

## **UK ALDERMASTON'S WASTE ACCUMULATION TRACKING SYSTEM (WATS)**

Matthew Cooper & Matthew Keep - Directorate of Technology, Atomic Weapons  
Establishment, Aldermaston, UK

### **ABSTRACT**

AWE Aldermaston has a number of Production Facilities which together generate approx. 1,700m<sup>3</sup> of waste per annum. An important aspect of AWE's UK Nuclear Site Licence the ability to show traceability of waste from source to final disposal. Traditionally, this tracking of waste items has been done using paper driven systems.

One AWE Facility have now developed a low cost and completely paperless method of tracking waste from source through to despatch to Waste Management. This is known as WATS, the Waste Accumulation Tracking System.

From the outset of it's development, WATS required consistent data entry. This has been achieved by using a combination of bar codes, hand held data capture units and networked personal computers. Data entry is carried out by placing unique bar codes on each individual waste item. Information related to the waste is scanned from the labels and process cards into the portable hand held unit. Data is downloaded through a networked PC into a database developed on a standard software package. Recorded data can be easily interrogated using a number of analysis and query functions producing specialised reports as and when required.

### **INTRODUCTION**

AWE manages the UK Nuclear Deterrent's life cycle on behalf of the British Government. It is based at two sites, eight miles apart, approximately fifty miles to the west of London. The larger of the two sites at Aldermaston employs over 4500 staff and acts as a research and manufacturing facility. The smaller site at Burghfield employs about 600 staff and concentrates on component manufacturing and warhead assembly. The site is owned by the UK's Ministry of Defence and operated by a management contractor Hunting BRAE, a consortium of Hunting Engineering, Brown and Root and AEA Technology.

AWE generates in excess of 1,700m<sup>3</sup> of radio-active waste per annum. Most of the waste is Low Level (LLW) and is sent for burial at the National LLW Repository at Drigg in Cumbria. Intermediate Level Waste (ILW), the equivalent of TRU waste, is stored in dedicated facilities on the Aldermaston site.

All radio-active waste at AWE is subject to rigorous quality procedures to ensure that they comply with company safety and environmental standards. These procedures generate a paper trail that requires careful management and is resource intensive.

In July 1997 AWE became a Licensed Site under the UK's Nuclear Installation Act. The Licence covers all aspects of AWE operations including waste. AWE is required to demonstrate that it can trace all of its waste from the point of generation through to final

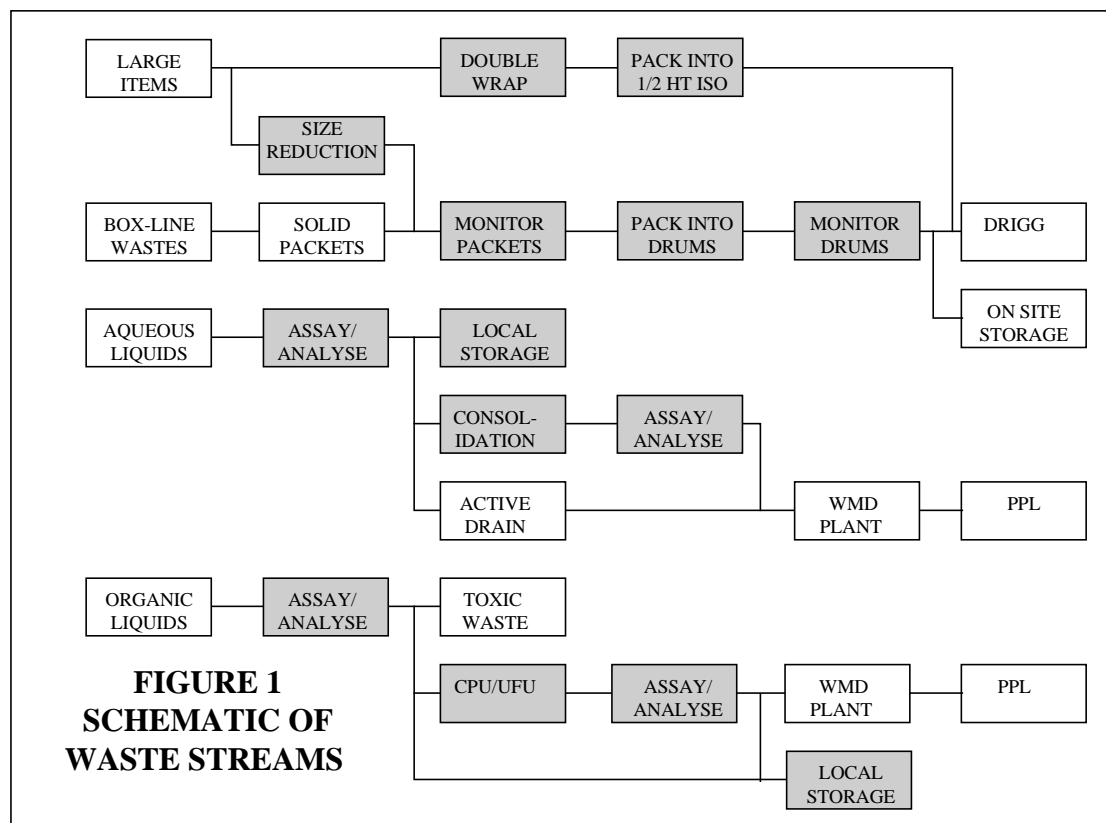
disposal with a licensed contractor. Information technology (IT) has had some impact on the process but most facilities still have a heavy dependency on paper driven systems.

