

Ask Dr. ALOHA: Working with Toxic and Odor Thresholds

At the Port of Oceanside City, Coast Guard Lieutenant Jim Holland has just received a radio message from the captain of an inbound vessel. A container on the vessel deck appears to be slowly leaking ethyl mercaptan (ethanethiol), and crew members have observed that a small pool of liquid has formed on the deck next to that container. While the vessel is underway, the crew can't stop the leak—it seems to be coming from a leaking valve next to the side of the container, where they can't reach it. The vessel is scheduled to arrive at Oceanside City within a few hours.

Because ethyl mercaptan is strong-smelling, even at low concentrations, it is commonly used as an additive to propane gas (which is odorless) so that people can detect gas leaks. At higher concentrations, though, its vapor is toxic. Therefore, Jim's first order of business is to decide whether to allow the vessel to enter port as planned, or to redirect it to a less populated location. Before making that decision, he wants to assess the level of toxic hazard that the vessel could pose to the city if the vessel enters port. To get this estimate, he turns to ALOHA.

Choosing a Toxic Level of Concern

To use ALOHA, he first must choose a **level of concern** (LOC)—the concentration of ethyl mercaptan gas in air that represents the hazard of concern. Because Jim is concerned about the toxic effects of ethyl mercaptan, he needs to choose a toxic threshold.

ALOHA contains two common **toxic LOCs** for ethyl mercaptan:

- The **IDLH** (Immediately Dangerous to Life and Health) limit, and
- The three-level **TEEL** (Temporary Emergency Exposure Limit).

The IDLH limit is used mainly to assist in making decisions regarding respirator use. The limit represents the concentration of a chemical in the air to which healthy adult workers could be exposed (if their respirators fail) without suffering permanent or escape-impairing health effects.

TEELs—ALOHA's default option for ethyl mercaptan—are designed to represent the predicted response of nearly all members of the general public to different concentrations of a chemical during a chemical incident, over a period of about an hour:

- TEEL-1 predicts irritations and other minor health effects.
- TEEL-2 predicts irritating, but reversible, health effects.
- TEEL-3 predicts serious impacts, perhaps death of compromised individuals.

Jim knows that **workplace exposure limits** (such as the IDLH limit) are not designed for public exposure situations. Workplace limits are designed to protect healthy, adult workers. Because age, health, and exertion influence how susceptible people will be to a pollutant, it's possible that some workplace limits may underestimate risk to the sensitive portions of the general population (such as elderly people, children, pregnant women, and people who are sick).

