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PUERTO RICO NUCLEAR CENTER

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?THERMOLUMINESCENCE DOSIMETRY IN

NORTHWEST PUERTO RICO

By

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and

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July 1, 1975

OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

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Dedication:

?hie contribution is respectfully dedicated to Dr. F. G-

Loman, Associate Director, Puerto Rico Nuclear Center

for hie help and advice in its formlation ani execution,

ACTON LEDOIMERT

In a progran of the scope described herein, there are many contributors, not all of whom can be considered directly responsible for the program, but without vhom, the program could not have been

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---Page Break---

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processing work which we rec

Computer Center, UPR, Ric Pit

members:

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(CHAPTER

?THE RADIOLOGICAL SURVEY

yy

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A, Introduction

?Thermoluninescent dosimetry (TID) has been described most succinctly by Cameron, Suntharalingan and Kenney (1968). The idea ?hat ionizing radiation danage in doped crystal material could be used as a basis for radiation dosimetry appears to have originated with Dantels (2950). ?The basse physical phenomenon vhich is used for TID can be adequately described by 8 crude crystal model as follows:

Tonizing radiation impinging upon certain crystalline material can create meta-stable states above the ground state (vatence band) and below the conduction band and cen Liberate electrons which can populate these states. Subsoquent ennealnent of the material caus

?the electrons to return to the ground state (valence

end). This repatriation of electrons is accompanied by the enisaion

of vistble Light of frequency deterninea by the energy difference

between the metastable state (trap) and the valence band.

?Tous, the acount of radiation which has been received by the

material can be inferred by measuring the azount of Light enitted (TL)

ty the material upon subsequent annealnent, This technique has evolved

tnrough @ sertes of studies using materials such as lithiua fluoride

(Lip) (Danieis soyd and Sanders, 1953), calcium fluoride containing

mall ancunts (?W 1f) of manganese (Caf,:Ma) (Ginther and Kirk, 1957)

and nore recently, calciun fluoride doped with small anounte of

aysprosiun (Ca¥g:Dy) (Lindeken, Jones and MeMilien, 1971; Lebrén, 1974).

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tn October, 1973, the Puerto Rico Water Resources Authority

sought the initiation of studies ained at determining tacksround radso-

logical characteristics of the northwestern quadrant of Puerto Rico.

Sone of the studies were required for supporting data for the environ mental report submitted ae part of the lincensing procedure in the establistment of themonuclear electric power generation facilities in Barrio Islote, Arecibo, Puerto Rico. (Pig. I). Previous studies of radiological characteristics of the area include the "Acroradioactivity Survey and Geology of Puerto Rico (AM9-1)" (Mackalior, 2966) wich ?consisted in mapping the radioactivity emanating fron the surface of puerto Rico using sodium iodide sensing equipment in an airplane flying at an altitude of 500 ft, The results are expressed in counts per second, and provide useful comparative levels for radioactivity observed in various sections of the Island.

?me only thermoluminescent TL studies yet undertaken in Puerto ico in conformance with Environmental Protection Agency requirenents that the dose measurement be made at a heighth of 3 ft. were those under- taken for the environmental report of Aguirre, Puerto Rico (Westinghouse

Biectric Corp., 1972), end the FRNC preliminary data evaluation for the

environmental report of Islote (Puerto Rico Water Resources Authority, Ag7h), Retimates of human dose equivalents in Puerto Rico have also

?been made and partially checked using TID (Lebrén, 197).

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Station Deseriptions

?The stations elected for study were believed to be located in directions in vhich natural (or accidental) plant emissions from Iolote would travel. Thus, the prelininary data base could be useful ?paseLine data for comparison with measurenents obtained during meclear plant construction at Islote, or after such @ plant vere put into operation

?the low-lying vegetation, tree bole direction as well as the Airections assuned by wind-swept pala boles all indicated low elevation win Girection in the prevailing on-shore trade wind @irections. Thus wind currents were assuned Girected predominantly toward the western south western, and south-south western parts of the island. Subsequent wind rose data taken within the proposed exclusion sone have supported ?these observations in full, at all altitudes (Puerto Rico Water Resources Authority, 1974).

