CEFAS
The Centre for Environment,
Fisheries & Aquaculture Science

Development of a mobile facility for monitoring of radioactivity in food during an emergency

Commissioned by

the Food Standards Agency

CEFAS Contract Report RP258
Environment Report RL11/03

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Development of a mobile facility for monitoring of radioactivity in food during an emergency

Centre for Environment, Fisheries and Aquaculture Science
Lowestoft Laboratory
Pakefield Road
Lowestoft
Suffolk
NR33 0HT

Completed in accordance with the terms of the contract and to CEFAS quality standards

P A Smedley and G J Hunt

2003

The work described in this report was carried out under contract to the Food Standards Agency

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SUMMARY

A small mobile facility has been developed which can be used by CEFAS on behalf of the Food Standards Agency for monitoring of radioactivity in food in an emergency. The facility consists of two Hyperpure Germanium detectors and three Sodium Iodide detectors with associated data analysis equipment, portable detector support tables and shielding. This equipment was designed to be modular, mostly packable in appropriate cases and easily transportable by means of a van or, for the sodium iodide systems, as hand luggage. The five systems are independent and can be operated in any location with protection if necessary from the weather, also if necessary for several hours on battery power before recharging. The Ge detectors would be used for identification and analysis of gamma emitting radionuclides in food; the cheaper NaI detectors, which have good measurement efficiency but poorer resolution, would be used primarily for measurement of nuclides already identified.

In this report the stages of the project and the equipment developed are described. Writing–up effort was devoted particularly to developing easy-to-use operating instructions for field use in an emergency, and these instructions are appended.

Minimum detectable activities have been derived for the different systems and typical nuclides. For example, for 287ml tub geometry and a 10 minute counting time, the MDA for ^{137}Cs is 36 Bq kg^{-1} for the NaI system, 28 Bq kg^{-1} for the Oxford Ge system and 15 Bq kg^{-1} for the Ortec Ge system.

1. INTRODUCTION

A previous project carried out for MAFF by CEFAS (G J Hunt and D J Andrews, 1998) investigated the feasibility of producing a mobile monitoring unit for nuclear emergencies and incidents. In that project, a range of options to meet the objectives was considered. The likely most cost-effective option was judged to be a modular system, transportable by fleet or hire vehicles. These would employ Ge detectors (advantageous in identifying gamma-emitting radionuclides of concern) and NaI detectors (for cost-effective rapid analysis of such radionuclides).

This proposal was carried forward into the current project, initially for MAFF as customer, after April 2000 for the Food Standards Agency. Initially with a timescale of 3 years, the objective was to acquire a Ge detector system and a NaI system in the first year and develop them, adding further NaI detectors in each of the 2 following years, thereby spreading the cost. During the course of the first year (1999) it became clear, however, that the cost of three NaI systems would be significantly cheaper than estimated; by extending the project for a further year, costs could be spread so as to afford a second Ge detector system. MAFF agreed to this proposal, and the necessary rescheduling of work, primarily to allow systems to be developed more in parallel than sequentially.

The first Ge detector system was acquired towards the end of year 1, however there were some teething problems necessitating a return to the manufacturers such that much of its development took place together with the second detector following the latter’s arrival at the end of year 2. The first detector is a standard p-type HpGe portable detector; the second is an n-type portable detector with carbon fibre end cap which provides an extended energy range down to ~30 keV to allow scanning for low energy gamma emitters such as I-125, I-129, or Am-241.

Portable tables and shielding, in modular form for ease of storage and transport, were designed and made for the Ge detectors, as well as robust boxes for transport purposes. The shielding will accommodate a range of standard sample geometries; the intention is to keep the number used to a minimum. The NaI detectors have been provided with appropriate bench stands and again with necessary boxes for transport, and will again accommodate standard geometries. The detectors have been calibrated with reference sources comprising a range of different matrices likely to be encountered.

In this report the stages of the project are described in more detail for the two detector types. Particular effort was expended in developing easy-to-use operating instructions for field use in an emergency, and these are appended.

2. SODIUM IODIDE DETECTORS

The optimum size of NaI detector for the current purpose, taking account of budget, efficiency and the need to accommodate samples and a detector support system was the popular 3”X 3” detector. Searches were made for suppliers of a system with high-voltage supply, amplifier and pulse-height analysis, at competitive cost. Our choice was for a system supplied by BIC Ltd, Warrington, which had the advantage of eliminating the traditional analogue-to-digital converter in favour of a sound card (which uses an identical principle) incorporated into the laptop PC used to accumulate the data. The associated software (FitzPeaks - J F Computing, Stanford-in-the-Vale) also had advantages in ease of use for the current purpose. This NaI system was significantly cheaper than from the mainstream suppliers, leading to the advantage referred to in section 3.

Detector stands were designed and built by a local engineering firm. The efficiency of the NaI detectors is such that no shielding is necessary for emitters of high-energy photons (say >500 keV) and where there is minimal interference with natural background peaks, but at lower energies and in the presence of interference, minimal shielding is advantageous. The need for minimal shielding helped to keep the design light and simple, and easy to accommodate different sizes of sample.

The system in operation in the field is shown in Figure 1.

A typical spectrum using a dummy source with ^{137}Cs is shown in Figure 2.

A typical data report is shown in Figure 3.

At present the detector is calibrated for a standard tub geometry (287 ml); this will be extended to a 1 litre bottle for measurement of liquids, eg milk. The detector is very versatile and could also be used for monitoring of suitably restrained live animals, for example sheep as was done post-Chernobyl.

Table 1 shows minimum detectable activity levels for the tub geometry.

3. GERMANIUM DETECTORS

Initially in this project it was intended to purchase just one portable Ge detector to provide the mainstay of identification and analysis of samples in the field, budgetary considerations being the limitation. However, by use of the savings achieved on the NaI detectors referred to in section 2 and by extending the project for a year to provide extra support for the capital charges, it proved possible to purchase a second Ge detector in year 2 of the project. This proposal was accepted by the Customer. For each Ge system, a number of suppliers were approached with broad requirements and a budget figure; the type and size of the detector and analysis system purchased was decided on the best system available within the budget.

Detector 1

This system was supplied by Southern Scientific Ltd., Lancing. For good efficiency versus cost at fission-product energies it consisted of a p-type detector of 50% efficiency relative to 3"X 3" NaI with aluminium end cap, and good energy resolution. The detector was provided by Oxford, of USA. It has a 5l liquid nitrogen Dewar vessel giving a holding time of about 3 days. The original analysis system ("ISPEC", Germany) also had potential advantages with a radio link such that the detector could be operated several hundred yards remotely from the controlling laptop computer. However, following delivery this system proved to suffer from significant noise problems, with first the analysis system and then the detector itself having to be returned to the manufacturer under warranty. The situation was complicated by a takeover of Oxford by Canberra. In the event, Canberra rectified the noise problem in the detector and provided an "Inspector" analysis system which connects directly to a laptop, and that is now the configuration used for this facility. Development proceeded alongside that for detector 2.

Detector 2

Our specification to suppliers on this occasion included a request for improved efficiency at lower photon energies than available with a standard p-type detector. This was at the Customer request that it would be advantageous to have good efficiency in the range 30keV upwards, so as to be able to detect particularly ^{241}Am to help look at alpha emitters in the event of an emergency involving them, with interest also in ^{125}I and ^{129}I. The system chosen was supplied by Perkin-Elmer (Wokingham) and consisted of an ORTEC detector of n-type with carbon-fibre end cap for good low-energy efficiency, and 60% efficiency relative to 3"X 3" NaI. The Dewar vessel on detector 1 was felt to be on the large size for good portability, thus we requested a 3l Dewar with a holding time of about 2 days. The analysis system is an ORTEC "nomad-plus" type controlled by a laptop computer and running "gammavision" software. This system performed to specification from delivery.

In order to provide a good limit of detection, the detectors were provided with shielding; however to control the weight, important for portability, the shielding was limited to 1" thickness of aged lead. This was machined in rings with a lid to allow easy carriage and assembly. Both detectors were provided with a modular table for mounting the detector in an upward-looking configuration for easy placement of the shielding and samples. The maximum sample size which can be accommodated is a standard laboratory 1l plastic bottle.

Detector 1 system is shown in Figure 4 with spectrum and report in Figures 5 and 6. Detector 2, set up in the rear of a transit van on field trials, is shown in Figure 7, with spectrum and report in Figures 8 and 9.

The detectors are currently calibrated using standard 287 ml tubs; this will be extended to 1l bottles for liquids (eg milk). Minimum detectable activities are given in Table 1.

