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Document Control Desk
United States Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Reference: UNIVERSITY OF MARYLAND, REQUEST FOR ADDITIONAL INFORMATION REGARDING THE LICENSE RENEWAL FOR THE MARYLAND UNIVERSITY TRAINING REACTOR ("MUTR") (TAC NO. ME1592), Docket No. 50-166, License No. R-70

The University of Maryland (UMD) hereby submits its responses to the NRC's Requests for Additional Information issued by letter dated September 8, 2011.

The September 8, 2011 RAIs concerned dose calculations submitted as Enclosure 2 to the University of Maryland letter of July 5, 2011. The dose calculations in Enclosure 2 addressed the occupational dose to workers, the dose to a member of the public in the Nuclear and Chemical Engineering Building next to the Maryland University Training Reactor (MUTR), and the dose at the nearest residence during a maximum hypothetical accident (MHA) and normal operations. In the calculations, UMD considered two operational modes of the ventilation system, namely ventilation "on" and ventilation "off". The purpose of these calculations was to demonstrate that the occupational doses to workers and doses to the members of the public would not exceed the limits of Title 10 of the Code *of Federal Regulations* (10 CFR) Part 20, "Standards for Protection Against Radiation." Request for Additional Information 1 raised four questions regarding the analysis of the consequences of the Maximum Hypothetical Accident.

As requested in Item 2 of your email of September 20, 2011, I am submitting our most up to date tentative schedule for the re-installation of the fission chamber and subsequent reactor operations to re-evaluate Ar-41 measurements and dose calculations initially in our July 5, 2011 submission in response to Request for Additional Information 2 issued by letter dated September 8, 2011. As you are aware, we have had a number of setbacks which impacted our original schedule which we provided to you in the 5 July letter.

Hopefully, all of the issues (mainly circuitry) have been resolved. At the present time, the final welding of the aluminum can that houses the fission chamber will be completed at the beginning of next week (the week of October 17, 2011). After the weld is leak tested, we will be able to begin installation back into the core by late next week. Assuming all proceeds well, installation and initial testing should be completed by 14 October. Per our original schedule, we anticipate three weeks of reactor operation (various power levels and run times), sample collection and analyses, followed by two weeks for final dose calculations and assessment and preparation of the final report which we anticipate can be submitted by November 18, 2011.

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The documents submitted today supplement the University's clarifications and responses to RAIs submitted by letter on the following dates: June 7, 2004; August 4, 2004; September 17, 2004; and October 7, 2004; April 18, 2005, April 25, 2006 (two letters); August 28, 2006 (two letters); November 9, 2006 and December 18, 2006; May 27, 2010; August 27, 2010; September 22, 2010 and December 14, 2010; January 31, February 2, March 17, May 2, July 5, July 29, September 27 and September 28, 2011.

If there are questions about the information submitted, please write to me at the address set forth above or email me at mohamad@umd.edu. Please copy Prof. Robert Briber on any such correspondence (same address; rbriber@umd.edu).

I declare under penalty of perjury that the foregoing is true and correct.

Sincerely,

Mohamad Al-Sheikhly
Professor and Director, Maryland University
Training Reactor

cc: Robert Briber
Enclosure

# Calculations of Doses to Occupational Personnel and Members of the Public due to MHA and Normal Operations at the Maryland University Training Reactor

Note:

Internal and external components of doses are denoted for each category as applies.

Dose conversion factors are taken from the RADAR website and are consistent with ICRP and IAEA values
http://www.doseinfo-radar.com/RADAR-INT-Occ.html

In the August 10, 2011 teleconference with the NRC and consultant it was determined that the most likely exposed member of the public would be an individual residing at the fence line to the reactor facility and not an individual outside the door since there should be no force pushing anything, like a cloud out through the cracks in such cases as a leak with the ventilation off.

Normal Operations doses will be determined based on Ar-41 concentrations measured following the restart and operation of the reactor.

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# External Submersion Gamma MHA Occupational Worker

| External Occupational Dose to Worker [ submersion gamma MHA Occupational Worker] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gamma Dose rate from the Cloud (DDE = Dγ) | | | | | | | | ON DDE rem | OFF DDE rem |
| | | | $\chi_0$ | | Avg $\chi_{t\ w/V}$ | Avg $\chi_{t\ w/L}$ | Dose $\chi_0$ | Dose $\chi_v$ | Dose $\chi_L$ |
| Isotope | $E_{\gamma,\ avg}$ (MeV) | Release mCi | $\chi$ [Ci/m$^3$] | Dγ [rads/s] | Vent factor | Leak factor | 300s [rads] | 300s [rads] | 300s [rads] |
| Kr-83m | 0.00939 | 0.465 | 2.748E-07 | 1.308E-09 | 7.870E-01 | 9.960E-01 | 3.925E-07 | 3.089E-07 | 3.909E-07 |
| Kr-85m | 0.15118 | 1.076 | 6.359E-07 | 4.874E-08 | 7.870E-01 | 9.960E-01 | 1.462E-05 | 1.151E-05 | 1.456E-05 |
| Kr-85 | 0.51400 | 0.018 | 1.064E-08 | 2.772E-09 | 7.870E-01 | 9.960E-01 | 8.317E-07 | 6.545E-07 | 8.284E-07 |
| Kr-87 | 0.40256 | 2.070 | 1.223E-06 | 2.497E-07 | 7.870E-01 | 9.960E-01 | 7.491E-05 | 5.895E-05 | 7.461E-05 |
| Kr-88 | 2.39210 | 2.959 | 1.749E-06 | 2.121E-06 | 7.870E-01 | 9.960E-01 | 6.363E-04 | 5.008E-04 | 6.337E-04 |
| Kr-89 | 0.22090 | 3.638 | 2.150E-06 | 2.408E-07 | 7.870E-01 | 9.960E-01 | 7.224E-05 | 5.685E-05 | 7.195E-05 |
| Kr-90 | 1.11870 | 4.133 | 2.443E-06 | 1.385E-06 | 7.870E-01 | 9.960E-01 | 4.156E-04 | 3.271E-04 | 4.140E-04 |
| Xe-133m | 0.03304 | 0.146 | 8.629E-08 | 1.446E-09 | 7.870E-01 | 9.960E-01 | 4.337E-07 | 3.413E-07 | 4.319E-07 |
| Xe-133 | 0.02330 | 8.516 | 5.033E-06 | 5.946E-08 | 7.870E-01 | 9.960E-01 | 1.784E-05 | 1.404E-05 | 1.777E-05 |
| Xe-135m | 0.42128 | 2.243 | 1.326E-06 | 2.831E-07 | 7.870E-01 | 9.960E-01 | 8.494E-05 | 6.685E-05 | 8.460E-05 |
| Xe-135 | 0.25466 | 3.844 | 2.272E-06 | 2.933E-07 | 7.870E-01 | 9.960E-01 | 8.800E-05 | 6.925E-05 | 8.765E-05 |
| Sr-89 | 0.00010 | 0.2500 | 1.478E-07 | 7.491E-12 | 7.870E-01 | 9.960E-01 | 2.247E-09 | 1.769E-09 | 2.238E-09 |
| Sr-91 | 0.62900 | 323.00 | 1.909E-04 | 6.088E-05 | 7.870E-01 | 9.960E-01 | 1.826E-02 | 1.437E-02 | 1.819E-02 |
| Sr-92 | 1.29200 | 365.50 | 2.160E-04 | 1.415E-04 | 7.870E-01 | 9.960E-01 | 4.245E-02 | 3.341E-02 | 4.228E-02 |
| Sr-93 | 1.66000 | 414.50 | 2.450E-04 | 2.062E-04 | 7.870E-01 | 9.960E-01 | 6.185E-02 | 4.868E-02 | 6.161E-02 |
| Cs-134m | 0.01792 | 0.5000 | 2.955E-07 | 2.685E-09 | 7.870E-01 | 9.960E-01 | 8.054E-07 | 6.339E-07 | 8.022E-07 |
| Cs-134 | 1.39800 | 0.8000 | 4.728E-07 | 3.351E-07 | 7.870E-01 | 9.960E-01 | 1.005E-04 | 7.912E-05 | 1.001E-04 |
| Cs-136 | 1.79500 | 6.5000 | 3.842E-06 | 3.496E-06 | 7.870E-01 | 9.960E-01 | 1.049E-03 | 8.254E-04 | 1.045E-03 |
| Cs-137 | 0.59510 | 124.00 | 7.329E-05 | 2.211E-05 | 7.870E-01 | 9.960E-01 | 6.633E-03 | 5.221E-03 | 6.607E-03 |
| Cs-138 | 1.04100 | 515.00 | 3.044E-04 | 1.606E-04 | 7.870E-01 | 9.960E-01 | 4.819E-02 | 3.793E-02 | 4.800E-02 |
| | | | | DDE = | | | **1.799E-01** | **1.416E-01** | **1.792E-01** |