The full station descriptions including the approximate distances from the proposed plant site st which dosimeter pairs were placed is shown in Table 1.1. All station locations except Barceloneta, Florida Adentro

?and Islote vere located in prevailing wind directions fron Ielote. Barceloneta and Florida Adentro lie in directions off the principal wind vector @irections, but date from these areas can be useful for comparison with umsual climatological conditions or aberrations in the ?usial air mass flow, ?Thue virtually complete land-side dosimetry was carried out. ?The relative locations of the stations can be inferred from

Fig. IT.

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©. Experimental Design

?The comercially available Harshaw-2000 TLD reader was the

This instrument consists

asic instrument used with CaF: Dy dosimeters,

of two parte. The detector part has heating planchet on which the 3/4

x 1/k inch square dosimeter 1s heated for given period of time between carefully paintained temperature Limits. In the experiments carried out ?the heating eyele wes for @ 30 second period, with initial heating of

?the platinum planchet from lo?C to 2ho"C in approximately 10 seconds followed by approximate 20 ceconds at the 240°C temperature level. Al).

calibration and field doce T's received precisely the sane temperature progran described. The light emitted by the dosimeter upon heating {s sensed by a photomiltiplier tube.

?The second part of the instrument measures the current from the photomiltiplier tube and integrates {t over the thirty second temperature ?program, ?Thus the TL read by the "integrating picoameter? is in photo-miltiplier charge or current-tine units. These current time units can only be related to the radiation dose received by the dosimeter 1f the nachine is calibrated using dosieters exposed to precisely known tonizing radiation doses before the field dose is accumlated.

?The calibration of dosimeters vas carried out using a Ce-137 source fa inom distance (75 inches) from the dosimeter which was packed ina lack plastic bag. Details of the PRI Cs-137 standard source activity, determination can be obtained from Mr. Santiago Gémez, Health and Safety

Division, Puerto Rico Nuclear Center. Inference of source dose was obtained

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?froa the fact that on Nov. 25, 197, the source dose at 75 inches was 7.8150 aR/hr

Dosineters were calibrated by exposing then to the Cs-137 source for three different periods of tine estimted to give doses

which upon readout woulld show TL's in the range in which fielé exposed

dosimeter Tl's lay. Conventional exposure times were between 11 and

72 minutes, ALL TL readouts, both on field exposed and calibration

exposed dosineters were carried out with dry nitrogen gas purging of

the detector systen. This refinenent is absolutely necessary vhen

ow dose (background) dosimetry is undertaken.

fonealnent of dosimeters was necessary both before field

placenent and before readout. A typical exposure cycle was as follows.

?me dosimeter wes annealed for 1 hr. at 400°C and exposed to the first

calibration dose. Tt wae then maintained in lead shielding (1 1/2 inches)

tor 24 hours and then ennealed at 80°C for 15 minutes. After cooling,

i vas readout over the 40°C - 240°C temperature program. The sane cycle

was repeated for calibration doses using txo different Ce-137 source

expomure times, each of which was different from the first exposure time.

?then the dosineters vere annealed and placed in field mounts for a minim

field exposure duration of 2h days.

?The field packs for mounting the dosineters consisted of ultra

low background polyethylene neutron activation vials. Tyo dosimeters

separated by @ short styrofoam plug were placed in each vial with @ onalt piece of paper containing identification or eross referencing data. The

vial vas tightly sealed and encloged in a layer of black plastic electrician

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First, the CaFs:Dy chip 1s not equally responsive to tonizing radiation of all types and all energies, and Ls mainly responsive to gamma and x-rays. Second, the TL emission of a CaFz:Dy dosimeter tends to fade with time.

one altemative to the ionizing radiation energy problea is to enclose the CaF: Dy dosineter vial in a leed sheath of .002 inches Aianeter end a tantalum sheath of .O1 inches. This alternative could not be undertaken within the time pemitted for the measurements, thovgh ?a correction involving the ratio of TL for a typical TWD mm with and without the sheath has been written into the comuter progres, Thus all future date obtained using the sheathed configuration can be compared with the data presented herein.

