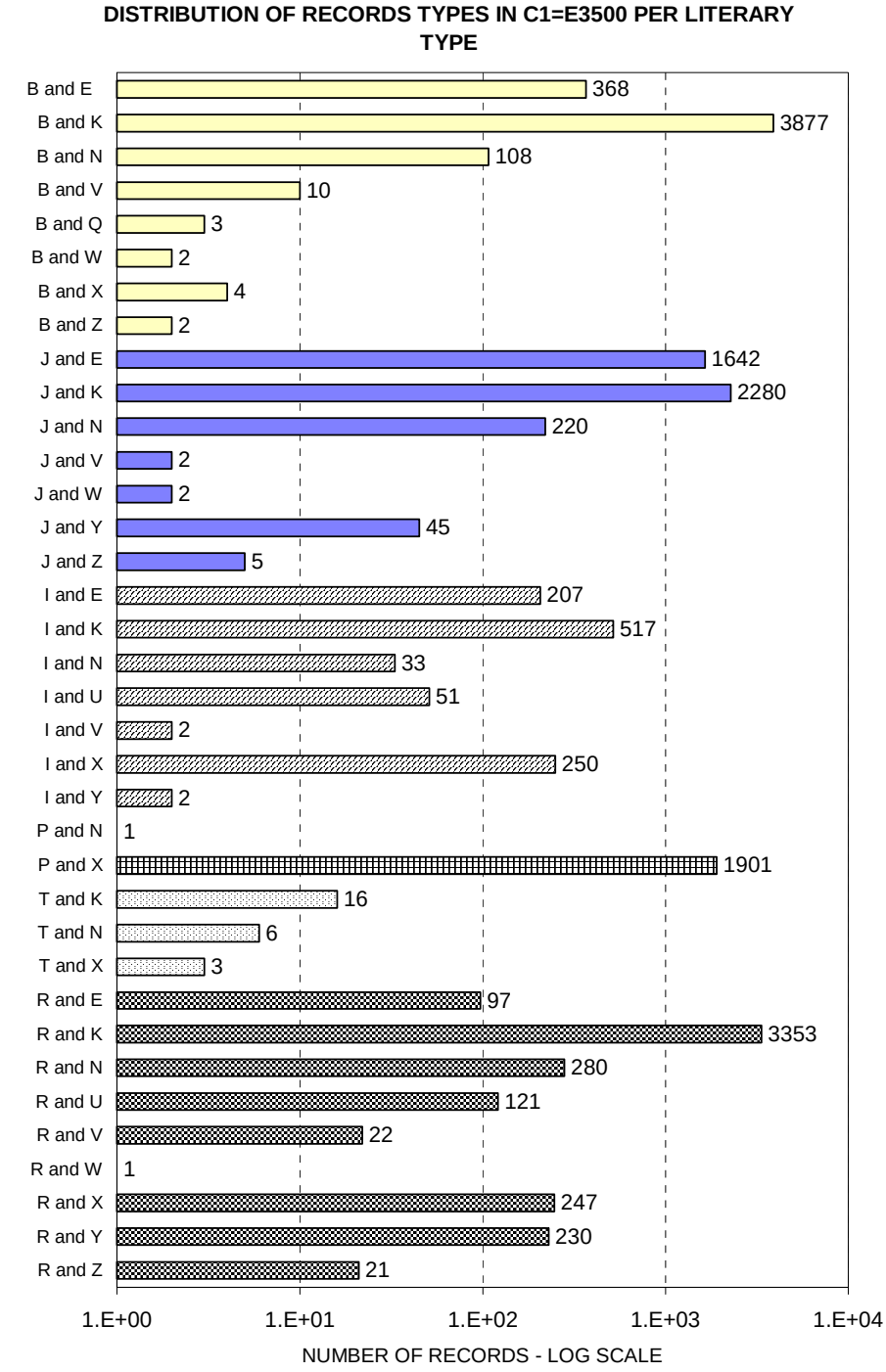


Figure 15



RECORDS TYPES:
B - BOOK J - JOURNAL-ARTICLE I - MISCELLANEOUS
P- PATENT T - COMPUTER MEDIUM OR TRANSLATION R - REPORT

LITERARY TYPES:
E - SHORT COMMUNICATION K - CONFERENCE L - DICTIONARY
N - NUMERICAL DATA Q - LEGISLATION U - THESIS
V - COMPUTER PROGRAM W - STANDARD
X - MICROFICHE-UNAVAILABLE FROM INIS Y - PROGRESS-REPORT Z - BIBLIOGRAPHY