# Internal MHA Occupational Worker

| Internal MHA Occupational Worker | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ventilation ON and OFF: MHA Occupational Internal Dose to Worker | | | | | | | | | ON CEDE [rem] | OFF CEDE [rem] |
| Isotope | Release [Ci] | $C_0$ [Ci/m$^3$] | Cv [Ci/m3] | $C_L$[Ci/m3] | $B_r$ [m3/s] | $t_{evac}$ [s] | DCF [rem/Ci] | $D_w$ [rem] | $D_{w\_v300s}$ [rem] | $D_{w\_L300s}$ [rem] |
| I-131 | 0.00405 | 2.3936E-06 | 1.8821E-06 | 2.3886E-06 | 3.33E-04 | 300 | 740 | 5.3085E-06 | 4.1741E-06 | 5.2974E-06 |
| I-132 | 0.00623 | 3.6820E-06 | 2.8952E-06 | 3.6743E-06 | 3.33E-04 | 300 | 407 | 4.4913E-06 | 3.5315E-06 | 4.4818E-06 |
| I-133 | 0.07250 | 4.2849E-05 | 3.3692E-05 | 4.2759E-05 | 3.33E-04 | 300 | 7770 | 9.9780E-04 | 7.8457E-04 | 9.9571E-04 |
| I-134 | 0.00954 | 5.6383E-06 | 4.4334E-06 | 5.6265E-06 | 3.33E-04 | 300 | 292.3 | 4.9393E-06 | 3.8837E-06 | 4.9289E-06 |
| I-135 | 0.00830 | 4.9054E-06 | 3.8571E-06 | 4.8952E-06 | 3.33E-04 | 300 | 1702 | 2.5022E-05 | 1.9675E-05 | 2.4970E-05 |
| Kr-83m | 0.000465 | 2.7482E-07 | 2.1609E-07 | 2.7425E-07 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-85m | 0.001076 | 6.3593E-07 | 5.0003E-07 | 6.3460E-07 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-85 | 0.000018 | 1.0638E-08 | 8.3649E-09 | 1.0616E-08 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-87 | 0.00207 | 1.2234E-06 | 9.6196E-07 | 1.2208E-06 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-88 | 0.002959 | 1.7488E-06 | 1.3751E-06 | 1.7452E-06 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-89 | 0.003638 | 2.1501E-06 | 1.6906E-06 | 2.1456E-06 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-90 | 0.004133 | 2.4427E-06 | 1.9207E-06 | 2.4375E-06 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Xe-133m | 0.000146 | 8.6288E-08 | 6.7848E-08 | 8.6107E-08 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Xe-133 | 0.008516 | 5.0331E-06 | 3.9575E-06 | 5.0225E-06 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Xe-135m | 0.002243 | 1.3257E-06 | 1.0424E-06 | 1.3229E-06 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Xe-135 | 0.003844 | 2.2719E-06 | 1.7864E-06 | 2.2671E-06 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Sr-89 | 0.00025 | 1.4775E-07 | 1.1618E-07 | 1.4744E-07 | 3.33E-04 | 300 | 5180 | 2.2938E-06 | 1.8036E-06 | 2.2890E-06 |
| Sr-91 | 0.323 | 1.9090E-04 | 1.5010E-04 | 1.9050E-04 | 3.33E-04 | 300 | 1073 | 6.1389E-04 | 4.8270E-04 | 6.1260E-04 |
| Sr-92 | 0.3655 | 2.1602E-04 | 1.6985E-04 | 2.1556E-04 | 3.33E-04 | 300 | 666 | 4.3117E-04 | 3.3903E-04 | 4.3027E-04 |
| Sr-93 | 0.4145 | 2.4498E-04 | 1.9262E-04 | 2.4446E-04 | 3.33E-04 | 300 | 0 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Cs-134m | 0.0005 | 2.9551E-07 | 2.3236E-07 | 2.9489E-07 | 3.33E-04 | 300 | 96.2 | 8.5198E-08 | 6.6991E-08 | 8.5020E-08 |
| Cs-134 | 0.0008 | 4.7281E-07 | 3.7177E-07 | 4.7182E-07 | 3.33E-04 | 300 | 35520 | 5.0333E-05 | 3.9576E-05 | 5.0227E-05 |
| Cs-136 | 0.0065 | 3.8416E-06 | 3.0206E-06 | 3.8336E-06 | 3.33E-04 | 300 | 7030 | 8.0938E-05 | 6.3642E-05 | 8.0769E-05 |
| Cs-137 | 0.124 | 7.3286E-05 | 5.7625E-05 | 7.3132E-05 | 3.33E-04 | 300 | 24790 | 5.4448E-03 | 4.2813E-03 | 5.4334E-03 |
| Cs-138 | 0.515 | 3.0437E-04 | 2.3933E-04 | 3.0374E-04 | 3.33E-04 | 300 | 170.2 | 1.5526E-04 | 1.2208E-04 | 1.5493E-04 |
| | | | | | | | Total | 7.8164E-03 | 6.1460E-03 | 7.8000E-03 |

