

END-OF-MISSION REPORT

IAEA TECHNICAL CO-OPERATION EXPERT MISSION

Radiotracer Experiments in FCCU and CFD Modeling, Kajang, Malaysia (October 12-23, 2009)

1. ADMINISTRATIVE INFORMATION

- 1.1. Project and Task No.: RAS/8/111-01.01
- 1.2. Project Title: Diagnosing Industrial Multiphase Systems by Process Visualization Using Radiotracers and Sealed Sources
- 1.3. Special Task Title: Radiotracer Experiments in FCCU and CFD Modeling
- 1.4. Expert's Name: Dr. H.J. Pant
- 1.5. Date of Assignment: October 12 - 23, 2009
- 1.6. Name of the National Counterpart: Dr. Jaafar Abdullah
- 1.7. Name of the Counterpart: Ministry of Science, Technology and Innovation, Malaysian Nuclear Agency, Bangi, Kajang, Malaysia

2. TERMS OF REFERENCE

- (1) To advise the counterpart about development and application of radiotracer technique for troubleshooting and process optimization in Fluidized Catalytic Cracking Units (FCCU) and wastewater treatment plants.
- (2) To conduct a field radiotracer investigation in a FCCU unit and to advise the counterpart and his team about the various practical aspects, including the following:

- Planning of experiment, selection and production of gas and solid phase radiotracers for FCCU applications.
 - Design and operation of tracer injection system and tracer injection procedure.
 - Identification of tracer injection and detection locations for tracings gas and solid phase radiotracers in different subsystems of a FCCU.
 - Calibration, testing of data acquisition system and sampling time for detection
- (3) To develop a suitable protocol for field experiments for FCC units
 - (4) Data analysis, interpretation, modeling and flow visualization
 - (5) Residence time distribution and case studies
 - (6) Demonstration of RTD analysis software
 - (7) To introduce CFD modeling and validation of CFD models using radiotracers
 - (8) New Developments and applications in radiotracer technology
 - (9) Delivering a series of lectures in the National Training Course (The assignment was converted into a National Training Course and was attended about 30 participants from PAT Group of MNA Kajang, industry and academic institutes).

Initially it was planned to conduct radiotracer investigation in a FCC unit in a refinery. However, the investigation could not be conducted because of non-availability of suitable radioisotopes such as Krypton-79 (gaseous tracer) and Lanthanum-140 (as irradiated catalyst) due to shutdown of reactor at Malaysian Nuclear Agency (MNA), Bangi, Kajang for major revamping. The efforts to import these radiotracers from nearby countries such as United Kingdom, Republic of Korea, India and Indonesia for FCCU investigation did not succeed.

Therefore, it was planned to conduct a radiotracer investigation in an aeration tank of a wastewater treatment plant belonging to M/s FPG Oleochemical Limited Kauantan, Phang (about 250 km from Kajang). The objective of the investigation was to measure the residence time distribution of wastewater in aeration tank. Iodine-131 (half life: 8 days) as sodium iodide was selected for the investigation and was imported from M/s GE Healthcare United Kingdom. About 200 mCi of Iodine-131 was used in the investigation. The radiotracer was instantaneously injected at the inlet of the tank and monitored at ten different strategically selected locations in the tank using waterproof scintillation detectors

(2" x 2" size) connected to a 12-Channel data acquisition system (DAS, Ludlum USA make). The DAS was set to record data at an interval of five minute. Since the expected mean residence time of wastewater in the aeration tank is about 12 days, the monitoring of the data is continued even after the assignment period. The data is being saved every after two days and being sent to the expert for analysis. It is expected that it may take about 20 days to record the complete residence time distribution curves at different locations. After the completion of the investigation, the expert will analyze and discuss the data with the counterpart and his colleagues through e-mails. The data monitoring is underway at the time of submission of this report.

