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Comparison of AEGL and ERPG/TEEL values for ALOHA Modeling

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U.S. DEPARTMENT OF ENERGY
National Nuclear Security Administration

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Issue

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- SNL Determine if Update to Screening Criteria Necessary
- SNL Adopted ERPG3 with 15 min Duration as Screening Criteria to Evaluate Facility Hazard Classification
- Current Protection Action Criteria (PACs)
  - AEGLS
  - ERPG
  - TEEL
- Hierarchy of values 60-minute AEGLs > ERPGs >TEELs

Issue

Acute Exposure Guideline Levels (AEGLs)

- Estimate the concentrations at which most people (including sensitive individuals) begin to experience health effects if they are exposed to a hazardous chemical for a specific length of time
- In November 2011, the National Advisory Committee for AEGLs was eliminated and the AEGL development process was modified
- Future development work on the AEGLs will focus on finalizing interim AEGLs through the National Academy of Sciences
- Derived from extensive reviews of animal and human studies
- As of early 2012, about 70 substances have final AEGLs and nearly 200 substances have interim AEGLs
- Three tiers are developed for five exposure periods: 10 minutes, 30 minutes, 60 minutes, 4 hours, and 8 hours

Issue

Acute Exposure Guideline Levels (AEGLs)

- **AEGL-3** - airborne concentration above which the general population could experience life-threatening health effects or death

- **AEGL-2** - airborne concentration above which the general population could experience irreversible other serious, long-lasting adverse health effects or impaired ability to escape

- **AEGL-1** - airborne concentration above which the general population could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. Effects are not disabling and are transient and reversible upon cessation of exposure

Issue

Emergency Response Planning Guidelines (ERPGs)

- Estimate the concentrations at which most people (excluding sensitive individuals) will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour
- Developed by the Emergency Response Planning committee of the American Industrial Hygiene Association
- Derived from extensive reviews of animal and human studies
- As of early 2012, about 145 chemicals have ERPGs
- experiencing other than mild transient health effects or perceiving a clearly defined, objectionable odor

Issue

Emergency Response Planning Guidelines (ERPGs)

- **ERPG-3** - maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects

- **ERPG-2** - maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action

- **ERPG-1** - maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient health effects or perceiving a clearly defined, objectionable odor

Issue

Temporary Emergency Exposure Levels (TEELs)

- Estimate the concentrations at which most people (including sensitive individuals) will begin to experience health effects if they are exposed to a hazardous airborne chemical for a given duration
- Derived by the U.S. Department of Energy Subcommittee on Consequence Assessment and Protective Actions (SCAPA) according to a specific, standard methodology
- Development methodology uses available levels of concern and manipulates current data using a peer-reviewed, approved procedure in order to establish the TEELs
- More than 3,000 chemicals have TEELs

Issue

Temporary Emergency Exposure Levels (TEELs)

- **TEEL-3** - airborne concentration of a substance above which it is predicted the general population could experience life-threatening adverse health effects or death

- **TEEL-2** - airborne concentration of a substance above which it is predicted the general population could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape

- **TEEL-1** - airborne concentration of a substance above which it is predicted the general population could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects. Effects are not disabling and are transient and reversible upon cessation of exposure

Issue

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- AEGLs
  - Based upon “better data”
  - Duration based values
  - Do not exist for all SNL listed toxics
- Apply a “Safety Factor” (i.e., 15 min release) to AEGLs?
  - More exact numbers
  - Based on real data
- Use 10, 20, 30 or 60 min Duration?

