DEVELOPMENT OF BAGLESS TRANSFER SYSTEMS AT BRITISH NUCLEAR FUELS PLC (BNFL)

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ABSTRACT

Bagless transfer systems can be used to reduce much of the large volume of plutonium-contaminated material that arises during glove box operations and can be used to fill and close large containers of waste (drums) whilst maintaining an uncontaminated surface.

We aim to present the results of development on a large bagless transfer system (18" dia) that can be used in conjunction with a range of drum sizes. In addition we discuss experience with a small bagless transfer system (6" and 8" dia) that operates on the purged port principle. This unit can be used to transfer items between active facilities and results in a much lower exposure of operators to airborne contamination than by conventional bagging systems.

INTRODUCTION

There are a number of alpha-active facilities associated with reprocessing spent nuclear fuel. These deal with material from which the bulk of the beta-gamma emitting fission products have been removed and as such demand a high level of containment without the massive shielding that is associated with beta gamma facilities. Transfer of material between alpha facilities or removal and subsequent storage of waste both currently rely on 'hands-on bagging' techniques. 'Bagging' involves heat sealing contaminated items into a PVC sleeve. Although the 'bagging' procedure has been used successfully and safely at BNFL for many years it does suffer from a number of disadvantages:

- the need for an operator in an active area
- the heat sealing process requires clean surfaces and some operator skill. The process is also relatively time consuming
- a faulty seal, though infrequent, can result in a release of contamination
- bagging produces secondary waste in the form of packaging material and encourages discarding reusable tools.

To overcome these disadvantages BNFL has developed two types of bagless transfer equipment.

- a small bagless transfer unit for movement of items between facilities and glove boxes in a reusable container
- a larger unit that can be used to fill drums directly from within a facility without an intermediate "bagging" stage.

In both cases the aim is to produce an externally uncontaminated package with minimal release of airborne activity. The small unit uses a robust transport container while the larger bagless transfer system can be used with a cheap "one trip" drum or a reusable waste container.

The Bagless Transfer equipment has been developed for alpha facilities but can be employed on any hazardous facility, where it is necessary to carry out operations remotely and avoid a release of contamination or generation of secondary waste.

SMALL BAGLESS TRANSFER SYSTEM

There are a number of small bagless transfer units that can be used to transfer material between alpha active facilities (1,2). These generally employ a seal that allows some transfer of contamination either by contact or deposition, see Fig. 1. The containers and ports are also not generally fully interlocked to prevent accidental maloperation of the system and thus require a rigorous management regime. In order to overcome these problems the purged port system was developed (3,4).

BNFL PURGED PORT

The major design principles for the BNFL purged port are to:

- minimize release of airborne contamination
- limit the transfer of activity from the facility to the outside of the transfer container
- provide an interlocked system to ensure the integrity of containment by preventing maloperation of the unit
- produce a robust unit requiring minimal maintenance
- allow operation within the facility by ambidextrous glove or a remote manipulator
- allow retro-fitting to active facilities using existing bagging features.

The port resulting from this design exercise has been tested under laboratory conditions to define the operating parameters. It has also been fitted to operational facilities

