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PLAN AND PROCEDURES FOR RAPID INVENTORY TAKING AT THE RESEARCH INSTITUTE FOR ATOMIC REACTORS*

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1. Abstract

A major element of a system for nuclear material protection, control, and accounting (MPC&A) is to take the physical inventory of the nuclear material periodically. Physical inventory taking (PIT) includes ensuring that all nuclear material on inventory is included in the facility records and that the measured content of items or containers (or at least a suitable random sample thereof) corresponds to the recorded values. A preliminary step to the conduct of the PIT is application of rapid inventory procedures that serve to provide the benchmark for the inventory, e.g., by identifying if any items are missing and also, if any unrecorded items are present. The Rapid Inventory approach is being implemented by the Research Institute for Atomic Reactors (RIAR) in Dimitrovgrad, Russia, as one of the first steps in the program to

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enhance nuclear materials safeguards at the site. This effort is being conducted under the US-Russian Cooperative Program on Nuclear Materials Protection, Control And Accounting (MPC&A), with assistance provided by specialists from U.S. Department of Energy National Laboratories. This paper summarizes the features of the existing physical inventory system at RIAR, discusses the upgrades being introduced, and provides some observations on the technology transfer process with regard to the safeguards program.

2. Introduction

In 1995, under an agreement between the US Department of Energy (DOE) and the Ministry of the Russian Federation for Atomic Energy (MINATOM), the Research Institute of Atomic Reactors (RIAR) -Dimitrovgrad was selected as one of the Russian Enterprises that would participate with US National Laboratories in expanded cooperation aimed at enhancing the nuclear Materials, Protection, Control and Accounting (MPC&A) Systems in both countries. The long term goal of the program is the completion of a comprehensive implementation plan, and its subsequent execution, addressing key MPC&A elements for all, or as many as possible, facilities at SSC-RIAR that contain appreciable amounts of highly-enriched uranium (HEU) and plutonium (Pu). The program has now been in operation for almost two years and substantial progress has been made which has been described elsewhere (Reference 1). The purpose of this paper is to focus on the physical inventory process as one element in the MPC&A program, describing the existing system at RIAR, the proposed upgrades, the steps for implementing the upgrades, and the current status of these activities.

3. Background

The State Scientific Center "Research Institute of Atomic Reactors" (SSC-RIAR) is located about 1100 kilometers southeast of Moscow, and about 7 kilometers from the city of Dimitrovgrad, Ulyanovsk Region, Russia,. The site was established in 1956 by the Soviet government with a focus on all aspects of reactor technology, reactor design, reactor operations, material science, fuel processing, fuel assembly design/construction, and radio nuclide production. Eight reactors are housed within the site's area of approximately 1.8 square kilometers. These are: the SM-2 (high Flux), ARBUS, VK-50 (a 50-megawatt boiling water (BW) power reactor), MIR a material inspection reactor, the BOR-60 a sodium cooled fast breeder, and 3 RBT reactors (water pool cooled). RIAR conducts material science investigations on BN and VVER irradiated fuel elements and fuel assemblies, moderators, reflectors, metal claddings and alloys. In addition, investigations are conducted on technical and operating issues regarding reactors and reactor safety related to the construction, loading and assembly as well as the production of radio nuclides. Although RIAR is primarily a research facility it interacts with and supports a number the Russian enterprises involved in nuclear materials production. All of these activities can involve substantial amounts of highly enriched uranium and plutonium which insures that well developed physical protection and materials control programs be in place. Given the nature of its activities it was considered a good candidate to serve as a model facility for introducing and implementing MPC&A related procedures and technologies.

In early 1996 representatives of RIAR and the US National Laboratories met to do a site

survey and conduct discussions to establish the scope and focus of the program. The activities were divided into the two major safeguards areas: physical protection (PP); and materials control and accounting (MC&A). These meetings resulted in a set of tasks approved by both parties, that served as the project development plan. Additional tasks have been added as the project evolved and currently there are about 50 individual interrelated MPC&A activities.

