Position Paper
U.S. Army Corps of Engineers
Criteria for the Application of 29 CFR 1910.120 (HAZWOPER)

Background

The U.S. Army Corps of Engineers (USACE), based upon more than 10 years of past experience investigating and remediating hazardous, toxic, and radioactive waste (HTRW) sites across the county, has recognized and concluded that onsite activities most often result in non-measurable occupational exposures and almost never produce occupational overexposures to contaminants of concern in excess of published standards. Despite this continual observation, and the fact that, in many cases, sound industrial hygiene judgement can demonstrate that onsite activities will not result in significant occupational exposures, 29 CFR 1910.120/ 29 CFR 1926.65 (HAZWOPER) tends to be unilaterally applied to all hazardous waste site operations. This practice generally continues due to the fact that OSHA has not provided a good definition of the phrase "employee exposure or the reasonable possibility for employee exposure to safety or health hazards," as it is used in the HAZWOPER standard paragraph (a)(1). OSHA's draft responses to Corps of Engineers inquiries on this subject, and subsequent conversations between OSHA technical experts and the USACE HTRW Center of Expertise have made it clear that OSHA expects the Corps of Engineers to formulate their own criteria which can demonstrate the absence of occupational health hazards due to exposures to contaminants of concern, so that 29 CFR 1910.120/ 29 CFR 1926.65 may be judged not to apply to specific HTRW site work.

Objective

This position paper defines the occupational health hazard criteria which the USACE feels is worthy of HAZWOPER application (here-after referred to as "applicability criteria"), and provides procedures which are consistent with EPA risk assessment methodology and good construction practice for determining compliance with the applicability criteria. Results of example calculations have been provided in Table 1 to illustrate the level of environmental soil contamination necessary to exceed applicability criteria.

HAZWOPER Standard Applicability Criteria

It is assumed that the inhalation intake from occupational exposures at or below the PEL (or published exposure levels, e.g. a TLV) is acceptable to OSHA, and that a health hazard occurs only when this intake is exceeded. Acceptable intake via the inhalation pathway can be calculated according to the following standard EPA risk assessment method:

Acceptable Intake = C x IHR x ET x 1/BW (1)
(inhalation-based)
(C)-Concentration [mg/m^3] = PEL (or pub exp level)
(IHR)-Inhalation Rate [2.5m^3/hr] (5)
(ET)-Exposure time [8hr/day] (5)
(BW)-Body Weight [70kg] (5)
Acceptable Intake - [mg/kg-day]

Demonstration of Compliance with Applicability Criteria

Compliance with applicability criteria is demonstrated by determining the total worker intake via all occupational pathways (ingestion, dermal absorption and inhalation), without regard for the use of personal protective equipment. Intake from each of the individual pathways is estimated by the following standard EPA risk assessment methods:

Ingestion Intake = C x IGR x 1/BW (1)
(C)-Concentration [mg/kg] = Project-specific Soils Concentration
(IGR)-Ingestion Rate [$5x10^{-5}$kg/day] (5)
(BW)-Body Weight [70kg] (5)
Ingestion Intake - [mg/kg-day]

Dermal Intake (absorption) = C x AF x SA x 1/BW x ABS (1)
(C)-Concentration [mg/10^6mg] = Project-specific Soils Concentration
(AF)-Adherence Factor [2.7mg/cm^2] (1)
(SA)-Surface Area [3160cm^2] (1)
(BW)-Body Weight [70kg] (5)
(ABS)-Skin Absorption Factor [unitless] = Chemical Class Specific (4)
Dermal Absorption Intake - [mg/kg-day]

Inhalation Intake = C x IHR x ET x 1/BW (1)
(C)-Concentration [mg/m^3] *
(IHR)-Inhalation Rate [2.5m^3/hr] (3)
(ET)-Exposure Time [8hr/day] (5)
(BW)-Body Weight [70kg] (5)
Inhalation Intake - [mg/kg-day]

* The concentration used to calculate the inhalation intake is estimated by the techniques listed below, which take into account vapor and particulate matter emission rates and dilution in the atmosphere.

