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ANSI Committee N13

Mr. Walter Cool
Occupational Health Standards Branch
Office of Standards Development

OP-713-4

N13.14 (formerly N721)
"Internal Dosimetry Standards for Tritium"

OCT 25 1979

Dr. John W. Poston
Chairman, ANSI Committee N13
School of Nuclear Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332

Dear Chairman Poston:

We have reviewed the comments on N13.14 (formerly N721), "Internal Dosimetry Standards for Tritium", as requested by your memorandum of October 15, 1979.

Consideration of the standard within the guidance that a negative ballot should be cast only when the document in question is less desirable than no standard, leads us to reaffirm our "yes" vote of August 8, 1979. However, the reservations expressed by NRC staff, and reflected in our letter, appear to be shared by a number of the other voters. It would be desirable to request the Working Group to consider the comments and to develop appropriate changes to the standard.

Sincerely,

15/

Walter S. Cool
Member, N13

15/

Dr. John V. Nehemias
Alternate Member

cc: MaryJo McCarrick
N13 Staff Assistant
4720 Montgomery Lane
Bethesda, Maryland 20014

Task No: NA

| | | | | | |
|-----------|----------|-----------|-----------|----------|--|
| OFFICE ▶ | OHSB:OSD | OHSB:OSD | | RHSS:OSD | |
| SURNAME ▶ | Cool:kms | Alexander | JNehemias | RAPurple | |
| DATE ▶ | 10/23/79 | 10/23/79 | 10/22/79 | 10/ /79 | |



SECRETARIAT-ANSI COMMITTEE N13 (RADIATION PROTECTION)

MEMORANDUM

JOHN W. POSTON, Ph.D.
CHAIRMAN, ANSI COMMITTEE N13
SCHOOL OF NUCLEAR ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GA 30332
(404) 894-3724

RICHARD J. BURK, JR.
SECRETARY, ANSI COMMITTEE N13
4720 MONTGOMERY LANE, SUITE 506
BETHESDA, MD 20014
(301) 654-3080

DATE: October 15, 1979

TO: N13.14 Voters

FROM: John W. Poston, N13 Chairman *JWP*

SUBJ: N13.14 (formerly N721)

In accordance with ANSI procedure 4.12.5, enclosed please find an unresolved negative N13.14 (was N721) ballot with comments as submitted by the EPA representative, R.H. Johnson, Jr. In addition, copies of affirmative ballots with comments are enclosed. Please review all these materials and, after careful consideration, notify N13 in Bethesda if you wish to change your vote to negative. Please note that the prescribed time period for this action is 30 days (rather than the usual 60-day period), therefore November 15 is the deadline for receipt in Bethesda.

This is an important standard. I again request that each of you give all the comments careful consideration.

JWP/mjmc

cc: Bryce L. Rich, HPSSC Chairman
MaryJo McCarrick, N13 Staff Assistant
Mary Vaca, ANSI

LETTER BALLOT

ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721
Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

RETURN TO: Health Physics Society, 4720 Montgomery Lane, Bethesda, MD 20014

DUE DATE: August 6, 1979

SHALL THE N13 COMMITTEE RECOMMEND TO THE BOARD OF STANDARDS REVIEW THAT THE REVISED PROPOSED STANDARD N721 BE APPROVED AS AN AMERICAN NATIONAL STANDARD?

I Vote: () Yes () No* () Abstain*

Name JW Poston Signature *John W. Poston*
Print or Type
Organization Represented N13 Date Aug 5, 1979

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over):

see attached comments + J. Auxier

FOR INFORMATION

John Poston -

If I could vote on this, do -
here is what I would do -
and we feel strongly about this -
is in my office now. John

FOR INFORMATION
Hal Butler

2

LETTER BALLOT
ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721

Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

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DUE DATE: August 6, 1979

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I Vote: () Yes

() No*

() Abstain*

Name JOHN A. Auxier
Print or Type

Signature J. A. Auxier

Organization Represented ORNL

Date June 20, 79

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over):

Values in table one are too high for Tritiated water for Bench-top operations. Caveats notwithstanding, the obvious conclusion of those desiring such operations is that it's O.K. to operate w/o surveillance on the bench - These level for tritiated water on the bench should be lowered by at least a factor of 10.

