# Teori Sistem Dosimetri

**Pusat Pendidikan dan Pelatihan**

**Badan Tenaga Nuklir Nasional**

# Biodata

| | | |
|---|---|---|
| 1. | **Name** | **Bimo Saputro** |
| 2. | Education | Bachelor Nuclear Engineering |
| 3. | Birth Day | Yogyakarta, October 13, 1993 |
| 4. | Specialist | Gamma Irradiator, Accelelator and Dosimetry |
| 5. | Mail Address | bimo-saputra@batan.go.id |
| 6. | Phone Number / WA | 0813 1941 7800 |

**Training Experience**

| Num | Year | Training Title | Time and Place |
|---|---|---|---|
| 1. | 2018 | ESR Spectometers | September, Indonesia |
| 2. | 2019 | Gamma Irradiator Facility | November to December, Serbia |
| 3. | 2020 | Irradiator Officer | July, Indonesia |

**Research Experience**

| Num | Year | Title |
|---|---|---|
| 1. | 2019 | Dosimetry Intercomparation Peformance |
| 2. | 2020 | Radiation Application for PPE Sterilization |

# Latar Belakang

## - Latar Belakang

Pemahaman dasar teknologi iradiator dan jaminan kualitas proses diperlukan sebuah pemahaman. Pemahaman ini menjadi dasar melakukan proses iradiasi sesuai standar, sehingga dapat menciptakan kepuasan bagi pelanggan iradiasi.

## - Manfaat -

1. Mampu memahami prinsip kerja iradiator gamma
2. Mampu mengaplikasi standar kualitas proses

## - Tujuan Pembelajaran

1. Mampu menjelasakan prinsip kerja iradiator gamma
2. Mampu menerapkan teknik dosimetri sesuai standar

# Pokok Bahasan

## - Jenis Iradiator -

1. Kategori Iradiator Gamma
2. Perbedaan Fungsi Berdasarkan Kategori Iradiator Gamma

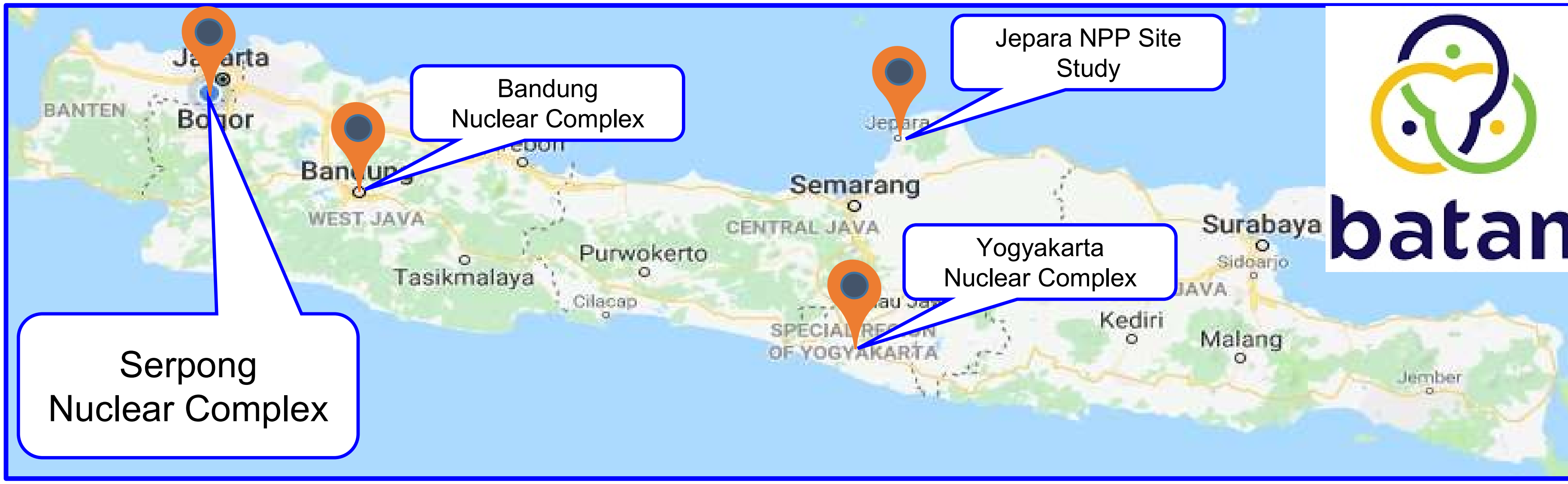
## - Aplikasi -

1. Definisi dan Prinsip Dosimetri
2. Standar Dosimetri Primer, Acuan, Transfer dan Rutin

## - Macam Dosimetri -

1. Definisi dan Prinsip Dosimetri
2. Standar Dosimetri Primer, Acuan, Transfer dan Rutin

# Fasilitas Iradiator BATAN





Merah Putih Gamma Irradiator

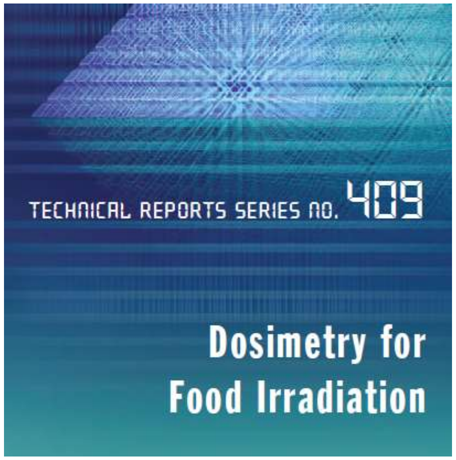
**BATAN Gamma Irradiator Milestone**

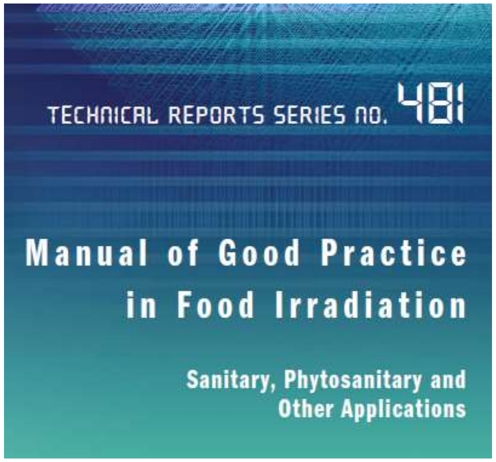
- **1958** – BATAN was Established
- **1968** – GAMMA CELL 220 Irradiator was construction
- **1975** – IRPASENA Gamma Irradiator was construction
- **1983** – IRKA Gamma Irradiator was construction
- **1992** – GAMMA CHAMBER 4000A Irradiator was construction
- **2017** – MERAH PUTIH Gamma Irradiator was construction

**50 years Experience** of Gamma Irradiation Operations

# Standar Iradiasi

batan




INTERNATIONAL STANDARD — ISO 14470

First edition 2011-12-01

**Food irradiation — Requirements for the development, validation and routine control of the process of irradiation using ionizing radiation for the treatment of food**

INTERNATIONAL STANDARD — ISO 11137-3

Second edition 2017-06

**Sterilization of health care products — Radiation —**

Part 3:
**Guidance on dosimetric aspects of development, validation and routine control**

INTERNATIONAL STANDARD — ISO 11137-1

First edition 2006-04-15

**Sterilization of health care products — Radiation —**

Part 1:
**Requirements for development, validation and routine control of a sterilization process for medical devices**

**Sterilization of health care products — Radiation —**

Part 2:
**Establishing the sterilization dose**

*Stérilisation des produits de santé — Irradiation —*

*Partie 2: Établissement de la dose stérilisante*

BADAN PENGAWAS OBAT DAN MAKANAN
REPUBLIK INDONESIA

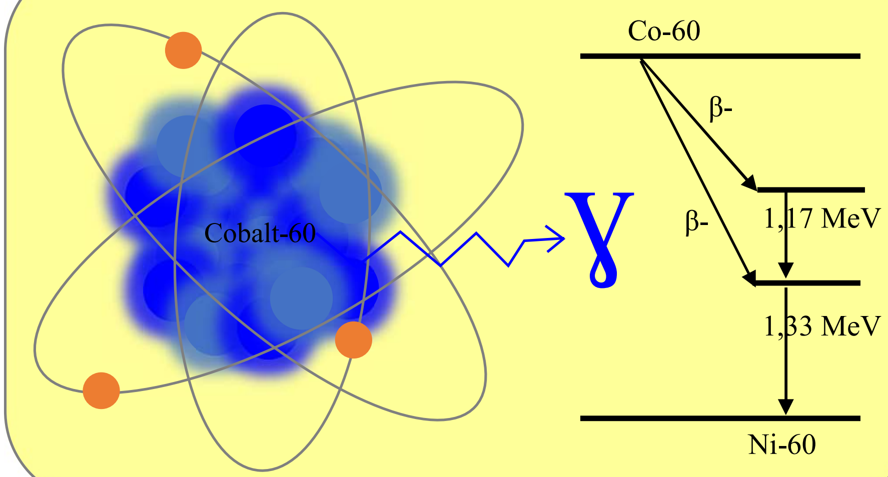
PERATURAN BADAN PENGAWAS OBAT DAN MAKANAN
NOMOR 3 TAHUN 2018
TENTANG
PANGAN IRADIASI