One of the most important initial tasks in the program was the preparation of a General Site Characterization Report by RIAR staff, which provided a thorough description of the pilot fast reactor fuel cycle. This was the segment of the Institute's operations identified as high priority for receiving upgrades because of the large amounts of both HEU and plutonium used under "direct application" conditions. It includes the BOR-60 fast breeder reactor, the fuel assembly production facility, and the central nuclear material storage facility (CSF), through which all nuclear material entering the Institute is handled. The report presents a description of the selected facilities and technological operations or processes involved with nuclear materials, the basic characteristics and physical form of the materials, the locations and flows of materials, the types of containers used for transport and the analysis of the existing accounting and control procedures. The report, which went through several iterations and reviews by the US Project team, also included an evaluation of the existing MC&A system. The RIAR staff identified a number of areas in need of improvement, including the physical inventory process, and suggested upgrades based on the newer technologies. These findings provide the basis for the rapid inventory improvements currently being implemented.

4. MC&A Activities at RIAR

The evaluation by RIAR specialists identified a number of elements of the existing MC&A system that needed improvement including the inventory process. Current inventory practices include the following:

a) Data entry and accounting are done manually or using old PC's with limited memory.

b) The lack of NDA and physical measurement equipment makes independent measurements during physical inventory impossible.

c) Items such as fuel assemblies and bulk materials in sealed containers are counted. Lead seals and stamps are used that are undocumented.

d) Receipts are based on shipper's data that can only be confirmed by destructive measurements after the package is transferred to the fuel fabrication facility.

5. Proposed Upgrades to Existing MC&A System

The RIAR study concludes with a listing of the proposed upgrades to the existing MC&A system and the physical inventory-taking activities, which are as follows:

a) Application of modern means of sealing the packages clearly indicating the loss of integrity.

b) Introduction of a computerized inventory system.

c) Usage of bar-coding technology.

d) Installation of a video monitoring system.

e) Application of Non-Destructive Analysis (NDA) measurements for verification of nuclear

materials accounting data.

f) Development of inventory procedures using nuclear materials measurement and identification methods.

Each of the upgrades was developed into an individual task mutually agreed upon by the US and Russian project teams. Not all of these upgrades would be implemented immediately but a group of tasks were identified as the rapid inventory plan that would provide a significant improvement in accounting activities in a relatively short time. The rapid inventory plan includes (a) input of hand recorded data into a computerized inventory record data base, (b) development and demonstration of rapid inventory procedures for the storage area, and (c) implementation of the procedures at other RIAR technological areas.

6. Rapid Inventory Plan and Procedures

The objective of a rapid inventory plan is to define a set of activities that can be carried out to determine the status of the nuclear material at a given location (for example, an MBA or interim storage vault). Various levels of rapid inventory procedures are possible. In a homogeneous storage area, such as a spent fuel storage pond or a given process line, rapid inventory procedures may consist of an item count. For mixed item storage areas, rapid inventory procedures could include the verification of the item identification, location, and tamper indicating device. The extent of verification to be carried out will be determined on the basis of the material control objective (source of request and the assumed threat) and the technological tools available to the MPC&A staff.

A preliminary step to the conduct of a full physical inventory is the application of rapid inventory procedures that serve to provide the benchmark for the inventory by identifying if any items are missing and also, if any unrecorded items are present. Rapid Inventory Procedures by design can be carried out on short notice and at any time during the reporting period, while a full physical inventory is normally carried out at the end of the reporting period. The procedures make use of computerized inventory records, bar codes, and tamper indicating devices (TIDs), and involve the identification and accounting of nuclear material containers and items without quantitative measurements. On completion of the Rapid Inventory Procedures, there will be a corrected data base with a one-to-one correspondence established between every record in the computerized accountability data base and every item in the selected area.

7. MC&A Training and Workshops

Prior to implementing the plan and procedures it was considered essential that the RIAR staff be introduced to the MC&A culture embodied in these new systems. This was accomplished by providing comprehensive MC&A workshops to RIAR management and staff based on the courses given in the US and to IAEA representatives. Topics included Vulnerability Assessments and Safeguards Effectiveness. In addition, a number of training sessions were conducted both in the US and in Russia addressing a particular technology or MC&A methodology. With regard to physical inventory, a two week working session was conducted at Brookhaven National Laboratory for several RIAR staff addressing the issues associated with introducing of the rapid inventory elements into the existing MC&A system at the Central Storage Facility.