# External Submersion Beta MHA Occupational Worker

| External Occupational Dose to Worker [submersion beta MHA Occupational Worker] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Beta Dose rate from the Cloud (SDE = $D_\beta$) | | | | Shallow Dose Equivalent SDE at 7 mg/cm$^2$ | | | | | | ON | OFF |
| | | | | $D_\beta = 2.45 \times E\text{-}7\ C\ E_{avg}\ e^{-\mu \times 0.007}$ mGy/hr | | | | | | SDE rem | SDE rem |
| | | release | $\chi_0$ | | | | Avg $\chi_{t\ w/v}$ | Avg $\chi_{t\ w/L}$ | Dose $\chi_0$ | Dose $\chi_v$ | Dose $\chi_L$ |
| Isotope | $E_{\beta,\ avg}$ (keV) | mCi | $\chi$ [Ci/m$^3$] | $\mu_{\beta,t}$ | $e^{-\mu\beta,t \times 0.007}$ | $D\beta$ [mGy/hr] | Vent factor | Leak factor | 300s [rads] | 300s [rads] | 300s [rads] |
| Kr-85m | 230 | 1.0760 | 6.3593E-07 | 3.3279E+01 | 7.9219E-01 | 1.0504E-03 | 7.870E-01 | 9.960E-01 | 8.7530E-06 | 6.889E-06 | 8.718E-06 |
| Kr-85 | 228 | 0.0180 | 1.0638E-08 | 3.3702E+01 | 7.8985E-01 | 1.7367E-05 | 7.870E-01 | 9.960E-01 | 1.4472E-07 | 1.139E-07 | 1.441E-07 |
| Kr-87 | 1329 | 2.0700 | 1.2234E-06 | 2.8316E+00 | 9.8037E-01 | 1.4450E-02 | 7.870E-01 | 9.960E-01 | 1.2041E-04 | 9.477E-05 | 1.199E-04 |
| Kr-88 | 366 | 2.9590 | 1.7488E-06 | 1.7129E+01 | 8.8701E-01 | 5.1466E-03 | 7.870E-01 | 9.960E-01 | 4.2888E-05 | 3.375E-05 | 4.272E-05 |
| Kr-89 | 1650 | 3.6380 | 2.1501E-06 | 2.1001E+00 | 9.8541E-01 | 3.1691E-02 | 7.870E-01 | 9.960E-01 | 2.6409E-04 | 2.078E-04 | 2.630E-04 |
| Kr-90 | 800 | 4.1330 | 2.4427E-06 | 5.7229E+00 | 9.6073E-01 | 1.7019E-02 | 7.870E-01 | 9.960E-01 | 1.4182E-04 | 1.116E-04 | 1.413E-04 |
| Xe-133 | 416 | 8.5160 | 5.0331E-06 | 1.4293E+01 | 9.0479E-01 | 1.7173E-02 | 7.870E-01 | 9.960E-01 | 1.4311E-04 | 1.126E-04 | 1.425E-04 |
| Xe-135m | 100 | 2.2430 | 1.3257E-06 | 1.1532E+02 | 4.4608E-01 | 5.3605E-04 | 7.870E-01 | 9.960E-01 | 4.4671E-06 | 3.516E-06 | 4.449E-06 |
| Xe-135 | 302 | 3.8440 | 2.2719E-06 | 2.2510E+01 | 8.5422E-01 | 5.3128E-03 | 7.870E-01 | 9.960E-01 | 4.4274E-05 | 3.484E-05 | 4.410E-05 |
| Sr-89 | 584 | 0.2500 | 1.4775E-07 | 8.8761E+00 | 9.3976E-01 | 7.3508E-04 | 7.870E-01 | 9.960E-01 | 6.1257E-06 | 4.821E-06 | 6.101E-06 |
| Sr-91 | 1354 | 323.0000 | 1.9090E-04 | 2.7595E+00 | 9.8087E-01 | 2.2983E+00 | 7.870E-01 | 9.960E-01 | 1.9152E-02 | 1.507E-02 | 1.908E-02 |
| Sr-92 | 1521 | 365.5000 | 2.1602E-04 | 2.3499E+00 | 9.8369E-01 | 2.9298E+00 | 7.870E-01 | 9.960E-01 | 2.4415E-02 | 1.921E-02 | 2.432E-02 |
| Sr-93 | 1000 | 414.5000 | 2.4498E-04 | 4.1980E+00 | 9.7104E-01 | 2.1564E+00 | 7.870E-01 | 9.960E-01 | 1.7970E-02 | 1.414E-02 | 1.790E-02 |
| Cs-134 | 156 | 0.8000 | 4.7281E-07 | 5.8735E+01 | 6.6289E-01 | 4.4322E-04 | 7.870E-01 | 9.960E-01 | 3.6935E-06 | 2.907E-06 | 3.679E-06 |
| Cs-136 | 116 | 6.5000 | 3.8416E-06 | 9.1732E+01 | 5.2617E-01 | 2.1255E-03 | 7.870E-01 | 9.960E-01 | 1.7713E-05 | 1.394E-05 | 1.764E-05 |
| Cs-137 | 170 | 124.0000 | 7.3286E-05 | 5.1725E+01 | 6.9623E-01 | 7.8631E-02 | 7.870E-01 | 9.960E-01 | 6.5526E-04 | 5.157E-04 | 6.526E-04 |
| Cs-138 | 1239 | 515.0000 | 3.0437E-04 | 3.1199E+00 | 9.7840E-01 | 3.3447E+00 | 7.870E-01 | 9.960E-01 | 2.7873E-02 | 2.194E-02 | 2.776E-02 |
| I-131 | 190.00 | 0.0041 | 2.3936E-09 | 4.3932E+01 | 7.3526E-01 | 3.0312E-06 | 7.870E-01 | 9.960E-01 | 2.5260E-08 | 1.988E-08 | 2.516E-08 |
| I-132 | 270.00 | 0.0062 | 3.6820E-09 | 2.6420E+01 | 8.3115E-01 | 7.4903E-06 | 7.870E-01 | 9.960E-01 | 6.2419E-08 | 4.912E-08 | 6.217E-08 |
| I-133 | 440.00 | 0.0725 | 4.2849E-08 | 1.3206E+01 | 9.1170E-01 | 1.5582E-04 | 7.870E-01 | 9.960E-01 | 1.2985E-06 | 1.022E-06 | 1.293E-06 |
| I-134 | 460.00 | 0.0095 | 5.6383E-09 | 1.2405E+01 | 9.1683E-01 | 2.1556E-05 | 7.870E-01 | 9.960E-01 | 1.7963E-07 | 1.414E-07 | 1.789E-07 |
| I-135 | 530.00 | 0.0083 | 4.9054E-09 | 1.0168E+01 | 9.3130E-01 | 2.1949E-05 | 7.870E-01 | 9.960E-01 | 1.8291E-07 | 1.439E-07 | 1.822E-07 |
| | | | | | | | | | Total SDE | 7.151E-02 | 9.050E-02 |

# Plume Model Calculations for MHA Occupational Worker

**Stability Class factors for 175, 200, and 300 meters downwind on the center line**

| | | | $\sigma_y$ [m] | | | | | $\sigma_z$ [m] | | | pi | wind speed | eff height |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| χ(x,0) [m] | A | B | C | E | F | A | B | C | E | F | π | μ [m/s] | H [m] |
| 175 | 40 | 27.5 | 20 | 10 | 7 | 28 | 18 | 4 | 5 | 2.5 | 3.14 | 2 | 7.3255 |
| 200 | 45 | 30 | 22.5 | 12.5 | 8 | 30 | 20 | 15 | 5.5 | 3 | 3.14 | 2 | 7.3255 |
| 300 | 70 | 46.5 | 35 | 18 | 13 | 55 | 30 | 22.5 | 8.5 | 4.7 | 3.14 | 2 | 7.3255 |

| | $[1/\mu\,\mu\,\sigma_y\,\sigma_z\,\pi]$ | | | | | $e^{-[1/2\,(H/\sigma)^2]}$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| χ(x,0) [m] | A | B | C | E | F | A | B | C | E | F |
| 175 | 1.4217E-04 | 3.2169E-04 | 1.9904E-03 | 6.3694E-03 | 9.0992E-03 | 9.6636E-01 | 9.2052E-01 | 1.8694E-01 | 3.4189E-01 | 1.3663E-02 |
| 200 | 1.1795E-04 | 2.6539E-04 | 4.7181E-04 | 4.2463E-03 | 6.6348E-03 | 9.7063E-01 | 9.3512E-01 | 8.8758E-01 | 4.1189E-01 | 5.0728E-02 |
| 300 | 4.1360E-05 | 1.1415E-04 | 2.0220E-04 | 1.8822E-03 | 2.6061E-03 | 9.9117E-01 | 9.7063E-01 | 9.4838E-01 | 6.8979E-01 | 2.9682E-01 |

| | $\chi/Q\ [s/m^3] = [1/\mu\,\sigma_y\,\sigma_z\,\pi] \times e^{-[1/2\,(H/\sigma)^2]}$ | | | | |
|---|---|---|---|---|---|
| χ(x,0) [m] | A | B | C | E | F |
| 175 | 1.3739E-04 | 2.9612E-04 | 3.7209E-04 | 2.1777E-03 | 1.2433E-04 |
| 200 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| 300 | 4.0995E-05 | 1.1079E-04 | 1.9177E-04 | 1.2983E-03 | 7.7355E-04 |

