

## Appendix E

# Smoke Support Sustainment Planning Tables

The tables in this appendix provide smoke pot spacing guidance and ammunition and fuel consumption data. Use the tables to determine ammunition or fuel

sustainment requirements for smoke missions.

Base your ammunition consumption planning on target size and smoke duration. Base fuel consumption

planning on smoke unit structure, smoke duration, and fuel delivery packaging.

## Smoke Pot Consumption

Table 24 is the spacing guide for smoke pots. When using Table 23 to determine actual spacing requirements, round up all answers

(decimals) to the next larger whole number.

Table 25, below and on the facing page, is the smoke pot consumption guide. To use this table, you must

know the length of the target area in meters and the spacing between pots in meters, plus how long the target must be smoked.

*Table 24. Smoke pot spacing guide.*

Wind Speed		Temp Gradient	Terrain	Spacing (Meters)		Meters to Target
Kmph	Knots			Haze	Blanket	
1-14	1-7	All	Open or Water	50	25	250
		Stable	Wooded	60	30	300
		Unstable or Neutral		70	35	350
15-25	8-13	All	Open or Water	40	20	200
			Wooded	50	25	250
26-32	14-17	All	Open or Water	30	15	150
			Wooded	40	20	200

*Table 25. Smoke pot consumption guide. (Part 1 of 2)*

Number of Smoke Pots Needed To Produce Smoke for a Mission												
Spacing	15m			20m			25m			30m		
Line Length	100m	500m	1,000m									
Smoke Time												
15 min	12	51	102	9	13	77	8	32	62	6	27	51
30 min	24	102	204	18	78	153	15	63	123	12	48	102
1 hr	48	204	612	36	156	306	30	126	246	24	108	204
3 hr	144	612	1,224	108	468	918	90	378	738	72	324	612

Continued

Enter the table from the left-smoke time. Locate the spacing between pots at the top of the table.

Under the spacing find your target length. The cell where this column

and the smoke time row intersect contains the number of pots needed.

## Fuel Consumption Tables

Use Tables 26 and 27 to determine fog oil and MOGAS consumption for smoke generators. These tables are based on normal con-

sumptions of a smoke generator platoon running all generators simultaneously. When a crew operates a

single M3A4 or M157 smoke generator, multiply the planning figure by 0.5.

Table 26. Fog oil consumption in gallons and [drums].

Platoon Type	1 hr	2 hr	4 hr	6 hr	24 hr	48 hr
<b>Motor Smoke (24 Generators)</b>	1,200 [22]	2,400 [44]	4,800 [88]	7,200 [131]	28,800 [524]	57,600 [1,048]
<b>Mechanized (7 M1059 Systems)</b>	700 [13]	1,400 [26]	2,800 [51]	4,200 [77]	16,800 [306]	33,600 [611]
<b>Dual Purpose (12 Generators)</b>	600 [11]	1,200 [22]	2,400 [44]	4,800 [88]	7,200 [131]	28,800 [524]
<b>Heavy Division Smoke Plt (6 M1059 Systems)</b>	600 [11]	1,200 [22]	2,400 [44]	4,800 [88]	7,200 [131]	28,800 [524]

Numbers in brackets = Drums      One drum = 55 gallons

Table 27. MOGAS consumption in gallons and .

Platoon Type	1 hr	2 hr	4 hr	6 hr	24 hr	48 hr
<b>Motor Smoke (24 Smoke Generators)</b>	72 [15]	144 [29]	216 [44]	864 [173]	1,728 [346]	3,456 [692]
<b>Mechanized Smoke (14 Smoke Generators)</b>	42 [9]	84 [17]	168 [34]	252 [51]	1,008 [202]	2,016 [404]
<b>Dual Purpose (12 Smoke Generators)</b>	36 [8]	72 [15]	144 [29]	216 [44]	864 [173]	1,728 [346]
<b>Heavy Division Smoke Plt (12 Smoke Generators)</b>	36 [8]	72 [15]	144 [29]	216 [44]	864 [173]	1,728 [346]

Numbers in brackets = Cans  
1 Can = 4.5 gallons in a 5-gallon can

Table 25 continued. (Part 2 of 2)

Number of Smoke Pots Needed To Produce Smoke for a Mission												
Spacing Line Length	40m			50m			60m			70m		
	100m	500m	1,000m									
<b>Smoke Time</b>												
<b>15 min</b>	6	21	39	5	17	32	5	14	27	3	12	23
<b>30 min</b>	12	42	78	9	33	63	9	27	48	6	24	45
<b>1 hr</b>	24	84	156	18	66	126	18	54	108	12	48	90
<b>3 hr</b>	72	252	468	54	198	373	54	162	324	36	144	270

# Ammunition Consumption Tables

Use Tables 28 through 31, below, to determine consumption rates for artillery, and mortar munitions.

