IRPA12 Refresher Course RC-20

Radiation protection in industrial applications of radioactive sources:

Prevention of Accidents in Gammagraphy

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Introduction: Why this subject?

- Prone to accidents and leaving orphan sources
  - Dominant usage in UNSCEAR list of accidents
  - Many instances of orphan sources
  - Radiation injuries and fatalities

- Terminology
  - Gammagraphy = gamma (ɣ)radiography
  - Industrial radiography = X- and ɣ-radiography

River Tyne, 1972

Contents

- Types of radiography and equipment
- Common causes of accidents
- Examples of serious accidents
- Mechanisms to learn lessons
- Roles of the different "Players"
- Emergency response
- Guidance material and training

Types of radiography (1)

Enclosure radiography

- Purpose built (?) shielded enclosure
  - "temporary" nature of some
  - Non-standard use
- Installed safety systems: warning lights and interlocks (?)
- Should be inherently safer: maintenance an issue
- Problems with open topped enclosures

Types of radiography (2)

Mobile radiography

- Within temporary barriers
- Portable warning and safety systems
- Adverse working conditions
- Often away from supervision
- Access control can be difficult
  - Multi-level
  - Need to liaise with site management and contractors
- Heavy reliance on procedures

Inherently more Hazardous

X-Radiography

- Typically 100 to 300 kV and 3 to 15 mA
  - Outputs 30 to 300 $mGy.min^{-1}$ at 1 m
  - At 10 cm: 3 to 30 $Gy.min^{-1}$
  - Collimation
- Need for automatic fail-safe safety and warning systems
- Integral part of design of enclosures
  - Emergency stop buttons/ pull cords
  - Search and lock up

Typical accidents from:

- poor design and maintenance of safety systems
- Lack of awareness and poor procedures

