A WORLDWIDE ASSESSMENT OF THE TRANSPORT OF IRRADIATED NUCLEAR FUEL AND HIGH-LEVEL WASTE

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ABSTRACT

The Secretariat of the International Atomic Energy Agency recently undertook informal contacts with many of the countries and organizations that have been involved in transporting irradiated nuclear fuel and high-level wastes, requesting information on shipments completed to date, and future shipment plans for these two types of radioactive material. Although the data provided are incomplete, the results are enlightening regarding the quantities of these materials that have been transported. This paper summarizes the results of this informal survey. Considering data from many of the larger shippers and some smaller shippers of these materials, it has been concluded that approximately 73,000 to 98,000 metric tons of heavy metal in the form of irradiated nuclear fuel and high-level waste have been transported throughout the world to date, and these shipments constituted approximately 24,000 to 43,000 flask shipments by all surface modes of transport (i.e. road, rail and sea).

INTRODUCTION

The International Atomic Energy Agency (IAEA) has for some time been striving to develop two databases, one a database for collecting and collating the number and various types of radioactive material shipments (SHIPTRAM), and the other a database which would collect and collate date on accidents that occur during the transport of radioactive material (EVTRAM). It would be desirable with SHIPTRAM to obtain comprehensive information on types, distance, and transport modes for all types of radioactive material. Such data alone would be beneficial in communicating to government officials, regulatory authorities, operators and the public the magnitude of transport occurring. In addition, if both databases were functioning, where shipment quantities could be coupled with accident statistics, the data would be useful in establishing a sound basis for performing radioactive material risk assessments, and the quality of data for communicating to government officials, regulatory authorities, operators and the public would be enhanced. This paper addresses recent efforts to initiate collection of part of the data needed for SHIPTRAM.

BACKGROUND

An attempt at collecting data on the transport of radioactive material was undertaken by the IAEA in the early 1980s. This action was recommended by the first meeting of the Agency's Standing Advisory Group on the Safe Transport of Radioactive Material (SAGSTRAM), which was the predecessor to the current Transport Safety Standards Committee (TRANSSC). The data collection was initiated in 1980. Data from 35 countries were summarized in a PATRAM '86 paper[1]. In that paper, it was noted that many of the inputs provided a mix of domestic and international shipments and many were judged to be incomplete. The report summarized that although much of the data

were inaccurate and incomplete, they provided a basis for approximating the magnitude of transport of radioactive material worldwide. Through extrapolation of the data obtained, it was estimated that between 18 and 38 million package shipments of radioactive material were transported annually in the early 1980s.

Recently the Secretariat of the IAEA undertook two initiatives related to the collection of shipping data. First, the IAEA held discussions with the World Nuclear Transport Institute (WNTI), which is working to establish a sound methodology for collecting data on shipments of nuclear fuel cycle radioactive material. The methodology could elicit data on the volumes of the various categories of material, transport modes, and distance travelled by packages of those materials.

Second, during 2000, the Secretariat undertook a literature search and concurrent informal contacts with many of the countries and organizations that have been involved in transporting irradiated nuclear fuel (INF) and high-level wastes (HLW), requesting information on shipments completed to date, and future shipment plans for these two types of radioactive material. This step was taken recognizing that there is no centralized international data collection effort for these material shipments, and indeed there is no mandate at an international level to collect such data. The data provided as a result of these informal contacts were supplemented by the literature search of published data. Although the data provided are informal and incomplete (not all countries/ organizations responded; and in many cases only partial data were submitted), the results are enlightening regarding the quantity of these materials that have been transported and the number of flask shipments that have been made. This paper summarizes the results of this survey.

DATA COLLECTION METHODS AND LIMITATIONS

The two sources of data were published literature and personal contacts. The personal contacts included consignors, carriers, consignees and competent authorities. In some cases, those contacted were unable to provided the requested information because of proprietary or security concerns. In addition, some individuals reported that there had not been any shipments in their country to date. Personnel were contacted in the following countries:

- Argentina
- Belgium
- Canada
- The Czech Republic
- France
- Germany
- India
- Italy
- Japan
- Lithuania
- Korea
- Lithuania
- The Russian Federation
- Spain
- Sweden
- The United Kingdom

Those who provided responses are acknowledged at the end of this paper.