|A somewhat more conventional procedure is to assume that the energy Gistribution of gamma and x-rays in the environment is very nearly ?the sane at the 3 ft. level over ali time and that a simple factor mlti-

plied by the measured Co-137 aR equivalent will correct for the change in energy response and stopping power of CaPy:Dy when exposed to natural ?vackground radiation, ?Thus, miltiplication of Cs-137 ek equivalents deduced tron the vbserved TL after field exposure by the factor 2.5 yields the effective dose absorbed in mr (Lindeken, Jones and McMillen, ign).

?wo @ifferent approaches my also be used for the fading cor~ rection. Lebrin (197i) applied a 20% increase to the measured dose based on the signal loss observed when dosineters vere exposed for 1/2 of &

standard tine interval and then shielded in lead for the renainger of

a

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of the tine, The measured "1/2-dose" was compared with the dose measured on dosineters exposed for the full tine interval.

Alternatively, one may use @ fading correction which stays rel- atively constent after the first 2% hours, deduced from the fading data of Derhan, Kathren and Corley (1972). Their data indicates that for ex- potures in excess of 2b days a correction of 164 £ af is realistic for caFpiDy. ?The field exposures were over periods in excess of 2 days, and many were in exces

ef the 33 day exposures by Lebron (1974). Thus the correction referred to as the "Denhan correction" in this report 4s an upward adjustment of 164 of the indicated dose,

Di Results and Discussion

?the recults are summarized in Tibles 1.2 - 1.5. The measured dose rates which passed the rejection tests applied in computer prograst ?TUDCALC are grouped according to the station in vhich the pairs were Located, these tables also give percent uncertainty in dose rate as calcu ated using the ansiysis in Chapter II. The mean dose rate for all dosimeter pairs associated with a particular station and the estimated uncertainty in the mean of the tvo values of each pair plus the mean estinated uncertainty for ali the pairs 4s also given.

?The values for Arecibo indicate rather low dose rat

Data collection in Arecibo was difficult because of the anount of pilferage, vandalism, or other losses of dosimeter vials oustained ven dosimeters vere set out for extended periods. The area from wich the data were

collected vas approximately two square miles. Highest and Lowest, doses

fare reasonably close and the standard deviation of the pairs over the

vurveyed it not Large (Table 1.6).

we

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?The four stations: Ielote, Arecibo, Arecibo Airport end Barce-

oneta gave substantially the amne dose rate of 100-200 eps during the

?AWS-1 survey (Mackallor, 1956), and within experimental error, the monn

?up readings at the 3 ft. level reflect similar dose rates for those four

stations, he mean TLD reading for Florida Adentro, Charco Hondo and Dos

Bocas also are consistent with the ARMS-1 survey as are the Lares, San

Sebastién and quebradiiies stations.

?Te Mayeguez station exhibits a doserate vhich is still reason-
able compared with ARUS-1 within the Limits expressed by the mean standard deviation (Table 1.6), though slightly on the high side. It is suggested that this my be due to the fact that the area surveyed in Mayaguer was rather Linited end a more widespread survey of the Mayaguez area such as ?the ARIS-1 survey might reveal e somevhat lover TLD dose than is indicated here.

Zt should be noted that the highest dose rate recorded during the ?TWD survey of Aguirre wae at Sabana Liana (11.'-11.5 Micro-rad/tir) and ?the lowest was recorded at a dairy north of San Felipe in this region (7,107.5 Miero-red/iir.). Tn no case aia any of the data taken in the present study exceed about 17 Micro-rad/hr, with average values substantially velow this value.

?the TID dose rate profile is, perhaps, better visualized by refer~
ring to Fig. TT. The route mubers of highways and secondary roads elong

ich dosimeters were placed are given in parentheses. The large type

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numbers beneath the station names are the mean doses for the stations

sampled, the areas encompassed by a station can be approxinated vy sub-
?tracting the values given for station sampling distances in Teble 1.1.
?Throughout this anslysis, the fading correction preferred has deen that given by Dexham, Kathren and Corley (1972) rather than Lebron (A974) vecause the following experiments indicated that even heavy lead

shielding unle:

?used under well-controlled conditions, may not keep the

caFz:Dy dosimeters from being exposed.

