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Measuring Radiation in Space with Bubble Detectors and the Effect of Radiation on Health System of Human Body

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Abstract. A bubble detector resembles a testing tube or a human fingertip in size and form. It has a material with small liquid droplets in it. When neutrons collide with the droplets, visible bubbles of trapped gas appear almost instantly. The number of bubbles in the surrounding neutron radiation may be measured optically or with a reader, and the number of bubbles reflects the degree of neutron radiation. The gas bubbles may be compressed again and used again. A bubble detector becomes a radiation sensor utilized to assess neutron levels. Neutrons account for 30 percent of the radiations that astronauts encounter in orbit. When protons collide with a spacecraft's shielding, neutrons are produced. To better monitor specific astronauts' neutron exposures throughout space missions, the Canadian Space Agency's Operation Space Medicine (OSM) Group is sponsoring the development of a personal detector device for space usage depending on Canadian bubble dosimeter technology. The current study focuses on mechanisms utilized for detecting radiation, Neutron detectors, and kinds of Neutron detectors, in addition to the effect of radiation on the health system.

Keywords: Measuring Radiation; Bubble Detectors; Operation Space Medicine; Health System.

INTRODUCTION

To mitigate radiological dangers, it is essential to effectively identify and measure the quantity of ionizing radiation in work and the environment [1–8]. It should utilize the capacity of ionizing radiation to interact with different things as a technique of detecting and quantifying it since we cannot detect it with any of our physical senses. The essential physical concepts utilized to identify ionizing radiation are introduced in this subject, which addresses these distinct interactions. It also goes through some of the most typical workplace detection methods [9–12].

Human health is endangered by nuclear radiation. Because of the absorption of the radiation energy, it causes considerable biological harm. When comparing the biological damage caused by gamma and neutrons, the neutrons cause greater biological damage than the same quantity of gamma energy absorbed in the tissues. As a result,

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determining the neutron's biological efficiency at low doses is critical, especially given the neutron's increased relative biological effectiveness. The unusually high energy threshold for fast neutrons, about 1 MeV, was one of the technological constraints of the Nuclear Track Detector found in the early 1980s. Due to this, the Nuclear Track Detector became insensitive to a huge portion of the lower energy neutrons. The discovery of Columbia resin CR39 or CR-39 resulted in some advances in the energy barrier lowered to about 100 keV. The detection limit for neutrons is 200 Sv. However, due to changes in the earlier concept of the quality factor for neutrons in the ICRP-60 recommendations, the detector detection threshold for neutron equivalent dose must be reduced by a factor of 5 to 10 in order to meet the requirement of 0.1 mSv per month detection threshold for personnel neutron dosimeters [13].

Several pieces of research on the reaction of super-heated liquid to radiation exposure were conducted since Glasser's work on the bubbles chamber [14]. Apfel [15] studied the use of super-heated emulsion detectors, which he eventually patented as the Super-heated Drop Detector. In this experiment, super-heated CCl 2 F 2 droplets were suspended in a viscous medium, and these drops' nucleation was seen after neutron irradiation. Ing and Birnboim [16] suggested the use of polymers as a host medium and developed reusable detectors. AECL, Canada, has a global patent that protects this new invention. The two types mentioned above of detectors are often referred to as Superheated Emulsion-based detectors. To the health physics community, the detectors mentioned above are super-heated Emulsion detectors.

Radiation Detecting Mechanisms

We depend on observing changes created by ionizing radiation once it interacts with materials since our bodies' senses cannot sense ionizing radiations. Radiation detectors work by sensing changes in the absorbing media due to energy transfer from radiation exposure to this medium. The following are some of the impacts generated by radiation exposure that enable to identify and determine the radiation:

Ionization

Beta and alpha radiation induce ionization directly, whereas neutron, gamma, and x-rays radiation do it indirectly. It is possible to gather the ion pairs that are formed, and the number of ion pairs number gathered may be connected to the quantity of radiation that causes the ionization. Ionization is a detecting method in several radiation monitoring systems [17].

Scintillation

Scintillation is the light generation by electrons moving from great-energy orbits to lower-energy orbits inside an absorbing substance. Excitation has caused the electrons to shift into greater energy orbits. (Recall from module 1.4 Interaction of Radiations with Matter that excitation occurs when ionizing radiation forces electrons to shift to greater energy levels momentarily.) The light that is emitted may be turned into an electrical signal. The electrons number transported into greater energy orbits determines the magnitude of the electrical signal, which may be connected to the quantity of radiation creating the scintillation. Scintillation is a particularly essential detecting technique for radiation detection, and scintillation detectors seem to be detectors that exploit this process [18].

Thermoluminescence

Once some materials absorb energy, electrons migrate to greater energy levels, referred to as "forbidden bands." They are locked in these bands till the material reaches a certain temp. As the electrons return to their previous level, the heating energy emits them, and the substance emits light. The light is turned into an electrical signal that may be attributed to the quantity of radiation that was incident. Personal doses (for example, dosages to specific persons) are monitored using thermoluminescent materials [19].