In early 1996 one of AWE manufacturing facilities decided to develop a data management system for its radio-active wastes. The main aim was to concentrate the majority of information relating to waste in one database and to make it accessible to a wide range of operators and managers. In order to allow efficient use of the data base two key considerations were the ease of data collection and the need for consistent data entry. These requirements were met using hand held data capture units with bar code wands to read and store information from pre-printed bar code labels and forms.

AWE engaged an IT contractor to develop the WATS on its behalf. The contractor had knowledge of a number of AWE's waste operations and worked in close collaboration to ensure that the system met our needs. Comprehensive training and testing have ensured that implementation has been straight-forward. To date 1,200 records and 15,000 transactions have been created on the WATS database.

### **Current Waste Streams**

The facility that developed WATS has a number of varied waste streams. These are summarised in Figure 1.



The AWE Solid Waste Manual segregate solid waste into LLW and ILW for the purpose of disposal or long term storage. However, to assist with the assessment of all waste from the production area two categorisations are used. These are defined as follows:

**Contact Waste** Waste that has had the potential to come into contact with radio-active material and may be contaminated. This includes waste from glove boxes, fume cupboards and decontamination operations.

**Non-Contact Waste** Waste that that has not had the potential to come into contact with radio-active material and is probably not contaminated. This includes general laboratory waste and work wear.

In plutonium facilities all contact waste will be sentenced for long term storage as ILW. However, due to the lower specific activity, contact waste from uranium facilities may be disposed of either LLW or ILW depending on the quantity of uranium associated with the waste items.

Waste Stream Quality Control Plans (WSQCP) use the contact/non-contact waste definitions to determine the procedure for managing the waste prior to despatch from the facility. For example all contact waste is subject to radiometric assay of individual waste items. Non-contact waste is packed into despatch containers without assay. The despatch containers for all waste is assayed prior to despatch from the facility. The WSQCPs also identify what records are to be kept and who is responsible for maintaining them.

## **DEVELOPMENT OF A WASTE INVENTORY CONTROL SYSTEM**

The original idea for a waste inventory system was conceived before AWE became a licensed site. At that time it was perceived that the system was only required to assist with the preparation of quality documentation of waste containers prior to their despatch to Waste Management. During the preparations for Nuclear Site Licensing it became clear that the waste inventory system would have to be capable of tracking waste from the point of generation through to despatch from the facility. It was at this point that the main principles behind WATS were established. They are summarised as follows:

- Central record keeping for all items of waste.
- Full traceability back to the point of generation.
- Consistent data entry.
- Ease of data entry on the job.
- Low cost & maintainability.

**Central Record Keeping For All Items Of Waste.** The current waste quality system demands that a considerable number of records relating to waste processing activities are maintained. Prior to the introduction of WATS these records were held in a combination of log books, loose leaf files and computer databases. One of the main drivers in the development of WATS was concentrate all the records in a central database that could be accessed by both operators and managers. It was agreed that the database would be developed in the AWE software standard, Microsoft Access, and reside on a local area network serving the facility.

