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Minimum Light Intensities Required for Reading

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MINIMUM LIGHT INTENSITIES REQUIRED FOR READING

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The minimum light intensity required for comfortable reading depends on a number of factors. The test here reported was made with a group of students of Iowa State College and it should be emphasized that the results sought were minimum intensities for the sake of making comparison between different types of lighting possible. The maximum intensity permissible would doubtless be found much farther from that ordinarily recommended than is the minimum.

Several investigators have reported results [1] on the illumination intensity desirable for reading under different systems of lighting. With the introduction of new types of lamps and lighting systems, and with the habits of people and their mode of living constantly changing, it seems desirable to establish anew what characteristics should be secured of the illumination used. What really counts in a lighting system is the effectiveness of the illumination secured in enabling one to see things easily and in comfort.

In order to have a definite means of comparison, the value of minimum intensity necessary for reading a considerable length of time was chosen. The printed material used throughout these tests was a page of print from the Electrical World, 1922. The conditions covered in the test included daylight, direct lighting with clear and daylight type lamps and indirect lighting.

For the daylight test the following instructions were used.

With the assigned printed material on the arm rest of your chair and facing west so as to get the light from the left, find that location for which you feel that you have just sufficient illumination to enable you to read for two or three hours without strain or fatigue. Begin with very low illumination intensity and increase it to the required intensity. Read the printed material for five minutes or longer to verify your former judgment. Change again if the position is found unsatisfactory.

For the other tests the instructions were as follows:

Sitting in a natural position, could you read the assigned printed ma-

1 Tran. I. E. S., Vol. 2,p. 590; 7, p. 590. Illum. Eng. Vol. 6, p. 42. Iowa Academy of Science. Vol. 29, p. 141; 31, p. 387. Elect. World. Vol. 80, p. 1268.

terial on the unshaded arm rest of your chair for two or three hours without strain or eye fatigue?

Judge each lighting condition by one of the following terms, if possible.

Intensity much too low
Intensity too low
Intensity just sufficient
Intensity higher than needed
Intensity much higher than needed.

For the direct system clear unshaded lamps were used and hence diffusion was reduced to a low value. For the indirect system enameled reflectors of the opaque bowl type were used, and thus no light passed directly from the filament to the printed page.

In each case the illumination intensity was measured and recorded. The results obtained showed that for 17 college students the minimum intensities required were as follows:

Daylight — 2.79 foot-candles.
C_1 lamp)
direct lighting) — 1.02 foot-candles
C_2 lamp)
direct lighting) — 1.01 foot-candles
C_1 lamp)
indirect lighting) — 0.85 foot-candles

Besides the seventeen who took part in all the above tests there were also twenty-four others who participated in the daylight test, forty-eight in the test with the C_1 lamp in direct lighting, twenty-eight in the test with the C_2 lamp in the direct lighting, and sixteen in the test with the C_1 lamp in the indirect lighting system. When all these are included in the calculations the result for daylight is 2.55 foot-candles, for

C_1 direct .....1.32 foot-candles
C_2 direst .....1.07 foot-candles
C_1 indirect .....0.88 foot-candles

The conclusions drawn from these experiments were as follows:

1. A considerably higher intensity is required for thoroughly diffused lighting than for any other. This bears out the results of previous investigations. Daylight is thoroughly diffused and hence the pupil contracts and more light is needed.

That a higher intensity is required when daylight is used may also in part be ascribed to the fact that we make more use of daylight than of any other and we have become accustomed to demanding a high intensity of indoor daylight, for we get a high intensity of daylight outdoors. Once being used to a high intensity of any system of lighting we do not feel that we can get along with any less.

2. The quality or color of the light makes practically no difference in the minimum intensity required.

3. A person wants highest intensity of that kind of lighting which he uses most commonly. It is for that reason that the requirements for the C_1 lamps in the indirect system were low. The indirect system is used much less than the direct and we get along with a lower intensity.

To be sure, the degree of diffusion was greater with the indirect system and hence a greater intensity might be demanded on that score, but evidently this was not sufficient to offset the lesser intensity required by the indirect system because it is used less.

The illumination intensity demanded by people is increasing from year to year. This is largely due to the increasing intensities we have been getting in artificial lighting and our desire to approach the intensities of the out of doors which we use most.

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X-RAY DIFFRACTION IN WATER 2° to 98°C: THE NATURE OF MOLECULAR ASSOCIATION

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X-ray diffraction ionization curves of water show (1) the presence of two definite peaks corresponding to the separation of diffraction planes of 3.27 A.u. and 2.11 A.u.; (2) the practically constant diffraction intensity of one peak over the temperature range, 2° to 98°C as compared with the gradual disappearance of the second peak with increasing temperature; (3) correspondence in angle of diffraction between these peaks and the chief diffraction intensities with ice crystals; and (4) the increase of peak width increasing temperature with a movement to indicating less distance of planes. It is difficult to reconcile these results with what was formerly regarded as the alteration, in complexity of the water molecule. The simplest explanation, emphasized by all the experiments in x-ray diffraction in liquids, is that the so-called molecular complexity is the arrangement of molecules in more or less orderly groups with intermolecular forces of distinct magnitude. With temperature increase the nature of the group changes, one set of planes becoming more poorly defined because of more slippage and less orderly arrangement. The alteration in grouping is also shown by the decrease in distance between planes. The group arrangement (cybotactic condition) describes the nature of what