SUMMARY OF THE PANEL DISCUSSION

In spite of some leveling in the demand for nuclear energy and in some decrease in U-costs a number of IAEA Member States are still interested in the utilization of Th as nuclear fuel. This is in order to evaluateed long-term fuel supply and to prevent for shortages in enriched U. RAR and EAR-I resources of Th which could be recovered at costs less than US $80/kg are estimated at around 2,4 million tonnes.

Conventional nuclear power plants can be designed for operation either in the U/Pu cycle, in Th-HEU cycle or in Th-Pu cycle. The main advantage of the Th-based fuel cycles is that is has a higher neutron yield of U-233, in comparison with the neutron yield of Pu 239 in the U/Pu cycle. Those benefits may be equalized by commercial disadvantage, due to the requirement of HEU and the problems related to reprocessing and refabrication in a closed fuel cycle since full remotization is needed. The once-through cycle by the use of Th/Pu fuel offers the possibility when applicated to LWR-systems to avoid those problems and having considerable savings in U-ore and enrichment work units.

In fundamental and reactor conception problems the papers concentrated mainly on the following questions: are there enough neutronics data and how to choose the optimal way for starting the Th-based fuel cycle in nuclear power, to prove the neutronic feasibility of thorium cycle in unmodified PWR's For other types of reactors there are no real plans involving a Th-based cycle. FRG has abandoned the utilization of Th in the future HTRs in favour to low enriched uranium. The reason is the current inavailability of HEU.

A crucial item in the nuclear core design is the uncertainties in the cross-section data for Th-232 and U-233. In France, CEA recommended data is in use which is updated from time to time. The work in this area is summarized in the enclosure, presented by the French delegate, Mr. Greneche from CEA, Saclay. In general, the data for Th-232 are more reliable than those for U-233. In the FRG data are used which are elaborated by detailed studies based on the available experimental data base and from irradiation experiments. China feels necessary to elaborate those data more in detail, specifically for LWR application.

In India an Expert Group is working on data for thermal and fast flux conditions. USSR is working with ABBN data (Russian origin) but also data from Japan and France are used to improve the data base.

For fuel manufacturing at least four different procedures are in practice:

- Powder production ex-oxalates and cold processing, sintering in H_2/Ar atmosphere;
- Powder production ex-oxalates and extrusion, sintering in H_2/Ar atmosphere;
- Vibrocompaction of sol/gel kernels;
- Pelletizing ex sol/gel kernels and sintering in H_2/Ar atmosphere.

It is acknowledged that the microstructure optimization is needed for high burnup fuel. This can at the moment only be reached by pelletizing ex sol/gel kernels, improved in its pressing performance by the addition of carbon black (Brazil, FRG). Fuel fabrication for blanket element do not need a micro-structure optimization due to its low burnup. Here the powder production ex oxalates and cold processing shows sufficient performance (India). To lower the sintering temperature sintering aids like Ca or Mg are successfully in use (FRG, India).
It was also emphasized, that the time for fuel dissolution in the reprocessing is influenced by its microstructure (FRG, Brazil). Also the addition of Ca or Mg seems to influence positively the dissolution behaviour (India, FRG) of irradiated fuel.

- The thermal design of pin-type fuel is not very much advanced. It seems that in the different countries different material data are used and different computer codes. Some countries are doing own measurement (Brazil, France, FRG, India) and some are using data from literature.

- The reprocessing and refabrication is heavily influenced by the radioactive by-products requiring heavily shielded devices. Italy has some experience in this area by the work with spent Elk River fuel from the USA. Generally, basic experiences are available but no work is going on on refabrication for the time being, even if

some national strategies need reprocessing and refabrication (France, India).

- All work presented in the meeting was addressed to oxide fuel. The question on the potential of metallic Th-fuel could not be answered in the Panel. However, it seems that work is going on in the USA at ANL to investigate this fuel type as a FBR-fuel. Alloys with Th-20%U - 4%Zr and Th-20%U - 10% Pu are under investigation. Irradiation testing up to 100 GWd/t seems to be available. The fuel pins have SS-clad and Na-bonding.