Data were also obtained from literature for shipments in the following countries:

- Canada
- Finland
- France
- Hungary
- The Russian Federation
- Slovakia
- Ukraine
- The former Soviet Union
- The United States of America

In addition, a survey was undertaken by the IAEA in the late 1990s, independently of this effort, with the primary purpose of documenting worldwide experience in wet and dry INF storage[2]. This document includes an assessment of worldwide experience with INF transport, but the survey had a limited scope. For example, Reference 2 indicates that "*The data presented indicate shipments originating in the countries shown. For example, the LWR fuels shipped by France indicates only that fuel from French AR storage pools shipped to AFR (OS) storage facilities, it does not include spent fuel shipped from other countries to France. Only fuel shipped from Japan to Europe is indicated in the data provided for Japan."* In some cases, the wet and dry storage survey document provided data for countries not covered by the current effort and, in those cases, it was used to supplement, where it appeared to be appropriate, the current data.

Through this process, data were collected on shipments of INF and HLW by all surface modes (road, rail, and sea), and in some cases the types of flasks used in the shipments were identified. Types of INF shipped, primarily from nuclear power plants (NPPs) included light water reactor fuels [including pressurized water reactor (PWR) and boiling water reactor (BWR) fuels], RBMK, CANDU, HTR, and fast breeder reactor (FBR) fuels, and gas-cooled reactor fuels [including Magnox reactor, advanced gas reactor (AGR) and graphite reactor fuels]. Because so many sources were used for the data, care was taken to provide an appropriate mass flow balance, striving to avoid double or triple counting of individual shipments.

It must be emphasized, however, that without a concerted effort to develop data on a consistent and complete basis, with adequate data quality assurance, the present results can only be treated as approximate and as providing a rough, probably lower bound estimate of shipments that have occurred.

RESULTS OF LITERATURE SURVEY AND DATA COLLECTION FOR INF SHIPMENTS

The data collected are summarized in the following tables:

1. INF Shipping experience to Sellafield

The transport of INF to Sellafield reported in Table 1 were provided by BNFL/PNTL. These shipments were accomplished by a combination of road, rail and sea modes. The data for Magnox and AGR fuel originating in the UK were approximated values, provided as average numbers per year, occurring over a specified period of time.

The rough estimates resulting from the values by BNFL/PNTL for Magnox/AGR fuel originating in the UK destined for Sellafield were compared with the values from the wet and dry storage survey[2]. This source reported that the total shipments of Magnox and AGR fuel within the UK were significantly higher than the estimates made using inputs from BNFL/PNTL. The values from the wet and dry storage study showed 43,177 MTHM transported from non-LWR UK NPPs, with a total of 28,854 flasks shipments. These values establish an upper bound for the estimates for these shipments. Both sets of values were used in the summary at the end of this paper, helping to demonstrate the range of uncertainty in the data.

Table 1. Shipments of INF to Sellafield reported by BNFL/PNTL.

Type of Fuel	Origin	Destination	Time Period	Approximate Net tonnage (MTHM)	Approximate Flask Loads
Magnox	UK NPPs	Sellafield	35 years/	~17,500	~5800
AGR	UK NPPs	Sellafield	late 1970s	3440	5504
Magnox	Japanese NPPs	Sellafield	1969 - 2000	1428	476
Oxide (LWR)	Japanese NPPs	Sellafield	30 years	3290	~940
Magnox	European NPPs	Sellafield	30 Years	1500	500
Oxide (LWR)	European NPPs	Sellafield	30 years	1365	~600
TOTALS TO SELLAFIELD				**~28,523**	**~13,820**

2. LWR INF Shipping experience to La Hague

The shipments reported by COGEMA of LWR fuel to La Hague (Table 2) were accomplished by a combination of road, rail and sea. For the European shipments, they are now mostly accomplished by rail; for transport from Japan, they are accomplished by sea. The last leg of all ship or rail-borne flasks includes a short-distance, heavy-haul road trip from Valognes rail terminal to La Hague.