KEPUTUSAN KEPALA BADAN PENGAWAS TENAGA NUKLIR
NOMOR : 11/Ka-BAPETEN/VI-99
TENTANG
IZIN KONSTRUKSI DAN OPERASI IRADIATOR

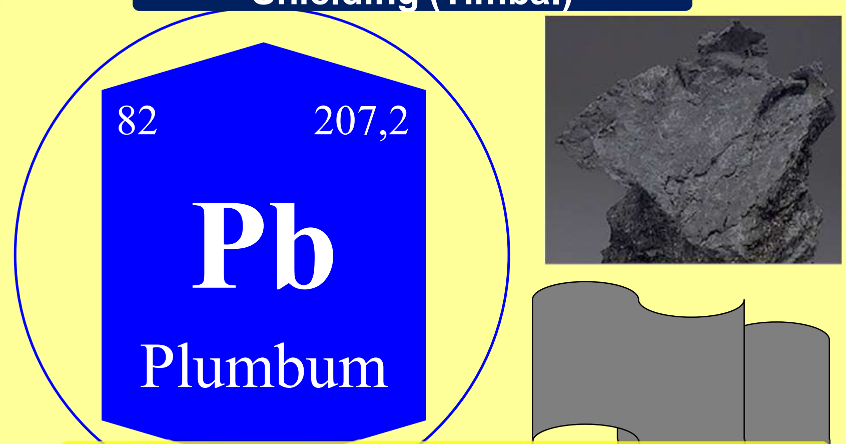
KEPALA BADAN PENGAWAS TENAGA NUKLIR,

# Komponen Utama Iradiator

## Sumber Cobalt



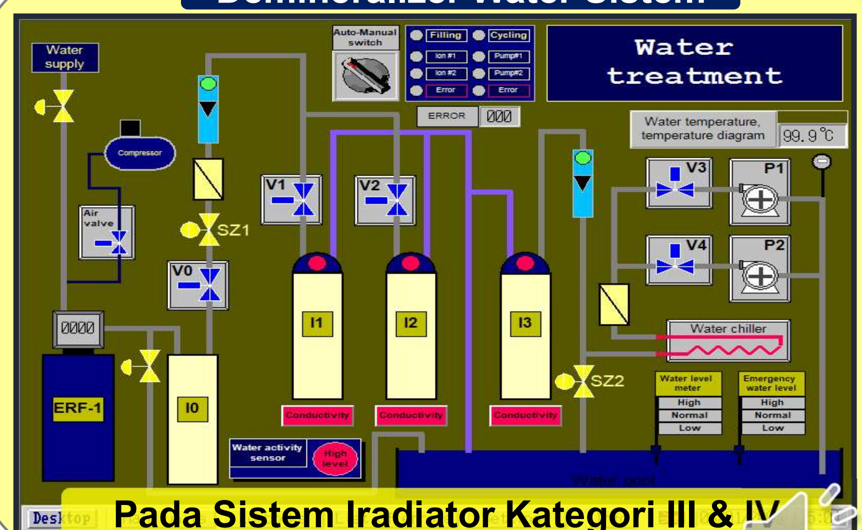

## Shielding (Timbal)




**Pada Sistem Iradiator Kategori I & II**

## Sistem Kontrol


## Demineralizer Water Sistem

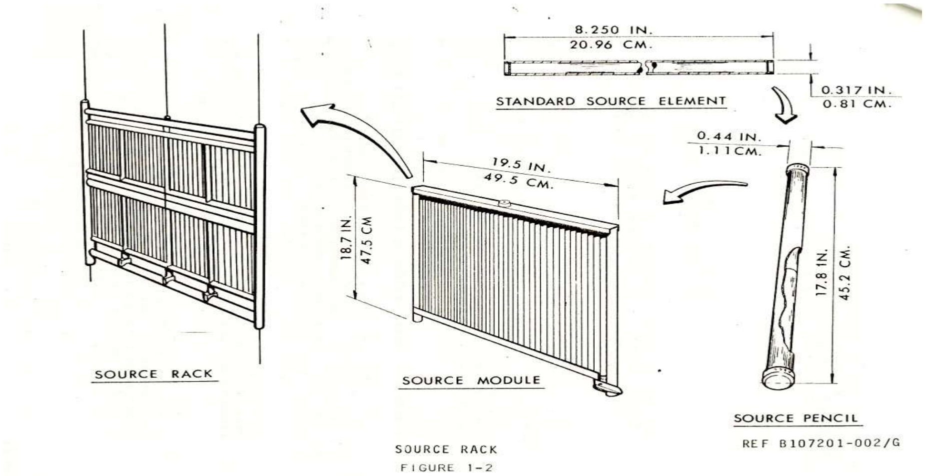



**Pada Sistem Iradiator Kategori III & IV**

# Gamma Facilities: Radiation Sources

**$^{60}$ Co :**

$$^{59}Co + n \Rightarrow {}^{60}Co \Rightarrow {}^{60}Ni + e^{-} \; (+\, 2\ \gamma \text{ photons})$$




**Half life: 5.26 years;**

**Photon energy: 1.17 MeV and 1.33 MeV;**

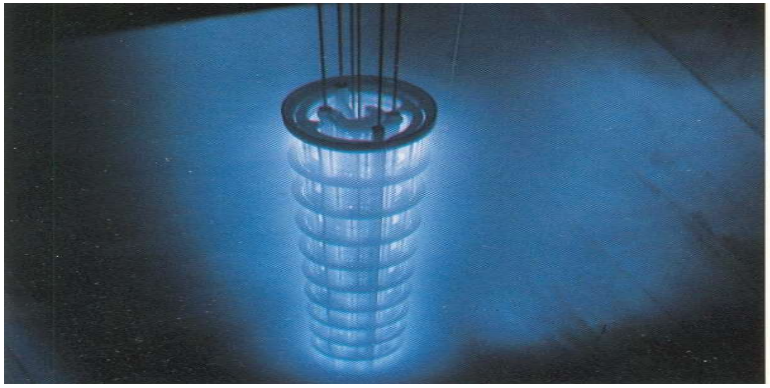
# Radiation sources

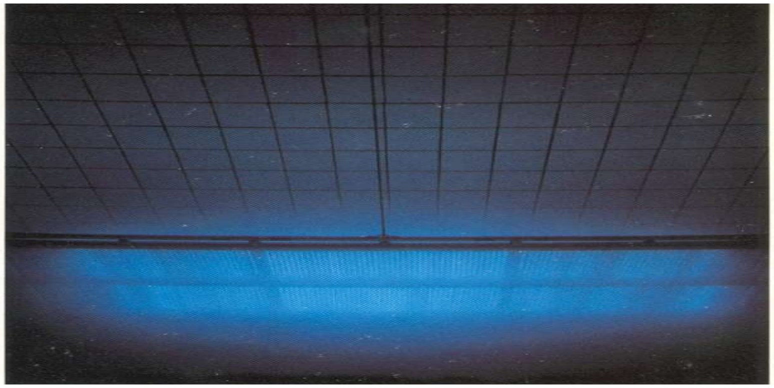
**$^{137}Cs$:**

$$^{137}Cs \Rightarrow {}^{137}Ba + e^- \; (+\ \gamma \text{ photon})$$

**Half life: 30 years;**

**Photon energy: 0.662 MeV;**





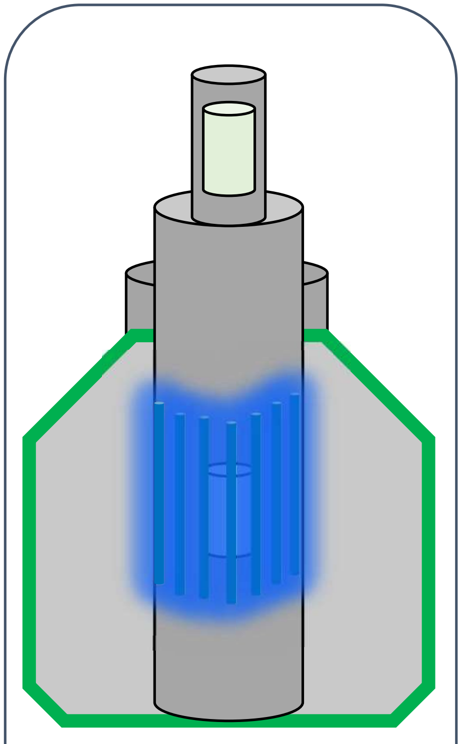
# Kategori Iradiator Gamma

Kontainer kering,
sumber diam,
sampel bergerak

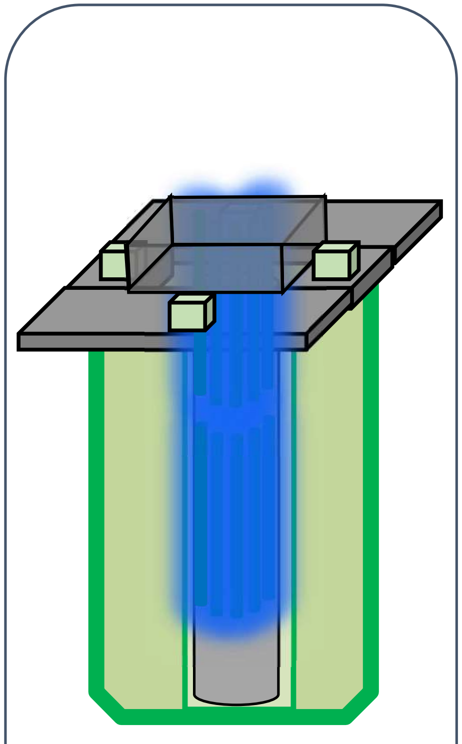
Kontainer kering,
sumber bergerak,
sampel diam

Kontainer basah,
sumber diam,
sampel bergerak

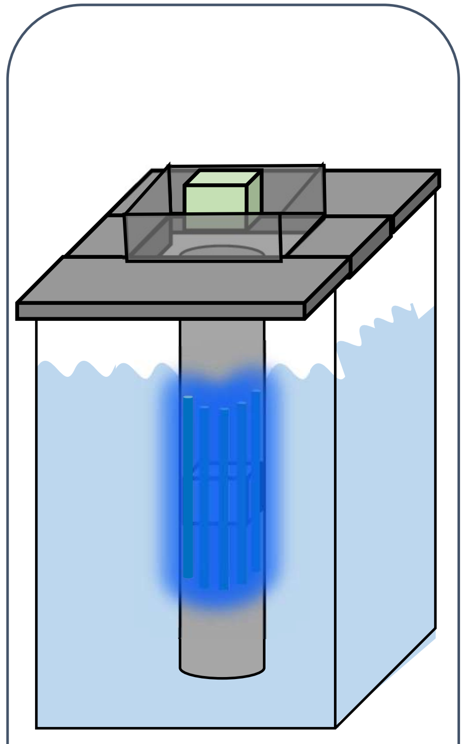
Kontainer basah,
sumber bergerak,
sampel diam