At each station, three lead blocks vere stacked up. Each

Lead block was efroular, 6 inches in aianeter and 3 inches thick.

?The center block had a amall hole érilied through the center Just
?wide encugh to contain a vial in vhich were two dosimeters. These

setups are referred to as "STD" in Appendix II. At the beginning of

a particular time interval, a pair of dosineters was placed inside this shielding and retrieved when the other dosineters in the station were

retrieved, Sonetines the indicated dose of these ?shielded? pairs was as

high asl Micro-rads/irand was never less than 0.7 Micro-rads/hr, Thus,

corrections based upon maintenance of dosineters with lead shields after

being exposed for 1/2 of the exposure period sean to be subject to sone

uncertainty.

These results also indicate that the assumption in the error

analysis (Chapter IT) thet at zero dose, sero TI, will be cbserved may not

be at all correct. It is clear that uncertainties in the lower dose

ay

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neasurenents (approximately the sane order as the measurenents thenselves)

indicate that regression data used to test higher measured field doses 1s

suspect vhen attempts are made to extrapolat

?thes for use st the lover

doe

In view of this observation, it is felt that future measurements

ought to make use of statistical sorting of dosineter pairs or trios such

?as that used by Lebrin (197), oF ultra low dose data for error and

rejection analyses should be taken.

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Fig. TZ. Map of Puerto Rico Showing the Location of Barrio Islote,

?the Propose ivclear Plant Site and Distance (in Km.) to

Major Coaetal Towns and Cities.

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PUERTO RICO WATER RESOURCES AUTHORITY

NORTH COAST NUCLEAR PLANT

UNIT NO. 1

BACKGROUND RADIOLOGICAL SAMPLING

LOCATIONS AND PROPOSED SITE

FG 281

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Fig. IT. Map of Northwest Puerto Rico Showing Approximate

Station Locations, Rosds and Highways Along Which Dosineters

were Placed (in Parentheses), and Mesn T1D-Weacured Doserates

(Large Type Beneath Station Names).

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Table 1.1

Station

Arecibo

Arecibo Airport

Barceloneta

chareo Hondo

Dos Bocas

Florida Adentro

Islote

Laree

Mayacue,

Quobradiitas

San Sebastian

15-20

B22

an-e5

Direction from

woR0-1 Site

WWF

sw

BSE - 8

WoW = Si

ssw

ser -8

Within Exclusion Zone

sw

ww

«

wow

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able 1.2

cums, ae tie

St, Bie, ?SSE

min ar Ente, (ene

Arecibo + 3% 6.23 +h

2

21g

185

Airport 6.630 + 20% 8.09, +1

009

6.665 20h

7179 1h

13.634 1

9.598 16

8.7 1%

22.168 1h

ie 4

8.708 Wh

6.12 1S

6.057 1

6.089 1%

7.694 1%

?Barceloneta, 5.758 + 2m 6.

Bs

iB 8

6.269 ah

?+ Using the ndeken-Denban corrections to the measured do

---Page Break---

?Table 1.3

Estimated Mean Moan Estimated

Uncertainty Dose Rate ?Uncertainty

Dose Rate Micro Dose Rat

t 4 9.98 +i%

1%

ih

ah

Dos Hocus + 8.95 119%

Florida + m6 sam

Raentre

BRUSRRRSRLE BRARRA

+ Using the Lindeken - Denham corrections to the measured dose.

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?Table 1.4

Islote 10.607,

8.906

9.696

8.271 Wh

1.825 Gh

etd ct

8.260 a

81460 1%

9.429 1h

9.227 xg

11.507

4.221 2

Tares: 1-559 + 20% 10.74 41%

8.594 18

7.960 1b

11.29, ls

7.833 1%

kg 1

11.553, 1h

13.085 1

a0tli90 im

e225 cred

9.061 Ft

16.982 ws

Mayasues 8.612 ax 9.32 +186

1.235 2,

ek 20h

8.650 wh

nize i

io.t03 xm

12.463 a

4 sing the Mndeken - Denha corrections to the measured dose.