JA

RECEIVED

JUL 9 1979

LETTER BALLOT
ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721

Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

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DUE DATE: August 6, 1979

SHALL THE N13 COMMITTEE RECOMMEND TO THE BOARD OF STANDARDS REVIEW THAT THE REVISED PROPOSED STANDARD N721 BE APPROVED AS AN AMERICAN NATIONAL STANDARD?

I Vote: Yes

No*

Abstain*

Name LARRY A. CROSS Signature [Signature]
Print or Type

Organization Represented American Nuclear Society Date 6/23/79

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over): See comment sheet.

COMMENT ON DRAFT N721

In Appendix C, page 28, 3rd paragraph, the meaning of one sentence is not clear.

If the intent is,

$(H_C \text{ estimated from absorbed HTO}) > 90\% \text{ total } H_C$, then I propose:

"...However, the dose equivalent to the whole body estimated from absorbed tritiated water following an acute exposure to tritiated water is generally considered to be at least 90% of the total committed dose equivalent."

If the intent is,

$(H_C \text{ due to absorbed HTO}) > 90\% \text{ total } H_C$, then I propose:

"...However, the committed dose equivalent from absorbed tritiated water is generally considered to be at least 90% of the total committed dose equivalent to the whole body."

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AUG 10 1979

LETTER BALLOT

ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721

Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

RETURN TO: Health Physics Society, 4720 Montgomery Lane, Bethesda, MD 20014

DUE DATE: August 6, 1979

SHALL THE N13 COMMITTEE RECOMMEND TO THE BOARD OF STANDARDS REVIEW THAT THE REVISED PROPOSED STANDARD N721 BE APPROVED AS AN AMERICAN NATIONAL STANDARD?

I Vote: Yes

No*

Abstain*

Name Marvin K Sullivan Signature Marvin K. Sullivan
Print or Type

Organization Represented Edison Electric Institute Date 8-2-79

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over):

See Attached

(6)

PACIFIC GAS AND ELECTRIC COMPANY

77 BEALE STREET • SAN FRANCISCO, CALIFORNIA 94106 • (415) 763-1000 • BY FIRST CLASS

July 3, 1979

Mr. James E. Sohngen
Edison Electric Institute
1140 Connecticut Avenue, N.W.
Washington, D.C. 20036

Dear Mr. Sohngen:

I have the following comments on the proposed Standard ANSI N721, "Internal Dosimetry Standards for Tritium."

1. Paragraph 6.3.4 - should be eliminated. Reason: unnecessary and confusing.
2. Paragraph 6.3 - should be modified as follows "...bioassay program required by the criteria of Section 5 to assure..."
New wording is underlined. Reason: clarity.
3. Paragraph 6.3.5 - insert "conducted" after "...shall be..."
Reason: clarity.
4. Paragraph 6.4 - "Diagnostic bioassay". This type of bioassay should be defined in Section 4. Is a "diagnostic bioassay" any different than a "routine bioassay" or is it just performed more frequently?
5. Paragraph 8.8 - How is the individual to produce a sample thereafter? Suggest rewording.

Also, is it reasonable to assume that tritium concentration in the urine within one hour of exposure is representative of the average concentration in body water? A far better sample would be a specimen from the morning voiding the day after the suspected exposure.

6. Section 8 - takes a lot of verbage to cover relatively little ground. For instance, I believe the first two sentences of Paragraph 8.13 could be eliminated with no loss of comprehension.

7

Mr. J. E. Sohngen

-2-

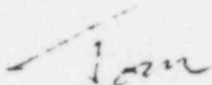
July 3, 1979

Also, are Paragraphs 8.4 and 8.5 really necessary? Perhaps they are misplaced and should be in Appendix B.

