Integrated Safeguards for the Plutonium Fuel Production Facility (PFPF)
- Development of Approach and Applications -

T. Nagatani, T. Asano, S. Fujiwara, S. Takahashi
Japan Atomic Energy Agency (JAEA), Ibaraki, Japan

1. Introduction

The IAEA concluded in June 2004 that there was neither indication of the diversion of nuclear material placed under safeguards, nor indication of undeclared nuclear materials or activities, in Japan as a result of verification activities based on a comprehensive safeguards agreement and an additional protocol. Based on this conclusion, safeguards implementation in Japan was transferred to an Integrated Safeguards (IS) scheme in September 2004 as a first country which has extensive nuclear industry. Then the IS approach was implemented for all Light Water Reactors (LWRs) in September 2004, and for Low Enrichment Uranium (LEU) fuel fabrication facilities in January 2005.

The Japan Atomic Energy Agency (JAEA) developed a draft IS approach for the Plutonium Fuel Production Facility (PFPF) which fabricates MOX fuel for JOYO and MONJU with the goal of providing efficient safeguards and reducing the burden of plant operation. The JAEA proposed this draft IS approach to the IAEA in 2004. On the other hand, the IAEA proposed in May 2005 to broaden the discussion of the IS approach beyond the PFPF to include other facilities in the Nuclear Fuel Cycle Engineering Laboratories (JNC-1 site) as an IS approach for the overall site. The JNC-1 site includes the Tokai Reprocessing Plant (TRP), Plutonium Conversion Development Facility (PCDF), PFPF, and some other facilities. Discussions on the concept of the IS approach for the JNC-1 site were started in August 2005 and agreement between the IAEA and the Japan SafeGuards Office (JSGO) was reached in March 2007. Currently, detail inspection procedures are discussed with JAEA/JSGO/IAEA and this approach will be implemented in the near future.

This report introduces the features of the IS approach for PFPF at the JNC-1 site and compares the conventional safeguards approach and the IS approach.

2. Overview of PFPF

2.1 Features of PFPF

The PFPF was constructed to supply MOX fuel for the prototype fast breeder reactor MONJU and the experimental fast reactor JOYO in 1987. Advanced technologies for MOX fuel fabrication were utilized to build an efficient process with a maximum fabrication capacity of approximately 5 ton-MOX (1ton-Pu) /year. Various automated fuel fabrication apparatuses have been introduced to PFPF to improve the performance of MOX fuel fabrication and decrease radiation exposure to facility operators.

2.2 Overview of safeguards approach for PFPF

The high degree of automation in the fabrication process has required that advanced safeguards technology be developed for the implementation of the IAEA safeguards. From the viewpoint of safeguards, some disadvantages were expected by introduction of automated process equipment (e.g. difficulty of access to the nuclear material, increased radiation exposure regarding the inspection activities, etc.). Therefore, JAEA conducted not only R&D on MOX fuel fabrication technologies but also R&D on safeguards technologies at PFPF to achieve efficient and effective implementation of safeguards with the minimum impact on the facility operation.

Fig-1 shows an overview of the safeguards systems at PFPF. PFPF is divided into three areas, the feed material storage, the assembly storage and the process areas, and proper safeguards systems for each area were developed and introduced. By introduction of these safeguards systems, the efficiency and effectiveness of safeguards has been improved at PFPF.

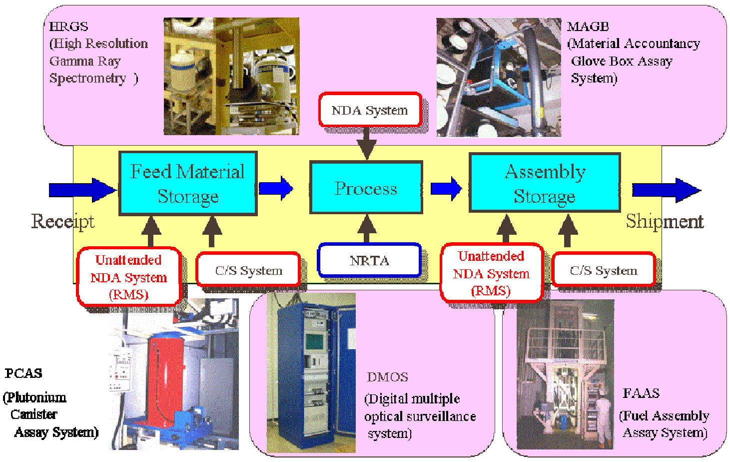

Fig-1 *Overview of the safeguards systems at PFPF*

2.2.1 Safeguards systems in the storage areas

In the two storage areas, unattended Non-Destructive Assay (NDA) systems and Containment and Surveillance (C/S) systems, were adopted.