Figure 16-a

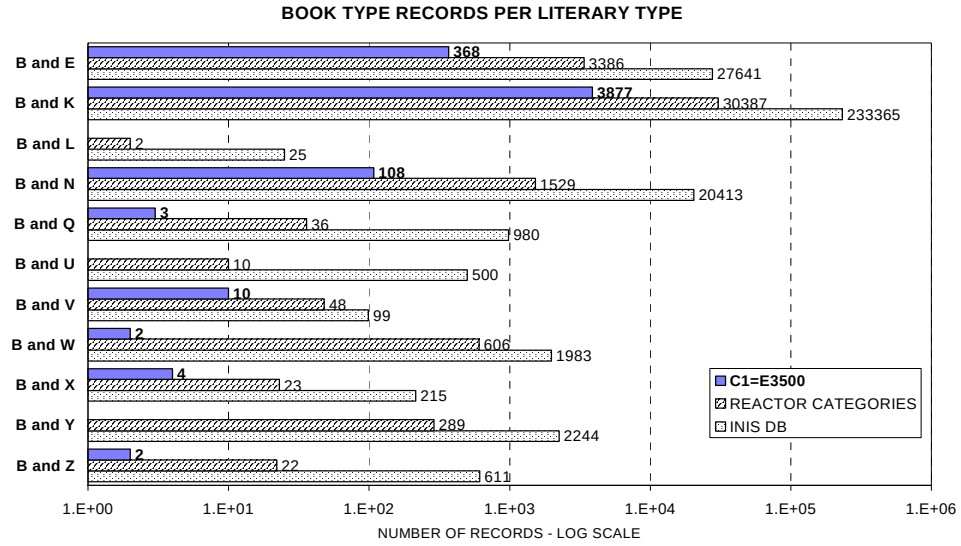


Figure 16-b

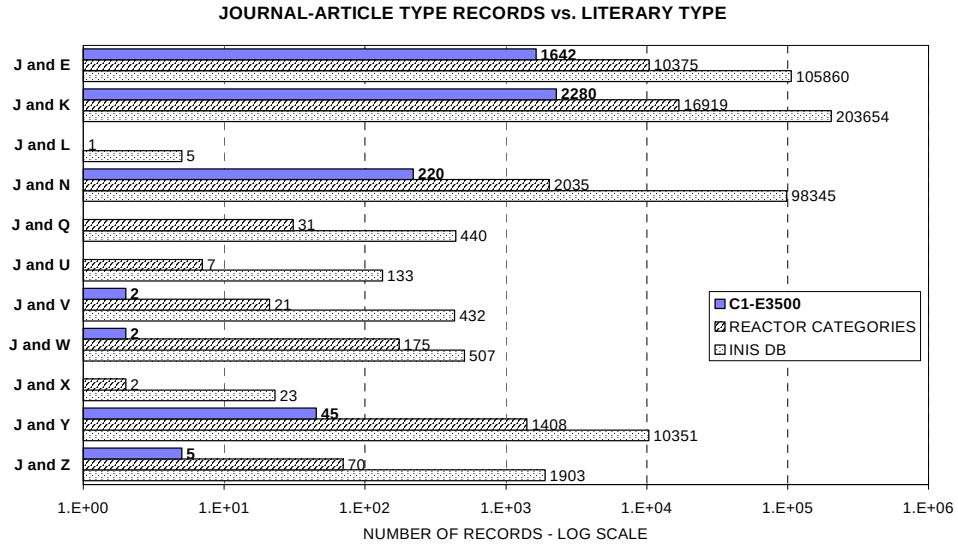
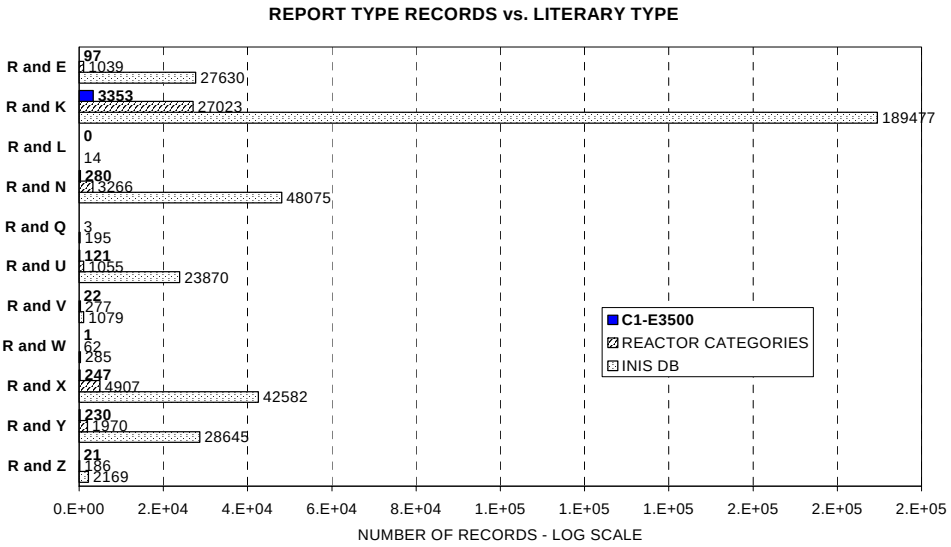