Chemical Mechanisms

Chemical reactions may be caused by ionizing radiation. This impact may be seen in personal dosimetry, medical x-rays, and industrial radiography when using photographic film. Ionizing radiation may speed up chemical processes in specific instances, and this method could be utilized to measure great doses throughout the irradiation of hospital devices [20].

Heating

Ionizing radiation may raise the temp of the absorbing material, and a precise determination of this rise could be used to calculate the radiation dosage. Because substantial doses have been required to generate even minor temp changes, this approach (called calorimetry) has not been suited for ordinary monitoring equipment in radiation protection. It is, nonetheless, employed as a major calibration reference for instruments [21].

Biological Mechanisms

Radiation at high concentrations may trigger biological alterations in live cells. Biological changes were only ever utilized to estimate doses in severe cases when persons have been suspected of receiving a large dosage by mistake [20].

DETECTORS OF NEUTRON

Because neutrons seem to be uncharged particles, they do not directly produce ionizing. Once they interact with matter, nevertheless, they generate secondary ionization particles, and it is through detecting these particles that they can identify neutrons. In neutron detectors, the most typical interactions seem to be [22];

- the reactions with boron-10 that generates radiations of alpha;
- the reactions with helium-3 that generates a proton; and
- elastic scatters using hydrogen nuclei.

For neutrons with energy up to around 0.5 eV, the first two reactions were more probable to happen. These neutrons seem to be in the thermal neutron (0.025 eV) region at the medium neutron range's bottom. Rapid neutrons may be detected via scattering of light.

Detectors of Neutron Types

For developing good neutron detectors, there seem to be various parameters to consider [23]:

- To interact with the detector material, moderating material should slow down quick neutrons (without absorbing them).
- For detectors that are not overly huge, the detector material should have a wide cross-section (for example, a great likelihood) for the specific reaction to happen.
- Inside the operating volume of the detector, all of the highly charged particles generated throughout the interactions with the detection material should be blocked.

The following are four kinds of neutron detectors that meet this requirement.

Boron trifluoride proportional counters

A gas-filled proportional counter loaded with boron-10 enhanced boron trifluoride makes up a boron trifluoride proportionality counter (BF3). This gas serves as the detector's filling gas and the target for entering thermal neutrons. Formula 1 describes the nuclear process that happens in the detectors [24]:

$$^{10}\mathbf{B} + \mathbf{n} \rightarrow {}^{7}\mathbf{Li} + \alpha \qquad \textbf{(1)}$$

This reaction was described as follows:

$^{10}B(n,\alpha)^{7}Li$.

The alpha particle and the lithium nucleus have enough energy to generate secondary ionization in the filled gas, which could be measured afterward. It is worth noting that certain neutron interactions create a gamma-ray with a mass of 0.48 MeV. An appropriate discrimination circuit is required to discriminate between the entering neutrons and the resulting gamma rays. Proportional counters on boron trifluoride may also identify intermediate and fast neutrons (reach 10 MeV). Nevertheless, in this scenario, a moderating substance such as polyethylene should be used to slow down the neutrons before they are captured (see Figure 1). Cadmium filters have been employed to ensure that the energy response is consistent.

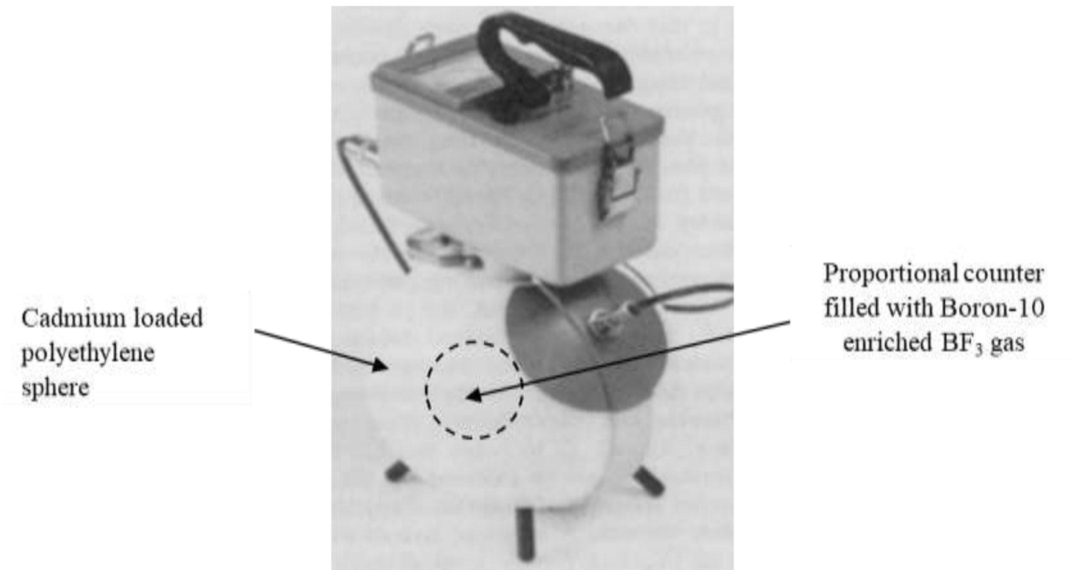

FIGURE 1. A Boron Trifluoride Counter

Boron trifluoride proportionally counters may be utilized for neutron spectroscopy and excellent detectors for fast neutrons, intermediate, and thermal.