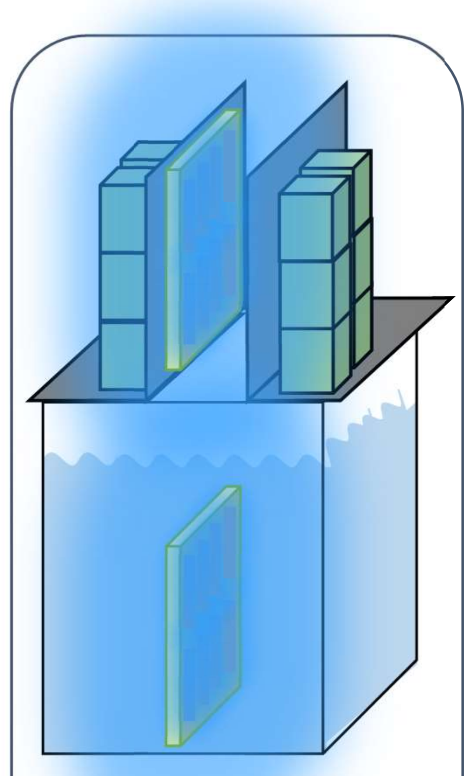
**Kategori I**



**Kategori II**

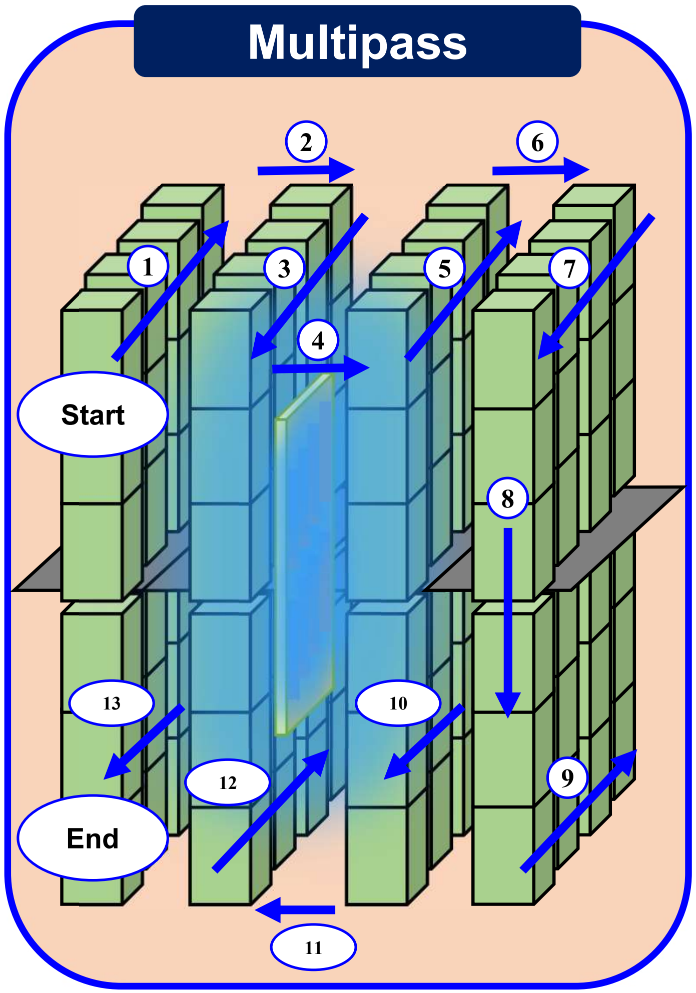


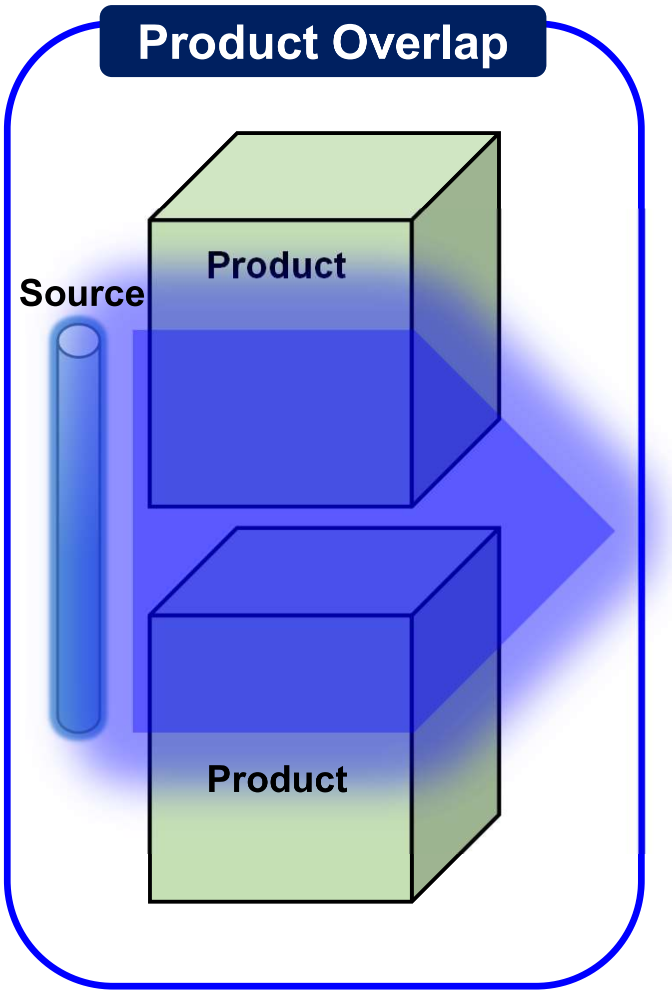
**Kategori III**



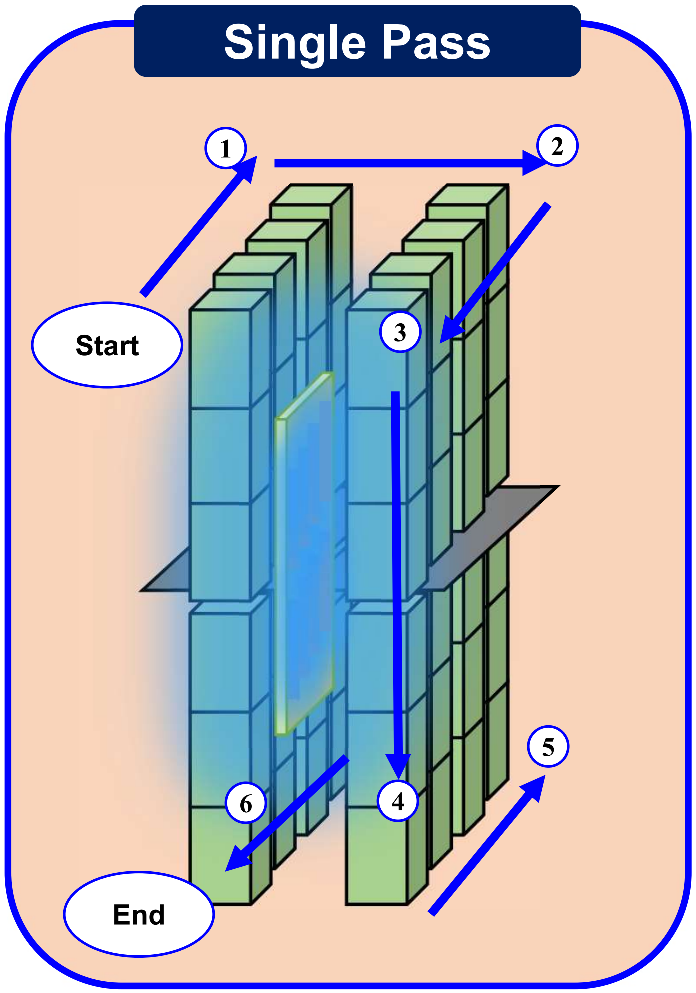
**Kategori IV**

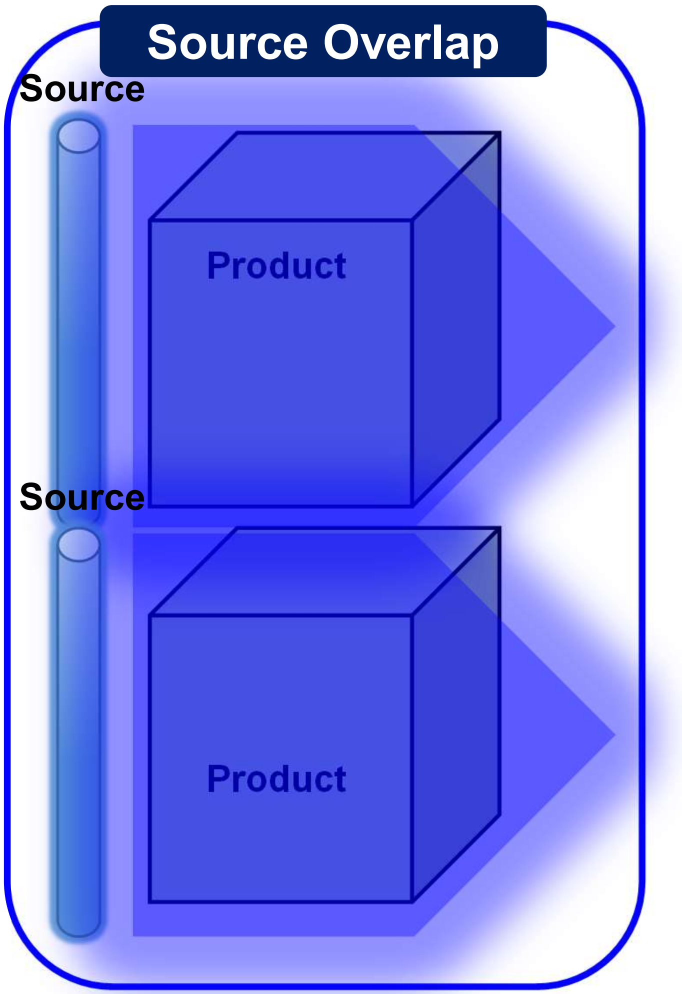
# Karakteristik Iradiator Gamma



# Karakteristik Iradiator Gamma



# Fasilitas Iradiator Gamma di PAIR

## 1. Iradiator Gamma Cell 220 Upgrade


- Dibangun : Tahun 1968 - Upgrade Tahun 2017
- Kategori : Kategori I
- Sumber : Cobalt-60
- Kap. Maks : 11 kCi
- Komisioning : 7 kCi per April 2018
- Aplikasi : Penelitian

## 2. Iradiator Gamma Chamber

**Aktivitas Sumber Radiasi Rendah**

- Dibangun : Tahun 1992
- Kategori : Kategori I
- Sumber : Cobalt-60
- Kap. Maks : 10 kCi
- Komisioning : 0,37 kCi per April 2018
- Aplikasi : Penelitian

# Fasilitas Iradiator Gamma di PAIR

## 3. Iradiator Karet Alam (IRKA)

- Dibangun : Tahun 1983
- Kategori : Kategori IV
- Sumber : Cobalt-60
- Kap. Maks : 300 kCi
- Komisioning : 70 kCi per April 2018
- Aplikasi : Industri dan Penelitian

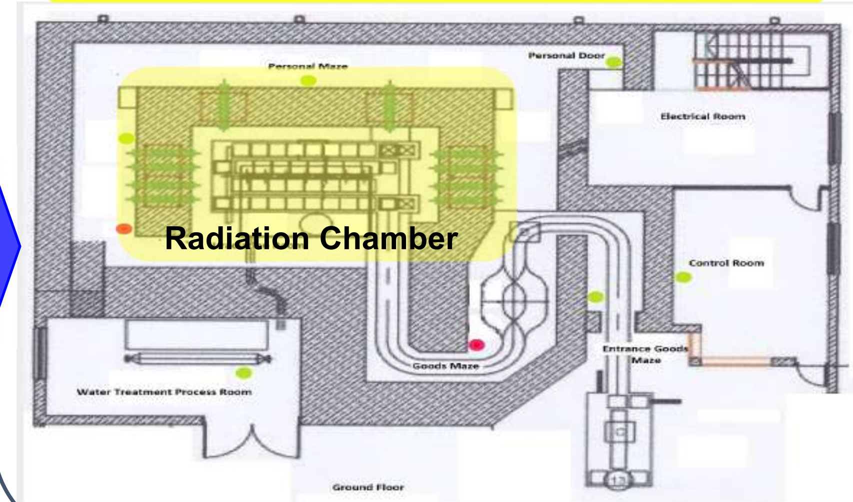
## 4. Iradiator Panoramic Serbaguna (IRPASENA)

- Dibangun : Tahun 1975
- Kategori : Kategori II
- Sumber : Cobalt-60
- Kap. Maks : 80 kCi
- Komisioning : 10 kCi per April 2018
- Aplikasi : Industri dan Penelitian

