

## **Management of Radiation Safety Records Using Custom Designed Computer Forms**

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*Maintenance of radiation safety records is a regulatory requirement for the practice of nuclear medicine. Record-keeping can be easily accomplished with personal computers (PCs), IBM or Macintosh. PCs equipped with calendar, word processing, spreadsheet, and desktop publishing software permit easy design of forms customized for the activities of any particular laboratory. The programs allow the drawing of floor plans, perform calculations, and keep data organized for easy entry and review of activities. The authors show how these forms can be produced and customized for nuclear medicine laboratories. Efficiently designed forms, tailored to specific activities, are of great benefit in documentation and compliance with radiation safety regulatory requirements.*

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Radiation safety records are required in nuclear medicine practice to demonstrate and validate, to inspecting agencies, the laboratory's compliance with the requirements of its radioactive materials license. This record-keeping requirement (1) can be a burden and compete with patient care activities. However, the organization of tasks and use of efficient forms minimizes the time and effort required for regulatory record-keeping and supervisory review of these records. Custom designed forms (2), tailored to specific activities are key to this effort.

A number of software packages are available commercially, specifically for the management of nuclear medicine tests and records. The software is, of necessity, written for the widest possible audience. Some of the common complaints are that the software is too complex for the needs of the user, cannot be used efficiently, cannot perform some function deemed necessary, forces one to do something not necessary, or cannot be changed easily with changing requirements in the laboratory. Another difficulty is that output often involves copious amounts of poorly organized

printouts. This results in records that are hard to review by supervisory personnel.

Ideally, customized software written in a high level computer language for each laboratory might be best, but even with a staff programmer on site, this would be a time consuming and costly undertaking (3). The programmer would need to be able to write modular packages with extremely good documentation and continually update the software as user requirements changed. Another problem is that professional programmers might not be sufficiently knowledgeable about the particular application. This would result in a very significant time commitment for both the user and programmer to ensure that the finished applications program was in a useful form.

A viable alternative to both methods is the use of personal computers (PCs) equipped with a few basic commercially available and easy to use software packages. These software packages do not require programming expertise in a high level language and are designed to be used by personnel who have a minimum knowledge of computers. Most nuclear medicine personnel would be able to customize their own record-keeping functions.

### **IMPLEMENTING A CUSTOMIZED RECORDS PROGRAM**

To implement a customized radiation safety record-keeping program, the following functions must be addressed: organization, scheduling, documentation, and supervisory review of performed activities.

#### **Organization and Scheduling**

Timely performance of all radiation safety regulatory requirements demands that time and thought be devoted to organization. This must be followed by appropriate scheduling of the work to be done. Most tests must be done periodically and a missed test or inspection can be grounds for regulatory censure. The following items must be addressed.

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1. Review and inventory of regulatory requirements (4), followed by conversion of requirements into specific tests and jobs to be done.
2. Creation of a master schedule so that not only monthly or quarterly tasks are accounted for, but that jobs and tests performed infrequently (i.e., yearly) are not forgotten.
3. Assignment of tasks to appropriate work areas for the jobs and tests that are to be done during a specific period of time (i.e., daily, weekly, monthly).

### Documentation and Review

Written procedures for the work to be done are necessary to ensure that the work is complete, proper documentation is obtained, and the record of the work is easily retained and audited. Some procedures require only a checkoff list while other procedures include instructions, drawings, and calculations. Such document maintenance requires forms specific to the activities performed. Periodically, or after completion of certain tests, a supervisory review of data collected is necessary to ensure completeness of each test and to identify any tests not done. Data forms should be designed to allow convenient review of the results.

### MATERIALS AND METHODS

We have explored, on both IBM and Macintosh (Mac) personal computers (PCs), easy to use calendar, word processing, spreadsheet, and desktop publishing software to generate customized forms and checklists for required tests and record-keeping. These forms include drawings, provide space for data calculations, and help promote data organization for easy review of activities.

Both a Mac IIsi (Apple Computer Inc., Cupertino, CA) and an IBM 386/25 PC clone equipped with Windows 3.1 (Microsoft Corporation, Redmond, WA), were used to produce the forms, checklists, and procedures. In addition to a calendar and various commonly used word processing programs, the two software packages found to be most useful for this task were a spreadsheet program, Excel v.4.0 for Windows and v.3.0 for the Mac (Microsoft Corporation, Redmond, WA) and a desktop publishing program, Page-Maker v.4.0 for Windows and v.4.2 for the Mac (Aldus Corporation, Seattle, WA).

The Mac IIsi was originally equipped with 5 megabytes (MB) of memory, which was adequate to run any of these programs. Additional memory, above 5 MB, was found to be helpful, since it allowed simultaneous use of multiple programs and facilitated transfer of text and drawings from one application to another. The IBM PC clone was equipped with 3.7 MB of memory which was adequate for running all of the above software.

The IBM clone was used with a 300 dots per inch (dpi) laser printer with 2.5 MB of memory. Output was also tried on dot-matrix printers with graphics capability and resolution as low as 70 × 124 dpi. The Mac was equipped with 300 dpi ink-jet and laser printers.