Helium Proportional Counters

In many ways, helium counters seem comparable to boron trifluoride proportionally counters. Thermal neutron capture seems to be the primary detection method; however, helium proportionally counters may be utilized to identify medium and fast neutrons provided a moderator. As the name implies, Helium proportionally counters employ helium as the filling gas and target. Formula 2 shows the crucial response [25]:

$$^{3}He + n \rightarrow {}^{3}H + p \tag{2}$$

This reaction was described as following:

$^{3}He(n,p)^{3}H$.

A tritium nucleus and a proton were generated in this process because these were the charged particles that cause secondary ionizing. For neutron spectroscopy, helium proportionally counters may be utilized once again.

Gas Recoil Proportionally Counter

The sensing technique for gas recoil proportionally counters was elastic scatter with hydrogen nuclei. A proportionally counter filled with such a hydrogen-rich gas, including methane, detects neutrons with energy larger than 500 keV in these counters. Energy is released when a speeding neutron collides with a single proton in a hydrogen nucleus. After that, this nucleus would create secondary ionization. In certain gas recoil proportionally counters, hydrogen atoms are provided by using polyethylene in the counter's walls. Thermal neutrons are absorbed by a thin cadmium film surrounding the counter [26].

Detectors for Bubbles

Bubbles detectors use small liquid droplets in a gel-like substance to identify bubbles. The incoming neutrons give the liquid droplets sufficient energy to cause them to boil and transform into a bubble [27]. These bubbles may be seen with the naked eye and counted (Figure 2).

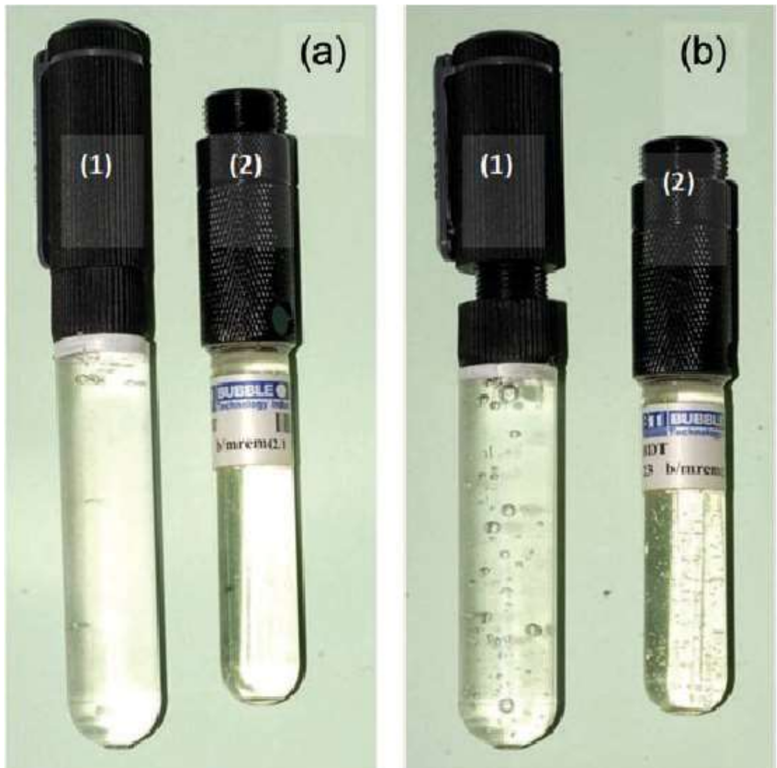

FIGURE 2. Detectors' Bubbles Before and After Exposure to Neutron, (left) and (right), respectively.

The real neutron dosage seems proportional to bubbles density, which remains constant in the substance until the dosimeter is reset. Personal dosimetry is the primary use for bubble dosimeters. They may, nevertheless, be utilized for environmental monitoring.

BUBBLE MEASUREMENTS METHODS

Because the size distribution of the oceanic bubble populations is the most crucial property to assess, great work has been put into developing a reliable, simple, and wide-ranging bubbles spectrometer.

Early Methods

Methodologies depend on bubble traps, acoustics, and photography were used in the early efforts to assess bubble populations. Those were successful at the time. However, they had certain drawbacks. The 60 cm length of the trap utilized by [28] offered a way of trapping the bubbles; nevertheless, every measurement began after the tiniest bubbles had risen to the top side, which took some time. This raises problems concerning the impacts of bubbles dissolution, growth, and coalescence, as a bubble with a radius of 25 m takes 8 minutes to travel through a 60-cm tube, yet only 3 minutes to dissolve at 10 cm deep in air-saturated water, according to the Stokes equation [29]. Because significant bubble amounts have been seen with mild breezes, the acoustic instrument utilized [30] caused some challenges in data interpretation. Biological activities were the sole explanation for the bubbles.