# Plume Model Calculations for MHA Occupational Worker Ventillation OFF (continued)

| MHA Plume Model 200 m Nearest Residence Ground Release Ventilation OFF (leakage) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MHA data Plume Model 200 m Nearest Residence | | | | | A 200 | B 200 | C 200 | E 200 | F 200 |
| Nuclides | $f_{L(5\%)}$ [$m^3/s$] | A [Ci] | $C_0$ [Ci/m3] | $Q_{L(5\%)}$ [Ci/s] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] |
| Kr-83m | 2.350E-02 | 4.650E-04 | 2.748E-07 | 6.458E-09 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Kr-85m | 2.350E-02 | 1.076E-03 | 6.359E-07 | 1.494E-08 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Kr-85 | 2.350E-02 | 1.800E-05 | 1.064E-08 | 2.500E-10 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Kr-87 | 2.350E-02 | 2.070E-03 | 1.223E-06 | 2.875E-08 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Kr-88 | 2.350E-02 | 2.959E-03 | 1.749E-06 | 4.110E-08 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Xe-133m | 2.350E-02 | 1.460E-04 | 8.629E-08 | 2.028E-09 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Xe-133 | 2.350E-02 | 8.516E-03 | 5.033E-06 | 1.183E-07 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Xe-135m | 2.350E-02 | 2.243E-03 | 1.326E-06 | 3.115E-08 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| Xe-135 | 2.350E-02 | 3.844E-03 | 2.272E-06 | 5.339E-08 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| | | | | | | | | | |
| Internal Component | | | | | A 200 | B 200 | C 200 | E 200 | F 200 |
| Nuclides | $f_{L(5\%)}$ [$m^3/s$] | A [Ci] | $C_0$ [Ci/m3] | $Q_{L(5\%)}$ [Ci/s] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] |
| I-131 | 2.350E-02 | 4.050E-03 | 2.394E-06 | 5.625E-08 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| I-132 | 2.350E-02 | 6.230E-03 | 3.682E-06 | 8.653E-08 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| I-133 | 2.350E-02 | 7.250E-02 | 4.285E-05 | 1.007E-06 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| I-134 | 2.350E-02 | 9.540E-03 | 5.638E-06 | 1.325E-07 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |
| I-135 | 2.350E-02 | 8.300E-03 | 4.905E-06 | 1.153E-07 | 1.180E-04 | 2.654E-04 | 4.718E-04 | 4.246E-03 | 6.635E-03 |

# Plume Model Calculations for MHA Occupational Worker Ventillation OFF (continued)

| A 200 | B 200 | C 200 | E 200 | F 200 | DCF | A 200 | B 200 | C 200 | E 200 | F 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| XL [Ci/m$^3$] | XL [Ci/m$^3$] | XL [Ci/m$^3$] | XL [Ci/m$^3$] | XL [Ci/m$^3$] | [rem/hr/Ci/m$^3$] | DDE [rem] | DDE [rem] | DDE [rem] | DDE [rem] | DDE [rem] |
| 7.618E-13 | 1.714E-12 | 3.047E-12 | 2.742E-11 | 4.285E-11 | 3.238E-02 | 2.466E-14 | 5.549E-14 | 9.865E-14 | 8.878E-13 | 1.387E-12 |
| 1.763E-12 | 3.966E-12 | 7.051E-12 | 6.346E-11 | 9.915E-11 | 9.096E+01 | 1.603E-10 | 3.608E-10 | 6.413E-10 | 5.772E-09 | 9.019E-09 |
| 2.949E-14 | 6.635E-14 | 1.180E-13 | 1.062E-12 | 1.659E-12 | 3.392E+00 | 1.000E-13 | 2.250E-13 | 4.001E-13 | 3.600E-12 | 5.626E-12 |
| 3.391E-12 | 7.630E-12 | 1.356E-11 | 1.221E-10 | 1.908E-10 | 5.242E+02 | 1.778E-09 | 3.999E-09 | 7.110E-09 | 6.399E-08 | 9.999E-08 |
| 4.848E-12 | 1.091E-11 | 1.939E-11 | 1.745E-10 | 2.727E-10 | 1.295E+03 | 6.278E-09 | 1.412E-08 | 2.511E-08 | 2.260E-07 | 3.531E-07 |
| 2.392E-13 | 5.382E-13 | 9.567E-13 | 8.611E-12 | 1.345E-11 | 1.696E+01 | 4.056E-12 | 9.126E-12 | 1.622E-11 | 1.460E-10 | 2.282E-10 |
| 1.395E-11 | 3.139E-11 | 5.580E-11 | 5.022E-10 | 7.848E-10 | 1.850E+01 | 2.581E-10 | 5.807E-10 | 1.032E-09 | 9.291E-09 | 1.452E-08 |
| 3.675E-12 | 8.268E-12 | 1.470E-11 | 1.323E-10 | 2.067E-10 | 2.467E+02 | 9.064E-10 | 2.039E-09 | 3.626E-09 | 3.263E-08 | 5.098E-08 |
| 6.297E-12 | 1.417E-11 | 2.519E-11 | 2.267E-10 | 3.542E-10 | 1.480E+02 | 9.320E-10 | 2.097E-09 | 3.728E-09 | 3.355E-08 | 5.243E-08 |
| Internal component continued | | | | | **Total DDE** | **1.032E-08** | **2.321E-08** | **4.126E-08** | **3.714E-07** | **5.803E-07** |

| | | | | CED | | A 200 | B 200 | C 200 | E 200 | F 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| $B_r$ [m3/s] | | | | DCF [rem/Ci] | | CEDE [rem] | CEDE [rem] | CEDE [rem] | CEDE [rem] | CEDE [rem] |
| 3.330E-04 | | | | 7.400E+02 | | 3.531E-09 | 7.946E-09 | 1.413E-08 | 1.271E-07 | 1.986E-07 |
| 3.330E-04 | | | | 4.070E+02 | | 2.988E-09 | 6.723E-09 | 1.195E-08 | 1.076E-07 | 1.681E-07 |
| 3.330E-04 | | | | 7.770E+03 | | 6.638E-07 | 1.494E-06 | 2.655E-06 | 2.390E-05 | 3.734E-05 |
| 3.330E-04 | | | | 2.923E+02 | | 3.286E-09 | 7.393E-09 | 1.314E-08 | 1.183E-07 | 1.848E-07 |
| 3.330E-04 | | | | 1.702E+03 | | 1.665E-08 | 3.745E-08 | 6.658E-08 | 5.993E-07 | 9.363E-07 |
| | | | | | **Total CEDE** | **6.902E-07** | **1.553E-06** | **2.761E-06** | **2.485E-05** | **3.883E-05** |
| | | | | | **TEDE [rem]** | **7.006E-07** | **1.576E-06** | **2.802E-06** | **2.522E-05** | **3.941E-05** |