### RESULTS AND DISCUSSION

An adequate printer was an important consideration in our work. The laser printer used with the Mac gave extremely high contrast and quality copy. However the ink-jet printer was much less costly and output from it was very acceptable. The laser printer for the IBM clone also produced a very high quality printout. The dot-matrix printer with graphics capability gave acceptable output, however the printing speed was slow. This was not a problem when printing master copies of forms; however, speed became a more important factor when printing numerous reports.

To demonstrate how the PCs and the software packages mentioned previously were used to help organize radiation safety functions in nuclear medicine, typical examples of some of the forms developed are presented. The authors also address how some of these forms were created and how they can be modified.

### Scheduling Calendar

Figure 1 illustrates the program, Calendar Creator Plus (Power Up Software, San Mateo, CA), which allows one to print a list of tasks. A task performed repeatedly only has to

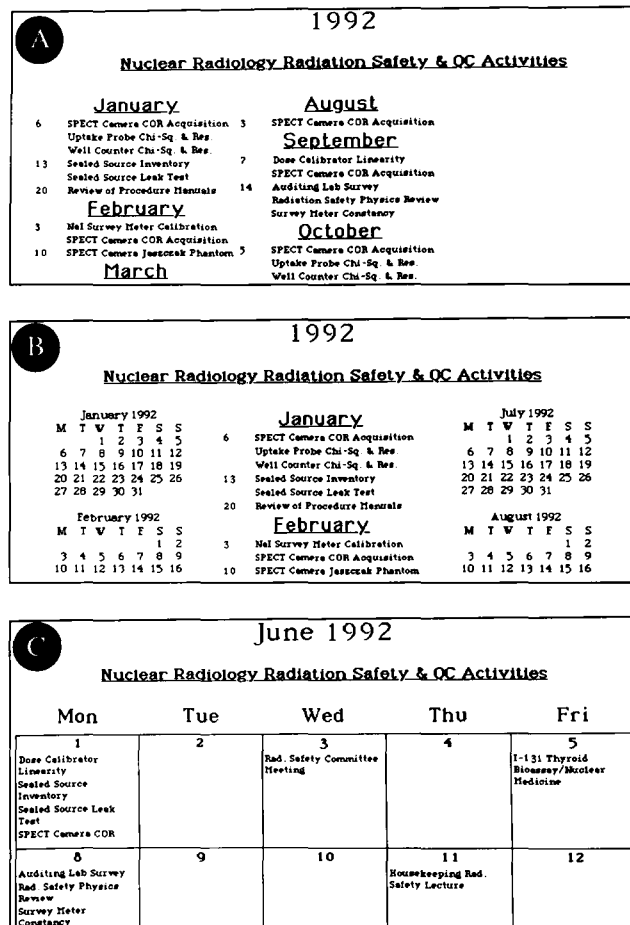


FIG. 1. Examples of a printout generated by a scheduling calendar program. (A) Event list of tasks arranged by dates. (B) Same event list with monthly calendars. (C) Event list printed in a monthly calendar format.

be entered once and the periodicity indicated. If the activity is not periodic, the date only has to be pointed out on a calendar which appears at the time of entry.

In the example shown, most entries were made on the Monday of the week that the work was due. This allowed some scheduling flexibility as to when the items would be performed. This list was posted and checked off as tasks were performed. A review of tasks completed, due, and in arrears was easily accomplished by looking at the list. Note that the format can be important. The list in Figure 1B, with the small calendars on the page, was found to be more useful to some than the bare list in Figure 1A.

As the amount and complexity of the work increased, the monthly calendar page printout in Figure 1C was more helpful in arranging work. Other calendar software is available to keep track of the time assigned for completion, provide reminders prior to when something is due, flag overdue items, and display the amount of time by which tasks are overdue.

### Auditing Review Form

A word processor was adequate to provide a check list which could be easily changed and updated. Figure 2 shows an example of page 1 of a quarterly radiological physics review and evaluation form. This form ensured that no task in the evaluation was left out. Numbered notes or comments entered on the last page of the report elaborated on any activities, deficiencies, or recommendations. Any tests performed at the time of the evaluation were entered on separate report forms and referenced on the quarterly evaluation

**QUARTERLY RADIOLOGICAL PHYSICS REVIEW AND EVALUATION**

Evaluation performed on \_\_\_/\_\_\_/\_\_\_ (Last evaluation on \_\_\_/\_\_\_/\_\_\_) Checks included:

Performed/Checked	Comments
1) Radiation level/wipe survey	(see report)
2) Sealed sources	NM lab: Cs137 NES356, SN 294-189-11 EKG lab: Cs 137 67-356 SN 205-109-50 (report/last done ___/___/___)
leak test (semiannual)	
inventory (quarterly)	NM lab: Cs137 above & EKG lab: Cs 137 above Ba-133 #8 mock iodine (3 uCi) Gamma standard set ICN mod R35 Includes: Ba133, Co57, Cs137, Na22, Mn54, Zn65, Co60
3) Dose calibrator	a) NM lab: CRC-50C b) EKG lab: CRC-30BC
linearity (quarterly)	(see report) a) ___ b) ___
accuracy (annual)	(report/last done) a) ___ b) ___
geometrical variation (at start)	(report/last done) a) ___ b) ___
4) Survey meter	a) Eberline E520 with TEW probe b) Victoreen 740 P ionization chamber (report/last done) a) ___ b) ___
calibration (annual)	a) source reads ___ expect ___
constancy check source (quarterly)	b) source reads ___ expect ___
5) Gamma counter/uptake probe	(see report)
Chi Sq./an. resolution (quarterly)	
6) Postings check	notice to employees, rad. warn signs, emergency numbers & procedures, typical patient doses, Xenon calculation, license and State regs.
7) Lab protective devices check	shields; syringe, vial, storage, prep.; lab coats, gloves, remote manip., needle disp., waste containers, security of sources.
8) Review of Records	
a) film badge	badges issued ___/___/___ to ___/___/___
b) incident, misadministration log	examine from ___/___/___
c) gamma counter/uptake probe	examine from ___/___/___
daily Cs-137 calib. (as used)	
d) incoming / outgoing	examine from ___/___/___
dose container survey log	
e) dose calibrator constancy	NM lab - examine from ___/___/___
f) rad. mat. / pat. dose record	NM lab - examine from ___/___/___
-dose receipt / return	
-dose assay / administration	
-patient / procedure / tech. id.	
g) daily radiation/wipe survey	NM lab - examine from ___/___/___

