International Conference on Occupational Radiation Protection:

Enhancing the Protection of Workers

Gaps, Challenges and Developments

IAEA Headquarters, Vienna, Austria, 1-5 December 2014

Overview of occupational radiation protection in the past and looking forward to the future challenges

[Caution: I will use many cartoons,…they represent real life situations…with a smile!]

Abel J. González

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International Occupational Radiation Protection

International Occupational Radiation Protection

Content

1. The Past:

From a Successful History

2. The Present:

New developments

3. The Future:

New (and old) Challenges

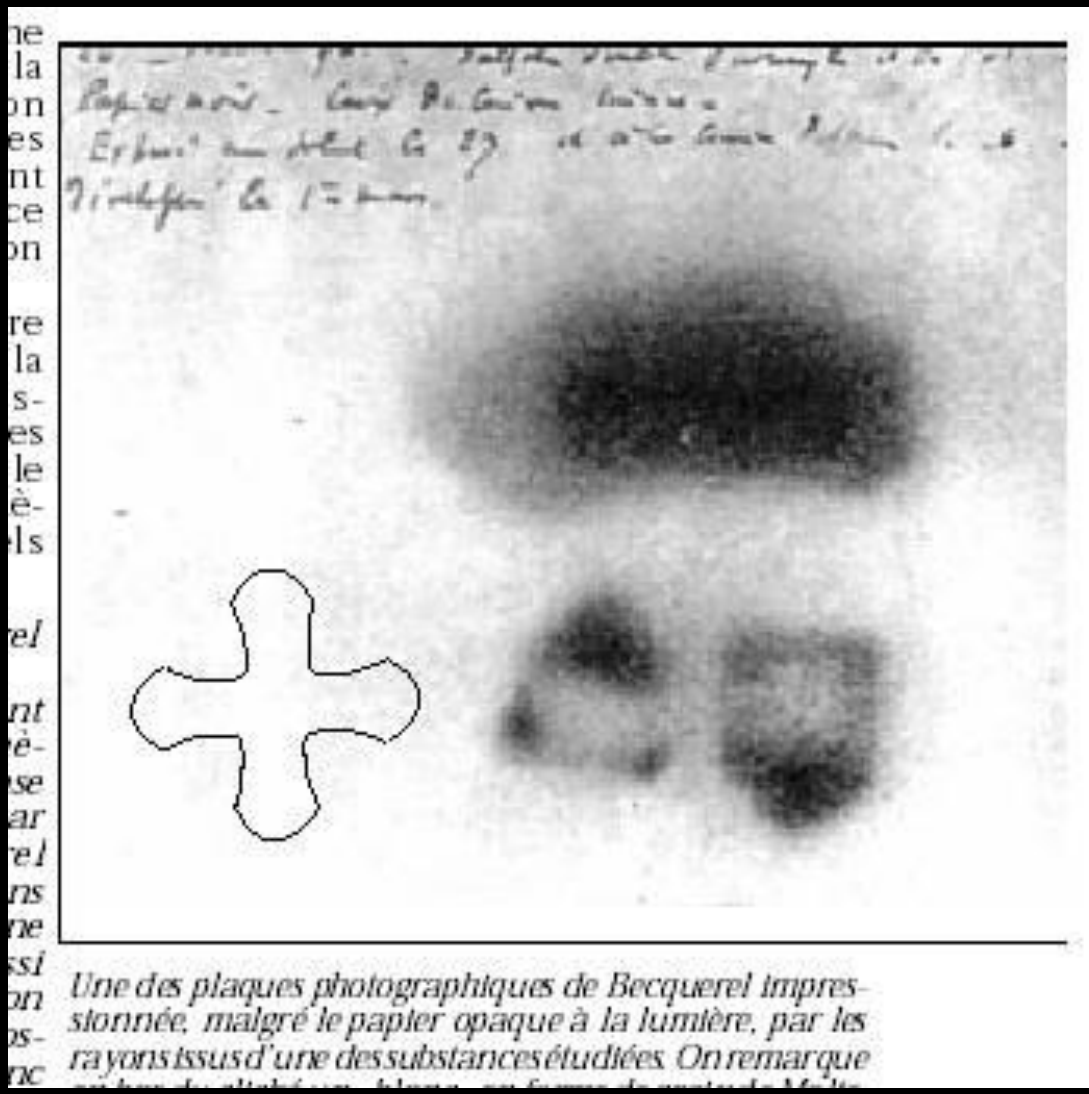
The Past

From a Successful History

8 November 1895, Wilhelm Röntgen discovers “A New Kind of Rays”

(Über eine neue Art von Strahlen)

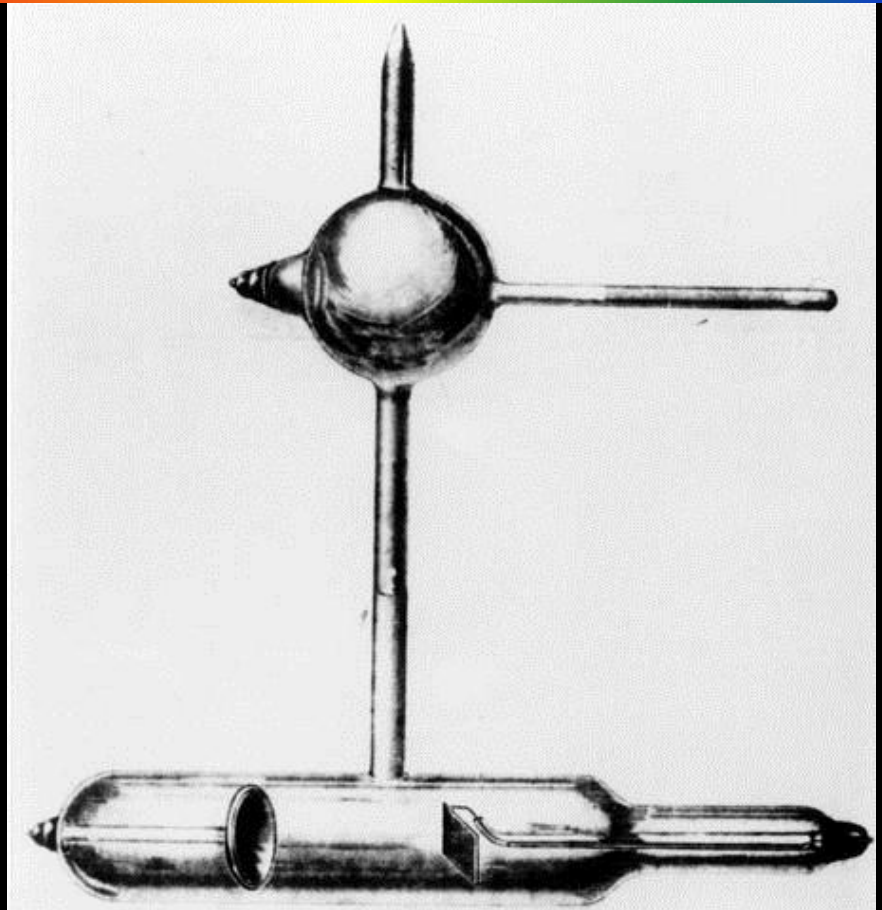
February 24, 1896: Henri Becquerel discovers of spontaneous radioactivity



Une des plaques photographiques de Becquerel impressionnée, malgré le papier opaque à la lumière, par les rayons issus d'une des substances étudiées. On remarque

March 21, 1896 – Pioneer in record time:

The first Siemens x-ray tube with regulated vacuum patented



Eine neue Röntgenlampe

mit regulirbarem Vacuum.

D. R. P. 91028.

Dr. William D. Coolidge *and his NEW*

MAGIC RAY

Producing as Many ELECTRONS Every SECOND as a TON of RADIUM

WHAT will it do for Humanity ?

By Robert Morell

X-RAY SPECS

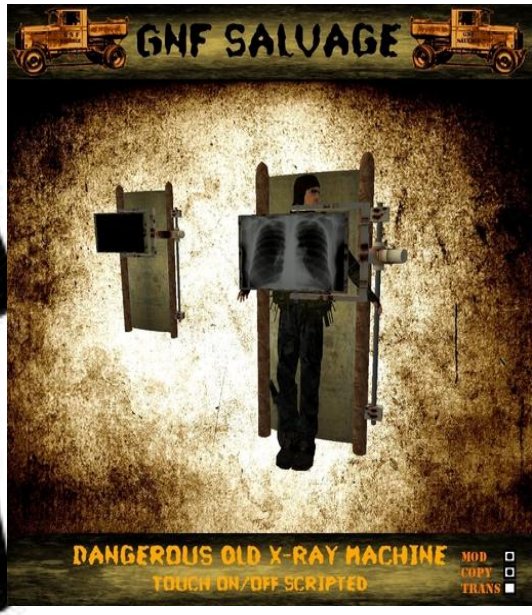
ONLY $1.00

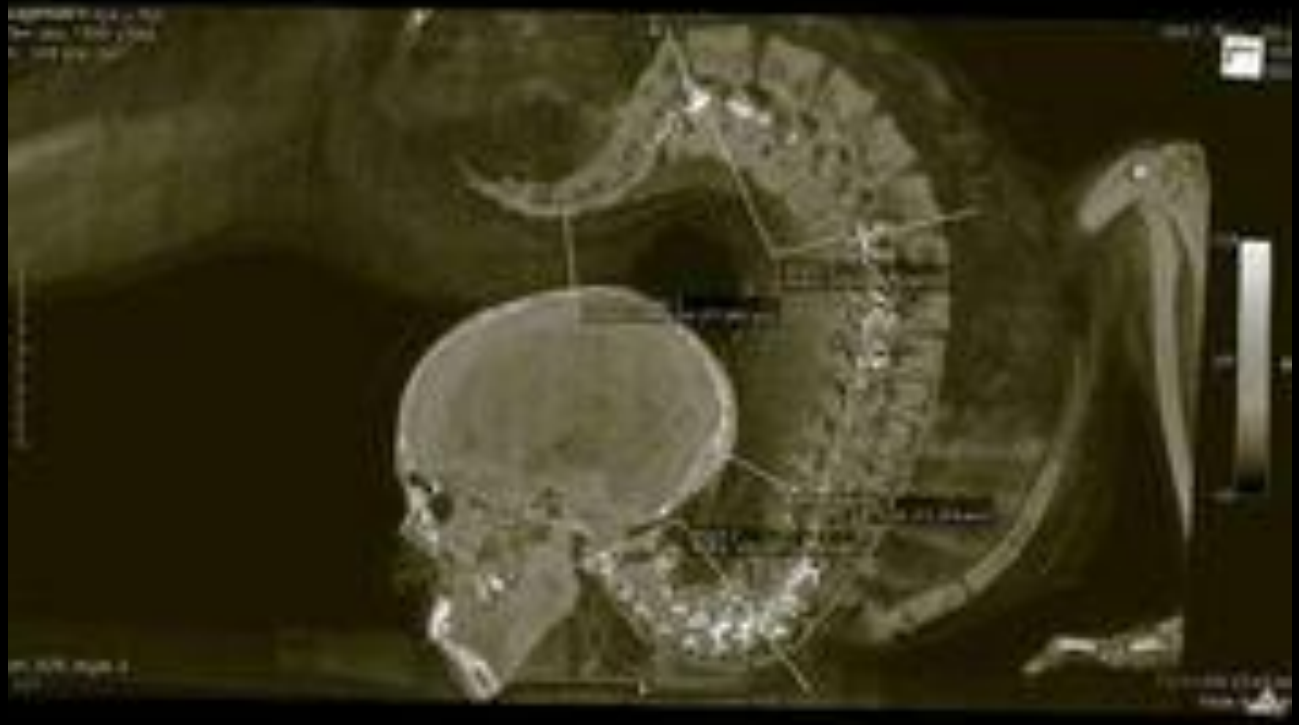
An Hilarious Optical Illusion

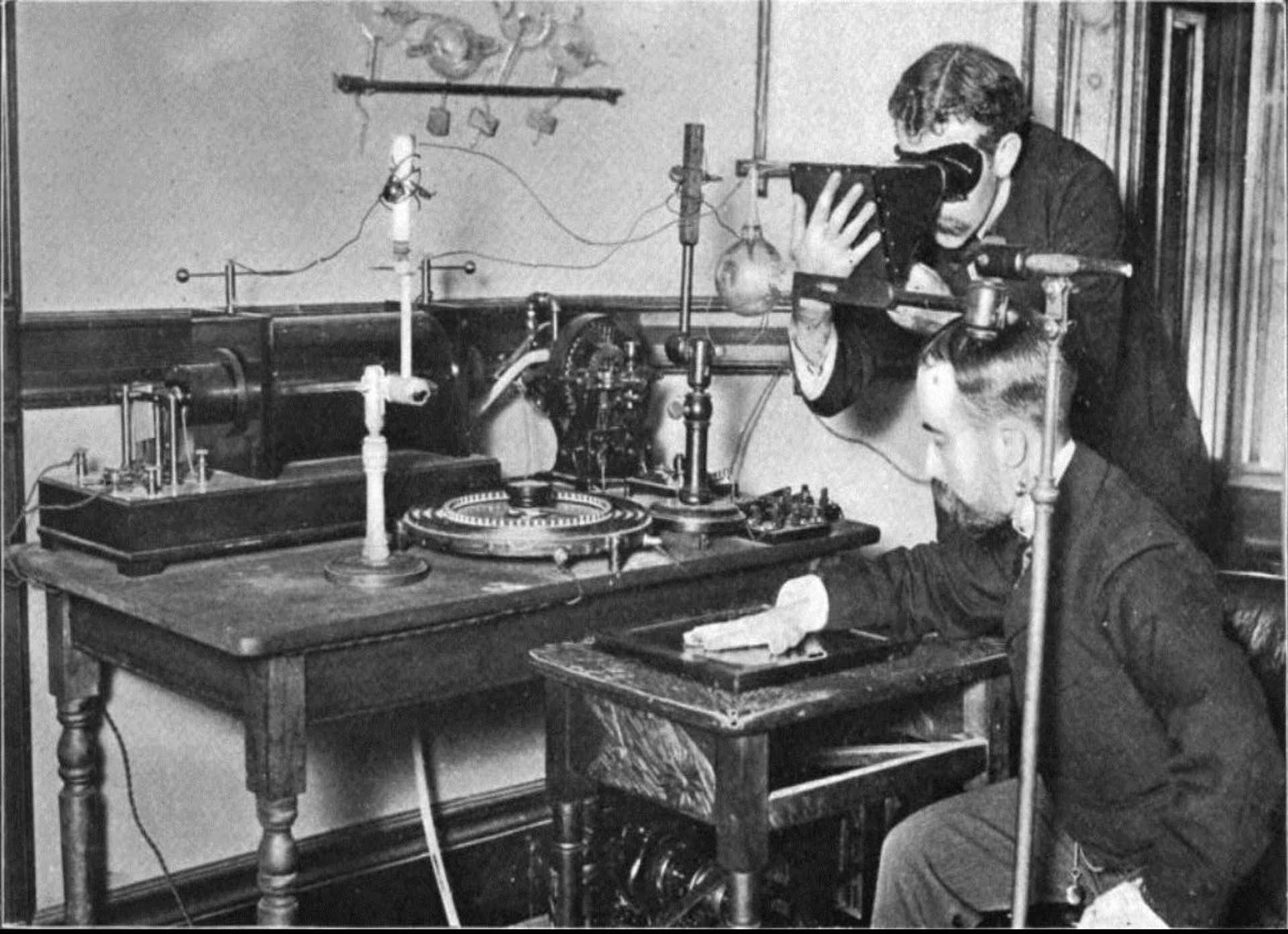
Scientific optical principle really works. Imagine—you put on the "X-Ray" Specs and hold your hand in front of you. You seem to be able to look right through the flesh and see the bones underneath. Look at your friend. Is that really his body you "see" under his clothes? Loads of laughs and fun at parties. Send only $1 plus 25c shipping charges. Money Back Guarantee.

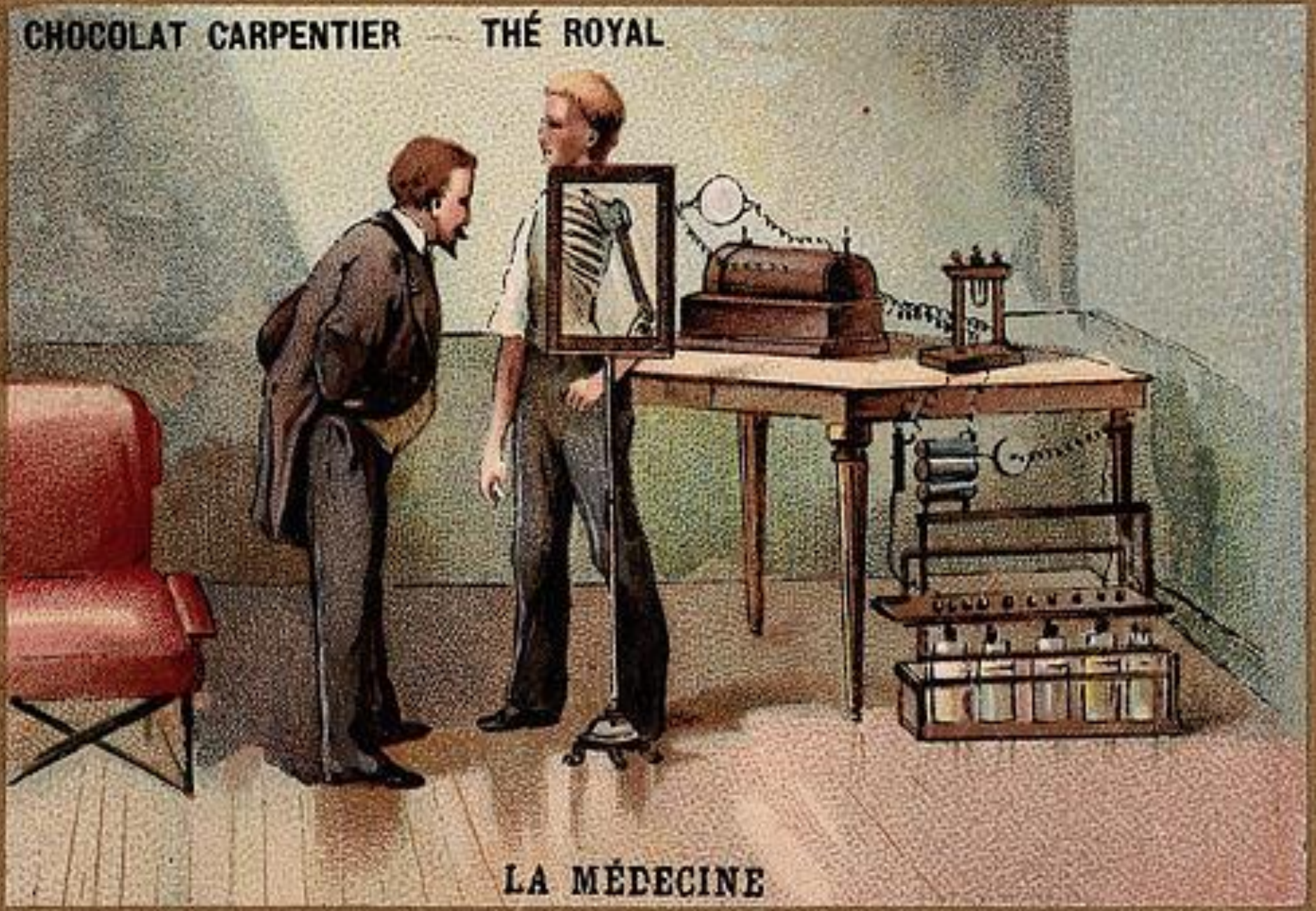
HONOR HOUSE PRODUCTS CORP., Lynbrook, N.Y. Dept. 97XR02


X-RAY FLUOROSCOPE


GNF SALVAGE
DANGEROUS OLD X-RAY MACHINE
TOUCH ON/OFF SCRIPTED
MOD
COPY
TRANS







RADIUM THERAPY

The only scientific apparatus for the preparation of radio-active water in the hospital or in the patient's own home.

