# BTS ENVIRONNEMENT NUCLÉAIRE

**E4** MODÉLISATION ET CHOIX TECHNIQUES EN

ENVIRONNEMENT NUCLÉAIRE

**U4.1** Pré-étude et modélisation

SESSION 2020

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###### Durée : 4 heures

Coefficient : 3

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**CORRIGÉ**

|  |  |  |  |  |  |  |  |  |  |  |  |
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|  | **A/** | **Intervention sur robinet 1 RRA 013 VP** |   |  |  |  |  |  |  |  |  |
|  |  | **1/** | **Étude dosimétrique prévisionnelle** |   |  |  |  |  |  |  |  |  |
|  |  |  | **1/** |  | EDP corps entier |  |  |  |  |  | A | B | C |
|  |  |  |  |  | Presta | Presta | Opération | Nb. intervenants | Durée en h | Position | H° en µSv·h-1 | Cexpo | Eindividuelle |
|  |  |  |  |  | en µSv |
|  |  |  |  |  | Robinetterie (les 3 intervenants sont dénommés A, B et C) | 10 | Démontage partie haute | A, B et C | 0,75 | PT1 | 140 | 0,7 | 74 | 74 | 74 |
|  |  |  |  |  | 20 | Démontage partie basse | A | 1 | PT3 | 12 | 0,7 | 8 | 336 | 336 |
|  |  |  |  |  | (Ouverture circuit) | B et C | PT1 | 480 | 0,7 |
|  |  |  |  |  | 30 | Décontamination | A | 0,5 | PT3 | 12 | 0,7 | 4 | 168 | 168 |
|  |  |  |  |  | B et C | PT2 | 480 | 0,7 |
|  |  |  |  |  | 40 | Expertise obturateur | A | 1 | PT3 | 12 | 0,7 | 8 | 168 | 168 |
|  |  |  |  |  | B et C | PT2 | 240 | 0,7 |
|  |  |  |  |  | 50 | Remontage partie basse | A | 1 | PT3 | 12 | 0,7 | 8 | 168 | 168 |
|  |  |  |  |  | (Fermeture circuit) | B et C | PT1 | 240 | 0,7 |
|  |  |  |  |  | 60 | Remontage partie haute | A | 1,25 | PT3 | 12 | 0,7 | 11 | 61 | 61 |
|  |  |  |  |  | B et C | PT1 | 70 | 0,7 |
|  |  |  |  |  | 70 | Requalification intrinsèque | A | 0,75 | PT3 | 12 | 0,7 | 6 | 37 | 37 |
|  |  |  |  |  | B et C | PT1 | 70 | 0,7 |
|  |  |  |  |  |  |  |  | Eindividuelle totale par intervenant en µSv | 120 | 1 012 | 1 012 |

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|  |  |  |  |  | E = | H°.t.WT.Cexpo |  |  |  |  |  |  |  |  |
|  |  |  |  |  | WT = | 1 | car corps entier |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **2/** |  | Très forte exposition des intervenants B et C alors que l'intervenant A est comparativement très peu exposé |  |  |
|  |  |  |  |  | Il convient de mieux répartir les doses entre les intervenants |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | S = | 2 143 | H.µSv |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | meilleur répartition par individu si chacun est exposé à environ | 714 | µSv |  |  |  |  |  |  |  |  |  |  |

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|  |  |  | **3/** |  | EDP optimisée : par exemple |  |  |  |  |  | A | B | C |
|  |  |  |  |  | Presta | Presta | Opération | Nb. intervenants | Durée en h | Position | H° en µSv·h-1 | Cexpo | Eindividuelle |
|  |  |  |  |  | en µSv |
|  |  |  |  |  | Robinetterie (les 3 intervenants sont dénommés A, B et C) | 10 | Démontage partie haute | A, B et C | 0,75 | PT1 | 140 | 0,7 | 74 | 74 | 74 |
|  |  |  |  |  | 20 | Démontage partie basse | A | 1 | PT3 | 12 | 0,7 | 8 | 336 | 336 |
|  |  |  |  |  | (Ouverture circuit) | B et C | PT1 | 480 | 0,7 |
|  |  |  |  |  | 30 | Décontamination | B | 0,5 | PT3 | 12 | 0,7 | 168 | 4 | 168 |
|  |  |  |  |  | A et C | PT2 | 480 | 0,7 |
|  |  |  |  |  | 40 | Expertise obturateur | C | 1 | PT3 | 12 | 0,7 | 168 | 168 | 8 |
|  |  |  |  |  | A et B | PT2 | 240 | 0,7 |
|  |  |  |  |  | 50 | Remontage partie basse | B | 1 | PT3 | 12 | 0,7 | 168 | 8 | 168 |
|  |  |  |  |  | (Fermeture circuit) | A et C | PT1 | 240 | 0,7 |
|  |  |  |  |  | 60 | Remontage partie haute | C | 1,25 | PT3 | 12 | 0,7 | 61 | 61 | 11 |
|  |  |  |  |  | A et B | PT1 | 70 | 0,7 |
|  |  |  |  |  | 70 | Requalification intrinsèque | C | 0,75 | PT3 | 12 | 0,7 | 37 | 37 | 6 |
|  |  |  |  |  | A et B | PT1 | 70 | 0,7 |
|  |  |  |  |  |  |  |  | Eindividuelle totale par intervenant en µSv | 684 | 688 | 771 |