page 1 (of 3)

FIG. 2. Page 1 of a quarterly radiological physics review and evaluation form generated by a word processing program.

form. An important feature of this form was the ability to easily update it to include new equipment and regulatory requirements.

### Radioactive Inventory, Patient Dose Entry, and Shipment Survey Forms

The form shown in Figure 3 contained mostly text, however a desktop publishing program was used to create it because the flexibility of the text arrangement on the form was greater with this software than with a word processor. Most of the radiopharmaceuticals obtained by institutions in the author's locale have been unit doses from a centralized nuclear pharmacy. This form was therefore designed with rows of boxes, so that the boxes on the left would accommodate the pharmacy unit-dose labels. To the right of each pharmacy label box, space was added for the necessary patient dispensing information.

Box#	Label Type (I < 0.5, II < 50, III < 200 surface mR/hr)	Date: _____	Survey by: _____
R A D I O A C T I V E  I N V E N T O R Y  P A T I E N T  D O S E  R E C O R D		Bkg. _____ mR/hr. Surface _____ mR/hr. TEW GM wipe _____ mR/hr	Returned unused: <input type="checkbox"/> Non-patient activity: <input type="checkbox"/>
		Activity added to other patient dose: To dose prescription# _____	Patient dose: Tech: _____ Study: _____
		Patient name: _____ Activity: _____ <input type="checkbox"/> mCi. <input type="checkbox"/> $\mu$ Ci. Assay time: _____ Date: _____ Administer dose within 30 min. of assay.	
		Bkg. _____ mR/hr. Surface _____ mR/hr. TEW GM wipe _____ mR/hr	Returned unused: <input type="checkbox"/> Non-patient activity: <input type="checkbox"/>
		Activity added to other patient dose: To dose prescription# _____	Patient dose: Tech: _____ Study: _____
		Patient name: _____ Activity: _____ <input type="checkbox"/> mCi. <input type="checkbox"/> $\mu$ Ci. Assay time: _____ Date: _____ Administer dose within 30 min. of assay.	
		Bkg. _____ mR/hr. Surface _____ mR/hr. TEW GM wipe _____ mR/hr	Returned unused: <input type="checkbox"/> Non-patient activity: <input type="checkbox"/>
		Activity added to other patient dose: To dose prescription# _____	Patient dose: Tech: _____ Study: _____
		Patient name: _____ Activity: _____ <input type="checkbox"/> mCi. <input type="checkbox"/> $\mu$ Ci. Assay time: _____ Date: _____ Administer dose within 30 min. of assay.	
		Doses from box continued on next page <input type="checkbox"/>	
Return Survey by: _____ Bkg. _____ mR/hr. Surface _____ mR/hr. TEW GM wipe _____ mR/hr			

FIG. 3. Radioactive inventory and patient dose record form generated by a desktop publishing program for a small nuclear medicine laboratory using unit doses.

When the form was used for unit doses, entering data was very simple and easy. The form also contained space for a receipt and a return radiation survey of the nuclear pharmacy radioactive transportation containers. For a small laboratory, where only unit doses are used, this simple form was adequate.

This form could be customized to accommodate any additional record-keeping unique to a particular laboratory. For example, additional spaces were added to accommodate quality control doses and thallium-201 reinjection doses. For a laboratory receiving a large number of radioactive shipments during a day, the shipment radiation survey space could be deleted from the form and maintained separately.

Larger institutions frequently dispense not only patient unit doses supplied by the centralized nuclear pharmacy, but also dispense patient doses from multidose vials, prepare kits from a bulk amount of a radiopharmaceutical, and dispense patient doses from these prepared kits. A modification of the original form in Figure 3, to accommodate these activities, is shown in Figure 4.