In the PFPF, flow verification which is required for receipt and shipment of nuclear materials is completely performed without any inspectors being present by introduction of unattended NDA systems. The first unattended NDA system was developed as the safeguards system for the feed material storage area under a joint research program with the Los Alamos National Laboratory (LANL) in 1988. Fig-2 shows an overview of this unattended NDA system. The Plutonium Canister Assay System (PCAS) was a pioneer among unattended NDA systems worldwide. The detector unit of the PCAS was designed as part of the automated canister-transfer system in the feed material storage area. The amount of plutonium in the storage canisters containing the MOX feed powder is measured in the feed material storage area by the PCAS just before transferring from/to the feed material storage area. Therefore, verification data are collected during normal operation without the inspector. Recently, this PCAS was upgraded to the Remote Monitoring System (RMS) to further improve efficiency of safeguards. The RMS has a capability to transmit verification data which are collected by the relevant unattended NDA system from the facility to the inspector's office.

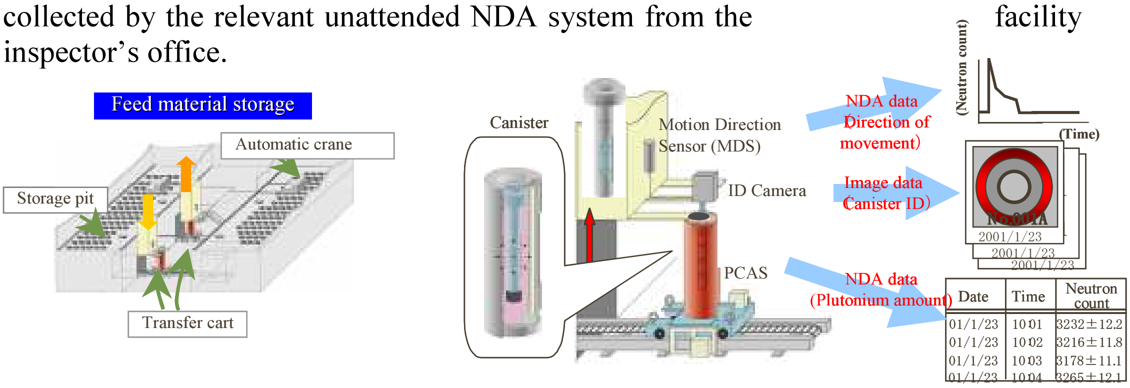

Fig-2 *Overview of the unattended NDA system*

Furthermore, inventory verification in the storage areas is not required during Interim Inventory

Verification (IIV) because all nuclear materials are covered by the C/S system known as the Digital Multiple Optical Surveillance system (DMOS) which was developed by IAEA. During IIV, only review of camera images is done.

2.2.2 Safeguards systems in the process area

In the process area, the physical forms of nuclear materials are changed (e.g. powder, pellet, fuel rod, assembly and so on). These materials are handled by the automated equipment and specific transfer containers are used for their storage and transfer. The suitable NDA system for the process equipment was developed (e.g. MAGB and HRGS in Fig-1). Furthermore, new types of NDA systems, Super glove Box Assay System (SBAS) and Waste Drum Assay System (WDAS) were developed because verification of the hold-up (adhesive nuclear material in the glove box) and the waste were required. These advanced NDA systems were developed and introduced under the joint research program with the LANL.

The Near Real Time material Accountancy (NRTA) system was introduced to evaluate the Material Unaccounted For (MUF) for the pellet fabrication process to improve effectiveness of safeguards. This MUF evaluation is performed in the monthly IIV and if the NRTA evaluation result is within acceptable levels, the sample size for verification can be reduced to about one-third.

2.2.3 Inspection effort

The timeliness goal for verifying of the plutonium oxide is defined as one month and the IIV is done once a month at PFPF 11 times a year in current safeguards approach. 14 PDIs (Person Days for Inspection) of inspector are spent for each IIV over a 2-day period and a total of 154 PDIs are spent for the 11 IIVs. The Physical Inventory Verification (PIV) is also carried out once a year for the 12th month and about 25 PDIs of inspector are needed in a 3-day period for this.