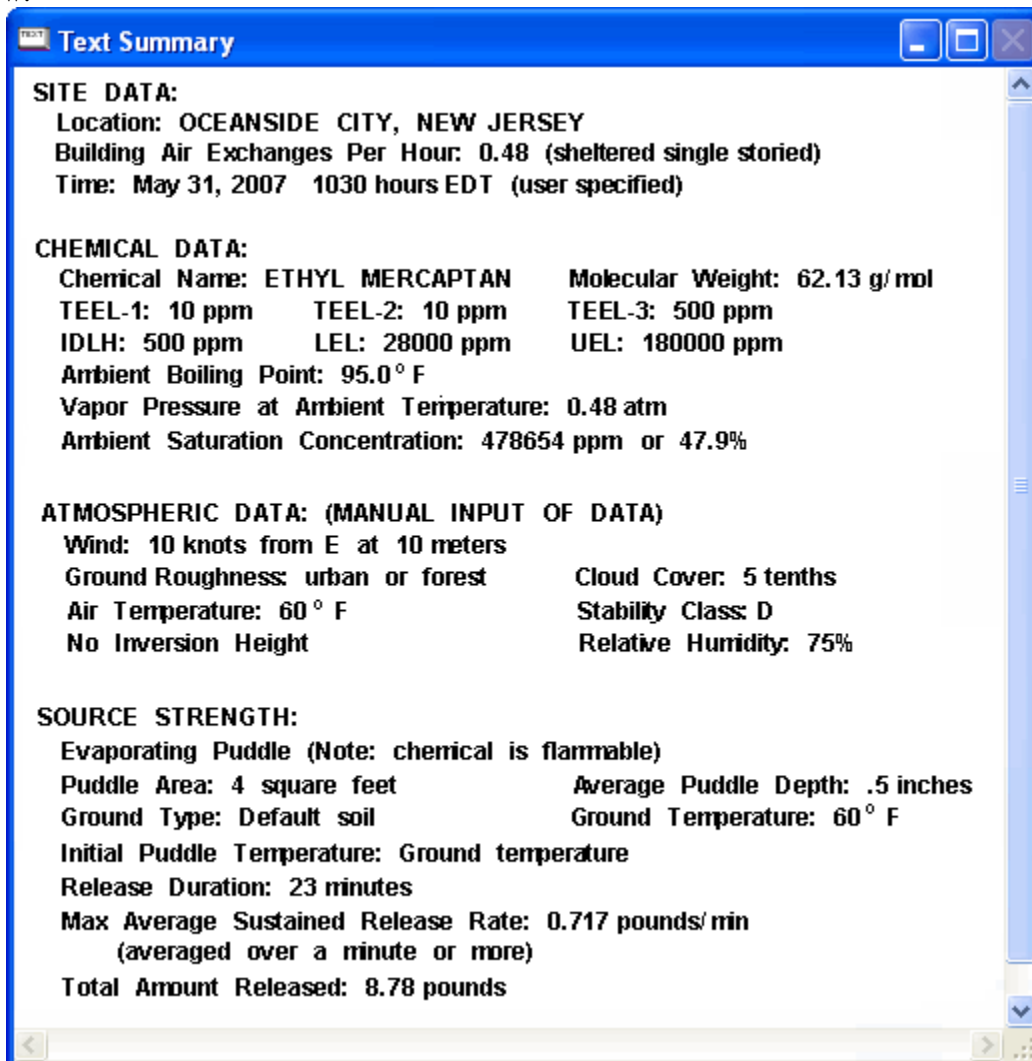
Jim also knows that ALOHA recommends using a **public exposure guideline** (such as TEELs) when they are available. TEELs are meant to be temporary best guesses, to be replaced by **ERPGs** and then **AEGLs** once those public exposure guideline values are defined. However, neither ERPGs nor AEGLs have been defined for ethyl mercaptan. So, given the available LOCs, Jim decides to use the TEEL values to assess the hazard, because they are the best fit for his situation.

Entering Scenario Information in ALOHA

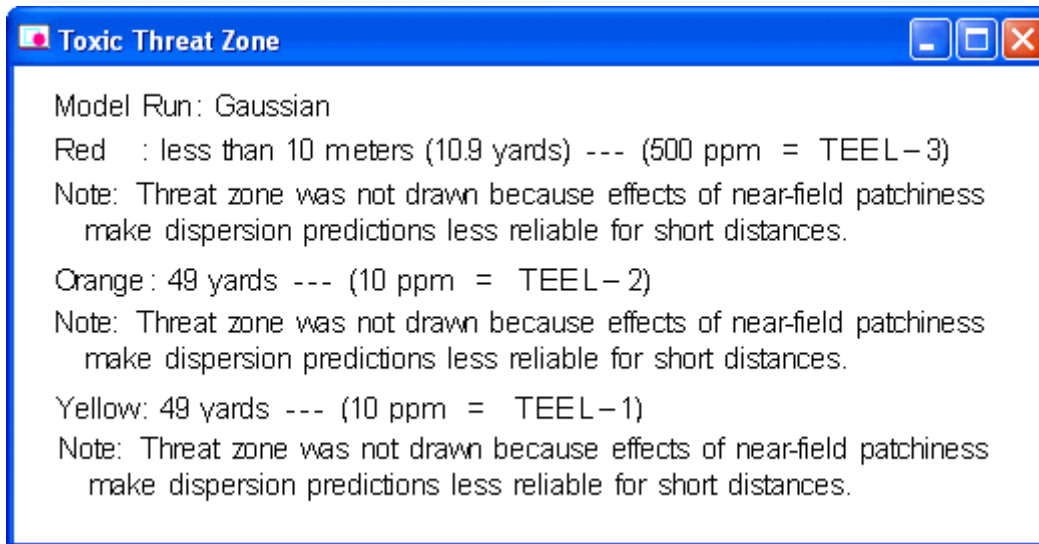
Jim starts ALOHA and begins to enter information about the spill scenario. To assess the hazard to Oceanside City, he assumes that the vessel, still leaking ethyl mercaptan, has docked at the port (which is adjacent to the main business district). He calls the National Weather Service to obtain information about the expected weather conditions for the vessel's estimated arrival time and location. He is especially concerned to hear that the prevailing wind would blow the ethyl mercaptan vapors from the dock directly into the city. He enters these weather conditions into ALOHA. However, Jim knows that if the vessel does end up docking in port, he'll need to get updated weather information and re-run the scenario.