7. Paragraph 10.1.2 - third sentence change "Table 10" to "Table 2."

If there are any questions, please feel free to call.

Sincerely,



Thomas A. Jenckes
Radiation Protection Advisor

TAJ:saw

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AUG 6 1979

LETTER BALLOT

ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721

Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

RETURN TO: Health Physics Society, 4720 Montgomery Lane, Bethesda, MD 20014

DUE DATE: August 6, 1979

SHALL THE N13 COMMITTEE RECOMMEND TO THE BOARD OF STANDARDS REVIEW THAT THE REVISED PROPOSED STANDARD N721 BE APPROVED AS AN AMERICAN NATIONAL STANDARD?

I Vote: (x) Yes

() No*

() Abstain*

Name Harry F. Schulte Signature [Signature]
Print or Type
Organization Represented NCRP Date Aug. 1, 1979

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over):

I think this is a very good standard and hence have voted in favor of adoption. As a recent addition to the N13 Committee I do have a few comments which I would appreciate having passed on to the Committee who wrote it. On page 4, paragraph 4.2 I don't like the term "quantity of radioactivity". This implies that radioactivity is a thing when it is really a process.

I cannot really understand paragraph 8.8

In paragraph 8.10 the term "standard error" is used. This is really an ill-defined term and if "standard deviation" is meant that term should be used. Actually, since the result is expressed in percent it should be "relative standard deviation" or "coefficient of variation."

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In appendix A, last sentence of third paragraph.- The wording "Hood is judged to give 10X the protection" is somewhat unclear. 10X the protection of what? It really means that it assumes that the hood will reduce the uptake to 0.1% or it reduces the uptake by a factor of 10 below that assumed where no hood is used.

These comments are merely points of clarification and not of substance and that is why I voted in favor of adoption.

RECEIVED

JUL 9 1979

LETTER BALLOT
ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721

Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

RETURN TO: Health Physics Society, 4720 Montgomery Lane, Bethesda, MD 20014

DUE DATE: August 6, 1979

SHALL THE N13 COMMITTEE RECOMMEND TO THE BOARD OF STANDARDS REVIEW THAT THE REVISED PROPOSED STANDARD N721 BE APPROVED AS AN AMERICAN NATIONAL STANDARD?

I Vote: Yes () No* () Abstain*

Name T. P. Loftus Signature *T. P. Loftus*
Print or Type
Organization Represented Dosimetry Group, Nat. Bur. of Standards Date July 3, 1979

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over):

- p. 4 The term "Dose Equivalent" should be defined.
- p. 5 5.1 This is very difficult to understand, perhaps because the last sentence contains about sixty words.

Shouldn't terms be defined before they are used. Why should it be necessary to look in section 6 for the definition of a term used in section 5.

How can the preparatory bioassay which is a "base line" measurement affect the uncertainty in estimating the total dose equivalent.
- p. 7 I don't understand the need for the "Quantities tabulated are:".
- p. 9 The last sentence implies that the committed dose equivalent is reduced by repeated measurements.

- p. 12 8.8 . . . "and produce a sample thereafter."?
This phrase should be clarified or deleted.
- p. 13 9.2 This part is very difficult to read and understand. It
sounds as if one estimates an upper limit to the dose equivalent
in order to choose a method for estimating the dose equivalent.
It sounds bootstrappy.
- In the last sentence it reads as if you receive a dose from the
bioassay results.
- p. 14 9.4, line 4. Is it the accuracy of the method that is to be
confirmed or the method itself?
- 9.5 Definition of Hc should read, " . . . equivalent calculated
from . . . "
- p. 15 9.6 Equations 1 and 2 are inconsistent.

The rest of the standard appears to be in good shape, although I have the
same problem with paragraph 3 in Appendix C as I had with section 9.2.

I have not checked the equations after Eq. 1 and 2; I will leave that to
those who are expert in this field.