Start with the wind speed, rate of fire, (or weapon and target size) and duration of smoke requested,

and use the table to discover the number of rounds required for the mission.

*Table 28. Quick smoke consumption data—155-mm smoke shell.*

Fire for Effect—Rounds Per Tube													
Wind Speed in Knots	Rate of Fire	Duration Requested by Forward Observer (in Minutes)											
		4	5	6	7	8	9	10	11	12	13	14	15
5	1 rd/min	2	2	3	3	4	4	5	5	6	6	7	7
10	1 rd/30 sec	2	3	4	5	6	7	8	9	10	11	12	13
15	1 rd/20 sec	3	4	6	7	9	10	12	13	15	16	18	19

*Table 29. Quick smoke consumption data—155-mm WP shell.*

Fire for Effect—Rounds Per Tube															
Wind Speed in Knots	Rate of Fire	Duration Requested by Forward Observer (in Minutes)													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
14515	1 rd/min	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10	1 rd/30 sec	4	6	8	10	12	14	16	18	20	22	24	26	28	30
15	1 rd/20 sec	6	9	12	15	18	21	24	27	30	33	36	39	42	45

*Table 30. Smoke ammunition consumption  
—artillery battery.*

Weapon (Target Size)	Duration of Mission	Total Rounds
155-mm HC (2,800 m x 50 m)	5 min	16
	10 min	40
	15 min	56
155-mm WP (1,200 m x 50 m)	2 min	24
	5 min	48
	15 min	128
105-mm WP (450 m x 35 m)	2 min	18
	5 min	36
	15 min	96

*Table 31. Smoke ammunition consumption  
—mortar platoon.*

Weapon (Target Size)	Duration of Mission	Total Rounds
107-mm WP (600 m x 40 m)	2 min	12
	5 min	27
	15 min	72
81-mm WP (300 m x 35 m)	2 min	12
	5 min	27
	15 min	72
60-mm WP (225 m x 35 m)	2 min	12
	5 min	27
	15 min	72

All figures assume 9 kmph crosswind.

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## Weather and Terrain

Environmental factors and terrain affect smoke cloud behavior. Steer-

ing winds, temperature gradients and the type of terrain are impor-

tant for accurately predicting smoke cloud travel.

### Weather

Meteorological conditions that have the most effect on smoke screening and munitions expenditures (including the deployment of smoke generators) include wind, temperature gradients, humidity, precipitation, and cloud cover.

#### Wind

The weather condition with the greatest impact on smoke operations is wind. Both wind direction and wind speed play a significant role in almost everything that deals with smoke operations. These factors are important in estimating equipment, munitions, and fog oil requirements for a smoke operation.

Wind direction determines where smoke must be released and where it will travel. Basically, there are four different types of wind directions that affect smoke operations: head winds, tail winds, flanking winds, and quartering winds. Favorable wind directions in relation to the smoke objective are the tail, quartering, and flanking winds (see Figure 17).

**Head winds** are those blowing from the smoke objective directly toward the smoke source and are unfavorable for smoke generator operations.

**Tail winds**, the most favorable for smoke operations, blow toward the smoke objective from behind the smoke source.

**Flanking winds** blow directly across the smoke objective and the smoke source and are generally favorable for smoke operations.

**Quartering winds** blow between the other winds toward the smoke objective.

It is important to make the distinction between those surface wind directions just discussed and steering winds. Steering winds occur between 6 meters and 200 meters above the earth's sur-

face. They are the winds that actually carry the smoke and determine the direction of smoke travel.