This apparatus gives a high and measured dosage of radio-active drinking water for the treatment of gout, rheumatism, arthritis, neuralgia, sciatica, tabes dorsalis, catarrh of the antrum and frontal sinus, arterio-sclerosis, diabetes and glycosuria, and nephritis, as described in Dr. Saubermann's lecture before the Roentgen Society, printed in this number of the "Archives."

DESCRIPTION.

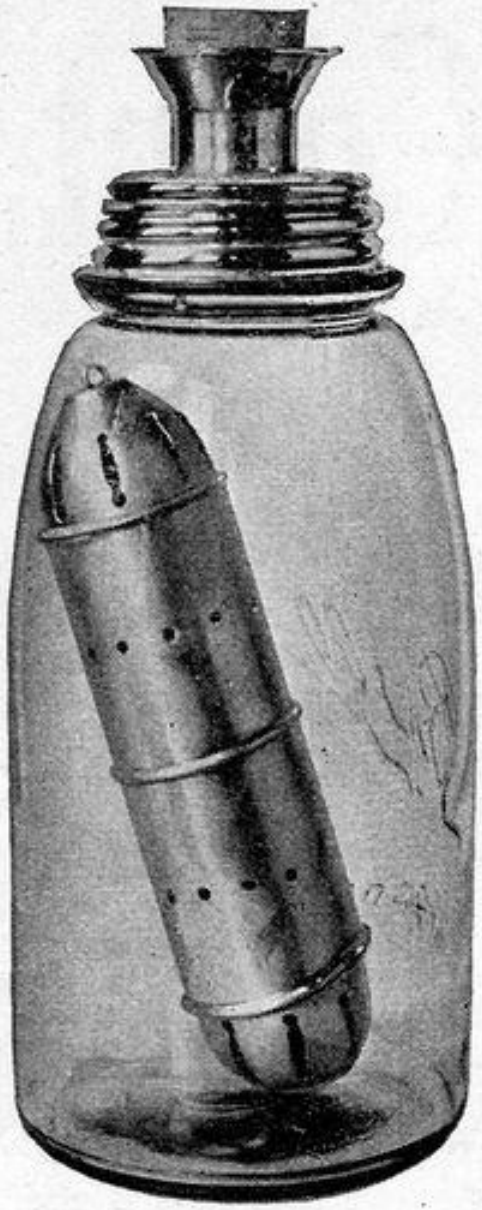
The perforated earthenware "activator" in the glass jar contains an insoluble preparation impregnated with radium. It continuously emits radium emanation at a fixed rate, and keeps the water in the jar always charged to a fixed and measureable strength, from 5,000 to 10,000 Maché units per litre per diem.

SUPPLIED BY

RADIUM LIMITED,

93, MORTIMER STREET, LONDON, W.

Telephone: 4791 MAYFAIR.



RADIUM
EMANATION WATER
Drives Out Uric Acid

Suffering from too much uric acid and diseases caused by faulty elimination—**Rheumatism, Gout, Periodical Headaches, Neuralgia, Constipation, Neurasthenia, Auto-Intoxication and Lack of Bodily Vigor**—quickly relieved in a natural way without drugs or chemicals by our new discovery

THE WAY TO MAKE RADIUM WATER IN YOUR OWN HOME

with our Rayode. A little device containing Radium enough to supply 2,700 Mache Units of Radio-activity, in two quarts of water every twenty-four hours, for less than 10c a day. The Rayode will last a lifetime.

SEND FOR FREE LITERATURE

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MÉTHODE

THO-RADIA

EMBELLISSANTE PARCE QUE CURATIVE

4°

DENTIFRICE

THO-RADIA

A BASE DE SELS DE THORIUM

FORMULE

du Docteur Alfred CURIE

Le grand tube :

6 francs

Astringent et bactéricide, il stérilise la cavité buccale, évite et combat les gingivites, prévient la carie et les pyorrhées alvéolaires. Il assainit les dents, laisse dans la bouche une délicieuse impression de fraîcheur, conserve l'éclat, la blancheur et l'intégrité de la dentition.

Pas de joli sourire sans de jolies dents

CHEZ LES PHARMACIENS EXCLUSIVEMENT

Radium Cosmetiques

NOTHING LIKE THEM IN U. S.

Face Lifting Without Plastic Surgery

Aimeray Radium Cosmetiques

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Do You Not Know? The Eyetome

Invented by Dr. Francis King, well-known Ocular Muscle Specialist. Is relieving all forms of Eye Troubles and doing away with glasses in great numbers of cases. Call or write 709 Grant Bldg., Los Angeles. VA. 3346.

All these uses should certainly have generated a lot of harm

Occupational protection did not exist at that time!

But, concern for protection was raised by the new profession: *radiologists*!


RÖNTGEN-X-RAY LABORATORY of the
MEDICO-CHIRURGICAL-COLL. & HOSP. PHILA. Pa.

Day 9

Day 11

Day 16

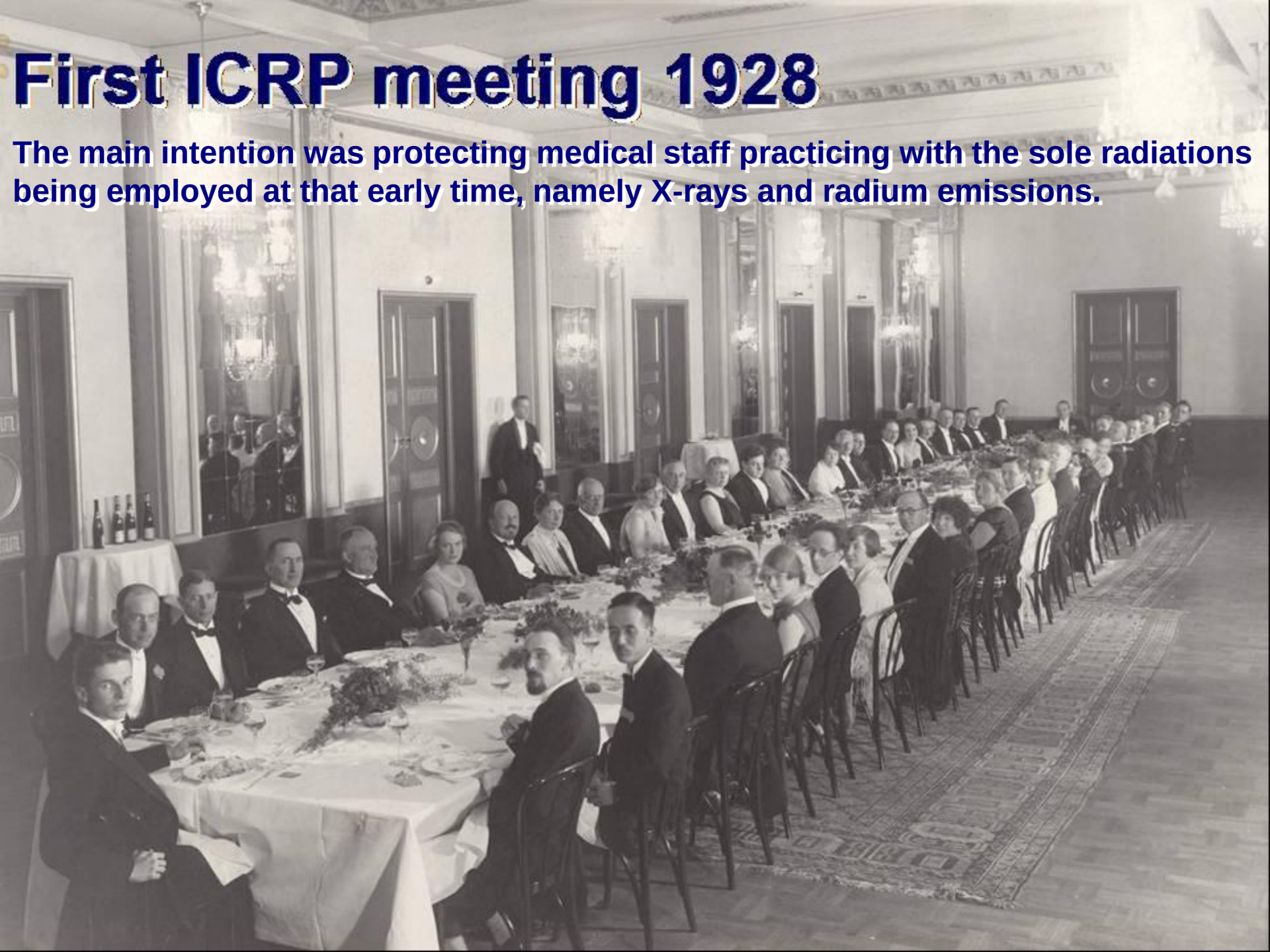
Day 24

Thus, in 1928, they established the *International X-ray and Radium Protection Committee*

Motive?: Occupational radiation protection (of radiologists)

First ICRP meeting 1928

The main intention was protecting medical staff practicing with the sole radiations being employed at that early time, namely X-rays and radium emissions.



INTERNATIONAL RECOMMENDATIONS FOR X-RAY AND RADIUM PROTECTION

on the proposal of the Radio-Physics Section adopted by the Second International Congress of Radiology in Stockholm, July 27th, 1928

First International Recommendations on Occupational Radiation Protection

- The dangers of over-exposure to X-rays and radium can be avoided by the provision of adequate protection and suitable working conditions.
- It is the duty of those in charge of X-ray and radium departments to ensure such conditions for their personnel.
- The known effects to be guarded against are:

  (a) Injuries to the superficial tissues;

  (b) Derangements of internal organs and changes in the blood.

The recommendations also reflected the wide ignorance at the time

- ‘X-ray dep. should not be situated below ground-floor level!
- ‘All rooms should be provided with:
  - windows affording good natural lighting and ready facilities for admitting sunshine and fresh air whenever possible!
  - adequate exhaust ventilation capable of renewing the air of the room not less than 10 times an hour!
  - air inlets and outlets arranged to afford cross-wise ventilation’!
- ‘All rooms should preferably be decorated in light colours’!

ICRP

First recommendations of the current ICRP series

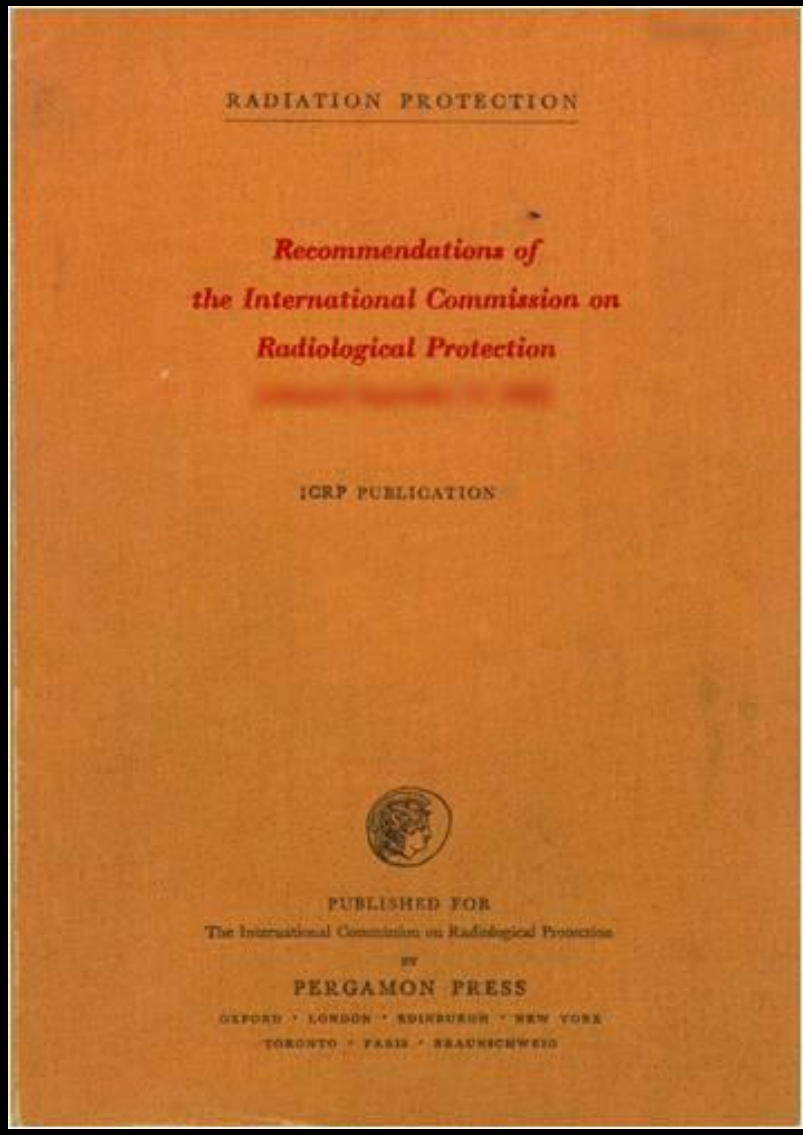
ICRP Publication 1 (1959)

ICRP defines *Occupational exposure*, *as follows:*

(37) Exposure of an *individual* who normally works in a controlled area constitutes occupational exposure.

.

(71) A controlled area shall be established where persons occupationally exposed could receive doses in excess of 1.5 rems/year.



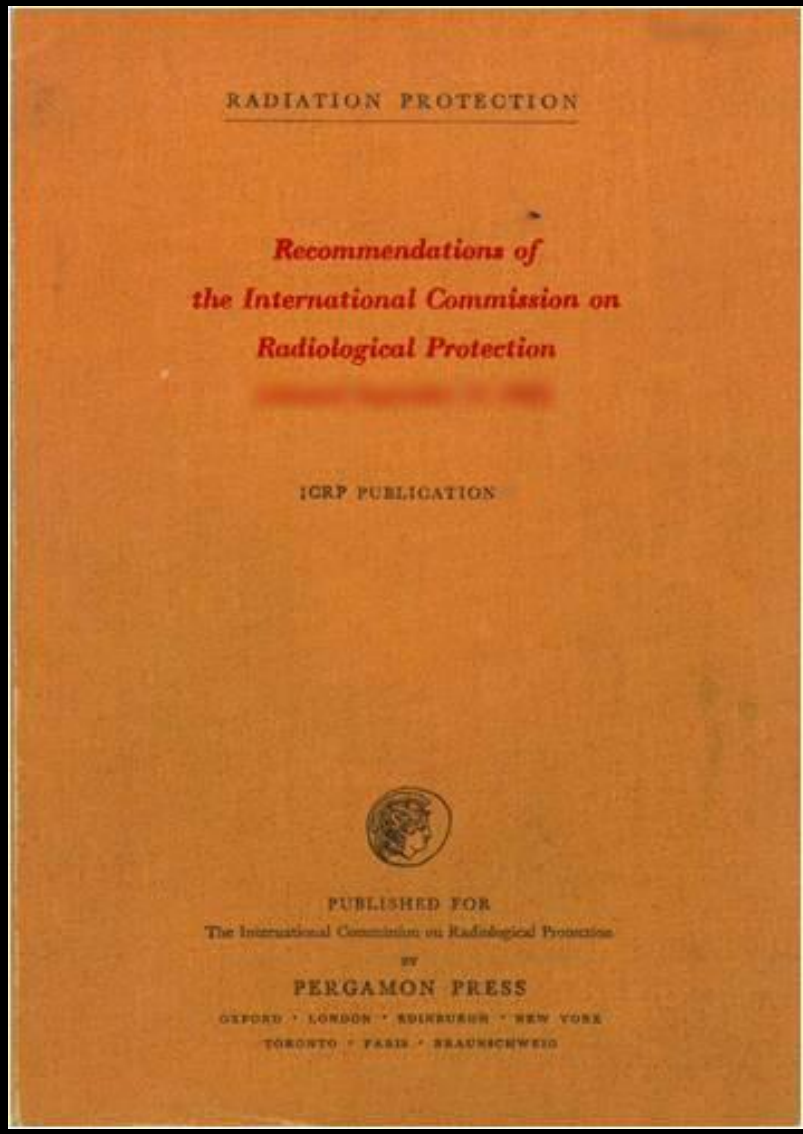
First recommendations of the current ICRP series

ICRP Publication 1 (1959)

(47) The maximum permissible total dose accumulated in the gonads, the blood-forming organs and lenses of the eyes at any age over 18 years shall be governed by the relation

$$D = 5(N-- 18)$$

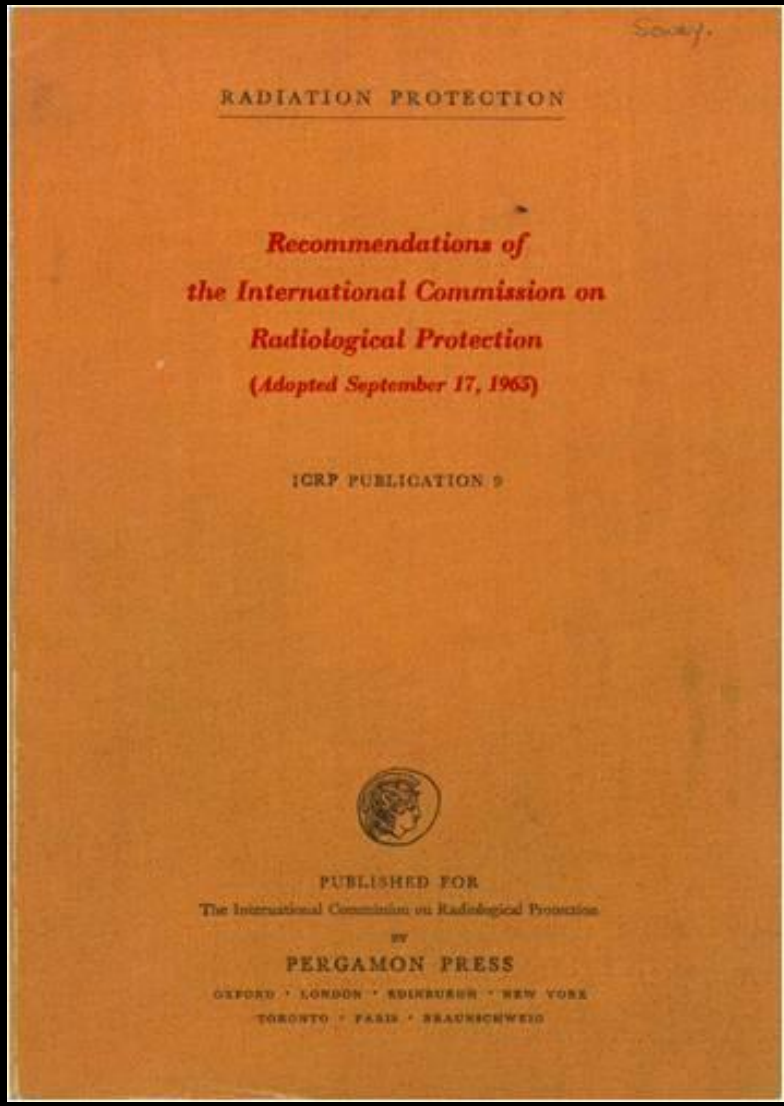
where D is tissue dose in rems and N is age in years.