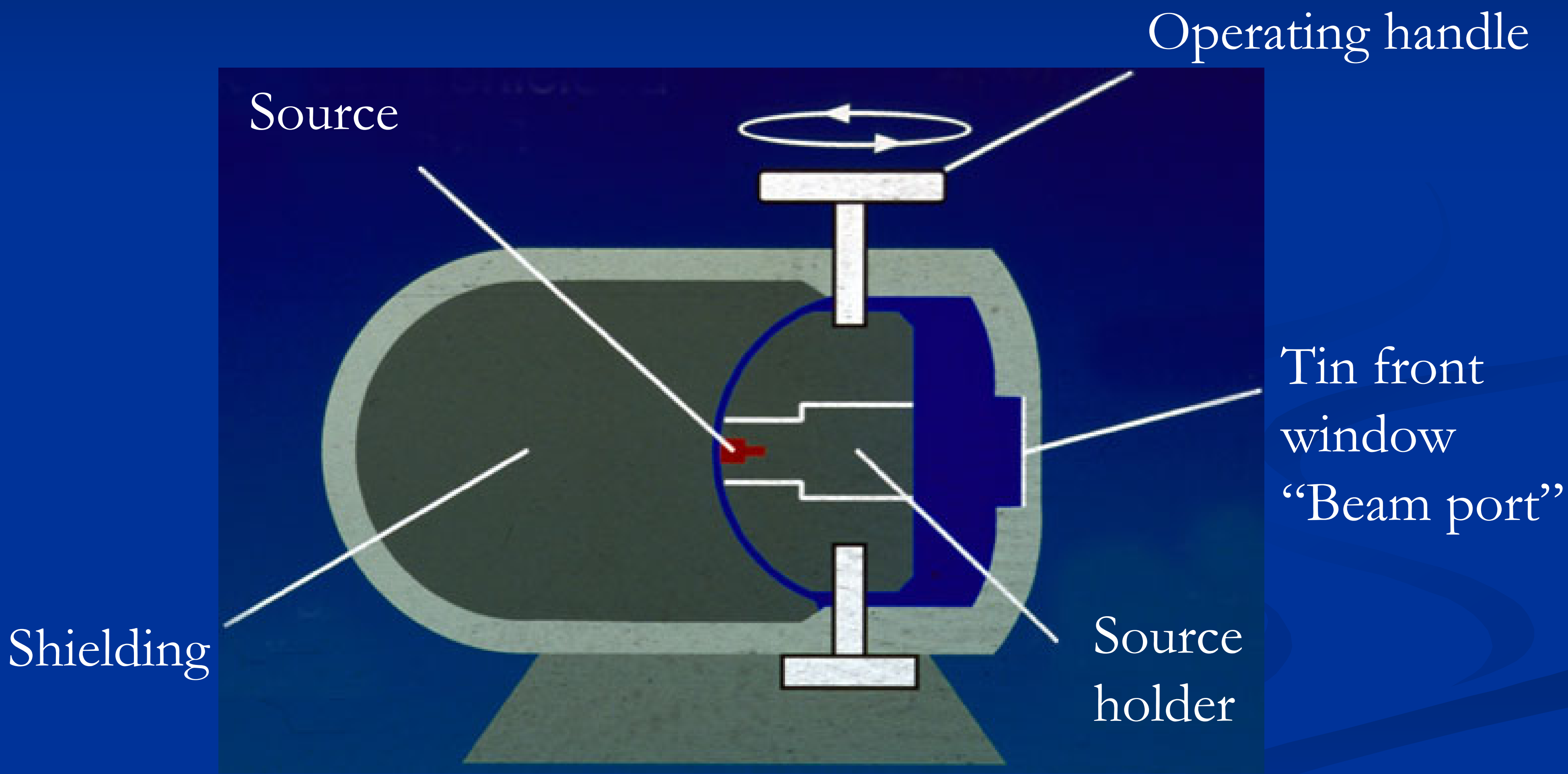
Linear accelerators

- Typically up to 8 MeV
- Outputs ~ 4 $Gy.min^{-1}$ at 1 m
- Specialist uses
- High quality (multiple redundancy) safety systems
- Higher degree of knowledge and training for operators