4. CONCLUSIONS AND FURTHER WORK

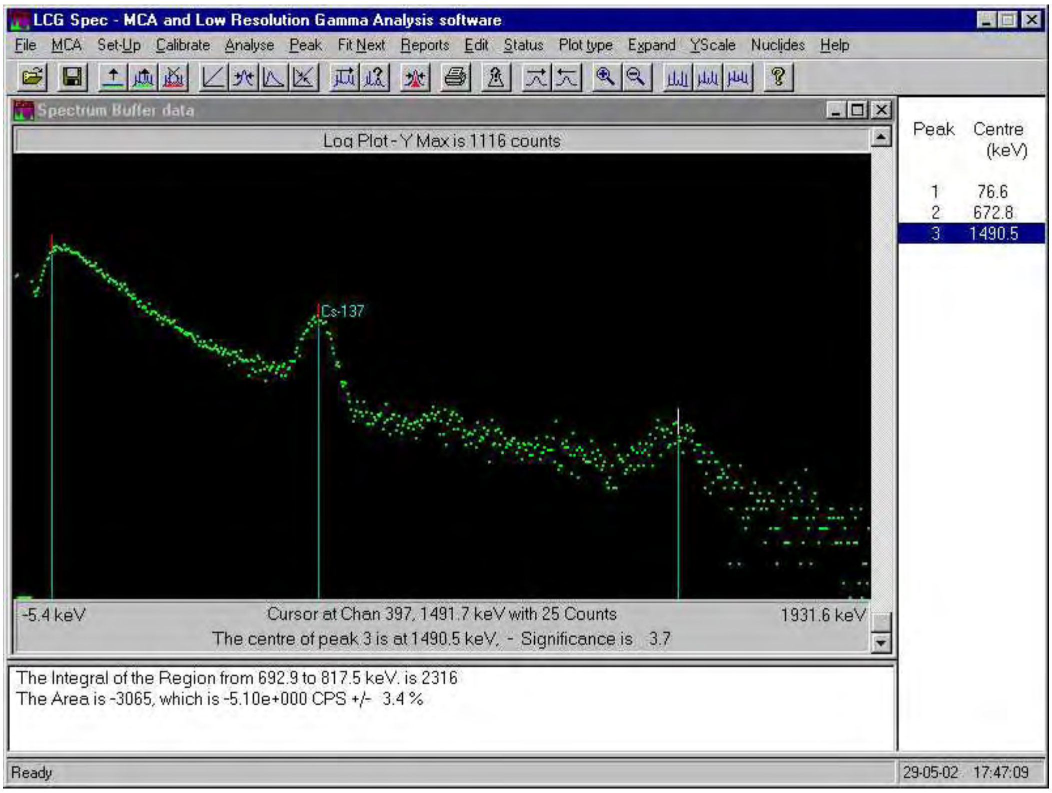
The equipment described in this report is a small, readily transportable system which is available for use in the event of an emergency. It needs further testing under field conditions to gain experience and to be able to address any shortcomings which may become apparent under these conditions. Also needed is a team of people who could use these systems in the field in the event of an emergency. We have proposed to address both these areas in follow-up work, using the equipment at the time of selected emergency exercises, and setting up a training and refresher programme for staff who would be involved in these exercises.

5. REFERENCE

G.J.Hunt and D.J.Andrews, 1998. "Investigation of the feasibility of producing a mobile monitoring unit for nuclear emergencies and incidents." CEFAS contract report C0289, Environment Tech Note RL6/98. Research Commissioned by MAFF, Ref RP0246.

Figure 1: Operation of the NaI System in the field.

Figure 2: Typical spectrum of NaI detector with ^{137}Cs-spiked source



```
Log Plot - Y Max is 1116 counts

-5.4 keV          Cursor at Chan 397, 1491.7 keV with 25 Counts          1931.6 keV
              The centre of peak 3 is at 1490.5 keV,  - Significance is   3.7

The Integral of the Region from 692.9 to 817.5 keV. is 2316
The Area is -3065, which is -5.10e+000 CPS +/-  3.4 %

Peak    Centre
         (keV)

  1      76.6
  2     672.8
  3    1490.5

Ready                                                       29-05-02   17:47:09
```

Figure 3: Analysis report generated by NaI system

```
                                  CEFAS
                                                                13-Mar-
2003 15:27
              ___________________________________________________

              S P E C T R U M    A N A L Y S I S    R E P O R T
              ___________________________________________________

 Spectrum file Analysed: qc_default.dat                 :     1234
 Sample Title          : mock sample containing  lowestoft laboratory
 Analysed by           : pas00
 Sample ID             : 1234                Sample type:
 Location              : lowestoft laboratory

 Measured on Detector:     1     Geometry:     1    MCA:     0
ADC:     0
 Live Time:     455 Secs.    True Time:     475 Secs.    Dead Time:
4.25 %

 Spectrum saved on 13-Mar-2003 at 15:27    Collected on 13-Mar-2003
at 15:13
 Sample  Taken  on 13-Mar-2003 at 15:13    Decayed      0 Days,     0
mins.
 Sample Size is    0.2500   kg             Sample Weight is    0.0000
 Sampling Uncertainy   0.0 %               Calibration Uncertainy
5.0 %
 Conversion Factor is    1.0000

            Geometry Description: 287ml tub
            Detector file number used:     1
            Energy     Calibration Performed on 13-Mar-2003 at 15:23
            Peak Shape Calibration Performed on 13-Mar-2003 at 15:24
            Efficiency Calibration Performed on 30-May-2002 at 16:26

 Analysis Parameters

   Energy Tolerance:        20.00 Kev.    Confidence Discriminator:
0.600
   Peak Area Error Sigma value:  1.645    Activity Error Sigma value:
2.000
   LOD Calculation Sigma value:  1.645


   Background Subtraction performed using data from: det_1.bkg
   Created from Spectrum Filename: bgd.dat
   Spectrum Title:
   Data saved on: 12-Mar-2003 at 15:21   Count-Time was    600
Seconds

   Calibration Uncertainty was not included
   Reported Activity values were rounded

   Analysis Library Used: Std Analysis.lib
   LOD Library Used:      Std Analysis.lib

   FitzPeaks Version: 3.27 25th February 2000

_____________________________________________________________________
_______
```

Figure 3 (Contd)