# Fasilitas Iradiator Gamma di PAIR


**Merah Putih Gamma Irradiator Building**

**Merah Putih Gamma Irradiator Layout**



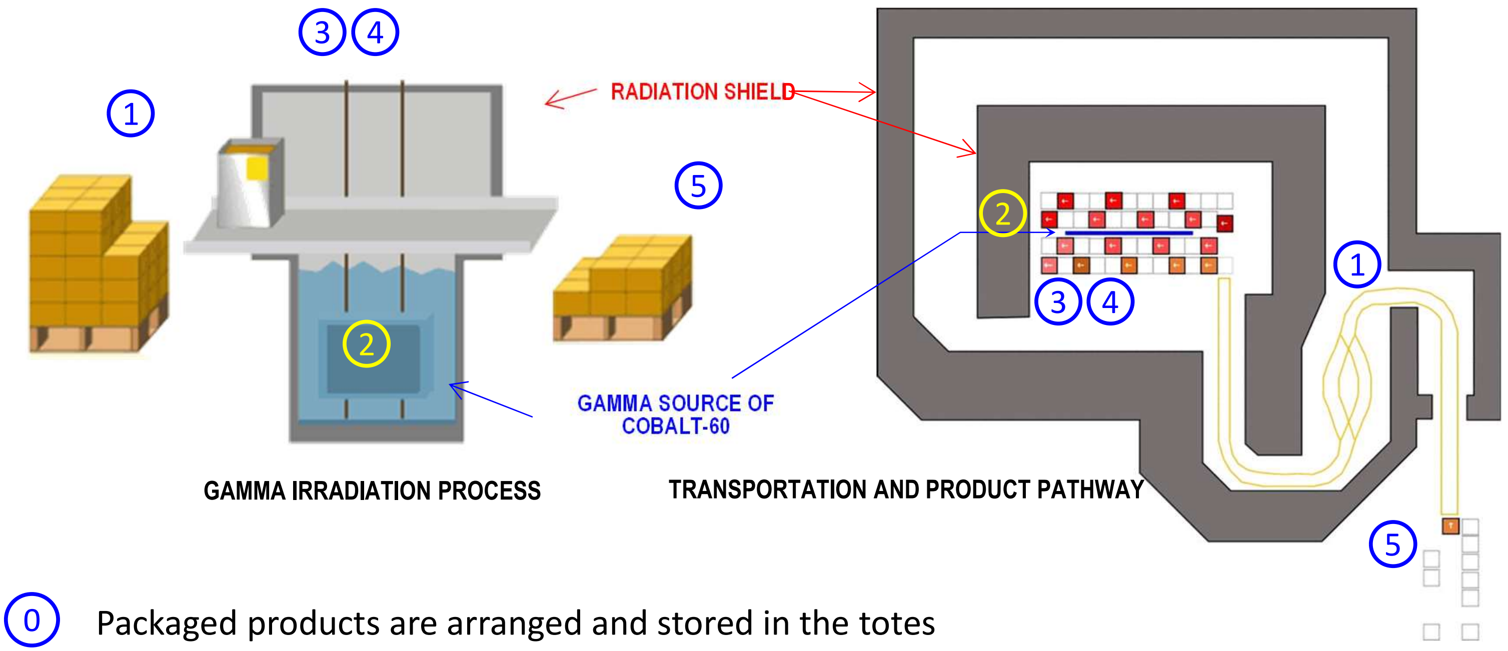

## Facility

- Utility and Generator System
- Water Treatment System
- Main Control Panel System
- Product Transport System

## Specification

- Construction : **November 2017**
- Category : Category IV
- Radioactive Source : Cobalt-60
- Max Capacity : 2000 kCi
- **Source Activity : 250 kCi per Feb 2019**
- Applications : Multipurpose

# Fasilitas Iradiator Gamma di PAIR




0 Packaged products are arranged and stored in the totes

1 Totes enter the irradiation chamber (bunker).

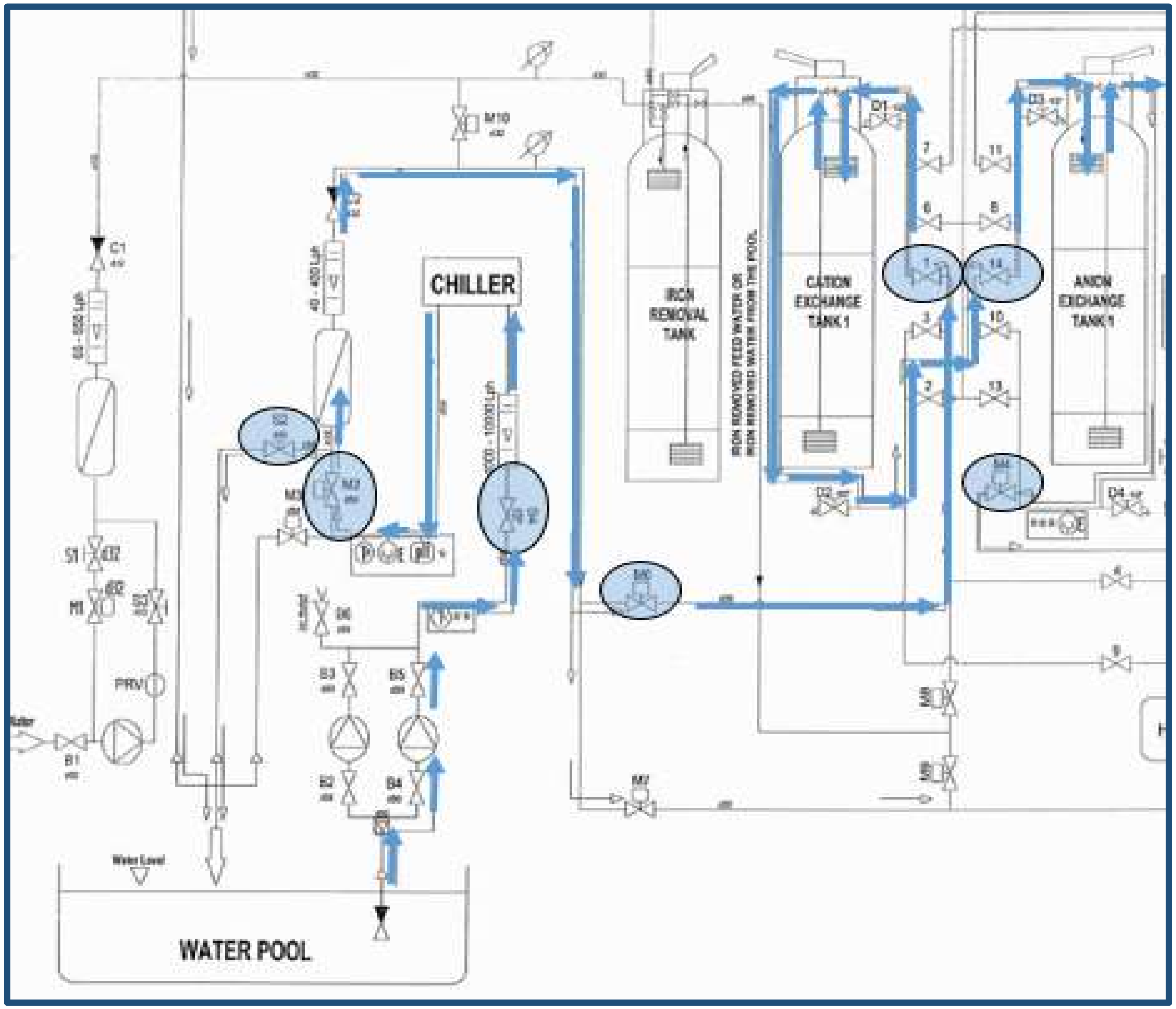
2 Gamma source of Cobalt-60 are ascended from the water pool for irradiation process.

3 Totes undergo the specific pathway to achieve the uniform irradiation dose.

4 Irradiation time is determined by the product type.

5 Post-irradiation: products are still intact with the initial packaging, ready to be distributed to the market.

# Water Treatment System




1. Menjaga Konduktivitas dibawah 10 micro siemens

2. WTS memiliki 2 sistem Anion dan Kation

3. Anion untuk menarik unsur mineral negatif

4. Kation untuk menarik unsur mineral positif

# Pemanfaatan Iradiator

## Penelitian

- Modifikasi Bahan (Crosslinking, Degradasi, Grafting, & Polimerisasi)
- Mutasi/ Pemuliaan tanaman
- Fitosanitari

Tanaman Utuh

Plantlet/Kallus

Benih

Kitosan

Super Absorban

## Industri

- Pateurisasi
- Sterilisasi

Kapsul herbal

Seasoning

Bahan baku kosmetik


Alat Kesehatan

Pangan

# Pemanfaatan Iradiator




PASTEURISASI



# Prinsip Dosimetri

## APA ITU DOSIMETRI?

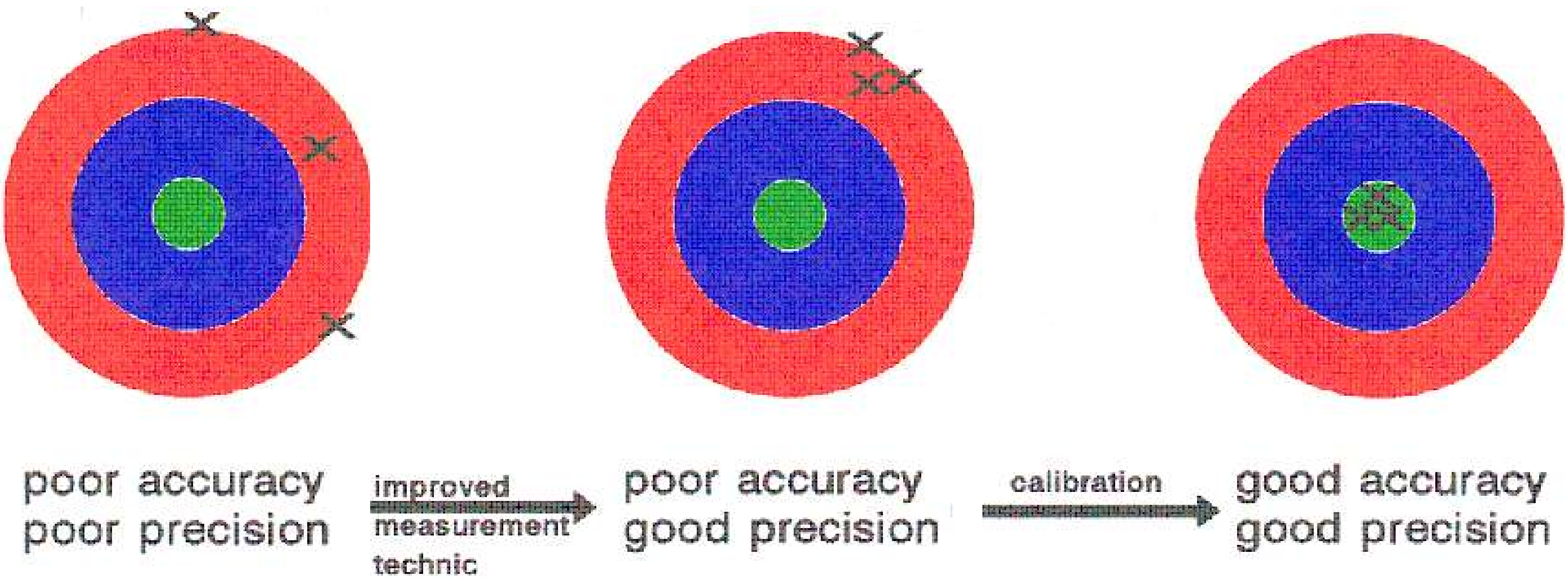
Bagian dari sistem kualitas total dengan memberikan jaminan kualitas dan dokumentasi, bahwa prosedur iradiasi telah dilakukan sesuai dengan spesifikasi.