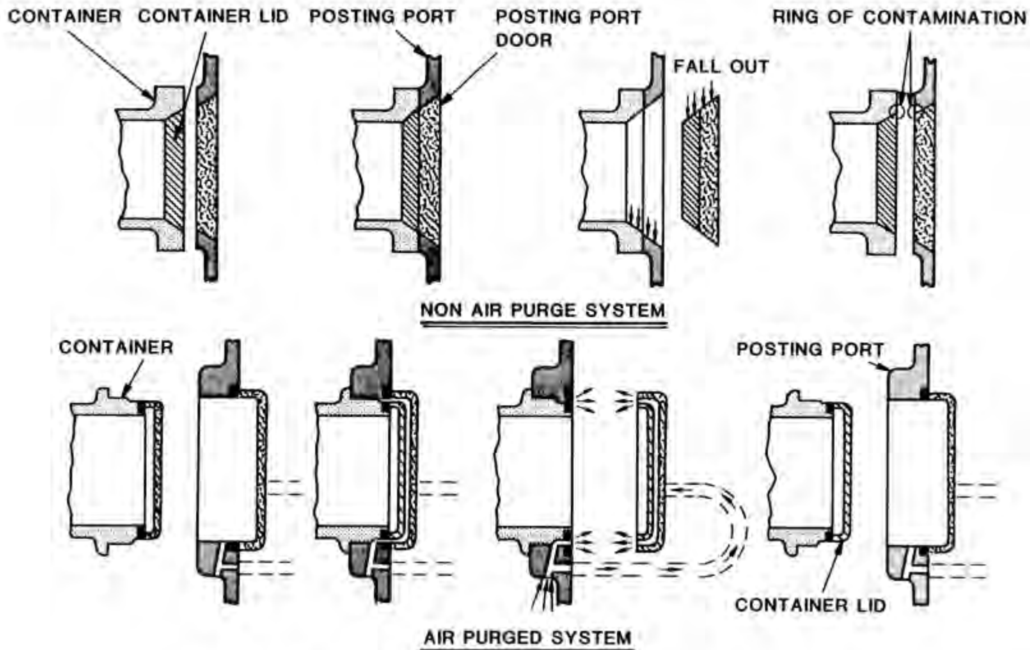

Fig. 1. Principles of Operation in an Air Purged System.

for evaluation and for routine transfers of alpha contaminated material.

The principle of operation of the port is shown in Fig. 1. The port and container are interlocked so that during the transfer cycle the containment cannot be accidentally breached. The port operates by the "double lid" system where the clean surfaces of the container lid and port door offer mutual protection. However, in this unit the 'purged port' principle is used to maintain contamination free surfaces by passing a gas stream through the gaps between the port door/container lid and the port/container seals. The gaps between these surfaces, particularly the seal gap must be minimized to limit the volumetric purge requirement for the port. Furthermore the port and container seals must be located with a high degree of concentricity to ensure an even purge rate over their circumference.

The unit has been designed to operate in dry and dusty alpha facilities and the materials of construction reflect this duty. Materials have been specified which are compatible with a more corrosive wet environment that handles solvents and mineral acids. As the ports are designed to fit existing 'bagging' features they have been produced in two sizes (nominal 6":140 mm and 8":160mm diameter).

The purge streams can be provided by:

- facility depression drawing air through the port
- a pressurised supply or forced purge. This can be air or an inert gas as required.

In both cases the purge is metered through a rotameter and protected by a suitable HEPA filter.

DEVELOPMENT TRIALS

A series of trials were carried out to establish operating conditions for the port. These trials investigated purge rate and port/container seal gap, with respect to release of airborne contamination and transfer of activity to the seals and surfaces of the unit (fixed and loose), during a series of transfer cycles. The test port was fitted to a dusty facility with a standing airborne concentration of up to 1×10^{-1} g/m^3 of PuO_2. Measurements of airborne release were made after 10 transfer cycles in a secondary 'clean' containment. Surface contamination levels were measured after 10 operations. These trials are summarised in Tables I and II respectively.

In order to sustain a low release of activity and purge rate it was necessary to use a port/container seal gap of 0.25mm-0.5mm. This requires a volumetric purge rate in the region of 4-6 litres/min or a facility depression of 1.0-1.5 inches water gauge. These resulted in an airborne contamination level of $< 10^{-9}$ g/m^3 of PuO_2 within the secondary containment (see Table I) and low levels of fixed and loose contamination (see Table II).

Comparison of the airborne contamination releases during operation of the BNFL port with other transfer systems is shown in Fig. 2. The purged port is equal to the normal bagging process, without the attendant risk of breaching

TABLE I

Airborne Contamination Generated From the BNFL Purged Port.

SEAL GAP (mm)	FORCED PURGE FLOW RATE (l/min)	DEPRESSION PURGE BOX DEPRESSION (inches water gauge)	SUPERFICIAL GAS VELOCITY (m/s)	MEAN AIRBORNE ACTIVITY (g/m^3 PuO_2)
0.25	4.5		0.52	2.6×10^{-10}
	4.0		0.46	4.9×10^{-10}
	3.0		0.34	9.4×10^{-10}
		1.5	0.23	3.3×10^{-10}
		1.0	0.17	1.8×10^{-10}
0.5	7.0		0.4	4.6×10^{-10}
	6.0		0.34	7.2×10^{-10}
	5.0		0.23	2.7×10^{-8}
		1.5	0.12	5.4×10^{-10}
		1.0	0.09	1.1×10^{-8}

TABLE II

Fixed and Loose Surface Contamination on Port and Container.

