BAPTIST MEDICAL CENTER OF OKLAHOMA

June 24, 1993

Linda Kasner
United States Nuclear Regulatory Commission
Region IV Office
611 Ryan Plaza Drive, Suite 1000
Arlington, TX 76011

Dear Ms. Kasner:

As I have discussed with you and Charles Cain over the telephone, on April 20, 1993 we observed a discrepancy between calculated activity and our dose calibrator reading for a P-32 sodium phosphate dose received from Mallinckrodt. Similar discrepancies had not been observed for previous doses obtained through the Syncor nuclear pharmacy. Several experiments and discussions (with Mallinckrodt, Syncor, and Capintec) were required to identify the sources of the discrepancy. Enclosed for your consideration is my summary and interpretation of these experiments and discussions.

Briefly, it is my opinion that previous P-32 doses received from Syncor were in agreement with Mallinckrodt assays within +/- 10%, so that no recordable events occurred prior to April 20, 1993. Two patients were treated with P-32 on April 20, 1993, I now believe that the activity received by these patients was 12.9% and 14.0% less than the prescribed activity. Therefore, both administrations were recordable events as defined in 10 CFR 35.2. Revised P-32 assay procedures have been issued to avoid this problem in the future.

If you have questions concerning this matter, please feel free to call me at 405-949-3296.

Sincerely your,

G. Scott Burns, Ph.D.
Physicist/RSO

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ANALYSIS OF P-32 ASSAY
(Revised)

A discrepancy observed between BMCO dose calibrator readings obtained when P-32 doses were supplied by different vendors (Syncor and Mallinckrodt) has been investigated, and the sources of the discrepancy have been identified. The following is a summary of the findings.

In an effort to understand the discrepancy several potential sources of error were investigated. The results are reported below in terms of the multiplicative correction which must be applied to the dose calibrator reading to obtain the true activity under the specific measurement conditions. All readings were obtained from the CRC-12 dose calibrator with the isotope selector at "Other" and the pot setting at 750 (recommended by Capintec for P-32).

1. Self-absorption as a function of isotope volume.
   Performed 5-5-93

Volume(ml)	Correction Factor(center position)
1.0	.797
2.0	.833

Conclusion: Over the likely range of administered volumes, the correction factor changes by only 4%, this does not account for the observed discrepancy.

2. Effect of syringe position within the dose calibrator.
   Performed 5-5-93

Volume = 1.0 ml

Position	Correction Factor
Center	.797
Bottom	.803

Volume = 2.0 ml

Position	Correction Factor
Center	.833
Bottom	.835

Conclusion: Syringe position has only marginal influence on the dose calibrator reading.

3. Effect of radioisotope in syringe needle.
Performed 5-11-93

Note: A small volume (about .07 ml) of radioisotope drawn into the syringe will reside in the syringe needle and syringe itself, and not be part of the volume measurement. This will increase the dose calibrator reading by a few percent over the expected value (which is based on activity/volume) since a nominal 1.0 ml of isotope will actually contain 1.07 ml.

Also this dose from Mallinckrodt was double-checked by their QC department prior to shipment, with no appreciable difference between measured and expected activity being observed.

Volume = 1.0 ml

Needle	Correction Factor(middle position)
On	.820
Off	.847

Conclusion: The "unmeasured volume" effect for the needle alone produces approximately a 3% error for a 1.0 ml volume, and will produce progressively less error as volume increases.

4. Total Unmeasured Volume
Performed 5-18-93

Experiment #3 accounts only for unmeasured volume in the syringe needle, and not the additional unmeasured volume within the syringe. To determine the total unmeasured volume, an analytical balance was used to measure the weight of the syringe (with needle and cap) with and without nominal volumes of 1.0 and 2.0 ml saline. Assuming the density of saline to be 1.00 g/cm , the average unmeasured volume was determined to be .07 ml. Thus a nominal 1.0 ml volume will actually contain 1.07 ml.

5. Effect of Syringe Volume
Performed 5-19-93

The effect of syringe volume was investigated by withdrawing equal volumes of P-32 into Monoject 3cc and 6cc syringes.

Volume = 1.0 ml

Syringe	Correction Factor
3 cc	.819
6 cc	.823

Volume = 2.0 ml

Syringe	Correction Factor
3 cc	.844
6 cc	.853

Conclusion: There appears to be no difference in the correction factor other than that attributable to the unmeasured volume effect referred to in experiment #4. Differences in self-absorption appear to be negligible.

6. Review of Syncor Procedure
Performed 6-3-93

Dr. Burns went to the Syncor lab to discuss assay procedures with Karen Barker. Discussion centered on the function of Syncor's computer program, volume withdrawal method, dose calibrator and settings used, and syringe types used. Findings included:

a. The program output gives the fraction of Mallinckrodt vial to be withdrawn in order to achieve the desired activity. The program corrects for decay from the Mallinckrodt assay date/time only.

b. Karen Barker indicated that she was aware of the "unmeasured volume" of .07 ml, and withdrew her volumes in order to achieve the correct total volume. For example, if she desired a volume of 1.5 ml, she would draw a syringe reading of 1.43 ml. This differs from the BMCO procedure to date.

c. It is Ms. Barker's practice to use 3 cc Becton Dickinson (BD) syringes for volumes up to 1.5 ml, and 6 cc Monoject syringes for larger volumes.

d. Syncor uses the Capintec CRC-12R dose calibrator. For P-32 assays the radionuclide setting is "Other" and the pot setting is 750 (identical to BMCO).

e. We conducted a P-32 assay using a 3 cc BD syringe and obtained a dose calibrator reading which was 3.0% below the expected reading based upon the Mallinckrodt assay.

f. We conducted an experiment to compare dose calibrator response for 3 cc Monoject and BD syringes using a 1.0 ml volume. We found the reading with the Monoject syringe to be 6.1% above the reading obtained with the BD syringe. This experiment was repeated at BMCO the following day, but this time the Monoject reading was 2.0 % below the BD reading. Note that separate withdrawals were required for each of the four measurements.