3. BACKGROUND INFORMATION

The Radioisotope Applications Programme in Malaysia began with its first reactor 1 MW TRIGA Mark II (PUSPATI) obtaining criticality on June 28, 1982 and forms an important part of Malaysia's programme of using nuclear technology for societal benefits. Malaysian Nuclear Agency (MNA), Bangi Kajang, (formerly known as MINT) under the Ministry of Science, Technology and Innovation (MOSTI), is responsible to carry out the programme in Malaysia. Radioisotope production in Malaysia began soon after the commissioning of TRIGA Mark II reactor at MNA, Kajang in 1982 and radioisotope research programme began at a very modest level. The scope of activities expanded over last two decades with the setting up of modern radioisotope processing laboratories and production of a variety of radioisotopes for various applications. With the commissioning of this reactor and production of various radioisotopes, an Industrial Technology Division was established to pursue research on various applications of radioisotopes in industry. Subsequently, a Plant Assessment Technology (PAT) Group was set-up under Industrial Technology Division of MNA to focus on industrial applications of radiotracer and sealed sources. Today the Group offers professional services to industry in Malaysia and also pursues the R&D programmes for advanced applications of radioisotopes. The sealed source applications such as gamma scanning, computer tomography, blockage in pipelines and industrial systems etc. are well established and widely used in industry for troubleshooting and process optimisation. The members of PAT Group are well trained and have good expertise to carry out such applications.

There is very good scope of applications of radiotracer techniques in industry in Malaysia. However the level of applications of radiotracers in industry still remains in its preliminary stage. One of the reasons for this could be non-availability of suitable radiotracers due to uncertain schedule of the reactor. This problem could be overcome by importing the radiotracer from the nearby countries such as Indonesia, Korea, India and United Kingdom. There is strong need to pursue and explore the applications of radiotracers in industry in Malaysia, and the PAT Group at MNA has been working toward it. The present assignment was aimed to train the members of the PAT Group and demonstrate the application of radiotracer techniques in industry. The assignment was undertaken as a part of an ongoing RCA project on “Diagnosing Industrial Multiphase Systems by Process Visualization Using Radiotracers and Sealed Sources (RAS/8/111-01.01)”.

4. STATUS OF PROJECT IMPLEMENTATION

4.1. Man Power Availability

A Group known as PAT Group consisting of the following members is established at MNA, Bangi, Malaysia:

Dr. Jaafar Abdullah - Permanent Staff (Project Manager)

Research Officer-12 (Permanent)

Technical staff-6 (Permanent)

Technical staff-2 (Contract)

The group is responsible for development and application of radiotracer and sealed source techniques for troubleshooting and process optimization in industry.

4.2. Training and Fellowship

The Project Manager Dr. Jaafar Abdullah and his colleagues are well qualified and trained in Industrial Applications of Radiotracer and Sealed Source Techniques. Some of them have been trained under IAEA's Training and Fellowship Programme.

4.3. Laboratory and Equipment

The following infrastructure, facilities and equipment are available in the counterpart institution.

- 1 MW TRIGA Mark II Reactor for production of radioisotopes and other research applications. The various radioisotopes such as Bromine-82, Molybdenum-99, Lanthanum-140, and Sodium-24 etc. are produced in this reactor.
- A suitable Radioisotope Laboratory for handling, preparation, dispensing and storage for radioisotope tracers with all the necessary equipment for radiotracer measurements and radiation monitoring. The equipment available in the laboratory are listed in Document 1D of this report.
- A suitable health physics laboratory with all the necessary equipment for radioisotope handling, radiation surveillance, monitoring, decontamination and waste disposals.

4.4. Major On-Going Activities

(a). Research and Development

Following R&D activities are presently carried out by Radioisotope Applications Group at the host institute (Malaysian Nuclear Agency, Bangi, Kajang, Malaysia).

- Development of various radiotracer techniques for applications in industry
- Development and application of industrial process tomography
- Development of improved version of column scanner
- Development of Computer Aided Radioactive Particle Tracking Technique (CARPTT)
- Development of neutron based gauge for measuring moisture in recycled paper
- Development of neutron induced prompt gamma ray technique

(b). Commercial Services to Industry

The commercial applications of radioisotope techniques are transferred to a private company and are being carried by the company with the support of MNA. The PAT Group provides technical support and consultancy to this company as and when required.