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|  |  |  |  |  | Disparité minime entre les dosimétries des différents intervenants |  |  |  |  |  |  |
|  |  |  |  |  | Dose collective S inchangée |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **4/** |  |  |   | Eindiv en µSv | Dose collective S en H.µSv |  |  |  |  |  |  |
|  |  |  |  |  |   |   | EDP initiale | EDP optimisée |  |  |  |  |  |  |
|  |  |  |  |  | Robinetterie | A | 120 | 684 | 2 143 |  |  |  |  |  |  |
|  |  |  |  |  | B | 1 012 | 688 |  |  |  |  |  |  |
|  |  |  |  |  | C | 1 012 | 771 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | L'opération reste très dosante et ce type d'exposition ne peut être envisagé qu'une fois par mois |  |  |  |  |
|  |  |  |  |  | Le reste du temps, les intervenants doivent être affectés à des travaux très peu dosants |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | **2/** | **Expertise de l'obturateur** |   |  |  |  |  |  |  |  |  |
|  |  |  | **1/** |  | v = | 5 900 | m/s |  |  |  |  |  |  |  |  |
|  |  |  |  |  | t = | 4,80 | µs |  |  |  |  |  |  |  |  |
|  |  |  |  |  | e = | 14,16 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **2/** |  | D = | 10 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | f = | 4,00 | MHz |  |  |  |  |  |  |  |  |
|  |  |  |  |  | N = | 16,9 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | N > e |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | La condition est réalisée. |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **3/** |  | x = | 2,95.t | avec t en µs et x en mm |  |  |  |  |  |  |  |
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|  |  |  | **4/** |  | t = | 1,60 | µs |  |  |  |  |  |  |  |  |
|  |  |  |  |  | x = | 4,72 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **5/** |  |  | L'écho correspondant au défaut sera masqué par celui qui correspond à l'axe |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | Le défaut sera vu en plaçant la sonde sur la face inférieure  |  |  |  |  |  |  |

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|  |  | **3/** | **Requalification intrinsèque** |   |  |  |  |  |  |  |  |  |
|  |  |  | **1/** | **1/** | k = | 33,1 | daN/mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 331 000 | N/m |  |  |  |  |  |  |  |  |
|  |  |  |  |  | hMax = | 84,0 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | F = | 2 780 | daN |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | **2/** | p = | 4,0 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  = | 90% |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | C = | 19,7 | N.m |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | **3/** | DV = | 350 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | FM = | 56 | N |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 5,6 | daN |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Effort très faible |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **2/** |  | n = | 21,0 | tr |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **3/** |  | préseau = | 6 | bar |  |  |  |  |  |  |  |  |
|  |  |  |  |  | DP = | 280 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | SP = | 0,062 | m2 |  |  |  |  |  |  |  |  |
|  |  |  |  |  | pMax = | 451 545 | Pa |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 4,5 | bar |  |  |  |  |  |  |  |  |

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|  |  |  | **4/** | **1/** | W = | 1 168 | J |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | **2/** | QV = | 105 | L/min |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 0,00175 | m3/s |  |  |  |  |  |  |  |  |
|  |  |  |  |  | P = | 790 | W |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | **3/** | t = | 1,5 | s |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | **B/** | **Interventions sur les échangeurs RRA / RRI** |  |  |  |  |  |  |  |  |
|  |  | **1/** | **Décontamination chimique en TEV** |   |  |  |  |  |  |  |  |  |
|  |  |  | **1/** |  | QTEV = | 950 | NL/min |  |  |  |  |  |  |  |  |
|  |  |  |  |  | V = | 6,0 | L |  |  |  |  |  |  |  |  |
|  |  |  |  |  | p1 =  | 300 | bar |  |  |  |  |  |  |  |  |
|  |  |  |  |  | p2 =  | 220 | bar |  |  |  |  |  |  |  |  |
|  |  |  |  |  | V' = | 3 120 | NL |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **2/** |  | t = | 3,3 | min |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 3 min 17 s |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **3/** |  | QHV = | 300 | NL/min |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Q2 TEV + HV = | 2 200 | NL/min |  |  |  |  |  |  |  |  |
|  |  |  |  |  | t = | 1,4 | min |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 1 min 25 s |  |  |  |  |  |  |  |  |  |