The vessel captain told him that crew members observed a small pool of ethyl mercaptan liquid on the ship's deck. They estimated the pool to be shallow and about 2 feet by 2 feet in area. From ALOHA's SetUp menu, Jim chooses the Puddle source option, and enters information about the puddle, guesstimating that it's about half an inch deep and at ambient temperature. He'll revise these entries and run ALOHA again if more information about the puddle becomes available. Given that the ethyl mercaptan is still leaking, Jim will make a point of checking back with the vessel captain from time to time to learn whether the pool has expanded in area.

When Jim has finished entering information about the scenario, his Text Summary screen looks like the one below.



Next, Jim selects Threat Zone from the Display menu. A dialog box appears asking him to choose the hazard he wants to analyze. Based on the scenario information Jim entered, ALOHA can model three hazards: toxic area of a vapor cloud, flammable area of a vapor cloud, or blast area of a vapor cloud explosion. Jim selects the toxic area option. A Toxic Level of Concern dialog box appears. Because Jim is using ALOHA's default TEEL options, he just clicks OK and ALOHA models the release.



Jim sees that ALOHA predicts that ethyl mercaptan vapors would pose a serious hazard to people only within a few yards downwind of the puddle. People are predicted to be most severely affected only within 11 yards of the puddle, and less seriously affected within 49 yards. These results indicate that ethyl mercaptan's toxic vapors could be a serious concern for people close to or on the deck of the vessel. However, Jim knows that ALOHA's prediction is only a ballpark estimate of the real area where concentrations may reach toxic levels. He will be alert to any new information about weather conditions or the circumstances of the spill and ready to run ALOHA with new information if necessary.

Jim advises the vessel captain to make sure that none of the ethyl mercaptan is leaking into the vessel or pooling in other confined spaces. Outside, on the deck of the vessel, the vapor from the evaporating puddle mixes quickly with the air and the concentration of the ethyl mercaptan vapor in the air remains low. However, in confined spaces, the concentration may rise high enough to present toxic and flammable hazards.

Estimating the "Phone Call Zone"