SEAL GAP (mm)	FORCED PURGE FLOW RATE (l/min)	DEPRESSION PURGE BOX DEPRESSION (inches water gauge)	CONTAMINATION (CPS)			
			LOOSE		FIXED	
			1	2	1	2
0.25	4.5		BG	BG	0-5	0-10
	4.0		0-2	0-3	0-10	0-5
	3.0		0-2	0-3	5-10	5-10
		1.5	0-2	0-2	0-5	0-5
		1.0	0-2	0-2	5-15	5-25
0.50	7.0		0-3	0-5	0-5	0-2
		1.5	0-3	0-3	5-12	0-2
		1.0	0-15	0-8	5-15	0-2

1 Inner Port Seal BG Background

2 Container Seal

Port door and container lid tested: all gave background level the bag, and is as good or superior to the proprietary units tested under similar conditions.

EVALUATION AND USE

The bagless transfer unit has been used for some 5000 transfers on the test facilities described above. Ports have also been fitted to two alpha active glove boxes at Sellafield that are used to dispense and analyze samples. These have been in place for some 3 months and are used, up to 5 times a day, to transfer materials between boxes. No abnormal levels of contamination or airborne release have been reported by the operators. Two units have also been fitted to production facilities for evaluation. The ports were fitted either directly onto facilities prior to active commissioning or were retro-fitted to active facilities. The retro-fitting was achieved either mounted on a replacement panel or directly onto a bagging ring. In both cases fitting was carried out within a temporary containment.

SUMMARY

The BNFL purged port offers a method of transferring material between hazardous facilities that:

- minimizes the spread of contamination and the possibility of an accidental breach of containment
- employs a robust reusable container that limits the generation of secondary waste
- enables operations to be carried out remotely.
- Typical applications include:
- transfer of samples or waste between facilities or to a central handling facility
- transfer of tools to a storage facility
- accommodation of specialist power tools in adapted containers. These can be used to provide a temporary service for facilities (eg. provision of a vacuum cleaner with a container).

LARGE BAGLESS TRANSFER SYSTEM

At BNFL, alpha contaminated waste is currently transferred from facilities to storage containers in PVC bags. These bags are loaded into drums that are closed manually prior to storage. The aim of the large bagless transfer unit is to enable waste to be loaded directly into drums from alpha facilities, using the double lid approach, and

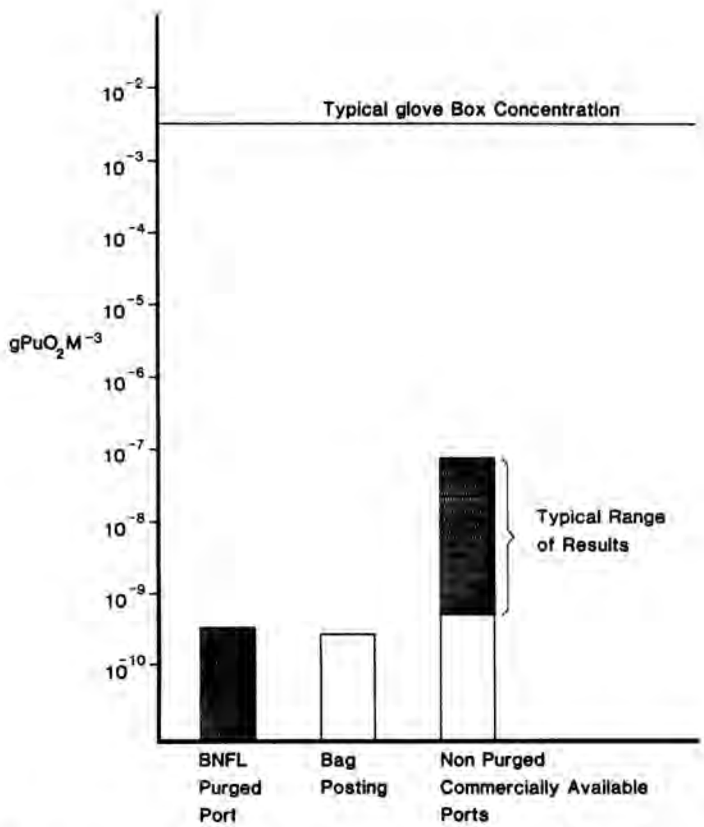

Fig. 2. Comparison of the Performance of Various Posting Ports.

remotely provide a package with externally uncontaminated surfaces.