<b>Pharmaceutical kit preparation from bulk:</b> Enter bulk prescription # _____ Radiopharmaceutical _____ Kit lot # _____ Pharm. QC: % Bound _____ Activity: <input type="checkbox"/> mCi. <input type="checkbox"/> $\mu$ Ci. Volume _____ ml Specific activity: <input type="checkbox"/> mCi/ml <input type="checkbox"/> $\mu$ Ci/ml Assay time: _____ Date: _____	<b>Returned unused:</b> <input type="checkbox"/> <b>Non-patient activity:</b> <input type="checkbox"/> <b>Bulk material:</b> <input type="checkbox"/> Bulk prescription # _____ Activity added to other patient dose: <input type="checkbox"/> To dose prescription # _____ <b>Patient dose:</b> Tech: _____ Study: _____ Patient name: _____ Activity: <input type="checkbox"/> mCi. <input type="checkbox"/> $\mu$ Ci. Assay time: _____ Date: _____ Administer dose within 30 min. of assay.
<b>Patient dose drawn from prepared kit:</b> Enter Kit lot # _____	
<b>Patient dose drawn from bulk:</b> Enter bulk prescription # _____	

**FIG. 4.** Radioactive inventory and patient dose record form with data-block inserts, created for a more complex nuclear medicine operation using mostly unit doses. The form was created with a desktop publishing program.

For a small laboratory, where doses are never prepared from bulk, the additional text in the boxes of the expanded form was a hindrance to the clarity of the form. The fact that these forms can be very easily customized for different laboratories adds greatly to their usefulness.

For a laboratory which uses a generator and prepares most of its pharmaceuticals, an entirely different form, shown in Figure 5, was found to be more appropriate. This form contained a separate section for generator elution and dispensing of eluate to patients or for pharmaceutical compounding. Separate sections were provided for each compounded pharmaceutical or multidose vial received. Under each of these sections, space was provided for recording patient dose dispensations.

This form included spaces for radiopharmaceutical quality control. The form also allowed for tracking the volume of the remaining radiopharmaceutical. Since the constraint of creating spaces for pharmacy labels was not a factor, this form was designed with spreadsheet software and took advantage of the typical column and row format of the spreadsheet.

**Daily Laboratory Wipe and Radiation Level Survey Form**

Desktop publishing software was used to create this form shown in Figure 6. Full advantage was taken of both the text and drawing capabilities of this software. Appendix 1 gives a

RADIOPHARMACEUTICAL RECEIVING, ELUTION, COMPOUNDING AND DISPENSING RECORD													
Generator Elution and TcO4 Eluate Distribution for Radiopharmaceutical Preparation or Patient Doses													
Generator Elution	Gen. Lot #	Date	Time	Conc mCi/ml	Activity mCi	Volume ml	Balance ml	Moly Assay uCi/Mo(mCi) Tc	Lot # /	Prescription #	Initials		
Radiopharm/Pat Name		Patient ID #											
Bulk Radiopharmaceutical (Either Compounded or Received) and Distribution for Patient Doses													
Bulk Radiopharmaceutical Received/Compounded	Lot #	Date	Time	Conc mCi/ml	Activity mCi	Volume ml	Balance ml	% Label	Lot #	Initials			
Patient Name		Patient ID #											
Bulk Radiopharmaceutical Received/Compounded													
Bulk Radiopharmaceutical Received/Compounded	Lot #	Date	Time	Conc mCi/ml	Activity mCi	Volume ml	Balance ml	% Label	Lot #	Initials			
Patient Name		Patient ID #											
Bulk Radiopharmaceutical Received/Compounded													
Bulk Radiopharmaceutical Received/Compounded	Lot #	Date	Time	Conc mCi/ml	Activity mCi	Volume ml	Balance ml	% Label	Lot #	Initials			
Patient Name		Patient ID #											
Record Page #													

**FIG. 5.** Radiopharmaceutical receiving, elution, compounding, and dispensing record for a nuclear medicine operation using a molybdenum-technetium generator. The form was created with a spreadsheet program.

demonstration of how the graphic and textual components were created and assembled under the desktop publishing program. This form includes survey instructions and action levels, a list of equipment to be used, and space for measurements, comments, and followup. An attempt was made

DAILY LABORATORY WIPE AND RADIATION LEVEL SURVEY							
<b>Action levels:</b> Contamination - >2X background on wipes (2000dpm/100cm <sup>2</sup> ) Radiation levels - >0.2 mR/hr hot lab (2 allowed, try to reduce) >0.2 mR/hr other areas (0.2 allowed, try to reduce) Document cleanup or action, notify RSO or supervisor							
<b>Survey Meter:</b> Ludlum 14C with TEW GM probe SN 14372 a) Measure radiation levels with side of probe in mR/hr. Record maximum level found. Mark location of excessive levels on drawing. b) Measure wipes with wiped area against thin window. Careful not to contaminate meter. Count for at least 10 sec. and estimate average. Use fast meter response time. c) To obtain reading in DPM = mR/hr x 2000dpm / 2 x bkg in mR/hr							
<b>measurements in mR/hr</b>							
month / yr. /	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Sun.
date:.....							
background:.....							
area max. rad. level:							
hot lab:.....							
scan room:.....							
wipes:							
1) dose calibr./work area.....							
2) shield/sink area.....							
3) storage/floor.....							
4) camera/computer.....							
5) ECT/body beds.....							
6) injection table.....							
7) floor/doors.....							
8) toilet/sink/floor.....							
Surveyor (initials):.....							
Comments :							

**FIG. 6.** Daily laboratory wipe and radiation level survey form for a small nuclear medicine laboratory, created with a desktop publishing program.

to reduce the amount of space necessary to keep records by trying to fit as much data as possible (a whole week of surveys) on one page. This economy of space and organization of data were especially valuable when this information had to be reviewed by supervisory personnel.