Volatile Organic Compound (VOC) Emission Rate

The VOC emission rate from excavating soils contaminated with volatile organic compounds is the sum of emission rates from the soil pore space and from diffusion and is expressed mathematically as follows:

$$ER = ER_{PS} + ER_{DIFF} \quad (2)$$

$$ER_{PS} = P \times Q \times 0.98 \quad (2)$$

$$ER_{DIFF} = \frac{(C_S)(10{,}000)(SA)}{\left(1.22\ X\ 10^6\ \frac{C_S}{P}\right) + \left(1.79\ X\ 10^9\ \frac{C_S}{P}\right)^{\frac{1}{2}}} \qquad (2)$$

where:

(ER)-total soil emission rate of compound [g/sec] (2)
(ER_{PS})-soil porosity emission rate of [g/sec] (2)
(ER_{DIFF})-diffusion emission rate of [g/sec] (2)
(P)-vapor pressure of compound [mm Hg] = Compound-specific
(Q)-excavation rate [0.05m^3/sec] = From USACE Experience
(0.98)-conversion factor [g/mm Hg - m^3] (2)
(C_S)-mass loading of compound in soil [g/cm^3] (2)
(10,000)-conversion factor [cm^2/m^2] (2)
(SA)-area of emitting surface [49m^2] = From USACE Experience
($1.22x10^6$)-conversion factor [cm^2-sec-mm Hg/g] (2)
($1.79x10^9$)-conversion factor [sec^2-cm-mm Hg/g] (2)

In most cases, contaminant data will be available as a soil concentration in units of mg/kg (ppm). Assuming a typical bulk density of undisturbed soil, the mass loading, C_S, can be related to the soil concentration as follows:

$$C_S = (C)\ (1.5\ g/cm^3)\ (10^{-6})\ (2)$$

(C)-Concentration of contaminant in soil [ug/g] (2)
(10^{-6})-Conversion Factor [g/μg] (2)

Particulate Emission Rate

The emissions of particulate matter (PM) from all transfer operations are expressed as follows:

$$E = \frac{k\ (0.0016)(M)\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{X_{H_2O}}{2}\right)^{1.4}} \qquad (2)$$

(E)-emissions [g] (2)
(k)-particle size multiplier [unitless] = 1.0 most conservative (2)
(0.0016)-empirical constant [g/Kg] (2)
(M)-mass of waste handled [Kg] = 1147 Kg (1 yd^3) From USACE Experience
(U)-mean wind speed [2.25m/sec] (3)

(2.2)-empirical constant [m/sec] (2)
(X_{H2o})-Percent moisture content [%] = 10% From USACE Experience

Emission (E) is an expression of the particulate matter mass emitted to the air for every cubic yard of soil moved. A particulate matter emission rate (PM ER) is obtained by multiplying E[g] by the excavation rate. The excavation rate is a project-specific variable and will have to be determined on a project-specific basis. A conservative excavation rate for particulate matter emissions based on USACE experience (and used in the example calculations in Table 1) is 4 cubic yards per minute which yields a PM ER of 0.013 g/sec.

Airborne Concentrations

A common method used by risk assessment practitioners for translating emission rates into airborne concentrations is Box Model Dilution (3). The mass per unit time emission rate is converted to a concentration by dividing the emission rate by the flow rate of air passing through an imaginary box over the construction area actively emitting contaminants to the air. The box size should be determined on an activity-specific/ site-specific basis. The box size (27m x 27m x 27m) used in the example calculations is based on USACE construction experience and good risk assessment practice (3). The flow rate of air passing through the box is calculated by multiplying the surface area of one side of the box (54 m^2) by the EPA standard default windspeed (2.25m/sec) (3). Therefore, for the example calculations, the flow rate(FR) is, 54m^2 x 2.25 m/sec = 121.5 m^3/sec.

Vapor concentrations for the examples are calculated as follows:

Vapor Concentration (mg/m^3) = ER (g/sec) x 1/FR (121.5m^3/sec) x 1000 mg/g

Contaminated particulate concentrations for the examples are calculated as follows:

$C_{(air)}$ (ug/m^3) = PM ER (0.013g/sec) x 1/FR (121.5 m^3/sec) x $C_{(Soil)}$ (ug/g)**

** Site-specific data should be used to determine soil concentration variables used in the calculations.

Example Calculation Results

The results from example calculations in Table 1 reflect the chemical concentrations ("soil action levels") of various chemicals likely to be found in hazardous waste site soils/sludges which will cause the above-described HAZWOPER standard applicablility criteria to be met or exceeded. (Note: These calculations are conservative. The dermal and inhalation intake estimates assume manual handling of contaminated soils/ sludges in an unrealistically calm atmosphere for an entire work day. Soils/sludges, whether contaminated or not, are rarely handled manually, but most often handled with heavy equipment, allowing little chance for dermal contact to the extent assumed in the calculations. Also, realistic (higher) wind speeds and atmospheric turbulence would dilute emissions to lower than calculated concentrations.)