ICRP Publication 9 (1965)

‘Occupational Exposure’

(41)… occupational exposure should now be considered to refer to the radiation exposure received by any worker in the course of his work.

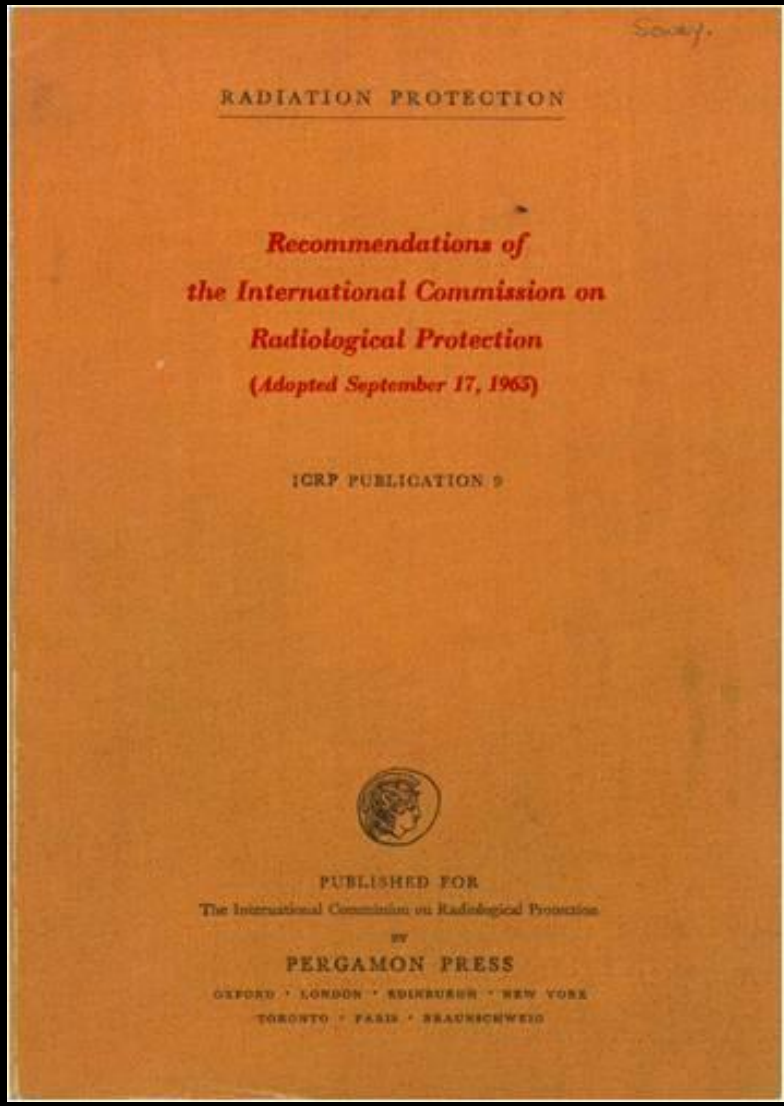


ICRP Publication 9 (1965)

‘Maximum permissible doses’

(56) The Maximum Permissible Doses recommended by the Commission are:

Gonads and red bone-marrow (and, in the case of uniform irradiation, the whole body)	5 rems in a year
Skin; thyroid; bone	30 rems in a year
Hands and forearms; feet and ankles	75 rems in a year
All other organs	15 rems in a year

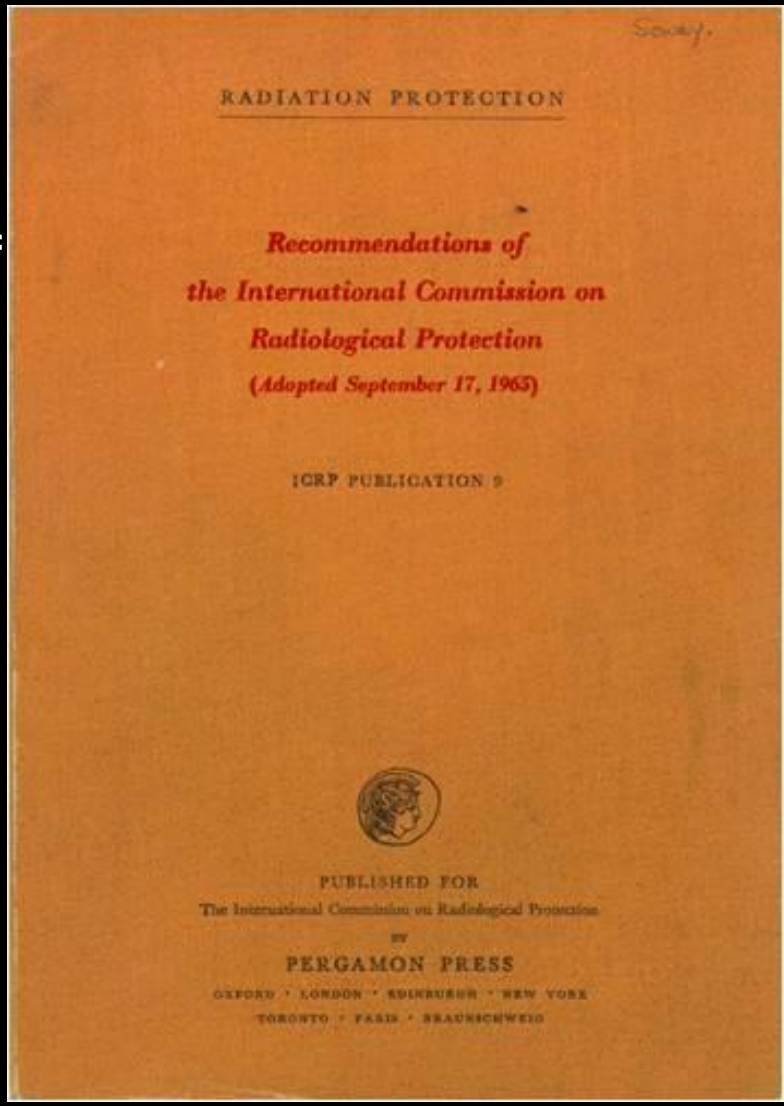


(70) The Maximum Permissible Doses that have been established for occupational exposure are regarded as upper limits, and the doses may have to be individually monitored and controlled to ensure that the Maximum Permissible Doses are not exceeded.

ICRP Publication 9 (1965)

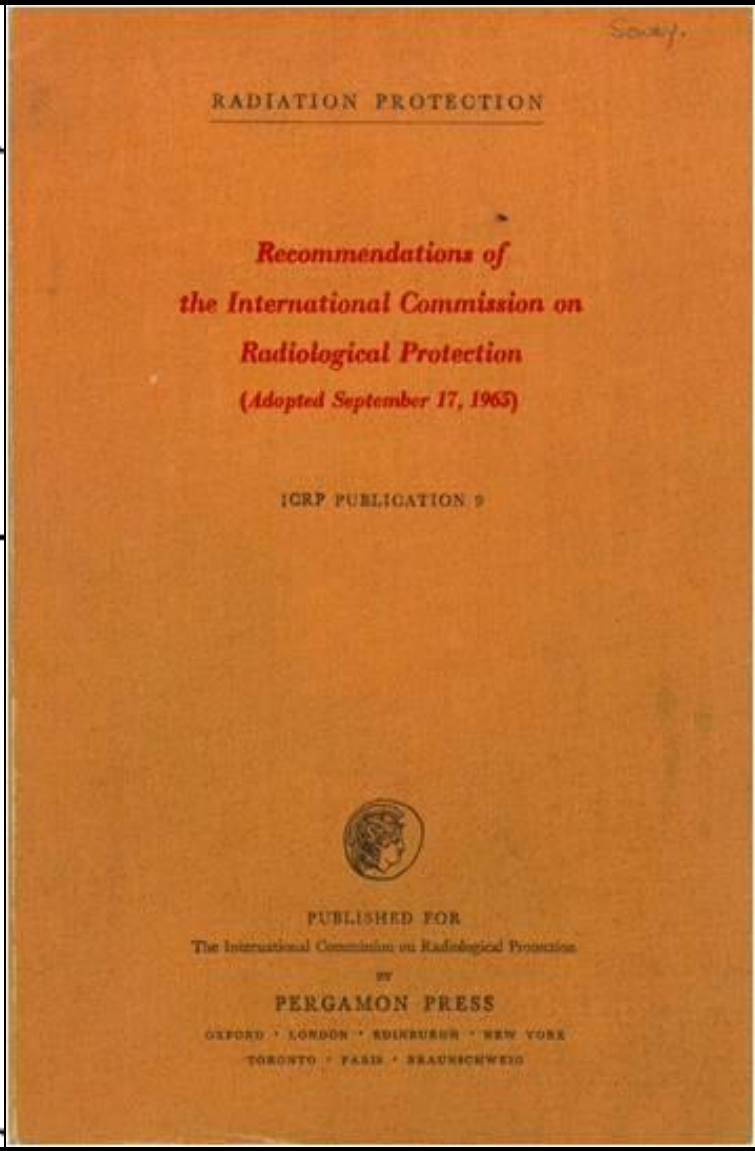
‘First link between workers and public limits’

(72) The annual Dose Limits for members of the public shall be one-tenth of the corresponding annual occupational Maximum Permissible Doses



SUMMARY OF DOSE LIMITS FOR INDIVIDUALS

Organ or tissue	Maximum Permissible Doses for adults exposed in the course of their work	Dose Limits for members of the public
Gonads, red bone-marrow	5 rems in a year*	0·5 rem in a year
Skin, bone, thyroid	30 rems in a year*	3 rems in a year†
Hands and forearms; feet and ankles	75 rems in a year*	7·5 rems in a year
Other single organs	15 rems in a year*	1·5 rems in a year

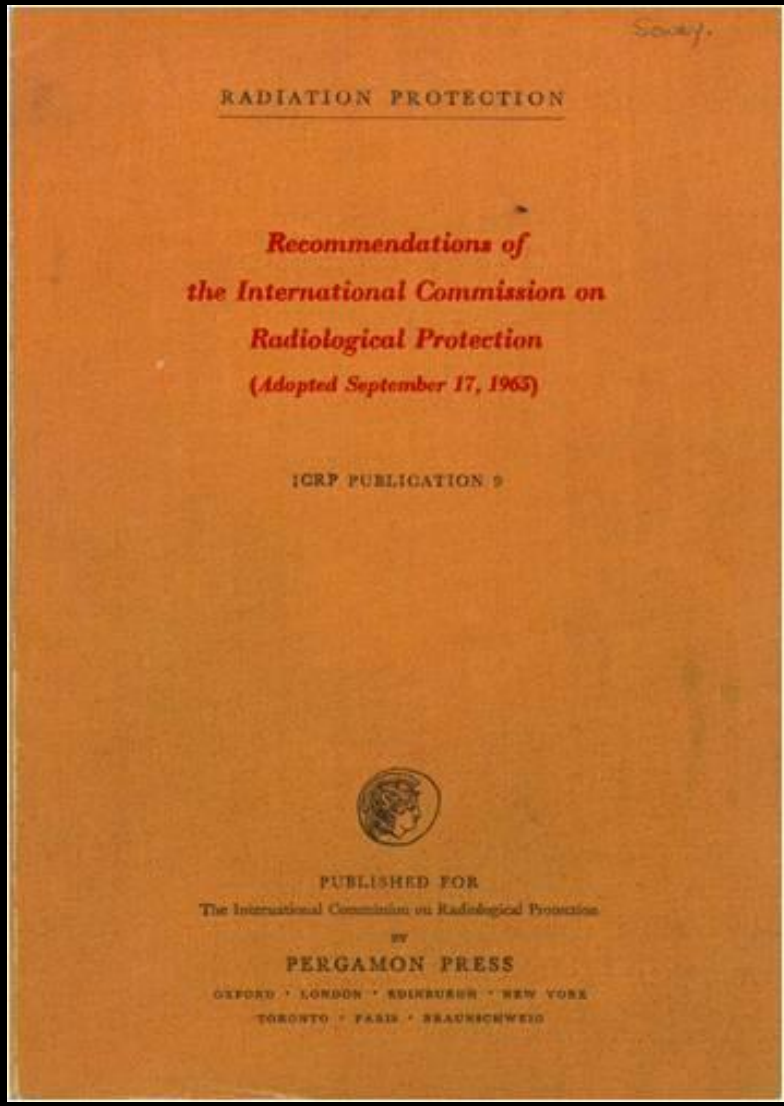


ICRP Publication 9 (1965)

Protection of women

- Women of reproductive capacity should be occupationally employed only under conditions where the dose to the abdomen is limited to 1.3 rems in a quarter, corresponding to 5 rems per year delivered at an even rate.

- Under these conditions, the dose to an embryo during the critical first two months of organogenesis would normally be less than 1 rem, a dose which the Commission considers to be acceptable.

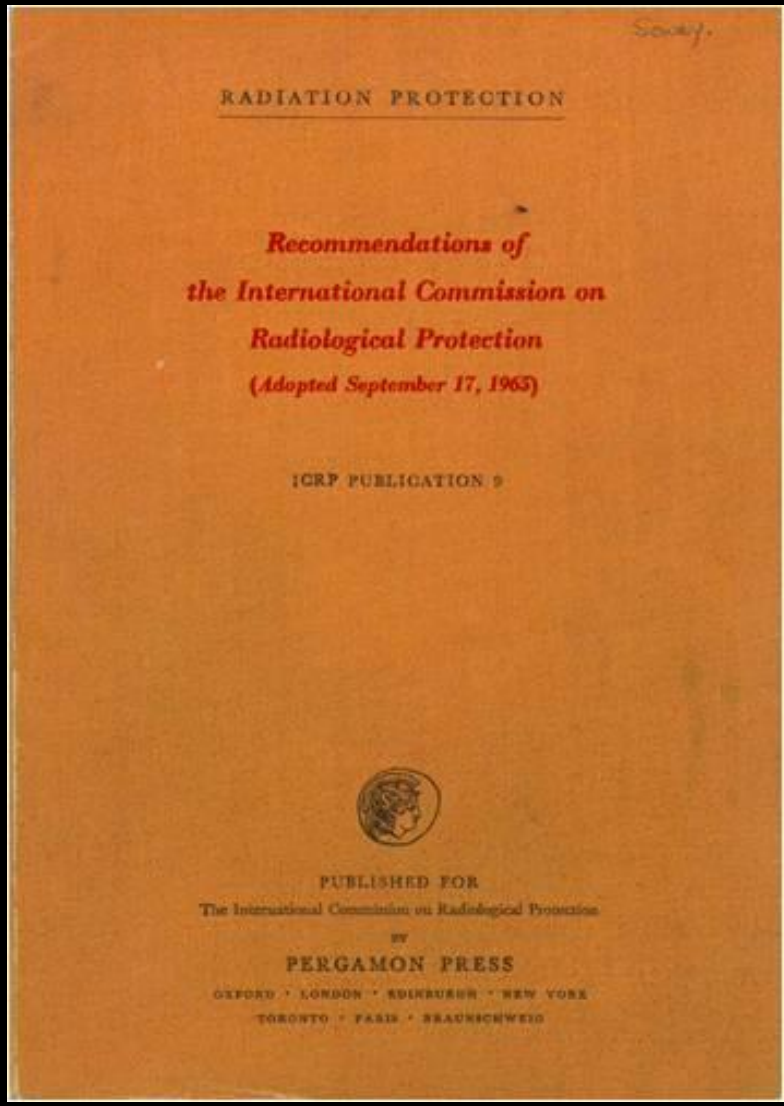


ICRP Publication 9 (1965)

Protection of pregnant women

When a pregnancy has been diagnosed, arrangements should be made to ensure that the exposure of the woman be such that the dose to her foetus, accumulated during the remaining period of the pregnancy, does not exceed 1 rem.

Practical experience indicates that the dose to the foetus during this period is usually substantially less than 1 rem.