8. The Central Storage Facility (CSF) - Building 132

The first area to which rapid inventory taking techniques are being applied is the Central Storage Facility (CSF). It is the receptacle of all incoming and outgoing shipments, and provides the link between the BOR-60 reactor and the fuel fabrication processing plant. The physical layout of the CSF is shown in Fig. 1. The flow of materials to and from the other major facilities is shown in Fig. 2. The CSF houses both fresh fuel assemblies (MOX and HEU) and spent fuel assemblies, and at any given time can contain 100-300 kilograms of 70-90% HEU and 100 kilograms of 55-94% Pu. All nuclear materials coming to the Institute from outside enterprises enter through central storage, by railway in sealed transport package units (TPU). The nuclear materials stored in the CSF are sorted in groups by type, limited only by space and nuclear safety considerations. Representative materials and their containers include the following:

a) **Pu Dioxide** - Stored in substantial quantities in Transport Packing Units (TPU). - Fig. 3

b) **Highly Enriched Uranium (HEU) Oxide** - Stored in two types of containers depending on quantity. - Fig. 4

c) **Uranium Dioxide pellets** - stored in thin-walled case type containers.

d) **Metallic Uranium** - Stored in steel containers.

e) **BOR-60 Fuel Assemblies (FA)** - Three types (Standard, Experimental, Dismountable) All in sealed steel cylindrical boxes. Fig. 5

Although the CSF contains a variety of materials and containers and handles outside shipments, several factors contribute to make it a preferred location to introduce the new inventory techniques. The PIT is straightforward, the material balance area (MBA) contains only discrete items, (no bulk quantities or material in process), and at present no physical measurements are made. The facility is uncluttered and has adequate space for bringing in the new equipment, and providing a dedicated area for MC&A operations.

9. New Technologies

The development of the rapid inventory capability involved the introduction of three new technologies and equally important are the procedural aspects associated with them concerning the acquisition, verification and maintenance of the databases. The technologies are:

9.1 Bar coding for Item Identification

One of the first items provided to RIAR was a complete set of equipment to establish a bar coding capability. This included the imprinting machine, computer hardware and software, scanners, and the associated labels and supplies. In addition several of the RIAR operations staff received a formal training course in bar coding technology and applications. This information was used to develop a basic alphanumeric coding scheme to be used initially in the storage area. The coding is limited to item identification at this time. The primary advantage of bar coding is the expected reduction in the number of errors in data entry. It also facilitates the entry of data into the computer. Bar code labels have been created and applied to sample containers and read

with the scanner. This information is transported to a local computer for storage only. Some work has been done by the Institute in developing the organization structure and procedures for using bar codes as part of the inventory system. At this writing the system is still in the trial and evaluation period which is expected to be completed by late 1997.

9.2 Tamper-indicating devices (TIDs)

In a similar manner the Institute was supplied with a selection of tamper-indicating devices commercially available and in use in the US and within the IAEA community. This included the e-cup and multi-lock types, as well as the mylar and pressure sensitive "adhesive" seals. A one week workshop was conducted by technical experts from the US National Laboratories covering both the procedural and the practical aspects of using the various TID's based on US experience. During this workshop the importance of establishing rigorous control program for TID's was emphasized. A substantial amount of time was spent in applying the seals to representative RIAR containers, in inspecting the seals for damage or tamper indications, and in documenting all of the operations. A large supply of seals was left with the Institute for their use. Following the workshop RIAR conducted their own evaluation, comparing the seals currently in use (lead imprint and mastic types) versus the newer types. The study included a number of factors such as strength, cost, operating environment, application, etc. and their final report indicated those selected for use in the central storage area. The TID's are now undergoing an operational trial period scheduled to be completed in late 1997.

9.3 Computerized Inventory Records System (CIRS)

The purpose of this task was to develop a capability at RIAR for rapid entry of data into a spreadsheet format utilizing modern computers and software that would be appropriate for this initial stage. RIAR was provided with pentium-type computers using Windows 95 and Microsoft Office with Excel and Access software. The plan was to essentially map the information that was currently being recorded manually in log books on to flat files on an excel spreadsheet. The first activity was to identify the nuclear accountability data elements called "passport data" in Russia, which includes isotopic composition, weight, impurities, packing information, etc, and accompanying shippers documents. The current system involves about 35 data elements and RIAR staff recommended about 10 more be included. These items were then used to define the data fields in terms of word length, type of entry, source etc. This information was assembled into approximately 15 data files such as shipper data, TID information, Batch characteristics, etc., that could form the basis of a relational data base in the future. Examples of these files are shown in Fig. 6 . Much of the data base development work was done during the two-week working session held at BNL in early 1997.