Nevertheless, it begs the issue of how bubbles wrapped in an organic layer respond acoustically. Due to these limitations, [31] developed a photographic approach that utilized three strobe lights and detected each bubble as a set of three bright spots matching the specular reflection of every strobe impulse from the bubbles. Later, the same strategy was successfully employed by [32].

Principles of the Available Techniques

Optical, photographic, and acoustic measurements, among others, were extensively recognized for years. As one would imagine, a single optimal approach for laboratory and field measurements that provides a sufficient size range, a high sample volume, a vast geographic area, depth coverage and accessible automated data processing has yet to be discovered [33].

Optical technique

The light-blocking concept [34] or dark-field specular reflection are used in the optical method [33]. A laser beam was fired into the liquid, and a photomultiplier was utilized to monitor the refracted and reflected light from gas bubbles (which may also be used for solid particles) as it passes through a tiny control container.

A pulse height analyzer amplifies and sorts the pulses from the optical detector depending on their height and length. The bubble's size should be greater than the light's wavelength. Although the approach is continuous, it only examines a flow section. The following are some of the advantages of devices that use this principle: Tiny size range: typically 10 -200 m reach to 800 m; modest sample volume; small geographic coverage; suitable for automated data processing. Optical techniques, including holography [35] and microscopy approaches, are often used for sizing the cavitation nuclei.

Photographic technique

The photographic imaging system comprises a camera with appropriate illumination and a watertight enclosure. 50 - 500 m has been the size range covered. Although the sample volume and spatial coverage were larger than the optical system, they must be limited so that resolution is not lost. The most important flaw in the photographic system seems to be the time-consuming analysis; data from still photographs are normally handled manually. This challenge was solved by utilizing a video camera rather than a still camera and advanced image processing software.

Nevertheless, as compared to still images, the resolution was reduced. Only huge diameters' bubbles =600 m and higher may be safely photographed with conventional video cameras. Great-resolution cameras are now only accessible at exorbitant rates due to technological limitations.

Acoustic technique

Bubbles diameters may be estimated acoustically using three measurements: acoustic wave scattering, excessive attenuation, and changes in sound velocity. Because these are frequency-dependent phenomena, two types of acoustic resonance may be utilized [33]: low-frequency (50-1000 Hz) resonance, wherein bubbles plumes resonate collectively, and high-frequency (10-400 kHz) resonance, where a single bubble was detected.

[30] found that the acoustic method has the following benefits: a) the bubbles resonance frequency seems to be inversely proportional to its radius, b) at resonance, the scatter and extinction cross-sections of bubbles were approximately 1000 times higher than its geometrical cross-section, and 3) bubbly solvents seem to be dispersive, for example, they insert complex compressibility to the real compressibility of a pure liquid, and the sound speed becomes a function of the frequency. By altering the sonar frequency, it may choose the bubble size range. The size range is normally 34 - 1200: m, although it may increase to 8 m and 0.25 cm in both directions. The sample volume and geographic coverage were substantially bigger than in the previous two systems, and the process was fully automated.

Others technique

The Coulter counter is a device often utilized to assess the dimensions of bubbles (and other particles) [36]. The suspended particles in an electrically conductive liquid flow one by one thru a tiny hole with emerging electrodes on either side. A particle passes through the aperture, displaces electrolyte, and impacts the resistance between the electrodes for a brief duration, resulting in a voltage pulse with a magnitude corresponding to the particle volume. The succession of pulses that result is amplified and tallied. The equipment can handle sizes ranging from 0.5 to 500: m. Pressure pulse approaches, Doppler bubbles detectors, and bubbles detectors depending on the second harmonic or non-linear combination of two frequencies are all described [36]. These are gadgets that use acoustic frequencies to communicate. A novel optical approach depending on the Kerr impact might be used to determine the size of bubbles.

The differences between the Obtainable Techniques

The differences between three particular systems carried out in the lab have been summarized in Table 1 [33]:

TABLE 1. The differences in the Obtainable Techniques

System name	Range of mean radius (µm)	Volume (cm^3)	Processing abilities
Light scattering Bubble Counter	10-150	0.012	Automatic analysis
Photographic Bubble-Imaging system	50-500	330	Tedious analysis
Acoustic resonator array	34-1200 (8-2500)	1250	Highly automated

The acoustic method is superior because it covers the biggest size range, has the highest sample volume, and is the simplest to automate data interpretation. It seems to be the most appropriate approach for determining bubble density in the field, particularly for long-term observation [37]. The other two approaches are more suited to laboratory research. The optical method is frequently selected because of the size range. With faster and cheaper computers, cameras that seem to be state-of-the-art in terms of speed and quality, and better image processing software, the photography approach would undoubtedly become more widespread.

The benefits of measuring radiation

- It can be used to measure the depth of a treatment vault.
- Good rejection for photons.
- Appropriate for great rate dose
  - No down duration
- Small size
  - It may be used for person dosimetry.
- Reusable
- Different energy ranges are accessible, ranging from warm to rapid.