**01** Dalam proses radiasi, validasi dan kontrol proses tergantung pada pengukuran dosis yang diserap.

**02** Pengukuran dosis serap menggunakan sistem dosimetri atau sistem yang memiliki tingkat akurasi dan presisi yang diketahui.

**03** Kalibrasi setiap sistem dosimetrik harus dapat tertelusur ke standar nasional yang sesuai.

# Accuracy and Precision



# ISO/ASTM Standards

*51204 Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing*

*51205 Practice for Use of a Ceric-Cerous Sulfate Dosimetry System*

*51261 Guide for Selection and Calibration of Dosimetry Systems for Radiation Processing*

*51275 Practice for the Use of a Radiochromic Film Dosimetry System*

*51276 Practice for the Use of a Polymethylmethacrylate Dosimetry System*

*51310 Practice for the Use of a Radiochromic Optical Waveguide Dosimetry System*

*51401 Practice for Use of a Dichromatic Dosimetry System*

*51431 Practice for Dosimetry in Electron Beam and X-Ray (Bremsstrahlung) Irradiation Facilities for Food Processing*

*51538 Practice for Use of the Ethanol-Chlorobenzene Dosimetry System*

*51540 Practice for Use of a Radiochromic Liquid Dosimetry System*

*51607 Practice for Use of the Alanine-EPR Dosim System*

*51608 Practice for Dosimetry in an X-Ray (Bremmstrahlung) Facility for Radiation Processing*

# Dosimetry – Sistem Penerapan

- **Aplikasi:**

  **- installation qualification;**

  **- operational qualification;**

  **- performance qualification;**

  **- process control;**

- **Sistem dokumentasi**

  **- Pengukuran traceable to a national standard or international standard,**

  **- Mengetahui nilai ketidakpastian dosimetri.**

- **Strata dosimeter:**

  **- primary-, secondary-, transfer standards;**

  **- routine systems;**

# Faktor Berpengaruh

1. **Irradiation conditions are different from calibration conditions:**

   **- temperature, dose rate, relative humidity, energy spectrum, irradiation geometry, etc.**

2. **Storage conditions:**

   **- before and after irradiation;**

3. **Instrumental errors:**

   **- absorbance and wavelength scale, scattered light, transfer of calibration curve from one instrument to another one, etc.**

# Environmental effects on dosimetry systems

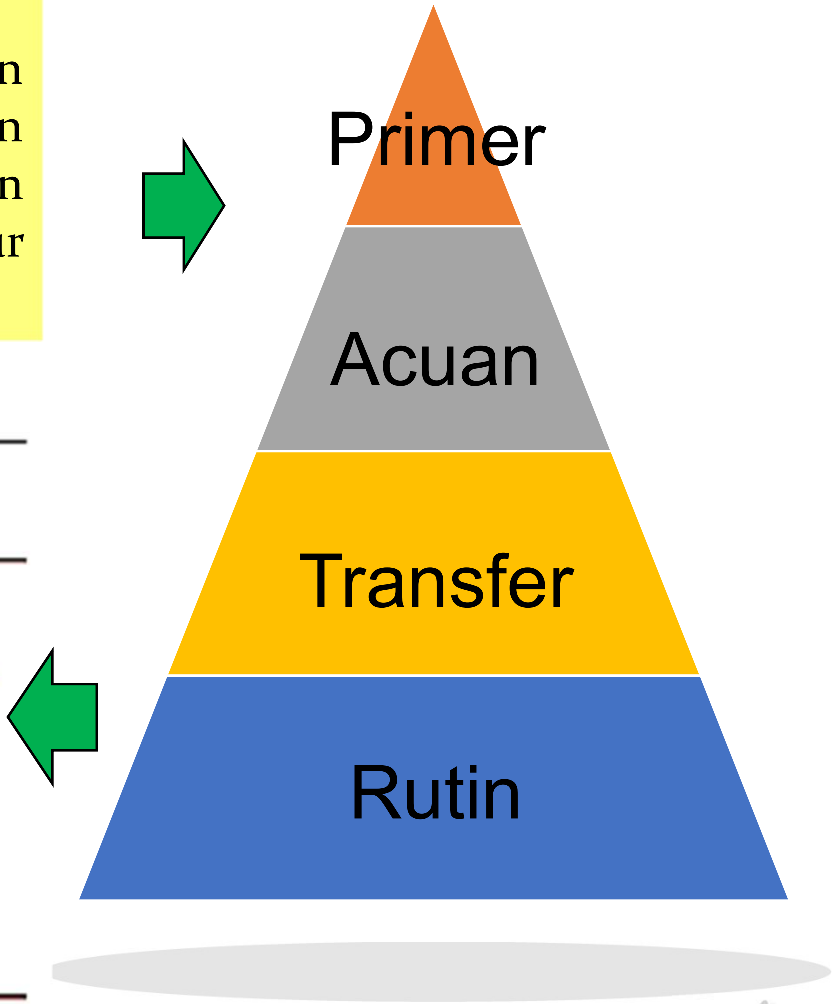
| Dosimeter | Measurement time after irr. | Humidity | Dose rate ($Gy\ s^{-1}$) | Irradiation temp. coeff., $(^oC)^{-1}$ |
|---|---|---|---|---|
| Alanine | 24 hours | yes | $< 10^8$ | + 0.25 % |
| Dichromate | 24 hours | no | $0.7 – 5x10^2$ | - 0.2 % |
| Ceric-cerous | immediately | no | $< 10^6$ | conc. dep. |
| ECB | immediately | no | $< 10^8$ | + 0.05 % |
| Calorimeters | immediately | no | $< 10^8$ | - |
| Perspex | 24 hours | yes | $< 10^5$ | + 1 % |
| FWT-60 | 5 min/60 $^oC$ | yes | $< 10^{13}$ | + 0.2 % |
| B3 | 5 min/60 $^oC$ | yes | $< 10^{13}$ | + 0.3 % |
| Sunna | 20 min/70 $^oC$ | no | $< 10^{13}$ | + 0.2 % |

# Dosimeter dan Jenisnya

APA ITU DOSIMETER?

Perangkat yang ketika diiradiasi, menunjukkan perubahan kuantitatif yang dapat dikaitkan dengan dosis yang diserap dalam suatu bahan menggunakan instrumen dan prosedur pengukuran yang tepat.

| Class | Calibration necessary? | Uncertainty ($k = 1$) | Examples |
|---|---|---|---|
| Primary | No | 1% | Calorimeter, ionization chamber |
| Reference | Yes | 2–3% | Calorimeter, alanine, dichromate, ceric-cerous, ECB, Fricke, |
| Transfer | Yes | 3–5% | Alanine, Fricke, dichromate, ceric-cerous, ECB |
| Routine | Yes | ≈5% | PMMA, radiochromic films, CTA, ceric-cerous, ECB |



# Dosimeter dan Standarnya

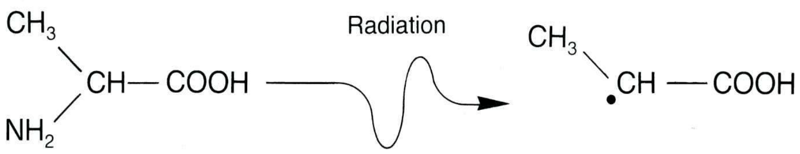
| Dosimeter system | Method of analysis | Useful dose range, Gy | Nominal precision limits | References |
|---|---|---|---|---|
| Fricke solution | UV – spectro-photometry | $3x10 - 4x10^2$ | 1 % | ASTM E 1026 - 04 |
| Ceric – cerous sulphate | UV – spectro-photometry | $10^3 - 10^6$ | 3 % | ISO/ASTM 51205 |
| Potassium dichromate | UV-VIS spectrophotometry | $5x10^3 - 4x10^4$ | 1 % | ISO/ASTM 51401 |
| Ethanol-mono-chlorobenzene | Titration,or HF oscillometry | $4x10^2 - 3x10^5$ | 3 % | ISO/ASTM 51538 |
| L - alanine | EPR | $1 - 10^5$ | 0.5 % | ISO/ASTM 51607 |
| Perspex systems | VIS - spectro-photometry | $10^3 - 5x10^4$ | 4 % | ISO/ASTM 51276 |
| FWT – 60 film | VIS - spectro-photometry | $10^3$ - $10^5$ | 3 % | ISO/ASTM 51275 |
| B 3 film | VIS - spectro-photometry | $10^3$ - $10^5$ | 3 % | ISO/ASTM 51275 |
| Cellulose triacetate | UV – spectro-photometry | $10^4$ - $10^6$ | 3 % | ISO/ASTM 51650 |
| Calorimetry | Resistance/ temperature | $1.5x10^3 - 5x10^4$ | 2 % | ISO/ASTM 51631 |

# Prinsip Dosimeter

***Pengukuran Dosis berdasarkan variasi metode:***

**- Peningkatan Temperatur (Kalorimeter)**

**- Perubahan Warna (Radiochromic, PMMA)**




**- Konsentrasi Radikal Bebas (Alanine)**

**- Perubahan Konduktivitas (ECB)**

**- Oksidasi Kimia Radiasi (Fricke)**

**- Pengurangan Kimia Radiasi (ceric-cerous, dichromate)**

**Primary standard dosimeters**
- **1 Kali kalibrasi**

**Reference standard dosimeters**
- **Kalibrasi oleh Lab nasional atau Lab terakreditasi**

**Transfer standard dosimeters**
- **Kalibrasi oleh Lab nasional atau Lab terakreditasi**

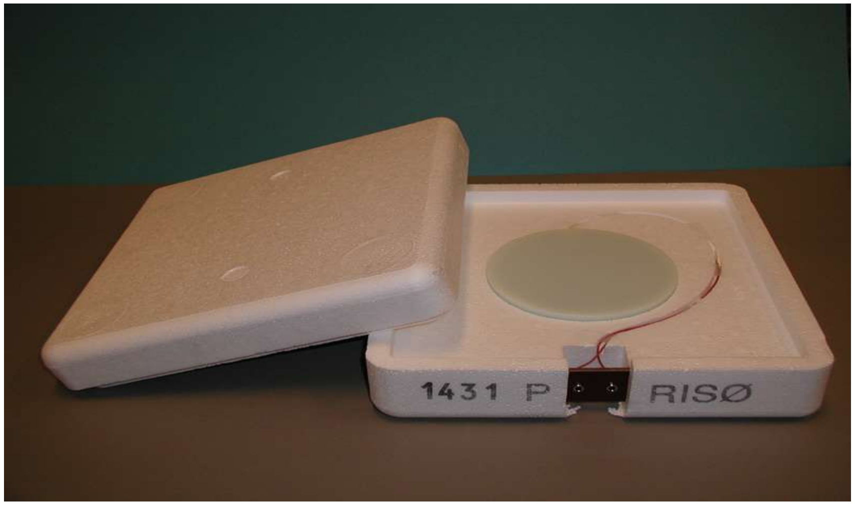
**Routine dosimeters**
- **Kalibrasi fasilitas / *in-plant***