Wind speed has as much influence on smoke behavior as wind direction has. Low wind speed or calm conditions allow smoke to remain in the target area for a longer period of time. In addition, some types of smoke behave differently at different wind speeds. For example, WP tends to pillar if winds are less than 9 knots (17 kilometers per hour). HC smoke rises when the wind speed is less than 4 knots (7 kilometers per hour), and it is torn apart by wind speeds over 13 knots (24 kilometers per hour). Smoke from mechanical smoke generators may be effective in higher wind speeds because of the great volume produced.

#### Temperature Gradients

Temperature, by itself, has no direct relationship with making effective smoke. It does, however, have an indirect relationship, which is a result of temperature gradients. Temperature gradients are determined by comparing the air temperature at .5 meter above the ground with the air temperature at 4 meters. Three types of temperature gradients influence smoke: unstable (lapse), neutral, and stable (inversion) (Figure 18, next page).

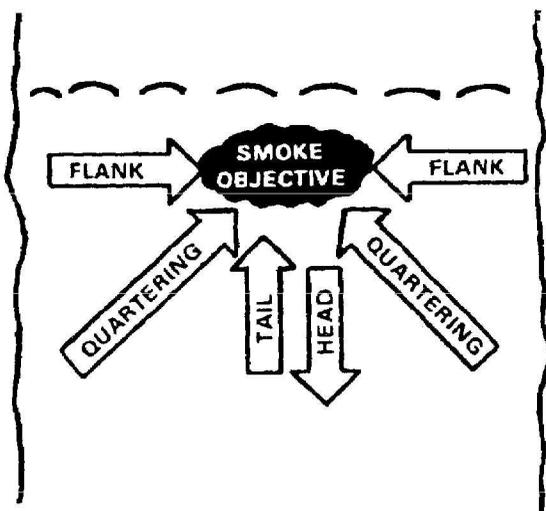


Figure 17. Classification of wind directions.

**Unstable.** An unstable (lapse) condition exists when air temperature decreases with an increase in altitude. This condition is characterized by vertical air currents and turbulence. Thus, smoke tends to break up and become diffused. Lapse conditions are best for producing smoke curtains.

**Neutral.** A neutral condition exists when air temperature shows very little or no change with an increase in altitude. Neutral conditions also exist when the wind speed is greater than 9 kilometers per hour. Under this condition, vertical air currents are very limited. Neutral conditions are best for smoke hazes and smoke blankets; however, this is not the most favorable temperature gradient for smoke.

**Stable.** A stable (inversion) condition exists when the air temperature increases with an increase in altitude. This condition greatly limits vertical air currents. A smoke cloud produced during inversion conditions lies low to the ground and

may reduce visibility at ground level. Inversion conditions are excellent for smoke hazes and smoke blankets but only if there is enough wind to carry the smoke over the target area.

### Humidity

Practically all smoke particles absorb moisture from the air. Moisture increases particle size and density and makes the smoke more effective. Most smoke munitions produce a denser (thicker) smoke when the humidity is high than when it is low; therefore, high humidity is generally favorable for smoke employment (Table 32).

### Precipitation

Since light rains decrease visibility, less smoke gives concealment during these rains. Heavy rains and

snow reduce visibility; therefore, smoke is rarely needed for concealment during those conditions. When used during periods of precipitation, smoke tends to remain close to the ground and spread out over a large area.

### Cloud Cover

The amount of clouds in the sky gives an indication of how smoke will act on the battlefield. The general rule is when the sky is covered with clouds, the atmosphere is relatively stable, and the conditions are generally favorable for making smoke.

Table 33, on the next page, provides a summary of favorable and unfavorable conditions for smoke production.

Table 32. HC and WP smoke yields in various humidities.

Relative Humidity	HC	WP
%	Effectiveness (Percentage)	Effectiveness (Percentage)
0	100	100
10	146	353
20	152	372
30	159	391
40	173	411
50	189	434
60	211	465
70	240	510
80	325	588
90	572	785

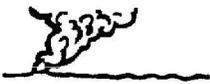
Time of Day and Weather Conditions	Temperature Gradient	Smoke Behavior (Wind Direction →)
Night—until 1 hr after sunrise. Wind speed is less than 9 kmph (5 knots). Cloud cover less than 30%.	Stable (Inversion) (Ideal)	
Day—most often between 1 to 2 hr before and after sunrise. Wind speed is 9 kmph (5 knots) or more. Cloud cover is 30% or more.	Neutral (Favorable)	
Day—beginning 2 hr after sunrise. Wind speed is less than 9 kmph (5 knots). Cloud cover is less than 30%.	Unstable (Lapse) (Marginal)	

Figure 18. Temperature gradient effects on smoke.