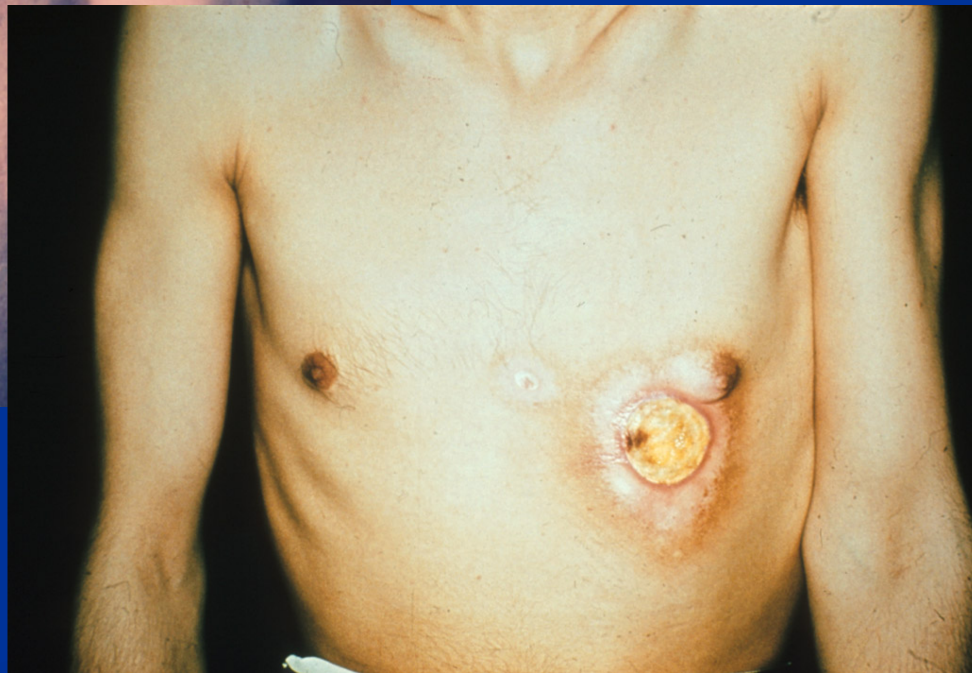
Typical radiography sources

Radionuclide	Energy (MeV)	Source output at 1m ($mGyh^{-1}$ per 37 GBq)	Half Life	Typical use for steel of thickness (mm)
Cobalt-60	1.17 and 1.33	13.0	5.3 y	50–120
Ir-192	0.2–1.4	4.8	74 d	10–70
Se-75	0.12–0.97	2.03	120 d	4–28
Yb-169	0.008–0.31	1.25	32 d	2.5–15