Drawbacks of measuring radiation

- There is a chance it will be temperature-dependent (5 percent per degree centigrade).
  - This may be mitigated by filling the chamber with a volatile liquid with vapor pressure, compensating for temp sensitivity.

- At high dosage measurements, bubbles overlap, making reading problematic.
- Might lose sensitivity during the time since degradation of the medium.

Measurements of measuring radiation

1. The bubbles detector cap was unscrewed, measuring and lowering the chamber's pressure.
2. Neutrons are emitted from the detector. The polymer is super-heated by neutron interactions, causing bubbles to develop.
3. Bubbles may be counted visually or optically. The fluency or absorbed dosage has been linked to the number of bubbles.
4. The bubbles detector has been reset by tightening the cap, which causes the internal pressure to rise.

BASIC PRINCIPLE

A super-heated liquid is a liquid that has been heated to a temp above its boiling point without vaporizing. A meta-stable state is one in which a liquid changes state and performs vaporization/gasification with the deposition of a very tiny quantity of energy (trigger energy), including the energy deposition generated by an impact neutron. For neutron and gamma radiation measurements, super-heated liquid droplets floating in an appropriate host medium have been utilized. Counting the nucleation number might be done optically or with a piezoelectric sensor sensitive enough to identify the little auditory disturbance created by bubbles. The number of nuclei formed due to neutron interactions seems proportional to the equivalent dosage.

Mechanism of Bubble Formation

Once a neutron with energy E n collides with a nucleus of molecular weights A, the max energy which this nucleus may get from the neutron thru head-on collisions seems to be provided by,

$$E_{max.} = 4AE_n/(A+1)^2 \quad (3)$$

The nucleus receiving this energy knocks out the orbital electrons of the surrounding atoms and shuttles through the liquid, depositing energy until the electron collision charge capture brings it to rest. One can qualitatively explain the vapor bubble nucleation mechanism using Seitz's thermal spike model [38]. The critical radius, i.e., R c, is calculated for a spherical bubble

$$\mathrm{R_c} = 2\gamma(\mathrm{T})/\Delta\mathrm{P}(\mathrm{T}) \quad (4)$$

Where γ(T) was the surface tension of liquid at temp T.

$$\Delta P(T) = PV(T) - P_0 \quad (5)$$

P v (T) is the vapor pressure of the super-heated liquid at temp T, and P 0 is the pressure of the surrounding medium. The minimum possible energy to nucleate a bubble can be estimated (Lo et al., 1988).

$$\mathrm{E}_{min} = 16\pi\gamma^3(\mathrm{T})/[\Delta\mathrm{P}(\mathrm{T})]^2 \quad (6)$$

The effective neutron detection threshold (MeV) or minimum possible energy to nucleate a bubble can also be expressed in terms of degree of super-heat. The super-heat degree is described as

$$S = (T - T_b) \quad (7)$$

T_b is boiling or saturation droplets temp at temperature T. Seeking a unified parameterization of experimental data; a new dimensionless quantity reduced super-heat is proposed which is described as

$$S = (T - T_b)/(T_c - T_b) \qquad (8)$$

S is called reduced super-heat. The semi-logarithmic in Figure 3 illustrates that an exponential trend links effective thresholds and decreased super-heat. Because it includes halogenated hydrocarbons, chlorofluorocarbons, and fluorocarbons, these associations apply to all halocarbons. Photon sensitization happens for $S \geq 0.51$, for example, when the emulsions are halfway between critical and boiling temps [27].