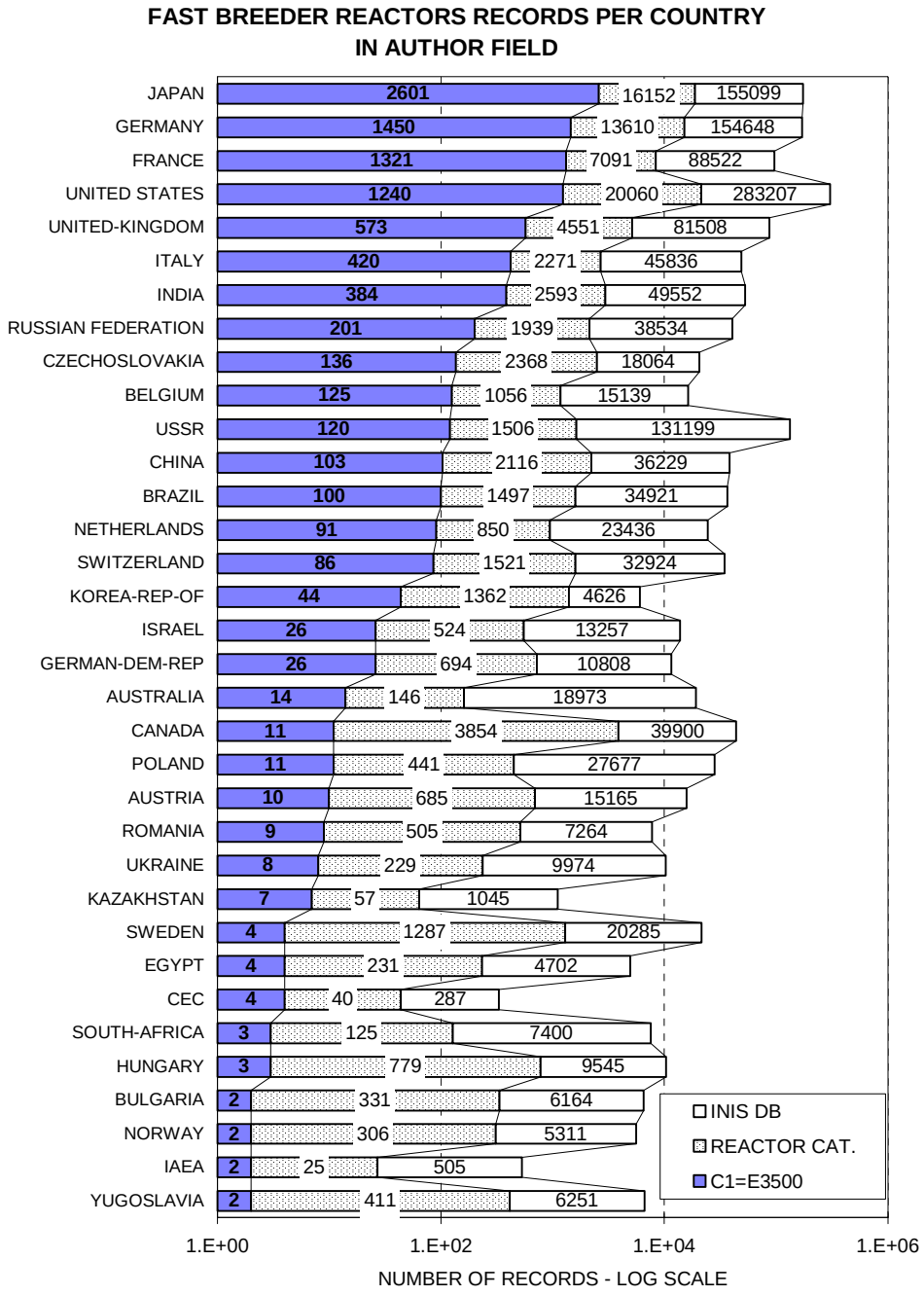
Figure 16-c



Authors, Institutions and Countries

The INIS Database records names of authors, institutions and countries of origin. Names of authors are commonly specified for journal articles and books, but exist in many cases for other record types as well. Country specific statistics referring to author's countries as well as to corporate entries are presented in Table 2. These data are independent of the country/organization of input, which are listed as well.
Figure 17 shows the distribution per country of records in fast power breeder reactor category compared to the respective values in the fission reactor categories and in the entire INIS Database, using country information from the author field.

Figure 17



In Figure 18, the country distribution of records in the fast power breeder reactor category is compared to the respective values in the fission reactor categories and to the entire INIS Database, using country information from the corporate entry field. These values are also independent of the country/organization of input. Corporate entries include corporate authors i.e. institutions responsible for the scientific content of publications and issuing organizations which are mentioned in the publication as editorially or organisationally responsible for the content of publication. Corporate author entries include academic institutions granting a degree, institutions organizing and/or sponsoring scientific meetings, as well as names of research institutes, laboratories, and names of conferences, symposia, meetings.