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AUG 10 1979

LETTER BALLOT

ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721

Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

RETURN TO: Health Physics Society, 4720 Montgomery Lane, Bethesda, MD 20014

DUE DATE: August 6, 1979

SHALL THE N13 COMMITTEE RECOMMEND TO THE BOARD OF STANDARDS REVIEW THAT THE REVISED PROPOSED STANDARD N721 BE APPROVED AS AN AMERICAN NATIONAL STANDARD?

I Vote: () Yes

No*

() Abstain*

Name Raymond H. Johnson, Jr.
Print or Type

Signature Raymond H. Johnson, Jr.

Organization

Represented U.S. Environmental Protection Agency

Date Aug. 2, 1979

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over):

(see attached comments).

RAYMOND H. JOHNSON, JR.

U.S. ENVIRONMENTAL PROTECTION AGENCY

Stephen T. Bard

Comments on ANSI-N721 Standard

Internal Dosimetry Standards for Tritium

General Comments

These standards are developed on the premise that tritium (HTO) is eliminated from the body with a ten day half-time. Since approximately 33% of the body hydrogen is associated with an organic fraction and it has been determined that there are two long-term compartments, some attempt should be made to account for this in the standard. This could be accomplished by using a simple three component exponential model for acute exposures and a specific activity approach for chronic intake. If the committee feels that this unnecessarily complicates the method, then the additional dose commitment from organic labeling could be accounted for by increasing the quality factor by an appropriate value.

In its present form, the dose model, which is based upon bioassay data, will always result in an underestimate of the dose commitment.

Specific Comments

Section 9.0 Interpretation of Bioassay Results.

Equations 1 and 2 of Section 9.6 provide an estimate of the whole body dose commitment to body water from an acute intake of tritium. It does not, however, consider the dose received to tissues due to organic labeling from HTO.

Consider an acute ³H intake resulting in a urine sample containing 10 Ci/liter (C₀). The predicted dose commitment from equation 2 (C_{T=0}) would be:

$$H = 4.2 (10 \mu\text{Ci/liter})$$

$$H = 42 \text{ mrem}$$

In order to compare this to the dose commitment from organic tritium this may be rearranged into the integral form:

$$\frac{10 \mu\text{Ci} - \text{days}}{1 \text{ kg} (0.069)} = 145 \frac{\mu\text{Ci} - \text{days}}{\text{kg}}$$

$$T_{-1/2} = 10 \text{ days}$$

$$1 \text{ liter} = 1 \text{ kg}$$

The kinetics of organic tritium labeling from acute HTO body water burdens.

It has been determined from the work of Snyder (Sn-68), Sanders and Reinig (Sa-65) and Bennett (Be-72) that hydrogen from body water is incorporated into two relatively long term hydrogen pools with half times of about 45 days and 400 days at the rate of about 0.055 liters (H₂O) and 0.01 liter (H₂O) day respectively.

At equilibrium, these two pools would consist of about 1000 gms of hydrogen derived directly from body water.

$$Q_2 = \frac{0.055 \text{ liters H}_2\text{O}}{\text{day}} \times \frac{111 \text{ gH}}{\text{liter}} \times \frac{45 \text{ days}}{0.693} = 400 \text{ gH}$$

$$Q_3 = \frac{0.01 \text{ liters (H}_2\text{O)}}{\text{day}} \times \frac{111 \text{ gH}}{\text{liter}} \times \frac{400 \text{ days}}{.693} = 640 \text{ gH}$$

Total 1040 gH

The uptake of ³H into these two compartments from a 10 μCi/liter acute body water burden concentration would be calculated as follows:

$$\frac{10 \text{ } \mu\text{Ci}}{\text{liter} \times 0.069 \text{ day}^{-1}} = \frac{145 \text{ } \mu\text{Ci} - \text{day}}{\text{liter}}$$