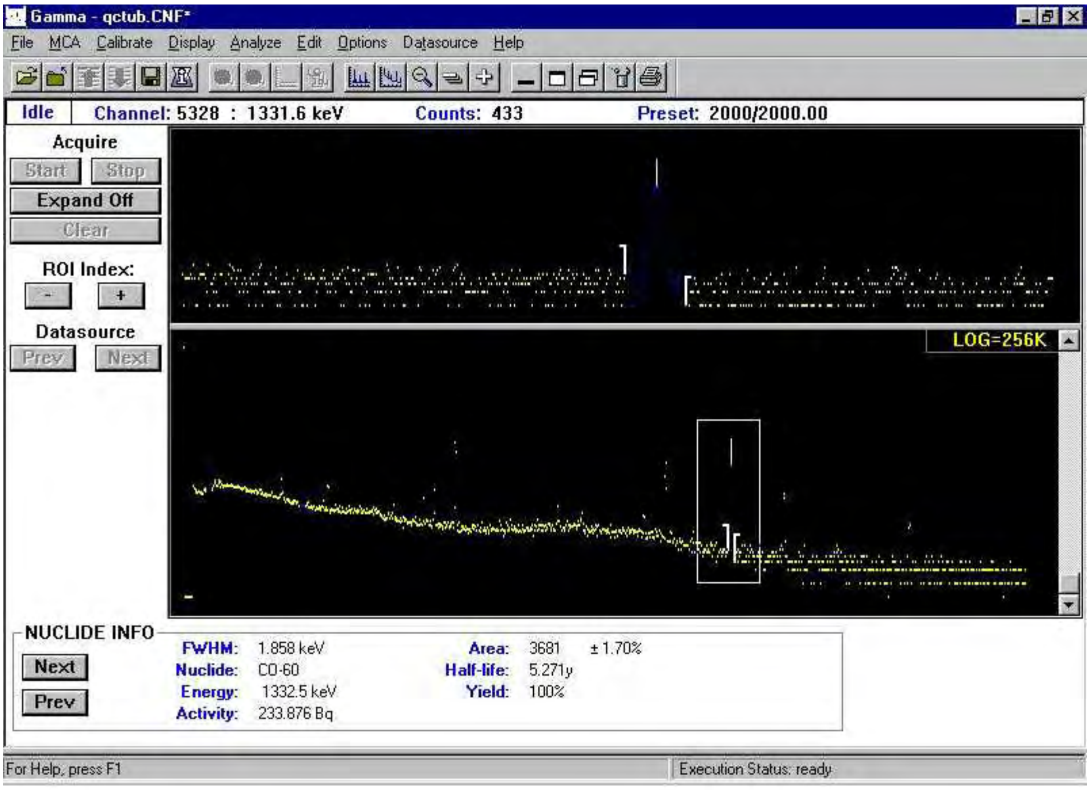
```
                 The following Radionuclides were found :-

 Nuclide  Confidence               Activity - Bq/kg
            Value         Measured               Decay Corrected

 Co-60       1.00    3.16e+03 +/-  6.20 %      3.16e+03 +/- 2.00e+02
     Calibration Source; Activation prod: Co-59(n,g)

 Cs-137      1.00    1.81e+03 +/- 12.00 %      1.81e+03 +/- 2.00e+02
     Calibration Source; Fission Product

 Am-241      1.00    1.79e+03 +/- 20.00 %      1.79e+03 +/- 3.60e+02
     Calibration Source; Daughter Pu-241



New_Page

                                                            13-Mar-
2003 15:27


              L I M I T   O F   D E T E C T I O N    R E P O R T


 Sample: mock sample containing  lowestoft laboratory
 Sample Taken on 13-Mar-2003 at 15:13

    Nuclide       Upper Limit                  - Bq/kg
                      Measured         Decay Corrected

    K-40     :      1.30e+03              1.30e+03
    Co-57    :      4.80e+01              4.80e+01
    Co-60    :      3.10e+03              3.10e+03
    Sr-85    :      7.50e+01              7.50e+01
    Y-88     :      2.20e+02              2.20e+02
    Cd-109   :      1.30e+03              1.30e+03
    Sn-113   :      8.30e+01              8.30e+01
    I-131    :      8.00e+01              8.00e+01
    CS-134   :      9.60e+01              9.60e+01
    Cs-137   :      1.90e+03              1.90e+03
    Ce-139   :      5.00e+01              5.00e+01
    Tl-208   :      8.70e+01              8.70e+01
    Pb-212   :      3.20e+02              3.20e+02
    Bi-212   :      1.40e+03              1.40e+03
    Pb-214   :      1.80e+02              1.80e+02
    Bi-214   :      1.90e+02              1.90e+02
    Ra-226   :      1.30e+03              1.30e+03
    Ac-228   :      4.30e+02              4.30e+02
    Am-241   :      2.30e+03              2.30e+03
```

Figure 3 (Contd)

```
                                                            13-Mar-
2003 15:27
                         ______________________________

                         S U M M A R Y      R E P O R T
                         ______________________________

 Sample: mock sample containing  lowestoft laboratory
 Sample Taken on 13-Mar-2003 at 15:13


    Nuclide                  Activity  - Bq/kg
                      Measured               Decay Corrected

    K-40     :      < 1.30e+03          < 1.30e+03
    Co-57    :      < 4.80e+01          < 4.80e+01
    Co-60    :        3.16e+03            3.16e+03 +/- 2.00e+02
    Sr-85    :      < 7.50e+01          < 7.50e+01
    Y-88     :      < 2.20e+02          < 2.20e+02
    Cd-109   :      < 1.30e+03          < 1.30e+03
    Sn-113   :      < 8.30e+01          < 8.30e+01
    I-131    :      < 8.00e+01          < 8.00e+01
    CS-134   :      < 9.60e+01          < 9.60e+01
    Cs-137   :        1.81e+03            1.81e+03 +/- 2.00e+02
    Ce-139   :      < 5.00e+01          < 5.00e+01
    Tl-208   :      < 8.70e+01          < 8.70e+01
    Pb-212   :      < 3.20e+02          < 3.20e+02
    Bi-212   :      < 1.40e+03          < 1.40e+03
    Pb-214   :      < 1.80e+02          < 1.80e+02
    Bi-214   :      < 1.90e+02          < 1.90e+02
    Ra-226   :      < 1.30e+03          < 1.30e+03
    Ac-228   :      < 4.30e+02          < 4.30e+02
    Am-241   :        1.79e+03            1.79e+03 +/- 3.60e+02

                                End of Report
```

Figure 4: Oxford Ge detector system

Figure 5: Typical spectrum of Oxford detector with multiple radionuclide source



Idle | Channel: 5328 : 1331.6 keV | Counts: 433 | Preset: 2000/2000.00

LOG=256K

FWHM: 1.858 keV
Nuclide: CO-60
Energy: 1332.5 keV
Activity: 233.876 Bq
Area: 3681 ± 1.70%
Half-life: 5.271y
Yield: 100%

For Help, press F1 | Execution Status: ready

Figure 6: Report produced by Oxford Ge detector system

```
*************************************************************************
*****        G A M M A   S P E C T R U M   A N A L Y S I S        *****
*************************************************************************


Filename: C:\GENIE2K\CAMFILES\qctub.CNF

Report Generated On              : 13/03/2003 16:12:46

Sample Title                     : Laboratory QC TUB Geometry
Spectrum Description             :
Sample Identification            : 2345
Sample Type                      : Sample
Sample Geometry                  : Tub

Peak Locate Threshold            :  5.00
Peak Locate Range (in channels) :     1 - 65535
Peak Area Range (in channels)   :     1 - 65535
Identification Energy Tolerance :    2.000 keV

Sample Size                      :  2.500E-001 kg

Sample Taken On                  : 01/11/1996 14:00:00
Acquisition Started              : 31/01/2003 15:28:48

Live Time                        :     2000.0 seconds
Real Time                        :     2009.7 seconds

Dead Time                        :   0.48 %


              Energy Calibration Used Done On       : 17/01/2003
              Efficiency Calibration Used Done On   : 30/01/2003
              Efficiency ID                         :

_Peak Analysis Report            13/03/2003 16:12:46              Page   2
```

```
**************************************************************************
*****           P E A K    A N A L Y S I S    R E P O R T            *****
**************************************************************************


     Detector Name:  DET01
     Sample Title:   Laboratory QC TUB Geometry
     Peak Analysis Performed on:  13/03/2003 16:12:46
               Peak Analysis From Channel:      1
               Peak Analysis To Channel:     8192

   Peak  ROI  ROI    Peak    Energy   FWHM  Net Peak  Net Area  Continuum
    No. start end  centroid   (keV)   (keV)  Area     Uncert.    Counts

    1    91-  101    95.20    23.37   1.08  4.79E+002   46.60   5.87E+002
    2   232-  248   239.21    59.37   1.04  1.95E+003   92.74   2.11E+003
    3   949-  961   955.02   238.32   1.04  5.94E+002   56.59   9.85E+002
    4  1176- 1188  1181.60   294.97   0.89  1.89E+002   43.47   6.46E+002
    5  1399- 1414  1408.17   351.61   1.01  5.71E+002   48.64   5.98E+002
    6  2037- 2056  2043.75   510.50   1.31  1.89E+002   44.65   5.08E+002
    7  2322- 2343  2332.58   582.71   1.36  3.62E+002   40.59   3.43E+002
    8  2426- 2448  2437.32   608.90   1.30  5.69E+002   45.33   3.81E+002
    9  2636- 2658  2646.55   661.20   1.44  8.52E+003   98.76   3.19E+002
   10  3636- 3655  3644.92   910.79   1.27  2.50E+002   32.91   2.38E+002
   11  3864- 3885  3874.52   968.19   1.47  1.54E+002   34.67   2.79E+002
   12  4471- 4489  4480.58  1119.71   1.41  1.67E+002   26.72   1.62E+002
   13  4676- 4706  4691.92  1172.54   1.84  3.85E+003   69.69   2.06E+002
   14  5313- 5342  5328.44  1331.67   1.86  3.66E+003   63.25   7.12E+001
   15  5828- 5855  5841.73  1460.00   1.86  8.65E+002   32.35   4.10E+001
   16  7045- 7064  7055.51  1763.44   1.43  1.47E+002   13.85   1.25E+001

M = First peak in a multiplet region
m = Other peak in a multiplet region
```

