γ-Prox

CLOSE PROXIMITY GAMMAGRAPHY

Christophe BERGERON – PCR – Lyon agency

16th European ALARA Network Workshop

Berne, 14-16 march 2016

INSTITUT de SOUDURE GROUPE

www.isgroupe.com

CE QUI NOUS LIE
NOUS REND PLUS FORTS

The base :

Ionizing radiation can be dangerous to humans, that is why it's important to be protected against it.

This is the purpose of radiation protection which is intended to protect the health of workers and public.

Three fundamentals principles :

- Justification
- Optimization
- Limitation

Justification principle :

No practice shall be adopted unless its introduction produces a positive net benefit.

Industrial radiography is a Non Destructive Testing (NDT) technology using ionizing radiation sources.

All exposures to ionizing radiation must be justified by the benefits reported on the risks of each NDT technology.

For example, it's better using ^{75}Se than ^{192}Ir

Optimization principle :

All exposures shall be kept As Low As Reasonably Achievable (ALARA), economic and social factors being taken into account.

For NDT controls, this is a complex processus, where several parameters could decrease workers exposure :

- **Reducing shot's number**
- **Reducing exposure time**
- **Increasing distance from the source**
- **Limiting radiation beam**
- **Reducing dose rate by using shields**
- **Improving work organization**

Limitation principle :

This principle requires that the dose to individuals from planned exposure situations, other than medical exposure of patients, should not exceed the appropriate limits.

French regulations limits are established for workers exposed to ionizing radiation :

	Workers		Non exposed workers
	A category	B category	Public
Rolling 12-month	20 mSv	6 mSv	1 mSv

In 2015, average dosimetry for Institut de Soudure's workers is 1.9 mSv over a rolling 12-month period : it was 4.0 mSv in 2004 !

Improve optimization :

Institut de Soudure designed an alternative solution for industrial radiography :

radiography with ^{192}Ir

γ-Prox with a ^{75}Se source

Energy and dose rate :

	^{192}Ir	^{75}Se
Radioactive half	74 days	120 days
Average photon energy	350 keV	220 keV
Specific constant for 1 TBq (27 Ci) at 1 m	135 mGy/h	54 mGy/h

At equal activity, radiation rate for a ^{75}Se source is divided by 2.5 compared to the ^{192}Ir

Advantage $^{75}Se/^{192}Ir$:

- Reduces environnement dose rate
- Reduces operator dose rate

^{192}Ir

250 µSv/h

Activity : 1 TBq

Dose rate at 2 cm (contact)

