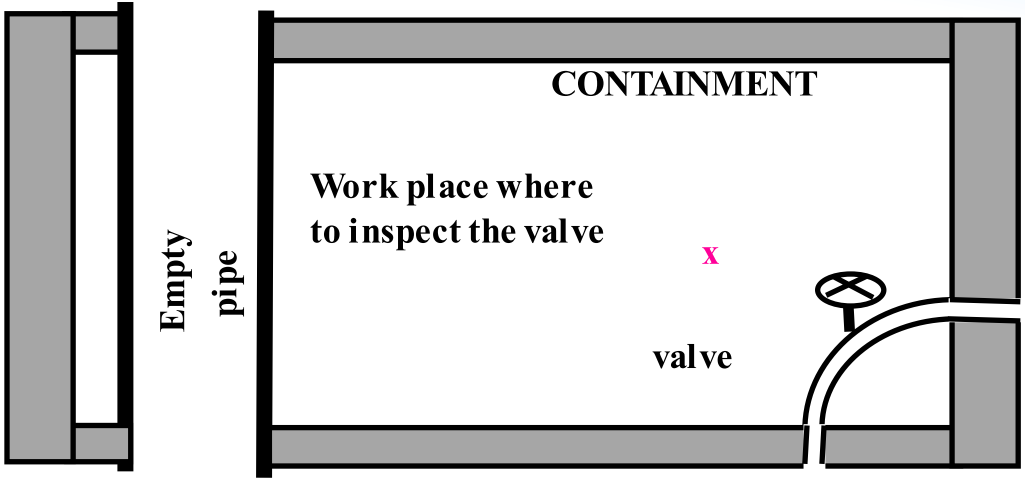
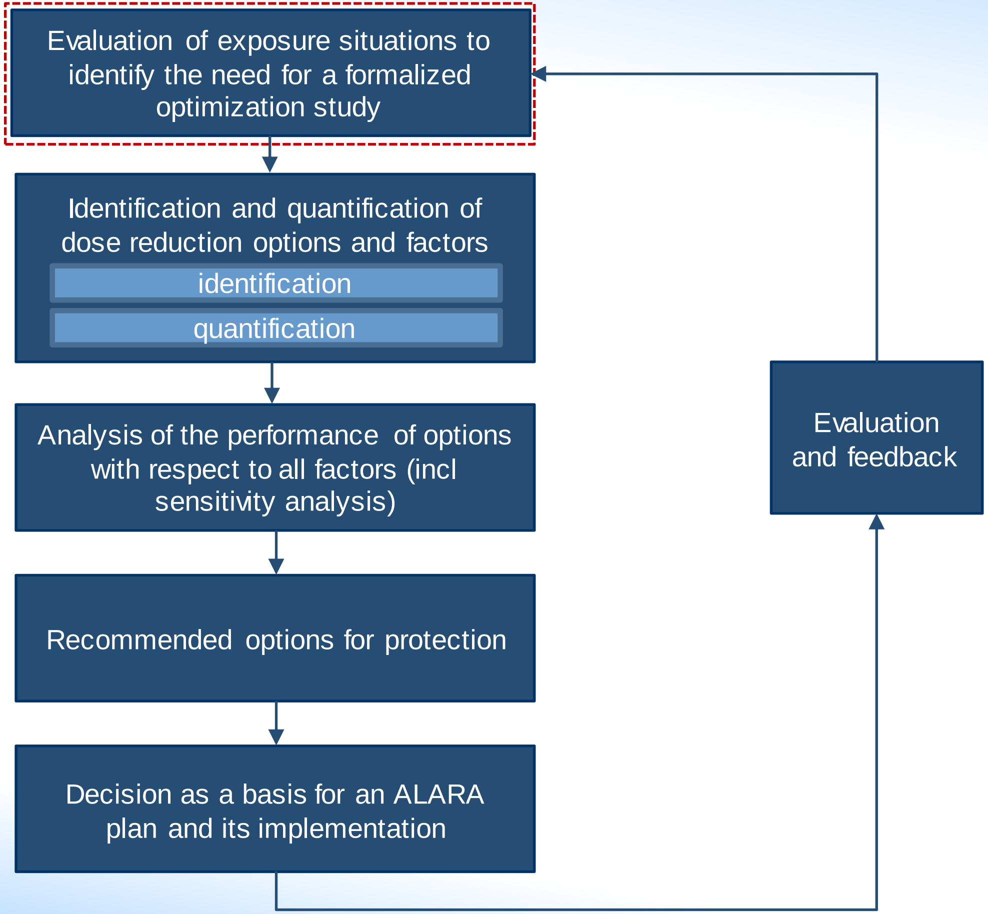
3.3 Implementation of the Optimization procedure: a theoretical case

An Example: an annual valve inspection



We will know follow the different steps of the optimization procedure:
What is the first step of that procedure?