**Full Traceability Back To The Point Of Generation.** Once an item has been declared as waste it is subjected to a number of processes and conditioning steps prior to despatch to Waste Management. Where waste is size reduced or consolidated it becomes difficult to identify from where the 'conditioned' item originated. Before WATS was introduced

self-adhesive labels were placed on items to identify their source and contents. It was not possible to easily establish the provenance of the item and whether it had undergone any conditioning steps. It was, therefore, decided that an essential function of WATS would be to track an items progress through the waste disposal process.

**Consistent Data Entry.** Discussions with the contractor and a number of other organisations that use computer driven waste inventory systems revealed that problems often arose when preparing reports or interrogating the database. This was mainly due to the failure of those inputting data to use a consistent format. An example of this is demonstrated when considering the generator of a waste parcel. If the operator is called James Smith he may enter 'JS', 'Jim Smith' or 'J Smith' as his generator identification. Clearly, when interrogating the database for items generated by James Smith items may be missed if the operator has not entered the correct wording in to the data field.

It was agreed that an attempt would be made to ensure that data entry was always consistent. All data types would be assigned codes and the database would check for validity when the data was inputted. It was considered that bar codes would provide a way of guaranteeing that the codes were always correctly entered. Some codes were assigned check digits to further improve the system's verification procedures.

**Ease Of Data Entry.** The development team agreed that the success of WATS would rely on ensuring that the work force used the system for all waste related operations. It was also agreed that the operators should be encouraged to input data either during operations or as soon as possible after their completion. It was decided that hand held data capture units with bar code readers would be used to record details of all waste transactions. Programmable units were selected so that data could be entered into 'on-screen' forms and to allow an element of data checking. At the end of the day the hand held units would be taken to a networked PC where data would be down-loaded onto the WATS database.

**Low Cost & Maintainability.** To secure funding it was appreciated at an early stage that WATS would have offer an economic benefit. To date the system has cost has been kept to below US\$ 100 000. This has been achieved by using off the shelf hardware, existing network arrangements and a specialist contractor to develop the software. Pre-printed labels for waste items have been manufactured at a cost of US\$0.25 each but all other bar codes have been created using bar code fonts on PC driven software.

Management of the database is undertaken by the network supervisor which minimises the effort to the facility. When the database is complete a support contract will be let with the software house to ensure that any problems can be dealt with swiftly and efficiently.

## **FUNCTIONALITY OF WATS**

WATS is essentially a stock control system. It is utilised in order to track every item of waste, whether it is solid or liquid, throughout the Facility from source to despatch. During the processing of waste each item will be moved and / or further processed, several times before finally being despatched to the on-site Waste Management Directorate. All of the information about movements of waste must be recorded in a running log. WATS provides the ability to do this.

All of the information about the waste item, generator, contents, area of generation, current location, etc. is collected using a combination of barcodes and hand held data capture units. Whenever the item is moved or processed further there are more barcodes available to describe the manipulation functions required. Once checked and saved in the memory of the hand held unit the information can be transferred into the main PC database via a 'cradle' transfer unit. All records are then easily accessible and edited, if required, through the Microsoft Access based system.

## **DATA FORMAT**

**Barcoding.** In order to reduce any errors with manually entered data and to ensure the data is of a consistently high quality a system of barcoding has been developed.

Every aspect of the waste process has been assigned an individual code. From the individual waste labels, area / station identifications and waste types to the generator identifications and manipulation functions they all have their individual barcodes and identifying prefixes. Code 39 is utilised for all of the barcodes used by the system. Each character consists of five bars (black) and four spaces with an asterix present at the start and end of the code.

The most important field for bar-coding is the series of unique individual barcodes used to identify each waste item. As discussed before, there are two different 'types' of waste which can be generated, contact and non-contact. Each of these two categories are then subdivided into HEU (Highly Enriched Uranium) and Pu (Plutonium) so that there are four types of waste label used in total. For ease of identification the different labels are coloured differently. The barcode and comparative 5 digit numerical code is visibly printed, each of the four types having a different prefix to the code. To ensure that there can be no error in scanning the barcode they have a 'check digit' at the end which verifies that the code scanned is correct and in the true order. The production of these labels was sourced externally from AWE.