Since smoke is carried by the wind, it usually follows the contours of the earth's surface. Therefore, the type of terrain over which the smoke travels has a tremendous impact on how effective the smoke

coverage will be in a specified area. Smoke will act differently over the different types of terrain.

### Terrain Effects

#### Flat, Unbroken Terrain and Over Water

On flat, unbroken terrain, and over water, the individual smoke streamers take longer to spread out

and mix with other streamers. Therefore, the uniform phase will usually develop a greater distance downwind.

### Obstructions

Obstructions, such as trees and small buildings, tend to break up smoke streamers. These streamers re-form, cover a much larger area, and eventually create a more uniform screen. This uniform screen develops much quicker and closer to the smoke source than if the terrain were open. A wooded area, which contains an abundance of obstructions, is the most favorable type of terrain for smoke generator operations.

### Large Hill Masses and Mountains

Steep hills and mountains tend to split winds. The winds eddy around the hills and mountains as well as over them. Large hill masses and rugged terrain cause strong cross currents. These currents disperse smoke excessively and create holes and unevenness in the smoke screen. In addition, thermally induced slope winds occur throughout the day and night. These conditions make it extremely difficult to establish and maintain a smoke screen. Wind currents, eddies, and turbulence in mountainous terrain must be continuously studied and observed.

### Slopes and Valleys

In areas where there are valleys and other types of slopes, the climatic conditions are usually different at different times of the day. These areas are characterized by thermally induced slope winds that occur throughout the day and night. During the daytime, the heating effect causes these winds to blow up the slope, and they are referred to as up-slope winds. At night, the cooling effect causes the winds to blow down the slopes, and they are called down-slope winds. This is a very general rule; however, it is one which needs to be kept in mind when planning smoke operations.

Table 33. Evaluating conditions for smoke employment.

Factor	Unfavorable	Moderately Favorable	Favorable
Wind	More Than 10 knots	Less Than 10 Knots	5 to 10 Knots
Atmospheric Stability Category	Unstable (Lapse) (Favorable for Smoke Curtain)	Neutral	Stable (Inversion) (Unfavorable for Smoke Curtain)
Humidity	Low	Moderate	High
Precipitation	None	Light Rain	Mist/Fog
Cloud Cover	None	Scattered	Overcast, Low Ceiling
Terrain	Even	Gently Rolling	Complex Topography
Vegetation	Sparse or None (Desert)	Medium Dense	Heavily Wooded or Jungle
Time of Day	Late Morning thru Late Afternoon	Midmorning	1 Hour Before EENT to 4 Hours After BMNT

BMNT—beginning morning nautical twilight

EENT—ending evening nautical twilight

## Appendix G

# Obscurants and How They Work

Obscurants are particles suspended in the air that block or attenuate a portion (or portions) of the electromagnetic spectrum. The six types of obscurants are natural

obscurants (such as fog); by-product obscurants (such as dust); visual smoke (such as WP); and bispectral multispectral and special obscurants. This appendix describes

the general characteristics of obscurants, how they work, and what obscurants the United States has in its inventory.

## Characteristics

Obscuration occurs when there is a decreased level of energy available for the function of seekers, trackers, vision enhancement devices, or the human eye. Battlefield visibility can be practically defined as the distance at which a potential target can be seen and identified against any background. Reduction of visibility on a battlefield by any cause reduces the amount of smoke needed to obscure a target or objective.

Obscuration generally is not associated with combat power because it is not a lethal tool on the battlefield. However, the deliberate use of smoke and the inadvertent or planned use of dust and/or adverse weather conditions on the battlefield have always been of value to units in the field.

In general, smokes are composed of many small particles suspended in the air. These particles scatter and absorb (attenuate) different spectra of electromagnetic radiation. This absorption reduces transmittance of that radiation through the smoke. When the density (concentration) of smoke material between the observer or EO device and an object exceeds a certain minimum threshold value (Cl), the object is considered effectively obscured.