4.5. Future Research and Development Programmes

Radioisotope Application Group at MNA, Bangi is planning to initiate the following new R&D Programmes in near future.

- Development of nano-radioactive particle for tracer applications
- Development of Single Radioactive Particle Tracking Technique for mapping flow fields in laboratory and pilot-scale flow system.
- Development of Single Photon Emission Tomography (SPECT) for industrial applications.

4.6. Equipment Needed: Equipment and expertise needed for development of CARPTT

4.7. Major Target Industries

The radioisotope applications are mainly focused to the following industries in Malaysia

- Wastewater treatment
- Oil and Petroleum
- Chemical and Petrochemical
- Maritime and Environment
- Palm oil industry

4.11. Literature and Books

The centre has a central library and the necessary relevant journals such as International Journal of Radiation and Isotopes and Radiation Physics and Chemistry are subscribed. In addition to this, the radioisotope techniques group has all the relevant books and literature.

4.12. Linkages

The PAT Group at MNA, Bangi is trying to develop links with various academic institutions, consultants and research and development departments of various industries in order to have joint research programmes. The Group organizes discussion meeting and conducts awareness programmes for the end-users from time to time. The work carried out by the Group is also presented in various national and international symposia.

5. WORK PROGRAMME

The work programme of the expert mainly included:

- Delivering a series of lectures on various aspects of tracer technology, applications of radiotracer technique for Fluidized Catalytic Cracking Units in petroleum refineries and wastewater treatment plants, and CFD modeling
- Discussion on various practical/technical issues regarding application of radiotracer applications in FCCUs.
- Demonstration and application of THYNRTD analysis software
- Conducting radiotracer experiments in a wastewater treatment plant
- Data analysis and interpretation

The detailed work programme is given below:

October 11, 2009 (Sunday)

- Departure from Mumbai and arrival at Bangi, Kajang, Malaysia at 0800 Hrs

October 12, 2009 (Monday)

- Reached Malaysian Nuclear Agency, Kajang at 0900 Hrs and met counterpart Dr. Jaafar Abdullah and Dr. Abd Nassir Ibrahim, Director, Industrial Technology Division.
- Attended the opening ceremony of the training course.
- Introduction with the participants
- Delivered three lectures (Basic Tracer Technology, Data treatment and analysis,).
- Held discussions with the counterpart about the experimental to be conducted.

October 13, 2009 (Tuesday):

- Delivered two lectures during morning hours and two lectures in the afternoon (Introduction to FCCU, Radiotracer Technology for FCCU Applications, Residence time Distribution Analysis, RTD case studies).
- Held discussions with the participants about practical aspects of radiotracer techniques.

October 14, 2009 (Wednesday)

- Delivered two lectures during morning hours and two lectures in the afternoon (Introduction to CFD, CFD Case Studies, Radioactive Particle Tracking Technique (RPT), RPT-Case Studies).
- Held discussions with the participants
- Meeting with Dr. Daud Mohamad Director General, MNA, Bangi, Malaysia.

October 15, 2009 (Thursday)

- Delivered a lecture on applications of radiotracer technique in wastewater treatment plants
- Held discussions and planning about the field radiotracer experiment
- Calibration and checking of the instruments and radiation detectors
- Made a checklist of all the equipment and material to be carried for field radiotracer experiment.

October 16, 2009 (Friday)

- Visited the radiotracer laboratory and discussion on operation of various equipment and facilities (See Table 1).
- Demonstrated the THYNRTD analysis software
- Held general discussions about various activities of tracer group and its future requirements.

