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The Examination of the High Voltage Waveforms of Diagnostic X-ray Generator Using Fluorescence Intensity

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INTRODUCTION

At a diagnostic X-ray generator, a subject is irradiated by X-ray , and a fluorescence occurs with the fluorescent by the transmitted X-ray. This fluorescence exposes a radiographic film, and we obtain a radiograph by developing the film. Therefore, the image on the radiographic film is the final output of the diagnostic X-ray generator. And, the photographic density that composes the image of the radiograph depends on a fluorescence intensity.

Up to this time, it was difficult to estimate the image on the radiographic film directly by using X-ray high voltage waveforms.

Therefore, we derived an experimental formula to estimate the fluorescence intensity with the fluorescent from the voltage and the current waveforms of X-ray tube[1)]. By this method, it is possible to study effects of the radiograph with high voltage waveforms of X-ray generator in detail.

METHOD

We show an experimental arrangement of an enlargement radiography as in Fig.1. And, in this arrangement, influences of a scattered X-ray are almost rejected. The material of a subject is acrylic resin.

According to a thickness of subject as a parameter, we show relations of the tube voltage V_x [kV] and a fluorescence intensity H_s[F/s] that were obtained by experiments as in Fig.2.

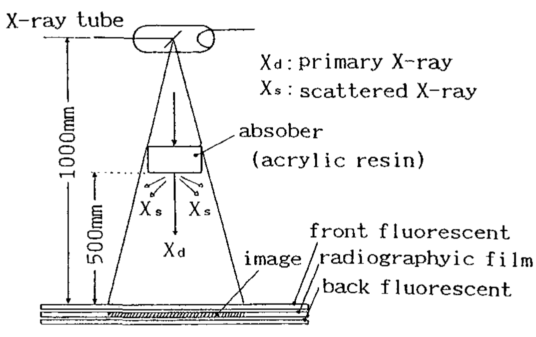


Fig.1 Method of experiment

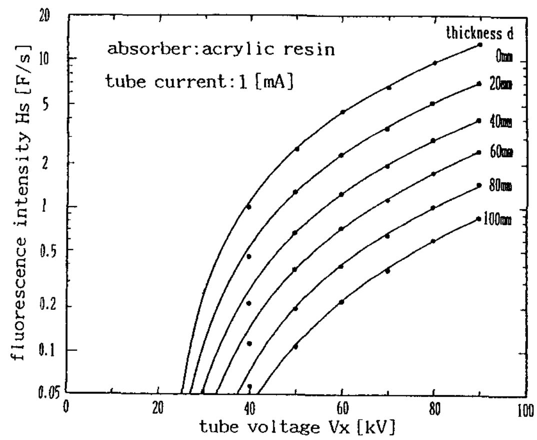


Fig.2 Tube voltage vs Fluorescence intensity

The fluorescence intensity H_s is approximately given by Eq.(1) ~ (3) ,and these expressions are led by these relations. d_n is thickness of a subject standardized by 1 [mm], V_n is the tube voltage standardized by 1 [kV], and I_n is the tube current standardized by 1 [mA]. And, H_r is a standard of fluorescence intensity, and the value is 1 [F / s].

$$H_s = H_o(V_m-22)^n \cdot I_m \cdot H_r \ [\mathrm{F/s}] \qquad (V_m>22) \qquad (1)$$

$$H_o = 6.42 \times 10^{-3}\exp(-4.93 \times 10^{-2}d_m) \qquad (2)$$

$$n = 5.2 \times 10^{-3}d_m + 1.8 \qquad (3)$$

Next, in order to evaluate an energy spectrum distribution of generated X-ray, we calculated fluorescent quantitative ratio α [$= E_1 / E_2$] to be shown as in Fig.3. And we calculated these α about a square wave and single-phase 2 peak wave to be shown as in Fig.4.

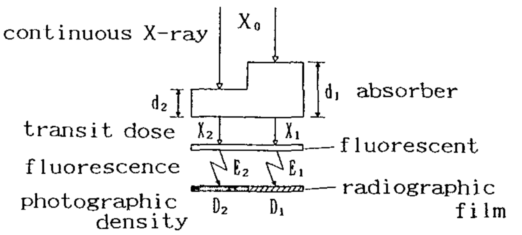
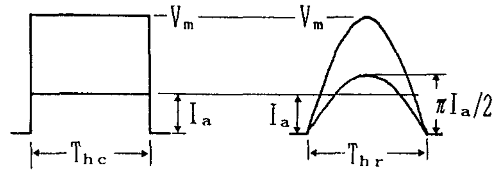


Fig.3 Measurement of Fluorescent quantitative ratio



(a) square wave (b) single-phase 2 peak wave

Fig.4 High voltage wave forms

RESULTS

We show results of calculating α as in Fig.5, when thickness of a subject is 40 [mm] and 20 [mm] . These curves show the relation between a maximum tube voltage and a fluorescent quantitative ratio about a square wave and single-phase 2 peak wave. By these relations , we can know each maximum tube voltage to give the same fluorescent quantitative ratio.

Next, we calculated each maximum tube voltage to give the same fluorescent quantitative ratio according to d_1 and d_2. These values of d_1,d_2 are shown on Table 1 .

As the result, each maximum tube voltage had the almost same value about all of combination for thickness d_1,d_2. We show these results as in Fig.6.