Then:

$$Q_2 = \frac{145 \text{ } \mu\text{Ci} \cdot \text{day}}{\text{liter}} \times \frac{0.055 \text{ liter}}{\text{day}} = 8.0 \text{ } \mu\text{Ci}$$

$$Q_3 = \frac{145 \text{ } \mu\text{Ci} \cdot \text{day}}{\text{liter}} \times \frac{0.01 \text{ liter}}{\text{day}} = 1.45 \text{ } \mu\text{Ci}$$

Estimated "tissue" dose

These two long-term compartments are not likely to be tissue specific, however, if we consider tissue to be 10% hydrogen by weight, the associated tissue mass would be:

$$Q_2 = 400 \text{ gm H} / 0.10 = 4.0 \text{ kg tissue}$$

$$Q_3 = 640 \text{ g H} / 0.10 = 6.4 \text{ kg tissue}$$

The time integrated activity would then be:

$$Q_2 = \frac{8 \text{ Ci} \times 45 \text{ days}}{4.0 \text{ kg} \cdot .693} = \frac{133 \text{ } \mu\text{Ci-days}}{\text{kg}}$$

$$Q_3 = \frac{1.45 \text{ Ci} \times 400 \text{ days}}{6.4 \text{ kg} \cdot .693} = \frac{130 \text{ } \mu\text{Ci-days}}{\text{kg}}$$

Labile Hydrogen

It was estimated that there are about 1000 gms of hydrogen associated with the two long-term compartments. Since there are about 2400 gms of organic hydrogen in the body we can make the conservative assumption that 1400 gms H(2400-1000) are in labile positions and readily exchange with H₂O (or HTO). The dose commitment of this 4th compartment is:

$$\frac{10 \mu\text{Ci liter (H O)} \times 1400 \text{ gH} = 126 \mu\text{Ci}}{2}$$

Liter x 111gH

$$1400\text{gH}/0.10 = 14 \text{ kg tissue}$$

$$T_{1/2} = 10 \text{ days}$$

$$Q_4 = \frac{126 \mu\text{Ci} \times 10 \text{ days}}{14 \text{ kg} \cdot .693} = 130 \frac{\mu\text{Ci-days}}{\text{kg}}$$

In summary each of the four hydrogen compartments would receive about the same dose commitment:

$$Q_1 = 145 \frac{\mu\text{Ci-days}}{\text{kg}} = 40 \text{ mrem}$$

$$Q_2 = 133 \text{ " " } = 40 \text{ "}$$

$$Q_3 = 130 \text{ " " } = 40 \text{ "}$$

$$Q_4 = 130 \text{ " " } = 40 \text{ "}$$

$$\text{Total} \qquad \qquad \qquad 160 \text{ mrem}$$

It seems, therefore, that the dosimetry of tritium in the body is not quite as simple as it appears and that the use of a one compartment model will always underestimate dose commitments even from acute intakes of tritium.

Section 9.6

Equation 1 calculates the dose equivalent (4) between bioassay samples while the action guides appear to be based upon the infinite

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dose commitment. It might be advisable, therefore, to insert an equation (1.5) between 1 and 2 for calculating the total dose commitment when C_T does not equal zero.

$$H = 0.3 C \frac{0}{R} (1 - e^{-kT})$$

(eq. 1.5)

where: $k = \ln C / C$

$$\frac{0}{T}$$

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9.4 2 uCi/liter Zero Cutoff.

The use of a 2 uCi/liter zero cutoff contradicts the action guide lines established in Table 2. A chronic 2 uCi/liter body water burden is about 10% of the present maximum occupational limit with an associated dose rate of 0.5 rem/year. It would therefore appear permissible to allow a chronic dose rate of 0.5 rem/year to go unrecorded while an acute dose commitment of 0.5 rem requires some remedial action.

A zero cutoff should be eliminated or reduced to a limit where it does not conflict with the action level guides.