What do you need to know in order to evaluate the stakes?

Having in mind that it is a theoretical example for pedagogical purposes

Evaluation of the exposure situation (1)

Feed-back data are available (≠ new job) through operational dosimetry (from previous years controls)

Most frequently available data are

Task collective dose: 2,5 man.mSv
Numbers of staff: 5 mechanics
Mean individual dose: 0,5 mSv

Fortunately the exposed workload is also available (not always the case)

Duration of exposure work: 5 hours
Ambient dose rate: 0,1 mSv/h

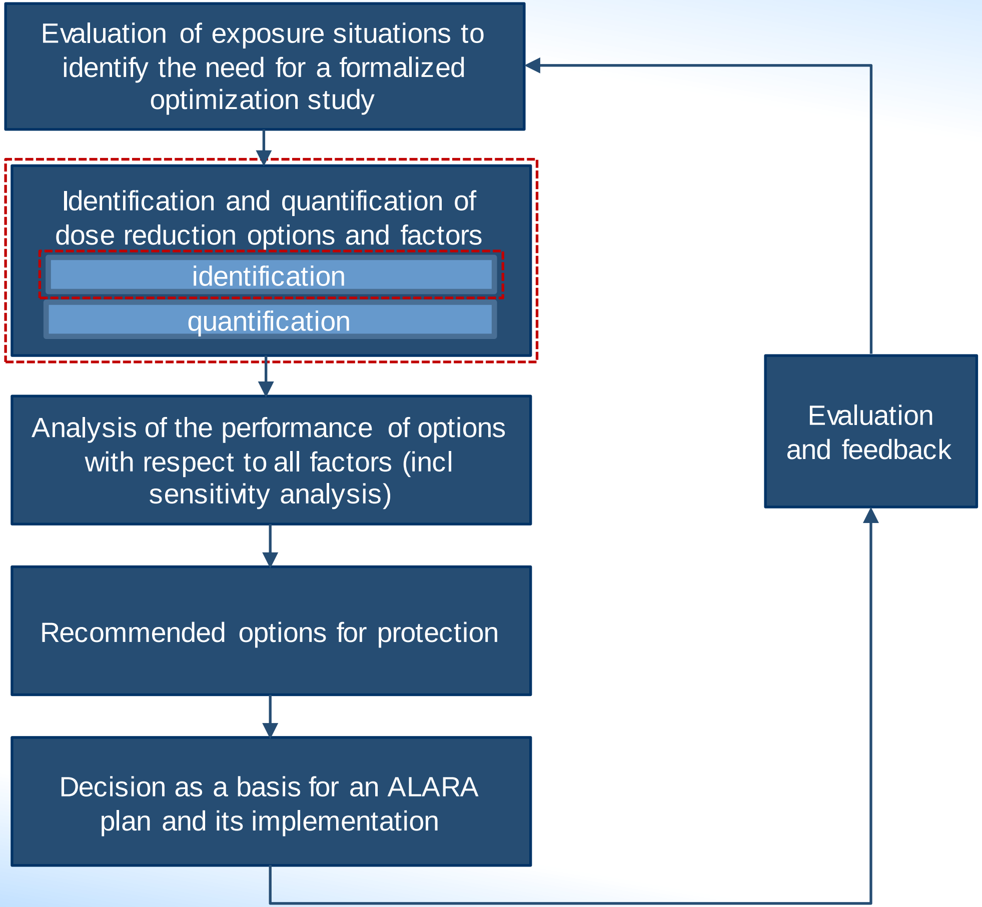
Stakes : the annual extrapolation for individual dose is around 100mSv it is very important and unacceptable ; a full team has to spend time for optimizing the situation; and you are that team !

Evaluation of the exposure situation (2)

Note that the **workload** is the exposed one (EWL: exposed workload) not the total workload

As well the ambiance dose rate is not a measured one or an average of measured ones; it is the “ **used average dose rate**” by the workers who are not staying at the same place during the whole task.

These two concepts are essential when predicting and assessing doses for a new task.