# Dosimeter Standar Primer

**01** **Dosimeter dengan kualitas metrologi tertinggi, ditetapkan dan dipelihara sebagai standar dosis serap oleh organisasi standar nasional atau internasional untuk kalibrasi lingkungan radiasi**

**02** **Aplikasi berdasarkan pengukuran kuantitas fisika dasar**

**03** **Contoh : Kalorimeter Rentang dosis 1,5 – 50 kGy**
ISO/ASTM 51631:2003 Practice for Use of Calorimetric Dosimetry Systems for Electron Beam Dose Measurements and Routine Dosimeter Calibrations

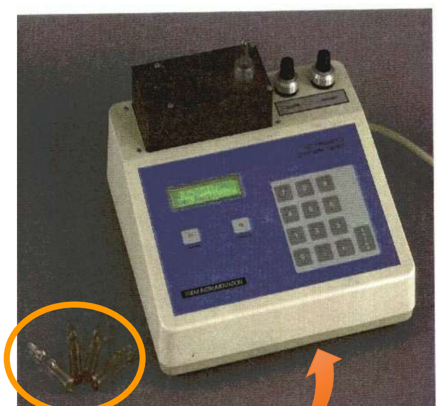



# Dosimeter Standar Acuan

- Dosimeter dengan kualitas metrologi tinggi, digunakan sebagai standar untuk memberikan pengukuran yang dapat ditelusur ke pengukuran yang dilakukan oleh dosimeter standar primer
- Membutuhkan kalibrasi dan digunakan untuk mengkalibrasi lingkungan radiasi dan dosimeter rutin

**Fase Cairan**

Contoh :
- Fricke
- Potassium dichromate



- ethanol-monochlorobenzene
- ceric-cerous

**Fase Padatan**

Contoh : Alanine

# Dosimeter Standar Acuan

## Dosimeter Fricke

- Rentang dosis pengukuran= 40 – 400 Gy
- Alat Ukur = UV-Vis Spektrofotometer
- Pembacaan Panjang Gelombang = 305 nm

## Dosimeter Alanine

- Rentang Dosis pengukuran = 10 Gy – 100 kGy
- Alat Ukur = Electron Spin Resonance (ESR)

# Dosimeter Standar Transfer

Sistem perantara dengan kualitas metrologi yang tinggi, digunakan untuk mentransfer informasi dosis dari laboratorium standar ke fasilitas iradiasi untuk ketertelusuran

Membutuhkan kalibrasi

Contoh dosimeter transfer

- Alanine
- Ethanol-Monochlorobenzene (ECB)
- Potassium dichromate
- Ceric-cerous

# Dosimeter Rutin

**01** Digunakan untuk pemetaan dosis serap dan kontrol rutin proses iradiasi

**02** Membutuhkan kalibrasi terhadap dosimeter acuan

**03** Contoh dosimeter rutin:


Perspex
(Red dan Amber)

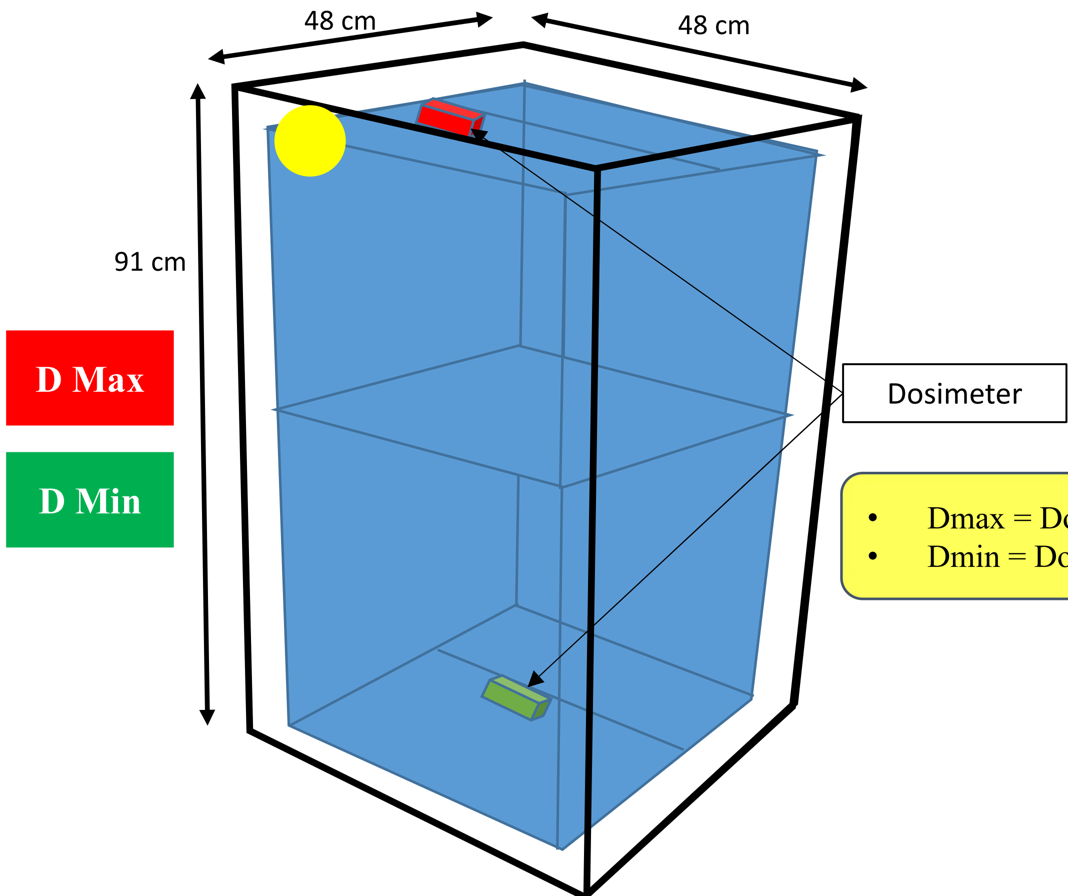
Radiochromic film (B3, FWT, Gafchromic)

# Dosimeter Rutin

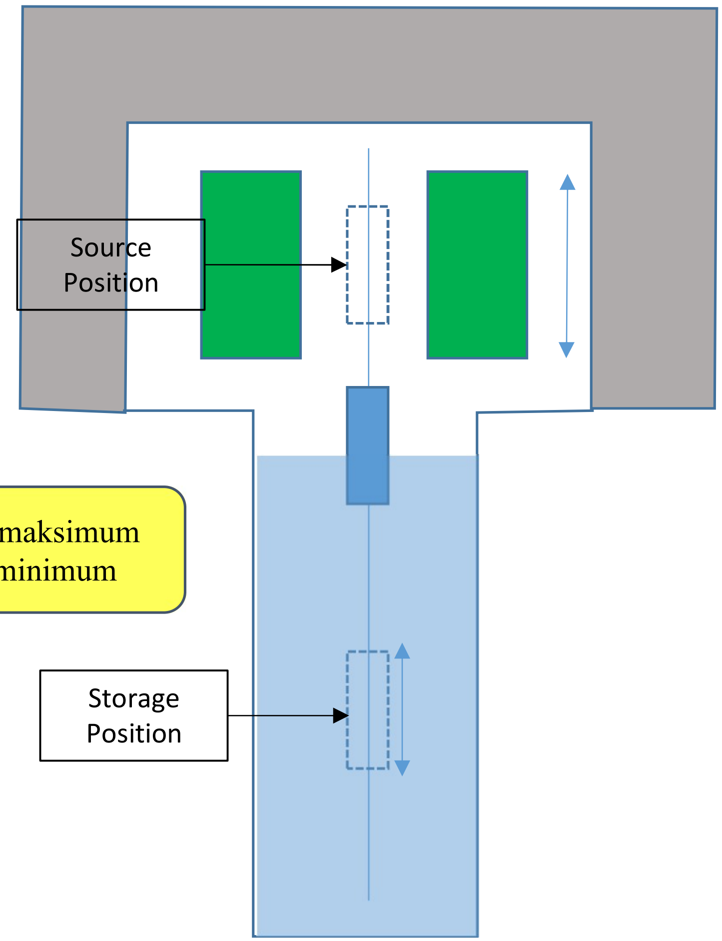
## Macam Dosimeter Rutin

| NO | DOSIMETER | PERALATAN | RANGE DOSIS (kGy) |
|---|---|---|---|
| 1. | Clear perspex | Spectrophotometer | 1 – 100 |
| 2. | Dyed perspex | Spectrophotometer | 1 – 50 |
| 3. | Ceric cerous sulphate | Potentiometry or Spectrophotometer | 1 - 100 |
| 4. | Ferrous-cupric dosimeter | Spectrophotometer | 1 – 30 |
| 5. | Cellulose triasetate | Spectrophotometer | 10 – 400 |
| 6. | Radiochromic dye films, solution, optical wave guide | Spectrophotometer | 0.001 - 100 |

# 3. Kontrol Rutin




- Dmax = Dosis maksimum
- Dmin = Dosis minimum




- Kalibrasi dosis dilakukan setiap 3 bulan sekali
- Untuk kontrol rutin, dosimeter dipasang pada setiap batch proses