Shutter type container



Radiation injury from Shutter type container



“Torch” type container

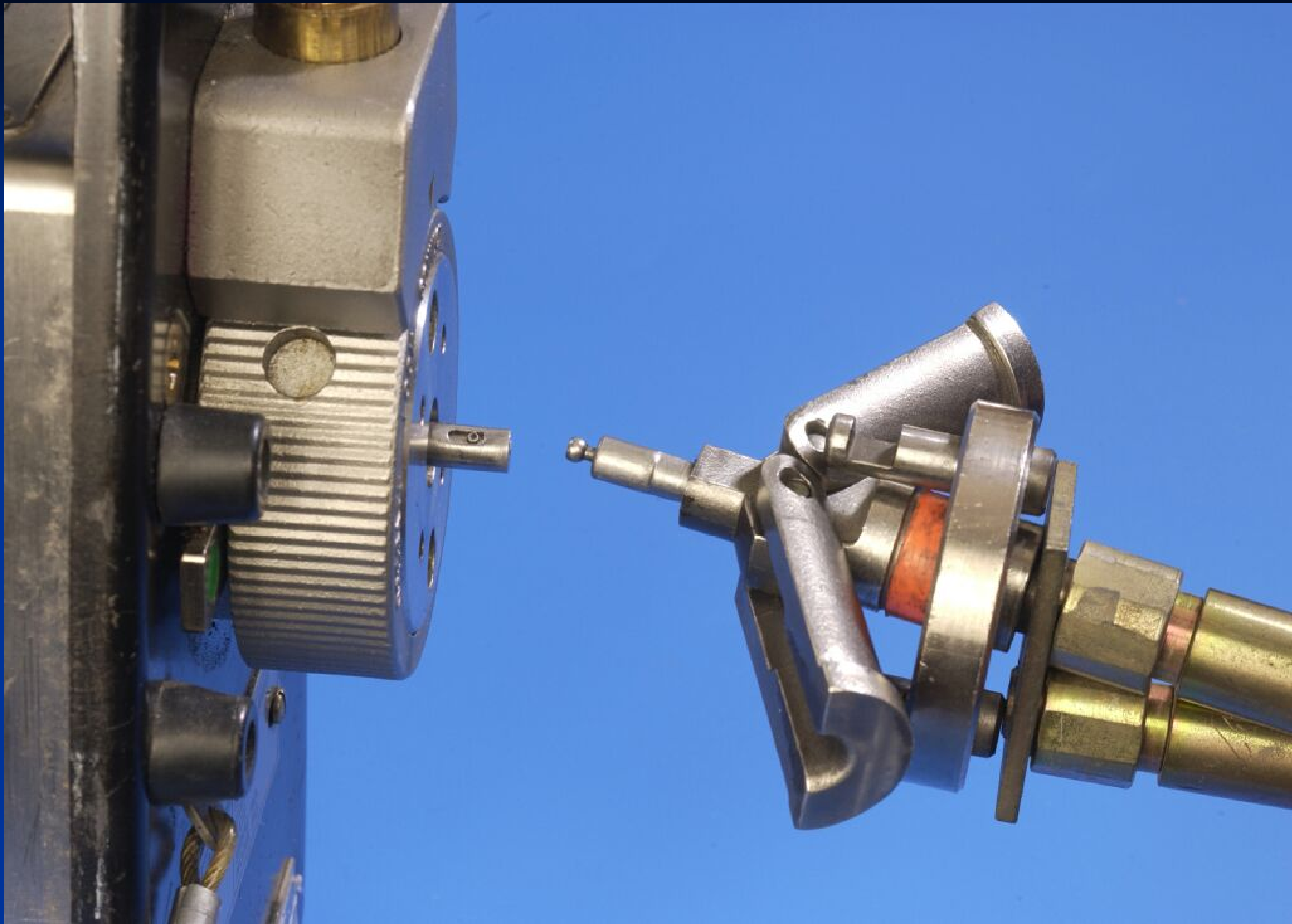
High cumulative doses due to proximity

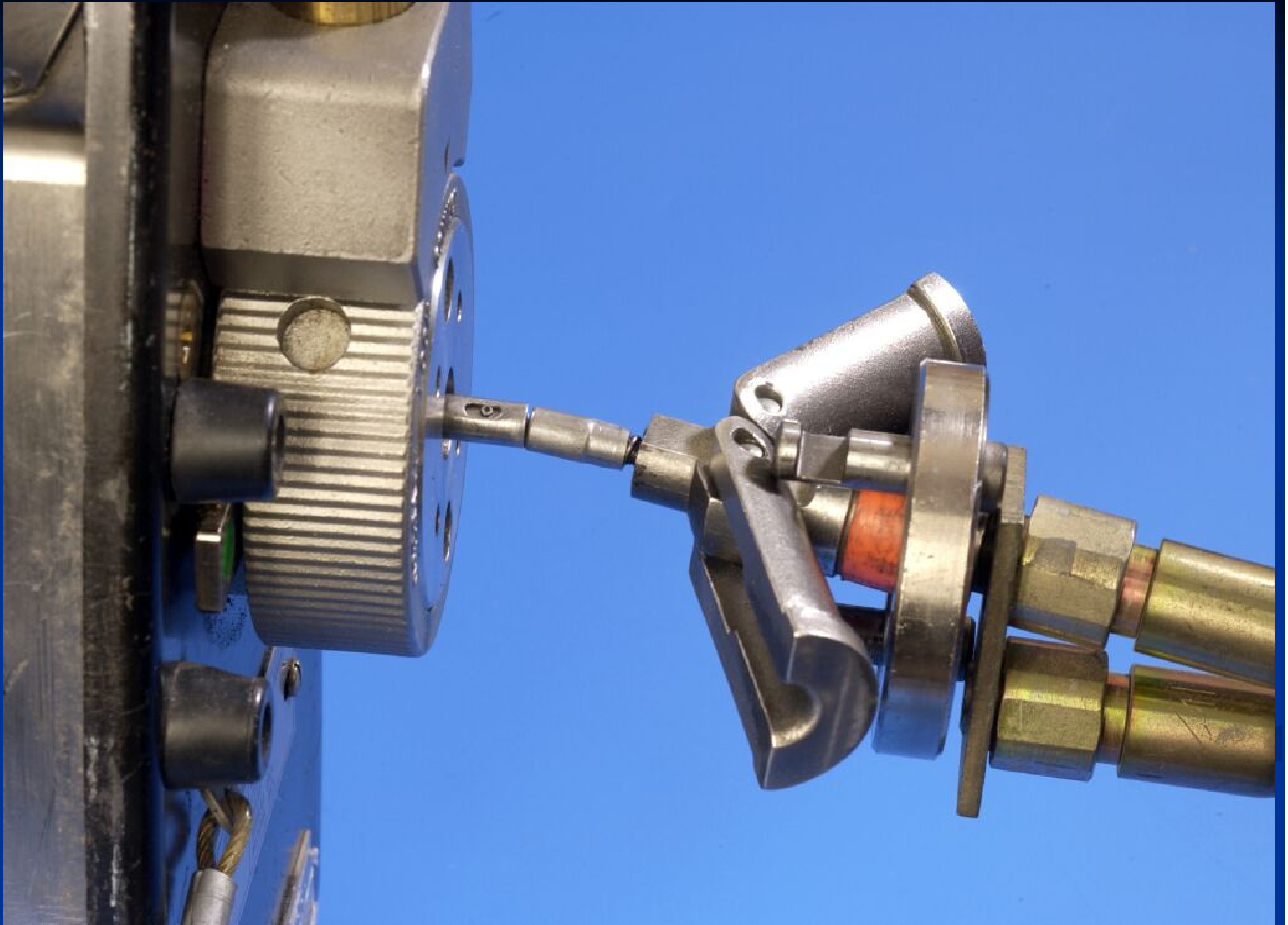
Misuse leading to radiation burns to the fingers