10. Conduct of the Rapid Inventory Procedure

A demonstration of the Rapid Inventory Procedure at the RIAR facility is planned for the last quarter of 1997. It is expected that additional information on the progress will be available at the time of presentation of this paper (October 1997). The demonstration will bring together the plans and technologies developed over the past year for use in the storage facility. The sequence

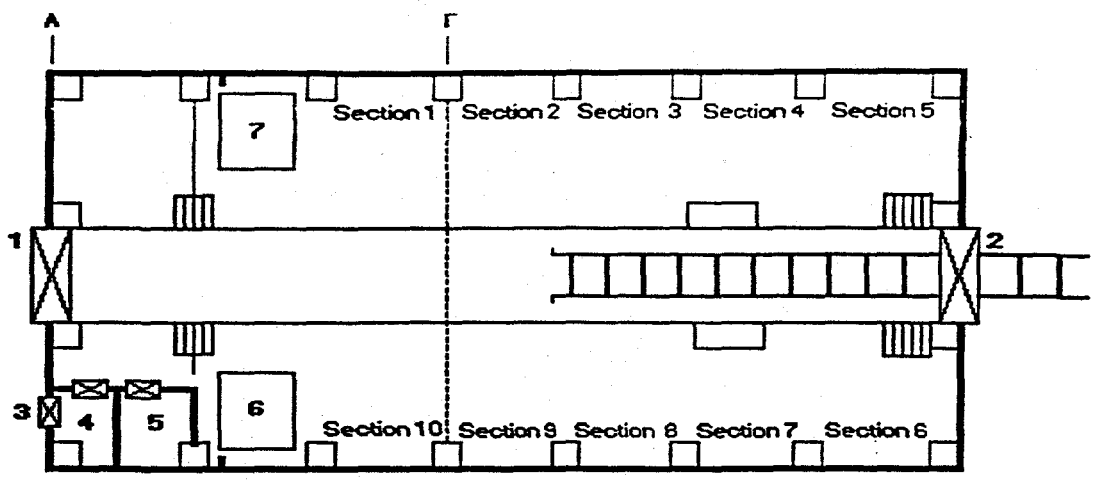
of steps that will make up the demonstration is shown in Fig. 7. The successful completion of the exercise will essentially complete the first phase of the physical inventory upgrades. The second phase of the program will involve the introduction of measurement equipment such as electronic scales and NDA equipment, providing the capability to determine and verify quantities of materials present in a more timely manner.

11. Conclusions

After some initial delays do to problems in delivering equipment in Russia and other matters the program is proceeding as planned. Both the management and staff of the RIAR facility are very receptive to the new methodologies being introduced, and in particular to the more advanced computer hardware and software. There is strong interest in the latest technologies such as active seals and more advanced bar code scanners, which must be balanced against the need to provide some upgrades within budget constraints. What is taking more time to absorb is the need for dedicated and independent MC&A organizations, detailed MC&A plans and procedures and rigorous record keeping that is required. With regard to equipment it is noted that the major manufacturers of measurement equipment are expanding their technical support activities into the more distant areas where the Russian nuclear facilities are located which will accelerate the transfer process. We are looking forward to the next phases of the program and the gradual assimilation of the new MC&A methodologies adopted as appropriate to the particular needs of the RIAR facility.

References

[1] Kharlanov, Y.I., et al., "US/Russia Government to Government Cooperation in Material Protection, Control and Accounting at the SSC-RIAR, Dimitrovgrad" (Proceedings of the 37th Annual Meeting of the Institute of Nuclear Materials Management (INMM), Naples, Florida 1996).



