Development of a Radiological and Nuclear Emergency Dose Assessment Program in a New Nuclear Nation – A Regulators Perspective

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The United Arab Emirates (UAE)

- The United Arab Emirates is a constitutional federation of seven emirates, formed in 1971:
  - Abu Dhabi,
  - Dubai,
  - Sharjah,
  - Ajman,
  - Umm al-Qaiwain,
  - Ra's al-Khaimah
  - Fujairah

- UAE lies along the south-eastern tip of the Arabian peninsula. Occupying an area of about 83,600 sq. km
Federal Authority for Nuclear Regulation (FANR)

- **FANR Formed in 2009 by the Nuclear Law:**
  - Independent regulator with respect to nuclear safety, security, radiation protection and safeguards in the UAE
  - One of FANRs roles includes establishing frameworks for emergency preparedness and response for nuclear and radiological facilities and activities
UAE Nuclear Power

• Currently 4 Korean APR1400 reactors under construction at Barakah:
  • Reference plants are Shin Kori 3 and 4 (under construction in Korea)
  • Unit 1 – commercial operation 2017
  • Remaining units, 2018, 2019, and 2020
  • When complete – 25% of UAEs electrical needs
  • FANR received the Operating License Application for Units 1 and 2 in March 2015
  • Fuel receipt - 2016
Nuclear Emergencies
Nuclear Emergencies - RASCAL

- FANR using RASCAL (version 4.3)
- US-NRC Code, developed over 25 years ago, continuously improved, includes Fukushima updates:
  - Multi-unit release
  - Increased calculation distance to 100 miles
  - Atmospheric transport
  - LTSBO
  - + others
RASCAL Customization Plan

• Without customization, only includes USA NPP and facilities

• FANR needed to customize to add Barakah units:
  • Gather Inputs from license application documents:
    • PSAR
    • EIA
    • NCMS
    • RASCAL manual
    • Verify against FSAR
  • Prepare Basis Document
  • Update and control RASCAL
  • Add customized files to all RASCAL PCs
How to Customize RASCAL (1)

- To add new sites RASCAL needs:
  - Modified Facility_NRC-430.mdb:
    - Climate data
    - Climate UF$_6$ – since N/A, fill with 0’s
    - Facility data
    - Met tower data
    - Site data
    - Site met stations
  - Hundreds of parameters – needs careful checking!
How to Customize RASCAL (2)

- Base Maps on multiple scales
  - From Google earth, and satellite
- Two empty folders which will hold met data when running RASCAL
- BNPP.gz0
  - Surface roughness file
  - 22 x 22 grid
    - 10.0, 5.0, 2.5, and 1.0 mile grid spacing
  - Roughness from satellite images and EPA AERSURFACE
- BNPP.top
  - Topography file
  - From Earth Explorer (GTOPO30)
RASCAL Training

- ~10 half day training modules
- Training ~10 FANR staff to use RASCAL + understanding protective actions
- Training for other departments to understand RASCAL capabilities (EMs, NSD, SRO, etc.)
- Once trained – periodic refresher training + drills
- Take part in full scale UAE exercises
- Training in other tools, such as SPADES+ and BARAM
Radiological Emergencies
Radiological Emergencies

- FANR elected to use IAEA TECDOC 1162, ‘Generic Procedures for Assessment and Response During a Radiological Emergency’, dose assessment methodology as described in Section E:
  - Point sources
  - Line and spill sources
  - Ground contamination – Exposure (internal + external) from contaminated ground, factoring in resuspension
  - Skin contamination – Beta
  - Inhalation – Exposure to airborne radionuclides, incorporating material fire release fractions, release rate, dispersion factors, wind, stability class, etc.
  - Ingestion
  - Air immersion
- All supplemented by other codes, such as RASCAL, IMBA, MicroShield, etc.
Why Develop a Software Tool for 1162?

- TECDOC requires multiple unit conversions, reading values from graphs, finding values in tables, etc.
- Takes time to use in a calculation and may result in errors under stressful conditions
- Developed software – easier/faster to change based on user requests
**Radiological Emergency Calculation Tool (RECT)**

- FANR developed RECT using Macro enabled Excel spreadsheet:
  - One tab per exposure type
  - Data tab containing all tables, graphs, etc. (locked)
  - All cells locked – except inputs (in red)
  - Dropdown menus for most inputs/unit selections
  - Summary sheet summarizing inputs/outputs
  - Warning when parameters outside of expected range
- Prepared documentation to support RECT
Radiological Emergency Calculation Tool (RECT)

Summary Page

Exposure Types | Effective Dose (mSv) | Report Information
--- | --- | ---
E1 - Point Source | - | Calculation completed: date/time
E2 - Line Source | - | Calculation By:
E3 - Ground Contamination | - | Input Information Source:
E4 - Skin Dose | - | Written data/message (attach)
E5 - Dispersion + CED (Internal) | - | Phone call/conversation
E5a - Fire Dispersion and CED | - | Other
E6 - Ingestion | - | Party
E7 - Air Immersion | - |
TOTAL | - mSv |