On the other hand, the operator also spends much effort for the inspection. The operator needs more than twice the total number of PDIs of inspector for support work of the inspection. Furthermore, in the current safeguards approach, the operator needs to stop the plant operation to allow the inspection activities to be carried out smoothly during the 25 days (IIV: 22 days, PIV: 3 days) per year noted above. Therefore, further reduction of the inspection effort and the burden of the plant operation has been the matter of concern for both the inspector and the operator.

3. Implementation of the IS to Japan

As a result of verification activities based on the comprehensive safeguards agreement and additional protocol between the IAEA and Japan, the IAEA Board of Governors meeting in June 2004 concluded that “there was neither indication of the diversion of nuclear material placed under safeguards nor indication of undeclared nuclear material or activities in Japan”. Consequently, the IAEA notified Japan that it would implement the IS scheme for Japan's nuclear activities from September 2004. Then the IS approach was implemented sequentially for all LWRs in September 2004, and for all LEU fuel fabrication facilities in January 2005. In this implementation, relaxation of the timeliness goal (e.g. Spent fuel: 3 months to 1 year) was done and the standardized IS approach of LWRs and LEU fuel fabrication facilities was developed by the IAEA.

However, for the MOX fuel facilities, the Standing Advisory Group on Safeguards Implementation (SAGSI) advised that the formal timeliness goal for unirradiated MOX in forms other than fuel assemblies at LWRs not be changed, but to approach the issue on a State- and facility- specific basis, and to define new safeguards measures allowing more adaptability. SAGSI also suggested that a number of efficiency measures would also bring about effectiveness benefits. These included greater use of unattended and remote monitoring technologies as different ways of achieving timeliness, and random and unannounced/short-notice inspections. SAGSI particularly supported unpredictability in the timing and intensity of verification activities as a means of enhancing both effectiveness and efficiency.

4. Development of the draft IS approach for PFPF

Based on the SAGSI recommendations, JAEA started the development of the draft IS approach for PFPF in cooperation with the Nuclear Material Control Center (NMCC) in order to achieve the following objectives.

- Reduction of number of support jobs for inspections
- Reduction of burden on the plant operation by the above inspections
- Establishment of the IS approach corresponding with the plant operation
- Contribution to establishment of the safeguards approach for a future MOX fuel fabrication plant.

In this development, the requirements of IS approach for PFPF were considered as follows based on the IS approach for LEU fuel fabrication facilities and LWRs.

- Improvement in transparency of facility operation
- Improvement in early detection capability of diversion of the nuclear materials
- Improvement in deterrent effect of diversion of nuclear materials

JAEA aimed at building a realistic IS approach by making effective use of safeguards technologies which had already been developed. The following key measures were selected to realize the requirements of the IS approach.

- Frequent declaration of the material accountancy information
- Frequent NRTA evaluations
- Remote monitoring of the nuclear material flow
- Application of the Random Interim Inspection (RII)

4.1 Concept of the draft IS approach proposed by JAEA

4.1.1 Improvement in transparency of facility operation

Improvement in transparency of facility operation is realized by the combination of frequent declaration of material accountancy data and expansion of the RMS to the entire PFPF. In current safeguards approach, declaration data are provided once a month in the IIVs. On the other hand, JAEA provides the material accountancy data more frequently (for example once a week) in the draft IS approach. Furthermore, this declaration is not only a Flow Key Measurement Point (FKMP) but also a Strategic Point (SP) of the process flow. Fig-3 shows a flow chart for the frequent declaration of material accountancy data.