Figure 6 (Contd)

```
F = Fitted singlet

Errors quoted at  1.000 sigma
_Interference Corrected Activity Report    13/03/2003 16:12:47      Page  3


*************************************************************************
*****   N U C L I D E   I D E N T I F I C A T I O N   R E P O R T   *****
*************************************************************************

     Sample Title:         Laboratory QC TUB Geometry
     Nuclide Library Used: C:\GENIE2K\CAMFILES\STDLIB.NLB

   ....................    IDENTIFIED NUCLIDES     ....................

   Nuclide    Id       Energy    Yield     Activity     Activity
   Name    Confidence  (keV)      (%)     (Bq /kg  )   Uncertainty

   K-40      0.974   1460.81*    10.67   2.19848E+003  1.78428E+002
   CO-60     0.971   1173.22*   100.00   2.01297E+003  1.16953E+002
                     1332.49*   100.00   2.11580E+003  1.21821E+002
   CS-137    0.992    661.65*    85.12   1.69917E+003  1.16525E+002
   BI-211    0.305     72.87      1.20
                      351.10*    12.20   4.58315E+002  6.81249E+001
                      404.80      4.10
                      426.90      1.90
                      831.80      3.30
   PB-212    0.302     74.81      9.60
                       77.11     17.50
                       87.20      6.30
                       89.80      1.75
                      115.19      0.60
                      238.63*    44.60   1.03187E+002  1.74755E+001
                      300.09      3.41
   BI-214    0.535    609.31*    46.30   1.71105E+002  2.09517E+001
                      768.36      5.04
                      806.17      1.23
                      934.06      3.21
                     1120.29*    15.10   2.45916E+002  4.83502E+001
                     1155.19      1.69
```

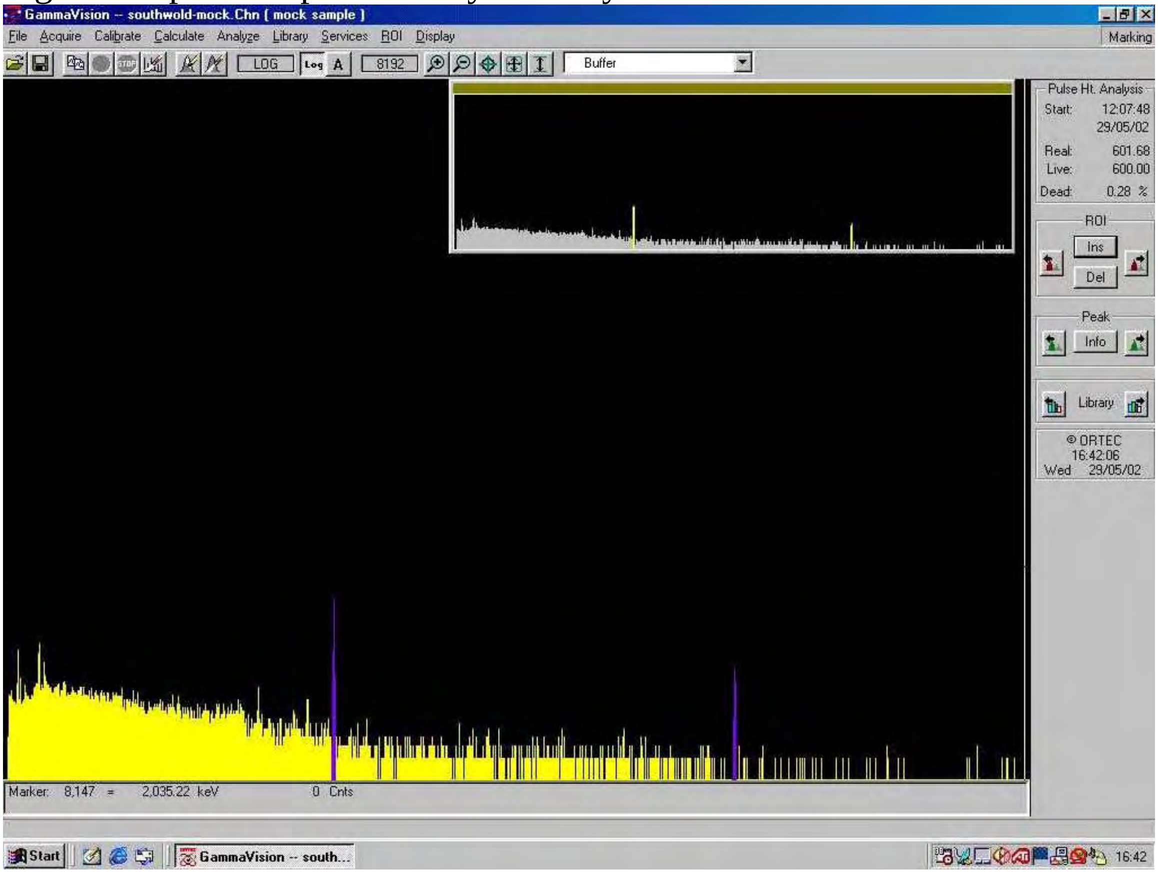
```
                  1238.11      5.94
                  1280.96      1.47
                  1377.67      4.11
                  1385.31      0.78
                  1401.50      1.39
                  1407.98      2.48
                  1509.19      2.19
                  1661.28      1.15
                  1729.60      3.05
                  1764.49*    15.80   2.81937E+002  4.35829E+001
                  1847.44      2.12
                  2118.54      1.21
   PB-214    0.444     74.81      6.33
                    77.11     10.70
                    87.20      3.70
                    89.80      1.03
                   241.98      7.49
                   295.21*    19.20   8.67211E+001  2.44557E+001
                   351.92*    37.20   1.50715E+002  2.24026E+001
                   785.91      1.10
_Interference Corrected Activity Report    13/03/2003 16:12:47      Page  4


   Nuclide     Id       Energy    Yield    Activity     Activity
   Name    Confidence  (keV)      (%)    (Bq /kg  )   Uncertainty

   TH-232    0.995     59.00*     0.19   2.79757E+005  2.89091E+004
   AM-241    0.999     59.54*    36.30   1.47891E+003  1.52825E+002

       * = Energy line found in the spectrum.
       @ = Energy line not used for Weighted Mean Activity
       Energy Tolerance :    2.000 keV
       Nuclide confidence index threshold =   0.30
```

Figure 6 (Contd)

```
    Errors quoted at  1.000 sigma

_Interference Corrected Activity Report    13/03/2003 16:12:47      Page  5


   **********   U N I D E N T I F I E D   P E A K S   **********

             Peak Locate Performed on:  13/03/2003 16:12:46
             Peak Locate From Channel:      1
             Peak Locate To Channel:     8192

       Peak   Energy          Peak Size in        Peak CPS
        No.   (keV)         Counts per Second   % Uncertainty

         1    23.37            2.3954E-001          9.73
         6   510.50            9.4714E-002         23.57
         7   582.71            1.8118E-001         11.20
        10   910.79            1.2504E-001         13.16
        11   968.19            7.6752E-002         22.58

       M = First peak in a multiplet region
       m = Other peak in a multiplet region
       F = Fitted singlet

       Errors quoted at  1.000 sigma
```

Figure 7: Ortec detector system

Figure 8: Spectrum produced by Ortec system



Pulse Ht. Analysis
Start: 12:07:48 29/05/02
Real: 601.68
Live: 600.00
Dead: 0.28 %

© ORTEC 16:42:06 Wed 29/05/02

Marker: 8,147 = 2,035.22 keV 0 Cnts

Figure 9: Report produced by Ortec system

```
*************************************************************************
*****       G A M M A   S P E C T R U M   A N A L Y S I S       *****
*************************************************************************


Filename: C:\GENIE2K\CAMFILES\qctub.CNF

Report Generated On            : 13/03/2003 16:12:46

Sample Title                   : Laboratory QC TUB Geometry
Spectrum Description           :
Sample Identification          : 2345
Sample Type                    : Sample
Sample Geometry                : Tub

Peak Locate Threshold          :  5.00
Peak Locate Range (in channels) :     1 - 65535
Peak Area Range (in channels)  :     1 - 65535
Identification Energy Tolerance :    2.000 keV

Sample Size                    :  2.500E-001 kg

Sample Taken On                : 01/11/1996 14:00:00
Acquisition Started            : 31/01/2003 15:28:48

Live Time                      :     2000.0 seconds
Real Time                      :     2009.7 seconds

Dead Time                      :   0.48 %
```