Recommendations

Past USACE experience performing hazardous waste site investigations and remediations, and actual worker exposures from these activities, coupled with the "soil action levels" illustrated in Table 1, indicate that "employee exposure or the reasonable possibility for employee exposure to safety or health hazards" from contaminants of concern is unlikely at many USACE managed hazardous waste sites.

Application of HAZWOPER to USACE managed hazardous waste projects should be based on procedures recommended in this position paper and the following criteria:

1. Contamination on the site must be well-characterized, either from previous investigations or from good reliable historical information.
2. Qualified occupational safety and health professionals in designated HTRW design districts shall perform the calculations, using the above techniques, to demonstrate compliance with standard applicability criteria.
3. The requirements of USACE Engineering Regulation (ER) 385-1-92, which internally implements the requirements of HAZWOPER, will be applied to the HTRW work, if the above-described standard applicability criteria are met or exceeded.
4. All regular safety and occupational health requirements specified in USACE Engineering Manual (EM) 385-1-1, The U.S. Army Corps of Engineer Safety and Health Requirements Manual (except Section 28, Hazardous, Toxic and Radioactive Waste (HTRW) and Underground Storage Tank (UST) Activities), and the following additional practices will be applied to the HTRW work, even if the standard applicability criteria are not met or exceeded.

a. The site supervisor in charge of the work will be trained to recognize potential hazards associated with HTRW activities, and will meet the training requirements specified 29 CFR 1910.120/1926.65 (e).

b. All unforseen hazards discovered while working onsite will be abated, if feasible, under the requirements of 29 CFR 1910.120/1926.65, and/or will require that the remaining work be performed in accordance with 29 CFR 1910.120/1926.65 (a)(1).

References

1. EPA-540/1-89-002; Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), December 1989.
2. EPA-451R-93-001; Models for Estimating Air Emission Rates from Superfund Remedial Actions, March 1993.
3. OSWER Directive 9285.7-01B, Human Health Evaluation Manual, Part B: "Development of Risk-based Preliminary Remediation Goals."
4. EPA Region III Risk Assessment Technical Guidance Manual, Assessing Dermal Exposure from Soil.
5. OSWER Directive 9285.6-03, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors."

Table 1
Example Calculation Results
"Soil Action Levels"

Contaminant of Concern	Published Standard PEL/TLV mg/m^3	**Acceptable Intake mg/kg-day**	***Soil Concentratation mg/kg***	Ingestion Intake mg/kg-day	Absorp. Factor	Absorption Intake mg/kg-day	Inhalation Intake mg/kg-day	**Total Intake mg/kg-day**
Parathion	0.1	**0.028**	***2100***	0.0015	10%	0.026	6.4E-5	**0.0276**
Aldrin	0.25	**0.071**	***5300***	0.0038	10%	0.064	1.6E-4	**0.068**
Chlordane	0.5	**0.14**	***10600***	0.0076	10%	0.129	3.2E-4	**0.137**
DDT	1.0	**0.28**	***21000***	0.015	10%	0.256	6.4E-4	**0.272**
Diazinon	0.1	**0.028**	***2100***	0.0015	10%	0.0256	6.4E-5	**0.0272**
Endrin	0.1	**0.028**	***2100***	0.0015	10%	0.0256	6.4E-5	**0.0272**
Toxaphene	0.5	**0.14**	***10600***	0.0076	10%	0.129	3.2E-4	**0.137**
PCB	0.5	**0.14**	***18100***	0.013	6%	0.132	5.5E-4	**0.145**
PCP	0.5	**0.14**	***4300***	0.003	24%	0.126	1.3E-4	**0.129**
TNT	0.5	**0.14**	***10600***	0.0076	10%	0.129	3.2E-4	**0.137**
Arsenic	0.01	**0.003**	***600***	0.0004	3.2%	0.0023	1.8E-5	**0.0027**
Cadmium	0.01	**0.003**	***1500***	0.001	1%	0.0018	4.5E-5	**0.0028**
Lead	0.05	**0.014**	***7300***	0.005	1%	0.009	2.2E-4	**0.0142**
Toluene	188.0	**53.7**	***10000****	0.007	0.05%	0.006	14.6	**14.61**
TCE	269.0	**76.8**	***10000****	0.007	0.05%	0.006	29.0	**29.01**

*Soil concentrations much lower than maxium allowable. 10000 mg/kg selected to demostrate the levels above normal (low ppm and ppb) necessary to exceed applicability criteria.