^{75}Se

20 µSv/h

Reduce scattered radiation by reducing the primary beam

Standard collimator + ^{192}Ir

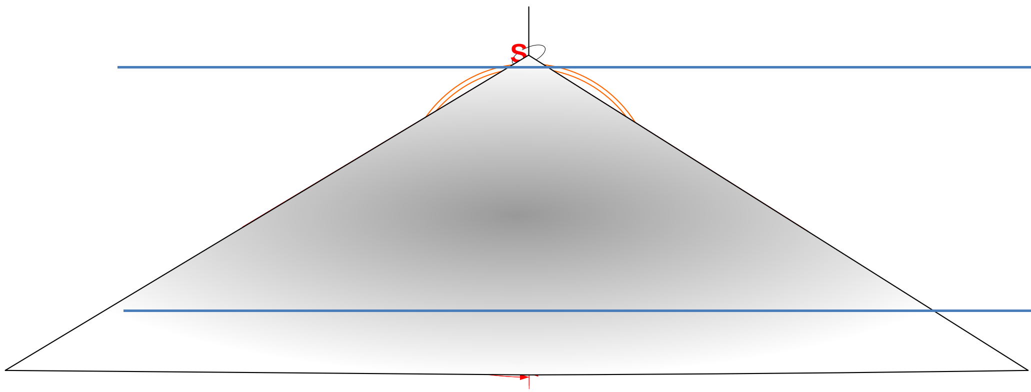
collimation angle : 60° x 120°

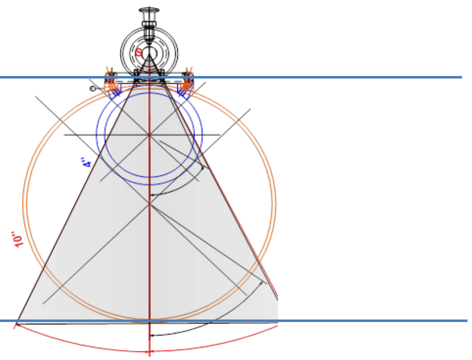
attenuation coefficient : 100

γ-Prox + ^{75}Se

collimation angle : 30° x 65°

attenuation coefficient : 1000

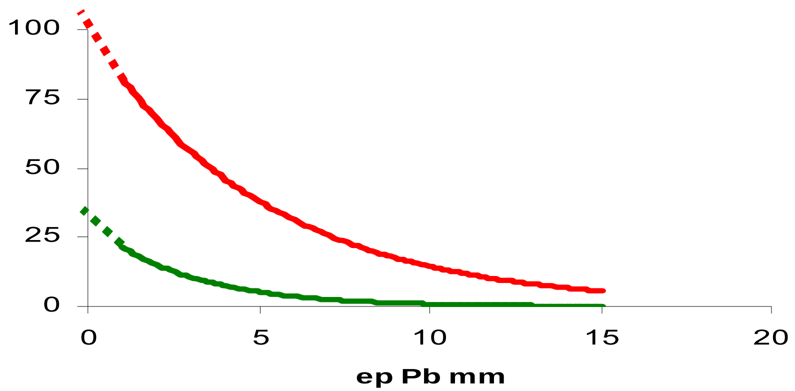




Radiation protection efficiency – shield attenuation

To reduce dose rate by two :

- 2 mm lead for ^{75}Se
- 4 mm lead for ^{192}Ir



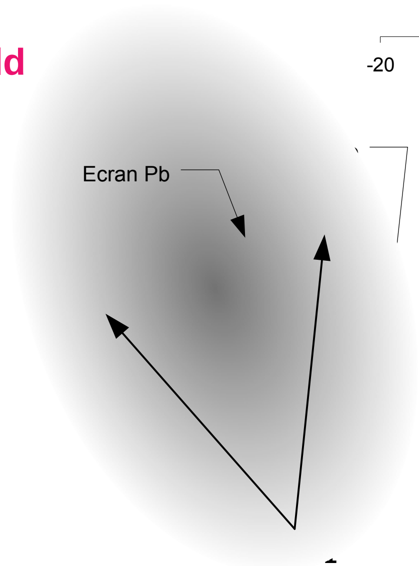
Lead thickness (mm)	Attenuation coefficient ^{192}Ir	Attenuation coefficient ^{75}Se
0	0	0
2	1.4	2
4	2	5,2
6	2.8	7
8	4	14,3
10	5.7	20,4