Table 2. Shipments of LWR INF to La Hague reported by COGEMA.

Origin	Quantity of LWR SNF Reprocessed at La Hague	Approximate Quantity of SNF Shipped(MTHM)	Estimated Flask Loads of LWR SNF
France	7072	~11,700	2600
Europe except France	5718	~10,000	2500
Japan	2944	2944	660
TOTALS	**15,734**	**~24,000**	**5760**

The wet and dry storage survey[2] indicates that 9006 MTHM of LWR fuels originating in France have been transported. This value is within about 20 percent of the value provided by COGEMA in Table 2. Also, for LWR INF originating in France, as reported in the wet and dry storage survey[2] the number of flask shipments was 1570. This value is significantly lower than the value shown in the data from COGEMA. As with the data for Sellafield, both sets of values were used in the summary at the end of this paper.

3. Non-LWR INF Shipping experience in France

The wet and dry storage survey[2] indicates that 10,507 MTHM of non-LWR INF have originated in France. The wet and dry storage survey[2] data are used in the summary at the end of this paper.

However, Reference 2 notes that these data did not include any information on number of flask shipments, origin or destination, nor did they include fast breeder reactor (FBR) fuel. In a paper presented at PATRAM '86[3], shipments of FBR fuel are reported as 10.6 MTHM in 125 flasks. These values are included in the summary at the end of this paper.

4. INF shipping experience in Belgium

The INF shipments from Belgium were all to La Hague as reported in Table 3. Although these shipments were also included in the data under Table 2 above, under the item "Europe except for France"; they are reproduced here for completeness. It is noteworthy that the wet and dry storage survey[2] showed only about half the quantity shipped as is reported here.

Table 3. INF shipping experience in Belgium.

Time Period	Origin	Destination	Mode	Distance (km)	Flask	Quantity (MTHM)
1979 - 1998	Tihange	La Hague	Road	~1000	NTL8	~127
1978 - 1998	Doel	La Hague	Road & Rail	~1050	NTL3 NTL3M	~510
1998 - 1999	Doel	La Hague	Road & Rail	~1050	TN12	~33
1978 - 1999	Belgium	La Hague	Road & Rail			670
TOTAL						**~1340**

5. INF shipping experience in Canada

The wet and dry storage survey[2] indicated that 100 MTHM of INF other than LWR fuels had been transported in 187 flask shipments. Data from the NPP operator within Canada indicates that they are currently undertaking, on average, approximately one shipment of INF and five shipments of HLW per year, all domestically within Canada.

6. INF shipping experience in the Czech Republic

Based upon discussions in 2001 with the Czech Republic competent authority, shipments of INF were initiated in 1989. During the period 1989 to 1992, INF from the Dukovany NPP was transported by rail for interim storage at the Jaslovske Bohunice NPP in the current Slovak Republic. These shipments constituted approximately 141 MTHM in 40 flask shipments (26 separate transports). The shipments to the Jaslovske Bohunice NPP were undertaken in TK-6 (Russian design) flasks and C-30 (German design) flasks. During the period 1995 to 1997, all of that INF was transported back to Dukovany, in 25 flask shipments (14 transports) using C-30 flasks and the CASTOR 440/84 dual-purpose flasks. Thus, 242 MTHM of Dukovany INF has been shipped in 65 flask shipments.

7. INF shipping experience in Finland

Early INF shipments from Finland to the former Soviet Union were reported in a paper presented at PATRAM '86[4]. In that paper, it was reported that WWER-40 INF was being returned from Loviisa's two NPPs to the former Soviet Union's supplier. These shipments were being made in the TK-6 type of flask using dual-mode (road and rail) transport. At that time, three shipments had been made (1981, 1982 and 1985). The wet and dry storage survey[2] reports that 233 MTHM have been transported in 65 flask shipments.