### Dose Calibrator Test Forms

A number of periodic tests are necessary for the proper maintenance of a radioisotope dose calibrator. These tests involve both data collection and mathematical analysis. Spreadsheet software with its column and row format and many mathematical functions is ideally suited to this task.

An illustration of the dose calibrator constancy test form is shown in Figure 7. The spreadsheet was used to calculate the decay of the standard used for these daily and weekly tests. Spreadsheets are especially useful for calculations involving dates and times, which can be entered using any of a number of standard formats. The software contains a calendar that keeps track of the number of days in each month and even leap years. Appendix 2 gives a more detailed demonstration of the capabilities of the spreadsheet software.

The dose calibrator constancy test form provides spaces for recording measurements and gives limits of acceptability for these measurements. A form was provided with spaces for daily measurements on the more commonly used settings of the dose calibrator. A variant of this form was provided with weekly spaces for the less commonly used isotope

Dose Calibrator Quarterly Linearity Test / Decay Method	
Radiology Dept./Nuclear Medicine Section	Dose Calibrator: Capintec Model CRC-30BC Serial # 31013

- [1] zero dose calibrator. [2] zero background (or record if not zero).  
[3] measure decay of Tc-99m over a range of values which include the patient doses administered.

Date of test (m/d/yr)	Time test actually done (h:m AM/PM)	Dose calibrator scale or range	Activity measured (mCi)	Background measured (uCi)	Activity predicted (mCi)	Variation (%)
1 6/15/92	1:05 PM		30.8		30.800	0.0%
2 6/15/92	4:05 PM		21.6		21.780	0.8%
3 6/15/92	8:05 PM		13.7		13.722	0.2%
4 6/16/92	1:05 PM		1.932		1.926	-0.3%
5 6/16/92	5:05 PM		1.304		1.214	-7.5%
6 6/16/92	9:05 PM		0.816		0.765	-6.7%
7 6/17/92	1:05 PM		0.124		0.120	-2.9%
8 6/17/92	6:05 PM		0.06		0.068	11.3%
9 6/17/92	9:05 PM		0.043		0.048	10.1%
10 6/18/92	1:05 PM		0.008		0.008	-6.2%
11						
12						

COMMENTS:  
Date for normal repeat of test is: 14-Sep-92 (Test performed quarterly or when serviced)

RSO review: Signed: \_\_\_\_\_ Measurements by: \_\_\_\_\_

- (1) Predicted activity is based on decay of 1st. reading  
(2) If variation is > than +/-5% then corrective action may have to be taken.

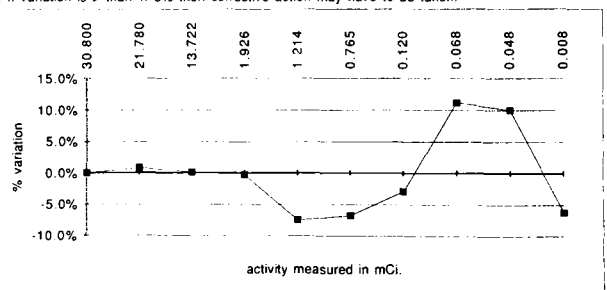


FIG. 8. Dose calibrator quarterly linearity test (decay method) form, created with a spreadsheet program.

**A**

Daily Readings Decay Chart For Cs-137 Dose Calibrator Constancy Source							
Dose Calibrator: Capintec Model CRC-30BC Serial # 30961			Source: Cs-137 0.213 mCi 11/13/1989				
Date:	Cs-137 dial setting 220			Tc-99m Tc-99m preset			Technologist initials:
	fr. -5% μCi	reading μCi	to +5% μCi	fr. -5% μCi	reading μCi	to +5% μCi	
1-Jan-92	191.4	211.5	355.6	393.0			
2-Jan-92	191.4	211.5	355.5	393.0			
3-Jan-92	191.3	211.5	355.5	392.9			
4-Jan-92	191.3	211.5	355.5	392.9			
5-Jan-92	191.3	211.5	355.5	392.9			
6-Jan-92	191.3	211.4	355.5	392.9			
7-Jan-92	191.3	211.4	355.4	392.8			
8-Jan-92	191.3	211.4	355.4	392.8			
9-Jan-92	191.3	211.4	355.4	392.8			
10-Jan-92	191.3	211.4	355.4	392.8			

**B**

Weekly Readings Decay Chart For Cs-137 Dose Calibrator Constancy Source										
Dose Calibrator: Capintec Model CRC-30BC Serial # 30961					Source: Cs-137 0.213 mCi 11/13/1989					
Week of:	Ga-67 Ga-67 preset			Tl-201 Tl-201 preset			I-131 I-131 preset			Technologist initials:
	fr. -5% μCi	reading μCi	to +5% μCi	fr. -5% μCi	reading μCi	to +5% μCi	fr. -5% μCi	reading μCi	to +5% μCi	
6-Jan-92	319.5	353.1	353.1	200.2	221.3	221.3	249.2	275.5	275.5	
13-Jan-92	319.3	353.0	353.0	200.1	221.2	221.2	249.1	275.3	275.3	
20-Jan-92	319.2	352.8	352.8	200.0	221.1	221.1	249.0	275.2	275.2	
27-Jan-92	319.1	352.7	352.7	199.9	221.0	221.0	248.9	275.1	275.1	
3-Feb-92	318.9	352.5	352.5	199.8	220.9	220.9	248.8	275.0	275.0	
10-Feb-92	318.8	352.3	352.3	199.7	220.8	220.8	248.7	274.9	274.9	
17-Feb-92	318.6	352.2	352.2	199.7	220.7	220.7	248.6	274.7	274.7	
24-Feb-92	318.5	352.0	352.0	199.6	220.6	220.6	248.5	274.6	274.6	

FIG. 7. Dose calibrator constancy test form generated by a spreadsheet program. (A) Example of a daily reading test form. (B) Example of a weekly reading test form.

settings. One month's worth of daily reading data for up to three different isotope settings, fit on one page. A full six months' worth of weekly reading data, for up to three isotope settings, were also included on one page.

