Radioactive Waste Management

WPSGD no. WPS/860/03

Geological Disposal:

Waste Package Identification System: Explanatory Material and Guidance

September 2016

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WASTE PACKAGE SPECIFICATION AND GUIDANCE DOCUMENTATION

WASTE PACKAGE IDENTIFICATION SYSTEM: EXPLANATORY MATERIAL AND GUIDANCE

This document forms part of the *Waste Package Specification and Guidance Documentation* (WPSGD), a suite of documents prepared and issued by Radioactive Waste Management Ltd (RWM). The WPSGD is intended to provide a 'user-level' interpretation of the RWM packaging specifications, and other aspects of geological disposal, to assist UK waste packagers in the development of plans for the packaging of higher activity waste in a manner suitable for geological disposal.

Key documents in the WPSGD are the *Waste Package Specifications* (WPS) which define the requirements for the transport and geological disposal of waste packages manufactured using standardised designs of waste container. The WPS are based on the high level requirements for all waste packages as defined by the *Generic Waste Package Specification* (GWPS) and are derived from the bounding requirements for waste packages containing a specific category of waste, as defined by the relevant *Generic Specification*.

This document provides explanatory material to assist waste packagers comply with WPS/410 *Requirements for Waste Package Identification System.*

The WPSGD is subject to periodic enhancement and revision. Users are therefore advised to refer to the RWM website to confirm that they are in possession of the latest version of any documentation used.

WPSGD DOCUMENT NUMBER WPS/860 - VERSION HISTORY		
VERSION	**DATE**	**COMMENTS**
WPS/860/01	September 2005	Aligns with GWPS (Nirex Report N/104) as published June 2005
WPS/860/02	March 2008	Responsibility for the WPSGD passed to the NDA RWMD. Aligns with Issue 2 of GWPS (Nirex Report N/104) as published March 2007. Minor updating changes incorporated.
WPS/860/03	September 2016	Specification updated to acknowledge creation of RWM. Aligns with GWPS (NDA Report No. NDA/RWMD/067) as published March 2012.

Abbreviations and acronyms used in this document

DNLEU	depleted, natural and low enriched uranium
GDF	geological disposal facility
GWPS	Generic Waste Package Specification
HHGW	high heat generating waste
ILW	intermediate level waste
LHGW	low heat generating waste
NDA	Nuclear Decommissioning Authority
OCR	Optical Character Recognition
RWM	Radioactive Waste Management Ltd
WPS	Waste Package Specification
WPSGD	Waste Package Specification and Guidance Documentation

1 Introduction

The Nuclear Decommissioning Authority (NDA) has established Radioactive Waste Management Ltd (RWM) as the body responsible for implementing UK Government policy for the management of higher activity radioactive wastes, as set out in the 2014 *Implementing Geological Disposal* White Paper [1]. The White Paper outlines a framework for managing those wastes in the long-term through geological disposal, which will be implemented alongside the ongoing interim storage of waste packages and supporting research.

RWM produces packaging specifications as a means of providing a baseline against which the suitability of plans to package higher activity waste for geological disposal can be assessed. In this way RWM assists those responsible for the management of radioactive waste in the development and implementation of such plans, by defining the requirements for waste packages which would be compatible with the anticipated needs for transport to and disposal in a geological disposal facility (GDF).

The packaging specifications form a hierarchy which comprises three levels:

- The *Generic Waste Package Specification* (GWPS) [2]; which defines the requirements for all waste packages which are destined for geological disposal;
- *Generic Specifications;* which apply the high-level packaging requirements defined by the GWPS to waste packages containing a specific type of waste; and
- *Waste Package Specifications* (WPS); which apply the general requirements defined by a Generic Specification to waste packages manufactured using standardised designs of waste container.

The packaging specifications, together with a wide range of explanatory material and guidance that users will find helpful in the development of proposals to package waste, make up a suite of documentation known as the *Waste Package Specification and Guidance Documentation* (WPSGD). For further information on the extent and the role of the WPSGD, all of which can be accessed via the RWM website, reference should be made to the *Introduction to the RWM Waste Package Specification and Guidance Documentation* [3].