Figure 18

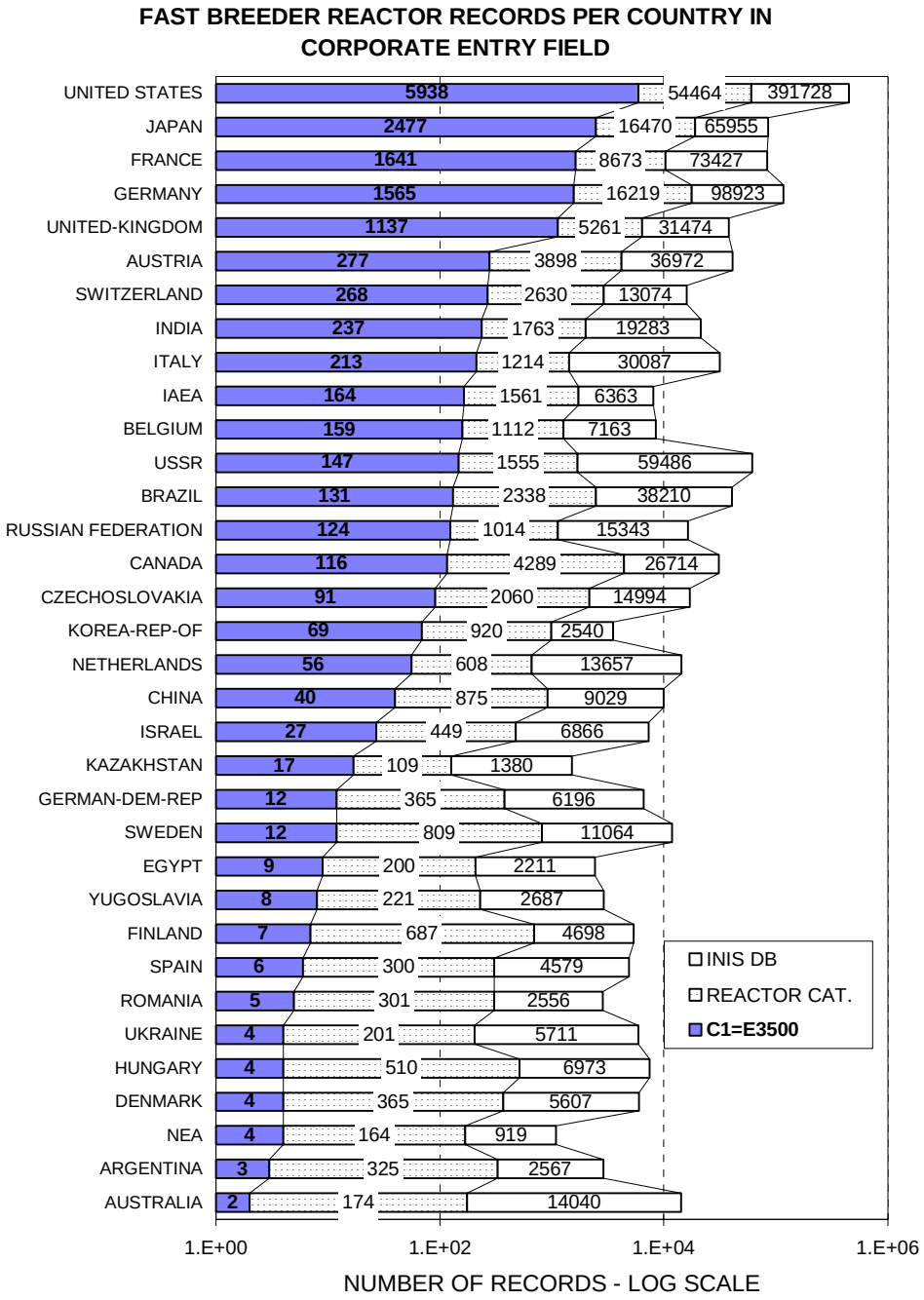


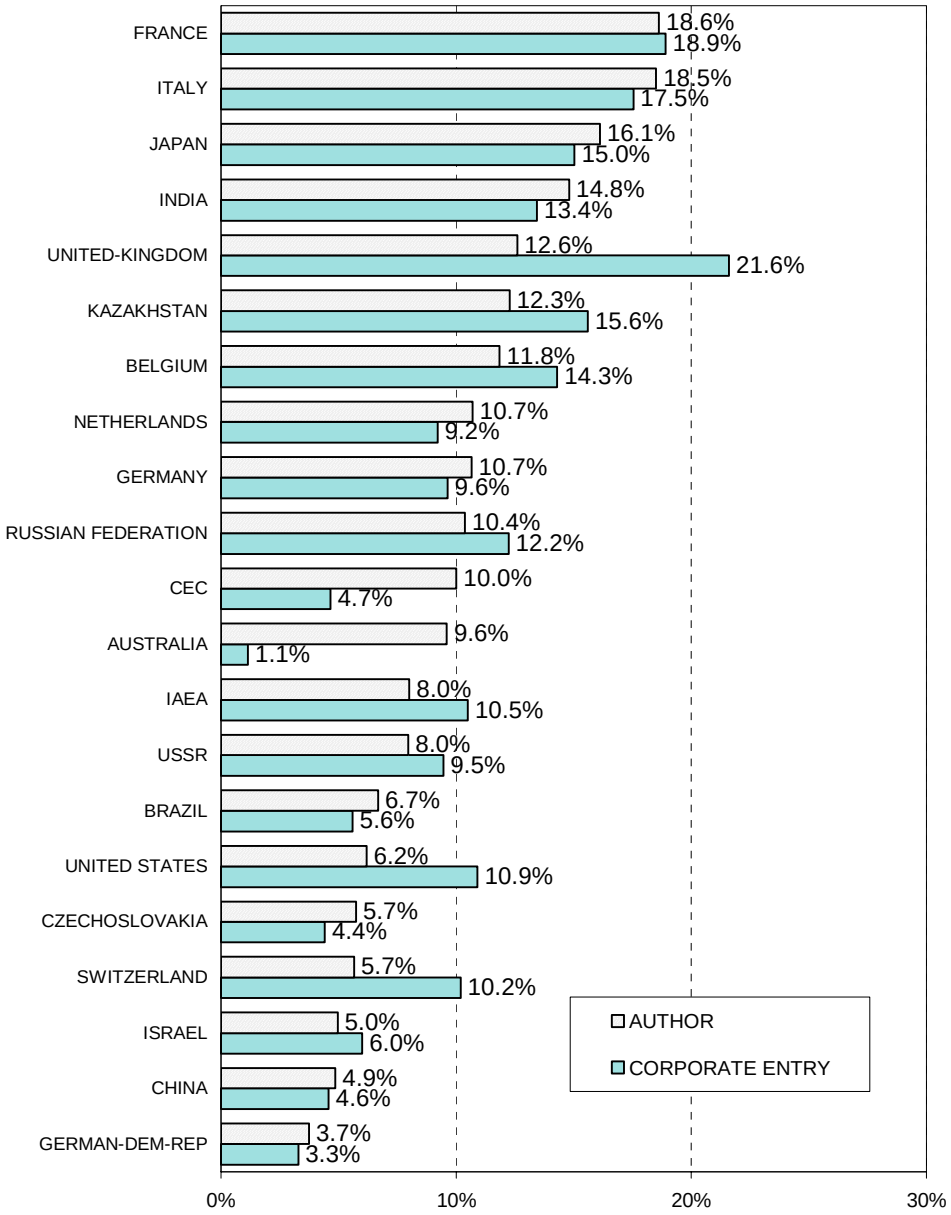
Table 2 Appearance of member countries/organisations in author, corporate and country of input fields for fast breeder reactor category (C1=E3500)