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able 1.5

Catcuiated

Dose Rate®

Station Micro

uebraaitias

San

Sebastian asa

Estimated.

10.67

Mean Estinated

Uncertainty

Dose Rate

+t

« Using the Lindeken - Denhan corrections to the measured dose.

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a et (02-00T a6 conte seer onsasoy,

4 we ?00-008 Secor appret gear serryrezaerd

a Ag't 006-002 igor oeL"et oun? upriewaes os

a we 005-05 nurot EIT esgre soe

9 out 0-008 68 eoo'tt we'9 swo0g s0q

6 get 08-002 66 ert eh opto oozwuy

a eve ose-008 49° 196" 910"9 oxsuapy WPHOTS

4 60 03-00 19 6leh eres ?vouopeora,

x wre 008-00 60"e negret 1s0"9 qaodsty oarooxy

? ert (002-00T 9 mee art oayoery

a et 02-00% we wos" ee"h syorst

(voysar3ea)

SAAT THERE OFA gE OT TT OT Sea COFRTS

?380g Jo suoyyuaxosgg oTHUTS Jo /squmOD ?90H ?29m 9800 ?S9y 9800

oxyeg Jo "ou UOFaBTASG ?Pas WueR ?O8OT T-SHEY co *sa9 3800]

Ort ores

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(CHAPTER II

SOATISTIONL VARIATION OF CaP, Dy: DOSIMETER (710-200)

RESPONGE UNDER TABORATORY CONDITTONS

wy

Artinar MeB. Block

Marto D.banus

Bagardo Hernéndez uéndes?

Rolando Mosquera Moreno?

Karl P, Prado!

ant

Pélix Santos Hernéndex

ABxperimental work carried out in partial fulfiliment of the

Master in Public Health Degree offered in Radiological Health,

Medical Physics Progran, Dr. E. 7. Agard, Director.

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Introduction and Sxperiment Description

In order to determine the uncertainty associated with car2:Dy

(11p-200) dosimeter data for non-statistically-sorted groups, the following

experiments were carried out, A group of 10 dosimeters (5 pairs) were

?exposed to know doses of gama radiation using the PRNC Co-137 source.

?The first dose selected was approxinately 2.75 mk, the second

7.75 aR. and the third 13.25 mR. The 10 dosimeters vere taken through

?the following cycle 5 times at each do ?Ames at 400% for 1 hour prior to irradiation, 2. Irradiation, 3, Storage for 2b hours in lead shielding. 4, Anneal at 80°C for 15 sinutes prior to thermoluminescence readout. 5. Readout over @ 50°C to 2N0C temperature range. Since the dosimeters are Light sensitive, care was exercised to exclude visible Light during handling and processing.

?The variation within the group of 10 as a function of dose was then evaluated. The variation of dosimeter pair values vas also of interest since field measurenents vere undertaken vith pairs of dosimeters rather than vith single chips. The mean response per dose of single dosineters and for dosimeter paire wat of interest at the three doses because field doses below the lovest dosimeter calibration dose value were inferred by Linear extrapolation from the low dose value to zero dose (zero TL). Likewise the doses which were sbove the highest calibration dose were ?also inferred from extrapolation using the intermediate and the highest

dose thermoluminescence (TL) response points to obtain TL response vs dose slope. this slope wae preemed to hold at higher field doses provided ?the doses were not excessively high (i.e. less than twice the highest

calibration dose).