Data Applicability Information

Date of Exposure:
Start Time of Exposure:
End Time of Exposure:
Total Exposure Time:
Location of Exposure:
Names of Exposed Individuals/Groups:

Notes:

Inputs to Determine External Dose from a Line Source and Spill

Instructions
1. Enter only values in red; the remainder are calculated using basic unit conversions
2. The final dose is determined using the methodology detailed in IAEA-TECDOC-1182 (E2) which is shown on the "Data" tab

INPUTS (Line Source)
- Radionuclide: Co-60 unitless
- Source Activity:
  - $0.00E+00$ kBq/m
  - $0.00E+00$ kBq/m²
  - $0.00E+00$ µCi/cm
  - $0.00E+00$ Ci/m²
- Distance from Source: 0.50 m
  - 1.64 ft
- Vertical Distance from Center of Spill: 100.00 m
  - 328.08 ft
- Spill Radius: 1.00 m
  - 3.28 ft
- Exposure Duration: 1.00 hours
  - 60.00 mins

INPUTS (Spill Source)
- Radionuclide: Cs-137 unitless
- Source Activity:
  - $0.00E+00$ kBq/m²
  - $0.00E+00$ Ci/m²
- Vertical Distance from Center of Spill: 325.08 m
- Spill Radius: 1.00 m
- Exposure Duration: 1.00 hours
  - 60.00 mins

OUTPUTS (Line Source)
- (mGy/h)/(kBq): 3.69E-07
- (mSv/h)/(kBq): 2.59E-07

OUTPUTS (Spill Source)
- (mGy/h)/(kBq): 9.56E-08
- (mSv/h)/(kBq): 6.26E-08

Effective Dose: $0.00E+00$ mSv
Dose Rate: $0.00E+00$ mSv/h
Radiological Emergency Calculation Tool (RECT)

Instructions
1. Enter only values in red, the remainder are calculated using basic unit conversions.
2. The final dose is determined using the methodology detailed in IAEA-TECDOC-1162 (E3) which is shown on the "Data" tab.

INPUTS
- Radionuclide: Co-60 unitless
- Average Ground Deposition: 0.00E+00 kBq/m²
- Shielding Factor: 0.70 unitless
- Occupancy Factor: 0.60 unitless
- Exposure Duration: 730.00 hours, 43,800.00 mins

Use the equation:

\[E_{eq} = \sum \left( \frac{C_{ij} \cdot CF_{ij}}{kBq/m^2} \right)\]

Here:
- \(E_{eq}\) = Effective dose from deposition for the period of concern [mSv]
- \(C_{ij}\) = Average deposition (ground) concentration of radionuclide \(i\) [kBq/m²]
- \(CF_{ij}\) = Conversion factor from Table E3; effective dose per unit deposition for radionuclide \(i\); includes external dose and committed effective dose from inhalation due to resuspension resulting from remaining on contaminated ground for the period of concern.
- \(i\) = Number of radionuclides

GUIDANCE FOR SHIELDING FACTORS

<table>
<thead>
<tr>
<th>Structure or location</th>
<th>Representative SF (i)</th>
<th>Representative range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m above an infinite smooth surface</td>
<td>1.0</td>
<td>-</td>
</tr>
<tr>
<td>1 m above ordinary ground</td>
<td>0.7</td>
<td>0.47-0.85</td>
</tr>
<tr>
<td>One and two-story wood-frame house (no basement)</td>
<td>0.4</td>
<td>0.2-0.5</td>
</tr>
<tr>
<td>One and two-story brick and block house (no basement)</td>
<td>0.2</td>
<td>0.04-0.4</td>
</tr>
<tr>
<td>House basement, one or two walls fully exposed - one story; less than 1 m of basement wall exposed - one story, less than 1 m of basement wall exposed - one story, less than 1 m of basement wall exposed - one story, less than 1 m of basement wall exposed</td>
<td>0.1</td>
<td>0.05, 0.03-0.15, 0.03-0.07</td>
</tr>
<tr>
<td>Three or four story structures (500 to 1000 m² per floor)</td>
<td>0.05</td>
<td>0.01-0.08, 0.001-0.07</td>
</tr>
<tr>
<td>Multi-story structures (&gt; 1000 m² per floor)</td>
<td>0.01</td>
<td>0.001-0.07</td>
</tr>
</tbody>
</table>

Dropdown menu for easy selection
Equations showing basis of RECT
Guidance for parameter selection
RECT Training

• Training provided for each exposure type for selected FANR staff
• Quiz completed by each trainee after training – based on UAE type sources/scenarios
• Review class after quiz completed
• **Resulted in several changes to RECT based on user feedback:**
  • Unit conversions
  • Warnings if parameters outside of ‘likely’ range
  • Pictures explaining geometry types
  • Clearer wording for inputs/outputs
• Refresher training in future
Future.....

- Drills/exercises
- Refresher training
- Nuclear exercises:
  - Prior to fuel receipt
  - Prior to fuel load
Thank you!

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www.fanr.gov.ae