- What do you want to know before identifying protection options?
- What can you imagine as protection options?
- Let's have a real brain storming all together
- Without rejecting a priori any idea
- Do not think about criteria for rejection or selection right now

Identification of protection options

It is possible to act on:

- The dose rate?:
  - Identification/localisation of sources...
- The duration of work?
  - work procedures
  - working conditions
- The number of exposed individuals?:
  - work procedures…

Need of teamwork

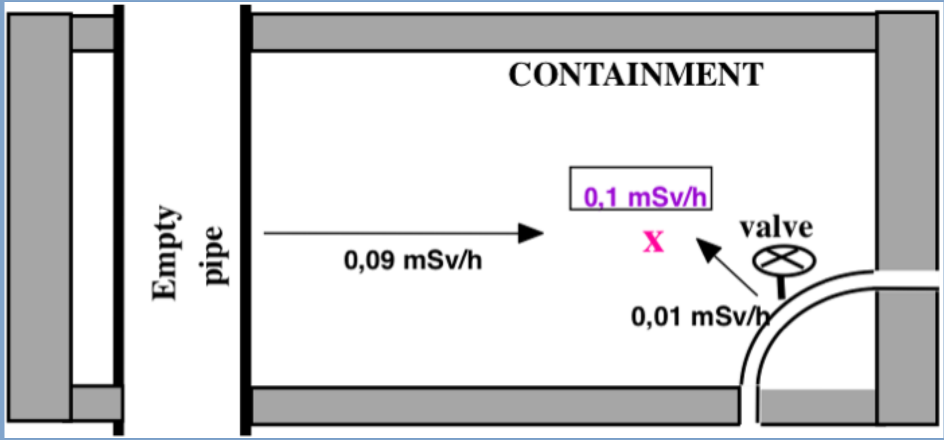
- (HP + other specialists; under the leadership of those in charge of the job)

Use of feedback data base, check-lists…

Identification of protection options (1)

To act on dose rates?

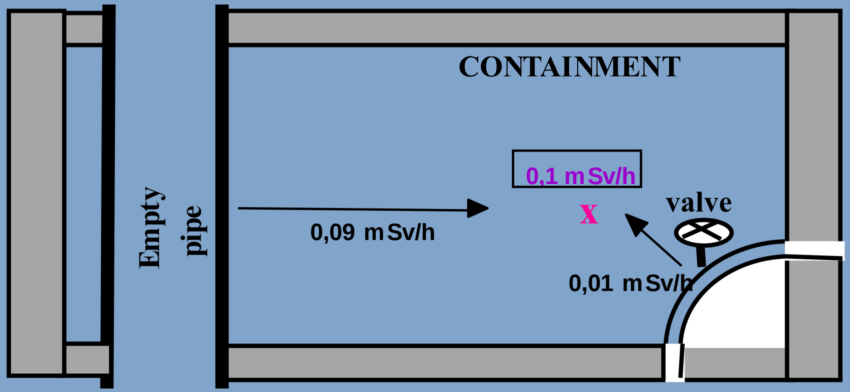
To identify sources



- **Possible actions:**
  - To keep pipe full with water
  - To install shielding
  - To decontaminate the pipe

Identification of protection options (2)

- **To act on dose rates?**
  - To identify sources



- **Possible actions:**
  - To keep pipe full with water
  - To install shielding
  - To decontaminate the pipe

Identification of protection options (3)

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To act on exposed workload?

- To identify mishaps and reworks (feed-back):
  - Lack of light
  - Not adapted totally manual tools

Possible actions:

- To install one halogen
- To modify tools

Identification of protection options (4)

- **To reduce the number of workers?**
  - analysis of work procedure

- **Possible actions:**
  - use of robots
  - 2 staff members should remain away from the containment (in a low dose area) during 2 hours

Having imagined all possible actions we have now to decide what would be the criteria upon which a decision will be made: what are they in your mind?