Speed was the main reason these forms were chosen as a means of collecting and evaluating the constancy data. These forms were kept with the dose calibrator for easy access, and consequently, very little time was required to record the data. The forms did not require any additional calculations and provided easy determination of acceptability to within the chosen limits.

Figure 8 demonstrates the dose calibrator quarterly linearity test (decay method) form. This form, produced on a spreadsheet, included instructions and criteria, equipment, and a clear presentation of results. An optional graph of the data was useful in the review of the results by supervisory personnel. Similar forms for dose calibrator accuracy and the geometrical variation tests were also created.

### Gamma Counter/Uptake Probe Full Width at Half Maximum (FWHM) and Chi-Square Measurement Form

This equipment test form, shown in Figure 9, was also created in a spreadsheet program. Since the two tests were usually performed on the two instruments at the same time,

Gamma Counter/Uptake Probe FWHM and Chi-Square Measurements																																																																																																																
Test date: 8/15/92		Nucleus Uptake System II MCA																																																																																																														
Radiology Dept./Nuclear Medicine Section		Nal well counter and uptake probe																																																																																																														
[1] Use Cs-137 gamma reference source [2] acquire FWHM data for 1 min [3] acquire CH-Sq data for well counter =15 sec, uptake probe = 1 min																																																																																																																
FWHM CALCULATIONS		CHI-SQUARE CALCULATIONS																																																																																																														
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FIG. 9. Gamma counter/uptake probe FWHM and chi-square measurement form, created with a spreadsheet program.

all the data and results were combined into one page. The form allows the user to calculate chi-square based on either 10 or 20 data readings.

Other forms were created to help in the performance of sealed source leak test calculations, survey meter calibrations, incoming and outgoing package surveys, radioactive waste storage for decay and disposal, and ALARA (as low as reasonably achievable) reports.

## SOFTWARE FEATURES

All three software packages had certain features which were useful for the creation of procedure forms or work forms for tests and documentation. Some of the most important features are summarized and discussed below.

### Word Processing Software

Word processors are useful for creating checkoff lists or writing and modifying laboratory procedures. Many extra features allow the use of myriad typefaces in various sizes, highlighting, underlining, reformatting, and editing of text. Documents can be merged in part or totally.

### Desktop Publishing Software

This software possesses some of the features of a word processor, with the added capability of creating drawings or adding graphics created elsewhere. This type of software allows more freedom in the movement and placement of drawings and blocks of text within the form. The ability to

increase or decrease the size of a drawing segment or text block was another feature that added versatility.

### Spreadsheet Software

Spreadsheet software is also very versatile and is useful for much more than performing calculations. Spreadsheet pages, organized into rows and columns, can be transformed into excellent data entry forms as well as reporting forms. Text is added easily to these forms in a number of styles, sizes, and formats to give directions or label data entries.

Spreadsheet forms allow users to perform a range of simple to complex calculations with the data, facilitate comparison of the results of calculations to known standards or some acceptable range, and generate appropriate warning or acceptance messages. A portion of the spreadsheet page is isolated and printed separately as the report.

Quantities, as values of standards or acceptance ranges, were entered into the spreadsheet form and could be changed easily with changing laboratory conditions. The software allowed graphs to be generated easily and placed on the final report form to explain or evaluate the data presented. The results of calculations, messages, and graphs changed automatically as the data entries were changed.

A drawback to the use of these spreadsheet forms is that if data has to be collected in a location where there is no PC, it will have to be entered twice; once in a temporary form, and later into a PC. That problem can be solved through the acquisition of a small and lightweight portable PC.

Compatibility of the three types of software discussed above, further enhances the utility of a PC. For example, drawings created in a desktop publishing program can be transferred to a spreadsheet, where placement and sizing of the drawing can strengthen the utility of the form. In addition, all the software packages work in a graphics environment, which allows the current version of the form to be displayed while it is still under design. The use of graphics printers eliminated the concern about the final form fitting the page, as the form could be decreased or increased in size during printing, within a range of continuous scaling factors.

## CONCLUSION

We found that the task of creating and maintaining radiation safety forms with the software packages described above could be performed by personnel with relatively little expertise in computer programming. The software packages allowed the users to customize forms for their needs relatively easily in a very user friendly environment.

Learning the appropriate commands to design or change the forms was made easier by a windows style environment. Drop-down help screens or menus organized the commands available to the operator by function category and displayed the individual command choices. The commands functioned in a very intuitive manner, as they performed specific operations on data, text, or graphics.

Novices only needed to learn a few rules prior to initial use of the software. On-line tutorials, which came with the software, were very useful in familiarizing the beginner with simple applications. The software packages allowed the user to tap into the more sophisticated and complex features of the software applications, as the user became more familiar with the software and its documentation.

