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PUERTO RICO NUCLEAR CENTER

RESEARCH IN PHOTOMULTIPLIER TUBE FATIGUE

Prediction, Acceleration and Correction

of

Fotigue Effects in Photomultiplier Tubes

+ J OPeeati0 BY UNIVERSITY OF PUERTO KICO UNDER CONTRACT

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PREDICTION, ACCELERATION AND CORRECTION

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1. Cantarell and 1, Almod6var

Work performed at Puerto Rico Nuclear Centers

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PHOTOMULIIPLIER TUBES

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ABSTRACT

Practical methods for correcting the effects of fatigue in photo

multiplier tube measurements are diacu

2. Also, & method 48 presented

for reducing the tine required for the saturation or stabilization of

phototubes from several hours to # fev oinutes.

?Two methods are proposed for the correction of fatigue effects

One sethod proceeds fron the experiuental predictabllity of fatigue

effects by means of plots or enpirical equations with a margin of error

of 1%, The other nethod proceeds from the synchronized measurenent of

fatigue together with the spectrum neasurenent.

1. RerRopucrrion

yea

fatigue of photomultiplier tubes, chat 12, the

abnormal variations with time in tube gai

i a peretatent source of

exror affecting phototube measurements.

In nuclear spectrometry, for instance, vhen a single channel analyzer
As used, fatigue continuously changes the phototube gain over the measure-

iment period, and a distorted spectrum is obtained. If the gain variation

Yoperated for che U. 8. Atomic Energy Gomission by the
University of Puerto Rico.

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The main difficulty in correcting fatigue effects in the past has
been that the phenonenon was relatively unknown and,until recently, could

not be reproduced. At present, the phenomenon is better known(4+8) and

sone empirical logarithnic equations are avatlable) froa which correc

tions can be derived. However, the application of the:

empirical equa~

tlons requires a knowledge of the permanent fatigue characteristics of

?the photomultiplier tube being used.

TL. BQUEMARNT AND EXPERIMENTAL PROCEDURE

A total of 30 Dunwat 6292, RCA 6242 and ROA $819 photomultiplier tuben vere studied, All wessureaente were nade using a thernostated aysten(®) in vitch the tenperature of operation was 23.00 + 0.25%.

spscteal measareasate were poctorued utilising a single cheanel analyzer manufactured by Baird Atonice Corporation and « 512 channel analyzer obtained fron the Nuclear Data Corporation,

Several gauma ray sources of Cs!57 were used, with intensities angiog from 1 t0 S0pte without collimation, and frou 25 to S804, collinted by lead rings. When stroag soures

were used, an auxiliary
weeker source was taployed for periodical measurenente of the photopeak

position. Samples of netural materiale auch as root:

leaves, sand, ete,

were measured without previous chenical treatuent.

A detailed description of equipsent and procedures vas given in an

earlier study.)

TLL, PREDICTION OF VATIGUE EFFECTS

A. Determination of Fommanent Patigue Characteristics of Photomlti~

plier Tubes

The main fatigue characteristics to be measured are:

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fatigue given by the pulse hetght variation Ac in the folloving

?equation: 7)

Bec e+ Sm top Ge +1) @

in

Here, ¢, 1s the position of the photopeak at the beginning of any measure-

ent, and C the channel attained by the photopeak at time t, The slot sm 0 equal to (0, D0y + eq). When equation (2) ta plotted as in ftp. 1,

tthe successive straight Lines of a fatigue curve are reprt

vented by = 1

front #0 to c= tg and by = 2 frome = ty tot = ty. For our purposes,

however, the value {= 1 fe euffletent. Furthermore, the peraneters cy

and by = cy/a are Likewise evaluated fron the fatigue curves measured

to determine the other characteristics of the phototube, by means of @

plot of the slopes mj versus the total variation of the photopesk position

Ach, obtained experinentally from the difference Cy - Cy (See fig. 2).

B. Prediction of Fatigue Behavior of Photomsltiplier Tubes

Once the permanent fatigue characterietics have been determined for

?2 phototube, any abnormal gain variations which may occur during measure-

ente can be predicted graphically.

The intensity I of the source £0 be measured 4s determined in about

fone minute of measurenent. The final saturation lintt Cy = AC +6, 18

calculated fron equation (1), and the straight Line between pointe 0 and

Gy then describes the expected fatigue behavior of the phototube (sent

og-plot).

Similarly, the fatigue curve can be predicted analytically with

equation (2). Since Aer = AG + Oy = Gp, and AC can be calculat

fron I by means of equation (1), the fatigue behavior of the phototube

given by equation (2) 1 known from the values of Gy and I determined

in the first minute of source meseurenent.

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Pigure 3 shove a y-ray spectrum of monazite sand obtained with @

v

stagle chancel analyzer.

The corrected spectrun (dotted Lines) vas

obtained by applying the methods described above. It should be noted

that In the region from 0.5 to 1.0 Mev, corrections are necessary so

to avoid attributing intensities to the wrong isotopes. The correct

Photopeak positions are indicated by arrows.

3. Correction by simul satu exent

Fatigue cen be measured continuously from the anode current varia~

elon registered on a recorder, or by repeated mexsurenents of the photo

peak position of a standard weak source between measurenents of different

samples. The forner method {s conventent for spectra which are deternined

with a single-channel analyzer, the Latter sethod is recounended when

multichannel anclyzer ie used. Corrections based on the synchronized

fatigue measurenents are then applied to the measured spectr:

VE. CONCLUSIONS

?The correction or elimination of fatigue effects present in photo~

multiplier tube measurenent 1s absolutely necessary if high precision in

nuclear spectronetry is to be obtained.

The long waiting periods required for stabilization of the measuring

ayaten as recommended by the manufacturcrs can be avoided by accelerating

tthe proc

with standard stronger sources

The methods for correcting fatigue discussed in this

useful because they lead to higher precision. The development of fast

rnethods for autonatic compensation of fatigue effects vould be highly desirable.

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Pig. 1 Variation of @ phototube gain with vorking time plotted versus

Tog (10 t +1). The stabilization Lime of sources Band 5

(one day) can be attained with a stronger souree Hin 4 and

0.5 win., respectively.

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= oi @ 3 4 8 6 7 6

TOTAL PULSE HEIGHT VARIATION. acy

Fig. 2. Detemmination of parameters bi and ct of equation 2 from two

Fatigue measucenente of a phototube.

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COUNTING RATE.

Fig. 3

MONAZITE SAND

-©0-0-MEASURED SPECTRUM

=-=- CORRECTED SPECTRUM

ENERGY (Men

cama ray spectrus of sonazite sand. Graphical-analytical

nethode vere used to obtain the corrected spectrum.

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