Identification of criteria

Efficiency

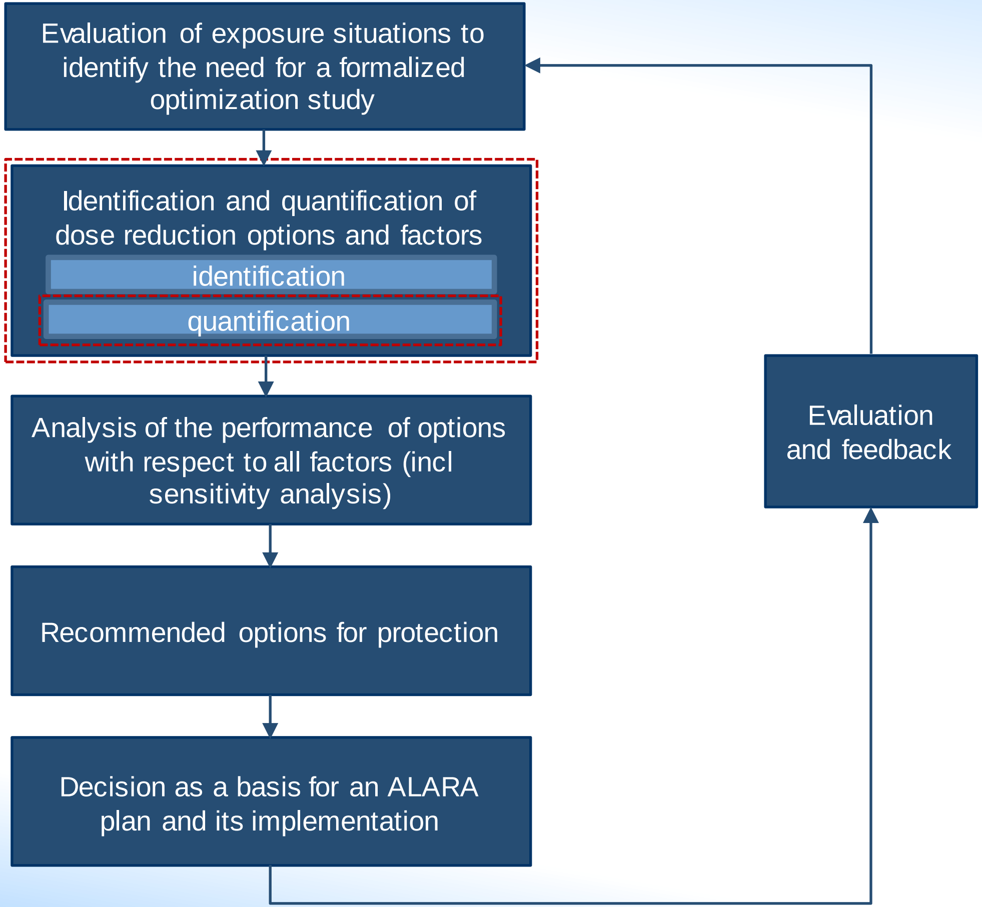
- Collective dose
- Individual doses
  - Individual doses distribution
  - Dose transfers between categories of workers

Feasibility

- Technical, planning, work organization

Costs

- Direct costs of the protection actions
- Operating costs avoided by implementing an action



The options to be assessed and the criteria are now known, each criterion may now be quantified (when possible) for each option.

Pipe full of water: the contribution of the big pipe decreases to 0,05 mSv/h

Install a shielding near big pipe: the contribution of the big pipe decreases to 0,06 mSv/h; 2 servicing people will install it.

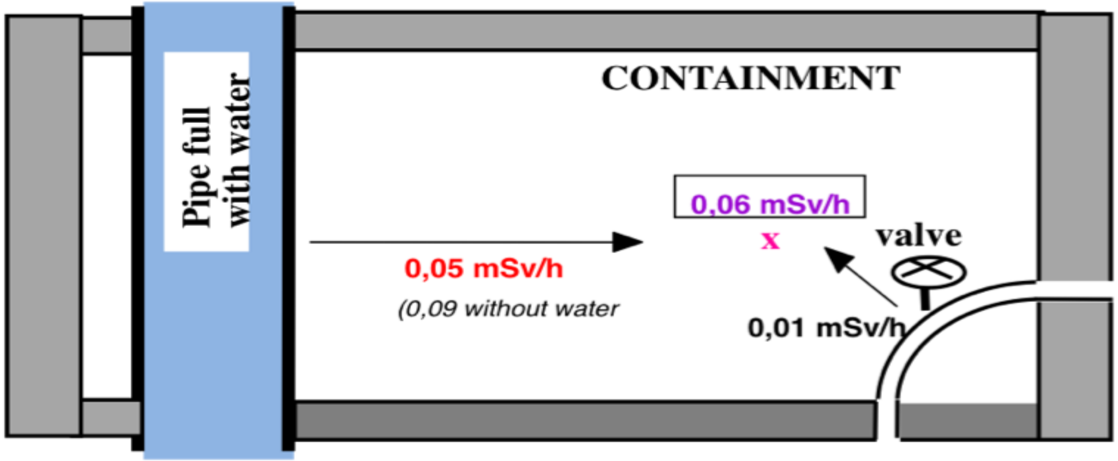
Calculate the efficiency of both actions