Since local regulatory requirements, enforcement customs, equipment, and even means of radiopharmaceutical acquisition can vary, the ability to customize the design of radiation safety forms is of significant practical importance. Our experience has shown that it is very helpful to be able to customize these record-keeping forms so that the forms fit the operation rather than the opposite. These forms, created and modified easily as needs changed, improved the organization and accuracy of radiation safety record-keeping in nuclear medicine.

Efficiently designed forms also minimized the toil of document maintenance by nuclear medicine technologists. This efficient design assured convenience and increased the probability that the required work would be performed on time and without error. When data were entered directly into forms on the PC, the calculations were performed by the computer, which minimized error.

Whatever software one uses, the final format of data and reports must be clear and presentable. Information must be easily viewed without unnecessary or distracting entries. This does not always occur with software that one cannot modify or can modify only with great difficulty. Clarity has often been sacrificed and necessary updates neglected due to inflexible software.

The commercial PC software discussed in this paper allows for the production of unique output formats, customized to the preferences of each user. The forms described, allow convenient review of the results for supervisory control purposes. Good organization of data and use of graphics in the forms aids in the review of safety data and the maintenance of control over radiation safety hazards, in keeping with the spirit of ALARA.

### ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of W. L. Furr, III and W. M. Mundy, EdD and the support of E. F. Binet, MD and G. J. Burke, MD in this work.

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### APPENDIX 1: DESKTOP PUBLISHING SOFTWARE

The following is a brief overview of the capabilities of the desktop publishing software, PageMaker. Examples are taken from the laboratory survey form in Figure 6.

Steps in Figure 10 illustrate, how an object, such as a gamma camera, can be drawn and labeled in a step-wise fashion with this software.

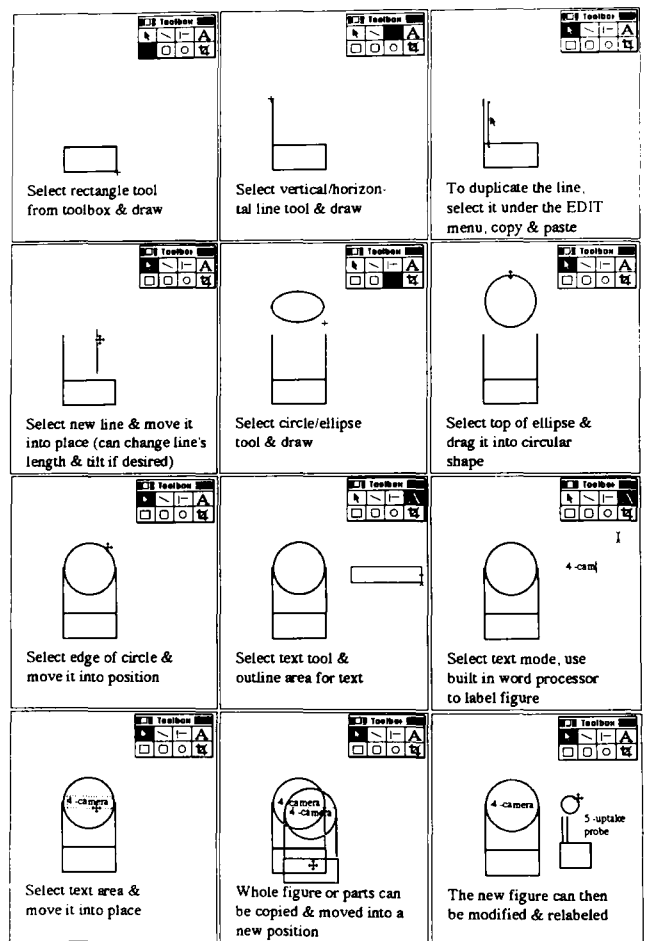
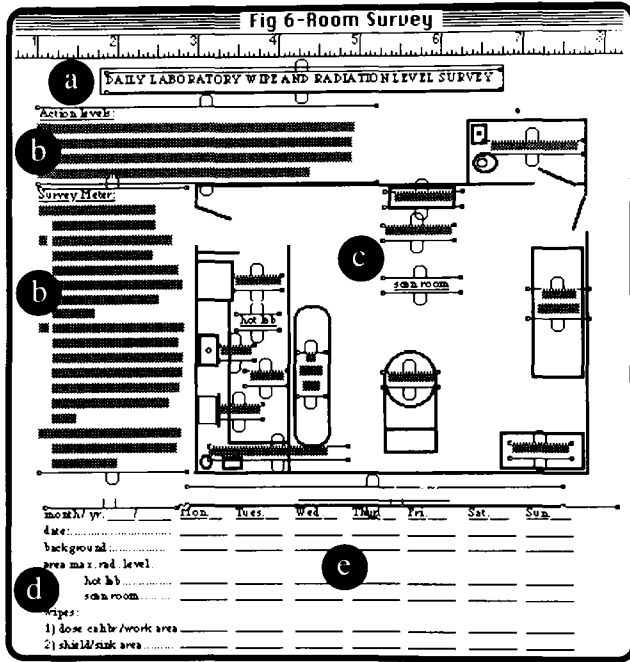


FIG. 10. Tutorial on drawing and labeling objects in a desktop publishing program.