Every waste package destined for long-term management must be allocated a unique identifier which will be used to:

- allow the waste package to be identified during all the relevant stages of long-term management, up to and including emplacement in the GDF;
- enable a record of the location of the waste package to be maintained throughout that long-term management; and
- provide an unambiguous and permanent link between the waste package and the *Waste Package Disposability Record* created and maintained during its manufacture and interim storage.

This document provides background and explanatory material to assist waste packagers comply with WPS/410 *Requirements for Waste Package Identification System* [4].

2 Identifier system and format

2.1 The identifier system

The identifier system specified for waste packages by RWM was originally developed for waste packages containing intermediate level waste (ILW) but is now anticipated to be used for waste packages containing all types of higher activity waste, which are to be subject to geological disposal.

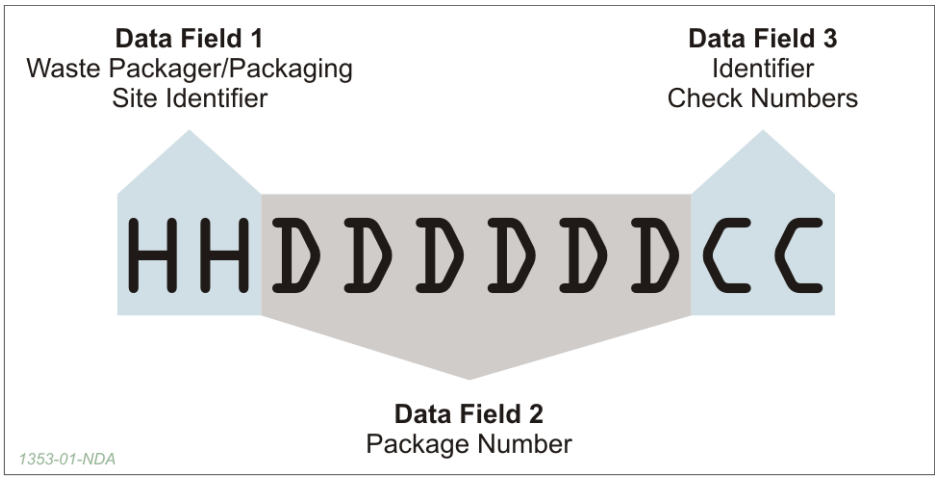
The format of the identifier (see below) allows the site of the waste arising and/or packaging, and/or the waste packaging plant where a waste package was manufactured, to be easily identified and permits the unique identification of up to 10^6 waste packages from that source. The full identification system also allows waste packages from up to 256 different sites or waste packaging plants to be separately identified.

The system is oversized in terms of the total number of waste packages than it can deal with (i.e. $>10^8$) when compared with the numbers expected from the packaging of the entire UK radioactive wastes inventory that is destined for geological disposal (i.e. of the order of 10^5 waste packages). RWM has created such a system to provide a contingency allowance to cater for future requirements, and to have sufficient flexibility to cover all of the foreseeable needs of the UK waste packagers.

2.2 The format of the identifier

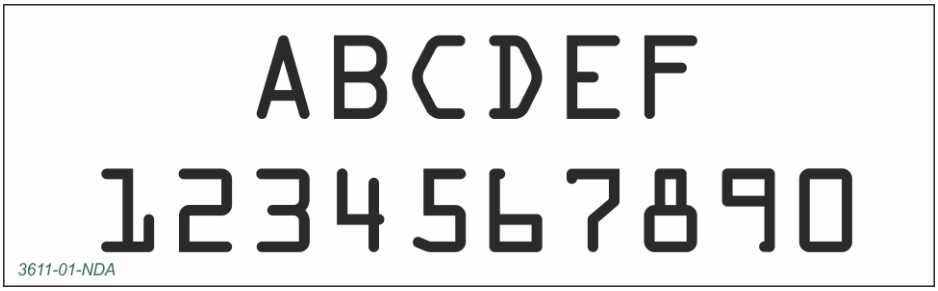
The basic form of such an identifier is ten alpha-numeric characters arranged in a horizontal sequence from left to right with no intermediate spaces or other markings, as shown in Figure 1.