October 17-18, 2009 (Saturday and Sunday): Weekend

October 19 (Monday)

- Departed from Bangi, Kajang at 1000 hours for field radiotracer experiment at Kuantan
- Reached Kuantan, Pahang at 1500 hours
- Visited to FPG Olechemical Plant at Kuantan, Pahang

- Held a meeting and discussions with engineers of FPG Olechemical regarding radiotracer experiment in an Aeration Tank of wastewater treatment plant
- Visited the wastewater treatment plant
- Identified and marked the tracer injection and detection locations in the plant
- Held discussions with the engineers about various arrangements to be made for the experiment
- Returned to hotel at 2100 hours (Hotel Vistana, Kuantan)

October 20, 2009 (Tuesday)

- Reached FPG Olechemical plant at 0900 hours with all the participants
- Attended safety briefing by FPG engineers
- Briefed the participants about the experiment and various practical aspects
- Visited the wastewater treatment plant and aeration tank along with the participants
- Showed the participants the identified tracer injection and detection locations
- Mounting the collimators, radiation detectors at 10 different strategic locations in the aeration tank
- Setting up of the data acquisition system
- Necessary preparation for tracer injection
- Background monitoring
- Performed and demonstrated dummy run of the tracer injection
- Tracer injected at 1655 hours (Iodine-131 as Sodium Iodide, Activity:200 mCi)
- Monitoring of the radiotracer by a computer controlled data acquisition system
- Returned to hotel at 2000 hours

October 21, 2009 (Wednesday)

- Reached FPG Olechemical plant at 0900 hours with all the participants
- Saved the collected data and data acquisition continued
- Plotted the saved data and discussed the same with the participants and the plant engineers
- Returned hotel at 1800 hours (Hotel Vistana, Kuantan)

October 22, 2009 (Thursday)

- Reached FPG Olechemical plant at 0900 Hrs with all the participants
- Saved the collected data and data acquisition continued
- Plotted the saved data and discussed the same with the participants Held detailed discussions about the data
- Returned to hotel at 1330 hours
- Delivered a lecture on RTD case studies in lectures hall booked in hotel
- Demonstrated the data treatment and analysis using THYNRTD software
- Attended closing ceremony at 1800 hours followed by dinner

October 23, 2009 (Friday)

- Visited to the plant at 1000 hours
- Saved the collected data and data acquisition continued
- Reviewed the data acquisition and had a meeting with plant engineer about the continuation of data acquisition even after departure of the expert, host and the participants
- Departed Kuantan at 1200 hours and reach Bangi, Kajang at 1800 hours.

(Since the expected mean residence time of wastewater in the aeration tank is about 12 days, so it was estimated that radiotracer will take about more than 24 days to completely come out of the aeration tank and record the complete RTD curve. So it was decided that, the participant, expert and host will leave the Kuantan and the data acquisition will continue. An engineer Mr. Rahman was trained to handle and save the data every two days till the radiation levels at the monitoring locations reaches to natural background radiation level. The saved data will be sent to the expert Dr. H.J.Pant and the host Dr. Jaafar for analysis. . After completion of the experiment, the expert will analyze and discuss the data with the counterpart and his colleagues. The experiment was going on at the time of submission of this report).

October 24, 2009 (Saturday)

- Departure from Bangi, Kajang at 2015 hours and arrival at Mumbai at 2240 hours

6. CONCLUSIONS

- An able and competent Radioisotope Application Group has been established at the MNA, Bangi. The mandate of the Group is to carry out research and development activities on Applications of Radioisotope Techniques and provide specialized services to the industry on commercial basis.
- All the permanent staff members (12 officers plus 8 technical) of the group are well trained in various aspects of Radioisotope Technology. However, in the area of ‘data interpretation and CFD modeling’ capability of the Group needs to be strengthened and improved.
- MNA, PAT Group has an elaborate infrastructure and necessary facilities to undertake projects on Radiotracer and Sealed Source Applications in Industry on R&D and commercial basis. The Group is planning to undertake a Radiotracer Investigation in complex flow systems such as Fluidized Catalyst Cracking Unit (FCCU) in industry in near future.
- The full potential of the available expertise and Radioisotope Techniques for Industrial troubleshooting and process optimization still needs to be exploited by the Malaysian industry.