Quantification of criteria (1)
Feasibility

	Protection action	Feasibility
1	Water in pipe	Yes
2	To install shielding	Yes
3	To install halogen	Yes
4	Put to distance 2 mechanics	Yes
5	Purchase of a modified tool	Yes
6	Decontamination of the pipe	Yes
7	Developing a Robot	No

Quantification of criteria (2)
Cost and efficiency (A)

To keep the pipe full with water

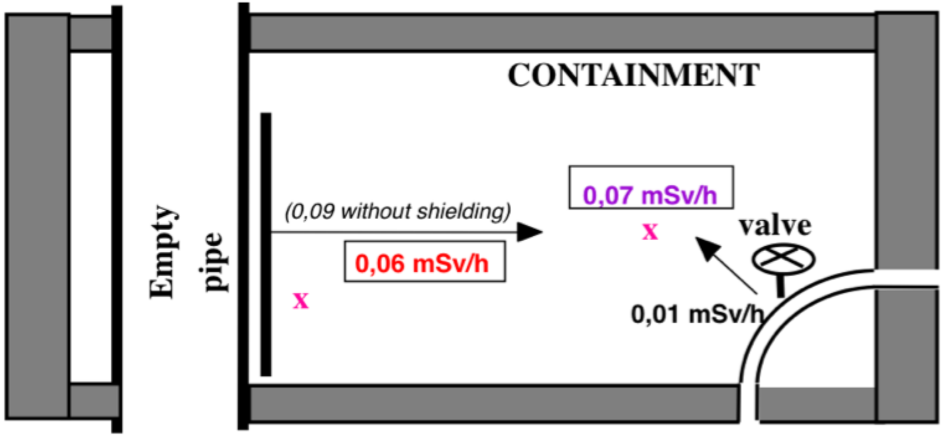


Individual dose: 0,06 mSv/h x 5 h = 0,3 mSv
Collective dose: 0,3 mSv x 5 = 1,5 man.mSv

No cost as it is possible just to change the task timing on the planning

Quantification of criteria (3)
Cost and efficiency (B)

To install the biological shielding



Quantification of criteria (4)

To install biological shielding - exposed workload

- To check the valve
  - 5 mechanics
  - 5 hours per mechanics

To install and withdraw the biological shielding

- 2 servicing staff
- 0.5 hour per individual
- The installation will cost nothing as the servicing people are already present and paid and ready to perform tasks at request.

Quantification of criteria (5)
Cost and efficiency

- **To install biological shielding - individual and collective doses**
  - To check the valve
    - 5 meca. x 5 hours x 0,07 mSv/h
      - 0,35 mSv/person;1,75 man.mSv
  - To install and withdraw biological shielding -
    - 2 serv. x 0,5 hours x 0,06 mSv/h
      - 0,03 mSv/person; 0,06 man. mSv
  - Total collective dose: 1,81 man.mSv

Quantification of criteria (6)

Install one halogen

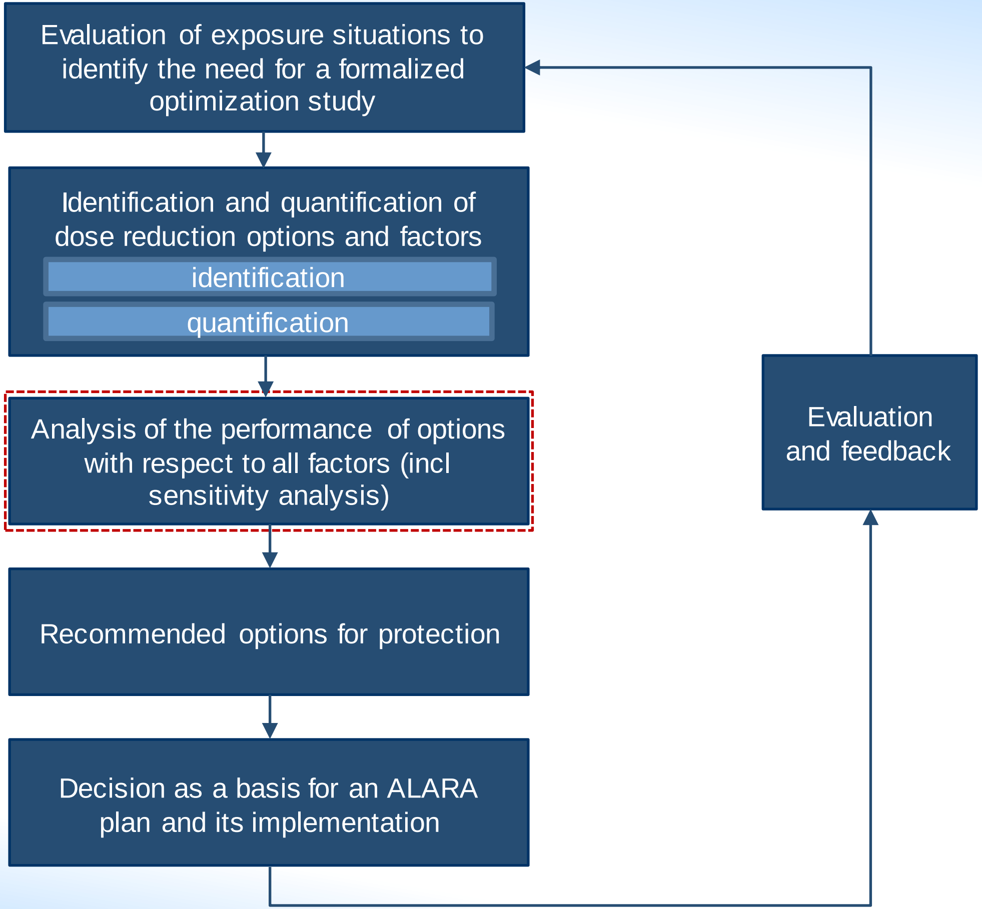
- Will allow reducing the exposed workload by 10% (1/2 hour) for each of the 5 mechanics.
- Individual and collective Dose :
  - 0,1 mSv/h x 4,5 hours = 0,45 mSv
  - 0,45 mSv x 5 mechanics= 2,25 man.mSv
- No cost as the halogen is available on site.