Figure 9 (contd)

```
            Energy Calibration Used Done On       : 17/01/2003
              Efficiency Calibration Used Done On   : 30/01/2003
              Efficiency ID                         :

_Peak Analysis Report            13/03/2003 16:12:46             Page  2


**************************************************************************
*****          P E A K   A N A L Y S I S   R E P O R T           *****
**************************************************************************


     Detector Name:  DET01
     Sample Title:   Laboratory QC TUB Geometry
     Peak Analysis Performed on:  13/03/2003 16:12:46
               Peak Analysis From Channel:      1
               Peak Analysis To Channel:     8192

   Peak  ROI  ROI    Peak    Energy   FWHM  Net Peak  Net Area  Continuum
    No. start end  centroid   (keV)   (keV)  Area     Uncert.    Counts

    1    91-  101    95.20    23.37   1.08  4.79E+002   46.60   5.87E+002
    2   232-  248   239.21    59.37   1.04  1.95E+003   92.74   2.11E+003
    3   949-  961   955.02   238.32   1.04  5.94E+002   56.59   9.85E+002
    4  1176- 1188  1181.60   294.97   0.89  1.89E+002   43.47   6.46E+002
    5  1399- 1414  1408.17   351.61   1.01  5.71E+002   48.64   5.98E+002
    6  2037- 2056  2043.75   510.50   1.31  1.89E+002   44.65   5.08E+002
    7  2322- 2343  2332.58   582.71   1.36  3.62E+002   40.59   3.43E+002
    8  2426- 2448  2437.32   608.90   1.30  5.69E+002   45.33   3.81E+002
    9  2636- 2658  2646.55   661.20   1.44  8.52E+003   98.76   3.19E+002
   10  3636- 3655  3644.92   910.79   1.27  2.50E+002   32.91   2.38E+002
   11  3864- 3885  3874.52   968.19   1.47  1.54E+002   34.67   2.79E+002
   12  4471- 4489  4480.58  1119.71   1.41  1.67E+002   26.72   1.62E+002
   13  4676- 4706  4691.92  1172.54   1.84  3.85E+003   69.69   2.06E+002
   14  5313- 5342  5328.44  1331.67   1.86  3.66E+003   63.25   7.12E+001
   15  5828- 5855  5841.73  1460.00   1.86  8.65E+002   32.35   4.10E+001
```

```
   16  7045- 7064  7055.51  1763.44   1.43  1.47E+002   13.85   1.25E+001

M = First peak in a multiplet region
m = Other peak in a multiplet region
F = Fitted singlet

Errors quoted at  1.000 sigma
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*************************************************************************
*****   N U C L I D E   I D E N T I F I C A T I O N   R E P O R T   *****
*************************************************************************

     Sample Title:         Laboratory QC TUB Geometry
     Nuclide Library Used: C:\GENIE2K\CAMFILES\STDLIB.NLB

   ....................    IDENTIFIED NUCLIDES     ...................

   Nuclide    Id       Energy    Yield     Activity     Activity
   Name    Confidence  (keV)      (%)     (Bq /kg  )   Uncertainty

   K-40      0.974   1460.81*    10.67   2.19848E+003  1.78428E+002
   CO-60     0.971   1173.22*   100.00   2.01297E+003  1.16953E+002
                     1332.49*   100.00   2.11580E+003  1.21821E+002
   CS-137    0.992    661.65*    85.12   1.69917E+003  1.16525E+002
   BI-211    0.305     72.87       1.20
                      351.10*    12.20   4.58315E+002  6.81249E+001
                      404.80        4.10
                      426.90        1.90
                      831.80        3.30
   PB-212    0.302     74.81       9.60
                       77.11      17.50
                       87.20       6.30
                       89.80       1.75
                      115.19       0.60
```

Figure 9 (contd)

```
                      238.63*    44.60   1.03187E+002  1.74755E+001
                      300.09        3.41
   BI-214    0.535    609.31*    46.30   1.71105E+002  2.09517E+001
                      768.36        5.04
                      806.17        1.23
                      934.06        3.21
                     1120.29*    15.10   2.45916E+002  4.83502E+001
                     1155.19        1.69
                     1238.11        5.94
                     1280.96        1.47
                     1377.67        4.11
                     1385.31        0.78
                     1401.50        1.39
                     1407.98        2.48
                     1509.19        2.19
                     1661.28        1.15
                     1729.60        3.05
                     1764.49*    15.80   2.81937E+002  4.35829E+001
                     1847.44        2.12
                     2118.54        1.21
   PB-214    0.444     74.81       6.33
                       77.11      10.70
                       87.20       3.70
                       89.80       1.03
                      241.98        7.49
                      295.21*    19.20   8.67211E+001  2.44557E+001
                      351.92*    37.20   1.50715E+002  2.24026E+001
                      785.91        1.10
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   Nuclide    Id       Energy    Yield    Activity     Activity
   Name    Confidence  (keV)      (%)    (Bq /kg  )   Uncertainty

   TH-232    0.995     59.00*     0.19   2.79757E+005  2.89091E+004
   AM-241    0.999     59.54*    36.30   1.47891E+003  1.52825E+002
```

```
       * = Energy line found in the spectrum.
       @ = Energy line not used for Weighted Mean Activity
       Energy Tolerance :    2.000 keV
       Nuclide confidence index threshold =   0.30
       Errors quoted at  1.000 sigma

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   **********   U N I D E N T I F I E D   P E A K S   **********

               Peak Locate Performed on:  13/03/2003 16:12:46
               Peak Locate From Channel:      1
               Peak Locate To Channel:     8192

       Peak   Energy          Peak Size in        Peak CPS
        No.   (keV)         Counts per Second   % Uncertainty

         1    23.37            2.3954E-001           9.73
         6   510.50            9.4714E-002          23.57
         7   582.71            1.8118E-001          11.20
        10   910.79            1.2504E-001          13.16
        11   968.19            7.6752E-002          22.58

       M = First peak in a multiplet region
       m = Other peak in a multiplet region
       F = Fitted singlet

       Errors quoted at  1.000 sigma
```

Table 1.   Minimum Detectable Activities (MDAs)

System	**Nuclide**			
	I-131	Cs-134	Cs-137	Am-241
BIC Ltd 3x3 NaI and FitzPeaks software	110 (1)	40 (1)	36 (1)	-
“	58 (2)	36 (2)	33 (2)	-
Oxford 50% ‘p’ type HpGe and Inspector analyser	27	26	28	-
Ortec 70% ‘n’ type HpGe and Nomad-plus analyser	16	17	15	36

Values are in Bq/kg^{-1} and are based on a 287ml tub geometry counted for 600 seconds under normal background conditions.

(1) NaI value for I-131 (364 keV) could be improved by the addition of a collar made from lead flashing put round the crystal which should reduce the background counts at this energy.

(2) Same count time but with ~4mm of lead sheet around the circumference of the crystal resulting in a ~45% decrease in background at 364keV thus improving the MDA.

Annex 1

EQUIPMENT OPERATING INSTRUCTIONS

For the
Sodium Iodide (NaI) detectors and FitzPeaks software

1.Introduction

This guide is to assist users, after appropriate training, to assemble the CEFAS Emergency Portable Gamma Spectrometry equipment in the field, complete testing and quality control checks, and use it for the determination of radioactivity in foodstuffs and other environmental materials.

2.Scope

This particular guide is only for the 3x3 Sodium Iodide (NaI) detectors and FitzPeak software. It covers the use of the equipment for the quantified measurement of radionuclides in the calibrated (88keV to 1.8Mev) energy ranges and only those samples that can be analysed on the assembled system (i.e. not covering whole body counting). It covers the usual quality control checks performed on such a system and the minor adjustments a trained user could make. It does not include the calibration and programming of the system, this is covered by the manufacturers' manuals and authorised, qualified personnel can only make such changes.

3.Training

Before using this equipment the user must first have received training in the following:

1. Handling of radioactive materials including check sources.
2. Instruction in the use of the NaI detector and FitzPeak software.

4.Safety

Relevant safety equipment will be provided and must be used.

5.Assembling the Equipment

Choose an area that is level, provides protection from the weather and is not affected by extreme fluctuations in temperature. Unpack the equipment from its box and either using the box or other flat surface place the detector tripod and detector assembly together in the upright position making sure they are stable. Unpack the personal computer (PC) placing it next to the detector at this point the user if required can connect an external mouse to the PC. If a second or third detector is to be used place it away from the first thus reducing the chance of cross counting between detectors.

Connecting up the leads

Connect the detector to PC lead (marked 1) to the PC at point 1, attach the other end (3) to the detector. Connect the PC to a power source using power adapter (4), if no mains power source is available use the internal battery supply. Locate the PCs on/off switch (just above the keyboard at F6 and F7) press firmly and release, the PC will now start to boot. Attach the portable power supply unit (PSU) lead (3) to the detector point (3), if an external supply is available plug the portable power units AC/DC adapter in and switch the PSU switch to on.

