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# **Theoretical Radiation Physics**

**Third stage- Radiology Techniques Department**

***Lecture (12)***

**By**

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## Lecture(12)

### The intensity of ultrasound waves

There are two scales of intensity , the absolute scale and the relative scale.

#### 1- The absolute scale of intensity (absolute Intensity):

In this scale, the intensity at a specific point is defined as follows,

It is the amount of energy that passing through unit time and through unit area perpendicular to the wave beam at that point ,and the Intensity in this definition is called **absolute intensity**.

The absolute intensity can be mathematically expressed by the following equation

$$I = E/A.t$$

Where

I: represent the absolute intensity at specific point, it is measured in(J/(sec.cm<sup>2</sup>)) or (W/cm<sup>2</sup>).

E: represent the energy of ultrasound waves , It is measured in joule(J).

A: represent the perpendicular area to the waves beam, it is measured in centimeter square(cm<sup>2</sup>).

t: represent the time interval that a specific point is exposed to ultrasound waves ,it is measured in second (sec).

Knowing the absolute scale of intensity is useful for two things

- 1- Knowing the effect of the intensity of the waves coming out of the wave generating device on the sensitivity of that device.
- 2- Knowing the dissipation energy in the tissues to be examined by ultrasound waves to evaluate the biological consequences.

## 2- The relative scale of intensity (relative Intensity):

Since the intensity level represents the logarithmic expression of the ratio of the intensity at a specific point to the intensity at a reference point, so we call the intensity level is the relative intensity or the intensity in decibels.

∴ relative intensity = intensity level

$$\text{Intensity level} = 10 \log_{10}(I/I_0)$$

$$\therefore \text{relative intensity} = 10 \log_{10}(I/I_0)$$

Where

I : represent the intensity at specific point.

I<sub>0</sub>: represent the intensity at reference point.

Often (I ) is the intensity emitted by the source and (I<sub>0</sub> ) is the intensity reflected from specific tissue.

Since the intensity level is measured in decibels (dB), so the relative intensity is measured in decibels (dB).

1- When

$$I = I_0 \quad (\text{at any reference point})$$

$$\begin{aligned} \therefore \text{Relative intensity} &= 10 \log_{10}(I_0/I_0) \\ &= 10 \log_{10}(1) \quad , \quad \log_{10}(1) = 0 \\ &= 0 \text{ dB} \end{aligned}$$

This means that there is no change in the relative intensity at any reference point.

2- When

$$I = (0.5) I_0$$

$$\begin{aligned} \therefore \text{Relative intensity} &= 10 \log_{10}(0.5 I_0/I_0) \\ &= 10 \log_{10}(0.5) \quad , \quad \log_{10}(0.5) \approx -0.3 \\ &= 10(-0.3) \\ &= -3 \text{ dB} \end{aligned}$$

This means that when the intensity changes to half of the original value, there is a decrease in the relative intensity by an amount of (3) dB.

3- When

$$I = 2 I_0$$

$$\begin{aligned} \therefore \text{Relative intensity} &= 10 \log_{10}(2 I_0/I_0) \\ &= 10 \log_{10}(2) \quad , \quad \log_{10}(2) \approx +0.3 \\ &= 10(+0.3) \\ &= +3 \text{ dB} \end{aligned}$$

This means that when the intensity changes to twice of the original value, there is increase in the relative intensity by an amount of (3 ) dB .

Since the half-value thickness (HVT) is the distance within the medium that reduces the original or reference intensity to half its value

So, for each half-value thickness (HVT), there is a decrease in the relative intensity by (3 dB).

And when the intensity changes by half more than once in a specific medium, we work on numbering (HVT) so that  $(HVT)_1$  is at the first change in intensity and  $(HVT)_2$  is at the second change in intensity , and so on , This can be seen in the following table, where  $(I = 1600 \text{ mW /cm}^2)$  , and  $(\text{m W} = 10^{-3} \text{ W})$  .

No. of (HVT)	Relative intensity(dB)	Absolut .int(mW/cm <sup>2</sup> )
0	0	1600 ( $I_0$ )
1	-3	800
2	-6	400
3	-9	200
4	-12	100
5	-15	50
6	-18	25
7	-21	12.5
8	-24	6.25
9	-27	3.125
10	-30	1.5625