Figure 1 Form of waste package identifier



The characters specified for the identifier are of the Optical Character Recognition A form (OCR-A), as specified by BS 5464: Part 1 [5] (Figure 2). The acceptable characters are the numbers 0 to 9 and the alphabetic characters A to F, the latter being used as part of a hexadecimal numbering system.

Figure 2 Acceptable OCR-A characters



The use of the OCR-A format is to provide the ability to automatically read (i.e. using an optical reader) waste package identifiers, thereby reducing the potential for errors that could arise from manual reading as well as minimising the dose-consequences of such an operation. To this end the OCR-A characters have been defined to permit reading by intelligent systems, even with significant levels of distortion and degradation.

2.3 Form of the identifier

A waste package identifier will comprise three data fields (Figure 1) within a ten character sequence, these being identified as Data Field 1, Data Field 2 and Data Field 3. The three data fields are specified as follows:

2.3.1 Data Field 1

Data Field 1 identifies the original source of the waste package (i.e. the waste packaging site and/or plant).

Data Field 1 consists of two sequential hexadecimal characters (HH) each of which is one of the following:

0 1 2 3 4 5 6 7 8 9 A B C D E F

Data Field 1 identifiers are allocated to waste packagers by RWM (see Appendix B).

2.3.2 Data Field 2

Data Field 2 identifies the package number from a particular waste packaging site or plant.

Data Field 2 consists of six sequential decimal characters (DDDDDD) each of which shall be one of the following:

0 1 2 3 4 5 6 7 8 9

Data Field 2 identifiers are allocated to individual waste packages by the waste packager.

2.3.3 Data Field 3

Data Field 3 is a check number which is derived mathematically from Data Field 1 and Data Field 2 (see below).

Data Field 3 consists of a two sequential decimal characters (CC) each of which shall be one of the following:

0 1 2 3 4 5 6 7 8 9

Data Field 3 identifiers are calculated for individual waste packages by the waste packager.

2.4 The check number system

Whenever long numbers are transcribed (manually or electronically), the possibility for errors to occur will exist. To ensure that such errors are identified at an early point during the identification of a waste package (or a waste container during the manufacture of waste packages) the identifier includes a check number which can be used by a computer database system to check automatically that the identifier entered or read is valid.

This is achieved by appending two check digits to the end of the basic eight digit identifier making a total of ten digits in the complete identifier. The method used for the generation and checking of Data Field 3 check numbers is further explained in Appendix A.

The check digits are calculated so that the resulting number is exactly divisible by 97, this value being used because this is the largest prime number which will always give a one or two digit check number, and because it has been verified to give reliable detection of a wide range of common errors [6].

This check number system, known as the 'Modified Streatfield Scheme' has been shown to have the following error detection rates [6].

(i)	Single transcription of a digit	100%
(ii)	double transcription of a digit	100%
(iii)	triple transcription of a digit	100%
(iv)	transposition of two digits	100%
(v)	transposition of 'ded' to 'ede'	100%
(vi)	double independent transcription	99.06%
(vii)	all possible errors	98.97%

When a computer program (e.g. a spreadsheet) is used to generate check numbers, the waste packager shall ensure that this is carried out using suitably validated software only.

3 Allocation of waste package identifiers

3.1 Allocation of Data Field 1 identifiers

Data Field 1 identifiers will be allocated by RWM to waste packagers on request.

In order to maintain the integrity of the identifier system for the foreseeable future, RWM will set up and retain the master file of the Data Field 1 identifier allocation, the current version of this record is presented in Appendix B.

In order to prevent the introduction of errors and confusion into the record system, each Data Field 1 identifier will only be issued to a single waste packaging site or plant and that site will have sole use of the entire batch of up to 10^6 identifiers associated with it.