RADIATION PROTECTION

Recommendations of
the International Commission on
Radiological Protection

1968
ICRP Publication 10

Evaluation of Radiation Doses to Body Tissues from Internal Contamination due to Occupational Exposure

PUBLISHED FOR
The International Commission on Radiological Protection
BY
PERGAMON PRESS
OXFORD · LONDON · EDINBURGH · NEW YORK
TORONTO · PARIS · BRAUNSCHWEIG

Annals of the ICRP

1977

ICRP Publication 24

Radiation Protection in Uranium and Other Mines

Pergamon

Annals of the ICRP

1977

ICRP Publication 27

Problems Involved in Developing an Index of Harm

Pergamon

Index of Harm

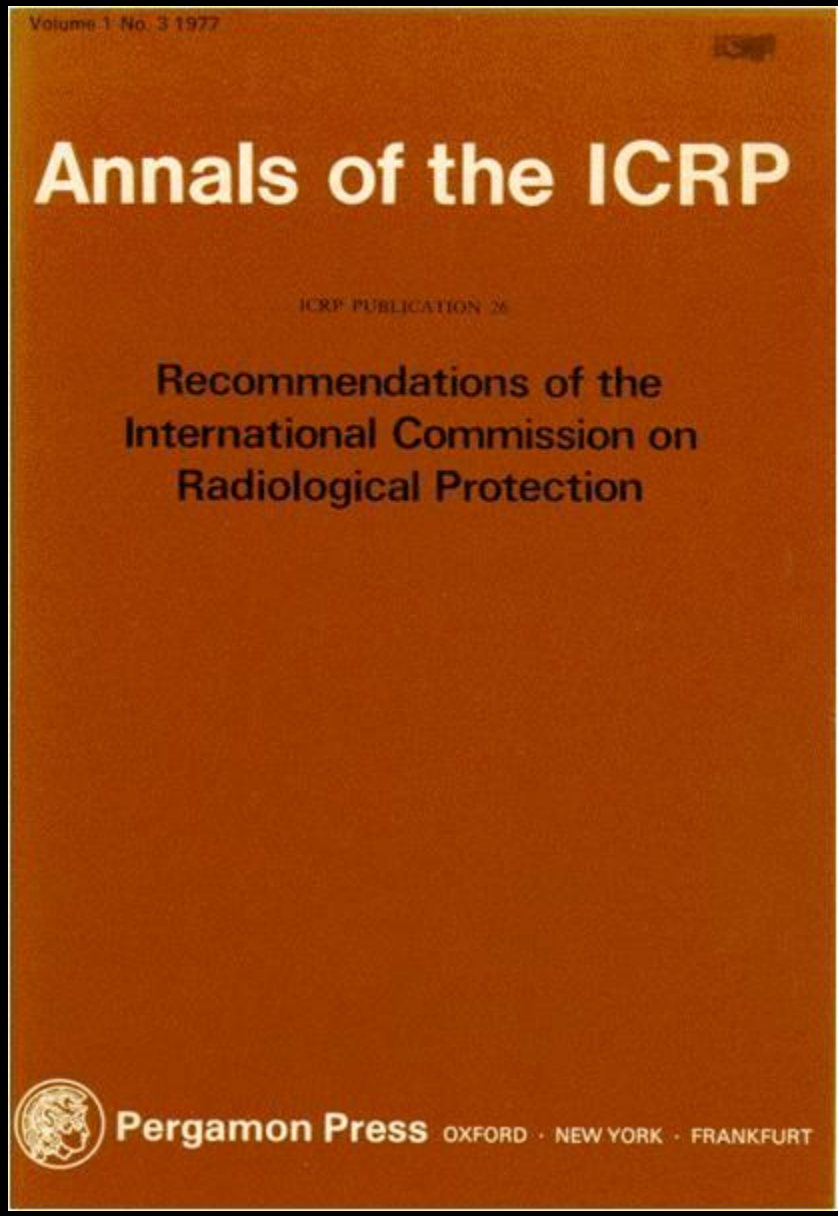
TABLE 1. FATAL ACCIDENTS, MALES, U.K., 1971

Age groups	Manufacturing industries			Construction		
	No. employed (thousands)	No. of deaths	Deaths per million per year (±SE)	No. employed (thousands)	No. of deaths	Deaths per million per year (±SE)
15–	450	6	13±5	117	7	60±23
20–	1 330	36	27±4	340	45	132±20
30–	1 200	52	43±6	270	46	170±25
40–	1 300	62	48±6	240	26	108±21
50–	1 170	61	52±7	200	43	215±33
60–	460	23	49±10	90	16	180±45
65–	140	6	43±18	26	5	192±86
All ages	6 050	246	41±3	1 280	188	147±11
Mean age (years)	40.1	43.3		38.0	40.9	

Risk = 0.4 10^{-4}/y - 1.5 10^{-4}/y

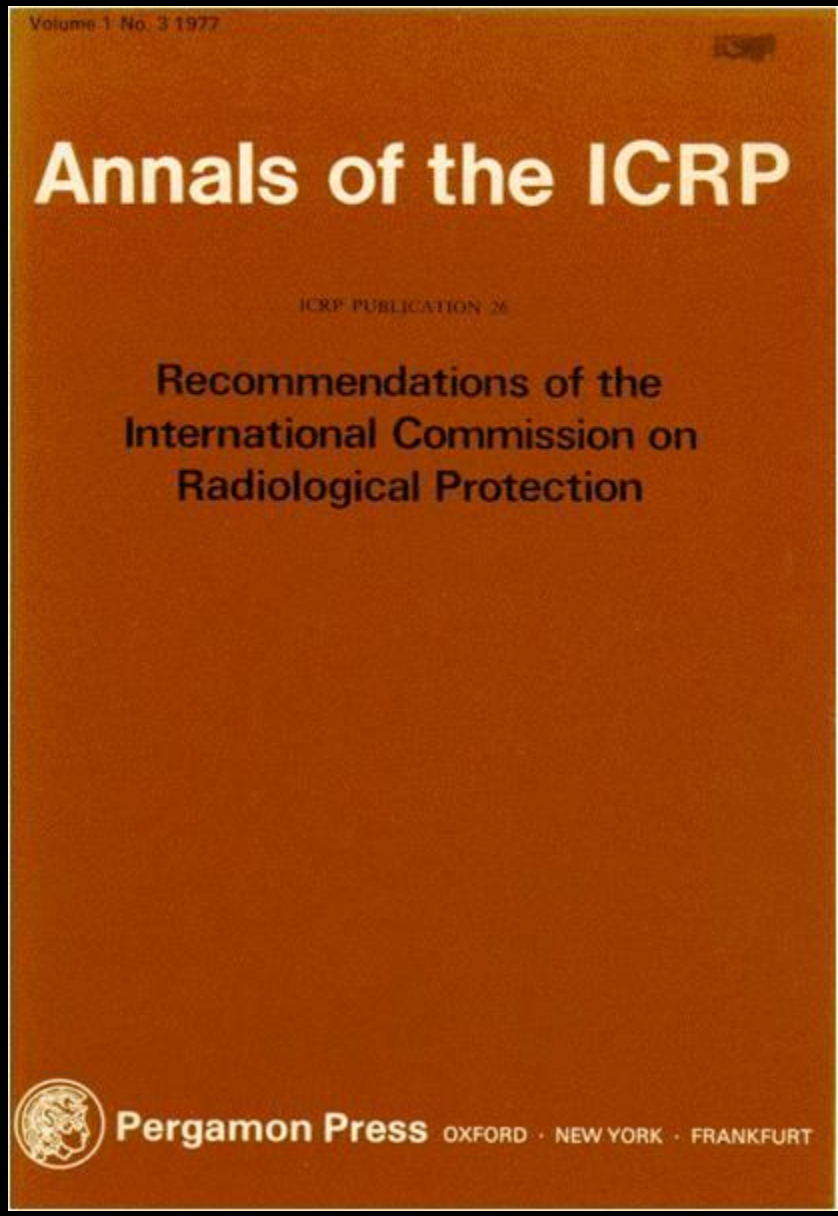
Publication 26 (ICRP, 1977)

(60) **For the purposes of radiation protection involving *individuals,* the Commission concludes that the mortality risk factor for radiation-induced cancers is about 10^{-2} Sv^{-1}, as an average for both sexes and all ages.**



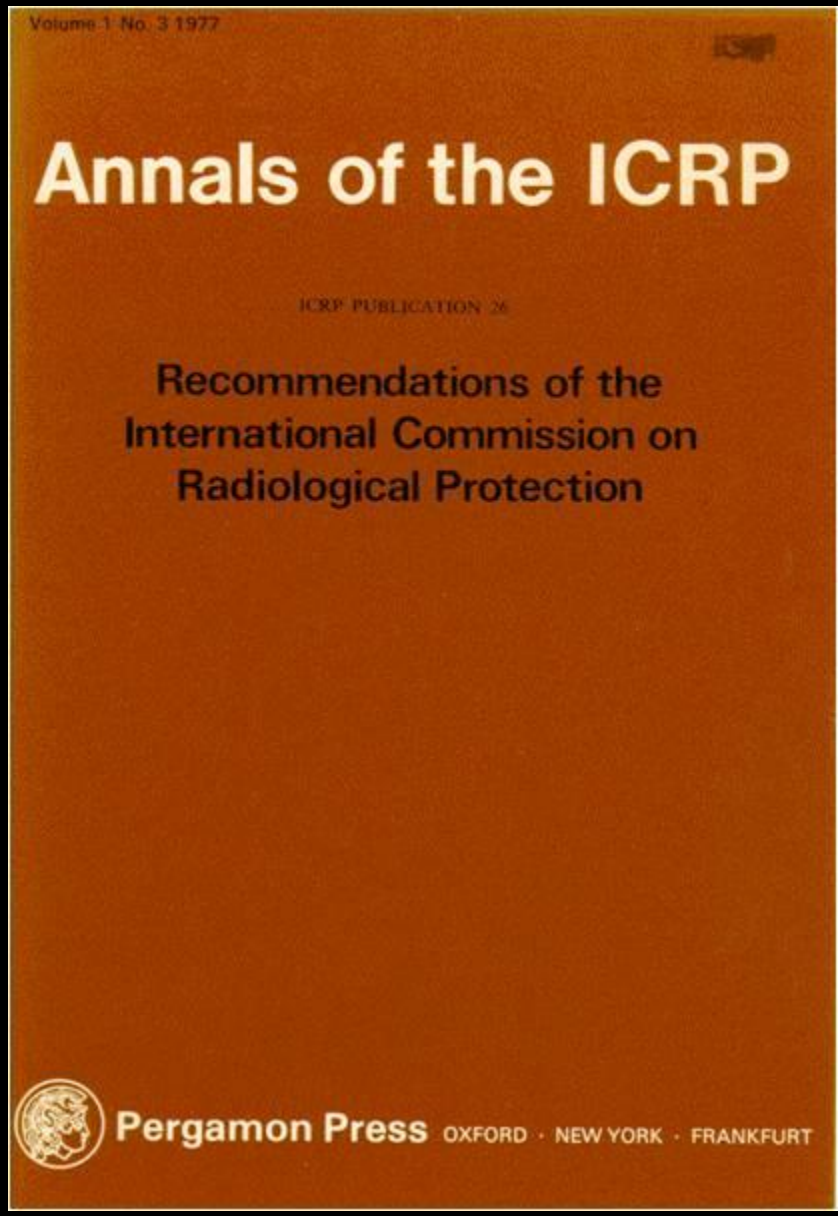
Publication 26 (ICRP, 1977)

(96) **The Commission believes that for the foreseeable future a valid method for judging the acceptability of the level of risk in radiation work is by comparing this risk with that for other occupations recognized as having high standards of safety, which are generally considered to be those in which the average annual mortality due to occupational hazards does not exceed 10^{-4}**



Publication 26 (ICRP, 1977)

(100) ..In the case of uniform exposure of the whole body, in circumstances where the Commission's recommendations, including the annual dose-equivalent limit of 50 mSv, have been applied, the distribution of the annual dose equivalents in large occupational groups has been shown very commonly to fit a lognormal function, with an arithmetic mean of about 5 mSv, and with very few values approaching the limit.



Publication 26 (ICRP, 1977)

(100) .. The application of the risk factors given

(10^{-2} Sv^{-1})

to the mean dose

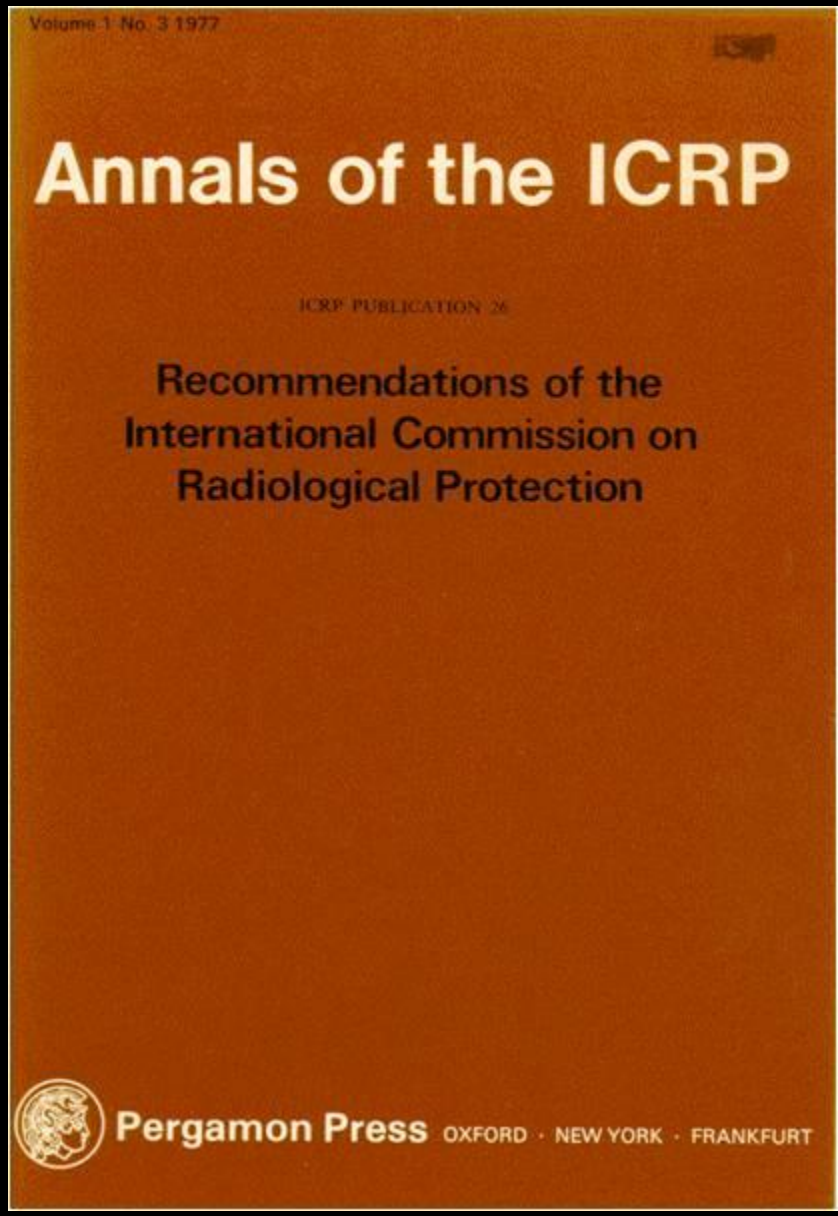
(5 mSv/year)

indicates that the average risk in these radiation occupations

($0.5\ 10^{-4}$/year)

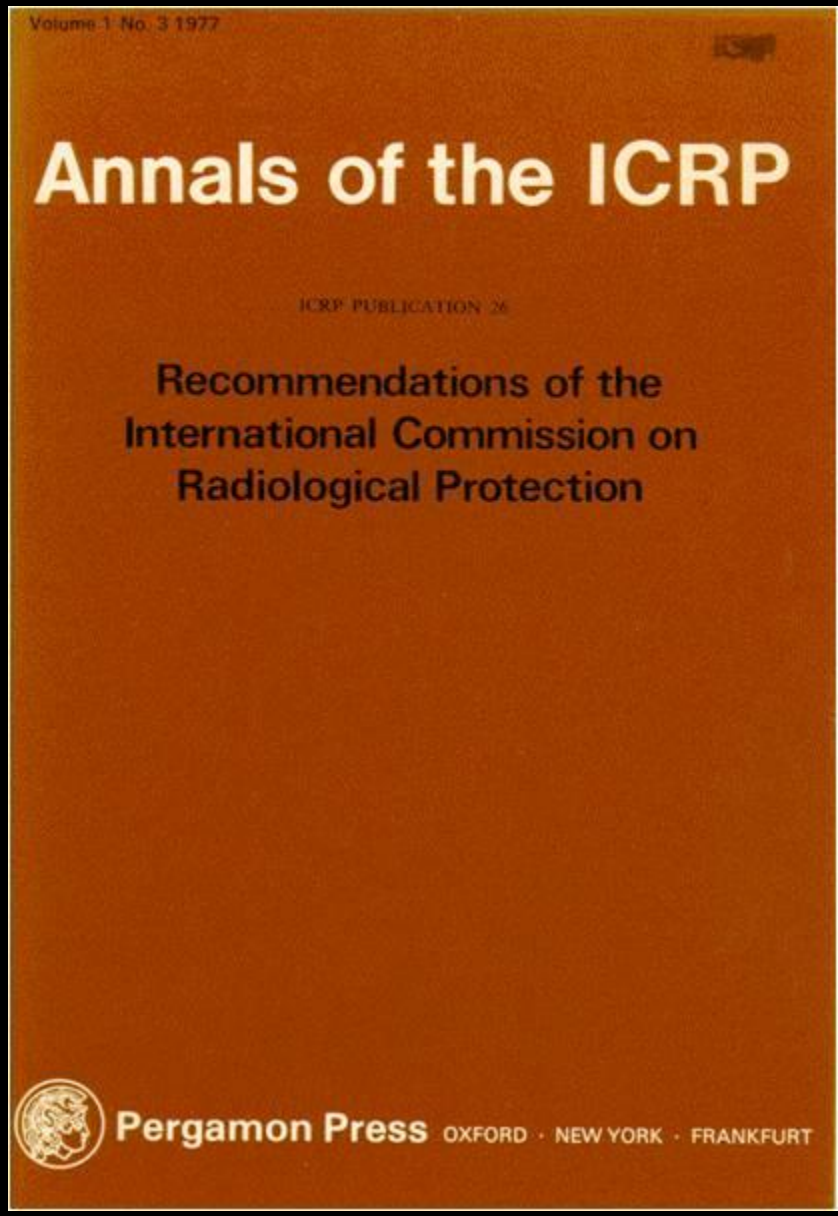
is comparable with the average risk in other safe Industries

(10^{-4} /year)



Publication 26 (ICRP, 1977)

(117) …..the level of acceptability for fatal risks to the general public is an order of magnitude lower than for occupational risks.