7. RECOMMENDATIONS

The recommendations to the counterpart institution and national counterpart, government and IAEA are given in separate sheets.

7.1. Recommendation to the Counterpart Institution and National Counterpart

- National seminars and field demonstrations should be organized from time to time to create awareness among the industrial engineers and end-users and promote the applications of radioisotope techniques in Malaysia. The current assignment involved conducting a National Training Course and field radiotracer investigation in a wastewater treatment plant in an Olechemical industry.
- The current linkages between MNA and user-industries need to be further strengthened.
- Although the sealed source techniques are well established and accepted by the Malaysian industry, the level of application of the radiotracer techniques is confined to only a few well-informed industries. It is therefore essential to plan for a much wider and aggressive marketing strategy to promote and commercialize these techniques in the Malaysian industry.

7.2. Recommendation to the Government

- There is a very good scope for application of radioisotope techniques in Malaysian industry and this scope should be fully explored and exploited. This could be achieved by augmenting the facilities and sustaining the activities of “Plant Assessment Technology Group” in Malaysian Nuclear Agency, Bangi, Malaysia. Therefore, it is recommended that the Government should provide sufficient funds to meet the requirements of the Group. This will also help the Group to develop and undertake radioisotope investigations in large-scale industrial systems such as Fluidized Catalyst Cracking Units in refineries.
- The Government should provide sufficient funding for human resources development and higher education of the young scientists of Plant Assessment Technology Group of MNA, Bangi.
- The Group is contemplating to initiate development of Computer Aided Radioactive Particle Tracking (CARPT) technique and single photon emission computer tomography (SPECT) in near future. The group does not have sufficient expertise and capacity to develop these techniques indigenously. Therefore, it is recommended that bilateral international co-operation with suitably identified countries may be initiated.

7.3. Recommendation to International Atomic Energy Agency (IAEA)

- The PAT Group at MNA, Bangi has good potential and expertise to apply the “Radioisotope Technology” in the Malaysian industry. In addition to offering commercial services, the Group is actively pursuing the development of Advanced Radioisotope based techniques such as Process Tomography, Nano-radioactive particles etc. The Group is also intending to initiate the development of Computer Aided Radioactive Particle Tracking technique (CARPTT) and Single Photon Emission Computer Tomography (SPECT) in near future and thus needs IAEA help/support in terms of Fellowships, expert mission and specific technical assistance to pursue these activities.
- Since the TRIGA Mark II reactor at MNA Bangi is very old and hence often shutdown, obtaining the radiotracers for industrial applications is quite uncertain, thus it is highly recommended that IAEA should look into other possibilities to help PAT, MNA, Bangi and may be other Tracer Group in other RCA member states in obtaining radiotracers from other alternative sources within the region.

Acknowledgements

I express my sincere thanks to the Government of Malaysia, Authorities at MNA, Dr. Jaafar Abdullah and his colleagues for all the help and support extended to me during my mission to Malaysia.

My thanks are also due to the authorities of M/s FPG Oleochemicals Sdn Bhd, Kuantan, Malaysia for allowing to conduct field radiotracer investigation in a waste water treatment plant as part of the training programme. I would also like to thanks Mr. Azahari Din (Operation Manager, FPG), Mr. Abas Sabami (Wastewater Leader, FPG) and Mr. Abdul Rahman (Radiation Protection Officer, FPG) for providing all the logical support and help during the investigation.

I also express my thanks Dr. Joon-Ha Jin, Technical Officer, IAEA, Vienna , Austria and Dr. P.Dias, RCA Focal Person, RCA Vienna, Austria for giving me an opportunity to undertake this mission.

DOCUMENT 1D

Project No: RAS/8/111-01.01

TECHNICAL CO-OPERATION IMPLEMENTATION - Project Equipment Status

Please list below equipment items provided by the IAEA or other sources that were available for the execution of the project and/or other equipment related to your professional activities available for future IAEA projects (or uses). Please attach additional sheets as necessary.