	COUNTRY/ORGANISATION	AUTHORS	CORPORATE ENTRY	INPUT ITEMS
1	JAPAN	2601	2477	3367
2	GERMANY	1450	1565	1715
3	FRANCE	1321	1641	1441
4	UNITED STATES	1240	5938	7230
5	UNITED-KINGDOM	573	1137	1717
6	ITALY	420	213	58
7	INDIA	384	237	205
8	RUSSIAN	201	124	161
9	CZECHOSLOVAKIA	136	91	298
10	BELGIUM	125	159	17
11	USSR	120	147	467
12	CHINA	103	40	128
13	BRAZIL	100	131	180
14	NETHERLANDS	91	56	938
15	SWITZERLAND	86	268	117
16	KOREA-REPUBLIC-OF	44	69	65
17	GERMAN-DEM-REP	26	12	33
18	ISRAEL	26	27	22
19	AUSTRALIA	14	2	21
20	CANADA	11	116	25
21	POLAND	11	2	7
22	AUSTRIA	10	277	12
23	ROMANIA	9	5	8
24	UKRAINE	8	4	5
25	KAZAKHSTAN	7	17	18
26	CEC	4	2	250
27	EGYPT	4	9	10
28	SWEDEN	4	12	10
29	SOUTH-AFRICA	3		17
30	HUNGARY	3	4	3
31	IAEA	2	164	1124
32	CZECH REPUBLIC	2	1	3
33	NORWAY	2	0	3
34	BELARUS	2	1	1
35	BULGARIA	2	0	1
36	PAKISTAN	2	1	1
37	YUGOSLAVIA	2	8	1
38	DENMARK	1	4	7
39	SPAIN	1	6	3
40	ARGENTINA	1	3	2
41	FINLAND	1	7	2
42	CUBA	1	1	1
43	LITHUANIA	1	0	1

The frequency of appearance of country names in the author field (Figure 17) was: Japan contributed 28%, Germany 16%, France 14%, USA 14%, United Kingdom 6%, Italy 5%. The comparison of the ranking order of countries according to their appearance in author (Figure 17) and corporate entry (Figure 18) fields shows a difference. The ranking of country name in corporate entry field is different: USA is leading, contributing 40%, followed by Japan (17%), France (11%), Germany (10%), United Kingdom (8%), etc.

The share of records in fast breeder power reactor category in fission reactor categories per country in author and corporate entry fields is shown in Figure 19.

Fig 19: SHARE OF FAST-BREEDER REACTOR RECORDS (C1=E3500) IN FISSION REACTOR CATEGORIES PER COUNTRY IN AUTHOR AND CORPORATE ENTRY FIELDS



Descriptors

Descriptors are scientific and/or technical terms (keywords) defined in the INIS Thesaurus, which is regularly updated. Each record in the database is indexed by subject specialists, i.e. a number of descriptors is assigned to each record. The use of such controlled terminology is considered as one of the most important tools for database retrieval.

The frequency of appearance of a number of typical descriptors in the fast breeder power reactor category (C1) and the whole of the INIS Database is shown in Table 3. The most frequently used descriptor in the fast breeder power reactor category is “REACTORS”. About 9% of records in the database assigned with the descriptor “REACTORS” fall in the fast breeder power reactor category. This is somewhat less than the share of category “Fast breeder power reactors” (E3500) in all fission reactor categories in the database. Almost half of the records in the database which have assigned descriptors “FAST REACTORS” and “EPITHERMAL REACTORS” are in the fast breeder power reactor category, meaning that these descriptors are present in either records with secondary fast breeder reactor or other categories. Appearance of descriptors “FBR TYPE REACTORS”, “BREEDER REACTORS”, and “LIQUID METAL COOLED REACTORS” in the INIS Database is almost twice as frequent as its appearance in the fast breeder power reactor category.

This means that fast breeder reactors are mentioned in other related categories almost as frequently as in the fast breeder power reactor category. Related categories include: Physical radiation effects on all metals and alloys (B2260); Metals and Alloys (B2200); Mechanical Properties (B2230); Corrosion and erosion (B2350, B2250); Spent fuel reprocessing (B1620); Fission Fuels (B1600); Environmental Aspects (Impact on Ecosystems) of Nuclear Installations (C5200); Environmental Aspects of design Basis and Hypothetical Accidents at Nuclear installations (C5240); Thermodynamics and Fluid Flow (E1100); Materials Testing (E1700); Reactor Control Systems (E2400); Research , Test, Training, Production, Irradiation and Materials Testing Reactors (E3600); Reactor Theory and Calculation (E2100); Power Reactors, Non-Breeding, Light Water Moderated, Non-Boiling Water Cooled (E3200); Power Reactors, Non-Breeding, Light Water Moderated, Boiling Water Cooled (E3100); Power Reactors, Non-Breeding, Graphite Moderated (E3300); Reactor Components and Accessories (E2200); Reactor Fuels (E2300); Other nuclear instrumentation and Methods (E4200); Waste Treatment and Management (E5100, E5200); Nuclear Power Economics (F1100); etc.