10.1.1 For Purposes of Preparatory Evaluation

This section states that the previous radiation history of new employees will be reviewed and that this will include the results of new bioassay data. The kinetics given in Section 9.0, however, are not sufficient to evaluate dose commitments for some former tritium workers returning to the industry.

Figure 1 is a long-term tritium excretion curve from a former tritium worker. Sampling was initiated about six months following termination of employment. A specific activity model from the results of the first sample (0.055 uCi/l) would indicate a body burden of:

$$0.055 \text{ uCi/liter} \times 43 \text{ liters} = 2.4 \text{ uCi}$$

The actual body burden at $t = 0$ is, however,:

$$Q_3 = \frac{0.055 \text{ uCi/l} \times 3 \text{ l/day}}{0.002 \text{ day}^{-1}}$$

$$Q_3 = 83 \text{ uCi}$$

It was calculated in the previous section that this long-term component (Q_3) was associated with about 6.4 kg of tissue so that the time integrated unit weight concentration would be:

$$\frac{83 \text{ uCi} \text{ day}}{6.4 \text{ kg} \cdot 0.002} = 6500 \frac{\text{uCi} \cdot \text{day}}{\text{kg}}$$

This is significantly higher than if it were assumed that 2.4 uCi were distributed equally throughout 43 kg of water with a 10 day half-time:

$$\frac{2.4 \text{ uCi} \text{ day}}{43 \text{ kg} \cdot 0.0693} = 0.8 \frac{\text{uCi} \cdot \text{day}}{\text{kg}}$$

It is thus possible to underestimate a unit tissue dose by a factor of 8000 in this instance.

References

1. (Sn-68) W. S. Snyder et al. "Urinary Excretion of Tritium Following Exposure to Man to HTO - A Two Exponential Model," Physics in Medicine and Biology, 13, 547-559 (1968).

2. (Sa-65) Sanders, S. M. and Reinig, W. C. "Assessment of Tritium in Man," "Proceedings of Diagnosis and Treatment of Deposited Radionuclide Symposium," Richland, Washington, May 1965.

3. (Be-72) B. G. Bennett. "The Radiation Dose Due to the Acute Intake of Tritium by Man," HASL, 1972.