1 - automobile entrance;
2 - railway entrance;
3 - personnel entrance;
4 - personnel's room (household);
5 - auxiliary room;

Fig. 1. Plan of the RIAR Central Storage Facility (CSF - Building 132) :

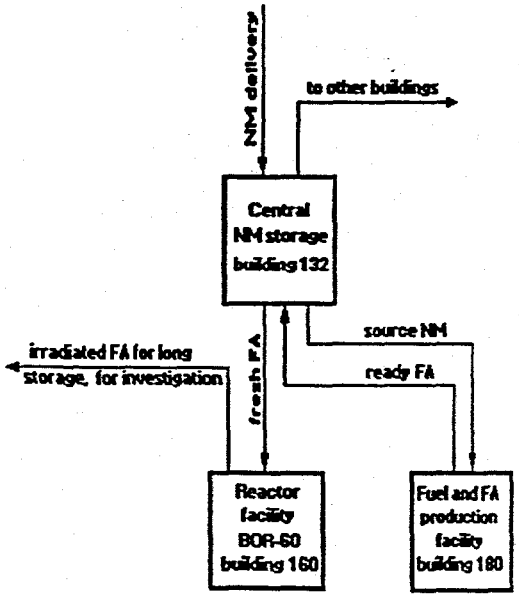
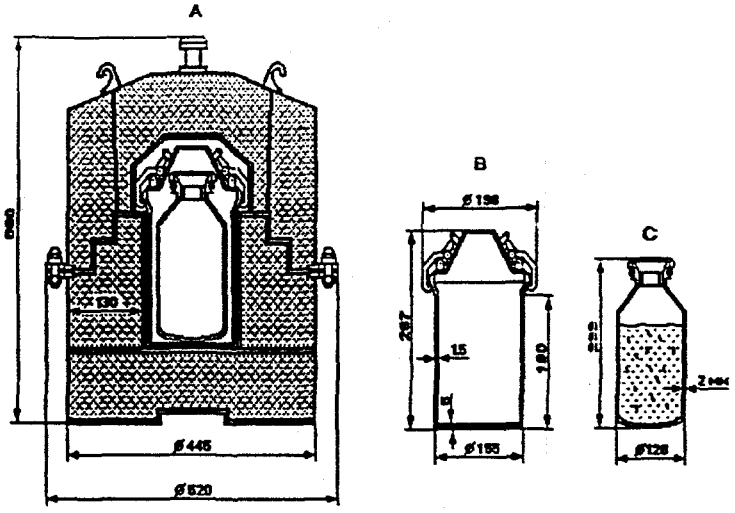
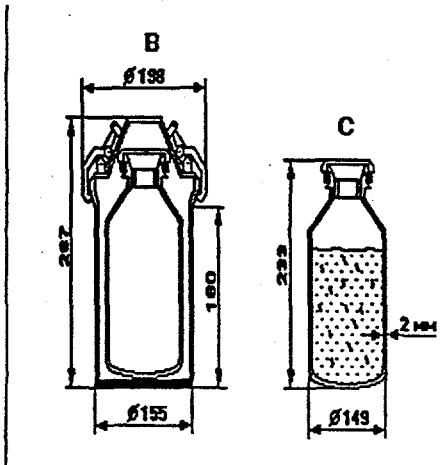