The table also lists the appearance of all the reactors either fast breeder or epithermal ones which are present by their names in the INIS Thesaurus. Most of them do not appear only in fast breeder power reactor category. It is indicated in the table that some of the most important descriptors in the INIS Thesaurus, were introduced in the INIS Thesaurus at the same time, (dates are cited in brackets).

Table 3 Appearance of typical descriptors in fast breeder reactors subject category (C1=E3500) and in INIS Database

DESCRIPTOR	C1=E3500	INIS DB	ratio
FAST REACTORS [July 75]	17458	36415	48%
epithermal reactors	17514	35549	49%
reactors	19090	221555	9%
actinide burner reactors	95	305	31%
afsr reactor	0	1	0%
aprf reactor	0	24	0%
bfs reactor	4	11	36%
bigr reactor	0	6	0%
bir reactor	0	5	0%
cefr reactor	0	4	0%
cfrmf reactor	6	69	9%
clementine reactor	2	4	50%
coral-1 reactor	0	4	0%
ecel reactor	0	1	0%
FBR TYPE REACTORS [July 75]	15783	28132	56%
aipfr reactor	0	1	0%
gcfr type reactors	413	696	59%
gcfr reactor	279	399	70%
lmfbr type reactors	10513	17740	59%
beloyarsk-3 reactor	222	372	60%
beloyarsk-4 reactor	1	3	33%
bn-1600 reactor	42	60	70%
bn-350 reactor	163	262	62%
bn-800 reactor	47	62	76%
bor-60 reactor	160	419	38%
cdfr reactor	84	100	84%
clinch river breeder reactor	459	707	65%
dfr reactor	78	201	39%
ebr-1 reactor	10	36	28%
ebr-2 reactor	611	1535	40%
enrico fermi-1 reactor	18	78	23%
joyo reactor	300	601	50%
kalpakkam lmfbr reactor	82	266	31%
monju reactor	392	563	70%
pfr reactor	332	541	61%
phenix reactor	426	632	67%
plbr reactor	18	25	72%
rapsodie reactor	151	251	60%
sbr-1 reactor	2	3	67%
sbr-2 reactor	1	1	100%
sbr-5 reactor	24	46	52%
snr reactor	667	1167	57%
snr-2 reactor	93	110	85%
super phenix reactor	603	825	73%
pec brasimone reactor	106	158	67%
zebra reactor	33	86	38%

Table 3 - continued

DESCRIPTOR	C1=E3500	INIS DB	ratio
fbrf reactor	0	28	0%
fca reactor	29	175	17%
fftf reactor	458	2066	22%
fr-0 reactor	0	5	0%
harmonie reactor	5	20	25%
hprr reactor	1	85	1%
ibr-2 reactor	2	284	1%
ibr-30 reactor	1	127	1%
ifr reactor	124	276	45%
kalpakkam pfr reactor	3	13	23%
kbr-1 reactor	1	3	33%
knk-2 reactor	172	296	58%
lampre-1 reactor	2	4	50%
masurca reactor	36	78	46%
purnima reactor	2	39	5%
purnima-2 reactor	1	8	13%
saref reactor	0	20	0%
sefor reactor	17	82	21%
sneak reactor	28	86	33%
sora reactor	0	16	0%
stf reactor	2	21	10%
tapiro reactor	5	21	24%
tibr reactor	0	1	0%
vera reactor	0	9	0%
viper reactor	7	24	29%
wntr reactor	0	1	0%
yayoi reactor	6	186	3%
zephyr reactor	1	19	5%
zppr reactor	69	226	31%
zpr-3 reactor	5	37	14%
zpr-6 reactor	8	63	13%
zpr-9 reactor	23	84	27%
zrr reactor	1	9	11%
BREEDER-REACTORS [*Jul 75*]	16445	30292	54%
INTERMEDIATE-REACTORS	1	43	2%
ENRICHED-URANIUM-REACTORS	1905	96292	2%
fast-fission [*Jul 75*]	14	1043	1%
fast-neutrons [*Jul 75*]	168	13642	1%
nuclear fuel conversion [*Jul 75*]	175	1633	11%
breeding [*Jul 75*]	853	11718	7%
LIQUID METAL COOLED REACTORS [*Jul 76*]	14312	26496	54%
LITHIUM COOLED REACTORS	15	70	21%
POTASSIUM COOLED REACTORS	12	92	13%
MERCURY COOLED REACTORS	4	7	4%
SODIUM COOLED REACTORS	5513	11388	48%
SZR TYPE REACTORS	200	403	50%