BNFL have designed and are developing a bagless transfer system that can operate through an 18" (457mm) orifice and can operate with two waste or storage packages:

- a cheap "one trip" drum that is fitted with a push fit lid which can be swaged into place after filling
- a reusable plastic container used in conjunction with an outer steel drum.

The principles of operation for the transfer system, with both packages, are depicted schematically in Figs. 3 and 4. The plastic container lid is held in the drum by a locating lip. It is removed by distorting the lid. This inner polythene drum provides a corrosion resistant sealed inner container whilst the outer drum is attached remote from the bagless transfer unit. The reusable storage package has a volume of ca 200 litres whilst the 'one trip' system can be used with any drum that can accommodate an 18" (457mm) push fit lid. Both containers can be used on the bagless transfer port in conjunction with a vibrating table, designed to improve the packing efficiency of loose waste during the filling operation. This vibratory table is incorporated into the mechanism that presents the container to the port. All operations in the lidding cycle are carried out remotely, governed automatically by a pre-programmed control station.

DEVELOPMENT TRIALS

Trials are underway to evaluate the equipment. To date these trials have concentrated on the 'one trip' system used in conjunction with a 500 litre mild steel drum. Tests have been carried out to measure outleakage during a filling and lidding cycle. The containment above the box was flooded with sulphur hexafluoride (SF_6) to give a 25% mixture in air. During complete cycles and indeed during vibrocompaction no SF_6 was detected in the vicinity of the clean side of the port, down to a limit of detection of ca 0.02%, implying a DF across the seal in excess of 1×10^3. No outleakage was detected when simulated waste (up to 0.04":1mm thick) was trapped in the drum/port seal.

A mock-up of the single trip system was also evaluated against transfer of contamination using a ^{24}Na aerosol. No detectable level of contamination was found on the drum or