# Plume Model Calculations for MHA Occupational Worker Ventillation ON (continued)

| Ventilation ON Max Concentration distance 200 m | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MHA data Plume Model 200 m Nearest Residence | | | | | | | A 200 | B 200 | C 200 | E 200 | F 200 |
| Nuclides | $f_v$ [$m^3/s$] | $f_{L(5\%)}$ [$m^3/s$] | A [Ci] | $C_0$ [Ci/m3] | $Q_v$ [Ci/s] | $Q_{L(5\%)}$ [Ci/s] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] |
| Kr-83m | 2.83 | 0.0235 | 4.6500E-04 | 2.7482E-07 | 7.7775E-07 | 6.4583E-09 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Kr-85m | 2.83 | 0.0235 | 1.0760E-03 | 6.3593E-07 | 1.7997E-06 | 1.4944E-08 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Kr-85 | 2.83 | 0.0235 | 1.8000E-05 | 1.0638E-08 | 3.0106E-08 | 2.5000E-10 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Kr-87 | 2.83 | 0.0235 | 2.0700E-03 | 1.2234E-06 | 3.4622E-06 | 2.8750E-08 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Kr-88 | 2.83 | 0.0235 | 2.9590E-03 | 1.7488E-06 | 4.9492E-06 | 4.1097E-08 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Xe-133m | 2.83 | 0.0235 | 1.4600E-04 | 8.6288E-08 | 2.4420E-07 | 2.0278E-09 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Xe-133 | 2.83 | 0.0235 | 8.5160E-03 | 5.0331E-06 | 1.4244E-05 | 1.1828E-07 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Xe-135m | 2.83 | 0.0235 | 2.2430E-03 | 1.3257E-06 | 3.7516E-06 | 3.1153E-08 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| Xe-135 | 2.83 | 0.0235 | 3.8440E-03 | 2.2719E-06 | 6.4294E-06 | 5.3389E-08 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| | | | | | | | | | | | |
| Internal component | | | | | | | A 200 | B 200 | C 200 | E 200 | F 200 |
| Nuclides | $f_v$ [$m^3/s$] | $f_{L(5\%)}$ [$m^3/s$] | A [Ci] | $C_0$ [Ci/m3] | $Q_v$ [Ci/s] | $Q_{L(5\%)}$ [Ci/s] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] | χ/Q [$s/m^3$] |
| I-131 | 2.83 | 0.0235 | 4.0500E-03 | 2.3936E-06 | 6.7739E-06 | 1.5919E-07 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| I-132 | 2.83 | 0.0235 | 6.2300E-03 | 3.6820E-06 | 1.0420E-05 | 2.4487E-07 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| I-133 | 2.83 | 0.0235 | 7.2500E-02 | 4.2849E-05 | 1.2126E-04 | 2.8497E-06 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| I-134 | 2.83 | 0.0235 | 9.5400E-03 | 5.6383E-06 | 1.5956E-05 | 3.7498E-07 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |
| I-135 | 2.83 | 0.0235 | 8.3000E-03 | 4.9054E-06 | 1.3882E-05 | 3.2624E-07 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |

# Plume Model Calculations for MHA Occupational Worker Ventillation ON (continued)

| A 200 | B 200 | C 200 | E 200 | F 200 | | A 200 | B 200 | C 200 | E 200 | F 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| $X_v$ [Ci/m$^3$] | $X_v$ [Ci/m$^3$] | $X_v$ [Ci/m$^3$] | $X_v$ [Ci/m$^3$] | $X_v$ [Ci/m$^3$] | DCF [rem/hr/Ci/m$^3$] | DDE [rem] | DDE [rem] | DDE [rem] | DDE [rem] | DDE [rem] |
| 8.9043E-11 | 1.9302E-10 | 3.2570E-10 | 1.3603E-09 | 2.6177E-10 | 3.2375E-02 | 2.8828E-12 | 6.2489E-12 | 1.0544E-11 | 4.4040E-11 | 8.4747E-12 |
| 2.0604E-10 | 4.4664E-10 | 7.5366E-10 | 3.1477E-09 | 6.0573E-10 | 9.0958E+01 | 1.8741E-08 | 4.0625E-08 | 6.8552E-08 | 2.8631E-07 | 5.5096E-08 |
| 3.4468E-12 | 7.4716E-12 | 1.2608E-11 | 5.2657E-11 | 1.0133E-11 | 3.3917E+00 | 1.1690E-11 | 2.5341E-11 | 4.2761E-11 | 1.7859E-10 | 3.4368E-11 |
| 3.9638E-10 | 8.5924E-10 | 1.4499E-09 | 6.0555E-09 | 1.1653E-09 | 5.2417E+02 | 2.0777E-07 | 4.5038E-07 | 7.5998E-07 | 3.1741E-06 | 6.1081E-07 |
| 5.6662E-10 | 1.2283E-09 | 2.0726E-09 | 8.6562E-09 | 1.6657E-09 | 1.2950E+03 | 7.3377E-07 | 1.5906E-06 | 2.6840E-06 | 1.1210E-05 | 2.1571E-06 |
| 2.7957E-11 | 6.0603E-11 | 1.0226E-10 | 4.2710E-10 | 8.2190E-11 | 1.6958E+01 | 4.7411E-10 | 1.0277E-09 | 1.7342E-09 | 7.2430E-09 | 1.3938E-09 |
| 1.6307E-09 | 3.5349E-09 | 5.9648E-09 | 2.4912E-08 | 4.7940E-09 | 1.8500E+01 | 3.0168E-08 | 6.5396E-08 | 1.1035E-07 | 4.6088E-07 | 8.8689E-08 |
| 4.2951E-10 | 9.3105E-10 | 1.5711E-09 | 6.5616E-09 | 1.2627E-09 | 2.4667E+02 | 1.0595E-07 | 2.2966E-07 | 3.8753E-07 | 1.6185E-06 | 3.1146E-07 |
| 7.3609E-10 | 1.5956E-09 | 2.6924E-09 | 1.1245E-08 | 2.1640E-09 | 1.4800E+02 | 1.0894E-07 | 2.3615E-07 | 3.9848E-07 | 1.6643E-06 | 3.2026E-07 |
| Internal component continued | | | | | **Total DDE** | **1.2058E-06** | **2.6139E-06** | **4.4106E-06** | **1.8421E-05** | **3.5449E-06** |

| | | | | CED | | A 200 | B 200 | C 200 | E 200 | F 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| $B_r$ [m3/s] | | | | DCF [rem/Ci] | | CEDE [rem] | CEDE [rem] | CEDE [rem] | CEDE [rem] | CEDE [rem] |
| 3.33E-04 | | | | 7.4000E+02 | | 3.4278E-09 | 7.4304E-09 | 1.2538E-08 | 5.2366E-08 | 1.0077E-08 |
| 3.33E-04 | | | | 4.0700E+02 | | 2.9001E-09 | 6.2864E-09 | 1.0608E-08 | 4.4304E-08 | 8.5256E-09 |
| 3.33E-04 | | | | 7.7700E+03 | | 6.4429E-07 | 1.3966E-06 | 2.3567E-06 | 9.8428E-06 | 1.8941E-06 |
| 3.33E-04 | | | | 2.9230E+02 | | 3.1893E-09 | 6.9135E-09 | 1.1666E-08 | 4.8723E-08 | 9.3761E-09 |
| 3.33E-04 | | | | 1.7020E+03 | | 1.6157E-08 | 3.5024E-08 | 5.9099E-08 | 2.4683E-07 | 4.7499E-08 |
| | | | | | **Total CEDE** | **6.6997E-07** | **1.4523E-06** | **2.4506E-06** | **1.0235E-05** | **1.9696E-06** |
| | | | | | **TEDE** | **1.8758E-06** | **4.0661E-06** | **6.8612E-06** | **2.8656E-05** | **5.5145E-06** |