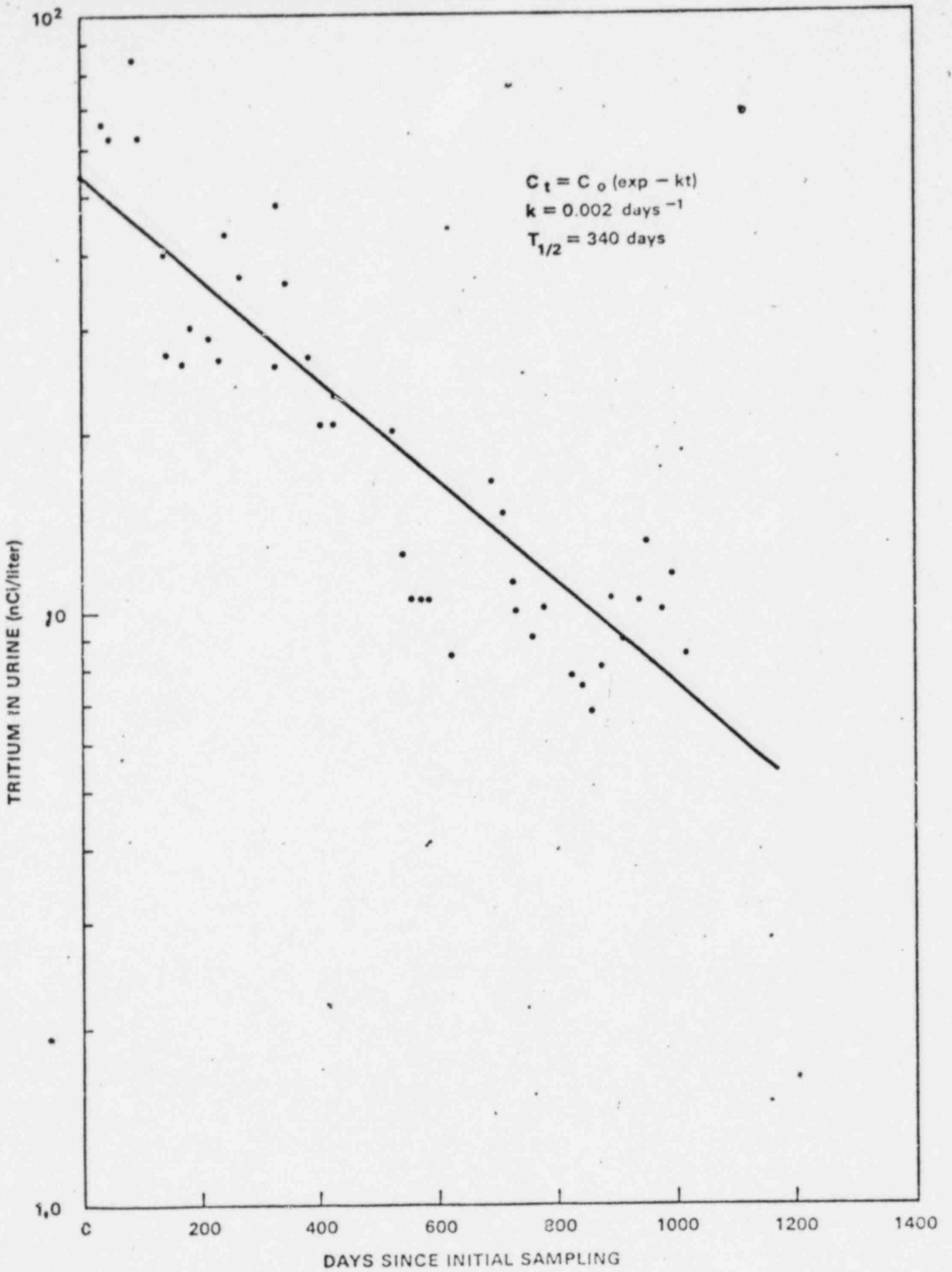


FIGURE 1 LONG TERM TRITIUM EXCRETION DATA (MOGHISSI 1978)

LETTER BALLOT
ANSI COMMITTEE N13

Topic: Final Approval of Proposed Standard N721

Internal Dosimetry Standards for Tritium

Authorized By: John W. Poston, N13 Chairman

Distributed By: MaryJo McCarrick, N13 Staff Assistant, on June 5, 1979

RETURN TO: Health Physics Society, 4720 Montgomery Lane, Bethesda, MD 20014

DUE DATE: August 6, 1979

SHALL THE N13 COMMITTEE RECOMMEND TO THE BOARD OF STANDARDS REVIEW THAT THE REVISED PROPOSED STANDARD N721 BE APPROVED AS AN AMERICAN NATIONAL STANDARD?

I Vote: Yes

No*

Abstain*

Name Walter S. Cool Signature Walter S. Cool
Organization Dr. John V. Nehemias ^{Print or Type} John V. Nehemias
Represented U S Nuclear Regulatory Commission Date 8/8/79

*If checked, explanatory remarks need be provided in the COMMENTS Section.

COMMENTS (below and over):

↓
Follow

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COMMENTS ON THE MAY '79 REVISION OF N721

On page 15, in equations 4 and 6, we would have preferred to have the half life shown, either as a number or even $T_{1/2}$. This would have made it a bit easier for users who may choose to follow the excretion of the individual involved and to calculate the dose to the individual based on the observed half life. Further, it would be of some help to express the equations such that it is very clear which items are included in the exponential functions.

On page 20, lines 6 and 7, it would be helpful if the words "if any" could be added to read: "...All special dosimetry evaluations shall be dated and signed by the person making the evaluation and computerized records, if any, shall be traceable to the responsible person." The intent of the change being to avoid any implication that computerized records are required.