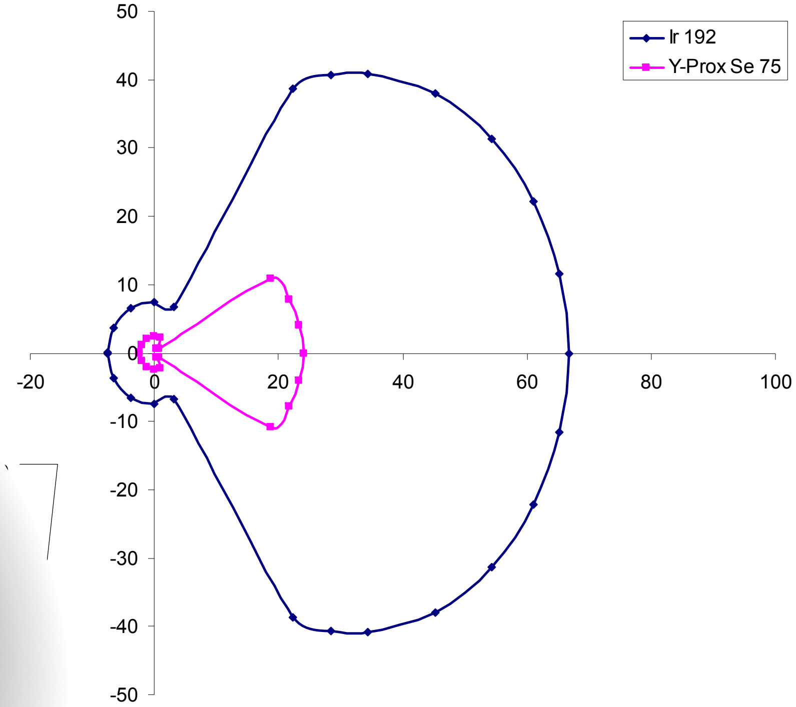
Isodose curve $^{75}Se/^{192}Ir$

- **Contact source technic**
  Pipe > 200 mm – 7.5 mm thickness x 2
  activity 1.4 Tbq (37 Ci)

Depleted uranium collimator + ^{192}Ir

γ-Prox + ^{75}Se + 2 mm lead shield



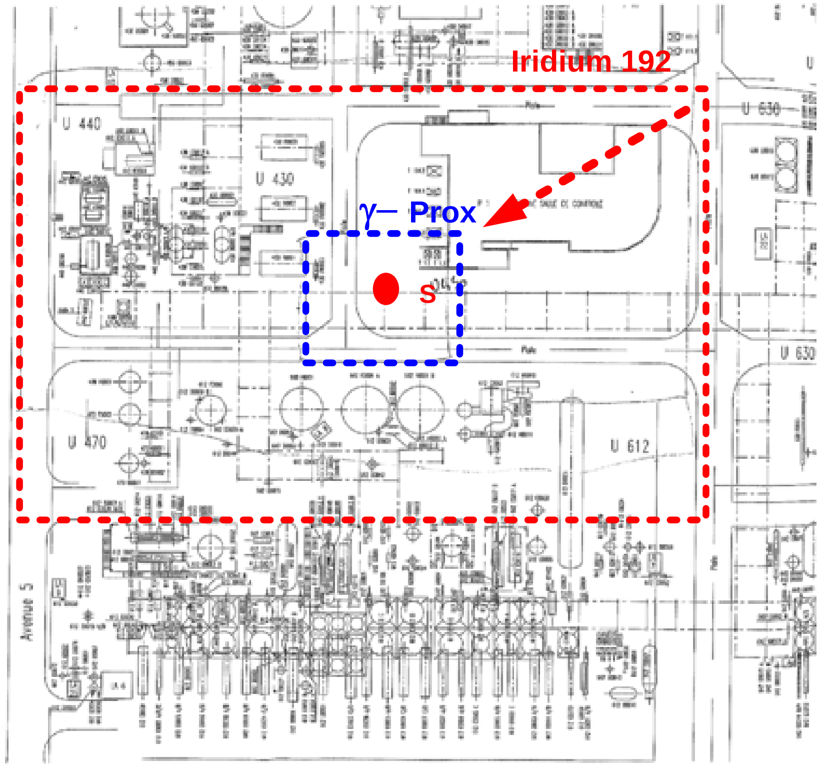


Reducing controlled area in relation to an ^{192}Ir source

- Safety distance reduced from 35 m to 10 m

- Reducing the safety barriers positionning time
- Reducing amount of lighting equipment (weight ...)

- More effective monitoring of the controlled area
- Improving working conditions by day work
- More visibility of safety barriers



Comparatif ^{192}Ir / γ-Prox + ^{75}Se for contact version 4” à 10”

^{192}Ir	γ-Prox + ^{75}Se
Safety distance about 35 meters Important controlled area surface Impossible day work Poor image quality for small thicknesses	Safety distance about 10 m Reduction of controlled area surface by 12 Controlled area easier to monitor Possible day work Best radiation spectrum quality allows to use faster film to reduce the exposure time Operator dosimetry divided by 5 to 10
Shorter exposure times (equal activity) Purchase cost source = 1	Greater exposure time x 2.5 for the same film Purchase cost = 1.8 Maximum thickness penetration < 30 mm (1.2 ″)

Conclusion

JUSTIFICATION :
Se

Co → Ir → Se

OPTIMISATION :
Special collimator

360° → 60° x 120° → 30° x 65°

LIMITATION :
γ-Prox

Environnemental doses

Personal doses