3.2 Allocation of Data Field 2 identifiers

It is the responsibility of the waste packager to allocate Data Field 2 identifiers to individual waste packages.

Since the identifier system has sufficient capacity, it is desirable that the waste packager takes advantage of this and allocates Data Filed 2 identifiers in a manner which clearly differentiates between packaging sites and plants, waste package types and, where possible, waste streams. This will provide a simple means of checking the origin and type of waste package as a back-up to the computerised database system.

Waste packagers are expected to devise a scheme where blocks of unique waste packages numbers are sub-allocated in this way. Waste packagers are advised to discuss their proposals with RWM at an early stage. The allocation scheme should be sufficient to cater for all wastes predicted to arise from a site, including decommissioning wastes, and should also include a contingency to allow for additional waste packages in the future.

4 Marking of identifiers on waste packages

The GWPS [2], which applies to all waste packages that are to be subject to geological disposal, requires that:

> *'The waste package shall enable unique identification until the end of the GDF operational period'*

This high-level requirement is made more specific to particular waste types, in the relevant Generic Specification for such waste. The Generic Specifications that currently exist[1] all include an additional requirement that:

> *'The waste package shall be marked at multiple defined locations with a unique alpha-numeric identifier.'*

The identifier is required to be a permanent feature of the waste package that, as a minimum, will be accurately readable by machine during waste package manufacture, interim storage, immediately prior to transport, and following receipt at a GDF. The waste package should also remain identifiable during the GDF operational period (i.e. until the disposal areas have been close and sealed). As a contingency against changes in reading technology in the future, identifiers should also be capable of being read by more traditional means (i.e. by eye).

For waste packages containing LHGW and DNLEU the Generic Specifications also include a requirement that:

> *'The waste package shall remain identifiable by automated systems for a minimum period of 150 years following manufacture.'*

This requirement is included to ensure that waste packages will remain identifiable at least until the end of the GDF operational period for those waste types.

No such duration of identifier legibility is currently specified for waste packages containing HHGW as the duration of the operational period for such wastes has not yet been defined. For waste container design purposes it is recommended that the same identifier longevity defined for waste packages containing LHGW and DNLEU is applied to those containing HHGW (i.e. 150 years).

It is noted that most, if not all, of the HHGW that will be packaged for geological disposal (e.g. vitrified product from the Sellafield Wastes Encapsulation Plant, and spent nuclear fuel) will already be marked with identifiers for various operational reasons. Whilst such identifiers may be used to identify the waste during its packaging for disposal (probably involving the over-packing of the waste), they are unlikely to be suitable for use as a waste package identifier.

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[1] Generic Specifications are currently available for waste packages containing:
- (i) low heat generating waste (LHGW - a broad category of waste that includes ILW and other materials with similar radiological properties);
- (ii) high heat generating waste (HHGW - including vitrified high level waste and spent nuclear fuel); and
- (iii) depleted , natural and low enriched uranium (DNLEU).

The specific requirements for the identification of waste packages manufactured using standardised designs of waste container can be found in the relevant WPS. In the case of waste containers intended for the packaging of LHGW each of the WPS includes a specification for the size of the identifier characters (i.e. between 6mm and 10mm high) together with specific multiple locations for the identifier.

Specific locations are specified for identifiers to permit automated reading systems to operate effectively, and multiple locations will aid in the ease of reading by reducing the need for the waste package to be moved during identification, minimising the possibility of the identifier being obscured by handling equipment, and providing redundancy in the event of damage to an identifier (e.g. caused by corrosion), and reduce the risk of waste packages becoming unidentifiable. When identifiers are to be marked directly on to the external surface of a waste container the locations are selected such that they are on thicker sections, to reduce any deleterious effect on the durability of the containment function of the waste container.

The recommended method of inscribing the identifier is to laser-etch the characters, which in the case of stainless steel surfaces is expected to satisfy the requirement specified for the longevity of the marking. In-house markings and additional labels may be applied by the waste packager if required for its own purposes, provided that they do not affect package performance. In particular, any additional identification, whether temporary or permanent, must not compromise the integrity or containment of the package. This should include a consideration of the materials used for such markings, guidance on which can be found in [7].