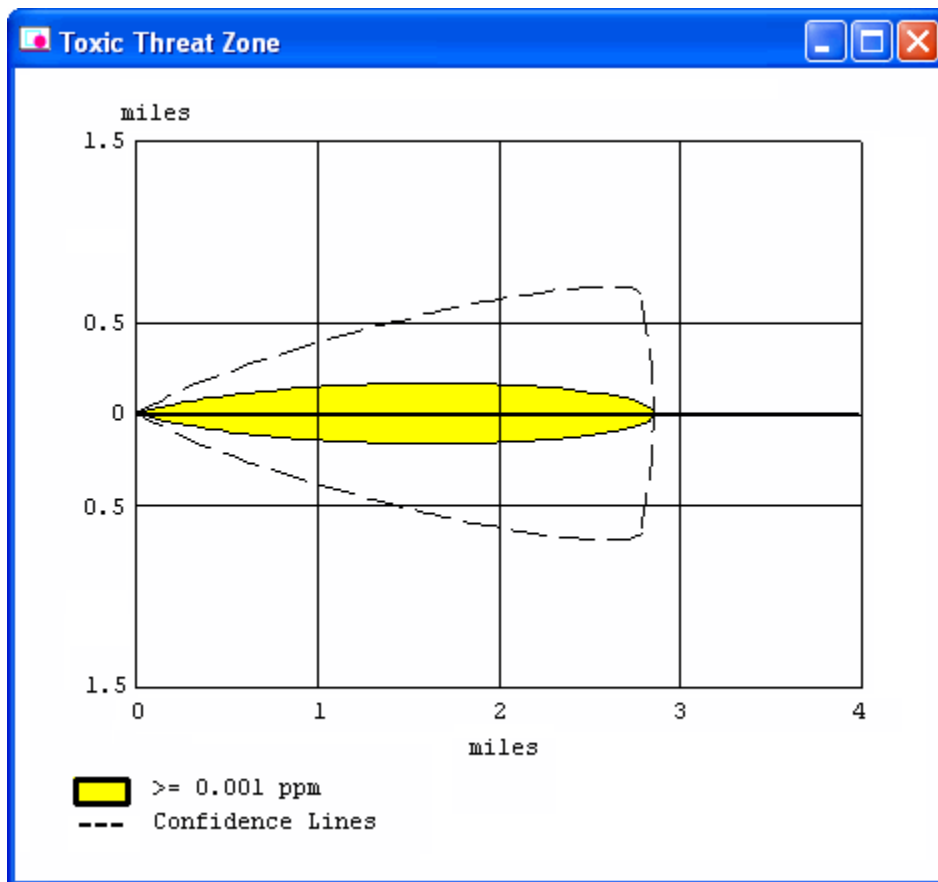
Jim has not finished his work with ALOHA. He knows that ethyl mercaptan has a very strong, unpleasant odor and that people may associate it with a gas leak. He also knows that during previous incidents, people have become very concerned when they smelled a spilled chemical. Jim would like to estimate the area where people might smell ethyl mercaptan vapors, even when chemical concentrations are well below toxic levels. Within this "phone call zone", people may call emergency services for information, report to local hospitals, or, in this case, call to report a gas leak. Jim wants to account for this possibility in his decision-making.

An odor threshold can be useful in emergency planning and response as a crude estimate of the phone call zone. A chemical's odor threshold is the lowest concentration of that chemical in air that people can smell. Ethyl mercaptan has a very low odor threshold, so most people will smell it even at very low

concentrations. Jim realizes that odor thresholds are imprecise measurements (because people naturally vary widely in their sensitivity to odors), but he just wants to get a rough estimate of the size of the phone call zone.

To estimate the phone call zone, Jim will use ethyl mercaptan's estimated odor threshold as his LOC in ALOHA. When he does this, ALOHA's threat zone will represent the phone call zone. He checks the U.S. Coast Guard CHRIS (Chemical Hazards Response Information Systems) manual and finds an estimate of 0.001 parts per million (ppm) as the approximate odor threshold of ethyl mercaptan. Actually, since odor thresholds are so imprecise, researchers normally report them as ranges rather than exact numbers (check Table 1, below, to see that these ranges can be very wide for some chemicals).

To use this odor threshold estimate in ALOHA, Jim selects Threat Zone again from the Display menu. He chooses the toxic area of a vapor cloud option, and then the Toxic Level of Concern dialog box appears again with the TEEL defaults selected. In the Yellow Threat Zone LOC pulldown list, Jim selects User Specified and types in 0.001 in the box that appears and selects ppm units. For the Red and Orange Threat Zone LOCs, Jim chooses None in the pulldown list.