After termination of the Panel Discussion a list of major activities worldwide in the area of Th-based nuclear fuels was compiled by the delegates from the different countries. No information was available in the Meeting from Canada, Japan, Romania and USA. IAEA staff members, Messrs. F. O'Hara, M. Ugajin and Mr. P. Bull of the Permanent Mission of Australia, prepared the reports on the status of the thorium-based fuel research and utilization programmes in the USA, Japan and Australia, correspondingly (attached). The report on "Status of Spent Fuel Management in Canada" presented at the IAEA Advisory Group on Spent Fuel Management in 1984 and reports by the Institute for Nuclear Power Reactors, Pitesti, Romania, presented to the IAEA, in the course of a research contract on "Data base for a PHWR operating on a once-through, low enriched uranium-thorium cycle" were used for filling the above mentioned list.

LIST OF MAJOR ACTIVITIES WORLDWIDE IN THE AREA OF TH-BASED NUCLEAR FUELS

Country	Programme		Directed towards					Areas of R and D						
	terminated	running	HTR	HWR	LWR	FBR	OTHER	Basic research	Strategy	Core design	Technology	Irradiation	Reprocessing	Refabrication
ARGENTINA		X		X				X	X		X			
AUSTRIA		X	X	X	X	X		Dynamic System Analysis Fuel Cycles (by literature)	X					
AUSTRALIA	1980	X						X see (attachment III)						
BRAZIL		X			X				X	X	X	X	X	
CANADA		X		X					X					
CHINA	1971	X	X		X			X X	X		X	X	X	
FRANCE	1979/82	X	X		X	X	X	X	X X	X X	X	X	X	
FRG	1985		X	X							X		X	X
FRG/BRAZIL Jointly		X			X					X	X	X	X	
INDIA		X		X		X		X	X		X	X	X(planned)	
ITALY	1974				X			X					X	X
JAPAN		X	X				X	X	X	X	X		X	
PAKISTAN	1983							X			X	X		
ROMANIA		X		X			X	X	X	X				
USA	1982		X		X		X	X	X	X	X	X	X	X
USSR		X	X		X	X		X	X	X				

Recommendations

- The capture cross-sections of Th is rather well-known in the thermal region. But in the fast energy range capture fission cross-sections and n-2n cross-sections must be known with a better accuracy. This could be achieved by differential thermal measurements. For U-233 better knowledge of cross-sections is needed in the whole energy range. For this aim it could be very helpful to have results available from clear integral experiments (bench-marking). It would be beneficial if this work could be done in cooperation.* Further information is needed in cross-sections for Pa-233 and U-234.*

- It appears that there may be discrepancies in the results obtained by different countries concerning core calculations for Th cycles (e.g. pin power peak calculations for PWR). It should be worthwhile to promote bench-marking studies on this problem.*

- There is a lack of information on the treatment of used Th for closed Th/U fuel cycles. Work on the reuse of Th would be emphasized.

- The powder technology for pelletizing should be investigated to assess its capability to optimize the microstructure of the fuel similarly to the pelletizing ex sol/gel kernels.

- The Member States working in the area of metallic fuel are invited to inform about their experience in order to assess its potential as on nuclear fuel. The IAEA is asked to distribute a reference list from the available reports in this area.

- It is recommended to hold in approximately 5 years a meeting on the progress in Th utilization. Possible objectives in this area meeting could be the evaluation of world-wide Th resources, basic

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* The Scientific Secretary was asked in cooperation with the other Divisions (Nuclear Data Base Section and Advanced Nuclear Power Technology Section) to endorse in the Agency the activities on collection and analyses of data on Th and U-233 cross-sections and on active core designs regarding utilization of Th fuels.

research of nuclear, physical and chemical properties of Th, strategies, reactor core and blanket concepts for different reactor types; fuel technology; reprocessing and refabrication in closed Th fuel cycles.

- Upcoming results on the different areas of activity in the Th investigation may be presented at the IAEA meeting.