

1996 Connecticut Remediation Standard Regulations

Derivation of Volatilization Criteria

Substances from releases may be located under structures. For volatile compounds, these substances may migrate from groundwater or soil vapor beneath a building into that structure. The 1996 volatilization criteria were developed as health-protective concentrations for volatile substances in these media designed to insure that any volatilization of substances into overlying structures is protective of potential exposures to building occupants. The criteria were derived using risk-based estimates of health protective concentrations of substances in indoor air. These values were then applied to a fate and transport model to derive associated environmental concentrations in groundwater and soil vapor that were unlikely to cause an exceedance of the Target Indoor Air concentrations.

In 2003, CT DEEP proposed an update to the derivation of Volatilization Criteria based on updated toxicity and exposure information as well as an updated fate and transport model. Information on the Draft 2003 Revisions to the Volatilization Criteria can be found at:

http://www.ct.gov/deep/lib/deep/site_clean_up/remediation_regulations/RvVolCri.pdf

Target Indoor Air Concentration Calculation

For Substances that are non-carcinogenic:

$$\text{Target Indoor Air Concentrations (ug/ m}^3 \text{ air)} = \frac{\text{RfDi} \times \text{HI} \times \text{BW} \times \text{ATnc} \times \text{CF}}{\text{IRair} \times \text{ED} \times \text{EF}}$$

For Substances that are carcinogenic:

$$\text{Target Indoor Air Concentrations (ug/ m}^3 \text{ air)} = \frac{\text{Risk} \times \text{BW} \times \text{AT} \times \text{CF}}{\text{CSF} \times \text{IRair} \times \text{ED} \times \text{EF}}$$

Where:

Variable	Description	Value	Units
ATc	Averaging Time carcinogens	25,550	days
ATnc	Averaging Time noncarcinogens	9,125	days
BW	Body Weight	70	kg
CSF	Cancer Slope Factor	chemical specific	1/mg/kg/d
CF	Conversion Factor	100	ug/mg
ED	Exposure Duration		
	Residential	30	years
	Industrial Commercial	25	years
EF	Exposure Frequency		
	Residential	350	days/year
	Industrial Commercial	250	days/year
HI	Hazard Index	1	unitless
IRair	Inhalation Rate		
	Residential	20	m ³ /d
	Industrial Commercial	10	m ³ /d
RfDi	Reference Dose - Inhalation	chemical specific	mg/kg/d
RL	Risk Level	1.00E-06	unitless
TAC	Target Indoor Air Concentration	chemical specific	ug/m ³

Simplified Formulas:

<u>Substance Type</u>	<u>TAC ug/m³</u>
Residential:	
Non-carcinogen	3650 x RfDi
Carcinogen	0.008517/CSFi
Industrial Commercial:	
Non-carcinogen	5110 x RfDi
Carcinogen	0.0143/CSFi

Volatilization Criteria for Ground Water

Site-Specific Volatilization Criteria for Ground Water may be calculated using the following equations:

$$GWC = TAC / (1000 \cong VF_{GW})$$

$$VF_{GW} = \frac{H [(D_{EFF-WS}/L_{GW})/(ER \cong L_B)] \cong 1000}{1+[(D_{EFF-WS}/L_{GW})/(ER \cong L_B)] + [(D_{EFF-WS}/L_{GW}) / (D_{EFF-CRACK}/L_{CRACK}) \cong \eta]}$$

$$D_{EFF-WS} = (h_{cap} + h_v) / [(h_{cap} / D_{EFF-CAP}) + (h_v / D_{EFF-S})]$$

$$D_{EFF-CAP} = D_{AIR} \cong (\theta_{ACAP}^{3.33} / \theta_T^2) + D_{WATER}/H \cong (\theta_{WCAP}^{3.33} / \theta_T^2)$$

$$D_{EFF-S} = D_{AIR} \cong (\theta_{AS}^{3.33} / \theta_T^2) + D_{WATER}/H \cong (\theta_{WS}^{3.33} / \theta_T^2)$$

$$D_{EFF-CRACK} = D_{AIR} \cong (\theta_{ACRACK}^{3.33} / \theta_T^2) + D_{WATER}/H \cong (\theta_{WCRACK}^{3.33} / \theta_T^2)$$

Where:

Term	Description	Units	Value
GWC	Ground Water Volatilization Criteria	ug/kg	calculated
TAC	Target Indoor Air Concentration	ug/m ³	substance-specific
VF _{GW}	Ground Water Volatilization Factor	mg/m ³	calculated
H	Henry ' s Law Constant	unitless	substance-specific
D _{EFF-WS}	Effective Diffusion-Ground Water to Soil Surface	cm ² /s	calculated
L _{GW}	Depth to Ground Water (= h _{CAP} + h _v)	cm	site-specific
h _{CAP}	Thickness of Capillary Fringe	cm	site-specific
h _v	Thickness of Vadose Zone	cm	site-specific
ER _R	Residential Enclosed Space Air Exchange Rate	1/s	.00014
ER _I	Industrial Enclosed Space Air Exchange Rate	1/s	.00023
L _{B R}	Residential Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
L _{B I}	Industrial Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
D _{EFF-CRACK}	Effective Diffusion through Foundation Cracks	cm ² /s	calculated
L _{CRACK}	Enclosed Space Foundation or Wall Thickness	cm	site-specific

η	Areal Fraction of Cracks in Foundations / Walls	unitless	.01
$D_{\text{EFF-CAP}}$	Effective Diffusion through Capillary Fringe	cm^2/s	calculated
$D_{\text{EFF-S}}$	Effective Diffusion through Soil (In Vapor Phase)	cm^2/s	calculated
D_{AIR}	Diffusion Coefficient in Air	cm^2/s	8.40E-02 or chemical specific
D_{WATER}	Diffusion Coefficient in Water	cm^2/s	1.00E-05 or chemical specific
θ_{ACAP}	Volumetric Air Content in Capillary Fringe	unitless	site-specific
θ_{AS}	Volumetric Air Content in Vadose Zone	unitless	site-specific
θ_{ACRACK}	Volumetric Air Content in Foundation/Wall Cracks	unitless	site-specific
θ_{WCAP}	Volumetric Water Content in Capillary Fringe	unitless	site-specific
θ_{WS}	Volumetric Water Content in Vadose Zone	unitless	site-specific
θ_{WCRACK}	Volumetric Water Content in Foundation/Wall Cracks	unitless	site-specific
θ_{T}	Total Soil Porosity	unitless	site-specific

Volatilization Criteria for Soil Vapor

Site-Specific Volatilization Criteria for Soil Vapor may be calculated using the following equations:

$$\text{SSVC} = \text{TAC} / (1000 \cong \text{VF}_{\text{SSV}})$$

$$\text{VF}_{\text{SSV}} = \frac{[(D_{\text{EFF-S}}/L_{\text{S}})/(ER \cong L_{\text{B}})]}{1 + [(D_{\text{EFF-S}}/L_{\text{S}})/(ER \cong L_{\text{B}})] + [(D_{\text{EFF-S}}/L_{\text{S}})/(D_{\text{EFF-CRACK}}/L_{\text{CRACK}}) \cong \eta]}$$

$$D_{\text{EFF-S}} = D_{\text{AIR}} \cong (\theta_{\text{AS}}^{3.33} / \theta_{\text{T}}^2) + D_{\text{WATER}}/H \cong (\theta_{\text{WS}}^{3.33} / \theta_{\text{T}}^2)$$

$$D_{\text{EFF-CRACK}} = D_{\text{AIR}} \cong (\theta_{\text{ACRACK}}^{3.33} / \theta_{\text{T}}^2) + D_{\text{WATER}}/H \cong (\theta_{\text{WCRACK}}^{3.33} / \theta_{\text{T}}^2)$$

Where:

Terms	Description	Units	Value
SSVC	Volatilization Criteria for Soil Vapor	$\text{mg}/\text{m}^3\text{-air}$	calculated
TAC	Target Indoor Air Concentration	$\text{ug}/\text{m}^3\text{-air}$	Substance-specific
VF_{SSV}	Volatilization Factor for Subsurface Vapors	unitless	calculated

Terms	Description	Units	Value
H	Henry's Law Constant	unitless	substance-specific
$D_{EFF S}$	Effective Diffusion through Soil (in Vapor Phase)	cm^2/s	calculated
L_S	Depth to Soil Vapor Sample	cm	site-specific
ER_R	Residential Enclosed Space Air Exchange Rate	1/s	.00014
ER_I	Industrial Enclosed Space Air Exchange Rate	1/s	.00023
$L_{B R}$	Residential Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
$L_{B I}$	Industrial Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
$D_{EFF-CRACK}$	Effective Diffusion through Foundation Cracks	cm^2/s	calculated
L_{CRACK}	Enclosed Space Foundation or Wall Thickness	cm	site-specific
η	Areal Fraction of Cracks in Foundations / Walls	unitless	calculated
θ_{AS}	Volumetric Air Content in Vadose Zone	unitless	site-specific
θ_{ACRACK}	Volumetric Air Content in Foundation/Wall Cracks	unitless	site-specific
θ_{WS}	Volumetric Water Content in Vadose Zone	unitless	site-specific
θ_{WCRACK}	Volumetric Water Content in Foundation/Wall Cracks	unitless	site-specific
θ_T	Total Soil Porosity	unitless	site-specific