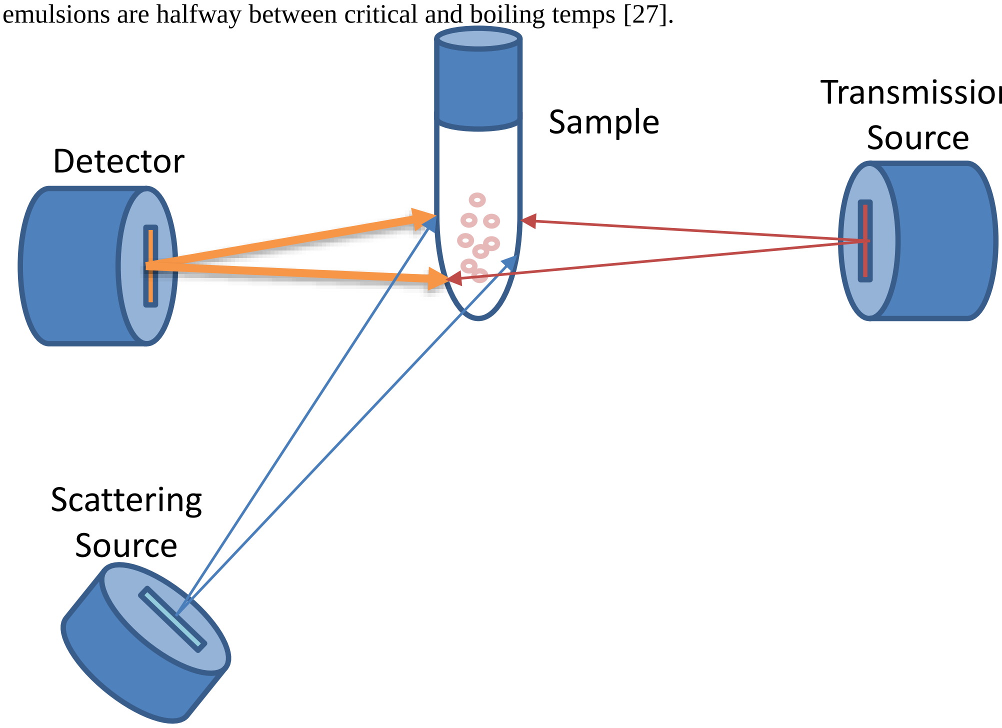

FIGURE 3. Basic principle of super-heated emulsion detector

THERMAL NEUTRON RESPONSE

The reaction of thermal neutron of CCl_2F_2 depending on detectors of superheated emulsion can be explained by:

$$^{35}_{17}\text{Cl} + \text{n} \rightarrow {}^{35}_{16}\text{Cl} + {}^{1}_{1}\text{Cl} + 17\text{keV} \qquad (9)$$

The chlorine ion interaction with incident neutron is responsible for causing the bubble nucleation when Freon-12 is used as the super-heated liquid.

Super-heated Liquids for Neutron and Gamma

The commonly used low boiling point refrigerants for super-heated Emulsion based neutron and gamma detectors are CCl_2F_2, $C_2Cl_2F_4$, $C_2H_3ClF_2$, C_4H_{10}, C_4F_8, etc. The physical properties of these refrigerants at 25°C are shown in Table 2. In addition to the liquids mentioned above, mixtures in various proportions of two refrigerants, HCFC, HFC, and Fluorocarbon compounds, can also be used to develop multiple threshold neutron and gamma detectors. Three such compounds, i.e., CF_3CH_2F, C_2HClF_4, and C_3F_6, have been reported. CF_3CH_2F and C_2HClF_4-based detectors were sensitive to neutron and can be environmentally friendly alternative droplet materials. C_3F_6 compound-based super-heated emulsion detector is sensitive to neutron and gamma radiation. These refrigerants may also be useful for developing a wide range of neutron spectrometers.

TABLE 2. Physical properties of Superheated Emulsion Detector liquids at 25°C

Chemical codes	**Chemic chemical formula**	**Boiling Point (^oC)**	**Critical temperature (^oC)**	**Liquid density (gm/cc) at 25^oC**
CFC-12	CCl_2F_2	-29.80	111.80	1.3
CFC-114	$C_2Cl_2F_4$	3.50	145.63	1.5
CFC-115	$CClF_2CF_3$	-37.95	80.10	1.3
HCFC-142B	$C_2H_3ClF_2$	-9.30	137.14	1.1
Isobutene	C_4H_{10}	-11.70	Data not available	0.6
HFC-134A	CF_3CH_2F	-26.50	101.20	1.21
HCFC-124	C_2HClF_4	-12.1	122.2	1.4
C-318	C_4F_8	-5.99	115.31	1.5
Hexaflouropropylene	C_3F_6	-29.00	Data not available	Data not available

Super-heated Emulsion Based Detector

The sensor material dispersed in the polycarbonate tube is 4cm 3 of firm transparent elastic polymer medium suspended with liquid drops of refrigerants. Once the pressure on the detector matrix was emitted by unscrewing the top of the detector, the liquid droplets became super-heated. These super-heated droplets vaporize once they interact with neutrons. The numbers of bubbles are proportional to the equivalent dose. The bubbles have been fixed in elastic intermediate and could be subsequently counted visually or with the help of a macro lens. Re- compressing the detector material transforms the bubble back into the droplet, and the detector can be reused as shown in Figure 4 [39]

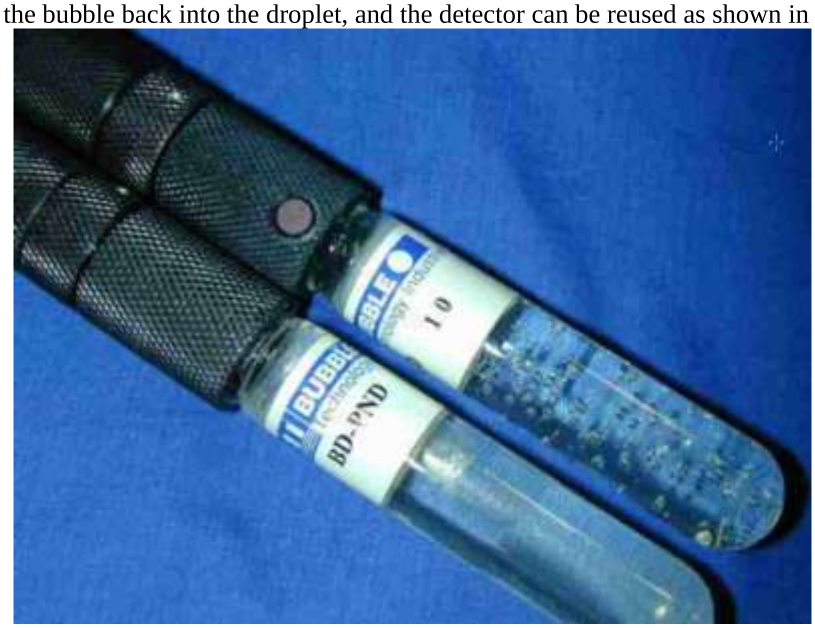

FIGURE 4. Super-heated emulsion-based detector (DLJ)