Logging on to the PC

This system uses WinNT operating system, to log on you must press in turn Ctrl, Alt and Del holding each button down in turn then release. A logon information screen will be displayed asking for a user name enter Administrator and select Ok (do not enter a password). FitzPeaks should automatically start if not double click on the LCG_SPEC icon on the desktop.

6.Quality Control (performance testing)

After the equipment has been assembled for the first time or at the beginning of a new counting day it is necessary to check its performance and if necessary make minor adjustments to peak positions.

Energy Calibration check and adjustment

The energy calibration must be checked when the equipment is first assembled and at least once a day after that. To do this place the appropriate check source on the detector making sure it is central. From the toolbar select File and Open Spectral data file, a list of spectral files will be displayed, choose QC_DEFAULT and open. Select from the toolbar MCA and check that the count time is set to 600 seconds (amend if necessary). Under MCA Clear data, this erases the current spectrum displayed, select MCA and Collect to start the count. When the count has completed (indicated by popup window) select Ok. A spectrum must be saved before analysis is performed this can done by selecting File and Save current spectrum, give the file a descriptive name (eg. qc-01-05-2003 indicating QC count for 1st May 2003) and Save. Select Analyse and Peak Search the results will be displayed at the right of the screen. If the peaks are within the expected range as listed on the source data sheet proceed to Efficiency check.

If the peak position needs minor correction (less than 10% difference to expected values) then select Calibrate then Auto-Energy Re-calibration and select Ok, the system will automatically update the energy calibration. To save the updated calibration go to File and Save Calibration and update the existing file.

If the peak channels and energies are more than 10% adrift a gain adjustment must be made. Set the count going as above using MCA Set-Up under the MCA option adjust the Amp Gain slider (2) up or down and clear data to check the energy with the cursor. When the correct position has been found allow the count to complete and use the Auto-Energy Re-calibration as above saving the calibration with the updated data.

Efficiency Calibration check

Using the spectrum from the energy calibration select Analyse and Full Analysis, save the spectrum at the prompt and select or remove peaks as necessary, a summary of activities will be displayed. Check these activities against the source data sheet values and that they fall within the expected range for this equipment. If the values differ significantly then further adjustments maybe required before using for sample analysis. If no further action is required then close the report window and select MCA and Clear Data ready to commence analysis.

7.Quality Control (Background testing and storing)

Most counting systems yield counts without the presence of a radioactive sample. This natural "background" radiation arises from natural or man-made radioactive elements distributed in and around the detector and its shielding as well as from cosmic rays.

In the analysis of samples, this natural background radiation is treated as a second radiation source, which must be subtracted from the total count-rates recorded across the whole energy spectrum when counting actual samples. The "background" must therefore be measured under exactly the same conditions as for the samples. The spectrum so obtained is stored in the computer memory for automatic subtraction of the appropriate background contribution from the spectra of all samples counted on that detector.

As this a portable unit a background count must be taken every time the unit is moved to a new location so to take in to account the change in ‘background’ count rate. It is advisable to take a count as part of the daily QC checks.

Counting a background.

Remove all samples and sources from the immediate area then select MCA, enter an appropriate count time (usually the same or greater than your sample count time) and select Collect. The count will start Once the count has completed select File and Save Current Spectrum in the following format**:** BGD_nn-mm-yy_hh-mm.dat and save.

Using a background count.

With the background spectrum on the MCA window select Analyse and Analyse and Save as Bkg use file det1.bkg and overwrite old file the system will now use this background for all subsequent analysis. If for any reason an old background needs to be used just use File and open spectral data file and Analyse and save as Bkg as above.

8.Counting samples.

Acquiring data and entering details

Once the samples have been prepared in an appropriate geometry and all QC checks have been completed the system is ready for use. Place containers in a thin walled polythene bag and seal the end with a tie or tape, this is to prevent contamination of the detector surface. Place the container centrally on the detector surface, select MCA and check that the pre-set count time is suitable and amend as necessary. Select Collect to start the count saving the previous spectrum if indicated.

During the count select Edit and update the sample details from the sample info sheet, entering description and location details under Sample Title, sample code under sample number, Quantity in kg and sample date and time of collection under sample taken, Ok to close.

9.Analysing the data

At the end of the count a popup screen will inform the user that ‘Pre-set Count Time reached’ click Ok to proceed. Select Analyse from the toolbar and Full Analysis, save changes naming the file as the sample code number from the sample info sheet. The program will now perform the analysis on the current spectrum, during the peak fit you may be asked if a peak needs adding select No unless there is evidence that the peak should be included. Peak fit asks this question because the system has found counts above background but they do not fit the required protocol to be included automatically and are ‘suspect’. When the analysis has completed a report will displayed listing the nuclides identified and their concentrations, this report can be saved using File and Save as (name the file using the sample code number). If a printer is available print the report and attach the printout to the sample info sheet. Close the report screen by selecting File and Exit, it is also advisable to re-save the spectrum by selecting File and Save spectral data, the system is now ready for the next count.

Recalling spectra

If for any reason you need to recall a spectrum only do so with the detector off (not in acquire) and select File, Open Spectral data file (if necessary save previous spectrum), select file and open. If the file is to be re-analysed make sure the correct background file is to be used (see ‘using a background count’).

Annex 2

EQUIPMENT OPERATING INSTRUCTIONS

For the

Oxford HpGe and Inspector analyser

1.Introduction

This guide is to assist users, after appropriate training, to assemble the CEFAS Emergency Portable Gamma Spectrometry equipment in the field, complete testing and quality control checks, and use it for the determination of radioactivity in foodstuffs and other environmental materials.

2.Scope

This particular guide is only for the Oxford p-type Hyper-pure Germanium (HpGe) gamma detector and Canberra Inspector analysis system and associated software. It covers the use of the equipment for the quantified measurement of radionuclides in the calibrated (59keV to 1.8Mev) energy ranges and only those samples that can be analysed in the assembled system (i.e. not suitable for whole body counting). It covers the usual quality control checks performed on such a system and the minor adjustments a trained user could make. It does not include the calibration and programming of the system, this is covered by the manufacturer manuals and authorised, qualified personnel can only make such changes.

3.Training

Before using this equipment the user must first have received training in the following:

1. The correct and safe handling of Liquid Nitrogen, including transportation.
2. Handling of radioactive materials including check sources.
3. Instruction in the use of the Oxford detector, Inspector analyser and the Canberra Genie 2000 software.

4.Safety

Relevant safety equipment will be provided and must be used.

5.Liquid Nitrogen Filling

Before using Liquid Nitrogen (LN_2) you must have read the safety guidance on handling Liquid Nitrogen and wear the correct protective clothing. Misuse may result in cold burns, frostbite or suffocation due to oxygen depletion.

Fill the detector in the horizontal position via the supplied adapter pipe at least 6 hours before use and in a well-ventilated location, precautions must also be taken to prevent damage to the surrounding area through spillage and venting of the liquefied gas.

Just before use refill to make sure the detector is full (a full Dewar can run for 72 hours between refills however it is recommended that the detector be refilled every day).

Further refilling of the detector has to be completed with the detector out of the table assembly and in the horizontal position to avoid excessive loss of liquid nitrogen.

6.Assembling the Equipment

Table and shield assembly

Before assembling the equipment the user must wear appropriate foot protection and if handling lead shielding gloves must be worn.

Choose an area that is well ventilated, level, provides protection from the weather and is not affected by extreme fluctuations in temperature.

Assemble and fasten both halves of the table together using the bolts provided, making sure that the table is stable.

Place the detector in the table in its upright position and fasten with Velcro straps.

Carefully place the detector tabletop over the detector, taking care not to damage the detector head, and fasten using the appropriate screws. At this point make sure the detector is sitting centrally in the hole and adjust as necessary.

While wearing gloves carefully place the lead rings over the detector using as many as necessary to accommodate the counting geometries.

Getting the Inspector and PC ready for use

Unpack the Inspector and the personal computer (PC) placing them next to the detector at this point the user if required can connect an external mouse to the PC.

Make sure the blue interface adapter (marked 2) is connected to the back of the PC and connect the communication lead (1) to the Inspector and the communication port at the back of the PC. Secure with the attached screws to prevent accidental removal while counting.

Make sure the equipment is switched off before proceeding further.