Smoke, placed between a target and viewer, degrades the effectiveness of that viewer by interfering with the reflected electromagnetic radiations. The amount of smoke required to defeat that viewer is highly dependent upon meteorological conditions, terrain relief, available natural light, visibility, and the absorption effect of natural particles in the atmosphere. Other factors include smoke from battlefield fires and dust raised from maneuvering vehicles and weapon fire.

The ability to detect and identify a target concealed by such a smoke cloud is a function of target-to-background contrast. Smoke clouds reduce target-to-background contrast, making the target more difficult to detect.

The effectiveness of obscuration depends primarily upon characteristics such as the number, size, and color of the smoke particles. In the visible range, dark or black smoke absorbs a large proportion of the electromagnetic waves striking individual smoke particles. During bright sunlight you need a higher concentration of black smoke to effectively obscure a target because black smoke particles are nonscattering. At night or in limited visibility, considerably less black smoke is needed.

Grayish or white smoke obscures in the visible range by reflecting or scattering light, producing a glare. During bright sunlight you need a lower concentration than with black smoke to effectively obscure a target. At night or in limited visibility, considerably more than black smoke is needed.

Years of experience with white smoke technology have shown it to be superior to black smoke for most applications. Available white smoke producers include WP and RP compounds, HC, and fog oil (SGF2). WP, RP, and HC are hydroscopic (that is, they absorb water from the atmosphere). This increases particle diameters and makes them more efficient in scattering light. Fog oils are nonhydroscopic and depend upon vaporization techniques to produce extremely small diameter droplets that absorb and scatter light.

Smoke produced by a smoke generator unit or from a series of smoke pots has four distinct phases: streamer, build-up, uniform, and terminal (see Figure 19, on the next page).

**Streamer phase** is the smoke cloud formed by a single smoke device before it begins to blend with the smoke from other sources.

**Build-up phase** is the stage of smoke cloud production when individual streamers begin to merge.

**Uniform phase** is a uniform smoke cloud that occurs after individual smoke streamers have merged. This is the phase commanders want over the target area.

**Terminal phase** is the stage of a smoke cloud in which the smoke has dispersed and concealment is no longer effective.

The diffusion of smoke particles into the atmosphere just above the earth's surface obeys physical laws. Wind speed, turbulence, atmospheric stability, and terrain all govern diffusion of smoke. Smoke

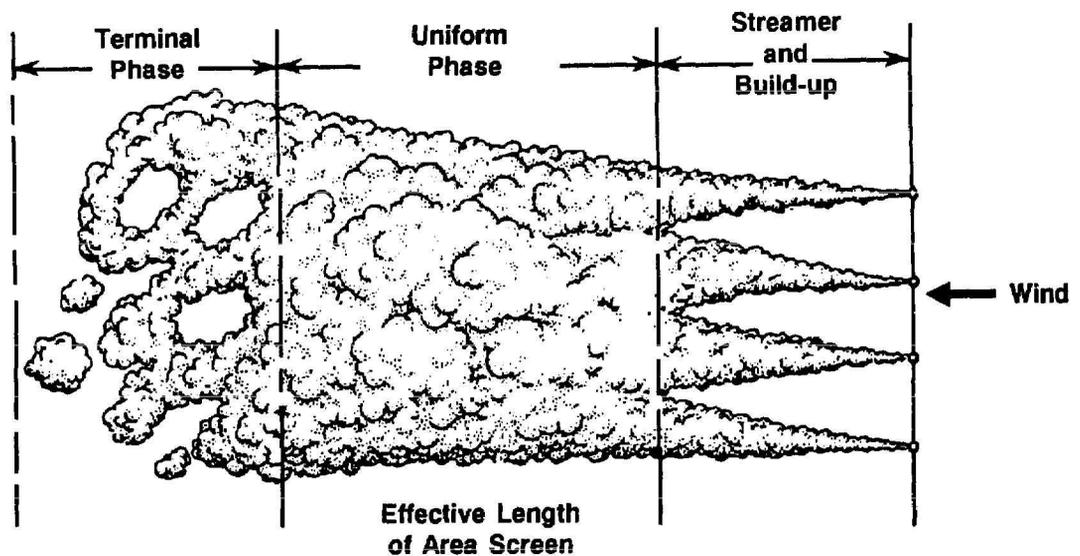


Figure 19. Phases of large-area smoke cloud.

diffusion on the battlefield originates from four basic smoke source configurations:

- Continuous point sources (such as smoke release from a smoke generator or smoke pot).
- Instantaneous point sources (such as bursting of a WP projectile).