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|  |  | **2/** | **Incidence dosimétrique** |   |  |  |  |  |  |  |  |  |
|  |  |  | **1/** |  | t = | 2 000 | h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | AV = | 1 | LDCA |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Eint = | 20 | mSv |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | t = | 1 | min |  |  |  |  |  |  |  |  |
|  |  |  |  |  | AV = | 10 | LDCA |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Eint = | 1,7 | µSv |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Le raisonnement est correct |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **2/** |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Les énergies des  correspondent à un spectre de raies |  |  |  |  |  |  |  |
|  |  |  |  |  | Ces raies sont caractéristiques d'un radioélément donné |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **3/** |  | A = | 3,4 | MBq |  |  |  |  |  |  |  |  |
|  |  |  |  |  | t = | 2 | h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | H°réf = | 0,22 | µSv/h.Bq |  |  |  |  |  |  |  |  |
|  |  |  |  |  | H° = | 748 | mSv/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Hpeau = | 1 496 | mSv |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **4/** |  | La dose peau prise en 1 fois est de 3 fois la limite annuelle acceptable |  |  |  |  |  |  |
|  |  |  |  |  | C'est un ESR (événement significatif radioprotection) qui sera quantifié sur l'échelle INES |  |  |  |  |
|  |  |  |  |  | Obligation légale de communiquer à l'ASN |  |  |  |  |  |  |  |  |

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|  |  | **3/** | **Analyse de l’incident par le PCRP** |   |  |  |  |  |  |  |  |  |
|  |  |  | **1/** |  | A = | 3,4 | MBq |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Emax = | 318 | keV |  |  |  |  |  |  |  |  |
|  |  |  |  |  | I = | 100% |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  = | 1,29E-03 | g/cm3 |  |  |  |  |  |  |  |  |
|  |  |  |  |  | n = | 1,37 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | R = | 66 | cm |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **2/** |  | D° à 10 cm = | 3,1 | mGy/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | WR  = | 1 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | H° à 10 cm = | 3,1 | mSv/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **3/** |  | E1 = | 1 173 | keV | I1 = | 100% |  |  |  |  |  |  |
|  |  |  |  |  | E2 = | 1 333 | keV | I2 = | 100% |  |  |  |  |  |  |
|  |  |  |  |  | D°1 à 1 m = | 0,52 | µGy/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | D°2 à 1 m = | 0,59 | µGy/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | D° total 1 m = | 1,1 | µGy/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | WR  = | 1 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | H° à 1 m = | 1,1 | µSv/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | H° à 10 cm = | 111 | µSv/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **4/** |  | H°+  à 10 cm = | 3,2 | mSv/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | H°+  à 1 m = | 1,1 | µSv/h | les  n'atteignent pas 1 m |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **5/** |  | A 1 m, rien n'est détectable (ambiance = 50 µSv/h) |  |  |  |  |  |  |  |
|  |  |  |  |  | A 10 cm, la contamination est facilement détectable (contaminamètre ou radiamètre) |  |  |  |  |  |
|  |  |  |  |  | La dose peau est très majoritairement due aux désintégrations  au contact  |  |  |  |  |  |
|  |  |  |  |  | Les désexcitations  sont finalement très peu dosantes |  |  |  |  |  |  |  |

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|  | **C/** | **Requalification fonctionnelle** |   |  |  |  |  |  |  |  |  |
|  |  | **1/** | **Performance des échangeurs RRA / RRI**  |  |  |  |  |  |  |  |  |
|  |  |  | **1/** |  | DI = | 18 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | DE = | 21 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | N = | 479 | tubes |  |  |  |  |  |  |  |  |
|  |  |  |  |  | L = | 2 372 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 2,372 | m |  |  |  |  |  |  |  |  |
|  |  |  |  |  | DM = | 19,5 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | S = | 139,2 | m2 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **2/** |  | CP = | 4,31 | kJ/kg.K |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  = | 917 | kg/m3 |  |  |  |  |  |  |  |  |
|  |  |  |  |  | QV = | 910 | m3/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 0,253 | m3/s |  |  |  |  |  |  |  |  |
|  |  |  |  |  | QM = | 232 | kg/s |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | CE = | 150 | °C |  |  |  |  |  |  |  |  |
|  |  |  |  |  | CS = | 142 | °C |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  = | 7 992 368 | W |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 8,0 | MW |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **3/** |  | CE = | 150 | °C |  |  |  |  |  |  |  |  |
|  |  |  |  |  | CS = | 140 | °C |  |  |  |  |  |  |  |  |
|  |  |  |  |  | ' = | 9 990 460 | W |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 10,0 | MW |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **4/** |  | / = | 20% |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Nettoyage impératif pour préserver les performances |  |  |  |  |  |  |  |
|  |  |  |  |  | Contribution à la fonction fondamentale de sûreté "refroidissement" |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **2/** | **Réglage du robinet RRA 013 VP** |   |  |  |  |  |  |  |  |  |
|  |  |  |  |  | QV contour = | 910 | m3/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | QV = | 300 | m3/h |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Débit en % = | 33% |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | Course en % = | 10% |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | hMax = | 84,0 | mm |  |  |  |  |  |  |  |  |
|  |  |  |  |  | h = | 8,4 | mm |  |  |  |  |  |  |  |  |