Issue

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AEGL Exposure Period Example

Germane (ppm)

	10 min	30 min	60 min	4 hr	8 hr
AEGL 1	1.0	1.0	1.0	1.0	1.0
AEGL 2	150	50	25	13	13
AEGL 3	740	250	120	31	31

Chlorine (ppm)

	10 min	30 min	60 min	4 hr	8 hr
AEGL 1	0.50	0.50	0.50	0.50	0.50
AEGL 2	2.8	2.8	2.0	1.0	0.71
AEGL 3	50	28	20	10	7.1

Current Evaluation Method

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- ALOHA 5.4.3
- 95% or 50% atmospheric / meteorological data
  - Evaluation used 95% atmospheric / meteorological data
- ERPG-3, if none, use TEEL-3
- Apply “Safety Factor” of 4 to ERPG / TEEL
  - Release duration 15 min.
  - Release rate = quantity/15 min
- For Comparative Analysis Use 10 lb. release

95% ALOHA Model Protocol

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- Location = Kirtland AFB, New Mexico
  - Latitude 35.2.0 N
  - Longitude 106.32.0 W
- Wind Tower Height = 10m
- Surface Roughness = Open Space
- Cloud Cover = Clear Skies
- Temperature = 20^{o}C
- Relative Humidity = 25%
- Inversion Height = 300 m
- Wind Speed = 1.5 m/s
- Stability Class = F

Source Input

Sandia National Laboratories

ERPG/TEEL

- Continuous Release
- Release Qty. = 10 lb.
- Release Duration = 15 min
- Release Rate = 303.0 g/min
  (10 lb./15 min)
- "Safety Factor" = 4

AEGL

- Continuous Release
- Release Qty. = 10 lb.
- Release Duration = 60 min
- Release Rate = 75.7 g/min
  (10 lb./60 min)
- "Safety Factor" = N/A

Published PAC Values (60 min)

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Chemical	PAC-3 (ppm)		
	AEGL-3	ERPG-3	TEEL-3
Ammonia	1100	750	n/a
Boron Trichloride	n/a	n/a	2.1
Carbon Monoxide	330	500	n/a
Chlorine	20	20	n/a
Dichlorosilane	50	n/a	n/a
Fluorine	13	20	n/a
Germane	0.5	n/a	n/a
Hydrogen Bromide	120	n/a	n/a
Nitrous Oxide	n/a	n/a	20000
Silane	270	n/a	n/a

Assumptions / Limitations

Sandia National Laboratories

- ALOHA 5.4.3 information is current/correct
- No AEGL / ERPG, PAC=TEEL
- AEGL and ERPG/TEEL not available for all chemicals
- Met data will vary based on the site, therefore varying the results of the model run
- 4 of 10 chemicals evaluated had both AEGL and ERPG/TEEL

Preliminary Modeling Data

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Chemical	Release Time (min)		Threat Zone Radius (m)			Concentration @ 100m (ppm)		
	AEGL	ERPG/ TEEL	AEGL-3	ERPG-3	TEEL-3	AEGL	ERPG	TEEL
Ammonia	60	15	30.00	72.00	n/a	99.40	397.00	n/a
Boron Trichloride	60	15	n/a	n/a	466.00	n/a	n/a	22.70
Carbon Monoxide	60	15	42.00	69.00	n/a	60.40	241.00	n/a
Chlorine	60	15	83.00	159.00	n/a	15.00	40.90	n/a
Dichlorosilane	60	15	35.00	n/a	n/a	9.83	n/a	n/a
Fluorine	60	15	162.00	262.00	n/a	31.40	101.00	n/a
Germane	60	15	634.00	n/a	n/a	13.60	n/a	n/a
Hydrogen Bromide	60	15	23.00	n/a	n/a	12.80	n/a	n/a
Nitrous Oxide	60	15	n/a	n/a	11.00	n/a	n/a	77.80
Silane	60	15	36.00	n/a	n/a	40.00	n/a	n/a