Statement from the 1987 Como Meeting of the ICRP.
***Annals of the ICRP 17(4),* i-v (1987).**

ICRP Publication 60 (1991)

The new recommendations were very detailed and still today are widely used in many radiation protection regulations, they addressed comprehensively the control of occupational exposure.

occupational exposure is the exposure incurred at work, and principally as a result of work

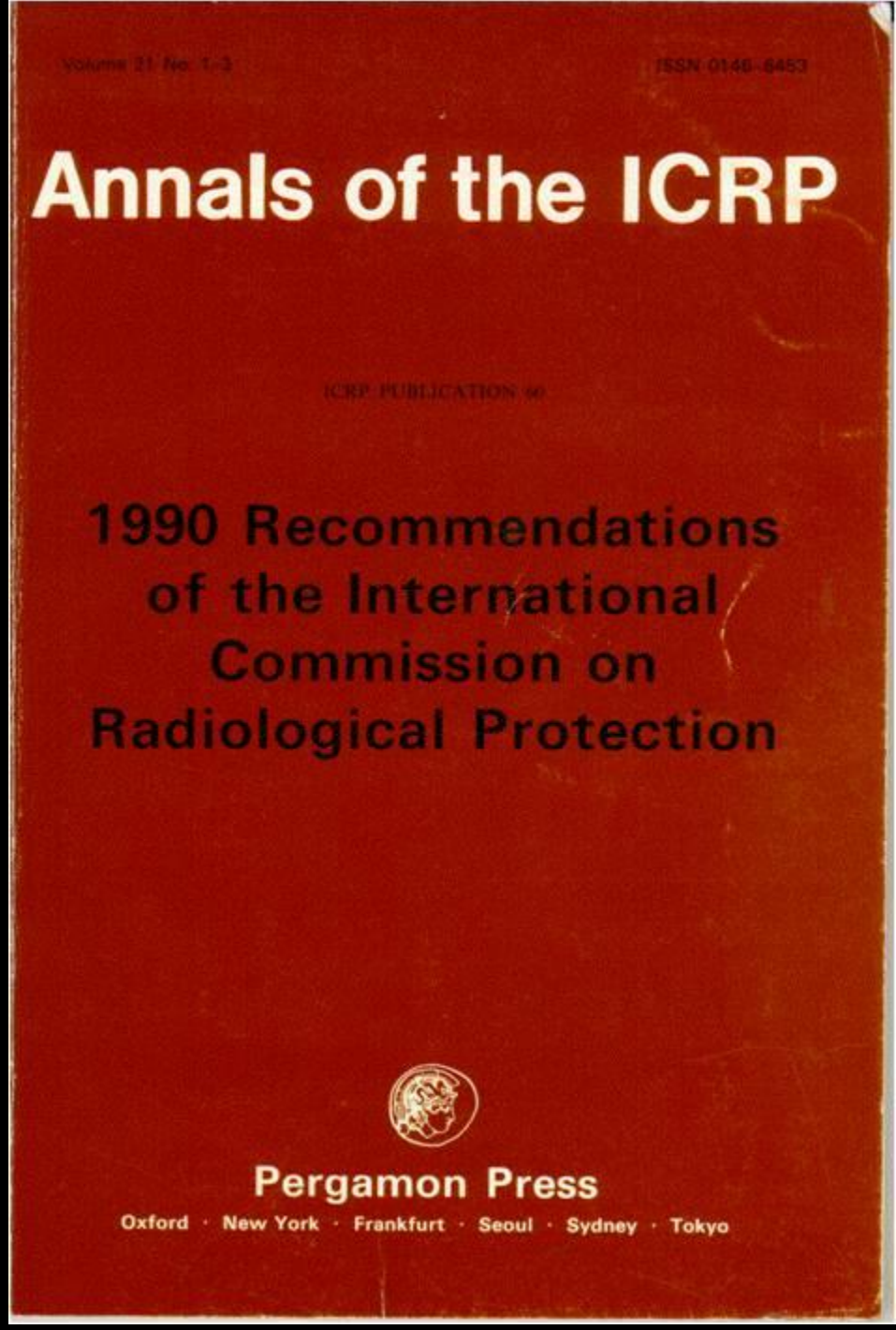


Table S-3. Nominal probability coefficients for stochastic effects

Exposed population	Detriment (10^{-2} Sv^{-1})[1]			
	Fatal cancer[2]	Non-fatal cancer	Severe hereditary effects	Total
Adult workers	4.0	0.8	0.8	5.6
Whole population	5.0	1.0	1.3	7.3

[1] Rounded values.
[2] For fatal cancer, the detriment is equal to the probability coefficient.

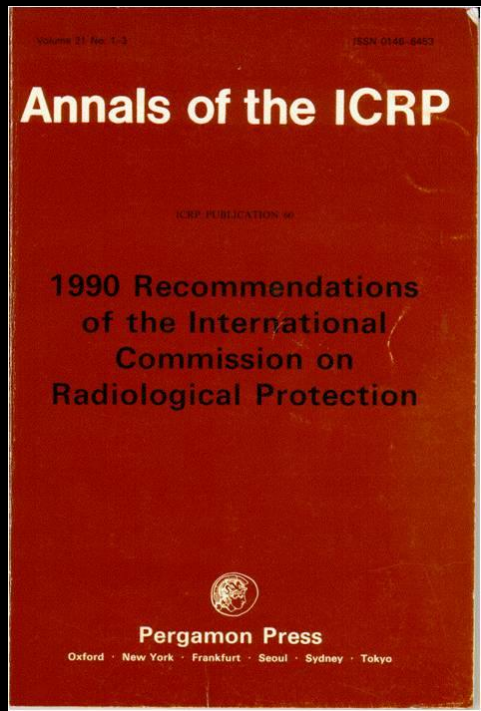
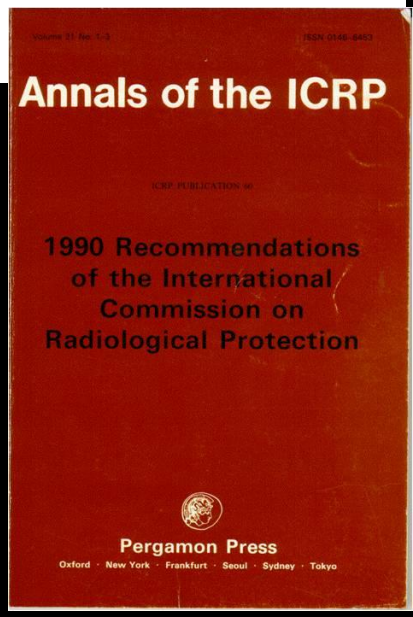


Table S-4. Recommended dose limits[1]

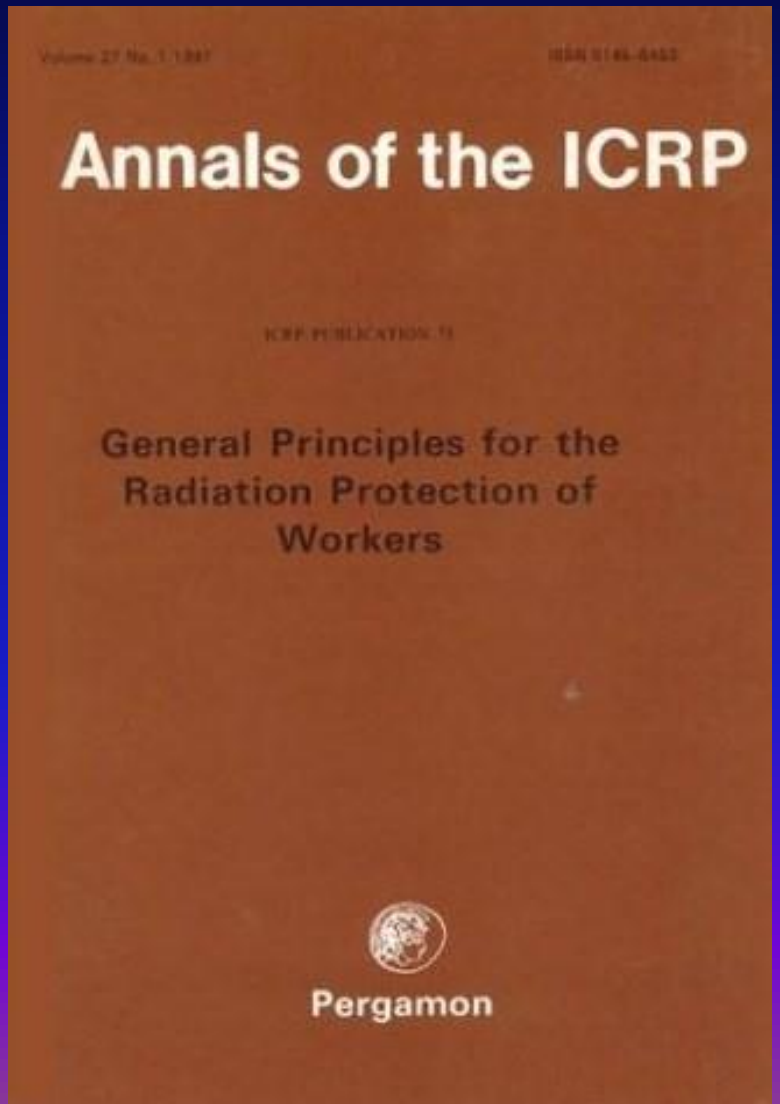
Application	Dose limit	
	Occupational	Public
Effective dose	20 mSv per year, averaged over defined periods of 5 years[2]	1 mSv in a year
Annual equivalent dose in		
the lens of the eye	150 mSv	15 mSv
the skin[4]	500 mSv	50 mSv
the hands and feet	500 mSv	



ICRP Publication 75

General Principles for the Radiation Protection of Workers

Ann. ICRP 27 (1), 1997

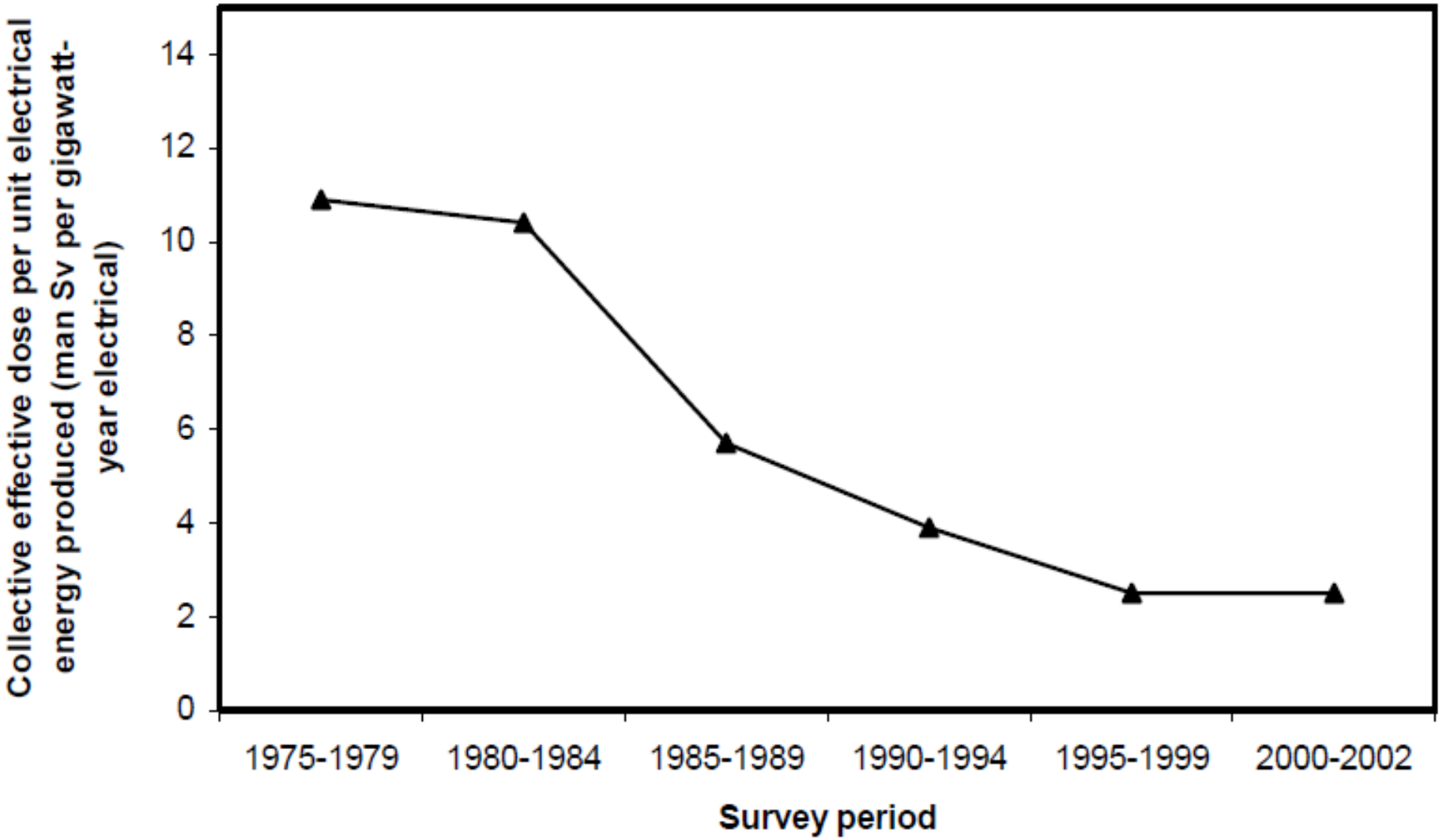


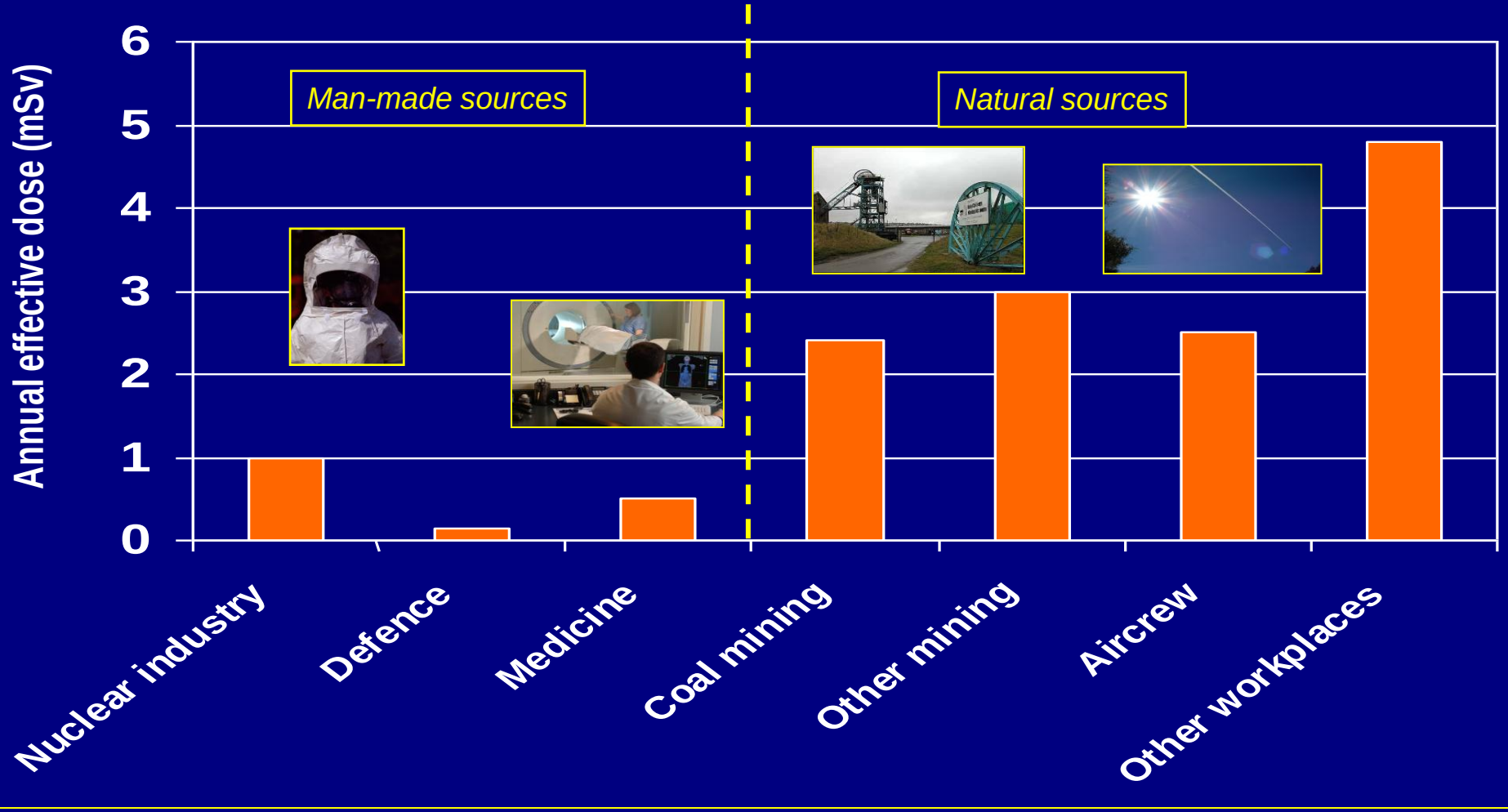
Occupational exposure

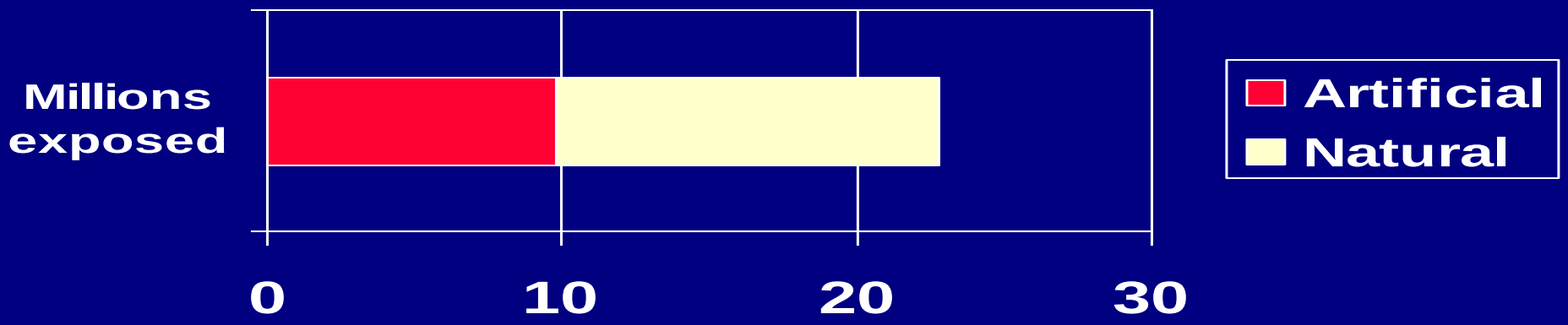
The exposure incurred at work principally as a result of work


UNSCEAR

Annual occupational collective dose at NPPs
(normalized to unit electrical energy produced)