Figure 11 shows how a number of text blocks are assembled into the final report form. The text blocks and their main features, as found in the survey report form, include the following.



**FIG. 11.** An example of how text blocks can be arranged on a page using a desktop publishing program. (A) Text heading, (B) instruction and information blocks, (C) figure labels, (D) data descriptor blocks, and (E) data blocks.

**A)** Select a cell by moving the cursor to it and clicking the mouse button. Cell coordinates appear on a segment of the entry line above the body of the spreadsheet. The cell is highlighted.

**B)** Enter text by simply typing. Text appears on another portion of the entry line. This line displays the contents of the active cell.

**C)** This entry line can be edited with standard word processing functions. Edit cursor is used for insertion, deletion, copying, etc. of text.

**D)** When the final version of text is acceptable, click on the check button to enter the text into the spreadsheet.

**E)** If adjacent cells are empty, text spills into them.

**F)** If the cells are occupied, text display is truncated. To make extra room for text, column width can be adjusted by moving the column separator line on top of the spreadsheet form.

**G)** Numerical data is entered in a similar manner. However, if the number's digits exceed cell width, the number is not displayed and column width or number's format must be changed.

**H)** Text or numerical data can be right justified, left justified, or centered by selecting a cell or highlighting a group of cells and clicking on icons above the entry line. Text can be displayed in italics or bold type in the same manner.

**FIG. 12.** Tutorial on entering text and numerical data into a spreadsheet.

1. *Text heading.* Useful features are different fonts, different text size, emphasis, and centering.
2. *Instruction and information blocks.* Useful features are the optimization of block placement, block shape, and text emphasis.
3. *Figure labels.* These require flexible label placement, label shape, and text size.
4. *Data descriptor blocks.* These require text placement in alignment with data and text emphasis.
5. *Data blocks.* These require the use of tabs to put data into columns, optimization of block placement, alignment with headings, and underlining of spaces.

Easy text duplication is essential and allows a fast creation of this form.

## APPENDIX 2: SPREADSHEET SOFTWARE

In this overview of the capabilities of the spreadsheet software, Excel (5), examples are taken from the FWHM and chi-square calculation form in Figure 9. The spreadsheet unit is a rectangular cell with the cells organized in rows and columns. Columns of cells are labeled by letters while rows are labeled by numbers.

**I)** Drop down menus, shown below, allow cell borders to be specified, and text fonts to be chosen, emphasized and highlighted. The height of a row of cells can be adjusted by moving the row separator line.

**J)** Format of numerical entries can be selected from a drop down menu or custom written and added to the menu. Examples shown are the number of places behind the decimal, use of comma separators, scientific notation, and fractions displayed as %. Dates and time are also handled in numerical formats.

**K)** Enter a formula by selecting a cell and typing in "=" followed by the formula. Cell designations do not have to be typed in, just point to the appropriate cell and click. When finished, click on the check button. The cell will always display the calculation results. The formula is hidden from view unless the cell is selected.

**L)** In addition to math functions, other functions as logical, statistical, lookup, text, etc. are available.

**M)** Cells containing dates (and/or times) can be used in computations. Dates and times are handled as days and fractions of a day. As an example, to find the next date for a quarterly test add the number of days in a year divided by four.

**FIG. 13.** Tutorial on formatting text and numerical data and the use of formulas in a spreadsheet.



Figures 12 and 13 illustrate how text and numerical data can be entered into the spreadsheet and the form customized to the user's needs and preferences. Figure 13 also illustrates the entry of formulas into the spreadsheet to allow a variety of mathematical and other functions (6).

Figure 14 shows some of the spreadsheet features, which allow flexibility and the ability to work with large numbers of cells.

N) Entry of formulas is often simplified to allow work with large numbers of cells. For example, to obtain an average of the values shown type "=SUM()", then highlight cells to be summed with the mouse.

O) Next finish with "/4" and click on the check button. The average appears in the cell.

	F
1	31,727
2	31,585
3	31,828
4	31,841
<Av.>	31,745

P) Text, style, borders, and formulas can be copied to other cells or replicated across a row of cells or down a column. H13 contains a formula which calculates the deviation of counts (H13) from average counts (H23) squared for n=1. See the entry line. To replicate the formula for other values of n, select cell H13 and highlight the ones below. Select Fill Down from the Fill drop down menu. The formula is replicated from H13 to the highlighted cells below. The \$ signs in front of both H and 23 assure that neither these column nor row designations change as the formula is copied. On the other hand, H13 changes automatically to H14 when copied to row 14, etc.

	G	H	I
11		CHI-SQUARED	
12	n	Well date	$(X_n - \bar{X})^2$
13	1	31,727	2,079
14	2	31,585	
15	3	31,828	
16	4	31,841	
17	5	31,864	
18	6	31,690	
19	7	32,019	
20	8	31,801	
21	9	31,454	
22	10	31,917	
23	<Av.>	31,773	

Q) The spreadsheet allows the document print area to be highlighted and defined. Above, this is the area to the left of the vertical dashed line. The area to the right is then used only as a worksheet. This feature allows calculations to be performed without cluttering the final report form.

R) A document preview feature is very helpful for designing the layout and appearance of the final form. Clicking on the magnification cursor allows any section of the document to be viewed in greater detail.

FIG. 14. A tutorial on working with larger blocks of cells in a spreadsheet. An illustration of the print preview feature is included.