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?The raw TL responses for the 10 dosimeters in the five experi- ments at each dose are presented in Tables 1, 2 and 3. Dosineter pairs fare taken to be consecutively mumbered (i.e, 1&2, 3&4 etc.). ?the arithmetic mean TL response of all 10 dosimeters, and the standard deviation on @ single Th-response from the entire group at each exposure is also tabulated. Also, the reproducibility of M-reeponse for all 10 dosimeters exposed 5 times to the sme dose is evaluated by calculating the ean TL for the 5 equal dose exposures and the standard deviation of © single TL response at a given exposure in the 5 exposure series. This latter quantity is probably most important in determining whether or not Pairs of TL values for field exposures ought to be rejected on the basis

of failure to lie within reasonable statistically variable Limits:

B, Rejection Paraueters for Field Dose Determinat son

Implicit in any criterion for rejection of pairs of T-values is an acceptance of sose absolute calibration value or a group of absolute calibration values in the absence of a known scaling factor (Linear or non-linear). Our criterion for rejection of field docimeter readings is dased on the TL-indicated Cs-137 equivalent doee in aR and our assumption of absolute values involves an acceptance of the (2-137 standard source values given.

A cursory inspection of the standard deviations of single chips ?exposed to particular levels of radiation (Tables 1, 2 and 3) indicates ?hat, with the possible exception of the highest dose, a simple differen ?ial propagation of uncertainties (Daniels et al, 1952; Pugh and Winslow,

2966) in the pair means is a slight over-simplication of the problem of

estimation of uncertainties were it not for the fact that no weighted

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function is used to calculate the pair means. A simple arithmetic function

io used vhich does not dmply differentiel multipliers other than unity.

?The caloulated propagated uncertainties in TL using pairwise averaging

are given in Table 4 as a function of dose, with the average uncertainty

for the pairs.

In practice the uncertainties calculated can be used by fitting

?the dose to the TL values using © known functional dependence, In the

?low dosage region, this functional dependence 4s very nearly Linear, Thus

?the TL per unit dose are isk, .W52 and .49h for the doses of 2.71, 7.676

and 13.158 aR respectively. Assuming zero TL with zero dose, convenient,

?equation for dose as a function of Tt is:

@)o-eB som som

in which D is the dose, TE is the measured thermoluninescence and a, b,

and ¢ are constants. Using the dose end TL-values from Table 4, a, by and

gare .0O7ELB, -.027871 end 2.225703 respectively.

of greater importance is the variation of uncertainty in Tt

Feadings with dose changes and variations in uncertainty of indicated

dose with changes in observed TL for the field-exposed dosimeter. In

this case, © convenient equation which takes into account nen-linear

changes in uncertainties is a quadratic equation for /\ Tf, the deviation

in themmoluminescence associated with an cbserved TL level, Expressing

this uncertainty as @ fraction of the measured Tl, 1s samewbet, more useful

in the actual data analysis

?The percent uncertainty in pair average for the three cs-137

doses: 2.742, 7.676 snd 13,158 aR are calculated to be: 22.09%, 14.90%

and 4,816 respectively from the data in Tables 1, 2 and 3.

---Page Break---

Tf the equation:

@)veaM semer

4m which Y 18 the percent uncertainty in measured TL (TE)and a, e, and

?are constants, is used, no assumption need be made for the uncertainty at zero exposure (zero TL). the calculated values of d, ¢ ani ¢ from the

data in Table bare: 0.002783, -0.019297 and 0.249039 respectively.

?the two regression equations - one for D and the other for ¥

Provide a basis for estimation of the uncertainty in sample dose of an

empoted dosimeter - AD.

thus if D = D (TE),

(3) ao-? (4) Om

recognizing that this is a first approximation to QD since the weighting

mction for AT: + (jt)

From equation (2),

in this case, is not unity.

() Qp=* Ga +26T +c) AR.

Pair values can now be rejected on the basis of whether or not the values

of average dose of the pairs plus-or-minus sone adjusted value of AD

inferred from (1) overlaps the individual doses interred from the measured

TL values, the quantity AD with scaling factor of unity ought to be a sufficient criterion provided that the coefficients a, », and ¢ and d, ¢

and f derived from experiments such as the one described are "double-

lind" in nature, or that the dosimeters used to measure field dose are

subjected to sone sort of initital laboratory statistical selection before

field use, by a single field investigator.