Ammonia

AEGL-3

99.4 ppm @ 100m

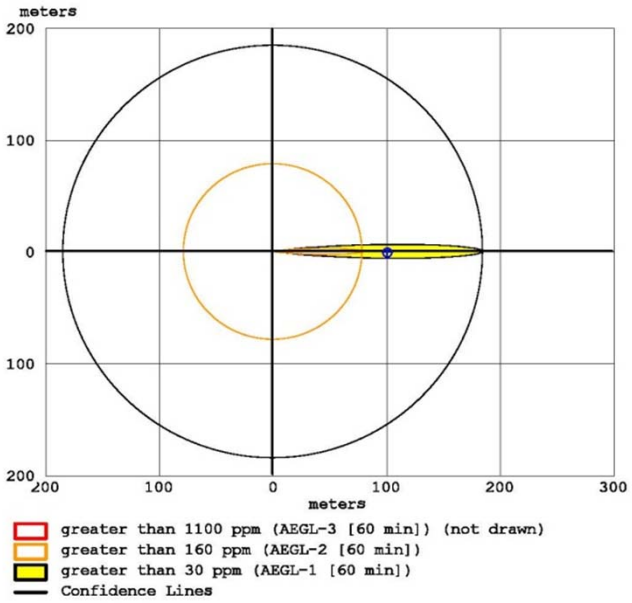
Toxic Threat Zone ALOHA® 5.4.3

```
Time: April 19, 2012  1001 hours MDT (using computer's clock)

Chemical Name: AMMONIA

Wind: 1.5 meters/second from E at 10 meters

THREAT ZONE:
  Model Run: Gaussian
  Red    : 30 meters --- (1100 ppm = AEGL-3 (60 min))
  Note: Threat zone was not drawn because effects of near-field patchiness
     make dispersion predictions less reliable for short distances.
  Orange: 78 meters --- (160 ppm = AEGL-2 (60 min))
  Yellow: 185 meters --- (30 ppm = AEGL-1 (60 min))
```



ERPG-3

397.0 ppm @ 100m

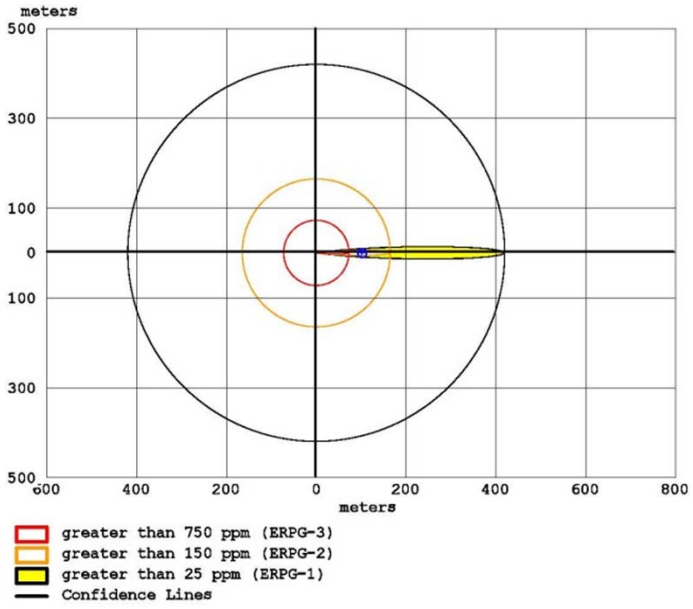
Toxic Threat Zone ALOHA® 5.4.3

```
Time: April 5, 2012  1006 hours MDT (using computer's clock)

Chemical Name: AMMONIA

Wind: 1.5 meters/second from E at 10 meters

THREAT ZONE:
  Model Run: Gaussian
  Red    : 72 meters --- (750 ppm = ERPG-3)
  Orange: 164 meters --- (150 ppm = ERPG-2)
  Yellow: 420 meters --- (25 ppm = ERPG-1)
```