7. Comparison of Syncor and BMCO Dose Calibrators
Performed 6-7-93

In order to identify any differences in the response of the two dose calibrators, we repeated the assay procedure at Syncor using a 3 cc BD syringe and then had Syncor deliver the same syringe to BMCO. Thus the following variables are held constant between the measurements: syringe type, syringe position, P-32 volume withdrawal technique. Both dose calibrators were carefully zeroed and corrected for background radiation. The Syncor measurement was 5.5 % below the expected result based upon the Mallinckrodt assay.

The BMCO result was 2.7 % below the expected result. The ratio of BMCO to Syncor dose calibrator readings was 2.85/2.77 = 1.029.

8. Attenuation Comparison: Plastic Syringes vs. Glass Ampules
Performed 6-10-93

Dr. Burns was able to obtain, from Mallinckrodt, glass ampules used for NIST-calibrated P-32 reference sources. Note that this is the "packaging" assumed by Capintec in their calculation of dose calibrator pot setting (per Capintec).

A nominal 2.0 ml volume of P-32 (actual volume=2.07 ml) was drawn into a 3 cc Monoject syringe and measured. This volume was then expelled into the 5 cc glass ampule, which already contained 3.0 ml of saline (per Mallinckrodt, the reference source volumes were always 5.0 ml). Residual activity remaining in the syringe was measured, and all readings listed below were corrected for background (reading was 0.01). The data were as follows:

Syringe reading: 8.49
Residual activity syringe reading: 0.27
Glass ampule reading: 7.58
Ratio of syringe/ampule activity = 8.49/(8.49-.27) = 1.033
Ratio of syringe/ampule readings corrected for activity differences = 8.49/(7.58x1.033) = 1.084
Correction Factor to BMCO D.C. Readings = 1/1.084 = 0.922

CONCLUSIONS

BMCO Dose Calibrator Corrections

Corrections to the BMCO dose calibrator readings are required primarily for:

1. differences in attenuation between the glass ampule and the plastic syringe; the glass ampule is the container used by Capintec in their determination of dose calibrator pot settings, while the BMCO assay is performed in the plastic syringe.

2. the unmeasured volume (about .07 ml) of P-32 present in the syringe when the BMCO assays of April 20, 1993 were conducted.

Other variables which are part of the assay procedure may contribute smaller uncertainties to the measurement. These factors include syringe type, syringe position, lot-to-lot fluctuations in activity per volume, and background corrections.

When corrections for attenuation differences and unmeasured volume are applied, BMCO dose calibrator readings agree with predictions based upon the Mallinckrodt assay to within 5 to 7 %. According to Mallinckrodt, the uncertainty in their assay may be up to +/- 5 %; uncertainties in the manufacturers specification of dose calibrator pot settings, and/or drift in dose calibrator

electronics may contribute additional uncertainties. Thus a 5 to 7 % discrepancy may well be equal to the overall uncertainty in the assay procedure.

When corrections for the unmeasured volume are taken into account, the ratio of expected dose calibrator reading to observed reading is about 0.86, this is an average value of several repetitions of the experiment. This ratio is not 1.00 due to several factors described in the previous paragraph, primarily the differences in attenuation between the glass ampule and the plastic syringe. In the future, dose calibrator readings must be multiplied by this factor (and the Capintec-recommended dose calibrator scaling factor of 100) to obtain the true activity within the syringe in microcuries.

Previous Assays of P-32 Received From Syncor

Syncor has, on two occasions, demonstrated the ability to draw doses which were within 6 % of the expected result based upon the Mallinckrodt assay. The results were low by 3.0 and 5.5 % on 6-3-93 and 6-7-93, respectively. As stated previously, Karen Barker was aware of the unmeasured syringe volume and routinely accounted for it as part of her volume withdrawal procedure. Syncor does not account for the difference in attenuation between the glass ampule and the plastic syringe (demonstrated to be about 8.4% for Monoject syringes in experiment #8). This error is partially offset by the fact that Syncor's dose calibrator reading was 2.8 % less than the BMCO reading even with all other known variables held constant (see experiment 7). Taken together these facts both explain the past agreement between Syncor and BMCO assay results, and allow the conclusion that doses received from Syncor have been within +/- 10 % of the Mallinckrodt assay. Thus past administrations using P-32 received from Syncor have not been recordable events.

BMCO Administrations on April 20,1993

On April 20, 1993 two patients were treated with P-32 sodium phosphate. The prescribed activities were 1.5 and 3.0 mCi. The activities received by these patients were 12.9 and 14.0 % less than the prescribed activities, based upon the Mallinckrodt assay. Thus both administrations were "recordable events" as defined by 10 CFR 35.2.