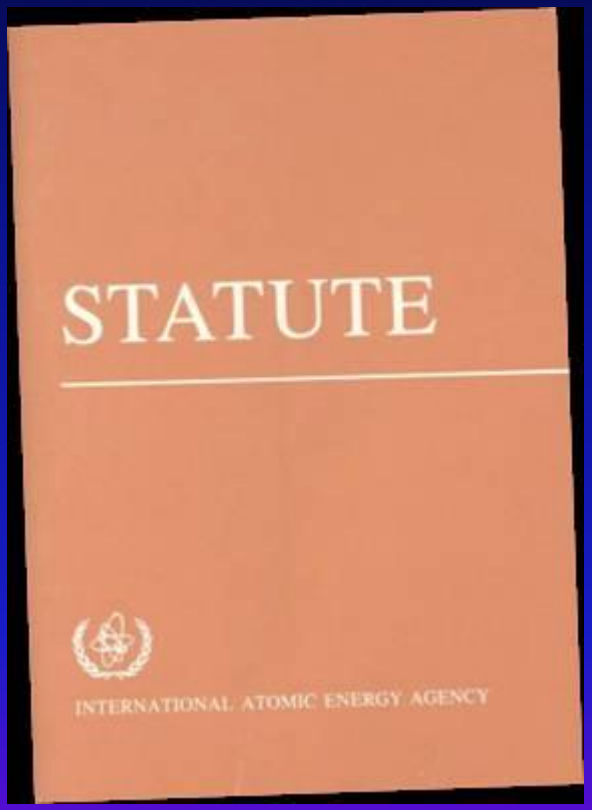



Annual effective dose (mSv)
0
1
2
3
4
5
6
Man-made sources
Natural sources
Nuclear industry
Defence
Medicine
Coal mining
Other mining
Aircrew
Other workplaces


Millions exposed
0
10
20
30
Artificial
Natural

IAEA

IAEA Statutory Functions

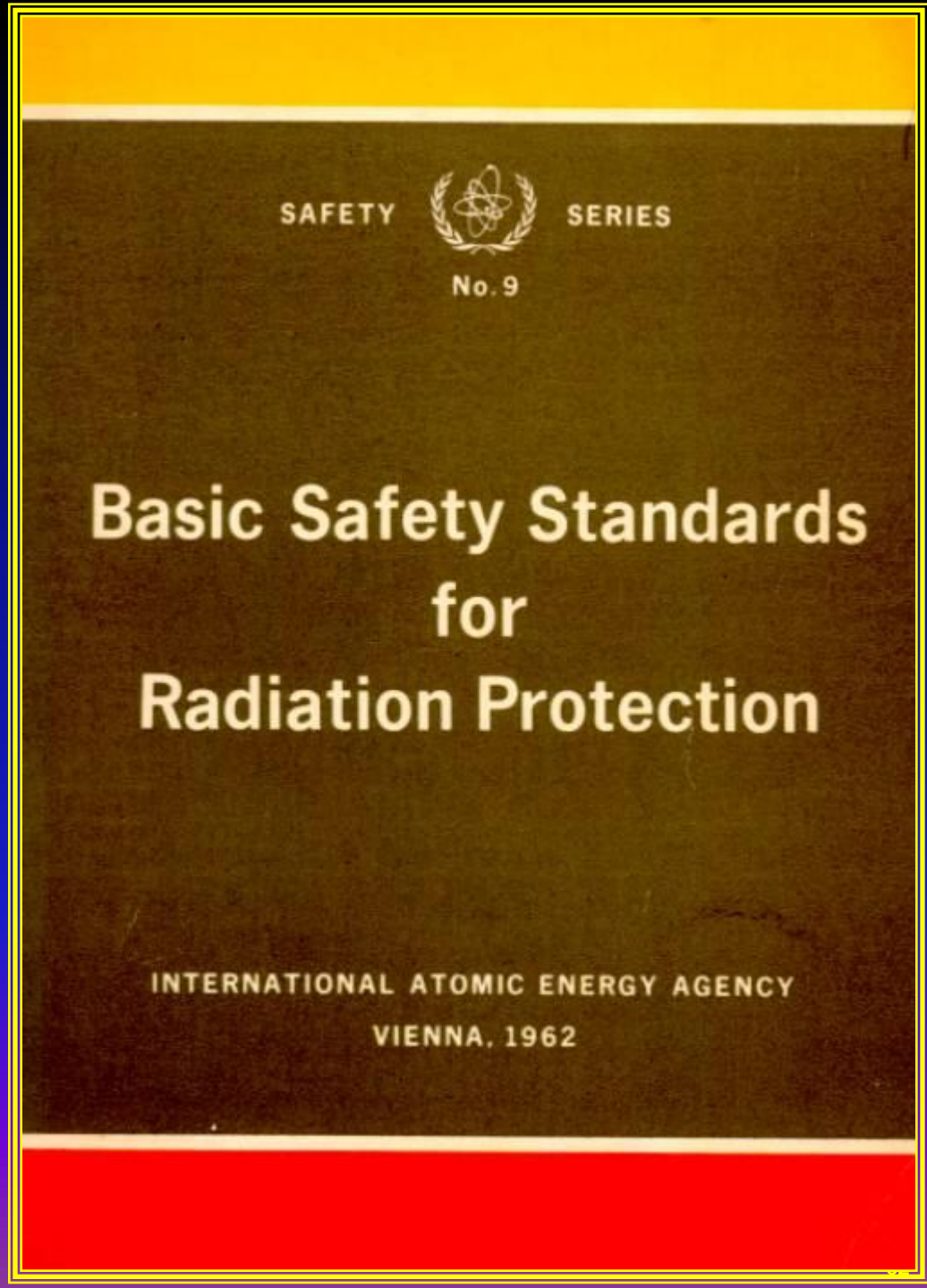


Under Article III.A.6 of its Statute, the IAEA is authorized: "*To establish… in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health.. including such standards for labour conditions, and to provide for the application of these standards….at the request of a State, to any of that State's activities in the field of atomic energy*."

International Safety Standards

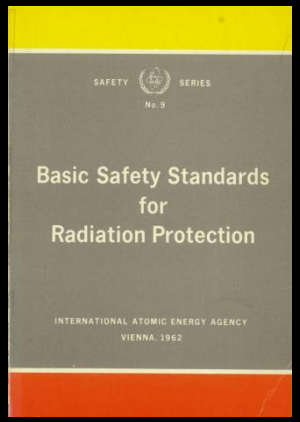
Long experience

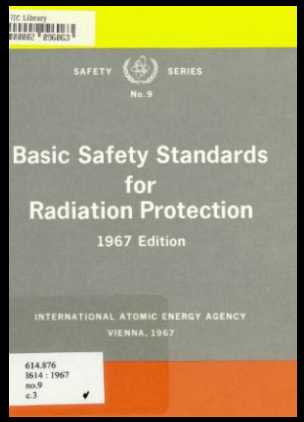
1962: first international standards.

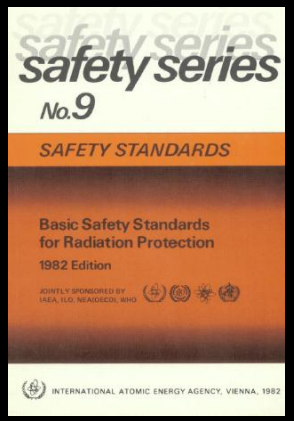


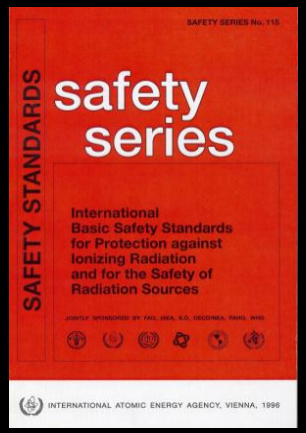
IAEA Basic Safety Standards

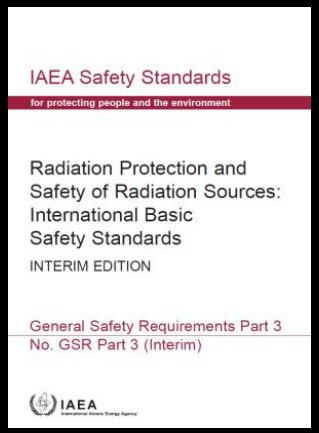
- 1962
- 1967
- 1982
- 1996
- 2011



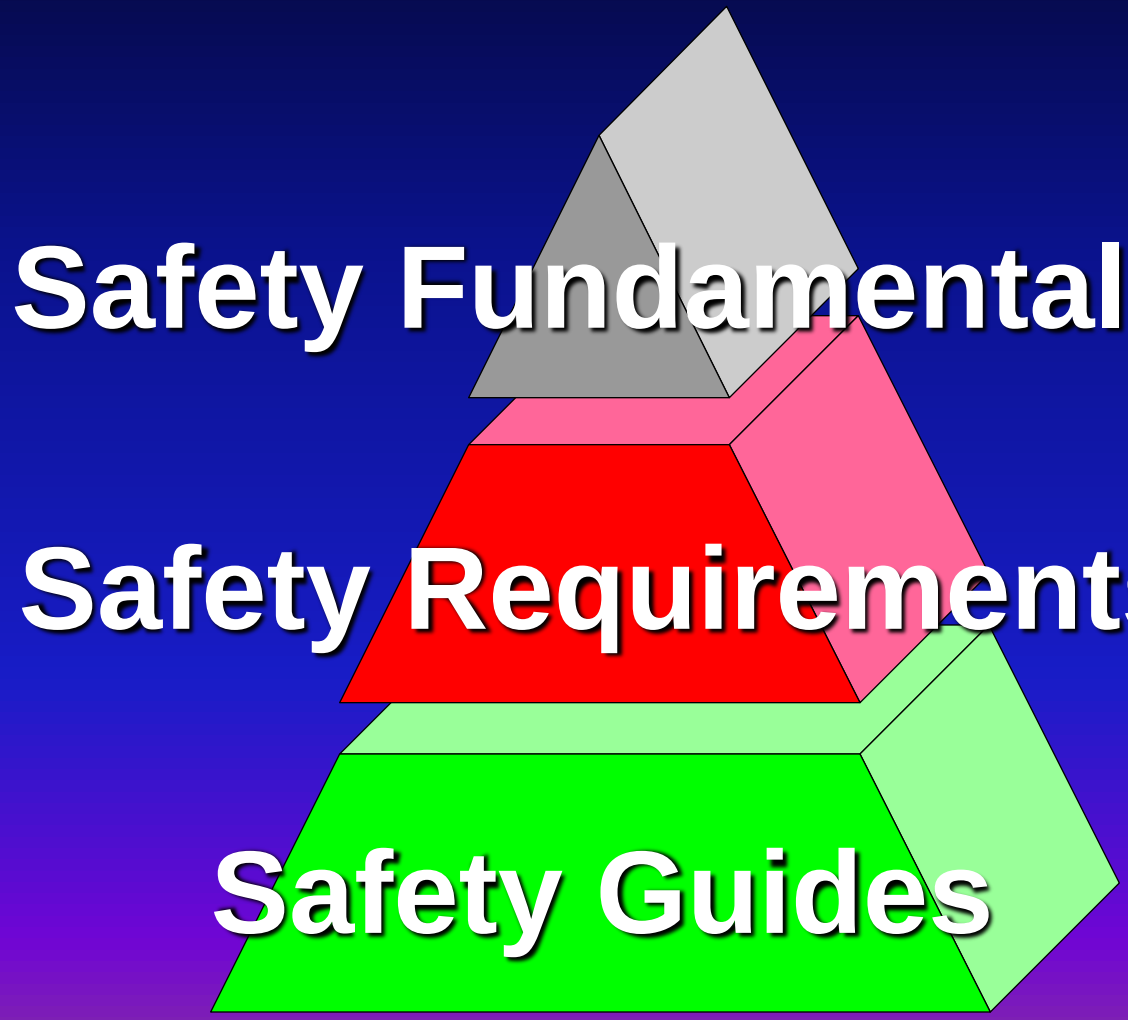








Safety Standards Hierarchy



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Safety Fundamentals

No. SF-1

IAEA
International Atomic Energy Agency

A large corpus of International Safety Standards is available


SAFETY GUIDES
Toiber

ILO

International Labour Organization

ILO Radiation Protection Convention No. 115 (1960)

Date of entry into force: 17.6.1962

Ratifications:

- Argentina 15.6.1978
- Azerbaijan 19.5.1992
- Barbados 8.5.1967
- Belarus 26.2.1968
- Belgium2.7.1965
- Beliz 15.12.1983
- Brazil 5.9.1966
- Chile 14.10.1994
- Czech Rep. 1.1.1993
- Denmark 7.2.1974
- Djibouti 3.8.1978
- Ecuador 9.3.1970
- Egypt 18.3.1964
- Finland 16.10.1978
- France 18.11.1971
- Germany 26.9.1973
- Ghana 7.11.1961
- Greece 4.6.1982
- Guinea 12.12.1966
- Guyana 8.6.1966
- Hungary 8.6.1968
- India 17.11.1975
- Iraq 26.10.1962
- Italy 5.5.1971
- Japan 31.7.1973
- Kyrgyzstan 31.3.1992
- Latvia 8.3.1993
- Lebanon 6.12.1977
- Luxembourg 8.4.2008
- Mexico 19.10.1983
- Netherlands 29.11.1966
- Nicaragua 1.10.1981
- Norway 17.6.1961
- Paraguay 10.7.1967
- Poland 23.12.1964
- Portugal 17.3.1994
- Russian Fed. 22.9.1967
- Slovakia 1.1.1993
- Spain 17.7.1962
- Sri Lanka 18.6.1986
- Sweden 12.4.1961
- Switzerland 29.5.1963
- Syrian A. R. 15.1.1964
- Tajikistan 26.11.1993
- Turkey 15.11.1968
- Ukraine 19.6.1968
- U.K. 9.3.1962
- Uruguay 22.9.1992

2. The Present

New Recommendations

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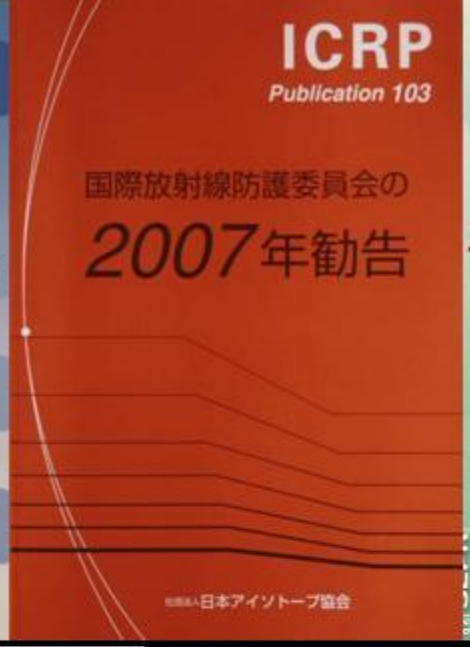
ICRP

Annals of the ICRP

ICRP Publication 103

The 2007 Recommendations of the International Commission on Radiological Protection


ICRP
国际放射防护委员会
2007 年建议书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2007年勧告
日本アイソトープ協会


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2007 de la Comisión Internacional
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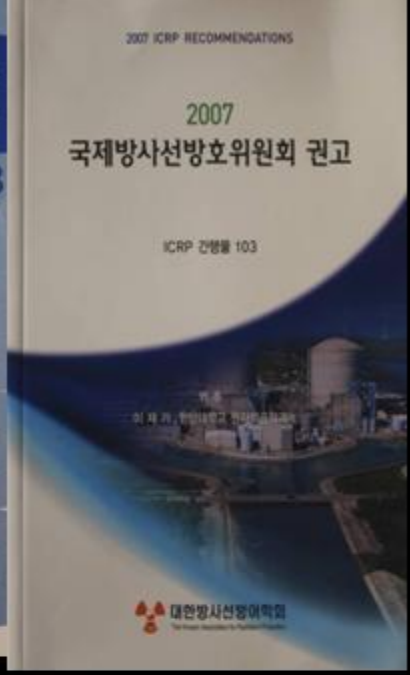
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ICRP 간행물 103
대한방사선방어학회


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Alain Rannou et Dominique Thierry
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Internationalen Strahlenschutzkommission
(ICRP) von 2007
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Verabschiedet im März 2007
Veröffentlichungen der
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Deutsche Ausgabe herausgegeben vom Bundesamt für Strahlenschutz


Aifm
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Pubblicazione ICRP 103
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DELLA COMMISSIONE INTERNAZIONA
PER LA PROTEZIONE RADIOLOGICA
Adottate dalla Commissione nel marzo 2007
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'The 2007 Recommendations of the International Commission on Radiological Protection'
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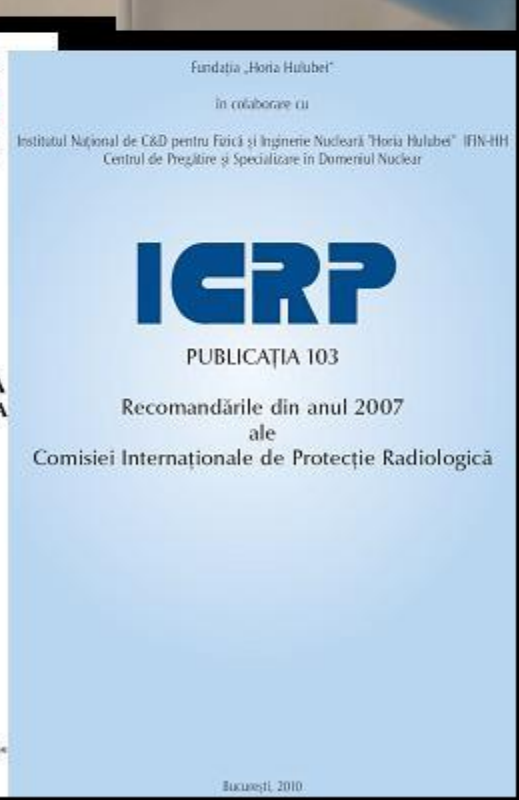
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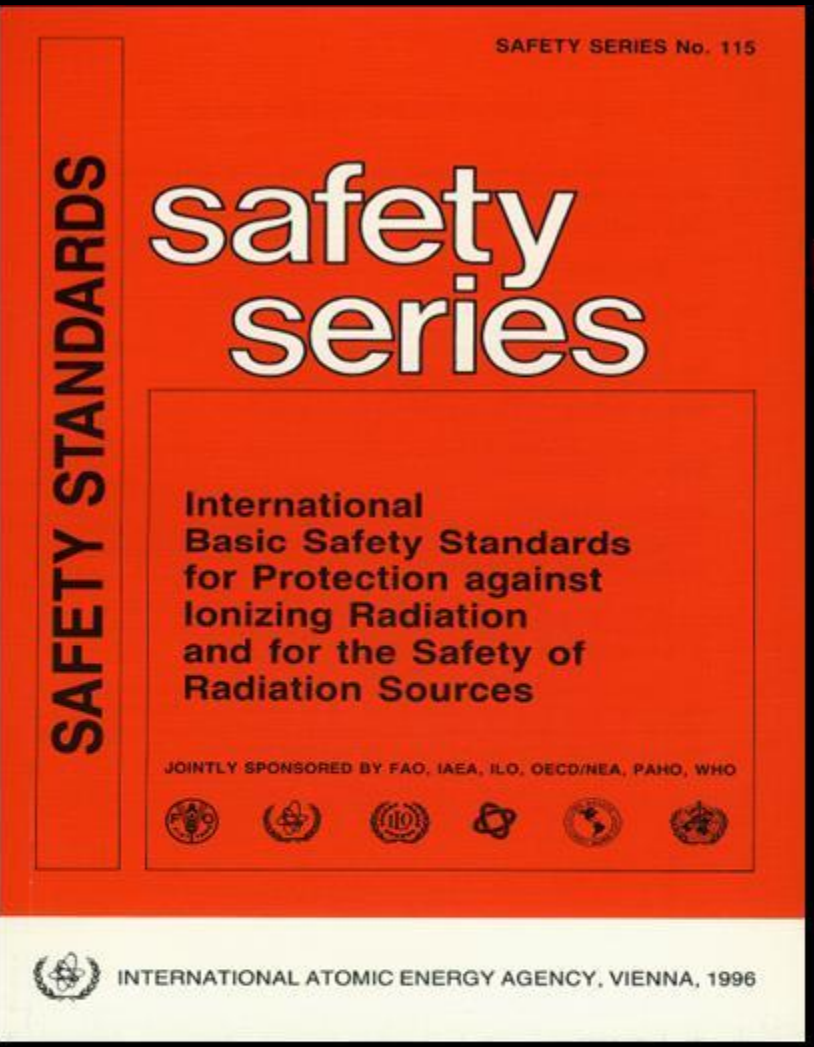
New Standards