Projection type / remote exposure containers

Projection type / remote exposure containers

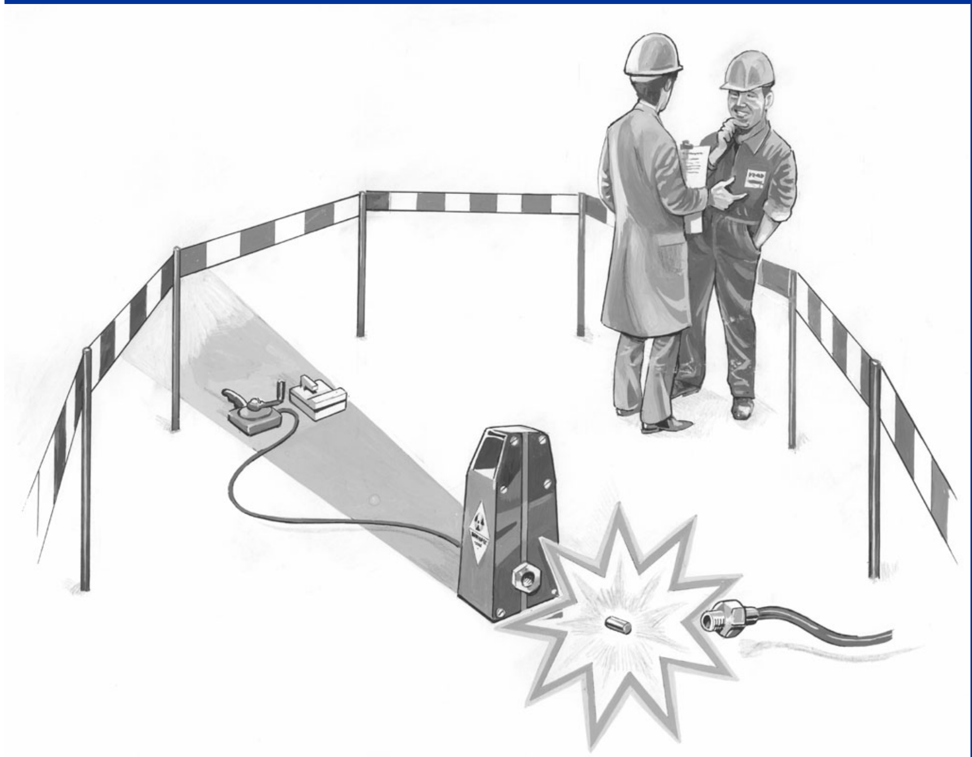
Source “pigtail”





Commonest direct cause of accidents

FAILURE TO ADEQUATELY MONITOR



Typical radiation injuries

Effective Control

Increased Risk of Loss of Control

Root Causes

- Lack of, or ineffective
  - Regulatory body
  - Regulations
  - Regulatory enforcement
  - Radiation protection services
  - Training of workers and management
  - Commitment by management to safety
  - RP programme in the organisation
  - Co-operation between employers

Morocco 1984

- 1.1 TBq Ir-192 industrial radiography source

- Disconnected from drive cable and fell out
- Picked up and taken home
- Out of control March - June
- 8 died
- Initially diagnosed as poisoning