Go to green place: 2 mechanics during 2 hours :

- Individual and collective Dose :
  - 3 mechanics x 5 h x 0,1 mSv/h = 1,5 man.mSv
  - 2 mechanics x 3 x 0,1 mSv/h = 0,6 man.mSv
  - Total collective dose: 2,1 man.mSv
- No cost : just better work organisation

Quantification of criteria (7)
Cost and efficiency

- **New tools**
  - They allow to reduce the number of mechanics from 5 to 3. The collective dose will therefore be 3/5 of the initial one.
  - 3 mechanics x 0,5 mSv = 1,5 man.mSv.
  - That option has a direct cost : write off of the material and indirect savings through the reduction of number of mechanics
  - The balance is 250 € for one operation.
- **Decontamination**
  - it allows to reduce the ambient dose rate by 70%. The collective dose will therefore be 30% of the initial one.
  - (0,07 x 0,1) mSv/h x 5 h x 5 mechanics. = 0,75 man.mSv
  - The balance of all costs (material amortization, chemical products, workload, and waste management); is 550 € for one operation



What do you suggest for starting the analysis ?

Analysis : cost and efficiency per intervention

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To rank all options by increasing cost and check the complementarities of all no cost options.
Are they complementary here?

Action	Ambient dose rate	Exposed work load	Nb of workers	Mean ind. dose (mSv)	Total coll. dose (Man.mSv)	Cost (€)
INITIAL SITUATION	**0,1 mSv/h**	**5 hours**	**5 mecha.**	**0,5**	**2,5**	
1. Water	**0,06 mSv/h** (- 40 %)	5 hours	5 mecha.	**0,3**	**1,5**	**nil**
2. Shielding	**0,07 mSv/h** (- 30 %) **0,06 mSv/h**	5 hours **0,5 hour**	5 mecha. **2 servicing**	**0,35** **0,03**	**1,81**	**≈ nil**
3. Light	0,1 mSv/h	**4,5 hours** (- 10 %)	5 mecha.	**0,45**	**2,25**	**nil**
4. Go to "green place"	0,1 mSv/h 0,1 mSv/h	5 hours **3 hours**	**3 mecha.** **2 mecha.**	**0,5** **0,3**	**2,1**	**≈ nil**
5. Tool	0,1 mSv/h	5 hours	**3 mecha.**	**0,5**	**1,5**	**250**
6. Deconta.	**0,03 mSv/h** (- 70 %)	5 hours	5 mecha.	**0,15**	**0,75**	**550**

Analysis : cost and efficiency

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If the no cost options are complementary and allow together to reduce doses higher than each taken separately, they should be mandatorily selected and implemented if there is no other reason not to select them.

In our case the four options are complementary in reducing the dose to the mechanics and they may be implemented together.

However one is introducing new workers, the installation of a shielding needs 2 servicing staff who belong to an highly exposed group. Therefore more discussion will take place for that option but the 3 others (water, light and put at distance) should be implemented they are as for sure reasonable and the new reference situation will include them before to check what is reasonable for the others.