8. INF shipping experience and plans in Germany

Data available in the literature[5] show that approximately 1,800 INF flask shipments have been made in or from Germany over 29 years. These shipments would include both those for transport to reprocessing and storage. Those shipments destined for reprocessing are already included in those reported in Tables 1 and 2. The data reported in the wet and dry storage survey[2] are lower than those shown in Ref. 5, only 1,657 as compared with 1,800 flask shipments of INF have originated in Germany.

Table 4 shows that between 1992 and 1998, shipments of INF to the German intermediate storage facilities at Gorleben and Ahaus have been made from four NPPs and from La Hague in France. Although the total quantity of INF shipped to these facilities was not available, the data provided indicate that at least 25 MTHM were transported during that time period in flask shipments.

Table 4. Shipments of INF to German storage facilities.

Facility	Time period	Mode and Distance (km)	Cask type & Number of Shipments	Quantity (MTHM)	Destination, SNF or HLW
KKP Philippsburg	1995	Rail (550) + road (20)	1 x CASTOR® IIa	5	Gorleben, SNF
La Hague	1996	Road (40) + rail (1400) + road (20)	1 x TS 28V	not available	Gorleben, SNF
GKN Neckarwestheim	1997	Road (10) +rail (600) + road (20)	1 x CASTOR® V19	10	Gorleben, SNF
HKG Hamm-Uentrop	1992-1995	Rail (100)	57 x 305 CASTOR® THTR/AVR	not available	Ahaus, SNF**
GKN Neckarwestheim	1998	Road (10) +rail (500)	3 x CASTOR® V19	10	Ahaus, SNF
KRB Gundremmingen	1998	Rail (600)	3 x CASTOR® V52	10	Ahaus, SNF
TOTALS			**66**	**> 25**	

* Transports organized by GNS. Consignor: NCS. Carrier: DB Cargo.

** From decommissioned Thorium Reactor

9. INF shipping experience in Hungary

The wet and dry storage survey[2] indicate that shipments of 258 MTHM have originated from Hungary in 72 flask shipments.

10. INF shipping experience in Italy

Table 5 provides information that was obtained from the competent authority in Italy, for INF shipments originating in Italy.

Table 5. INF shipping experience in Italy.

	Shipments of SNF from				
	Latina NPP (GCR) to Sellafield (UK) by ENEL*	**Trino NPP (PWR) to Sellafield (UK) by ENEL**	**Trino NPP (PWR) to Saluggia (I) by ENEL**	**Garigliano NPP (BWR) to Saluggia (I) by ENEL**	**Totals**
Mode	Sea & Land	Sea & Land	Road	Road	
Time Period	1966 - 1991	1991 – 1993	1984	1985 - 1987	
MTHM	1360	51	14.7	66.4	**1492.1**
Total distance (miles)	830	680	31	437	
Number of flasks per shipment	6	2	1	1	
Number of shipments	97	21	9	43	**170**
Number of Flask Shipments	582	42	9	43	**676**

* ENEL (National Electricity Company) was the consignor

The shipments from Italy to Sellafield are included in Table 1, the other shipments to Saluggia are included in the summary at the end of this paper.

It was reported that for all of the shipments within and from Italy, no accident or incident occurred; and that current issues are:

- no shipments of INF or HLW have been carried out in Italy since 1993
- Presently there are 1763 INF elements (330.5 MTHM) stored at Saluggia, deposit, Trino NPP, and Caorso NPP
- A recent decision is that
    - Send part of the INF (53.4 MTHM)for reprocessing from Saluggia (Italy) to Sellafield (UK)
    - Develop an interim dry storage capability at the NPP sites for the remaining INF
- HLW from the reprocessing of INF will be sent back to Italy
    - Estimate 210 packages of HLW of 150 litres each
    - Capacity of flask yet to be defined, this will determine the number of shipments to be made

11. <u>INF shipping experience in Japan</u>

The following information was provided by the Japanese competent authority. Table 6 summarizes the Japanese experience in shipping INF for the limited period 1995 - 1999. Since the data showing all shipments to BNFL (Sellafield) and COGEMA (La Hague) are already included in the data in Tables 1 and 2, these details are only shown here for the sake of completeness.