Carbon Monoxide

AEGL-3

60.4 ppm @ 100m

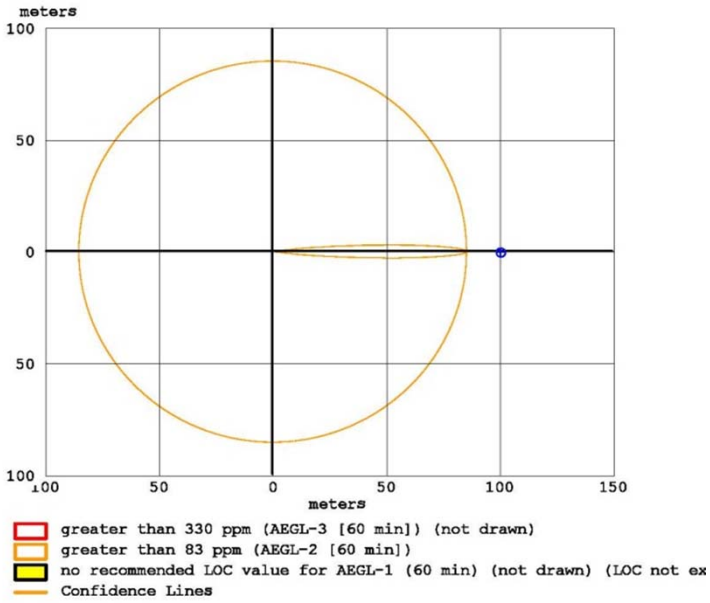
Toxic Threat Zone ALOHA® 5.4.3

```
Time: April 19, 2012  1001 hours MDT (using computer's clock)

Chemical Name: CARBON MONOXIDE

Wind: 1.5 meters/second from E at 10 meters

THREAT ZONE:
  Model Run: Gaussian
  Red    : 42 meters --- (330 ppm = AEGL-3 (60 min))
  Note: Threat zone was not drawn because effects of near-field patchiness
     make dispersion predictions less reliable for short distances.
  Orange: 85 meters --- (83 ppm = AEGL-2 (60 min))
  Yellow: no recommended LOC value --- (N/A = AEGL-1 (60 min))
```