EQUIPMENT	PURCHASE ORDER NO	DATE OF ARRIVAL	FUNCTIONING SATISFACTORILY	IF NOT - WHAT IS THE PROBLEM	REMARKS
Provided by IAEA NONE					
Others (Funded by MOSTI, MNA, Kajang)					
2"x2" Scintillation detector (20 Nos.)	Ludlum USA Bicron USA	About 10 year back	Good	NA (Not applicable)	Funded by MNA, Bangi, Kajang
1"x1" Scintillation detector (8 Nos.)	Bicron USA/Saint Gobain USA	About 10 year back	Good	NA	Funded by MNA Bangi, Kajang
0.5" dia x 0.5 thick scintillation detector (3 Nos.)	Bicron USA	About 7 year back	Good	NA	Funded by MNA Bangi, Kajang
12-Channel data acquisition system (2 Nos.)	Ludlum USA	About 5 year back	Good	NA	Funded by MNA Bangi, Kajang
Liquid tracer injection system (2 Nos.)	KAERI, Korea and Germany	October 2009	Good	NA	Funded by MNA Bangi, Kajang
Automatic Gamma scanner (1 No.)	Indigenously developed	Indigenously developed	Good	NA	Funded by MNA Bangi, Kajang
Laptop PC (as part of data acquisition system) (5 Nos)	Procured from local market	Recently purchased from local market	Good	NA	Funded by MNA Bangi, Kajang
Various types of lead collimators (~ 20 Nos.)	Indigenously developed	Fabricated during last 10 years	Good	NA	Funded by MNA Bangi, Kajang
Detector to DAS connecting cables of different length with winch system (~30 Nos.)	Procured from local market	Recently purchased from local	Good	NA	Funded by MNA Bangi, Kajang
Multi phase flow rig (Semi industrial scale) (1 No)	Indigenously developed	About 5 year back	Good	NA	Funded by MNA Bangi, Kajang

DOCUMENT 1D (Continued)

Project No: RAS/8/111-01.01

TECHNICAL CO-OPERATION IMPLEMENTATION - Project Equipment Status

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EQUIPMENT	PURCHASE ORDER NO	DATE OF ARRIVAL	FUNCTIONING SATISFACTORILY	IF NOT - WHAT IS THE PROBLEM	REMARKS
Provided by IAEA NONE					
Others (Funded by MOSTI, MNA, Kajang)					
Gamma and X-ray process tomography systems (5 Nos)	Indigenously developed	Fabricated during last 10 years	Good	NA	Funded by MNA Bangi, Kajang
Microtomography system (1 No)	SkyScan, Belgium	2007	Good	NA	Funded by MNA Bangi, Kajang
Pilot-scale column (1 No)	Indigenously developed	About 7 year back	Good	NA	Funded by MNA Bangi, Kajang
Gamma Scorpion (1 No)	Indigenously developed	About 7 year back	Good	NA	Funded by MNA Bangi, Kajang
Pipe Scanner (2 Nos.)	Indigenously developed	Fabricated during last 10 years	Good	NA	Funded by MNA Bangi, Kajang
Neutron Back Scattering Gauge (3 Nos.)	Indigenously developed	Developed during last 10 years	Good	NA	Funded by MNA Bangi, Kajang
Corrosion under insulation profiler (1 No)	GNS, New Zealand	~ 2002	Semi-Good	Erratic response	Funded by MNA Bangi, Kajang
Soil moisture density gauge (1 No)	Troxler USA	~ 2002	Good	NA	Funded by MNA Bangi, Kajang

TRAVEL RECORD FORM

THIS DOCUMENT MUST BE COMPLETED AND RETURNED AT THE END OF YOUR MISSION

Project No.: RAS/8/111-01.01

Expert's Name: Dr. H.J. Pant

Address: Isotope Applications Division,
Bhabha Atomic Research Centre,
Mumbai-400085, India.

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Subject:	PANT/HARISH JAGAT MR 10OCT BOM KUL/TA 9137

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