# Dose to the nearest member of the public in the case of an MHA

Gamma submersion dose component

| **Ventilation OFF (leakage)** | | | |
|---|---|---|---|
| **MHA Gamma submersion dose at fence line** | | | |
| **Isotope** | **5% / hr leakage** | **Gamma submersion dose 2 hr OFF rads** | **Eγ, avg (MeV)** |
| Kr-83m | 3.8543E-08 | 6.6057E-07 | 0.00939 |
| Kr-85m | 1.0939E-07 | 3.0185E-05 | 0.15118 |
| Kr-85 | 2.1276E-09 | 1.9960E-06 | 0.514 |
| Kr-87 | 1.4901E-07 | 1.0948E-04 | 0.40256 |
| Kr-88 | 1.1945E-08 | 5.2152E-05 | 2.3921 |
| Xe-133m | 1.7032E-08 | 6.8670E-06 | 0.2209 |
| Xe-133 | 1.0011E-06 | 2.0441E-03 | 1.1187 |
| Xe-135m | 4.8535E-08 | 2.9271E-06 | 0.033042 |
| Xe-135 | 4.2142E-07 | 1.7922E-05 | 0.0233 |
| I-131 | 4.7699E-07 | 3.3083E-04 | 0.38 |
| I-132 | 5.5311E-07 | 6.7336E-04 | 0.667 |
| I-133 | 8.2903E-06 | 8.6250E-03 | 0.57 |
| I-134 | 5.6649E-07 | 7.4755E-04 | 0.723 |
| I-135 | 8.8504E-07 | 1.3666E-03 | 0.846 |
| | **Total** | **1.4010E-02** | **rem** |

# Dose to the nearest member of the public in the case of an MHA

Beta submersion dose component

| **Ventilation OFF (leakage)** | | | | |
|---|---|---|---|---|
| **Beta submersion Dose at fence** | | | | |
| **Isotope** | **$C_{avg}$[Ci/m$^3$]** | **10% of $C_{avg}$[Ci/m$^3$]** | **$E_{avg}$ [Mev]** | **rem** |
| Kr-85m | 5.29386E-07 | 5.29386E-08 | 0.227 | 1.99003E-05 |
| Kr-85 | 9.85633E-09 | 9.85633E-10 | 0.251 | 4.09684E-07 |
| Kr-87 | 1.2234E-06 | 1.2234E-07 | 1.27 | 0.000257296 |
| Kr-88 | 1.34825E-06 | 1.34825E-07 | 0.28 | 6.25156E-05 |
| Kr-89 | 1.46857E-07 | 1.46857E-08 | 1.4 | 3.40474E-05 |
| Kr-90 | 2.42662E-06 | 2.42662E-07 | 0.8 | 0.000321479 |
| Xe-133 | 5.01927E-06 | 5.01927E-07 | 0.1 | 8.31191E-05 |
| Xe-135m | 4.55344E-07 | 4.55344E-08 | 0.1 | 7.54049E-06 |
| Xe-135 | 2.18743E-06 | 2.18743E-07 | 0.28 | 0.000101427 |
| | | | **Total rem** | **8.88E-04** |

# Dose to the nearest member of the public in the case of an MHA

Internal dose component

| Ventilation OFF (leakage) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **MHA Internal Component at Fence** | | | | | | | |
| **Isotope** | **Release [Ci]** | **$C_{avg}$ [Ci/$m^3$]** | **2 hr leakage (10%)** | **$B_r$ [m3/s]** | **$t_{evac}$ [s]** | **DCF [rem/Ci]** | **Internal rem at fence** |
| I-131 | 0.00405 | 2.3893E-06 | 2.3893E-07 | 3.33E-04 | 7200 | 740 | 4.2391E-04 |
| I-132 | 0.00623 | 3.1791E-06 | 3.1791E-07 | 3.33E-04 | 7200 | 407 | 3.1022E-04 |
| I-133 | 0.07250 | 4.2142E-05 | 4.2142E-06 | 3.33E-04 | 7200 | 7770 | 7.8509E-02 |
| I-134 | 0.00954 | 3.8971E-06 | 3.8971E-07 | 3.33E-04 | 7200 | 292.3 | 2.7312E-04 |
| I-135 | 0.00830 | 4.6570E-06 | 4.6570E-07 | 3.33E-04 | 7200 | 1702 | 1.9004E-03 |
| | | | | | | **Total rem** | **8.1416E-02** |

# Dose to the nearest member of the public in the case of an MHA

External beta dose component from volume cloud inside reactor bay

| **Ventilation ON/OFF** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Beta Dose rate from the volume cloud inside the reactor at fence** | | | | | | | |
| **Dβ = 1.1 x E+3 C Eavg [mrad/hr]** | | | | | | | |
| **Isotope** | **$E_{\beta,avg}$ (keV)** | **mCi** | **C [μCi/g]** | **$\mu_{\beta,t}$ air** | **$e^{-\mu\beta,t}$** | **Dsurf [mrad/hr]** | **2 hr exposure Dsurf [mrad]** |
| Kr-85m | 230 | 1.0760 | 4.9155E-04 | 2.8994E+01 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-85 | 228 | 0.0180 | 8.2229E-06 | 2.9371E+01 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Kr-87 | 1329 | 2.0700 | 9.4564E-04 | 2.3374E+00 | 3.6114E-48 | 4.9925E-48 | 9.9849E-48 |
| Kr-88 | 366 | 2.9590 | 1.3518E-03 | 1.4708E+01 | 2.9816E-299 | 1.6226E-299 | 3.2453E-299 |
| Kr-89 | 1650 | 3.6380 | 1.6619E-03 | 1.7223E+00 | 1.1015E-35 | 3.3227E-35 | 6.6454E-35 |
| Kr-90 | 800 | 4.1330 | 1.8881E-03 | 4.7975E+00 | 4.2128E-98 | 6.9996E-98 | 1.3999E-97 |
| Xe-133 | 416 | 8.5160 | 3.8904E-03 | 1.2224E+01 | 7.6822E-249 | 1.3676E-248 | 2.7352E-248 |
| Xe-135m | 100 | 2.2430 | 1.0247E-03 | 1.0325E+02 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Xe-135 | 302 | 3.8440 | 1.7561E-03 | 1.9444E+01 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Sr-89 | 584 | 0.2500 | 1.1421E-04 | 7.5127E+00 | 3.2615E-153 | 2.3928E-154 | 4.7857E-154 |
| Sr-91 | 1354 | 323.0000 | 1.4756E-01 | 2.2767E+00 | 6.1711E-47 | 1.3562E-44 | 2.7124E-44 |
| Sr-92 | 1521 | 365.5000 | 1.6697E-01 | 1.9319E+00 | 6.1349E-40 | 1.7138E-37 | 3.4277E-37 |
| Sr-93 | 1000 | 414.5000 | 1.8936E-01 | 3.4953E+00 | 1.1331E-71 | 2.3601E-69 | 4.7202E-69 |
| Cs-134 | 156 | 0.8000 | 3.6546E-04 | 5.1813E+01 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Cs-136 | 116 | 6.5000 | 2.9694E-03 | 8.1715E+01 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Cs-137 | 170 | 124.0000 | 5.6647E-02 | 4.5502E+01 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Cs-138 | 1239 | 515.0000 | 2.3527E-01 | 2.5809E+00 | 4.1247E-53 | 1.3226E-50 | 2.6451E-50 |
| | | | | | **Subtotal** | **3.3398E-35** | **3.3398E-32** |