APPLICATIONS

Neutron Dosimetry

Several global organizations use bubble detectors to measure personal neutron exposures regularly. [40]. The monitoring is extremely important, streaming through the nuclear reactor, nuclear submarine or neutron camera, or pulse neutron accelerator where neutron fields are high and localized. Bubble Technology Industries improvised the earlier bubble detector, i.e., BD-100, with temperature compensation by modifying the device's design. The temperature-compensated Bubble Detector is useful for personal neutron dosimetry and is named BD-PND. The above

BD-PND has been tested at Defence Laboratory, Jodhpur, in relationships of dynamic range, reproducibility, reliability, repeated use, temp dependence, energy dependence, etc. [41]. These detectors are particularly sensitive to neutrons (at least an order of value more sensitive than any other passive apparatus). The detectors provide an isotropic reaction, an instantaneous visual dosage recording, and are fully unaffected by gamma-rays. The introduction of temperature compensation resolved the earlier technical limitations of the bubble detector by introducing a special proprietary material on the top layer of the suspended polymer medium. A new bubbles detector was also applied for thermal neutron monitoring using a 6 Li compound dispersed during the polymer material [42].

Framework scientific LLC in the United States has created an active electronic gadget ideally suited for region monitoring systems surrounding great-energy accelerators [43]. A new device (RAISA) depending on bubbles detectors was developed to satisfy long-term space mission radiation monitoring demands. RAISA has two bubble detectors, although only one of them is employed as a radiation sensor at any one moment. Once the first detector has gathered the max amount of bubbles, a microprocessor activates the second detector and compresses the first. RAISA may run continuously for several years by changing back and forth. RAISA may be utilized for radiation monitoring at any nuclear power plant [44]. The dosage and dosage speed ranges in RAISA were large, and bubble counting was transmitted electronically as the bubbles developed. Defense Laboratory, Jodhpur, has also developed active electronic devices based on super-heated emulsion detectors. A continuous area monitoring electronic acoustic device has also been developed to monitor neutron levels near nuclear installations [45]. New acoustic instrumentation for super-heated drop detectors has also been developed using high-quality electret microphones and adaptive electronics [46].

Neutron Spectrometry

BTI, Canada developed bubble detectors with variable neutron energy thresholds by altering the formulation. The neutron energy thresholds of the developed bubbles detector were 10, 100, 600, 1000, 2500, and 10,000 keV. Various organizations have utilized the bubbles detection spectrometer to characterize neutron emissions in nuclear industries, management of fissile materials, and accelerator facilities (for example, [47]). The developed bubble detectors are completely insensitive to gamma radiations. Defense Laboratory, Jodhpur, has also prepared bubble detectors with the threshold of 1.2, 100, 500, and 5000 keV [48]. The DLJ-developed bubble detectors have also been tested at RRCAT, Indore, for monitoring streaming through shielding in INDUS-1 [49].

Space, Aviation crew, high energy accelerator, and heavy-ion research

The interesting application of bubble detector spectroscopy is measuring the neutron spectrum in space. The bubble spectrum using the above detectors has been measured in the Russian satellites BIO-COSMOS (BION) and Russian space station MIR [42]. The neutron levels seemed relatively stable in the order of 100 Sv daily, despite the varied orbital factors and timings. Large numbers of neutrons over 10 MeV emerged in the beam, as some theories had predicted, while neutrons around a few MeV have been anticipated since they are "evaporation neutrons." [42]. Great energy protons have generated great energy neutrons.

Bubble detectors are also popular for monitoring commercial and military aviation crews [50]. The survey conducted among commercial aircrew of continental North America and Caribbean flights showed annual exposure levels >1mSv. The bubble detector spectrometer is also popular among high-energy accelerators from MeV to GeV range to estimate photo-neutron contributions in intense photon fields. For the search for weakly interacting large particles, super-heated emulsions seem appealing. Two multinational multi-collaborative projects have recently constructed arrays of super-heated emulsion modules for use in subterranean labs with exceptionally low muon and neutron backgrounds. These detectors have energy thresholds for nuclear recoils of less than 10 keV and almost full beta and gamma background discrimination. Therefore, they should allow for a large increase in cold dark matter sensitivity. [51].