The data for domestic shipments is included in the summary at the end of this report.

Table 6. INF shipments from and within Japan.

	Facility	**Mode**	**Fiscal Year**	**1995**	**1996**	**1997**	**1998**	**1999**	**Totals**
OverSeas	BNFL	Sea & Land	MTHM	156.2	35.2	45.4	61.7	83.1	381.6
			Flask	58	12	16	22	28	136
	COGEMA	Sea & Land	MTHM	149.9	92.7	69.3	-	-	311.9
			Flask	34	29	15	-	-	78
Domestic	JNC	Sea & Land	MTHM	63.2	30.5	0	0	0	93.7
			Flask	22	10	0	0	0	32
		Land	MTHM	12.2	24.0	0	0	0	36.2
			Flask	4	8	0	0	0	12
	JNFL	Sea & Land	MTHM	-	-	-	7.7	23.7	31.4
			Flask	-	-	-	2	4	6
Total MTHM Overseas									**693.5**
Total Flask Overseas									**214**
Total MTHM Domestic									**161.3**
Total Flask Domestic									**50**
Total MTHM									**854.8**
Total Flask									**264**

Table 7 provides a projection of INF shipments from and within Japan for the period 2000 – 2004.

Table 7. Projected INF shipments from and within Japan.

	Facility	Mode	Fiscal Year	2000	2001	2002	2003	2004	Totals
OverSeas	BNFL	Sea & Land	MTHM	71	18	-	-	-	89
Domestic	JNFL	Sea & Land	MTHM	250	300	350	400	400	1700
Total (MTHM), 2000 – 2004									1789
			Fiscal Year	2005	2006	2007	2008	2009	
Over Seas	BNFL	Sea & Land	MTHM	-	-	-	-	-	0
Domestic	JNFL	Sea & Land	MTHM	800	850	850	800	800	4100
Total (MTHM), 2005 –2009									4100
TOTAL PROJECTED (MTHM), OVERSEAS, 2000 - 2009									**89**
TOTAL PROJECTED (MTHM), DOMESTIC, 2000 - 2009									**5800**
TOTAL PROJECTED (MTHM), OVERSEAS AND DOMESTIC, 2000 - 2009									**5889**

12. INF shipping experience in the Netherlands

The wet and dry storage survey[2] indicates that the Netherlands has originated shipments of 257 MTHM in 295 flask loads. These data are already included in Tables 1 and 2.

13. INF shipping experience in the Russian Federation

In a paper presented at PATRAM '89[6], shipments from some WWER-1000 NPPs from three NPPs had been undertaken. During the period 1985 to 1989, 12 INF flask shipments had been completed by rail, 9 in the TK-10 type of flask (3 MTHM capacity), and 3 in the TK-13 type of flask (6 MTHM capacity). This early information is supplemented by the wet and dry storage survey[2], which indicates that the Russian Federation has originated shipments of 1,000 MTHM of non-LWR INF in 100 flask shipments, and 2,500 MTHM in 400 flask shipments.

14. INF shipping experience in Slovakia

The wet and dry storage survey[2] indicates that Slovakia has originated shipments of 60 MTHM of non-LWR INF in 600 flask shipments, and 320 MTHM in 100 flask shipments. However, these could include the return shipments of the Dukovany NPP INF which, as noted above, was returned from the Jaslovske Bohunice NPP back to the Czech Republic in the late 1990s (see report on the Czech Republic above). In the summary at the end of this report, this has been considered in establishing a range of uncertainty in the values for the INF shipments originating from Slovakia.