Assuming that the paraseters char

ferizing the readout of

dosimeter TL i.e. heating cycle, nitrogen flow and annealnent times are

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?the sane for both field and controlied exposure measurenents the data

in Tables 1, 2 and 3 is sufficiently general for field-correction

applications such as pair value rejections,

?Thus

(5) Ad = (021654 TH - wossthe H+ 2.205703). ATE

in which JE 4s the mean value for a dosincter pair, V is calculated

from equation (2) and

(6)47E = (v)- (HE)

As an Ailustration, consider vat the estinated uncertainty

tn D, AD, would be if a thermoluninoscence of 1,245 resulted fron the

mean of @ ficld~patr measurement. From Table 4: TE

0.275 b

and ¢ are know, s0 AD of an inferred exposure 4 calculable. In

order to use this uncertainty data with otter TE meanuresents on a

feltvexpoted dosineter, the derivation of AD as a function of TE is

the most useful equation of all ant it may be readily inserted in a

computer routine for testing the patra of dosages calewated.

thos Table 5 gives A\D as @ function of SL near three inom

dotes. Using the sane type of regression equation as before, a general

?expression for the uncertainty in indicated dose a function of indi

?gated dose may now be evaluated:

(Dad: = woe eg gt ry

{in Which the subscript J refers to dote indicated using the TL observed

for a field exposed dosimeter with? calibration data of TE as a function

of Yom dose. velusting the three constants from the data in Tabie 4,

(8) Ad; = .023835 ny? ~ cen Dy + 57655.

?This equation is the basis for estimated uncertainty in dose, when the

dose is derived ty interpolation of calibration dose vs TL points.

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C. Extrapolation and Interpolation of Calibration curves

?The inference of doses from ficld measurenents yielding TL values

which Lie between two know calibration points presents no serious obstacle,

Lebrén (1974) has used the statistics) sorting (selection) method with

dosimeter handling procedures currently in practics in the PRNC Terrestrial

Ecology laboratory facilities through it is unclear vhat statistical r

Jection procedure yas used in his work, Assuming Linear function of the

?log of TL response versus calibration dose, his method has sone advantage

relative rapidity with watch many samples can be processed, and

his field dose uncertainty estinat:

fare approximately 30f, not considered
@ large uncertainty for the type of field vork which was carried out.

?The data in Tables 1, 2 and 3 do chow that a Linear interpol:

{Hon of calibration data can be used to derive unknowm field doses tron
measured TL's without introduction of excessive errors, provided doses
larger than approximately 15 mi of cs-137 equivalent are not encountered
Using @ standard 30-50 dey $e14 exposure for the characterisation of local
chviromental radioactivity Cs-137 dose equivalents as high as 1b mk have
been infrequently encountered. In arcas of high doserate, shorter field

exposure times can be used to maintain the lover uncertainties introduced

by the Linear interpolation approximation, Another alternative in thie

case 4s to select chips vhich have lower sensitivity, einee thie charac

teristic can vary widely from chip to chip. Our experience indicates that

overlong exposure tines increase the risk of vandalism of dosimeters placed

in field stations, Furthemore, 2ong exposures may be iupractical s¢

mp fs used

fan environmental monitor under future Muclear Regulatory

Commission (NRC) policy comituente.

-T-

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Extrapolation of calibration dose versus TL curves to doses belov

?the Lowest TL observed in the Ce-137 calibration is difficult. Tt ie not clear that the measurement techniques used in this study warrant the sumption of zero TL for zero dosage. Thus Linear or first order slope-correction derived curves fram zero dose up to the lowest, calibration

dose may be subject to errors in TL approaching the values of the indicated aoe. Sone of the experiments described in chapter 1 suggest that an un-certainty of 100f {8 not unreasonable sf the linear extrapolation 1s employed. ?The additional ascumption that the lowest calibration dose point {s fixed

and sbsolutely correct for the purposes of eero-to- lowest-dose slope determination is not good. However, in the absence of reliable very lov

dose data, this approach has been used and the values which result should

be regarded as trend indicators, unsuitable for all but the most qualitative

of interpretations.