Gamma dosimetry

Gamma-sensitive bubble detectors (BD-GAMMA) by BTI, Canada, and gamma-sensitive super-heated drop detectors by Aphel Enterprises, USA, have also been developed. BTI, Canada has successfully applied temperature compensation to the gamma detector similar to that done for the neutron detector. These detectors may be used for 3-D dosimetry photon-emitting brachytherapy sources [51]. Another interesting application of bubble detectors is dark matter detection [52]. Defense Laboratory, Jodhpur has also developed a Gamma bubble detector, which has been tested and calibrated at RSS, RSSD, BARC, and Mumbai [53]

Defense Applications

The detector has wide applications in Defence, particularly leakage neutron measurements in nuclear submarines, neutron shielding efficacy of armored vehicles, and neutron measurements during the process of transportation of fissile materials. These sensors may be one of the fastest indicators of the neutron Initial Nuclear Radiation zone after the Atom bomb explosion. The presence of fast neutrons having an average energy of 2.0MeV is a very good indicator for a fission-based nuclear explosion in the INR zone. Whereas for fusion-based explosions based on D-T and T-T reactions, the threshold-based super-heated Emulsion detector can play a vital role in confirming the type of fusion device. For discrimination of fission and fusion type nuclear weapon devices in any nuclear emergency, such detector may play a vital role.

Educators and police can use the Gamma detector and neutron detectors, Nuclear Emergency response team particularly in nuclear fall-out or dispersion of radioactive materials in case of a dirty bomb explosion. The radiation surveyors and workers, if any one of them needs to know the presence of gamma radiation instantly. These sensor devices are user-friendly and more suitable than any other existing sensors. Any illiterate person can also know the presence of gamma and neutron radiations using such detector devices. Due to extremely high sensitivity and the fast response time of the detector, very low radiation levels can also be detected instantly. The sensor does not require any power and is light in weight.

X-RAY EFFECT ON LIVES

X-rays have been widely used in medicine for a long period (approximately more than 100 years). Most of us will have an X-ray examined at some point in our lives, either when we suspect a broken bone or at the dentist.

Working X-rays mechanism: Standard X-ray images are obtained by placing a part of the body in front of the X-ray machine and shooting short pulses of X-rays at it. Radiation easily passes through muscle, fat, and skin, but the bones absorb it because it is denser. Bones appear white on the image being produced, unlike less dense tissues that appear darker.

Types of X-rays

The most commonly used x-ray images are:

- Radiography: The most common type of X-ray, and is used to detect bone fractures, examine the chest, or at the dentist. Radiography uses the least amount of radiation possible.
- Fluoroscopy: This procedure allows X-rays to be viewed in real-time so that images can be taken exactly when needed. Fluoroscopy looks at things like the intestines by taking a drink containing barium, which shows up on X-rays as it moves through the gut. Fluoroscopy uses slightly more radiation than the standard X-ray rate, but the amount of radiation is very small.
- Computerized tomography: a computerized tomography scan takes several images and uses a higher radiation dose. The patient lies on a table with a ring-shaped scanner running over it. Using X-rays for the scanner takes a series of "slices" that allow the production of 3D images.

The Potential Risks

Since we are often exposed to very low quantities of radiation, it happens naturally all around us. However, large dosages may alter the DNA in our cells, increasing the chance of developing cancer in later life. Although having an X-ray examination exposes us to radiation, the quantities of radiation we are exposed to are extremely low, and the advantages exceed any possible concerns by a considerable margin. Before the test, protective gear is also recommended to be worn to lessen the quantity of radiation that contacts other body areas. For instance, a lead apron must be worn with an X-ray of the arm to prevent radiation from penetrating other places. Before visiting the X-ray department, it should tell the doctor if they are expecting since radiation exposure might damage the unborn child.

- It is useful to contrast the quantity of radiation we get from an X-ray scan with the typical amounts of radiation present in everyday life to clarify the situation further. For instance, we are subjected to three times as much radiation on a long trip as we are during a chest X-ray. When a fractured bone is being examined, we are subjected to the same number of X-rays as we would on a typical day.
- Our radiation exposure will vary depending on the sort of picture we get. The treating physician will carefully assess the number of scans undergone since, for instance, a CT scan generates a larger dosage than ordinary X-rays because it captures numerous photos.

The Benefits

Radiation-based imaging is a crucial step in the diagnostic process since it may provide clinicians with a precise image of what is happening within the body. In conjunction with physical exams, blood tests, and x-rays, it aids medical professionals in diagnosing the issue and providing the best care. X-rays may result in unexpected findings when a patient is checked for something completely different.

X-rays may guide physicians throughout life-saving operations and assist them throughout medical procedures, in addition to giving pictures of the body for diagnostic reasons. Once have any questions, speak to a doctor and a radiologist. It is always vital to weigh the advantages of getting an X-ray. We can now identify more medical disorders quickly and effectively because of medical imaging technology advancements, which allow us to live longer and healthier lives.

CONCLUSION

- Radiation detectors relying on ionization consist of gas-filled and solid-state conductivity detectors.
- In terms of the temperature range of operation, neutron response, stability, and real-time response, the Superheated Emulsion Detectors for neutron and gamma radiations are matured technology.
- One of the most impressive aspects of these detectors is that their characteristics can be varied easily to match specific applications, e.g., changing the composition of super-heated emulsion materials. One can make an extremely sensitive detector capable of detecting well.

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