Connect the Inspector to detector lead in the following sequence. Main connector (6) and High Voltage supply (7) to the back of the Inspector. At the detector end of the lead connect pre-amp (3), signal output (4) and lastly High

Voltage (5). For safety and to prevent accidental damage secure the leads to the table off the floor.

Connect the power supplies to the equipment (either mains or battery), if using the Inspector on mains also connect one charged battery as backup to prevent data loss during possible power outages.

7.Powering up the Equipment

Inspector and PC

Make sure the power supplies are connected, turn on the Inspector using the toggle switch on the left-hand side of the case, the power diodes marked A and B will illuminate, one will flash to indicate the supply being used.

Switch on the PC by pressing in the power switch on the left-hand side (you may need to slide the protective cover back). The PC will take a few moments to boot, once successfully booted up double click on the Inspector Icon from the Desktop to run the Genie 2000 interface.

Once the Genie software is running select File, Open Datasource and choose Detector, a list of available detectors will be displayed select DET01 and Open. The last spectrum acquired will be displayed in the spectra window.

Detector High Voltage supply (Bias)

To power up the High Voltage select from the tool bar MCA, Adjust. Select HVPS and switch status to ON. In the top left of the Adjust window ‘WAIT’ will be displayed as the voltage is gradually ramped up to the required setting, once this clears go to Next and Exit. The HV diode on the front of the Inspector will be illuminated and the bi-colour diode at the base of the detector will be green.

Note if the detector diode is red the detector is warm, the HV will then automatically be shutdown and the detector will not operate. It must be refilled with LNO2 and allowed to cool until the diode turns back to green.

8.Powering Down the Equipment.

If you need to disconnect the detector for any reason, for example packing the equipment away or just refilling with LNO2 all that needs to be done is to go to MCA, Adjust select HPVS and switch status to OFF. The detector leads can then be disconnected in the reverse order (see ‘Assembling the Equipment’).

9.Quality Control (performance testing)

After the equipment has been assembled for the first time or at the beginning of a new counting day it is necessary to check its performance and if necessary make minor adjustments to peak positions and Pole-Zero (detector signal pulse baseline compensation).

Setting up a check source.

Place a suitable check source on the assembled detector and close the shield. Clear the spectrum, if necessary save the data if you have not already done so. Before counting the check source check source details need to be entered by selecting the option Edit, Sample Info. Enter the info as given on the check source data sheet. Load Cal option will give the user a list of current efficiency calibrations, select the appropriate one for the check source.

Select Analyze, Execute Sequence and choose CEFAS RUN QC option, the detector will start to acquire data for the check source.

System adjustments.

If a Pole-Zero adjustment is necessary (poor resolution or first count after installation) then while this data is acquiring go to MCA, Adjust and select AMP, Next. The Auto P/Z option will be displayed select and Exit, this may take a little time indicated by the ‘wait’ in the top left of the adjustment window.

Please note: After any adjustment is made, be it to the Pole-Zero or peak position (gain adjustment) it is necessary to refresh (clear) the spectrum so that the changes are applied.

As the data is acquiring Expand the peak and check the position of the Co-60 1332.5 keV peak +/- 1.0 keV (channel position should be 5330 +/- 2). If necessary make adjustments by selecting MCA, Adjust, AMP, most adjustments will be made using the S-Fine gain.

Checking source data.

At completion of the count check the reported activities, FWHM and peak positions against the data on the source data sheet, if these are within specified limits save the spectrum and clear ready for the next count. If adjustments are needed repeat this procedure and make the necessary alterations.

10.Quality Control (Background testing and storing)

All gamma-spectrometric counting systems yield counts without the presence of a radioactive sample. This natural "background" radiation arises from natural or man-made radioactive elements distributed in and around the detector and its shielding as well as from cosmic rays.

In the analysis of samples, this natural background radiation is treated as a second radiation source, which must be subtracted from the total count-rates recorded across the whole energy spectrum when counting actual samples.

The "background" must therefore be measured under exactly the same conditions as for the samples. The spectrum so obtained is stored in the computer memory for automatic subtraction of the appropriate background contribution from the spectra of all samples counted on that detector.

As this is a portable unit a background count must be taken every time the unit is moved to a new location so to take in to account the change in ‘background’ count rate. It is advisable to take a count as part of the daily QC checks.

Counting a background.

Remove all samples and sources from the immediate area and check that the shield is empty and close ready for starting the count.

Clear the previous spectrum and save as necessary, go to Edit, Sample Info and enter the background details. Title should include location and the sample date and time will be today’s. The sample id will be BGD, no calibration or weight need to be entered. Exit to save the information.

Next select Analyze, Execute Sequence and choose CEFAS RUN BGD option, the detector will start to acquire background data. When the count is complete a report will be generated.

Storing and using a background count.

The acquired spectrum can be stored by selecting File, Save As , enter the filename as BGD_nn-mm-yy_hh-mm and save.

To use the stored background for the next counting run select Edit, Analysis_Sequence and load CEFAS SETUP. A list of analysis sequences will be displayed in the right-hand window, select Area Correction and double click. In the Bkg File click Select and choose the file to be used. Click OK and Yes to overwrite and OK to close the Edit window. The system will now run only with the chosen background.

11.Counting samples.

Once the samples have been prepared in an appropriate geometry and all QC checks have been completed the system is ready for use. Place containers in a thin walled polythene bag and seal the end with a tie or tape, this is to prevent contamination of the detector surface. Place the container on the detector and carefully place the shield lid on top. Make sure all sources and samples have been removed from the counting area.

Entering sample details

Clear previous spectrum saving as necessary. Select Edit, Sample Info and enter details from the sample info sheet. Include the sample code number, description and location details under Sample Title, enter SAMPLE for the

Sample ID, Quantity in kg and sample date and time of collection. Load Cal will give you a list of available geometry calibrations, select the appropriate one for the sample and load. When all the edits have been completed select OK to close the edit window.

Start the sample count

Select from the toolbar Analyze, Execute Sequence and choose CEFAS Setup, the detector will start its count. At the end of the pre-set time a results report will be generated keep this report with the sample info sheet.

Saving the spectrum

It is advised to save the spectrum so that it can be recalled at a later date for further analysis, to do this select File, Save As and enter the sample code number from the sample info sheet and save. Remove the sample from the shield, the detector is now ready to count the next sample.

Recalling spectra

If for any reason you need to recall a spectrum select File, Open Datasource. Make sure the file option is selected (not detector) and choose the required spectrum and open. The spectrum will be displayed in the window if you need to go back to the detector display select Datasource from the main toolbar and choose DET01, the current spectrum for the detector will be displayed.

Annex 3

EQUIPMENT OPERATING INSTRUCTIONS

For the

ORTEC HpGe and Nomad-plus analyser

1.Introduction

This guide is to assist users, after appropriate training, to assemble the CEFAS Emergency Portable Gamma Spectrometry equipment in the field, complete testing and quality control checks, and use it for the determination of radioactivity in foodstuffs and other environmental materials.

2.Scope

This particular guide is only for the Ortec N-type Hyper-pure Germanium (HpGe) gamma detector, Nomad-plus analysis system and associated software. It covers the use of the equipment for the quantified measurement of radionuclides in the calibrated (59keV to 1.8Mev) energy ranges and only those samples that can be analysed in the assembled system (i.e. not suitable for whole body counting). It covers the usual quality control checks performed on such a system and the minor adjustments a trained user could make. It does not include the calibration and programming of the system, this is covered by the manufacturer manuals and authorised, qualified personnel can only make such changes.

3.Training

Before using this equipment the user must first have received training in the following:

1. The correct and safe handling of Liquid Nitrogen, including transportation.
2. Handling of radioactive materials including check sources.
3. Instruction in the use of the Ortec detector, Nomad-plus analyser and Gammavision software.

4.Safety

Relevant safety equipment will be provided and must be used.

5.Liquid Nitrogen Filling

Before using Liquid Nitrogen (LNO2) you must have read the safety guidance on handling Liquid Nitrogen and wear the correct protective clothing. Misuse may result in cold burns, frostbite or suffocation due to oxygen depletion.

Fill the detector in the horizontal position via the supplied adapter pipe at least 6 hours before use and in a well-ventilated location, precautions must also be taken to prevent damage to the surrounding area through spillage and venting of the liquefied gas.

Just before use refill to make sure the detector is full (a full Dewar can run for 36 hours between refills however it is recommended that the detector be refilled every day).

Further refilling of the detector has to be completed with the detector out of the table assembly and in the horizontal position to avoid excessive loss of liquid nitrogen.