D. Cavest tector

?The analysis presented above ts a practical epproach to a field research problea. The confidence which can be placed in single field Reasurenents carried out at different tines (and frequently at different Locations) 1s never very great. There simple is no substitute for the classic £ and t tests when data significance te at issue, Such tests generally need considerable data taken over the sane period of tine, using substantially the same techniques in order to be conscientiously applied,

Im this, the initial survey of Northwest Puerto Rico, resources

cf man power, instrmentat ion and (most important) time aia not permit

nore than a general description of radiation levels using TLD. Presumably,

+8.

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future measurements of background radioactivity will

apie to build

?upon the experience obtained herein, Analysis of variance using

accepted techniques

hould be high on the list of priorities in such

future stuates.

---Page Break---

?Table 1

2.741 ae

?TORETBORTE Tea oS Str ver

| Posineter # in Bogue 2 2 3 Swposures Single Exposure,

a 1.183 2.549 1,600 1.407 1.285 1.605 + 0.550

2 0.953 1.0ke 1.128 1.261 2.269 Las 5 0.238

3 L217 1.640 1.279 1.314 1.578 1.366 0.234

4 2.3MB 1.468 1.034 1.358 1.288 2.303 0.1m

5 2.040 2,626 1.438 1.157 1.289 1,310 £ 0.232

6 0.760 1.663 1.116 1.28 1.377 1.207 + 0.306

1 0.986 2.345 0.9m 1172 1.228 Lak + 0.261

8 1.065 1.302 1.089 1em 1.2 1.168 + 0.110

9 2.312 0.207 2.013 1.131 1.336 2.082 + Oto

do 1.47 2,001 1.073 1.151 1.359 12M 0.23%

Moan Response

(Intra-grou

Ton-sorted 10s. 1,383 1.207 1.26 1.298

St. Deviation

ofa single

Dosineter

TL in the Group 40.176 £0.595 20.206 10.09% 40.131

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Table 2

Dove: 7.676 aR.

ILsReapanae aan oF 3 Sea Deviation

Dosineter # for Emomre 2 2 3b Brporures Single Exponure

a h.o6e 3.6 3.7 3.763 3.8868 3,770 ¢ 0.21h

2 3.979 2.577 Mobs 3.557 3.06 3.4m + 0.603

3 3.T15 2.730 3.936 3.296 3.203 3.356 + 0,48

4 3.904 2.65 3.977 3.658 3.608 3.564 40,534

5 3.716 2.596 3.910 3.376 3.176 3.359 + 0.538

6 3.705 2.593 4.013 h.o7e 3.637 3.660 + 0.643

1 3.s2 2.005 3.792 3.065 2.005 3.196 0.57

8 3.661 2.793 4.092 3,030 3.182 3.34 + 0.532

9 3.689 e7la 3.692 3.518 3.018 3.338 + 0.kes

10 3.754 eThr 3.815 4.00 3.b52 3.578 £0.58

Mean Response

Setar 3.706 2.722 3.908 3,601 3.306

Sta. Deviation

of & Single

Dosineter TL

Am the Group

40.262 £0.45 40.134

0.368 40.315

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Th-Response Yeon oF

Dosimeter # for Bposure 2 uw

L 5.646 5.638 5.832 5.405 5.79% 663,

2 5.899 5.551 5.631 5.337 5.797 5.643,

3 5.725 5.73 5.802 5.388 5.746 5.679

4 6.12 9.682 5.94 5.633 6.112 5.908

5 5.694 5.577 5.879 5.229 5.820 5.640

6 5.839 5.643 5.455 5.668 5.902 5.701 £0.176

7 5.521 5,386 5.620 5.797 5.534 5.572 +5 0.152

8 5.852 5.737 5.717 5.015 5.890 5.642 + 0.358

9 5.578 5.30 5.423 5.302 5.919 5.505 + 0.258

10 6.0N8 5.616 6.335 - 6.826 6.206 +2 0.508

Mean Response

(fon-sorted

Intragroup) 5.79 5.587 5.761 5.19 5.937

Sta. Deviation

of & Single

Dosineter Ti

in the Group £0,200 20.2h2 40.263 40.043 10.353

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Table 5

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1.616 34h 40.516 1.183

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