Fig. 2. Movement of Nuclear Material in RIAR Fast Reactor Fuel Cycle

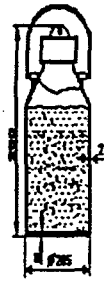


A - Shielded transport container
B - tight container
C - can with PuO_2

Fig. 3. Transport Package Unit (TPU) for PuO_2

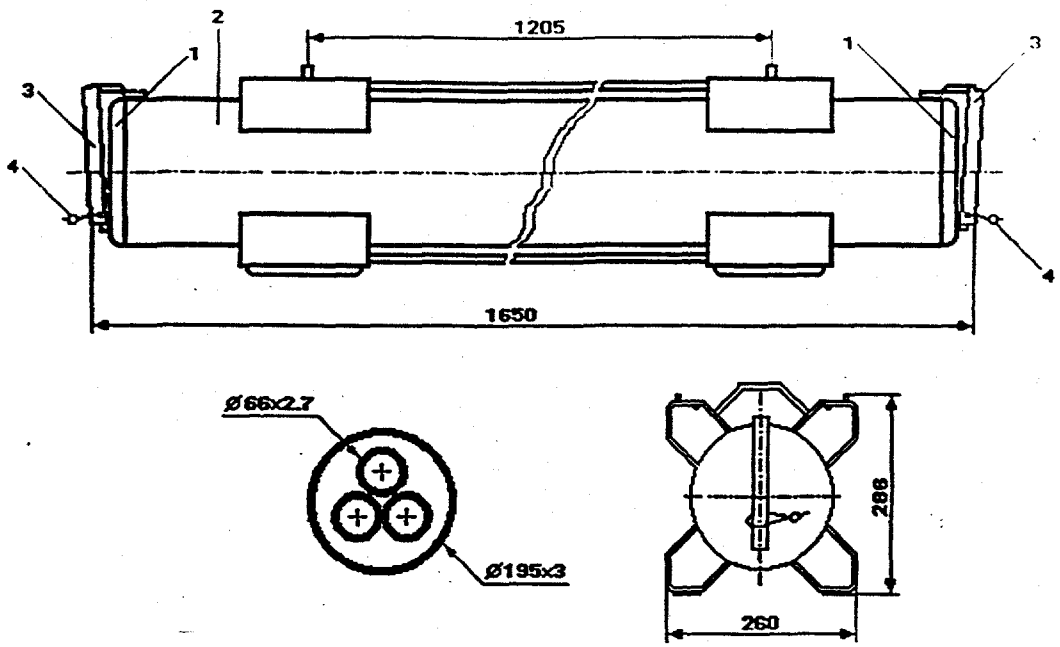


Type 1: Material content up to 5 kg.
B - tight container
C - can with UO.



Type 2: Material Content up to 10kg

Fig. 4. Package for highly-enriched U oxide



1 - cover;
2 - steel box;
3 - latch;
4 - seal

Fig. 5 . Transport package for the BOR-60 reactor Fuel Assembly (FA).

Паспортные данные Passport.dbf

Идентификац. номер инвенарной единицы	F-97/8
Штриховой код	BYU-87/59
Дата произведения записи	01/01/97
Общая масса	234
Единицы измерения массы	кг
Масса тары	200
Масса материала	34
% основного материала	34
% влаги	1.5
MED	45
Идентификац. номер партии материала	BY-678/98
Штриховой код контейнера	GTR-9
Местонахождение штрихового кода	LKU/7

Данные партий материала Batch.dbf

Идентификационный номер партии материала			BN-7/676
U%235	5	%железо	0.1
U%236	2	%барium	0.6
U%237	1	%свинец	3
U%238	1.5	%кальций	2
Pu%238	0	%никель	1.11
Pu%239	0.003	%бор	2
Pu%240	1	%кобальт	1
Pu%241	0.11	%магний	2
Pu%242	0.11	%хром	1
Добавки%	5.6	%калий	2
%самарий	1	%магнезий	2
%кремний	2	%ванадий	0.7
%алюминий	1	%берил	3
%натрий	2	%гадолиний	1
		%кадмий	1

Перевозки Shipper.dbf

Идентификац.номер груза	TRT-789	Вид материала	Pu240
Дата получения	07/04/96	Предполагаемое использование	Топливо
Отправитель	Маяк	Кредитный слип	UY-89
Идент.номер накладной	GH-87	Штриховой код контейнера	BYU-678
Идент.номер поставщика	BVC/56-7	Сертификац.номер контейнера	CF-ytu-97
Транспортировка	Поезд	Номер контейнера	234-UY
Идент.номер сертификата	HG-0	Вид опечатывания	Колпачек
Местный сертификат	GT-4-7	Идент. номер пломбы	HJK-789
Количество единиц	5	Состояние пломбы	Проверено
Вес материала	7		
Единицы веса	кг		

Информация на ярлыке Tag.dbf

Идентификац. номер инвенарной единицы	G-876
Штриховой код	B/8789
Местонахождение штрихового кода	L-45/9
Описание инвентарной единицы	PuO_2
Идентификационный номер контейнера	CY-567
Вес	234
Единицы веса	кг
Идентификац. номер партии материала	B98-567
Делящееся материалы	65
Вес делящихся материалов	3

Fig.6. Computerized Data Forms - Sample Database Files

Rapid Inventory Procedures		
Type of Rapid Procedure	**Verification**	**Data Requirements**
I. Level I: Item count		
a. Total number of items in MBA	count items	gross count
b. Total items by type (container/ bulk form)	record item count by type of container	total items by container
II. Level II Identification of items		
a. Identification of each item	read bar code	bar code listing of items
b. Identification of items and location	read item and location bar code	correlated listing of items and location
c. Verification of item and location	check bar code against type of material and location	bar-code tag-data data base

Fig. 7 Rapid Inventory Procedures Diagram