# Dose to the nearest member of the public in the case of an MHA

External gamma dose component from volume cloud inside reactor bay

| **Ventilation ON/OFF** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Gamma Dose rate from the volume cloud inside the reactor at fence** | | | | | | | | | | |
| **Nuclides** | **Gamma Constant [rem/hr/Ci/m2]** | **$(r^2 + h^2)/h^2$** | **A [Ci]** | **Time [hr]** | **half-life [hr]** | **$Avg_v$ [Ci/m3] ON** | **linear energy absorption coeff $m^{-1}$** | **$Avg_v$ [Ci/m3] OFF** | **$Dose_v$ ON [rem]** | **$Dose_L$ OFF [rem]** |
| Kr-83m | 0.11873 | 1.25 | 0.000465 | 2 | 1.83 | 2.286E-07 | 3.01502E-05 | 2.28776E-07 | 3.803E-08 | 3.8063E-08 |
| Kr-85m | 0.16013 | 1.25 | 0.001076 | 2 | 4.48 | 5.8871E-07 | 3.24794E-05 | 5.89185E-07 | 1.321E-07 | 1.3221E-07 |
| Kr-85 | 0.00156 | 1.25 | 0.000018 | 2 | 93907.2 | 1.0629E-08 | 3.84318E-05 | 1.06382E-08 | 2.324E-11 | 2.3256E-11 |
| Kr-87 | 0.43253 | 1.25 | 0.00207 | 2 | 1.271667 | 9.4246E-07 | 3.83024E-05 | 9.43176E-07 | 5.712E-07 | 5.7167E-07 |
| Kr-88 | 1.02453 | 1.25 | 0.002959 | 2 | 0.047333 | 1.1943E-07 | 3.02796E-05 | 1.19448E-07 | 1.715E-07 | 1.7149E-07 |
| Xe-133m | 0.11225 | 1.25 | 0.000146 | 2 | 52.512 | 8.565E-08 | 3.01502E-05 | 8.57209E-08 | 1.347E-08 | 1.3484E-08 |
| Xe-133 | 0.10297 | 1.25 | 0.008516 | 2 | 125.88 | 5.0151E-06 | 3.01502E-05 | 5.01923E-06 | 7.236E-07 | 7.2425E-07 |
| Xe-135m | 0.32008 | 1.25 | 0.002243 | 2 | 0.254833 | 4.5512E-07 | 3.83024E-05 | 4.55342E-07 | 2.041E-07 | 2.0424E-07 |
| Xe-135 | 0.18947 | 1.25 | 0.003844 | 2 | 9.09 | 2.1856E-06 | 3.59732E-05 | 2.18741E-06 | 5.803E-07 | 5.8077E-07 |
| I-131 | 0.28293 | 1.25 | 0.00405 | 2 | 192 | 2.3873E-06 | 3.83024E-05 | 2.38929E-06 | 9.465E-07 | 9.4729E-07 |
| I-132 | 1.4274 | 1.25 | 0.00623 | 2 | 2.3 | 3.1766E-06 | 3.79142E-05 | 3.17906E-06 | 6.354E-06 | 6.3589E-06 |
| I-133 | 0.4088 | 1.25 | 0.0725 | 2 | 20.8 | 4.2108E-05 | 3.83024E-05 | 4.21425E-05 | 2.412E-05 | 2.4142E-05 |
| I-134 | 1.5728 | 1.25 | 0.00954 | 2 | 0.876667 | 3.8943E-06 | 3.79142E-05 | 3.8971E-06 | 8.583E-06 | 8.5892E-06 |
| I-135 | 0.8609 | 1.25 | 0.0083 | 2 | 6.61 | 4.6532E-06 | 3.73966E-05 | 4.65702E-06 | 5.614E-06 | 5.6182E-06 |
| Sr-89 | 0.00008158 | 1.25 | 0.00025 | 2 | 1212 | 1.4771E-07 | 3.01502E-05 | 1.47712E-07 | 1.689E-11 | 1.6886E-11 |
| Sr-91 | 0.41366 | 1.25 | 0.323 | 2 | 9.5 | 0.0001841 | 3.83024E-05 | 0.000184102 | 0.0001067 | 0.00010672 |
| Sr-92 | 0.72002 | 1.25 | 0.3655 | 2 | 2.71 | 0.00019061 | 3.46792E-05 | 0.000190608 | 0.0001923 | 0.00019232 |
| Sr-93 | 1.35605 | 1.25 | 0.4145 | 2 | 0.13 | 4.5733E-05 | 0.00003235 | 4.57327E-05 | 8.69E-05 | 8.6904E-05 |
| Cs-134m | 0.070448 | 1.25 | 0.0005 | 2 | 2.9 | 2.6285E-07 | 3.01502E-05 | 2.62852E-07 | 2.595E-08 | 2.5949E-08 |
| Cs-134 | 0.99937 | 1.25 | 0.0008 | 2 | 18063 | 4.728E-07 | 0.000033644 | 4.72804E-07 | 6.621E-07 | 6.6213E-07 |
| Cs-136 | 1.34384 | 1.25 | 0.0065 | 2 | 314.4 | 3.8374E-06 | 0.000031056 | 3.83738E-06 | 7.226E-06 | 7.2264E-06 |
| Cs-137 | 0.38184 | 1.25 | 0.124 | 2 | 262800 | 7.3286E-05 | 3.83024E-05 | 7.3286E-05 | 3.921E-05 | 3.9214E-05 |
| Cs-138 | 1.26614 | 1.25 | 0.515 | 2 | 0.54 | 0.00017145 | 0.000036232 | 0.00017145 | 0.0003042 | 0.0003042 |
| | | | | | | | | **Sub Total** | **7.853E-04** | **1.836E-03** |

# Dose to the occupational worker in the case of normal operations

External gamma dose component

Release activity TBD

| **External Occupational Dose to Worker** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Gamma Dose rate from the Cloud (DDE = Dγ)** | | | | | | | | **DDE Rem ON** | **DDE Rem OFF** |
| | | | $\chi_0$ | | Avg $\chi_{t\ w/v}$ | Avg $\chi_{t\ w/L}$ | Dose $\chi_0$ | Dose $\chi_v$ | Dose $\chi_L$ |
| **Isotope** | **$E_{\gamma,\ avg}$ (MeV)** | **Release mCi** | **$\chi$ [Ci/m$^3$]** | **Dγ [rads/s]** | **Vent factor** | **Leak factor** | **300s [rads]** | **300s [rads]** | **300s [rads]** |
| Ar-41 | 1.29300 | | #VALUE! | #VALUE! | 7.870E-01 | 9.960E-01 | #VALUE! | #VALUE! | #VALUE! |