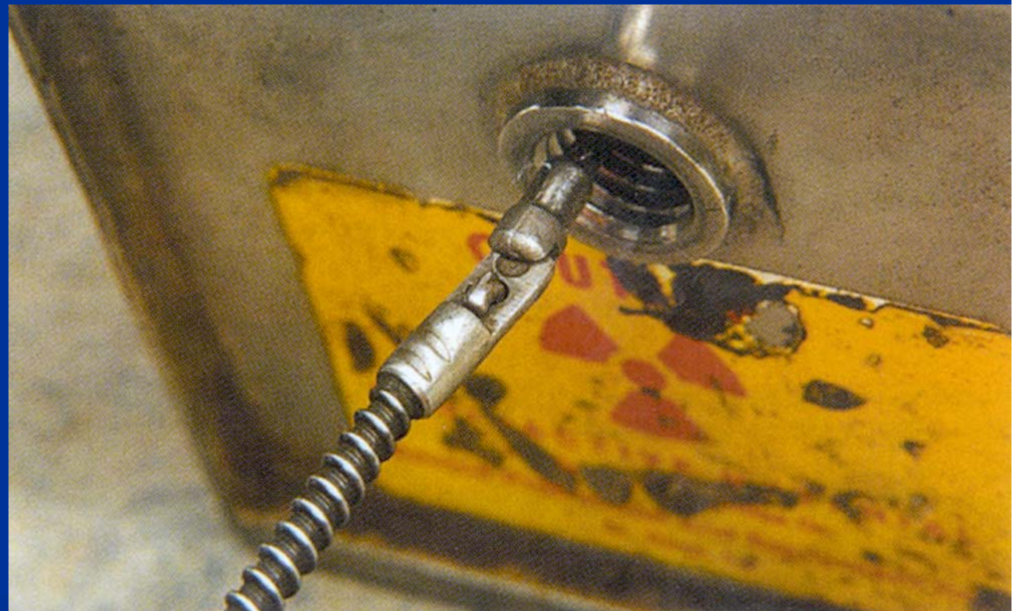
Cairo, Egypt 2000

1.85 TBq Ir-192 industrial radiography source

- Similar causes and scenario to Morocco accident
- Picked up by farmer
- Farmer and son died

Yanango, Peru 1999

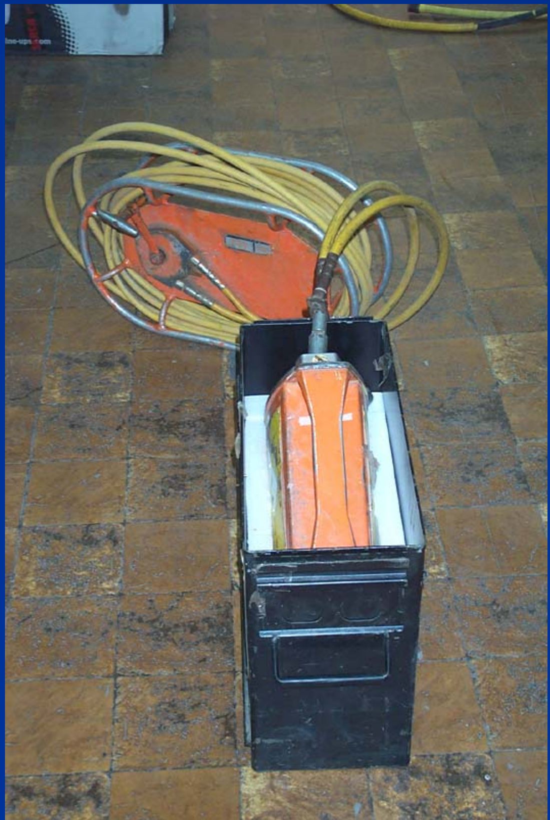
- 1.37 TBq Ir-192 : remote exposure container: source detached
- Picked up by welder and taken home
- Pain in right thigh: sought medical assistance
- Meanwhile wife sat on source in trousers
- Loss of source identified and its recovery within 24 hours
- Heroic medical treatment but lost one leg