ERPG-3

241 ppm @ 100m

Toxic Threat Zone ALOHA® 5.4.3

```
Time: April 7, 2012  1607 hours MDT (using computer's clock)

Chemical Name: CARBON MONOXIDE

Wind: 1.5 meters/second from E at 10 meters

THREAT ZONE:
  Model Run: Gaussian
  Red    : 69 meters --- (500 ppm = ERPG-3)
  Orange: 83 meters --- (350 ppm = ERPG-2)
  Yellow: 110 meters --- (200 ppm = ERPG-1)
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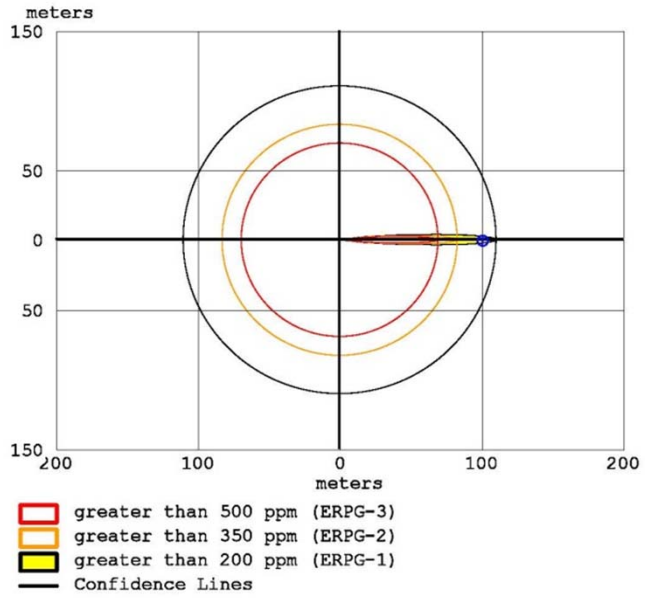
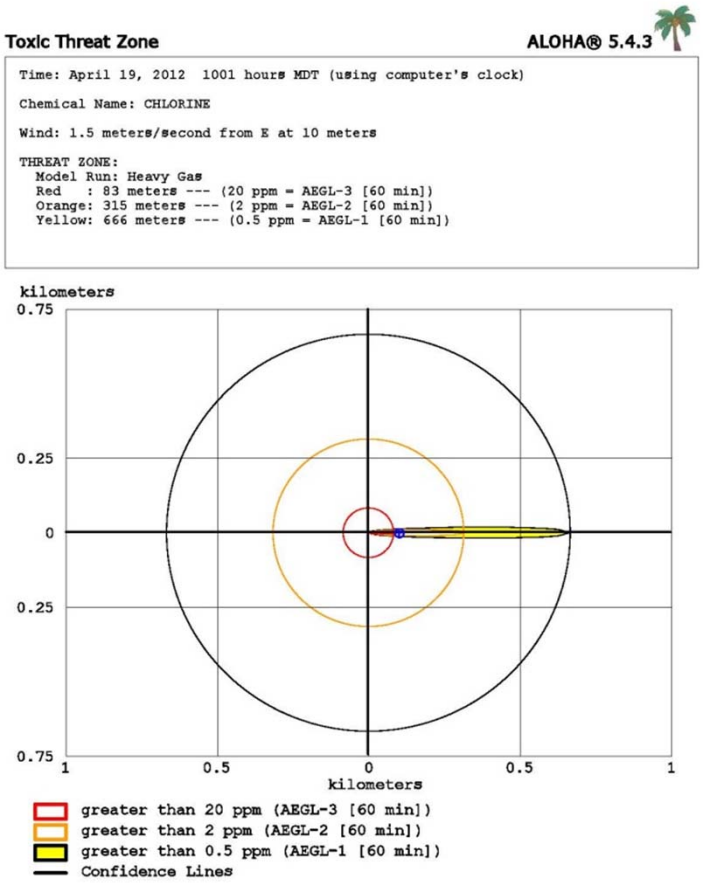


Chlorine

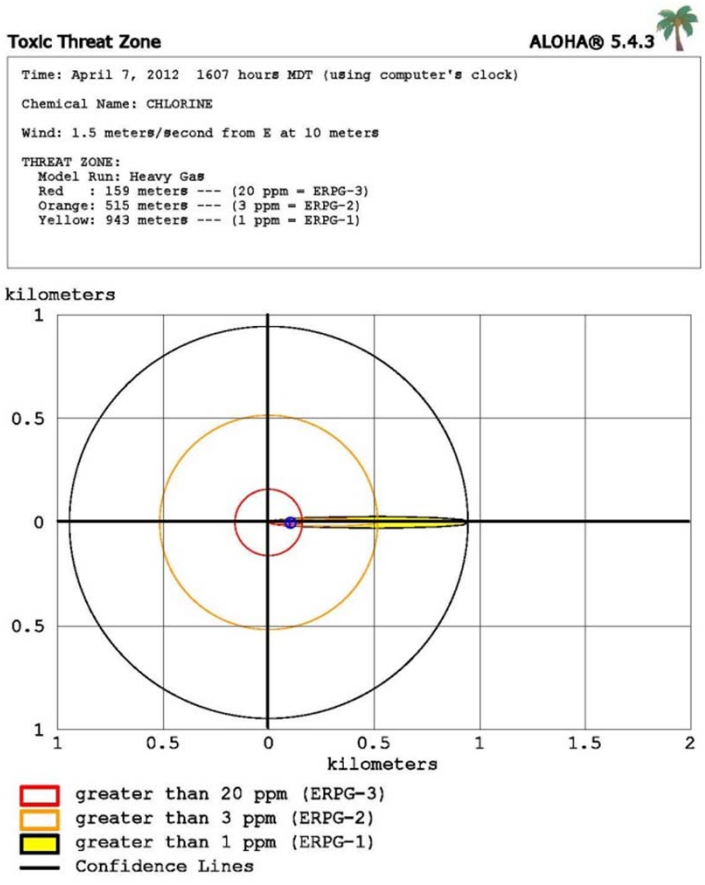
AEGL-3

15 ppm @ 100m



ERPG-3

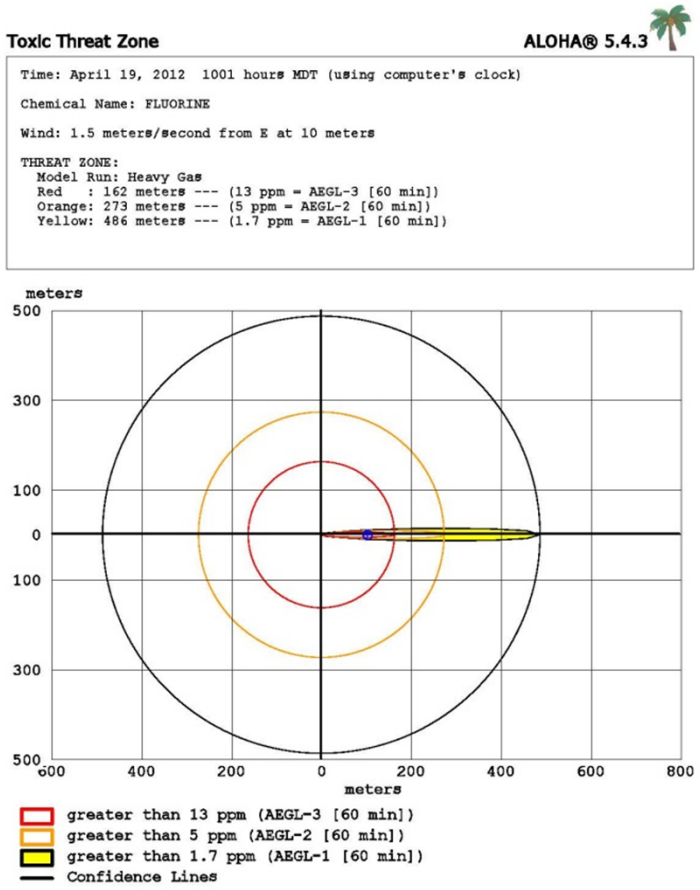
40.9 ppm @ 100m



Fluorine

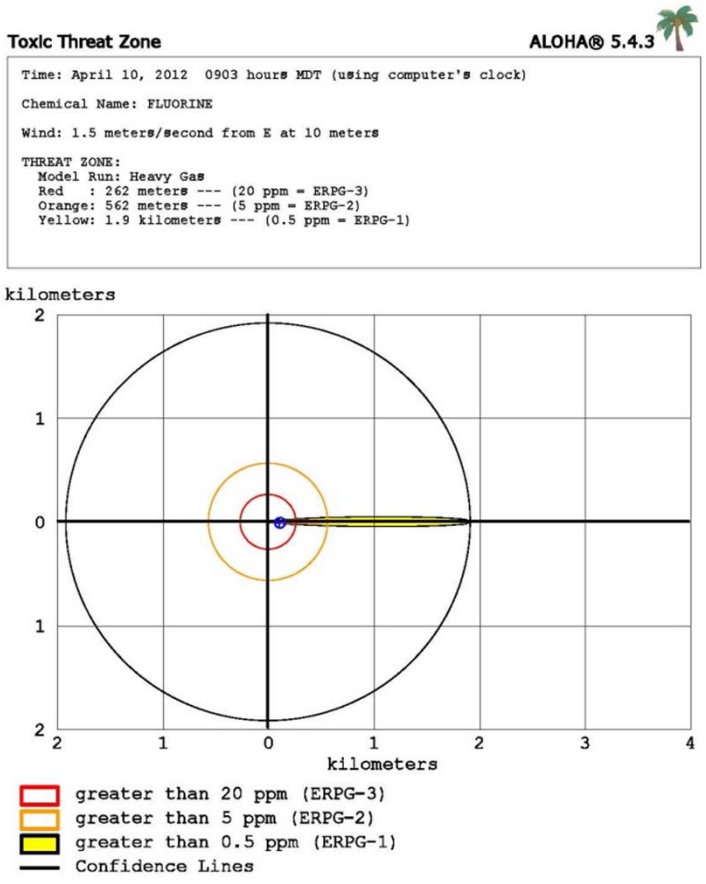
AEGL-3

31.4 ppm @ 100m



ERPG-3

101 ppm @ 100m



Conclusions

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- Based on Data:
  - ERPG-3/TEEL-3 is more conservative
  - AEGL-3 shows lower concentration at a closer distance
- Need more AEGLs to be published
- Compare new AEGL values to old ERPG values
- More information is required to make further conclusions on validity of using AEGLs vs. ERPG/TEELs

Recommendations

Sandia National Laboratories

- Stay with current ERPG-3 methodology

- Additional Evaluation Recommended:
  - No “Safety Factor” applicability for AEGLs
  - Switch between newly adopted AEGLs and old ERPG values
  - Use 10-min or 20-min AEGLs with corresponding release duration