In the case of identifiers which are marked on ‘plates’ which are attached to the external surface of a waste package, the waste packager will have to demonstrate that the plates will remain attached to the waste packages for the required period (i.e. at least 150 years) and that the means of attachment (e.g. using screws or adhesive) will not deleteriously affect the long-term integrity of the waste container.

5 Quality management

The allocation and use of waste package identifiers by waste packagers will be subject to the quality requirements of the relevant RWM Specification [8]. All activities relevant to licensing of a GDF will be conducted in accordance with appropriate quality management arrangements.

The objective in establishing and operating a quality management system is to provide an integral framework of procedures which will ensure that the work is adequately controlled, documented and correctly carried out. It is the responsibility of the waste packager to develop, operate and maintain an appropriate quality management programme which meets all the RWM quality assurance requirements as specified in the RWM specification.

References

1 DECC, *Implementing Geological Disposal, A Framework for the long-term management of higher activity radioactive waste, Department of Energy and Climate Change,* URN 14D/235, 2014.

2 NDA, *Geological Disposal: Generic Waste Package Specification,* NDA Report No. NDA/RWMD/067, 2012.

3 RWM, *Geological Disposal: Introduction to the RWM Waste Package Specification and Guidance Documentation*, WPS/100/04, 2015.

4 RWM, *Geological Disposal: Specification for waste package Identification system,* WPS/410/03, 2016.

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6 Nirex, *An Assessment of the Error Detection Rates of the Nirex Waste Package Check Number System*, Nirex Report 66, 1990.

7 BNFL, *Design Guide for Materials Evaluated for Contact with Stainless Steel,* BNF.EG.0023_1_B, 2001.

8 RWM, *Geological Disposal: Waste Package Quality Management Specification,* WPS/420/01, 2016.

Appendix A Determination and verification of a check number

The check number of a waste package identifier (i.e. Data Field 3) is derived from both Data Field 1 and Data Field 2, using one or both of two similar methods.

For both methods, the first stage is to convert the hexadecimal digits of Data Field 1 to their decimal equivalents to produce a four digit decimal number. In the hexadecimal system, the characters A to F represent 10 to 15 respectively in the decimal system. In converting from hexadecimal to decimal the numerical digits are preceded by a 0. Thus, for example, FF becomes 1515, F2 becomes 1502 and 22 becomes 0202.

The converted value of Data Field 1 is placed in front of Data Field 2 to produce a 10 digit decimal number.

For Method 1, the second stage of the process is to add two zeros (i.e. multiply by 100) to the end of the converted identifier, to create a 12 digit decimal number.

Generating Data Field 3 (i.e. CC) makes use of the modulo function *nmodm* which gives the remainder when n is divided by m. For example, 26*mod*4 equals 2 since 26 ÷ 4 = 6 remainder 2.

Data Field 3 is generated by the following algorithm:

$$CC = 97 - XXXXXXXXXXXX \bmod 97$$

Where XXXXXXXXXXXX is the 12 digit decimal value derived from Data Field 1 and Data Field 2.

Note that Data Field 3 must be a two digit number, if the algorithm above returns a single digit result it should be preceded by a 0.

For Method 2 the second stage of the process is to multiply the ten digit decimal number produced by Data Field 1 and Data Field 2 by 3 instead of by 100. This is because, since 100 = 97 + 3, the remainder on dividing by 97 will be the same if a number is multiplied by 3 instead of by 100. This fact may be useful if check digits are generated by hand or by electronic calculator, since fewer significant digits are needed. The algorithm above is used to yield a value of CC.

It is recommended that both methods (i.e. multiplying by 100 and 3) are used to ensure the validity of the code used to determine Data Field 3.