15. INF shipping experience in Spain

The information in Table 8 was provided by the competent authority of Spain. Since these shipments will already be covered by the data in Tables 1 and 2, they are only provided here for completeness.

Table 8. INF shipments from Spain.

Origin	Destination	Mode	Time Period	Total Number of SNF Assemblies	Estimated Quantity of Heavy Metal (MTHM)
José Cabrera	UK (Sellafield)	Road/ Maritime	1971-1983	241	~108
Santa Mª de Garoña	UK (Sellafield)	Road/ Maritime	1971-1983	500	~50
Vandellós 1	France (La Hague)	Rail	1972-1994	Not Available*	Not Available*

* Non fissile material (irradiated natural uranium); the wet and dry storage survey[2] indicates that the quantity of INF from Vanellós is approximately 1900 MTHM.

16. INF shipping experience in Sweden

The information in Table 9 was provided by the carrier/consignor in Sweden. These shipments have all been made in a purpose-built, INF Code ship, the M/S Sigyn. All transport has been by sea except for the NPP located on the storage site (CLAB). The data provided here are more current than those provided in the wet and dry storage survey[2].

Table 9. INF shipping experience in Sweden.

Mode	Time Period	Quantity (MTHM)	Number of Flasks	Number of SNF Elements
Sea*	1985 – 2000	3300	1100	16,000

* The ship M/S Sigyn travels approximately 25,000 nautical miles per year. All of the sea transports are combined with short-distance land transports.

17. INF shipping experience in Ukraine

The wet and dry storage survey[2] indicates that Ukraine has originated shipments of 1,300 MTHM in 300 flask shipments.

18. INF shipping experience in United States of America

Shipments within the United States of America[7,8] of commercial power INF are summarized in Table 10.

Table 10. INF shipping experience in the United States of America

Time period	Mass of SNF Shipped (MTHM)		Number of Flask Shipments		Totals		Source
	Road	Rail	Road	Rail	Mass of SNF (MTHM)	Number of Flask Shipments	
1964 – 1978	472.5	348.1	1565	126	820.6	1691	Ref. 7
1979 – 1997	356.3	1096.6	1181	153	1452.9	1334	Ref. 8
1964 - 1997	828.8	1444.7	2746	279	2273.5	3025	

RESULTS OF DATA COLLECTION FOR HLW SHIPMENTS

Data were collected from COGEMA on the shipping experience and plans for HLW shipments from La Hague. Data were also provided by individuals and documents from Belgium and France, but those data duplicated what was obtained from France. The data for shipments of HLW already completed from COGEMA are summarized in Table 10.

Table 10. Shipments of HLW from La Hague reported by COGEMA.

Destination Country	Time Period	Shipments	Approximate Quantity (MTHM)	Flask shipments/ Mode
Japan	1995 – 2000	5	390	12/ Road, Ship & Rail
Germany	1996 – 1997	2	97	3/ Road & Rail
Belgium	2000	1	33	1/ Road & Rail
TOTALS		**8**	**520**	**16/ All Surface Modes**

Details on those shipments, provided by COGEMA, are summarized in Table 11.

It is expected that the future trend will be for HLW shipments to continue from La Hague. It has been estimated that, based on 20 to 28 HLW canisters per flask (with an average of 25 canisters per flask):

- to Europe (other than France) there will be approximately 180 flask shipments of HLW (5850 MTHM), and
- to Japan, there will be approximately 90 flasks shipments (2925 MTHM).

Table 11. Details on shipments of HLW from COGEMA.