External beta dose component

Release activity TBD

| **External Occupational Dose to Worker** | | | | **Shallow Dose Equivalent SDE at 7 mg/cm$^2$** | | | | | | **ON** | **OFF** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Beta Dose rate from the Cloud (SDE = $D_\beta$)** | | | | **$D_\beta$ = 2.45 x E-7 C $E_{avg}$ $e^{-\mu \times 0.007}$ mGy/hr** | | | | | | **SDE rem** | **SDE rem** |
| | | **release** | $\chi_0$ | | | | Avg $\chi_{t\ w/v}$ | Avg $\chi_{t\ w/L}$ | Dose $\chi_0$ | Dose $\chi_v$ | Dose $\chi_L$ |
| **Isotope** | **$E_{\beta,\ avg}$ (keV)** | **mCi** | **$\chi$ [Ci/m$^3$]** | **$\mu_{\beta,t}$** | **$e^{-\mu\beta,t \times 0.007}$** | **Dβ [mGy/hr]** | **Vent factor** | **Leak factor** | **300s [rads]** | **300s [rads]** | **300s [rads]** |
| Ar-41 | 400 | | #VALUE! | 1.5106E+01 | 8.9966E-01 | #VALUE! | 7.870E-01 | 9.960E-01 | #VALUE! | #VALUE! | #VALUE! |

# Dose to nearst residence in the case of normal operations

Plume model factors

| **Stability Class factors for 175, 200, and 300 meters downwind on the center line** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\sigma_y$ [m] | | | | | $\sigma_z$ [m] | | | | | pi | wind speed | Effective height |
| χ(x,0) [m] | A | B | C | E | F | A | B | C | E | F | π | μ [m/s] | H [m] |
| 175 | 40 | 27.5 | 20 | 10 | 7 | 28 | 18 | 4 | 5 | 2.5 | 3.14 | 2 | 7.3255 |
| 200 | 45 | 30 | 22.5 | 12.5 | 8 | 30 | 20 | 15 | 5.5 | 3 | 3.14 | 2 | 7.3255 |
| 300 | 70 | 46.5 | 35 | 18 | 13 | 55 | 30 | 22.5 | 8.5 | 4.7 | 3.14 | 2 | 7.3255 |
| | | | | | | | | | | | | | |
| | $[1/\mu\ \sigma_y\ \sigma_z\ \pi]$ | | | | | $e^{-[1/2\ (H/\sigma)^2]}$ | | | | | | | |
| χ(x,0) [m] | A | B | C | E | F | A | B | C | E | F | | | |
| 175 | 1.4217E-04 | 3.2169E-04 | 1.9904E-03 | 6.3694E-03 | 9.0992E-03 | 9.6636E-01 | 9.2052E-01 | 1.8694E-01 | 3.4189E-01 | 1.3663E-02 | | | |
| 200 | 1.1795E-04 | 2.6539E-04 | 4.7181E-04 | 4.2463E-03 | 6.6348E-03 | 9.7063E-01 | 9.3512E-01 | 8.8758E-01 | 4.1189E-01 | 5.0728E-02 | | | |
| 300 | 4.1360E-05 | 1.1415E-04 | 2.0220E-04 | 1.8822E-03 | 2.6061E-03 | 9.9117E-01 | 9.7063E-01 | 9.4838E-01 | 6.8979E-01 | 2.9682E-01 | | | |
| | | | | | | | | | | | | | |
| | $\chi/Q\ [s/m^3] = [1/\mu\ \sigma_y\ \sigma_z\ \pi] \times e^{-[1/2\ (H/\sigma)^2]}$ | | | | | | | | | | | | |
| χ(x,0) [m] | A | B | C | E | F | | | | | | | | |
| 175 | 1.3739E-04 | 2.9612E-04 | 3.7209E-04 | 2.1777E-03 | 1.2433E-04 | | | | | | | | |
| 200 | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 | | | | | | | | |
| 300 | 4.0995E-05 | 1.1079E-04 | 1.9177E-04 | 1.2983E-03 | 7.7355E-04 | | | | | | | | |

# Dose to nearst residence in the case of normal operations (continued)

| Ventilation ON dose to nearest residence using plume model | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | A 200 | B 200 | C 200 | E 200 | F 200 |
| **Nuclides** | **$f_v$ [$m^3$/s]** | **$f_{L(5\%)}$ [$m^3$/s]** | **A [Ci]** | **$C_0$ [Ci/m3]** | **$Q_v$ [Ci/s]** | **$Q_{L(5\%)}$ [Ci/s]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** |
| Ar-41 | 2.83 | 0.0235 | | #VALUE! | #VALUE! | #VALUE! | 1.1449E-04 | 2.4817E-04 | 4.1877E-04 | 1.7490E-03 | 3.3657E-04 |

| A 200 | B 200 | C 200 | E 200 | F 200 | | A 200 | B 200 | C 200 | E 200 | F 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **DCF [rem/hr/$Ci/m^3$]** | **DDE [rem]** | **DDE [rem]** | **DDE [rem]** | **DDE [rem]** | **DDE [rem]** |
| #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | 8.1700E+02 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |

| Ventilation OFF dose to nearest residence using plume model | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | A 200 | B 200 | C 200 | E 200 | F 200 |
| **Nuclides** | **$f_v$ [$m^3$/s]** | **$f_{L(5\%)}$ [$m^3$/s]** | **A [Ci]** | **$C_0$ [Ci/m3]** | **$Q_v$ [Ci/s]** | **$Q_{L(5\%)}$ [Ci/s]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** | **χ/Q [$s/m^3$]** |
| Ar-41 | 2.83 | 0.0235 | | #VALUE! | #VALUE! | #VALUE! | 1.1795E-04 | 2.6539E-04 | 4.7181E-04 | 4.2463E-03 | 6.6348E-03 |

| A 200 | B 200 | C 200 | E 200 | F 200 | | A 200 | B 200 | C 200 | E 200 | F 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **$X_v$ [$Ci/m^3$]** | **DCF [rem/hr/$Ci/m^3$]** | **DDE [rem]** | **DDE [rem]** | **DDE [rem]** | **DDE [rem]** | **DDE [rem]** |
| #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | 8.1700E+02 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |

# Dose to nearest member of public in the case of normal operations

Dose to an individual at the fence line surrounding the reactor

| Ventilation OFF (leakage) Normal Operations | | | |
|---|---|---|---|
| Gamma submersion dose at fence line | | | |
| Isotope | $C_{avg}$[Ci/m$^3$] | Eγ, avg (MeV) | rem |
| Ar-41 | TBD | 1.293 | TBD |

| Ventilation OFF (leakage) Normal Operations | | | |
|---|---|---|---|
| Beta submersion Dose at fence | | | |
| Isotope | $C_{avg}$[Ci/m$^3$] | $E\beta_{avg}$ [Mev] | rem |
| Ar-41 | TBD | 0.253 | TBD |

| Ventilation ON/OFF | | | | | | |
|---|---|---|---|---|---|---|
| Beta Dose rate from the volume cloud inside the reactor at fence | | | | | | |
| $D\beta \approx 1.1 \times E{+}3\ C\ E\beta_{,avg}$ [mrad/hr] | | | | | | |
| Isotope | $E\beta_{,avg}$ (keV) | mCi | C [μCi/g] | $\mu\beta$,t air | $e^{-\mu\beta,t}$ | Dsurf [mrad/hr] |
| Ar-41 | 0.253 | TBD | TBD | 13.25 | 1.755E-6 | TBD |

| Ventilation ON/OFF | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gamma Dose rate from the volume cloud inside the reactor at fence | | | | | | | | | | |
| Nuclides | Γ [rem/hr/Ci/m2] | $(r^2 + h^2)/h^2$ | A [Ci] | Time [hr] | half-life [hr] | $Avg_v$ [Ci/m3] ON | linear energy absorption coeff m$^{-1}$ | $Avg_v$ [Ci/m3] OFF | $Dose_v$ ON [rem] | $Dose_L$ OFF [rem] |
| Ar-41 | .69597 | 1.25 | TBD | 2000 | 1.83 | TBD | 3.5 | TBD | TBD | TBD |