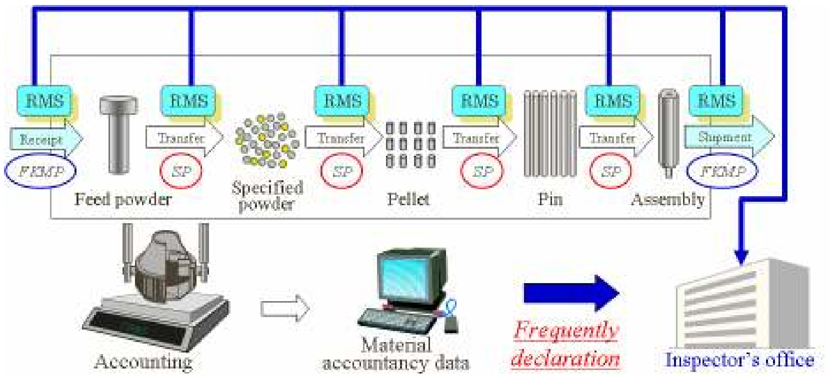

Fig-3 *Flow chart for the frequent declaration of material accountancy data*

With this improvement, the inspectorate can identify the location of nuclear materials in the PFPF and know the status of plant operation at the inspector's office. Furthermore, the reliability of the operator's declaration can be confirmed by expanding the RMS to the entire facility.

4.1.2 Improvement in early detection capability of diversion of the nuclear materials

Improvement in early detection capability of nuclear materials diversion is realized by frequent NRTA evaluations and expansion of the RMS to the entire PFPF. In current safeguards approach, NRTA evaluations are done once a month as part of the IIV. On the other hand, the operator provides the declaration data more frequently in the draft IS approach and so the inspector can make the NTRA evaluations more frequently (for example once a week). Fig-4 shows a scheme for frequent NRTA evaluations.

With the frequent MUF evaluation by the NRTA system, the early detection capability is improved. Furthermore, the reliability of operator's data can also be confirmed independently by expanding the RMS to the entire PFPF.

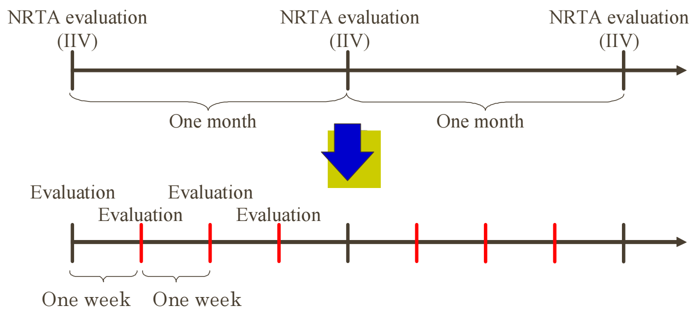

Fig-4 *Scheme for frequent NRTA evaluations*

4.1.3 Improvement in deterrent effect of diversion of the nuclear materials

Improvement in deterrent effect of materials diversion is realized by introduction of the short notice RII. In current safeguards approach, inspection activities are performed on a scheduled date in the IIV that is known well in advance. On the other hand, inspection activities of RII are carried out a randomly-selected date and only short advance notice is given in the draft IS approach. As the operator does not know when the RII is performed, the deterrent effect is improved.

4.2 Schematic of the draft IS approach

Not only inventory data but also detailed nuclear material flow data are declared by the operator frequently. Reliability of these data is confirmed by RMS at SPs. The inspectorate makes frequent MUF evaluations using the NRTA system based on the frequent declaration data. Furthermore, correctness of the operator's declarations is verified in RIIs. Fig-5 shows a schematic drawing of this draft IS approach; the efficiency of safeguards is improved without loss of safeguards effectiveness.

The JAEA proposed in March 2004 this draft IS approach to IAEA.

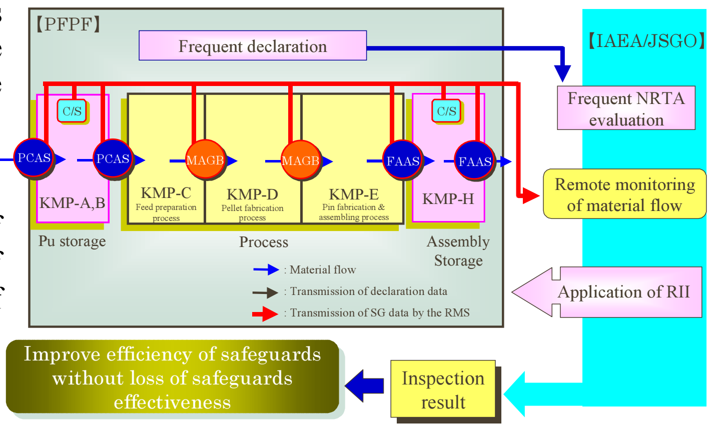

Fig-5 *Schematic drawing of the draft IS approach*

5. The RII procedure

5.1 Situation on the day of inspection

Almost all measures for the draft IS approach can be implemented by modification of technologies which has already been developed. The most difficult measure to be implemented is the RII. JAEA has not had any experience in carrying out an inspection during operation of the PFPF.