	Flasks	Number of Canisters	Date of Departure	Date of Arrival	Transport
Germany					
1st return	1 Flask (TS 28 V)	28	20 Ap1996	8 May 1996	Road + Rail
2nd return	2 Flasks (CASTOR HAW 20/28 CG)	2 x 28	17 Feb 1997	5 Mar 1997	Road + Rail
Belgium					
1st return	1 Flask (TN 28 VT)	28	04 Apr 2000	05 Apr 2000	Road + Rail
Japan					
1st return	1 Flask (TN 28 VT)	28	23 Feb 1995	25 Apr 1995	Sea, Cap Horn
2nd return	2 Flasks (TN 28 VT)	40 (2x20)	13 Jan1997	18 Mar 1997	Sea, Cape of Good Hope
3rd return	3 Flasks (TN 28 VT)	60 (3x20)	21 Jan 1998	13 Mar 1998	Sea, Panama Canal
4th return	2 Flasks (TN 28 VT)	40 (2x20)	25 Feb1999	15 Apr 1999	Sea, Panama Canal
5th return	4 Flasks (TN 28 VT)	104 (4x28)	29 Dec 1999	23 Feb 2000	Sea, Panama Canal

SUMMARY

The results of this literature search and informal survey regarding the shipments of INF and HLW are summarized in Table 12. The table takes into account the various sources of data, and have attempted to account for each shipment only once. There is a fairly wide range of uncertainty in the data resulting from the various sources of data used in this assessment. In addition, the values shown in Table 12 are probably low since not all countries that have transported INF and HLW have reported data, many of the data sources are not complete, and no attempt was made to document the shipments of research reactor fuel that have been made.

In summary, considering the data that were made available from individual informal contacts and that were obtained from review of the literature, and considering that most of the large shippers of INF and HLW have been addressed and many of the smaller shippers also, it can be estimated that:

- approximately 73,000 to 98,000 metric tons of heavy metal in the form of both INF and HLW have been transported throughout the world to date, and
- these shipments constituted approximately 24,000 to 43,000 flask shipments by all surface modes of transport (i.e. road, rail and sea).

Table 12. Estimated worldwide shipping experience with INF and HLW.

Shipments	Estimated Quantity (MTHM)	Estimated Number of Flasks
LWR/Magnox/AGR to Sellafield and La Hague	50,000 – 75,000[a]	18,500 – 37,100[a]
FBR France (domestic)	11	125
Non-LWR originating in France	10,507	n/a
Canada (domestic)	100	187
Czech Republic (to/from Slovenia)	242	65
Finland to USSR/Russian Federation	233	65
Germany (domestic, to storage)	>25	66
Hungary (originating)	258	72
Italy (domestic)	81	52
Japanese (domestic)	161	50
Russian Federation (domestic)	3500	500
Slovakia (originating)	380[b] (239 – 380)	700[c] (635 – 700)
Sweden (domestic)	3300	1100
Ukraine (originating)	1300	300
United States of America	2274	3025
HLW from La Hague	520	8
APPROXIMATE TOTALS	**73,000 – 98,000**	**24,000 – 43,000**

[a] Uncertainty results from range of data from two sources of data for shipments of non-LWR fuels within the UK.

[b] 141 MTHM of these could be those shipped back to the Czech Republic

[c] 65 of these flask shipments could be those shipped back to the Czech Republic

CONCLUSION

As with the former study reported by the IAEA at PATRAM '86, the data are "incomplete" and "inaccurate". They do, however, provide a basis for approximating the magnitude of the transport of INF and HLW that has occurred over about the past 40 years. The data provided in this paper are viewed as being beneficial for communicating to the public the magnitude of experience that has resulted world wide from the transport of irradiated nuclear fuel, and is starting to be developed in the transport of high-level waste.

In addition, with the added knowledge that there has been no known accident or incident involving the transport of these materials that has led to the injury or death of a person as a result of the radioactive nature of the cargo, the magnitude of the shipments that have been undertaken to date further confirm the Resolution on Safety of Transport of Radioactive Material passed at the 1998 IAEA General Conference which recognized "*that compliance with regulations which take account of the Agency's Transport Regulations is providing a high level of safety during the transport of radioactive materials*"9.

Finally, it is noted that the collection of these data was undertaken informally. Should there be parties that wish to clarify their inputs, or if others desire to provide additional inputs, such contributions to this collection of information would be welcomed by the IAEA Secretariat. As this information is clarified, the IAEA Secretariat will consider placing an updated version of this document on its website.

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