Radiography accident in Cochabamba, Bolivia, 2002

- 670 GBq Iridium-192 source in remote exposure container
- Lone working in trench
- Failed to monitor after exposure
- Could not remove drive cable

Cochabamba: transport to La Paz



Cochabamba accident

- 55 passengers exposed for 8 h journey
- Source collected and recovered next day
- Delay in informing authorities
- Investigations by authorities and IAEA

Cochabamba: dose reconstruction

Passenger doses from reconstruction: 0.19 Gy

Worker doses from Chromosome Aberration Analysis: ~ 0.2 Gy

Learning the Lessons: Feedback mechanisms

- IAEA
  - Accident investigation reports
  - Safety series No. 7
  - RADEV → Regulatory Authority Information System (RAIS)
  - INES
- IRID, UK www.irid.org.uk
  - Fields to categorise and aid navigation
  - Descriptive field for use in training
- RELIR, France: www.relir.cepn.asso.fr
- European ALARA Network
  - Newsletters and website www.eu-alara.net
  - Workshops – Rome, October 2001
    - NDT ALARA Network

Guidance Documents

- IAEA
  - Safety Series 13 (1999): new one in preparation
- National Authorities
  - NRC: Industrial Radiography Toolkit

  www.nrc.gov/materials/miau/industrial-uses/rad-toolkit.html
  - HSE: Work with Ionising Radiations and ACOP

  www.hse.gov.uk/radiation/ionising/publications.htm

Roles: Regulators

Effective Regulatory Infrastructure

- Regulations adapted to national needs
- Appropriately resourced regulatory body (s)
- Appropriately trained regulators
- Enforcement programme
- Support of critical mass of RP infrastructure

Sets tone for compliance and safety culture

Qualified Experts

- Meets national qualification or certification criteria
- Often consultants not employee
- Management retain responsibility for compliance
- Major part of RP infrastructure
  - Range of clients, interface with regulators etc

Well placed to have positive influence on RP practices

Management

- Key responsibility
- Safety culture
  - Procedures, local rules, equipment, RP programmes
  - Risk assessments
  - Supervision, maintenance, reviews, investigations
- Training
- Co-operation with clients and others

Well managed operations are quickly apparent to regulators and crucial to RP compliance

Radiographers

- Appropriately trained
- Follow procedures
  - MONITOR AFTER EACH EXPOSURE
  - Personal alarm monitors: useful but an adjunct
- Ability to deal with problems on site
  - Recognition of problems
  - Pressure from clients and others
  - Emergency situations
- Report back issues to management

Responsibility to work safely

Clients

- Responsibility for those working on their sites
- Financial "muscle" and thus influence
- Co-ordination and co-operation of workforces
  - Permit to work schemes
  - Temporary source storage arrangements
- QEs can help clients "police" their sites
- Should feature in regulatory programme

Clients can be very influential on RP practices:

Use that influence

Emergency Preparedness

- Risk assessments
- Development of emergency plans
- Training to recognise an emergency and implement response
- Appropriate equipment
- Exercises and periodic reviews of plans
- Reporting and identification of lessons

Training

TRAINING,

INCLUDING REFRESHER TRAINING,

UNDERPINS

SAFETY IN INDUSTRIAL RADIOGRPHY

AND

THE PREVENTION OF ACCIDENTS

IAEA Training Materials for Industrial Radiography

- Radiation Protection in Industrial Radiography
  - RPO, operators and mangers
  - Lecture plan, lecture notes, module overview, practical exercises, PP presentations, other info
  - 1 to 2 weeks
- Training for Regulators on Authorisation and Inspection……
  - Regulatory inspectors
  - 3 Parts
    - I: Organisation and implementation of National regulatory program for control of radioactive sources: 1 week
    - II: Authorisation and Inspection…. : 1 week
    - III: On the job training : 6 to 8 weeks

Conclusion

- Industrial radiography still provides significant potential for accidents
- Accidents continue to happen
- Means to prevent accidents are well documented

Needs appropriate regulatory infrastructure

And

Commitment of those involved