IAEA Safety Standards

for protecting people and the environment

Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

INTERIM EDITION

General Safety Requirements Part 3

No. GSR Part 3 (Interim)

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Preparedness and Response for a Nuclear or Radiological Emergency

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REQUIREMENTS

No. GS-R-2

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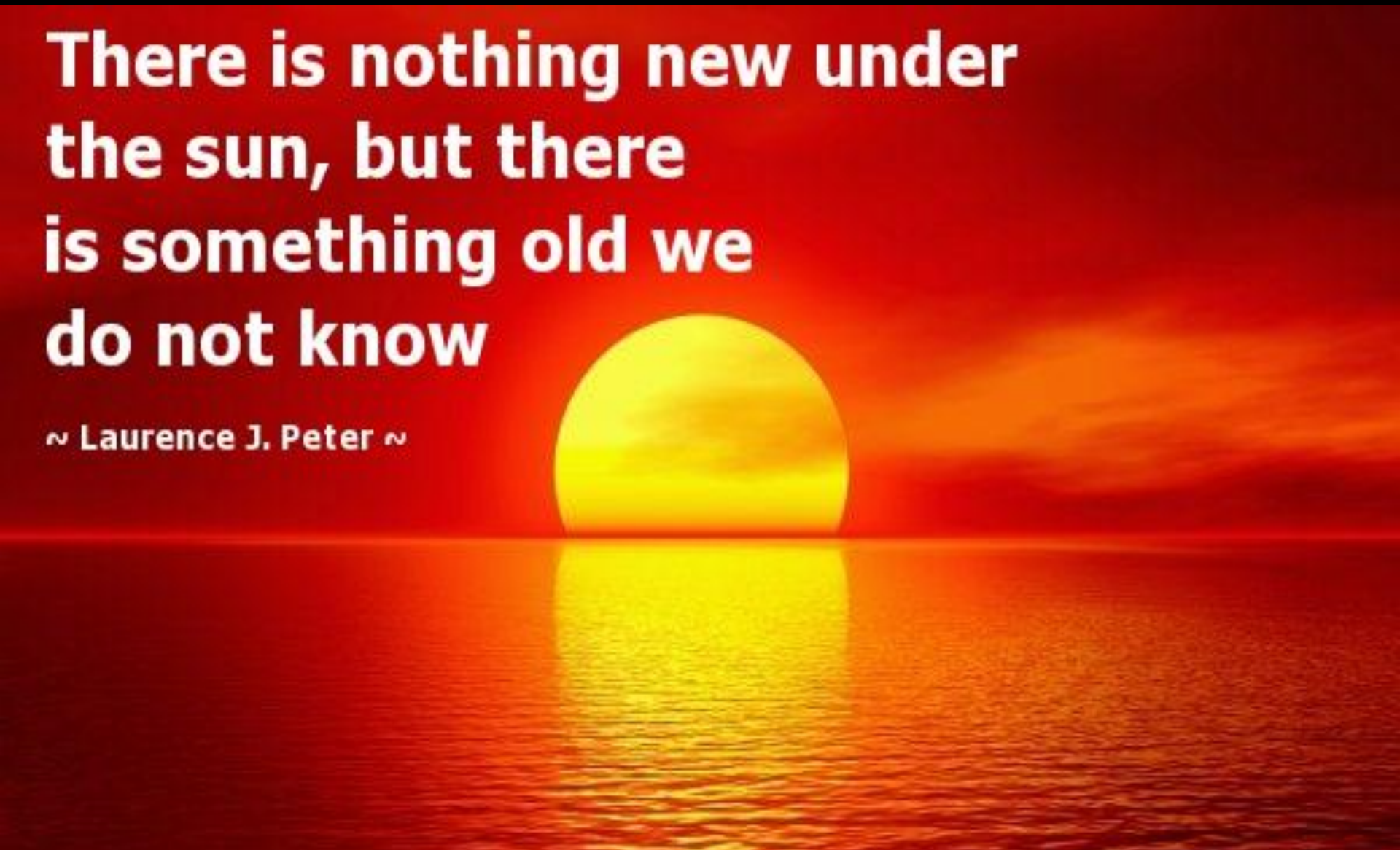
The Future


There is nothing new under the sun, but there is something old we do not know
~ Laurence J. Peter ~

OCCUPATIONAL RADIATION PROTECTION:

PROTECTING WORKERS AGAINST EXPOSURE TO IONIZING RADIATION

Proceedings of an
International Conference,
Geneva, 26–30 August 2002

IAEA
International Atomic Energy Agency

IOP PUBLISHING JOURNAL OF RADIOLOGICAL PROTECTION

J. Radiol. Prot. 33 (2013) 497–571 doi:10.1088/0952-4746/33/3/497

MEMORANDUM

Radiological protection issues arising during and after the Fukushima nuclear reactor accident

Abel J González[1], Makoto Akashi[2], John D Boice Jr[3], Masamichi Chino[4], Toshimitsu Homma[4], Nobuhito Ishigure[5], Michiaki Kai[6], Shizuyo Kusumi[7], Jai-Ki Lee[8], Hans-Georg Menzel[9], Ohtsura Niwa[10], Kazuo Sakai[2], Wolfgang Weiss[11], Shunichi Yamashita[10,12] and Yoshiharu Yonekura[2,13]

First challenge:

What occupational exposure is?

BSS 105

- All exposures of workers incurred in the course of their work, with the exception of exposures excluded from the Standards and exposures from practices or sources exempted by the Standards.

ICRP 103

- All exposure incurred by workers in the course of their work, with the exception of:
  - excluded exposures and exposures from exempt activities involving radiation or exempt sources;
  - any medical exposure; and
  - the ***normal local*** natural background radiation.

IAEA Glossary

- All exposure of workers incurred in the course of their work, with the *exception* of *excluded exposures* and *exposures* from exempt *practices* or *exempt sources*.

New BSS

- Exposure of workers incurred in the course of their work.

New EC Directives

- Exposure of workers, apprentices and students, incurred in the course of their work.

Scientific issues

Some scientific issues

- Probability-dose relationship for tissue reactions.
- Inferring risks ≠ Attributing effects!

Quantification issues

Quantities

- Physical
- Protection
- Operational
- Recording

Challenges

- Protection, operational and recording quantities vary. Traceability?
- Correct use of collective dose: collective dose per unit ‘goodness’.

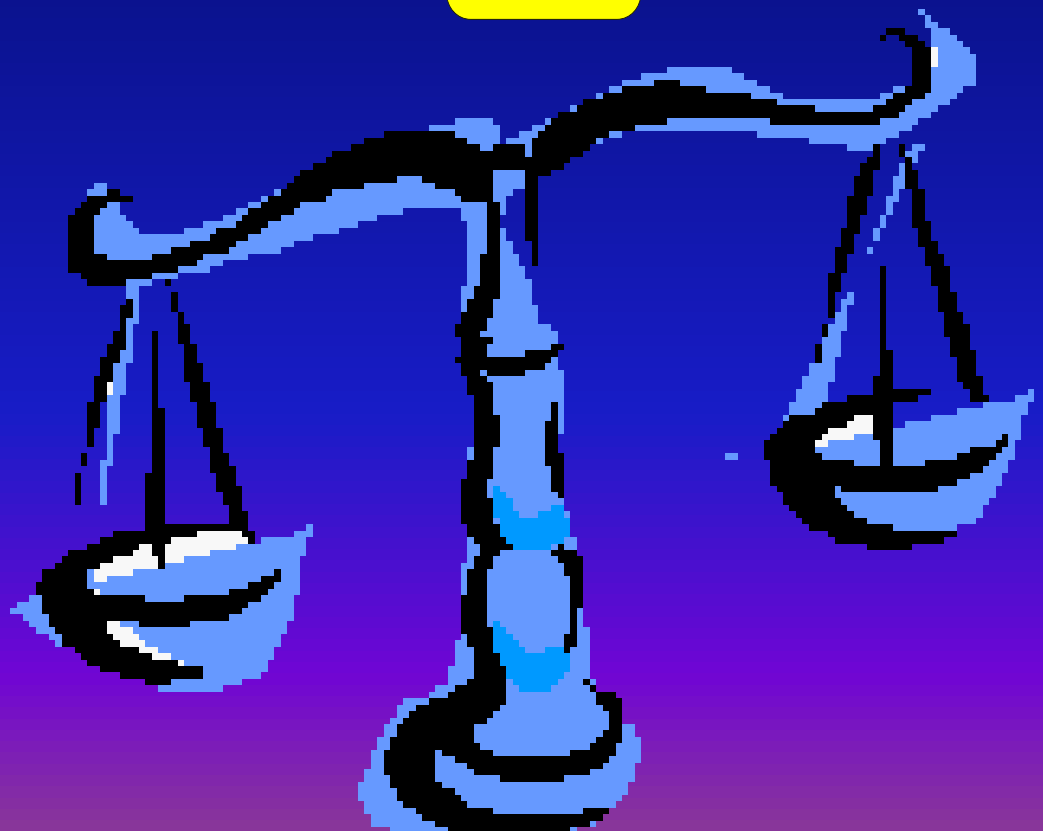
  (How to measure ‘goodness’ in work?)
- Protection quantities defined for low doses: Applicability to accidents?
- Can the effective dose be used for single organ exposure?

Issues on the radiation protection principles in occupational emergency exposure

Justification

Occupational Benefit?

Radiation detriment



Justification in emergency exposures

The ethical dilemma:

- **Teleology?**

  'Mind the ends, which justify the means'

or

- **Deontology?**

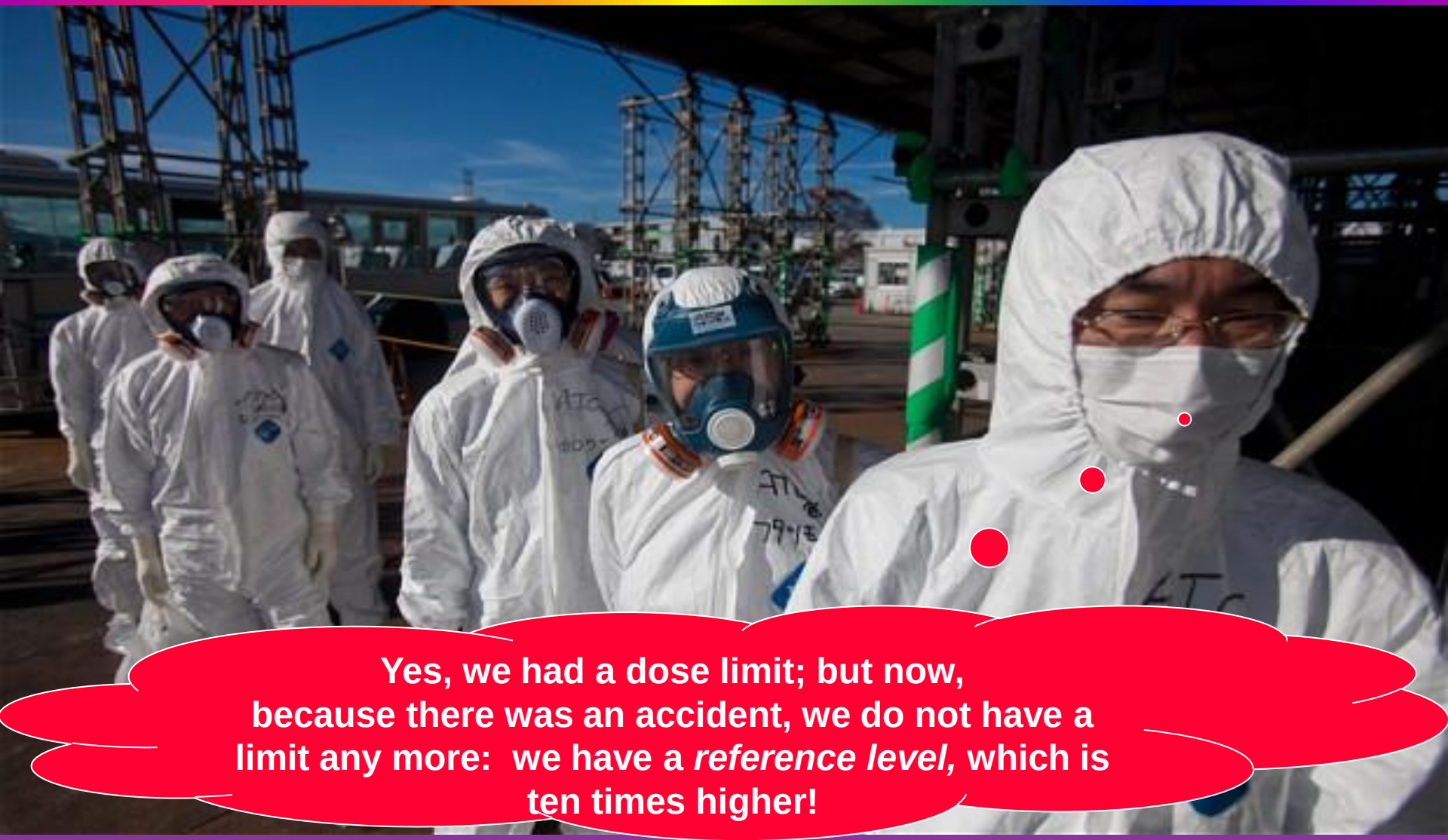
  'Not do unto others what they should not do unto you'

Optimization of protection


You just wait: protectio n is being optimized

Restriction of Individual Doses

The logic of dose limits



Yes, we had a dose limit; but now, because there was an accident, we do not have a limit any more: we have a *reference level*, which is ten times higher!

Are the numerical ‘dose limits’ logical?

The ‘logical’ process:

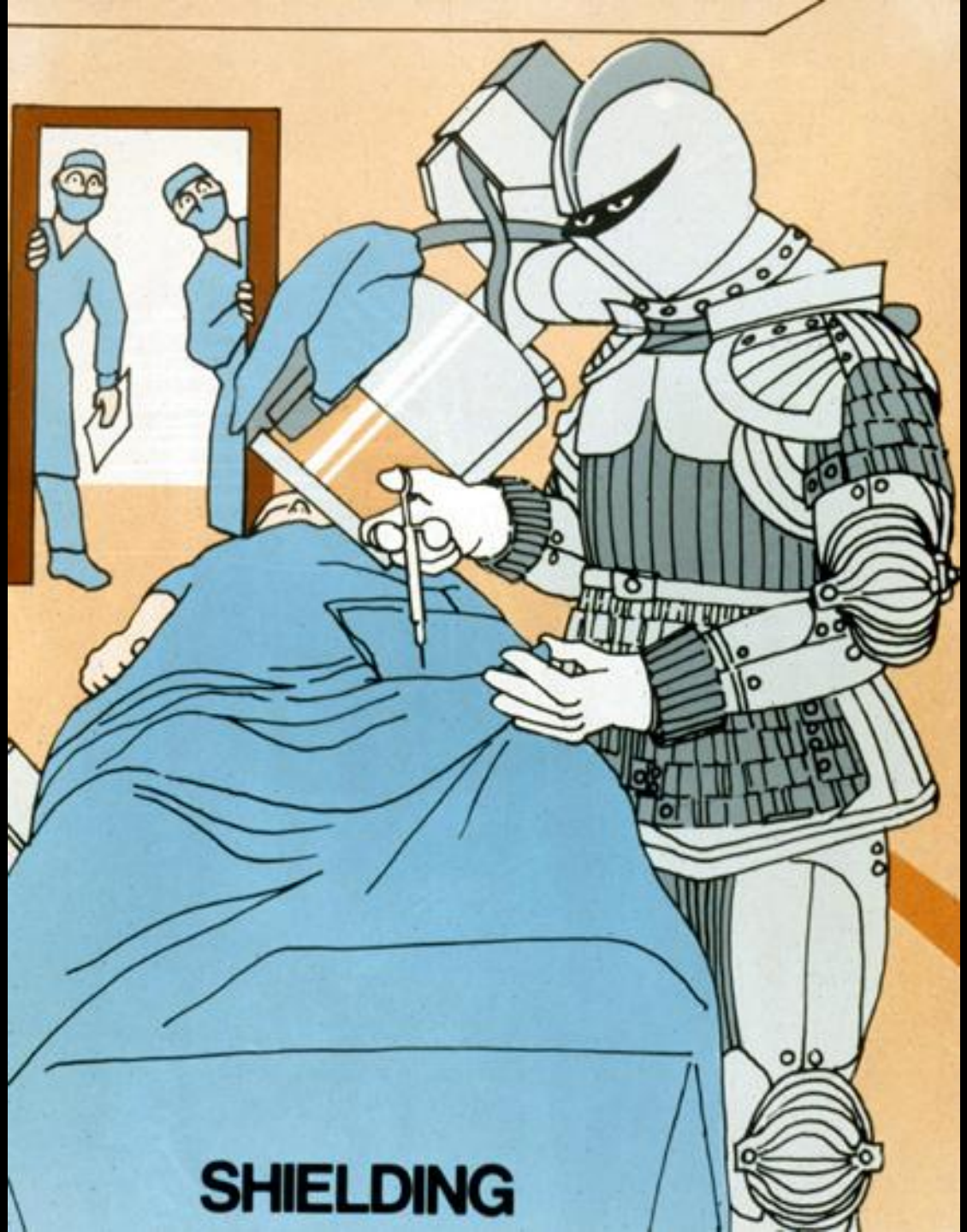
1. The risk of ‘safe’ industries 0.4 10^{-4}/y-1.5 10^{-4}/y
2. The radiation risk factor → 1%/Sv
3. Result:
   - Occupational limit = 50 mSv/y
   - Public limit (one order of magnitude lower) = 5mSv/y
4. Hiroshima reevaluation → risk = 5%/Sv
5. New limits:
   - Public = 1mSv/y
   - Occupational = 20mSv/y ???