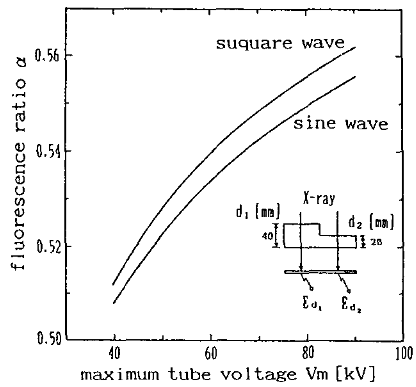


Fig.5 Fluorescent quantitative ratio of each waves

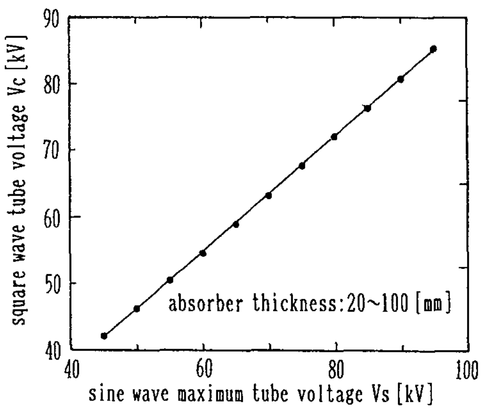


Fig.6 Equivalent square wave tube voltage

Table 1 Thickness of absorber

	d_1[mm]	d_2[mm]		d_1[mm]	d_2[mm]
1.	40	20	6.	80	40
2.	60	20	7.	100	40
3.	80	20	8.	80	60
4.	100	20	9.	100	60
5.	60	40	10.	100	80

We show high voltage waveforms of the single-phase 2 peak X-ray generator to be actually measured as in Fig.7. And, we calculated the maximum tube voltage of a square wave to give the same fluorescent quantitative ratio by these high voltage waveforms. We show the result as in Fig.8. At actual high voltage waveforms, a distortion occurs on the waveforms to show it as in Fig.7. Therefore, we think that the equivalent square wave tube voltage of actual waveform gets a little small in comparison with that of ideal waveform as in Fig.8.

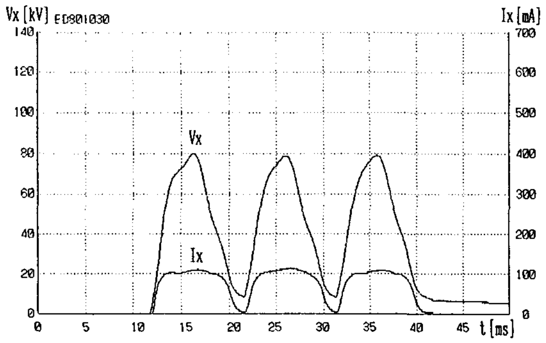


Fig.7 Actual high voltage waveforms (80 kV, 100 mA, 30 ms)

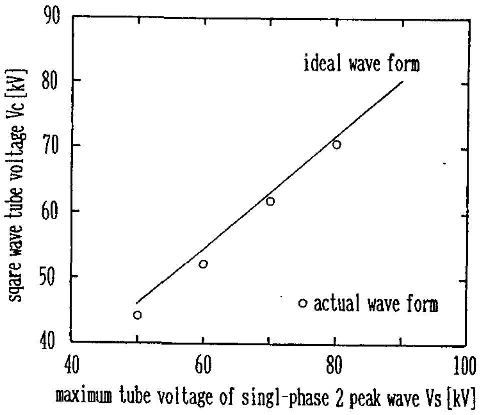


Fig.8 Equivalent square wave tube voltage (Actual high voltage waveforms)

DISCUSSION

We fixed our eyes upon a fluorescent quantitative ratio that generated with fluorescent by the transmitted X-ray on a subject of different thickness. We calculated values of each maximum tube voltage to give the same fluorescent quantitative ratio about tube voltage waveforms of a square wave and single-phase 2 peak wave. And, each maximum tube voltage were almost equal about all of combination for the thickness. As the result, we think that energy spectrum distributions of X-ray to be generated by the square tube voltage waveform and single phase 2 peak waveform are almost equal. We can calculate the maximum tube voltage of a square wave to give the same fluorescent quantitative ratio for any other waveforms. By this method, we may be able to judge a tube voltage waveform to have the same energy spectrum distribution.

CONCLUSION

1. We measured relations between a thickness of subject and a fluorescence intensity and tube voltage, according to the experiments. By these relations, we derived an approximate expression to estimate the fluorescence intensity by using these parameters.
2. We calculated a value of each maximum tube voltage to give the same fluorescent quantitative ratio of tube voltage waveforms of a square wave and single-phase 2 peak wave. With the maximum tube voltages to give the same fluorescent quantitative ratio, we think that energy spectrum distributions of X-ray that generated by the square tube voltage waveform and the single-phase 2 peak waveform are almost equal .
3. The method proposed by us can be applicable for any other tube voltage waveforms. Therefore, we think that it is possible to evaluate a tube voltage waveform by using a fluorescence intensity or photographic density as an index.

REFERENCE

1) Izumi Ogura: "A technique for Creating Pseudo Image contrast in a Simple X-ray Photograph": Trans.IEE of Japan,Vol.118-A (3),233-238,1998