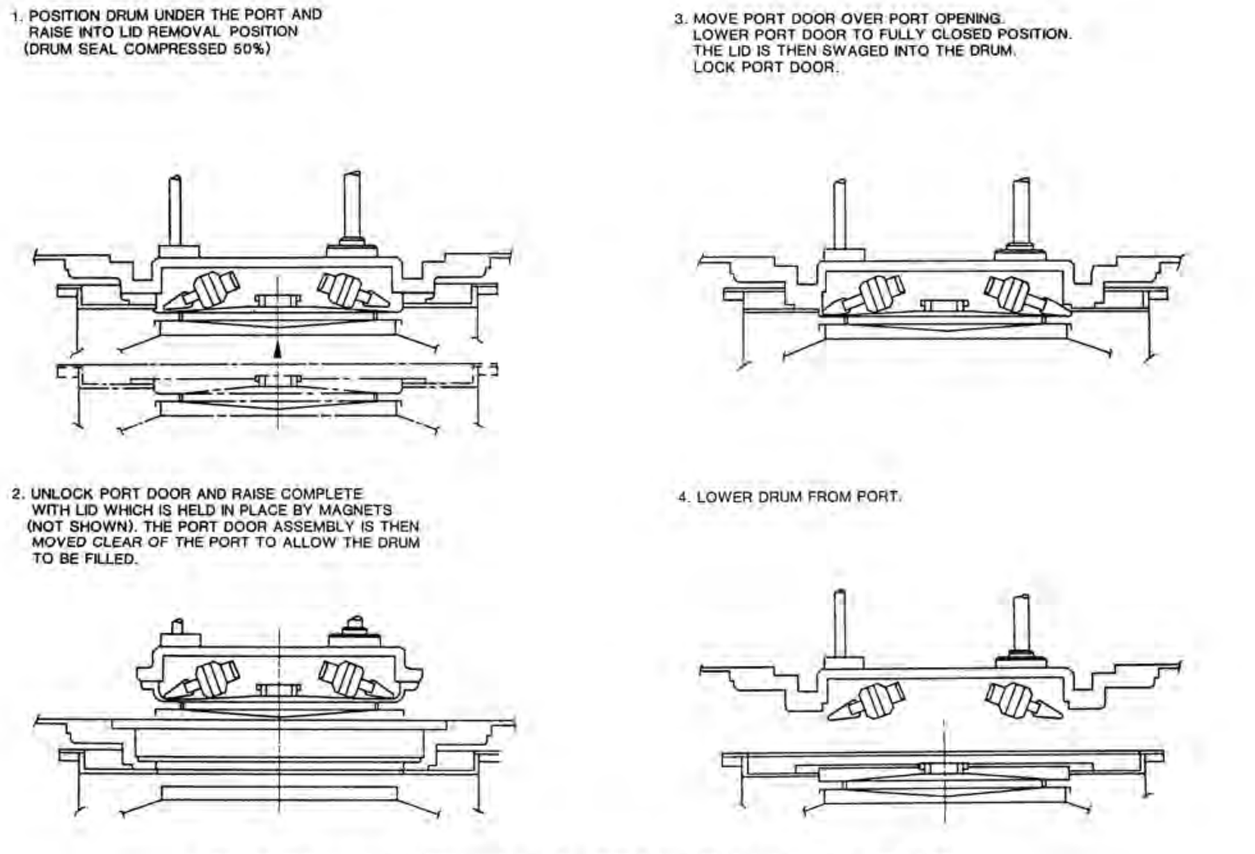

Fig. 3. Sequence of Operations for 500 Litre Disposal Drum Port Door.

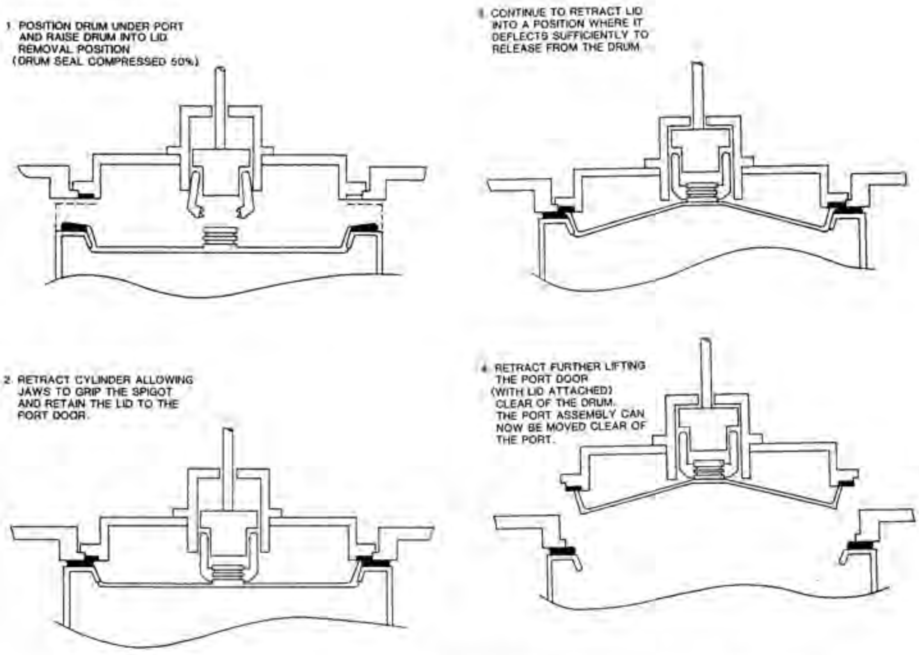

Fig. 4. Sequence of Operations for 200 Litre Storage Drum Port Door.

the door after a lidding cycle (< 5 cps by swab) and the level of airborne contamination in the vicinity of the clean side of the door was below the limit of detection, indicating a DF across the port of at least 1×10^5.

SUMMARY

A bagless transfer system has been devised that operates through an 18" (457mm) orifice and can be used remotely with:

- a cheap 'one trip' drum
- a reusable package consisting of a reopenable plastic inner protected by an engineered steel outer drum.

Initial trials indicate the port can be operated without significant release or transfer of contamination.

Typical applications include:

- permanent packaging of waste
- packing of waste in a container from which the waste can be recovered for further treatment
- storage of reusable items without generation of secondary waste

FUTURE DEVELOPMENTS

The small purged ports will continue to be fitted to facilities at BNFL to evaluate their performance over a range of operating conditions. Further trials will be carried out to demonstrate the 18" Bagless Transfer unit and proving trials will be carried out on a larger version of the port with a nominal 45" orifice.

The Bagless Transfer systems have all been designed and tested by BNFL. Detailed experimental trials on the purged port were carried out by UKAEA at AEE Winfrith.

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