In the case of IIV, the operator knows when the IIV is to be performed. Consequently, the operator stops the plant operation and carries out some preparative tasks for the inspection. Therefore, all nuclear materials are itemized and stored in the intermediate storage area and the only hold-up remains in the glove box (Fig. 6).

On the other hand, the RII will be done on a randomly-selected day and the verification activities will be carried out without interruption of operation. Furthermore, the operator will not able to carry out any preparative tasks. Therefore, at the time of the RII, some nuclear materials are in the intermediate storage area, others are in the glove boxes and some nuclear materials are being transferred from the intermediate storage to the glove boxes (Fig. 6).

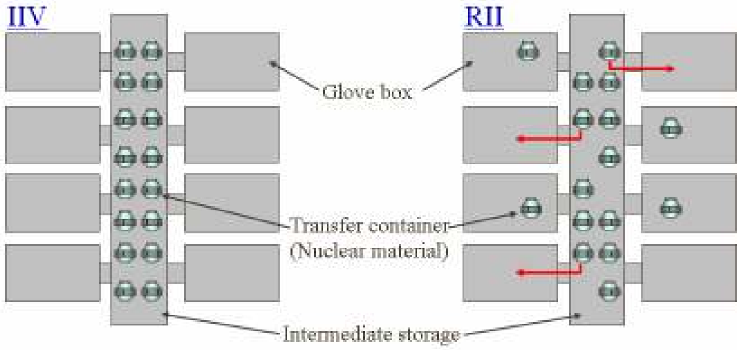

Fig-6 *Situation on the day of inspection*

5.2 Basic concept of the RII

The concept of the RII for PFPF was discussed with JAEA/JSGO/IAEA to minimize the burden on the plant operation.

There are some difficulties to perform the RII in comparison with the IIV. As mentioned above, only a short prior notice is given for the RII and the facility remains in operation. The operator starts to make an itemized list just after receiving the notification. It takes only about 20 minutes to make the itemized list because PFPF has the computerized material accountancy system. During this period, some nuclear material may be moved to/from the glove boxes and the selected item may not exist at the time of inspection. Furthermore, the nuclear materials which are being treated in the glove boxes cannot be measured by any of the NDA systems until completion of the treatment.

The work day at PFPF begins at 8:30 AM and nuclear material movement is started from 9:00 AM. Therefore, the following procedure was proposed to avoid or to minimize the above situation.

(1) Notification is given at 8:30 AM.
(2) The operator provides declaration data (e.g. the itemized list) to the inspectorate within 15 to 20 minutes after notification.
(3) The operator provides information on items that have a transfer planned from the intermediate storage to a glove box on the day of the RII.
(4) The inspectorate prepares the sampling plan (the verification plan) by 9:00 AM.
(5) If verification items have been selected from among items with a planned transfer, these samples will be verified first as high priority items to minimize the burden on the plant operation.
(6) The verification activities are started by 9:00 AM.
(7) If nuclear materials which are being treating in a glove box have been selected, these items will be verified after treatment. The Continuity of Knowledge (CoK) of the selected items is maintained by portable surveillance cameras which are set up around the glove box.

According to this procedure, the operator needs to stop operation for only selected items that have a transfer planned from the intermediate storage area to the process area (glove box). Even for these items, process treatments can be started about 30 minutes after completing the verification.

Practicability of this procedure will be confirmed in rehearsals in the near future. The application of the RII has merits not only for the inspector but also the operator. In the case of the IIV, the operator must stop the plant operation for a total of 22 days (2days/inspection x 11 times a year). However, in the case of the RII, this is unnecessary and the added operation time is equivalent to one month's normal operation.

6. IS approach for JNC-1 site

Based on the concept of the draft IS approach for PFPF proposed by JAEA, the IAEA proposed in May 2005 to broaden the discussion of the IS approach beyond the PFPF to include other facilities in the JNC-1 site as an IS approach for the overall site. Discussion of the IS approach for JNC-1 site was started in August 2005 among JAEA/JSGO/IAEA.