All other barcodes used for the system have been produced 'in-house'. They also have their own individual prefixes to identify the category of the information and up to 5 digit code to identify an item more specific in the category. These barcodes do not have check digits, consequently simple errors in the reading of the code can occur. These errors can be easily rectified once the information is downloaded into the PC. Examples of barcode formats are shown in figure 2.

**Figure 2 - Table to show examples of barcode formats used for WATS**

<b>Complete Code</b>	<b>Explanation</b>	<b>Category</b>	<b>Specific ID</b>	<b>Check Digit</b>
*A00005F*	Pu Contact	A	00005	F
*B01005H*	Pu Non-Contact	B	01005	H
*C00005H*	HEU Contact	C	00005	H
*D01002G*	HEU Non-Contact	D	01002	G
*Q1WAS*	Area Reference	Q1	WAS	N/A
*Q2PAP*	Solid Waste Type	Q2	PAP	N/A
*Q3BOT*	Liquid Waste Type	Q3	BOT	N/A
*Q4MJK*	Generator Identification	Q4	MJK	N/A
*QS12345*	Criticality Station	QS	12345	N/A
*Q0MV*	Manipulation Function	Q0	MV	N/A

The barcodes themselves are utilised in a number of different forms:

- The unique individual barcodes are available as labels with an adhesive backing. These are placed onto all waste items, or drum to contain the waste as soon as they are generated. The only exceptions are soft items of non-contact waste such as gloves.
- Barcodes for the identification of 'Generators' are attached to tags and are worn by each individual. Each generator has their own uniquely identifying 3-digit code related to their initials.
- Barcodes used to identify a 'Criticality Station' are fixed in the locality of the station.
- The series of barcodes used for identifying particular waste contents, Manipulation Functions and other functions such as 'Save The Record' is supplied in a laminated A4 form known as the 'Crib Sheet'. All of the functions are listed in sequence so that an operator can follow through systematically.

The types of Manipulation functions available to the Operators are:

- Generating a waste item - any waste item, including waste drums / containers.
- Packing A Drum - for use with packages.
- Unpacking A Drum - for use with packages.
- Move Item - for moving large waste items / drums / containers.
- Break Up Item - to be used if an item is broken down into smaller items, e.g. fissile content too high.
- Consolidate Item - for transferring of liquids into another container which may already contain liquid.
- Destroy Item - used to remove an item from the waste tracking system.
- Despatch Item - to Waste Management.

## **DATA CAPTURE**

The data capture units (DCU) and the associated equipment comprise of:

1. PSION HC120 Hand Held Unit
2. PSION HC Re-Chargeable Battery Pack
3. PSION 1MB (RAM) Solid State Disk
4. PSION 512K 'Flash' Pack

5. PSION Hewlett Packard Barcode Wand
6. PSION HC Expansion Module Barcode Wand Interface
7. PSION HC Range Mains Adaptor
8. HC Cradle, Model TC.

The DCU consists of listed items 1 - 6. There are a dozen of the portable units in the Facility used by all staff involved in the generation or processing of wastes. Data collected is held in the memory of the RAM pack, while the programme to run the unit is retained in the Flash Pack. The 9V main battery is expected to last for a number of weeks, depending on the degree of use, with a 3V back-up battery installed also. Re-Charging the main battery takes a matter of hours. Each area within the Facility is responsible for their DCU and ensuring that it is fit for use by re-charging when necessary.

**Operation of DCU.** With a small number of exceptions, the operation of the unit is done so without the operator using the keypad. Switching the unit on/off, using the menu and entering the waste item identification (only used in situations when physically scanning the barcode can not be achieved) are the only circumstances where the keypad is used.

**The Scanning Process.** The unique barcoded labels are placed on each individual waste item. The DCU is used to scan the barcode in order to generate the item on WATS. Other information related to the waste, such as the area it was generated, its contents and the individual generator(s) are scanned from the labels and crib sheet into the DCU. Every time a barcode is scanned a 'beep' noise will be emitted as an acknowledgement. Once the data entry is believed to be correct it is saved into the memory. If the information is incomplete an alarm will sound during the saving process and the Operator is to follow the instructions on the screen in order to complete the transaction. The collection of data can be performed all day without the need to download the information although the downloading operation is routinely carried out at the end of every working day in order to ensure that information is not lost or discarded.