Table 3 - continued

DESCRIPTOR	C1=E3500	INIS DB	ratio
PLUTONIUM-REACTORS [*Jul 75*]	1091	2641	41%
PLUTONIUM-RECYCLE [*Jul 75*]	86	1522	6%
fuel cycle	970	12334	8%
GAS-COOLED-REACTORS [*Jul 75*]	921	18470	5%
AIR COOLED REACTORS	123	881	14%
EXPERIMENTAL-REACTORS [*Jul 75*]	1853	10314	18%
RESEARCH AND TEST REACTORS [*Jul 75*]	2660	28546	9%
ZERO-POWER-REACTORS [*Jul 75*]	429	3313	13%
POWER-REACTORS [*Jul 75*]	4259	111425	4%
REACTOR COMPONENTS	9065	88813	10%
REACTOR-CORES	2870	19003	15%
REACTOR-LATTICES	70	2117	3%
REACTOR-COOLING-SYSTEMS	2466	24686	10%
LIQUID-METALS	1222	7936	15%
SODIUM-	8315	44954	18%
REACTOR-SAFETY	2441	45335	5%
SAFETY-	3304	89841	4%
SAFETY-ANALYSIS	258	10925	2%
REACTOR-ACCIDENTS	2394	48867	5%
RISK-ASSESSMENT	200	22511	1%
FAILURES-	717	21651	3%
AVAILABILITY-	69	4369	2%
RELIABILITY-	528	17566	3%
REACTOR-OPERATION	841	17650	5%
REACTOR-FUELING	460	4793	10%
PLUTONIUM-	2464	37678	7%
URANIUM-	3431	186899	2%
NUCLEAR-FUELS	1494	27032	6%
ENRICHED-URANIUM	35	4269	1%
MIXED-OXIDE-FUEL	463	3660	13%
REACTOR-MATERIALS	2178	37573	6%
REACTOR-CONTROL SYSTEMS	243	9015	3%
REACTOR-MAINTENANCE	206	6267	3%
REACTOR-INSTRUMENTATION	247	4926	5%
REACTOR-LICENSING	116	7439	2%
REACTOR-KINETICS	650	7180	9%
REACTOR-START-UP	169	2321	7%
REACTOR-SHUTDOWN	476	5386	9%
DECOMMISSIONING-	41	6203	1%
REACTOR-DECOMMISSIONING	34	2994	1%
REACTOR-DISMANTLING	20	1916	1%
THERMODYNAMICS-	342	11234	3%
SHIELDING-	387	13308	3%
SHIELDS-	249	4242	6%
CALCULATION-METHODS	190	23305	1%
COMPUTER-CALCULATIONS	663	21388	3%
COMPUTER-CODES	2311	60005	4%

Conclusions

Quantitative data obtained in the present analysis show that about 11% of records concerned with fission reactor related subject categories in the INIS Database are related to fast breeder power reactors. The share of records related to other non-breeding power reactor categories as fraction of the total number of records in fission reactor categories is 40%.
According to *Nuclear Power Reactors in the World, April 1999 edition*, there were 4 fast breeder power reactors in operation out of 434 power reactors in total, (i.e. only 0.9%), producing 0.3% of total power (MWe), and 2 fast breeder power reactors under construction (6% in the total number of fission rectors under construction). Comparison of these figures with the number of records in respective INIS subject categories, shows the significance of subjects related to research and technology related to fast breeder power reactors.

Analysis of the appearance of records assigned a secondary subject category related fast breeder power reactors shows that the majority (39%) of these were assigned with the primary category "Environmental aspects of nuclear installations", and that about 28% are concerned with some other fission reactor related subject categories.

Seven countries/organisations contributed about 90% of records falling into fast breeder reactor category: United States (37%), Japan (17%), United Kingdom (9%), Germany (9%)France (7%), IAEA (6%), Netherlands (5%). The highest contribution has come from countries having most developed nuclear programs which involve research and development in the field of fast breeder reactors technology. The share of records assigned with fast breeder power reactor primary category in the total number of records in fission reactors and in the entire INIS Database per country of input indicate the interest in fast breeder reactor related research and technology in the mentioned countries. The Netherlands, although not a leading country in fast breeder reactor technology is among first ten contributors because of its developed scientific publishing activity, indicating the interest of the international community in fast breeder power reactors. The case of the IAEA is similar due to the Agency's task to promote nuclear energy and co-ordinate activities in development of related technology.

The majority of records in the fast breeder power reactor category refer to pieces of literature written in English (68.7%). One could conclude that the majority of authors from non-English speaking countries are submitting their publications in English, i.e. that the language of research and technology in fast breeder power reactors is English, which is valid for the publications related to fission reactors and all the subjects in the scope of the INIS Database.

The distribution of the number of fast breeder power reactor related records by record type shows that almost one third are journal-articles, one third are reports and 21% are books. Analysis of the number of records by literary type shows that the majority of records (63%) in fast breeder power reactors category were published as conference publications.

The appearance of country names in the author field was: Japan 28%, Germany 16%, France 14%, USA 14%, United Kingdom 6%, Italy 5%. The appearance of country name in the corporate entry field is different: USA is leading contributing 40%, followed by Japan (17%), France (11%), Germany (10%), United Kingdom (8%), etc.