He sees that ALOHA predicts that the phone call zone could extend for more than 2 miles downwind, as the threat zone above shows. This prediction suggests to Jim that widespread public concern could develop in Oceanside City, if the vessel were to dock at the port. Again, he bears in mind the fact that this threat zone is just a ballpark estimate of the real area where people may detect ethyl mercaptan. People with especially sensitive noses may detect ethyl mercaptan's odor at distances farther from the vessel than the threat zone indicates. Others with poorer senses of smell may not detect the odor even if they are well

within the area covered by the threat zone. Still, Jim is glad to have at least a general idea of the extent of the area where public anxiety could be high.

Having obtained ballpark estimates of the potential area where a toxic threat could develop if the vessel were to enter port, as well as the potential area where people might smell the chemical and contact emergency services, Jim now feels better prepared to decide whether to allow the vessel to enter port.

Table 1: Odor thresholds in parts per million of some ALOHA chemicals

Chemical	U.S. Coast Guard CHRIS Manual	American Association of Railroads	American Industrial Hygiene Association
Acetaldehyde	0.05	0.01-0.031	0.0028-10000
Acetone	100	0.66-320	0.037-0.15
Ammonia (anhydrous)	46.8	0.037-20	0.043-53
Benzene	4.68	0.16-320	0.78-160
Carbon monoxide	odorless	odorless	odorless
Carbon tetrachloride	>10	15-50	1.6-706
Chlorine	3.5	0.02-3.5	0.021-3.4
Cumene	1.2	-	0.0051-1.3
Cyclohexane	-	0.41	0.52-784
Dicyclopentadiene	<0.003	0.02	0.003-0.011
Ethylbenzene	140	0.25-2.3	0.092-0.60
n-Hexane	-	-	65-248
Hydrogen sulfide	0.0047	0.13	0.00007-1.4
Phosgene	0.5	0.125-1	0.12-5.7
Styrene monomer	0.148	0.02-0.47	0.0047-61
Sulfur dioxide	3	3	0.33-5
Toluene	0.17	0.17-40	0.021-69
Vinyl chloride	260	260-25,000	-
o,m,p- Xylene	0.05	0.2-4	0.081-5.4

References

- **American Association of Railroads (AAR)** The official AAR site (<http://www.aar.org/>). The AAR odor threshold values in the table above are from the AAR Bureau of Explosives' 1996 *Emergency Action Guides*. (Washington, DC: AAR.)
- **American Industrial Hygiene Association (AIHA)** The official AIHA site (<http://www.aiha.org/>). The AIHA odor threshold values in the table above are from a list AIHA published in 1989 called *Odor thresholds for chemicals with established occupational health standards*. (Akron, OH: AIHA.)
- **Chemical Hazards Response Information System (CHRIS)** The CHRIS odor threshold values in the table above are from the online version (<http://www.chrismanual.com/>) of the CHRIS Manual on this U.S. Coast Guard site.

For More Information

- AEGLs: <http://response.restoration.noaa.gov/aegls>
- ALOHA: <http://response.restoration.noaa.gov/aloha>
- ALOHA Tools: <http://response.restoration.noaa.gov/alohatools>
- Ask Dr. ALOHA Articles: <http://www.response.restoration.noaa.gov/ADA/overview>
- ERPGs: <http://response.restoration.noaa.gov/erpgs>
- IDLHs: <http://response.restoration.noaa.gov/idlhs>
- Levels of Concern: <http://response.restoration.noaa.gov/locs>
- Public Exposure Guidelines: <http://response.restoration.noaa.gov/pubexpguides>
- Toxic Levels of Concern: <http://response.restoration.noaa.gov/toxiclocs>
- TEELs: <http://response.restoration.noaa.gov/teels>
- Workplace Exposure Limits: <http://response.restoration.noaa.gov/workexplimits>