Once collected, checked and saved the data is ready to be downloaded into the networked PC via the data transfer device, the 'cradle'. The DCU connects to the 'cradle' which is in turn connected to the PC. The PC utilised for this operation is centrally located within the Facility.

## **DATABASE OPERATION**

**Downloading Data.** The operating platform for the database is Microsoft Access. Once transferred into the PC the data is retained in a holding screen prior to visual checks by the operator. As soon as the information on the holding screen is deemed to be correct it is 'posted' into the Main Database. At the holding screen stage the system has the ability to recognise any errors relating to partially scanned barcodes. In particular, the errors highlighted are those where the barcode / information does not relate to anything that it recognises. These are errors which are easily rectified by the Operator. The order that information is entered into the system is also important. If the logic sequence is missing a step, the holding screen will highlight it and the information will not be downloaded into the Main Database until the information gap is filled. An example of an information gap would be data displaying that a waste package had been

'unpacked' from a drum with no evidence that it had been 'packed' into that drum in the first place. The cause of this discrepancy may be that the data from a hand held unit has not been downloaded yet. By flagging this fact to the Operator it enables them to search for the unit / data and to check that procedures are being followed correctly if required.

**Access Privilege.** Access to the system is limited to particular personnel. There are a number of different levels of access privilege, which are assigned to individuals depending upon their requirements. Levels of access range from:

- Operator - able only to download information and enter data. Limited access to the information available in the system. Editing ability is only available at the holding screen stage.
- Supervisor - access available to all areas of the system with the ability to edit if required. The ability provided for a number of reporting / analysis tools to be utilised.
- Reporting - access limited to the retrieval of reports from the system. No editing rights are permitted.

As the database operates via the Facility network access to the records can be readily available through any PC providing the individual has the correct access privileges.

**Data Storage.** The Main Database is where the information about all of the records is stored. Primarily the database is divided in two with a solid and liquid side. Each side is then subdivided into a number of smaller databases which are all inter-related and cross referenced. For instance, with solids there is a data set for drums and one for wastepacks. Wastepacks are usually stored in drums, as the two databases are fully cross referenced information can be sought about either item from either direction.

Current information about the waste items is available when the appropriate reference number, derived from the unique individual barcode, is accessed. Information detailed includes:

- Type of waste - whether it is HEU, Pu, Contact or Non-Contact.
- Status - e.g. in the case of a wastepack the status could be that it is 'drummed'.
- Other References - e.g. the unique identification of the drum that the wastepack is stored inside.
- Current Area / Criticality Station
- Last Action information - e.g. type of action, date / time, generator identification etc.
- Fissile holdup / activity
- Contents - e.g. in the case of a wastepack, whether it contains paper, plastic, metal, etc.

**Traceability.** One of the most important aspect of the system is the ability to record a complete 'transaction history' for each waste item to ensure that it can be properly tracked from source to despatch. Whenever information about a particular waste item is recorded by the data capture unit and downloaded into the system the following information is retained as the transaction history:

- Type of transaction - e.g. move, pack, unpack etc.
- Unique individual reference number of item involved in transaction - e.g. the drum that the wastepack was packed into.
- Date & Time.



- Generator Identification - two generator id's can be entered if required for the purposes of traceability.
- Area or Criticality Station that the event took place.

**Analysis.** Another useful function of the database is the ability to produce specialised forms / reports and to interrogate the system using the analytical tool, namely the 'Query Engine'.

A number of prepared reports have been developed within the system in order to mirror those needed prior to using WATS. The reports vary from being daily summary reports, immediate fissile inventory reports and shipment details reports to the monthly waste accumulation report and quarterly fissile accountancy reports. To create the reports the PC operator will be required to go to the correct section and enter the required date field for the reporting period. The database will then call up the relevant information automatically.

One of the most important forms is called the 'Solid Waste Record Card' (SWRC). All waste that is despatched from the Facility must be accompanied by a SWRC that details all of the information about the shipment such as the contents, fissile holdup and weight. For the staff of a Facility that produces a significant amount of waste per annum, the automation involved in the fulfilment of this requirement is of major benefit. In all of the cases the database will retrieve information from specific fields in order to fulfil each request.

The Query Engine provides the facility to interrogate the database in other ways that have not previously been considered during the creation of the specialised reports. The function is a flexible way of analysing the data by allowing information from any field in the database to be pitched against any other so that other specialised reports can be produced.