The frequency of appearance of a number of typical descriptors in the fast breeder power reactor category (C1) and the whole of the INIS Database is analysed. It shows that about half of the typical frequently used descriptors ("FAST REACTORS", "EPITHERMAL REACTORS", "FBR TYPE REACTORS", "BREEDER REACTORS", and "LIQUID METAL COOLED REACTORS") are assigned to the fast breeder power reactor category. This means that fast breeder reactors are mentioned in other related categories almost as frequently as in the fast breeder power reactor category. Related categories include: Physical Radiation Effects on all Metals and Alloys (B2260, B2200); Mechanical Properties (B2230); Corrosion and Erosion (B2350, B2250); Spent Fuel Reprocessing (B1620); Fission Fuels (B1600); Environmental Aspects (Impact on Ecosystems) of Nuclear Installations (C5200); Environmental Aspects of Design Basis and Hypothetical Accidents at Nuclear Installations (C5240); Thermodynamics and Fluid Flow (E1100); Materials Testing (E1700); Reactor Control Systems (E2400); Research , Test, Training, Production, Irradiation and Materials Testing Reactors (E3600); Reactor Theory and Calculation (E2100); Power Reactors, Non-Breeding, (E3200, (E3100, E3300); Reactor Components and Accessories (E2200); Reactor Fuels (E2300); Other nuclear instrumentation and Methods (E4200); Waste Treatment and Management (E5100, E5200); Nuclear Power Economics (F1100); etc.

References

1. *INIS: Subject categories and Scope Descriptions, IAEA, Vienna, 1997*
2. *INIS: Thesaurus, (Rev. 38) IAEA, Vienna, 1999*
3. *INIS: Authority List for Corporate Entries and Report Number Prefixes, IAEA, Vienna, 1997*
4. *Nuclear Power Reactors in the World, April 1999 edition, Reference data Series No. 2, IAEA, Vienna 1999*
5. *IAEA Research Reactor Database (RRDB)*

ANNEX 1

Table 1. REACTOR TYPES AND NET ELECTRICAL POWER, REACTORS CONNECTED TO THE GRID, 31 DEC. 1998

TYPE	PWR		BWR		GCR		AGR		PHWR		LWGR		WWER		**FBR**		OTHER		TOTAL	
COUNTRY	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe
ARGENTINA									2	935									2	935
ARMENIA													1	376					1	376
BELGIUM	7	5712																	7	5712
BRAZIL	1	626																	1	626
BULGARIA													6	3538					6	3538
CANADA									14	9998									14	9998
CHINA	3	2167																	3	2167
CZECH REP													4	1648					4	1648
FINLAND			2	1680									2	976					4	2656
FRANCE	57	61420													1	233			58	61653
GERMANY	14	15919	6	6363															20	22282
HUNGARY													4	1729					4	1729
INDIA			2	300					8	1395									10	1695
JAPAN	23	18425	28	24872											1	246	1	148	53	43691
KAZAKHSTAN															1	70			1	70
KOREA	12	10411							3	1929									15	12340
LITHUANIA											2	2370							2	2370
MEXICO			2	1308															2	1308
NETHERLANDS	1	449																	1	449
PAKISTAN									1	125									1	125
ROMANIA									1	650									1	650
RUSSIA											15	10219	13	9064	1	560			29	19843
S AFRICA	2	1842																	2	1842
SLOVAKIA													5	2020					5	2020
SLOVENIA	1	632																	1	632
SPAIN	7	5911	2	1439															9	7350
SWEEDEN	3	2705	9	7335															12	10040
SWITZERLAND	3	1692	2	1387															5	3079
UK	1	1188			20	3400	14	8380											35	12968
UKRAINE											3	2575	13	11190					16	13765
USA	69	64969	35	31454															104	96423
TOTAL	206	195848	92	79242	20	3400	14	8380	29	15032	20	15164	48	30541	4	1109	1	148	434	348864

Reference Data Series No. 2, NUCLEAR POWER REACTORS IN THE WORLD, April 1999 Edition, International Atomic Energy Agency, Vienna, 1999

Table 2. REACTOR TYPES AND NET ELECTRICAL POWER, REACTORS UNDER CONSTRUCTION, 31 DEC. 1998

TYPE	PWR		BWR		GCR		AGR		PHWR		LWGR		WWER		**FBR**		OTHER		TOTAL	
COUNTRY	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe	No	MWe
ARGENTINA									1	692									1	692
BRAZIL	1	1229																	1	1229
CHINA	4	3090							2	1330									6	4420
CZECH REP													2	1824					4	3154
FRANCE	1	1450																	1	1450
INDIA									4	808									4	808
JAPAN			2	1863															2	1863
KOREA	2	1900							1	650									3	2550
PAKISTAN	1	300																	1	300
ROMANIA									1	650									1	650
RUSSIA											1	925	1	950	2	1500			4	3375
SLOVAKIA													3	1164					3	1164
UKRAINE													4	3800					4	3800
TOTAL	11	10080	2	1863	0	0	0	0	9	4130	1	925	10	7738	2	1500	1	1300	36	27536

ANNEX 2 - OPERATIONAL FAST EXPERIMENTAL REACTORS IN THE WORLD
ACCORDING TO IAEA RESEARCH REACTORS DATABASE(RRDB)

No	REACTOR	COUNTRY	TYPE
1	ZPR FAST	CHINA	critical - fast
2	MASURCA	FRANCE	critical - fast
3	PHENIX	FRANCE	critical - fast
4	FBTR	INDIA	fast breeder
5	RSV TAPIRO	ITALY	fast source
6	FCA	JAPAN	critical - fast
7	JOYO	JAPAN	fast sodium cooled
8	IBR-30	RUSSIA	fast - pulsed
9	BOR-60	RUSSIA	fast breeder
10	FBR-L	RUSSIA	fast breeder
11	IBR-2	RUSSIA	fast breeder
12	VIPER	UK	fast burst
13	SPR-II	USA	fast burst
14	SPR-III	USA	fast burst
15	FAST-BURST SKUA	USA	fast burst
16	FAST-BURST FBR	USA	fast burst
17	APRFR	USA	fast burst-mobi