Protection of volunteers (comforters and careers?)

Neither workers nor public

- Regulating exposure of volunteers?
- Similarities with comforters and careers?

Practical issues: interventional radiology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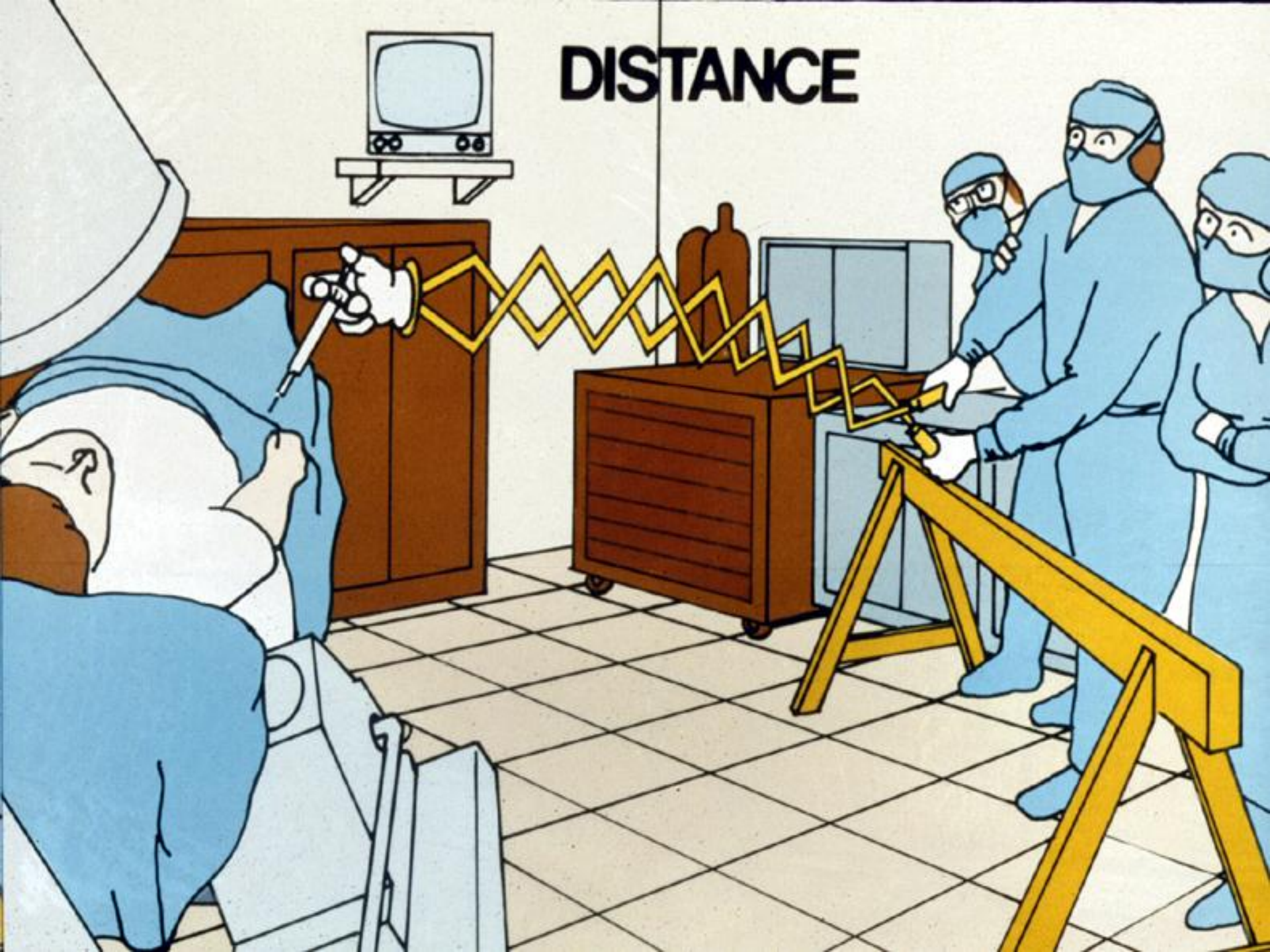
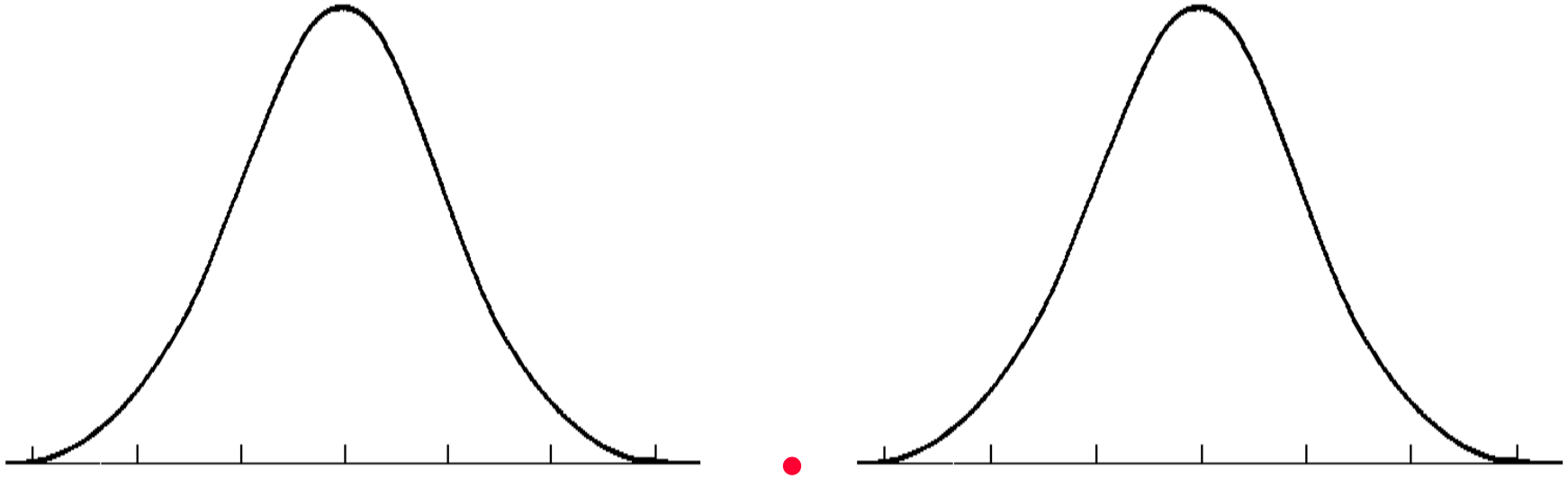

DISTANCE

Practical issues: radon



Non-smokers

Smokers

NOMINAL RISK

Education and training

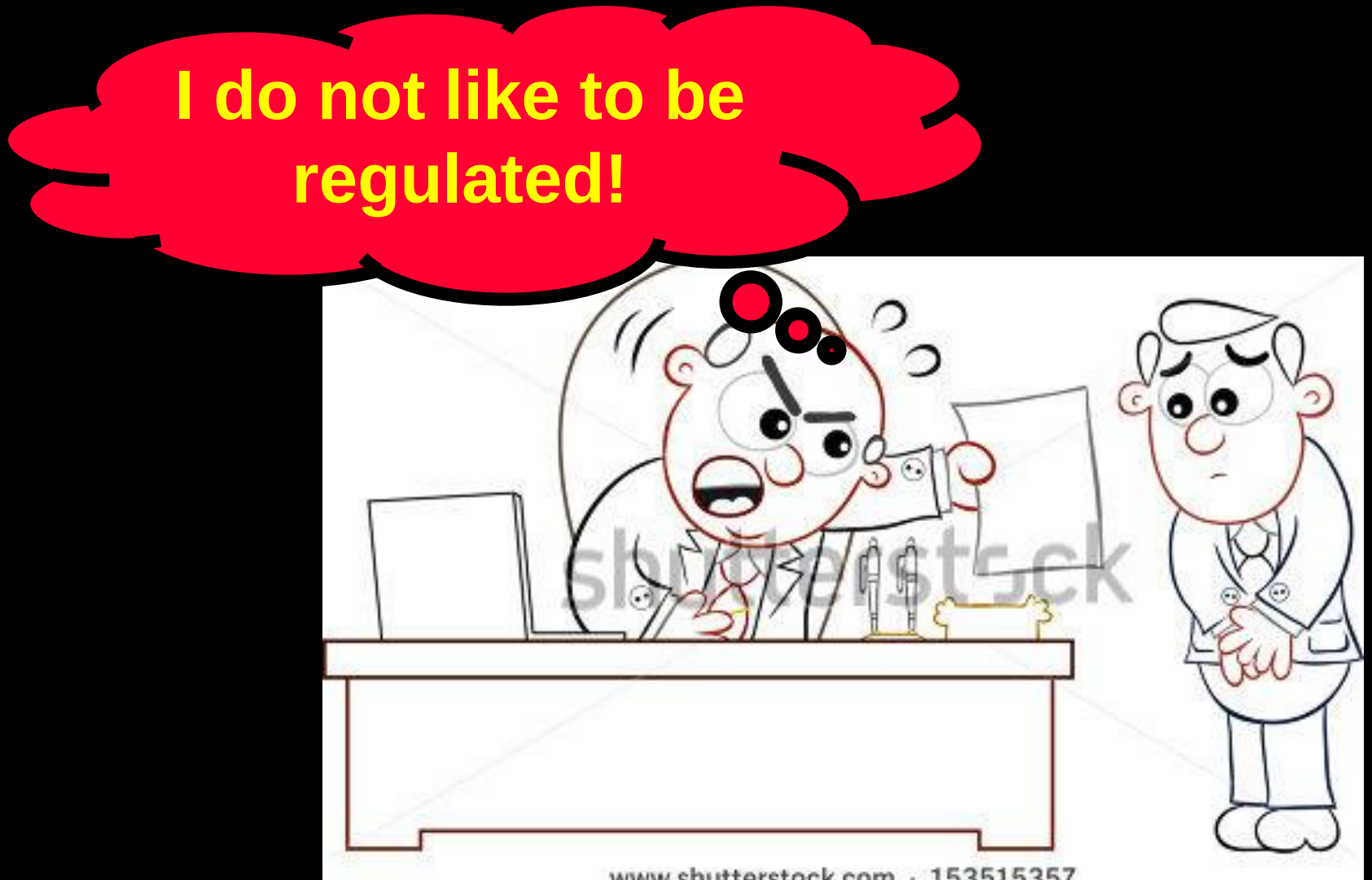
ILO Radiation Protection Convention, 1960 (No. 115)

- **Article 9 - 2.**

  All workers directly engaged in radiation work shall be adequately instructed, before and during such employment, in the precautions to be taken for their protection, as regards their health and safety, and the reasons therefor.

Workers versus developments

Employers versus regulations

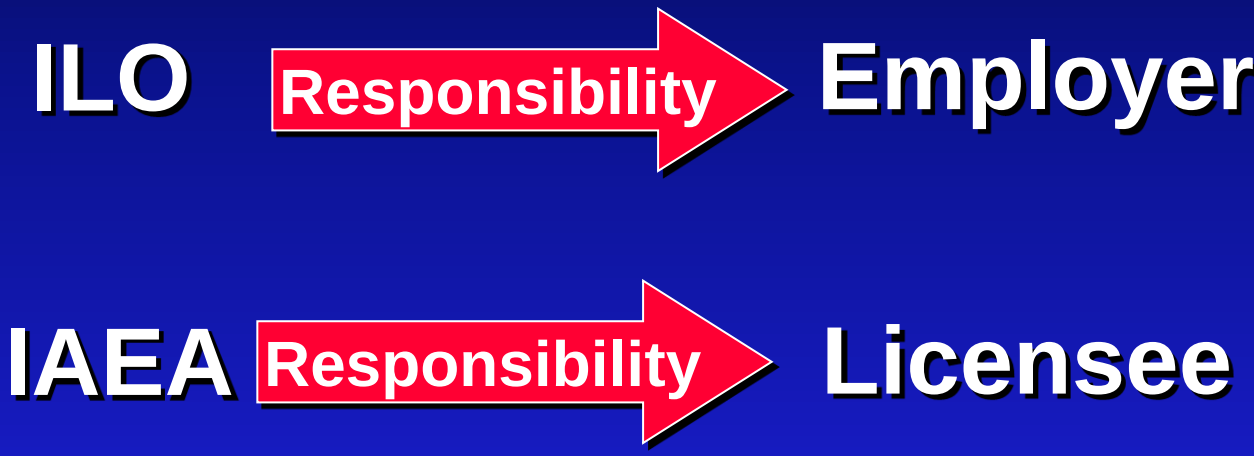


Engaging workers and employers?

Some legal issues

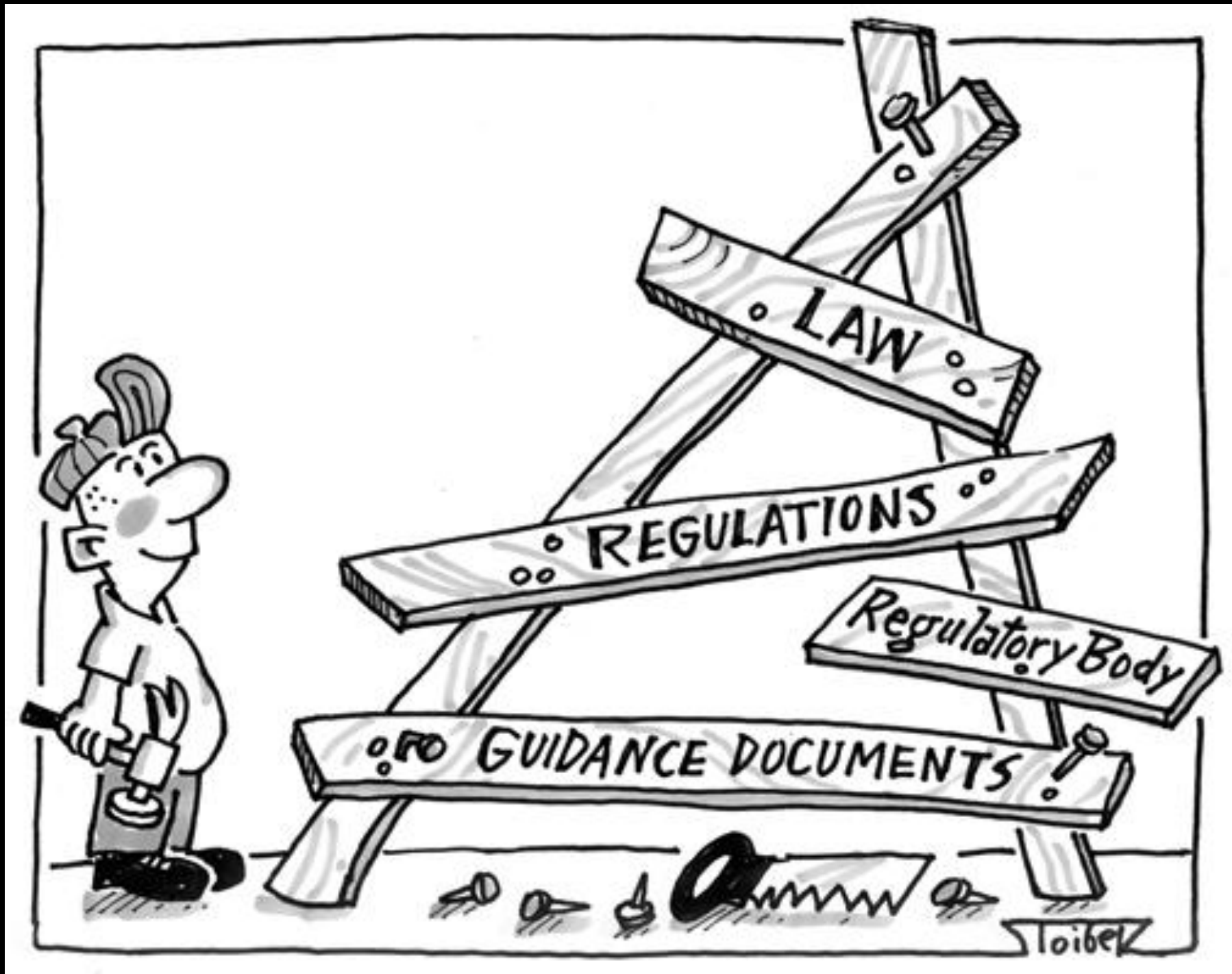
- A (dose) limit that may be violated?
- From attributability to imputability.
- Who is responsible?
  - Government (multiple regulators)
  - Licensee or registrant or ‘undertaker’
  - Employer

Mismatch



Employer ≠ Licensee

Institutional arrangements


LAW
REGULATIONS
Regulatory Body
GUIDANCE DOCUMENTS !
Stoibel

Epilogue

The IAEA and ILO, in co-operation with workers, employers and with relevant organizations, should:

(1) Convert the Vienna Statement into a renewed Action Plan, which should reproduce the success of the Geneva Action Plan.

(2) Start the process of drafting a renewed Convention 105

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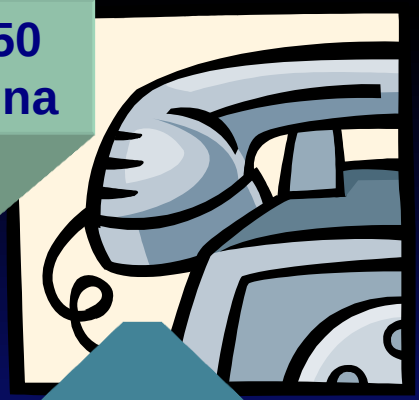

+5441163231306

Thank you!

agonzalez@arn.gob.ar, abel_j_gonzalez@yahoo.com