6.Assembling the Equipment

Table and shield assembly

Before assembling the equipment the user must wear appropriate foot protection and if handling lead shielding gloves must be worn.

Choose an area that is well ventilated, level, provides protection from the weather and is not affected by extreme fluctuations in temperature.

Assemble and fasten both halves of the table together using the bolts provided, making sure that the table is stable.

Place the detector in the table in its upright position and fasten with Velcro straps.

Carefully place the detector tabletop over the detector, taking care not to damage the detector head, and fasten using the appropriate screws. At this point make sure the detector is sitting centrally in the hole and adjust as necessary.

While wearing gloves carefully place the lead rings over the detector using as many as necessary to accommodate the counting geometries.

Getting the Inspector and PC ready for use

Place the Nomad Plus portable Spectroscopy system on the table next to the detector and open the case, make sure that the power switch is in the off position and the High Voltage (HV) is on zero.

Unpack the personal computer (PC) and place it on top of the Nomad, connect one end of the parallel lead (marked 1) to the parallel connector at the rear of the PC and the other to the Nomad connector marked Comp. Take the black detector lead and plug in the push fit connector (2) into the socket marked HpGe, the connector is slotted so take care to line up the plug correctly before insertion. Connect the HV lead (3) in to the HV socket, connect the other end of the cable to the detector starting with the pre-amp (4) followed by bias shutdown (5), signal output (6) and lastly the HV lead (7). There will be spare leads and connectors on both the detector and the black lead, these are for testing purposes and are not to be used.

Connect the Nomad plus and PC to a power source, if no mains power source is available use the internal battery supply.

7.Powering up the Equipment

Nomad and PC

Make sure the power supplies are connected (if using external ones) and first turn on the Nomad using the power switch top right. The red led should be lit if not check power connections and battery. Plug in the PC (if using external supply) and switch on by pressing the round button top left of the keyboard. Once booted the PC should automatically go into the spectroscopy software package (GammaVision 32) if it doesn't then double click on the GammaVision icon on the desktop.

Detector High Voltage supply (Bias)

Check that the HV dial on the Nomad is set to zero, go to the PC and select Acquire from the toolbar and Adjust Controls. In the box displayed there are several adjustments that can be made, in the right-hand side of the box is a check box called Enable HV, click on this once to turn on, the HV led on the Nomad will come on. Unlock the bias control knob and turn it until the inner ring indicates 1/0 (in the PC window –100 volts will be displayed), increase the voltage slowly (100 volts a second) until –1000 volts is indicated on the PC and pause for a minute to allow the voltage to stabilise. Continue increasing the voltage at 100 volts per second until the window displays –4800 volts (inner ring 8/0 outer 4) lock off the dial and close the control window.

8.Powering Down the Equipment.

If you need to disconnect the detector for any reason, for example packing the equipment away or just refilling with LNO2 all that needs to be done is go to Acquire from the toolbar and Adjust Controls. In the box displayed on the right-hand side of the box is a check box called Enable HV, click on this once to turn off, the HV led on the Nomad will go off. Then turn the HV control knob on the Nomad back to zero. The detector leads can then be disconnected in the reverse order (see 'Assembling the Equipment').

9.Quality Control (performance testing)

After the equipment has been assembled for the first time or at the beginning of a new counting day it is necessary to check its performance and if necessary make minor adjustments to peak positions. Pole-zero adjustments can be made but this is not recommended to done when being used in the field, as this requires additional test equipment.

Setting up a check source.

Place a suitable check source on the assembled detector and close the shield. Select 'Acquire' from the toolbar and click on 'Start/Save/Report' use default settings and enter all details. Give the sample a pre-set live-time of a minimum of a 600 seconds, the display will then clear and counting will commence.

System adjustments

As the check source is being counted expand the Cobalt-60 1332.5 keV peak and using the cursor check its channel position, the channel should be 5330 +/- 2. If the position is to high or to low then select ‘Acquire’ and click on ‘Adjust Controls’ and by selecting and adjusting the gain by small amounts the peak channel position will change. The spectrum must be cleared after each adjustment is made either using the ‘Clear’ option under Acquire or clicking on the Clear Detector Icon from the toolbar. Once the peak is in the required position close the Adjust Controls window and wait for the count to complete.

10.Checking source data

When the count has completed check the activities for Am-241, Cs-137 and Co-60 and make sure they fall within 10% of the source data sheet values, if they fall outside then check all detector settings and repeat the count. If problems still occur contact the senior analyst for assistance.

11.Quality Control (Background testing and storing)

All gamma-spectrometric counting systems yield counts without the presence of a radioactive sample. This natural "background" radiation arises from natural or man-made radioactive elements distributed in and around the detector and its shielding as well as from cosmic rays.

In the analysis of samples, this natural background radiation is treated as a second radiation source, which must be subtracted from the total count-rates recorded across the whole energy spectrum when counting actual samples. The "background" must therefore be measured under exactly the same conditions as for the samples. The spectrum so obtained is stored in the computer memory for automatic subtraction of the appropriate background contribution from the spectra of all samples counted on that detector.

As this a portable unit a background count must be taken every time the unit is moved to a new location so to take in to account the change in ‘background’ count rate. It is advisable to take a count as part of the daily QC checks.

Counting a Background

Remove all samples and sources from the immediate area and check that the shield is empty and close ready for starting the count.

Select Acquire from the toolbar and click on the Start/Save/Report option. Enter all the details (weight is 1kg and the date will be today’s) make sure the pre-set time is the same or greater than your proposed count time for the samples you wish to analyse (in an emergency situation samples are usually 600 seconds). When the background has completed and a report generated make a note of the background file name and close the report window (WordPad) by going to File and Exit.

Storing and using a background count.

To include the background in the analysis of samples you must first select Analyze from the toolbar then Settings, Peak Background Correction (PBC), Edit PBC. A PBC file will displayed, this file will be a previously created PBC and will be discarded, go to the top left of the editing window and click on the Microsoft Window symbol, a drop down menu will be displayed, select New. The Edit window will clear, go back to the drop down menu (top left) and select Show Analysis…, a list of files will be displayed, select the one to be used in the background correction and open. A second window will be opened containing a list of Nuclides select these by clicking on the top left windows icon just above the list and Copy All to PBC. The list of nuclides will be displayed in the Editing window, select the Editing windows top left icon and Save PBC table As, enter the name in the following format (BGD_nn-mm-yy_hh-mm) and close the window.

Before a PBC can be used as part of the sample analysis you must update the analysis settings, you do this by selecting Analyze, Settings, Sample Type, a Analysis options window will be opened. Select the Corrections Tab and enter the PBC filename and make sure there is a tick against the On box and nothing in the Internal. Click OK to close and save changes and yes to save option with detector. The system will now run only with the chosen background.

12.Counting samples.

Once the samples have been prepared in an appropriate geometry and all QC checks have been completed the system is ready for use. Place containers in a thin walled polythene bag and seal the end with a tie or tape, this is to prevent contamination of the detector surface. Place the container on the detector and carefully place the shield lid on top. Make sure all sources and samples have been removed from the counting area.

Entering sample details and initialising the count

Make sure that the report window has been closed and select Analyze and Settings, the Analysis Options window will be displayed. Select Sample tab and check that the Calibration file selected is appropriate for the geometry and weight of sample being counted, if it isn’t correct select a more suitable calibration (Internal check box must not be ticked). Click OK to close the Analysis Options window and if requested save the changes.

Select Acquire, Start/Save/Report and use default settings file, enter pre-set live-time required, from the sample info sheet enter description of sample (include location details and description of material), weight of the sample minus the container weight and decay correction date (collection date) and time (optional), the sample will commence counting. At the end of the count a report is generated which can be printed (if printer attached), the report is automatically saved and can recalled at anytime. Close the report window and remove the counted sample from the detector ready for the next sample.

Recalling Spectra

If for any reason you need to recall a spectrum select File from the toolbar and Recall. Select the CHN file (Ortec spectra) required and Open, the spectrum will be loaded to the Buffer window. To go back to the detector display select Display and Detector (Display and Buffer goes back to the Spectrum in the Buffer window).

CEFAS
The Centre for Environment, Fisheries & Aquaculture Science

The Centre for Environment, Fisheries & Aquaculture Science
Lowestoft Laboratory, Pakefield Road,
Lowestoft, Suffolk NR33 0HT UK
Tel: +44 (0) 1502 562244
Fax: +44 (0) 1502 513865
www.cefas.co.uk