## **COMMISSIONING PHILOSOPHY**

**Commissioning.** The active 'Controlled Area' commissioning took place over a twelve month period. A significant aspect of the commissioning was to allow the Operators to gain some useful experience of operating the system and equipment. Also, of significant importance was to test the new system against the old manual paper driven system to ensure that it was robust and accurate. To this end the two systems were initially operated in parallel and a number of checks performed in order to ensure its suitability.

WATS was not completed and introduced in one attempt. The expectations of the system were outlined to the contractor in an initial specification. The system was carefully constructed to a level where Operator experience could be realised before any hands-on commissioning could take place.

The commissioning process involved:

1. Training of staff with the new equipment.
2. Development and introduction of the solid side of the system. A limited number of staff in the Facility were involved during this part of the operation.

3. To thoroughly test the operation of WATS for solid waste using all of the Facility resource.
4. Once it was considered that the solid side was complete and that all of the issues had been addressed the query engine and reports for the solid data were produced and fully tested.
5. Development, introduction and testing of the liquid side.
6. Introduction and testing of query engine / reports for liquid data.

The system was continuously updated during the commissioning period to take account of minor changes and improvements that were suggested by the contractor / AWE staff during its operation.

**Problem Identification / Solving.** The commissioning of WATS was no different from any other commissioning period, with a number of problems identified and their resolution required. Most of the problems identified turned out to be relatively minor changes to the software code largely resulting from communication differences between the contractor and AWE staff. However, there were a number of changes that were required after operating the system. Examples of the problems surpassed include:

- Operators typing into the DCU on too many occasions - When the DCU's were used at first the Operators had the ability to enter all of the codes for any barcode used in the Facility. The ingenuity of the Operators meant that abuse of the system was possible by individuals keying in other Generator Identifications or Area codes without actually physically going to the area in question. This was not ideal as there would be an element of doubt as to whether the data was accurate. Now all keyed entry's are blocked except for the package unique barcode which can be entered manually if required.
- Items, packages in particular, being 'Moved' not 'Packed' / 'Unpacked' - In some circumstances the tracking of waste was not found to be accurate because Operators were 'moving' packages between drums and not 'unpacking' from one drum and 'packing' into a different one. This resulted in the loss of accurate information when packages were tracked through the database. The situation was resolved by ensuring more extensive training was carried out and the 'holding' screen / checking was introduced so that any similar problems would be flagged as soon as they had taken place.
- System 'creating' information to fill in gaps - Initially the database looked at data on a minute by minute basis. If instances arose where transactions were recorded at taking place in the same minute the database would look to register the transactions in alphabetical order, for example, if a package was unpacked from drum no.1 and packed into drum no.2 in the same minute the recorded information would indicate that the package was packed into no.2 before being unpacked from drum no.1. In this case the database would create the missing steps where the sequence of events recorded would be:
  - Unpack from drum no.1
  - Pack into drum no.2 (original recorded entry)
  - Unpack from drum no.2
  - Pack into drum no.1
  - Unpack from drum no.1 (original recorded entry)

- End of transaction history

As can be seen there are many unnecessary additional steps that have been added resulting in the transaction record showing that the package was loose and not contained in a drum. To rectify this situation the recording of information now takes place every second.

## **THE FUTURE OF WATS**

WATS has provided significant benefits to waste tracking throughout the Facility for both Operators and Managers. The new software driven system has been welcomed by the Operators using the system on a daily basis as more experience of operating the equipment allowed them to recognise the new method of data recording is advantageous compared to the old paper driven system. Managers are now able to have a more realistic account of the waste movements and accumulations which are present in the Facility. The ability to interrogate and analyse the recorded data is another advantage that the new system has over the paper driven system with the data available being of a more concise and accurate nature. The database is also available for access by a number of different Managers who would normally be required to formally request the information from the Section who deal with the waste.

At AWE WATS would be applicable in a number of other Facilities. The system itself can be simply adjusted to suit each individual Facilities need. The success of this system within one Facility at AWE will provide reassurance to other Facilities at AWE and Companies / Agencies around the World that this type of tracking system can be an advantage in areas of data management.

© British Crown Copyright 1999 / MOD

Published with the permission of the Controller of Her  
Britannic Majesty's Stationary Office.