In the IS approach for JNC-1 site, the same kinds of nuclear materials are considered as borrowable materials, and the areas where the same classified nuclear materials are handled are defined as a sector. A detailed safeguards approach has been developed for each sector. Fig-7 shows an overview of the IS approach for the JNC-1 site which was developed for all nuclear facilities (TRP, PCDF, PFPF, PPFF and etc.) there.

Other features of the site approach are summarized as follows.

- A specific safeguards approach is developed for each sector and applied to it.
- The safeguards approach for each sector is based on four measures (frequent declaration of material accountancy data, frequent NRTA evaluations, application of RMS and introduction of RII).
- SPs are established between sectors.
- The RII is applied at randomly-selected sectors.

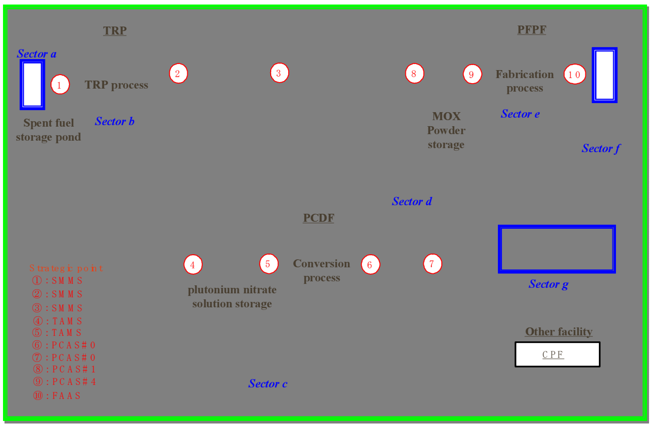

Fig-7 *Overview of the IS approach for JNC-1 site*

The concept of the IS approach for JNC-1 site was agreed upon between JSGO and IAEA in March 2007. Details of the RII procedure are under discussion at present.

7. Conclusion

The concept of the IS approach for the JNC-1 site was agreed between JSGO and IAEA. Details of the inspection procedures are under discussion at present. Practicability will be confirmed in a rehearsal in the near future. By implementation of this approach, not only inspection effort but also the burden on the plant operation will be reduced.

The IS approach will be implemented to the PFPF in the near future. This is the first case in the world that applying IS approach to facility which treat the plutonium with bulk forms. JAEA understands that the concept of this approach would be contributed to the establishment of the safeguards approach for the future MOX fuel fabrication plant.

[Reference]

[1] H.O. Menlove, R.H Augustson, R. Abedin-Zadeh, B. Hanssen, T. Ohtani. M. Seya and S. Takahashi, "Remote-Controlled NDA Systems for Feed and Product Storage at an Automated MOX Facility," Proceedings of INMM 30th Annual Meeting, July 9-12, 1989.

[2] H.O. Menlove, M.E. Abhold, G. Eccleston, J.M Puckett, T. Ohtani, H. Oshima, H. Kobayashi, and S. Takahashi, "Smart Unattended Systems for Plutonium Safeguards," JNMM Vol. XXIV, Number IV, July 1996.

[3] Takashi Asano, S. Takahashi, S. Namekawa, H. Maruyama, M.E. Abhold, W.C. Harker, S.E. Buck, and M.R. Sweet, "Development of Remote Monitoring for Unattended Mode NDA in PFPF (Phase II)," Proceedings of INMM 40th Annual Meeting, July 25-29, 1999.

[4] Shigeo Fujiwara, H. Maruyama, A. Takada, S. Takahashi, D.H. Beddingfield, M.E. Abhold, S.E. Buck, W. J. Hansen, D.G. Pelowitz "Field Trial Experiences of Remote Monitoring System for Unattended Mode Nondestructive Assay (NDA) in PFPF," Proceedings of INMM 43rd Annual Meeting, June 23-27, 2002.

[5] Junichi Ninagawa, S. Fujiwara, S. Takahashi, T. Asano, D.H. Beddingfield "Future plan of the remote monitoring system at PFPF and its expected effect" ,Proceedings of INMM 45th Annual Meeting, July 18-22, 2004.

[6] Takashi Asano, S. Takahashi, M. Kikuchi "Consideration on the integrated safeguards approach for PFPF", Proceedings of 26th Annual Meeting of INMM Japan Chapter, November 10-11, 2005.