- Posisi sumber  tampak atas

# Prosedur Dosimetri

1. Kalibrasi Laju Dosis

2. Pemetaan Distribusi Dosis Serap

3. Kontrol Rutin Dosis

# Tujuan Kalibrasi

- **Memastikan respon dosimeter dan dosis serap.**

- **Influence factors:**

  **- dose rate**

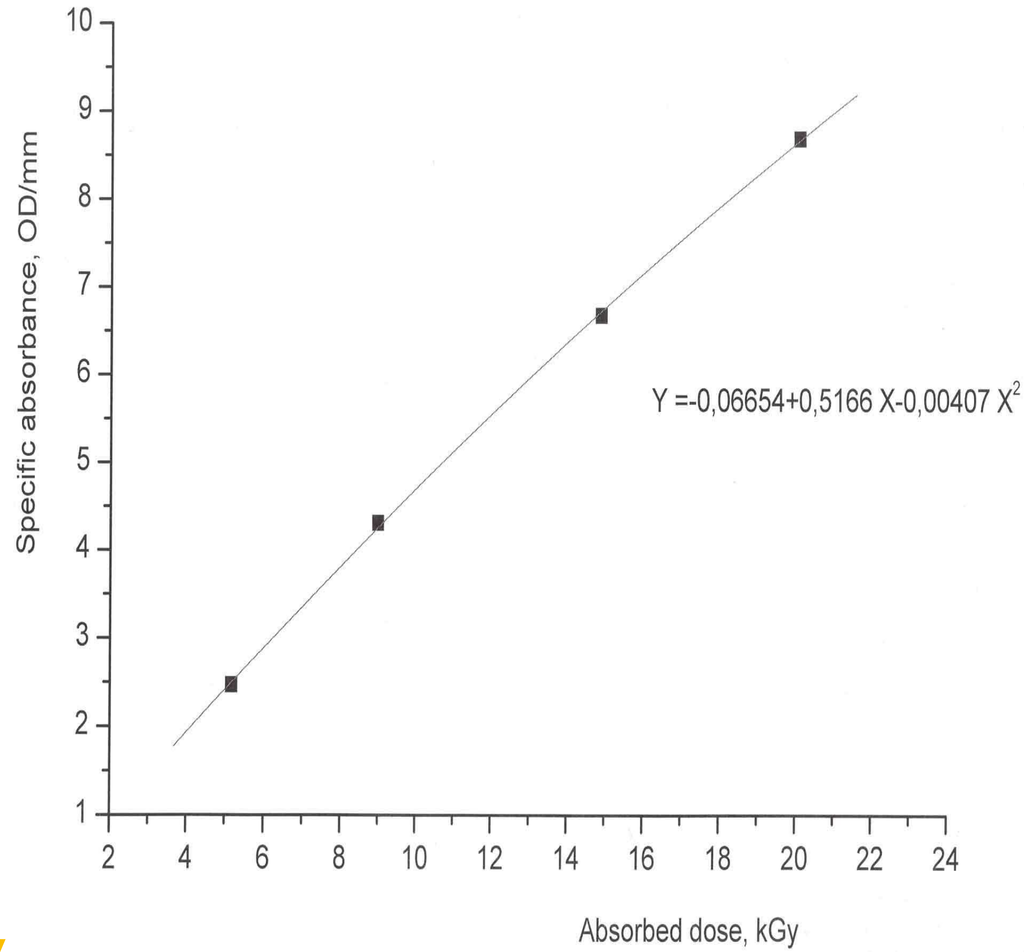
  **- temperature**

  **- storage (time, conditions)**

  **- humidity**

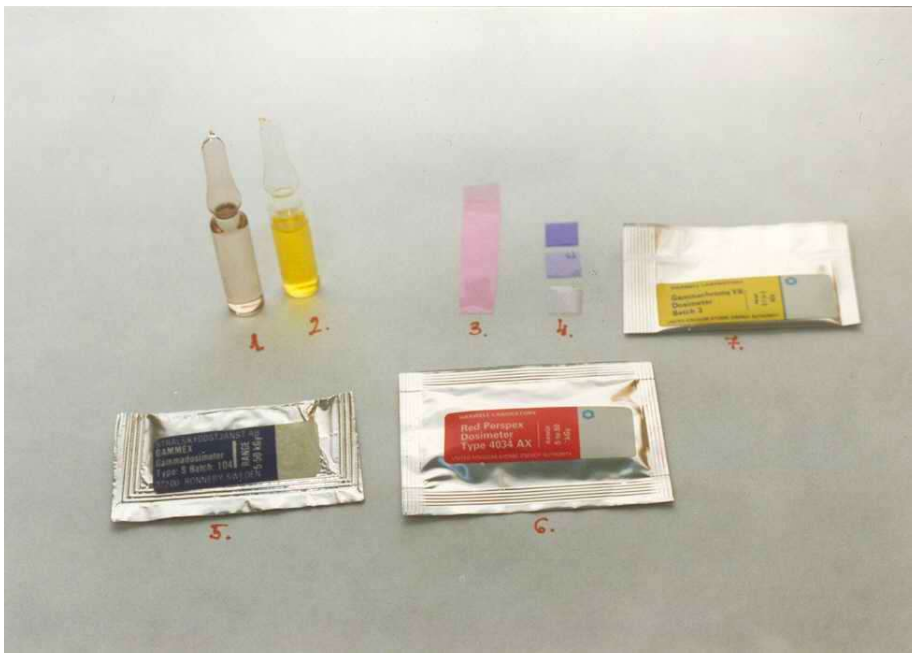
  **- light**

- **Meminimalisir efek dari faktor pengaruh melalui optimalisasi kondisi kalibrasi**



# Kalibrasi

- Calibration of dosimeter




- Calibration of equipment

# Kalibrasi

- - **Spectrophotometer:**
- absorbance and wavelength scale with calibrated optical filters;

- - **Thickness gauge:**
- calibrated gauge blocks;

- -**Thermometers:**
- calibrated thermometers;

- - **Resistance measurement (Ohm-meter for calorimeters):**
- calibrated reference resistor;

- - **Humidity meters:**
- saturated salt solutions;

# Kalibrasi

- - **Dose range:**
- Larger dose range than intended use;

- **Number of dose points:** (4 dosimeters at each point)
- Dose range less than one decade: 5 points (at least)
- - arithmetically (10 - 20 - 30 - 40 - 50 kGy);
- Dose range greater than one decade: 5 points (at least) per decade
- - geometrically (1 - 1.5 - 2.3 - 3.4 - 5.1 - 7.6 - 11.4 - 17 - 26 - 38 - 58 - 87 kGy);

- - **Batch calibration:**
- Each new batch must be calibrated (annual checks);
- Don’t use manufacturers`s calibration curve - unless verified;

# 1. Kalibrasi Laju Dosis

**Tujuan :**
**Mendapatkan hubungan antara respons dosimeter dengan dosis aktual**


01 — Dosimeter standar (Alanine) dari Lab standar sekunder di kirim ke fasilitas

02 — Dosimeter diiradiasi pada dosis yang ditentukan

03 — Dosimeter dikembalikan ke Lab standar sekunder

04 — Dosimeter diukur pada Lab Standar kemudian hasilnya dikirim ke fasilitas

05 — Verifikasi laju dosis pada fasilitas

# 1. Kalibrasi Laju Dosis

## Dose Range : 20 Gy – 887 Gy

DTU

DTU Nutech

DANAK
CAL Reg. nr. 286

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Risø High Dose Reference Laboratory is accredited by *DANAK - Danish Accreditation*

## Reference Dosimeter Certificate

**Certificate no.: 19C-109A**

Measurement with **alanine reference** dosimeters irradiated at the customer's facility according to HDRL instruction HDRL-I-15 and HDRL-I-16.

**Customer:** National Nuclear Energy Agency of Indonesia
Centre for Isotope and Radiation Application
Lebak Bulus Raya Street No.49
Pasar Jumat, South Jakarta
Indonesia 7002 JKSL

**Order no.-reference:** 266/PO/September 19 DTU - Mrs. Irmawati

**File** 19C-109A Batan
**Date** 2019.11.07

**Signature**

Arne Miller
Head of Risø HDRL

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DTU

**Measurement data**

Received at Risø: 2019
Measured: 2019
Instrument: Bruk
Environment: Tem
Rel. 

**Results** (dose to water, kGy)

| Serial no. BK616 | Irr. Temp., $T_{irr}$ [°C] | Dose [Gy] | Overall uncertainty ($k$=2) [Gy] | Overall uncertainty ($k$=2) [%] |
|---|---|---|---|---|
| 892 | 32.9 | **28** | 0.9 | 3.3 |
| 893 | 32.2 | **38** | 1.3 | 3.3 |
| 894 | 34.3 | **54** | 1.7 | 3.2 |
| 895 | 33.2 | **77** | 2.5 | 3.2 |
| 896 | 32.3 | **116** | 3.7 | 3.2 |
| 897 | 32.5 | **174** | 5.6 | 3.2 |
| 898 | 34.1 | **264** | 8.5 | 3.2 |
| 899 | 34.5 | **400** | 12.9 | 3.2 |
| 900 | 35.2 | **603** | 19.5 | 3.2 |
| 901 | 34.9 | **918** | 29.6 | 3.2 |
| BK158 | The irradiated control dosimeter was measured before and after shipment: No change observed within measurement uncertainty ($k$=2) | | | |

DTU



**Irradiation data** (information provided by user)

Facility: Gamma Cell 220 Upgrade BATAN

| Date of irradiation [yyyy.mm.dd] | Serial no. BK616 | Approx. Dose [Gy] | Temp. (start) [°C] | Temp. (end) [°C] |
|---|---|---|---|---|
| 2019.10.15 | 892 | 20.0 | 30.8 | 33.4 |
| 2019.10.15 | 893 | 30.5 | 30.9 | 32.8 |
| 2019.10.15 | 894 | 46.5 | 33.5 | 34.7 |
| 2019.10.15 | 895 | 70.8 | 32.6 | 33.5 |
| 2019.10.15 | 896 | 107.9 | 30.2 | 33.3 |
| 2019.10.15 | 897 | 164.5 | 30.3 | 33.6 |
| 2019.10.15 | 898 | 250.7 | 33.2 | 34.6 |
| 2019.10.15 | 899 | 382.0 | 32.7 | 35.4 |
| 2019.10.15 | 900 | 582.2 | 33.8 | 35.9 |
| 2019.10.15 | 901 | 887.3 | 31.1 | 36.8 |
| Control | 0 | 0 | -- | -- |
| Irr. control | BK158 | 10 | 25 | 25 |

batan

# 1. Kalibrasi Laju Dosis

**Dose Range : 1,35 KGy – 60 KGy**

DTU

DANAK
CAL Reg. nr. 286

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## Reference Dosimeter Certificate

**Certificate no.: 19C-109A**

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**File** 19C-109A Batan
**Date** 2019.11.07

**Signature**

Arne Miller
Head of Risø HDRL

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DTU

HDRL 19C-109B
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**Irradiation data** (information provided by user)

Facility: Gamma Cell 220 Upgrade BATAN

| Date of irradiation [yyyy.mm.dd] | Serial no. BK616 | Approx. Dose [Gy] | Temp. (start) [°C] | Temp. (end) [°C] |
|---|---|---|---|---|
| 2019.10.15 | 902 | 1352.4 | 33.6 | 36.9 |
| 2019.10.15 | 903 | 2061.6 | 32.4 | 37.1 |
| 2019.10.16 | 904 | 3141.3 | 32.1 | 35.3 |
| 2019.10.16 | 905 | 4787.5 | 33.8 | 36.6 |
| 2019.10.16 | 906 | 7296.6 | 31.8 | 36.6 |
| 2019.10.16 | 907 | 11120.5 | 31.6 | 36.1 |
| 2019.10.17 | 908 | 16948.5 | 30.8 | 36.2 |
| 2019.10.17 | 909 | 25830.8 | 32.0 | 37.6 |
| 2019.10.18 | 910 | 39368.1 | 30.3 | 37.1 |
| 2019.10.18 | 911 | 60000.0 | 33.8 | 44.7 |
| Control | 0 | 0 | -- | -- |
| Irr. control | BK159 | 10 | 25 | 25 |

DTU

**Measurement data**

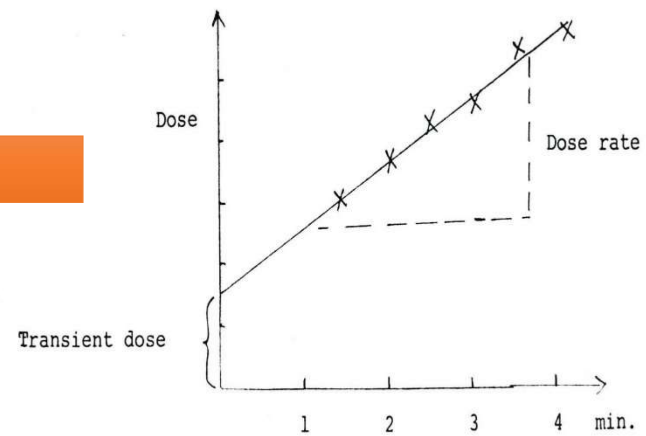
Received at Risø:
Measured:
Instrument:
Environment:

**Results** (dose to water, kGy)

| Serial no. BK616 | Irr. Temp., $T_{eff}$ [°C] | Dose [kGy] | Overall uncertainty ($k$=2) [Gy] | [%] |
|---|---|---|---|---|
| 902 | 35.8 | **1.39** | 0.05 | 3.2 |
| 903 | 35.5 | **2.12** | 0.07 | 3.2 |
| 904 | 34.2 | **3.22** | 0.10 | 3.2 |
| 905 | 35.7 | **4.93** | 0.16 | 3.2 |
| 906 | 35.0 | **7.58** | 0.24 | 3.2 |
| 907 | 34.6 | **11.5** | 0.37 | 3.2 |
| 908 | 34.4 | **17.5** | 0.56 | 3.2 |
| 909 | 35.7 | **26.7** | 0.86 | 3.2 |
| 910 | 34.8 | **40.9** | 1.3 | 3.2 |
| 911 | 41.1 | **63.0** | 2.0 | 3.2 |
| BK159 | The irradiated control dosimeter was measured before and after shipment: No change observed within measurement uncertainty ($k$=2) | | | |

Dosimeter fricke diiradiasi pada beberapa titik waktu tertentu dengan pengulangan 3x

Mengukur absorbansi menggunakan spektrofotometer

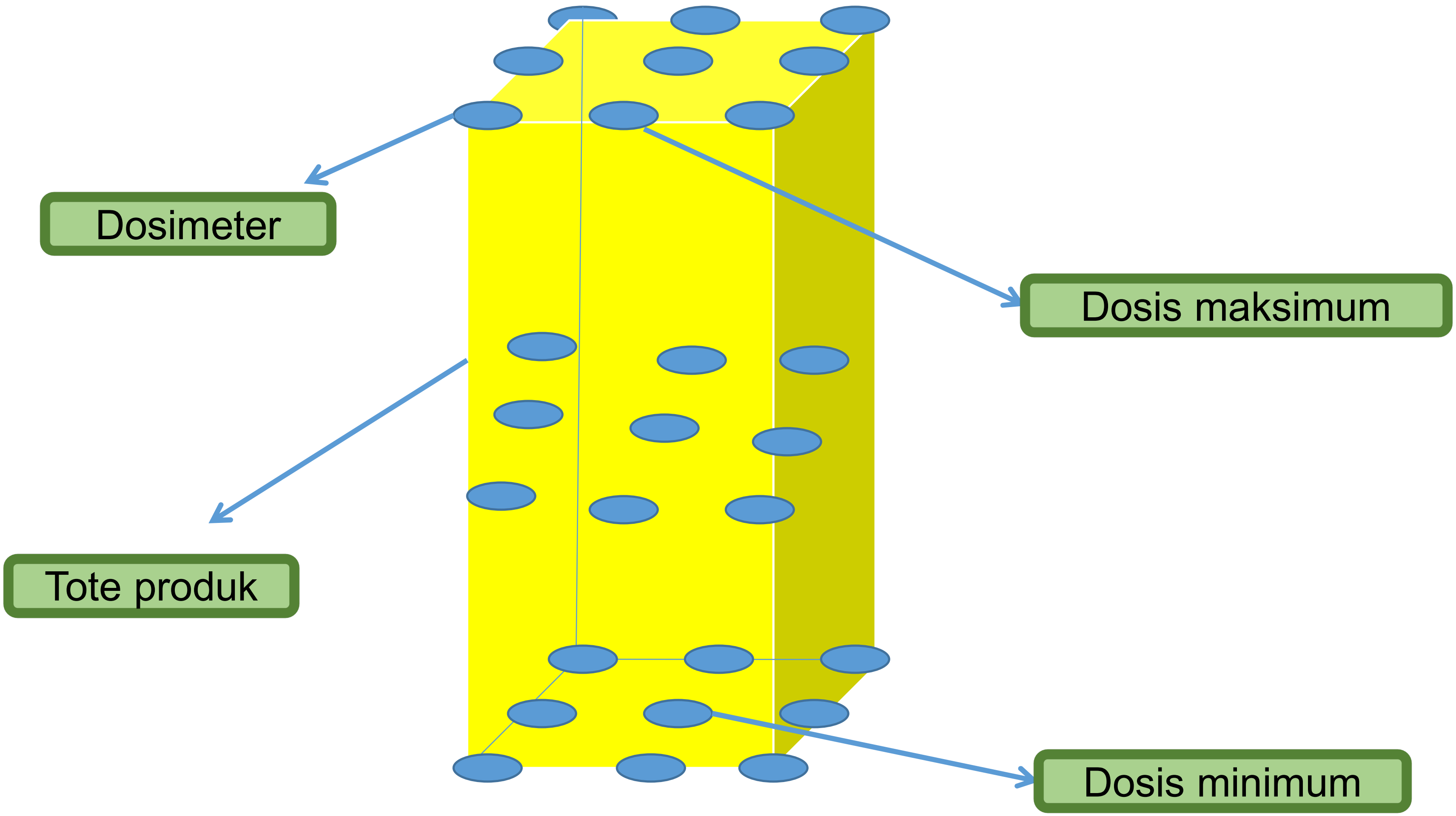



Didapatkan kurva kalibrasi dan persamaan fungsi

Didapatkan laju dosis sebagai acuan iradiasi rutin/kontrol

# 2. Pemetaan Distribusi Dosis

- 27 Dosimeter ditempatkan pada 27 titik dalam tote
- Didapatkan posisi untuk dosis maksmimum dan minimum



# Verifikasi Fasilitas Iradiator

### 1. Food Irradiation Facility and Operator Details

1.1. What are the name and address of the facility?

1.2. What is the general layout of the irradiation facility, what conveyor system is used (if appropriate) and what is the size and type of irradiation container?

1.3. Is the facility designed to irradiate products continuously or batch-wise?

1.4. What is the legislation that the organization needs to comply with? [For example, national and international][4]

1.5. What is the management structure at the facility?

### 3. Regulatory Authority Control

These questions may only be necessary when the auditors are in facilities which are not in their home countries.

3.1. Which national regulatory authority(s) (including national plant protection organizations) are responsible for the following:

— Licensing the irradiation facility?
— Prior approval to irradiate food?
— Official control and audit of the facility?

[Useful information to gather includes: dates of regulatory visits, people met, time spent at the facility, any non-compliance found, written reports, reported remarks, deadlines for correction, corrective actions implemented and follow-up visits]

3.2. Which licences or permits have been issued for the irradiation of food? [It may be useful to obtain a copy of the licence, permit or official documentation relating to the official approval to irradiate food]

3.3. What official control and supervision does the regulatory authority perform?

### 2. Product Information

2.1 What type of food is irradiated?

2.2. What is the purpose of irradiation?

2.3. Is it unprocessed (raw) food, or has it been processed or manufactured?

2.4. Is any other treatment combined with irradiation of the product?

### 4. Radiation Source

4.1. What type of ionizing radiation is used to process the food? [For example, gamma ray, electron beam and X ray]

**For radionuclide sources**

4.2. Which radionuclide is used? [For example, $^{137}Cs$ or $^{60}Co$]

4.3. What is the current activity of the radionuclide source (in Bq or Ci)?

4.4. When was the last replenishment, when and how much was the loading?

4.5. How is the radiation source stored when not in operation (e.g. water pool or dry store)?

4.6. Is there a positive indication of the correct operational and the correct safe position of the radiation source, and is it interlocked with the product movement system?

# Verifikasi Fasilitas Iradiator

## 5. Dosimetry

5.1. What types of dosimeter are used for dose validation and routine dose measurements?
[Are the dosimeters suitable for the application, and has the impact of environmental conditions (e.g. low temperature for frozen foods) on dose reading been accounted for?]

5.2. How are dosimeters calibrated, and is the dose traceable to a national standard?

5.3. What is the uncertainty in the dose measurement?

5.4. Are reference dosimeters used to verify the calibration of dosimeters?

5.5. What procedure is used for dose validation?

5.6. What is the position and magnitude of minimum and maximum dose in the product to be irradiated?

## 6. Food Irradiation Process Control

**Product**

6.1. Have all the process variables been identified?

6.2. Is the product to be treated fit for irradiation?

6.3. Is the food product prepacked, or is it treated in bulk?

6.4. What are the characteristics of the packaging material (suitability, hygienic condition, transport and handling)?

6.5. Are there standard operating procedures and quality assurance procedures in place to control the irradiation of food?
[Are they are up to date, accurate and cover all relevant aspects? Are they used by the operator? What evidence is there that people use these procedures? It may be useful to obtain copies of these documents]

6.6. What measures have been taken to ensure that treated and untreated foods are separated at all times?

# Verifikasi Fasilitas Iradiator

### 7. Records and Documentation

**Product traceability**

7.1. What is the format and content of records kept for each batch of treated food? [For example, nature and type of product being treated, packaging identification marks or shipping details, bulk density, type of source or electron machine, dosimetry, dosimeters used (calibration details) and date of treatment]

7.2. How long are records kept and in what form?

7.3. What documentation accompanies irradiated food destined for export?

7.4. What are the details of labelling used to identify the product or details of shipping documentation?

**Process control**

7.5. What records are maintained for each irradiation batch of food?

**Dosimetry**

7.6. What records are kept of dosimetry measurements? [For example, archives, calibration log, calibration schedule and other records]

**Personnel training**

7.7. What are the qualifications of those responsible for validation, routine control, operation and maintenance of the facility? [For example, academic qualifications, formal training and work experience]

### 8. Packaging and Labelling

8.1. What is the labelling of the prepackaged foodstuffs? [For example, are they labelled as 'irradiated' or 'treated with ionizing radiation'? Are any special logos used (e.g. Radura)? Is the name of the food clear, is there a list of ingredients, a date of minimum durability, the name and address of the manufacturer/packager? Are there any special storage instructions or any instructions for use?]

8.2. What shipping documents are used? [Do these documents state that the food is irradiated? Do they identify the irradiation facility in some way, do they include the date of irradiation treatment, do the papers identify the food and the lot or batch number of the food products?]

# Latihan Soal

## - Soal -

1. Berapa kategori iradiator gamma?

2. Sumber bergerak, penyimpanan kolam. Kategori berapakah iradiator tersebut?

3. Berapa jenis klasifikasi dosimetri? Sebutkan!

4. Sebutkan 3 jenis dosimeter Acuan!

5. Sebutkan 2 Jenis dosimeter Rutin!

# Rangkuman

## - Kesimpulan -

1. Terdapat 4 kategori iradiator gamma, yaitu kategori I, II, III, IV.

2. Terdapat 4 klasifikasi dosimeter, yaitu primer, acuan, transfer dan rutin

3. Dosimeter primer hanya perlu dikalibrasi 1 kali.

4. Kalibrasi dosimeter acuan harus mengacu pada labolatorium standar nasional atau internasional

5. Dosimeter rutin harus mengacu pada hasil kalibrasi dosimeter acuan

# Terima Kasih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|---|---|