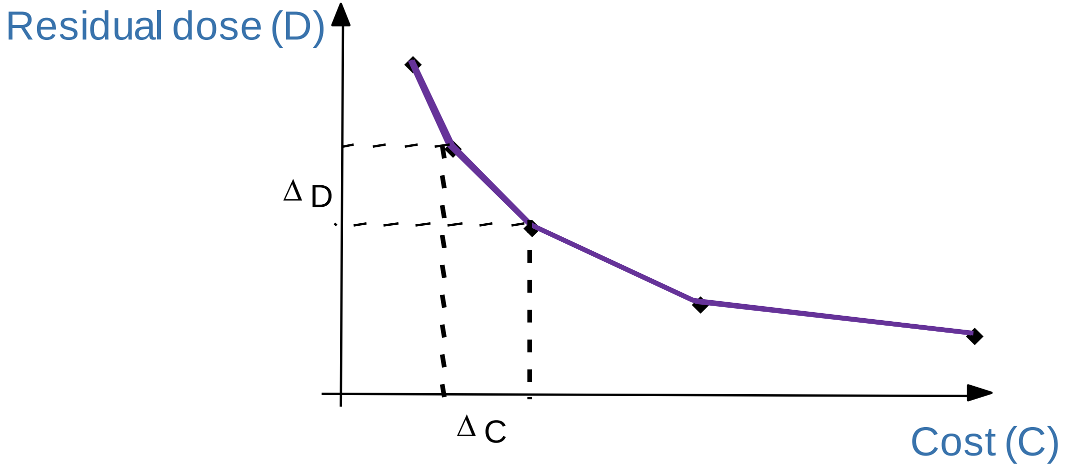
The case of no cost option being solved, it is now necessary to envisage all combinations of the remaining options with the new reference.

Analysis: where to stop? What is reasonable?

Action	Ambient dose rate	Exposure time	No. of workers	Average individual dose (mSv)	Total collective dose (man.mSv)	Cost (€)
Initial situation	*0.1 mSv/h*	*5 hours*	*5 mechanics*	*0.5 mSv*	*2.5*	
Reference (water + light + distancing)	0.06 mSv/h 0.06 mSv/h	4.5 hours 2.5 hours	3 mechanics 2 mechanics	0.27 mSv 0.15 mSv	1.11	almost nil
Reference + biological shielding	0.04 mSv/h 0.04 mSv/h 0.03 mSv/h	4.5 hours 2.5 hours 0.5 hours	3 mechanics 2 mechanics 2 servicing staff	0.18 mSv 0.1mSv 0.015 mSv	0.77	almost nil
Reference + tools	0.06 mSv/h	4.5 hours	3 mechanics	0.27 mSv	0.81	250
Reference + tools + biological shielding	0.04 mSv/h - 0.03 mSv/h	4.5 hours - 0.5 hours	3 mechanics - 2 servicing staff	0.18 mSv - 0.015 mSv	0.57	250
Reference + decontamination	0.02 mSv/h 0.02 mSv/h -	4.5 hours 2.5 hours -	3 mechanics 2 mechanics -	0.09 mSv 0.05 mSv -	0.37	550
Reference + tools + decontamination	0.02 mSv/h - -	4.5 hours - -	3 mechanics - -	0.09 mSv - -	0.27	800

Not all combinations of options have been envisaged ; when decontamination was implemented , it allowed to reduce the same dose rate than shielding without putting more exposure on high exposed individuals , ie providing better equity; therefore we have not selected both together

Analysis: where to stop? What is reasonable? (1)
The differential cost benefit analysis