Example Calculation - Parathion

$C_{(Soil)}$(soil concentration) - 10000 mg/kg

PEL/TLV - 0.1 mg/m^3

Acceptable Intake = PEL (0.1 mg/m^3) x IHR (2.5 m^3/hr) x ET (8 hr/day) x 1/BW (70 kg)
= .028 mg/kg-day

Site Specific Intake

Ingestion Intake = $C_{(Soil)}$ (10000 mg/kg) x IGR (5 x 10^{-5} kg/day) x 1/BW(70 kg)
= 0.007 mg/kg-day

Absorp. Intake = $C_{(Soil)}$ (10000 mg/10^6mg) x AF(2.77 mg/cm^2) x SA (3160 cm^2/day) x 1/BW(70 kg) x ABS(.1)
= .125 mg/kg day

Inhalation Dose

$$E(g) = \frac{k(1)(.0016\ g/kg)M(1147\ kg)\left(\frac{U(2.25\ m/sec)}{(2.2\ m/sec)}\right)^{1.3}}{\left(\frac{X_{H2O}(10\%)}{(2)}\right)^{1.4}}$$

E = .198 g/yd^3 soil dumped

PM ER = E (.198 g/yd^3) x Soil Excavation Rate (.067 yd^3/sec) = .013 g/sec

Contaminant ER = PM ER (.013 g/sec) x $C_{(Soil)}$ (10000μg/g) = 130 μg/sec

$C_{(Air)}$Dilution in Box = ER ($1.3x10^{-4}$ g/sec) x 1/FR(121.5m^3/sec) = $1.07x10^{-6}g/m^3$

Inhalation Dose = $C_{(Air)}$ (.001 mg/m^3) x IHR (2.5 m^3/hr) x ET (8 hr/day) x 1/BW (70 kg)
= .0003 mg/kg-day

Total Dose:
Ingestion - 0.007 mg/kg-day
Absorption - 0.125 mg/kg-day
Inhalation - 0.0003 mg/kg-day
0.132 mg/kg-day

Acceptable = .028 mg/kg-day

Example Calculation - Toluene

Starting Soil Concentration - 10000 mg/kg

PEL/TLV = 188 mg/m^3

Acceptable Intake = PEL (188 mg/m^3) x IHR (2.5 m^3/hr) x ET (8 hr/day) x 1/BW (70 kg)
= 53.7 mg/kg-day

Site Specific Intake

Ingestion Intake = $C_{(Soil)}$(10000 mg/kg) x IGR (5 x 10^{-5} kg/day) x 1/BW (70kg)
= .007 mg/kg-day

Absorp. Intake = $C_{(Soil)}$ (10000 mg/10^6 mg) x AF (.25 mg/cm^2) x SA(2910 cm^2/day) x 1/BW (70 kg) x ABS (.005)
= 5.2 x 10^{-4} mg/kg/day

Inhalation Intake

$$ER = ER_{ps} + ER_{Diff}$$

$$ER_{Diff} = \frac{C_s(.015\ g/cm^3)(10000\ cm^2/m^2)SA(49\ m^2)}{\left(1.22 \times 10^6\ cm^2\text{-sec-}mm\ Hg/g \frac{C_s(0.015\ g/cm^3)}{P\ (30\ mm\ Hg)}\right) + \left(1.79 \times 10^9 \frac{C_s(0.015\ g/cm^3)}{P\ (30\ mm\ Hg)}\right)^{\frac{1}{2}}}$$

ER_{Diff} = 4.7 g/sec

ER_{ps} = P(30mm-Hg)(0.05m^3/sec)(98g/mm Hg-m^3) = 1.47 g/sec

ER = 6.17 g/sec

$C_{(air)}$Dilution in Box = ER (6.17 g/sec) x 1 /FR (121.5m^3/sec)
= .051 g/m^3 = 51 mg/m^3

Inhalation Dose = $C_{(air)}$ (51 mg/m^3) x IHR (2.5 m^3/hr) x ET (8 hr/day) x 1/BW (70 kg)
= 14.6 mg/kg-day

Total Dose

Ingestion - 0.007 mg/kg-day

Absorption - 0.0005 mg/kg-day

Inhalation - 14.6 mg/kg-day

14.61 mg/kg-day

Acceptable Dose - 53.7 mg/kg-day