The validity of a full waste package identifier can be readily checked when the check digits CC have been appended as Data Field 3 to Data Fields 1 and 2. The identifier is valid if the decimal equivalent of the identifier (i.e. with data Field 1 replaced by its four digit decimal equivalent) is exactly divisible by 97.

The following are examples showing the calculation of check numbers, using each of the two methods outlined above.

Method 1	Partial identifier	
	B1987654	E7123456
Conversion of Data Field 1 to decimal	1101987654	1407123456
Multiply by 100	110198765400	140712345600
Division by 97	Remainder = 38	Remainder = 14
Check Number = 97 – Remainder	59	83
Full identifier	B198765459	E712345683

Method 2	Partial identifier	
	B1987654	E7123456
Conversion of Data Field 1 to decimal	1101987654	1407123456
Multiply by 3	3305962962	4221370368
Division by 97	Remainder = 38	Remainder = 14
Check Number = 97 – Remainder	59	83
Full identifier	B198765459	E712345683

The validity of these identifiers is verified as follows:

Operation	Full Identifier	
	B198765459	E712345683
Conversion of Data Fields 1 and 2 to 12 digit decimal number	110198765459	140712345683
Division by 97	Remainder = 0	Remainder = 0

Appendix B Current allocation of waste package identifiers

First digit of Data Field 1															
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**A**	**B**	**C**	**D**	**E**	**F**
-	MoD	AWE	-	Former UKAEA Sites	-	Commercial Power Stations		-	-	Others	Former BNFL Sites			-	-
00	10	20	30	40 DSRL	50	60 Berkeley	70 Hunterston B	80	90	A0 GE Healthcare	B0 SL MBGWS	C0	D0	E0	F0
01	11	21	31	41 Windscale	51	61 Bradwell	71 Torness	81	91	A1	B1 SL MEP	C1	D1 LLWR	E1	F1
02	12	22	32	42 Harwell	52	62 Dungeness A	72	82	92	A2	B2 SL WEP	C2	D2	E2	F2
03	13	23	33	43 Winfrith	53	63 Hinkley Point A	73	83	93	A3	B3 SL WAGR	C3	D3	E3	F3
04	14	24	34	44	54	64 Oldbury	74	84	94	A4	B4 SL WTC	C4	D4	E4	F4
05	15	25	35	45[2]	55	65 Sizewell A	75	85	95	A5	B5 SL WPEP	C5	D5	E5	F5
06	16	26	36	46	56	66 Trawsfynydd	76	86	96	A6	B6 SL 3m^3 boxes	C6	D6	E6	F6
07	17	27	37	47	57	67 Wylfa	77	87	97	A7	B7 SL 3m^3 boxes	C7	D7	E7	F7
08	18	28	38	48	58	68 Berkeley Labs	78	88	98	A8	B8	C8	D8	E8	F8
09	19	29	39	49	59	69 Dungeness B	79	89	99	A9	B9 SL WVP[3]	C9	D9	E9	F9
0A	1A	2A	3A	4A	5A	6A Hartlepool	7A	8A	9A	AA	BA Springfields	CA	DA	EA	FA
0B	1B	2B	3B	4B	5B	6B Heysham I	7B	8B	9B	AB	BB Chapelcross	CB	DB	EB	FB
0C	1C	2C	3C	4C	5C	6C Heysham II	7C	8C	9C	AC	BC Capenhurst	CC	DC	EC	FC
0D	1D	2D	3D	4D	5D	6D Hinkley Point B	7D	8D	9D	AD	BD	CD	DD	ED	FD
0E	1E	2E	3E	4E	5E	6E Sizewell B	7E	8E	9E	AE	BE	CE	DE	EE	FE
0F	1F	2F	3F	4F	5F	6F Hunterston A	7F	8F	9F	AF	BF SL Stillages	CF	DF	EF	FF

Set not currently allocated	Set nominally allocated	Set firmly allocated

[2] Identifiers from this set have been used on waste containers used for non-active commissioning trials etc.
[3] WVP does not use the RWM numbering system for vitrified product containers. This batch of numbers is held for the future overpackaging of WVP products for geological disposal

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