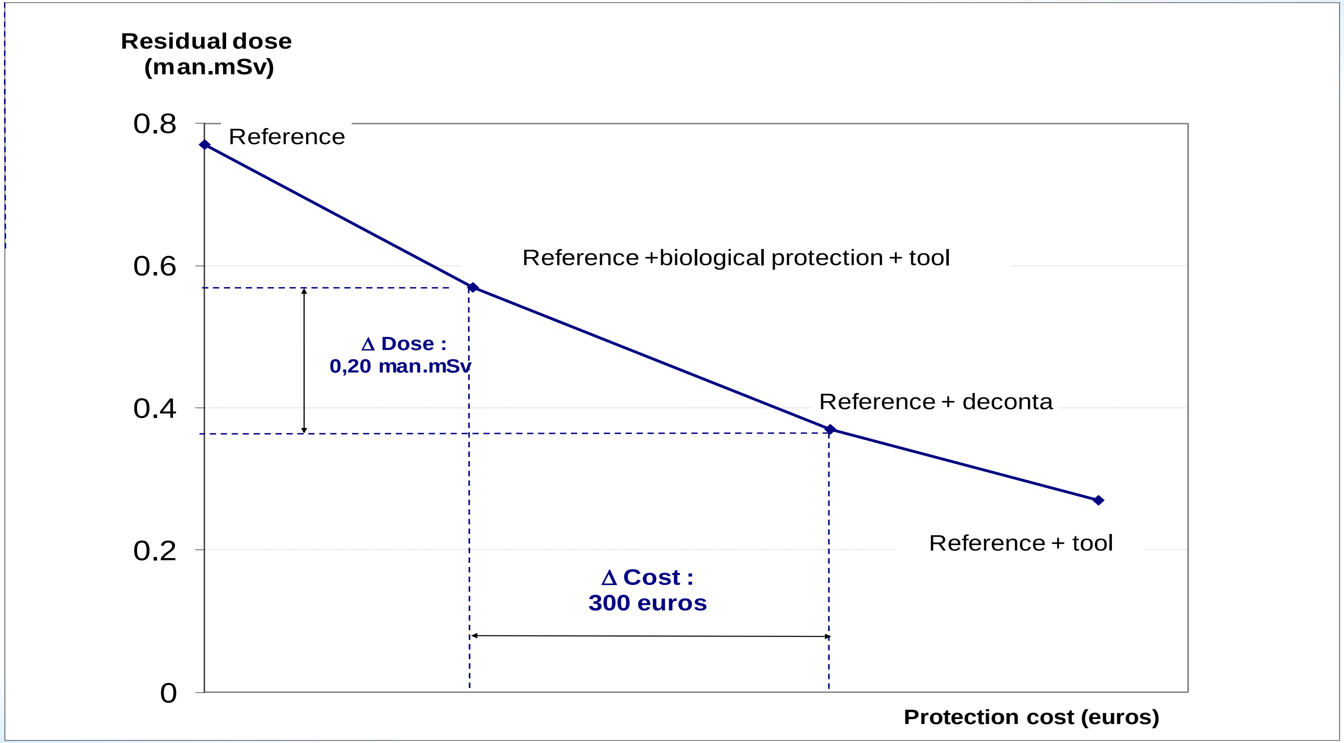


- **DC / DD** : implicit cost of an avoided dose unit
- α : reference monetary value of a dose unit
  => "what is agreed to be paid in order to avoid one dose unit "
- **Optimum** : **DC** / **DD** ≤ α

Analysis: where to stop? What is reasonable? (2)

Action	Cost	Δ Cost extra cost	Collective dose	Δ Dose avoided dose	Δ Cost/Δ Dose
Initial situation			2.5 man.mSv		
Reference (water + light + distancing)	Almost nil	-	1.11 man.Sv	1.39 man.mSv	-
Reference + biological shielding	**Almost nil**	-	0.77 man.mSv	0.34 man.mSv	-
Reference + tools + biological shielding	250 €	250 €	0.57 man.mSv	0.20 man.mSv	1250 €/ man.mSv
Reference + decontamination	550 €	300 €	0.37 man.mSv	0.20 man.mSv	1500 €/ man.mSv
Reference + tools + decontamination	800 €	250 €	0.27 man.mSv	0.10 man.mSv	2500 €/ man.mSv

Analysis: where to stop? What is reasonable? (3)



Analysis: where to stop? What is reasonable? (4) Existence of a reference value

- Reference monetary value of the man-sievert: 1800 €/man.mSv
- The protection actions «reference +biological shielding + tools» and «reference + decontamination» lead to implicit costs of the avoided man-Sievert lower or equal to the reference value, therefore they are acceptable
- The optimal action is the acceptable action providing with the largest collective dose decrease. Here it is reference + decontamination.

Existence of a reference value

Who decides such a reference value ?

- Generally the management

Where does it exists?

- in most facilities in the nuclear field

Is there a method to assess it ?

- ICRP proposed a method to assess it; it will be presented later on

Is there a single value in a country?

- Not at all there can exist several with at least a factor ten or more

Is it often used?

- Not so often; mainly for important decision

What happens when a facility has no reference value?

- Let’s discuss together

The alpha value

A recent international review of the used alpha value is to be found in:

« The values and the uses of the reference monetary value of the man.Sievert. Results of an International Survey », Radiation Protection, SFRP, Volume 55, Number 3, July-September 2020, pp.207 – 214.