- Continuous line sources (such as a series of smoke generators set up crosswind).

- Area sources (such as munitions that scatter smoke-generating submunitions like the armored vehicle smoke grenade launchers).

## Natural Obscurants

Natural obscurants are produced by nature and are therefore no drain on our assets. However, they are uncontrollable and may aid the enemy as much as friendly forces. We can use natural obscurants to our advantage if we accurately predict the weather and if there is a firm understanding of the impact of that weather on the battlefield. Natural obscurants will create large recognition and identification problems. Examples of natural obscurants are darkness, fog, sandstorms, and precipitation.

### Darkness

Darkness is the most common form of obscurant found on the battlefield. Darkness will degrade visual observation and target-acquisition devices that are not equipped with active infrared, image intensification, or thermal imaging. Systems equipped with these devices

can operate at near-normal efficiency during periods of reduced visibility or darkness.

### Fog

Fog can be an effective form of obscurant for use on the battlefield. Fog has the capability of providing a good obscurant on the battlefield because it will attenuate visual and near infrared signals in the same manner as visual smoke. Ice fog can also be a very effective obscurant because it degrades systems that operate by the use of a longer wavelength such as thermal imagers. Fog also degrades laser range finders and target designators.

### Sandstorms

Sandstorms are encountered in arid and semiarid regions and can have a dramatic effect on military operations. These storms will usual-

ly effectively obscure all observation and target acquisition devices with the possible exception of ground surveillance radars and other related devices operating in the microwave region of the electromagnetic spectrum.

### Precipitation

Precipitation can definitely obscure battlefield viewers depending on the concentration. Rain, mist, sleet, or snow will degrade battlefield visibility greatly. When these elements are present in heavy concentration, there is no need to produce smoke. These elements can reduce visibility by themselves. The use of image intensifiers, active infrared systems, thermal imagers, laser range finders, and ground surveillance radars can be degraded and possibly defeated when the concentration of precipitation is heavy.

## By-Product Obscurants

By-product obscurants that produce concealment are a result of other activities associated with battlefield operations. They are often inadvertent; however, when understood, they may be planned and used to the advantage of friendly forces. Examples of by-product obscurants are smoke from burning vehicles and buildings and dust caused by vehicular movement and artillery/mortar fire.

### By-Product Smoke

Smoke produced by fire on the battlefield will obscure viewers. This fire can be man-made or naturally produced by elements such as lightning. Other methods of generating fires that may result from a man-made device are fires produced by mortar or artillery rounds. Whether naturally produced or man-made, this obscurant will decrease visibility on the battlefield.

### Dust

Battlefield dust is like the proverbial two-edged sword: its presence and use can cut both ways. For example: dust can be used for —

- Concealing details of military forces and movement. Dust is often an indicator of movement of troops and equipment. If the amount of dust generated is large (perhaps deliberately so), details of troop movement can be obscured. If no dust is desired, a simple expedient is to keep the road wet, which can be done if sufficient equipment and ample water are available.

- Blinding enemy observation points to deprive him of the opportunity to adjust fire. Artillery volleys or naval salvos can be used to temporarily obscure a narrow field of view for a short period of time. HE dust clouds are generally only effective as obscurants for several seconds but may be effective up to a minute or more.

- Degrading performance of precision-guided munitions and EO sensors. HE dust can be used to interfere with the target acquisition sequence or to break "lock-on" of an acquired target.

Dust, depending on how it is produced, can obscure different portions of the electromagnetic spectrum, in either the visible, infrared millimeter wave, or radar portions. Dust is often produced inadvertently by bombing, gunfire, and vehicular movement. However, we can plan and use dust to the advantage of friendly forces. Dust degrades the performance of sensors and precision-guided munitions.

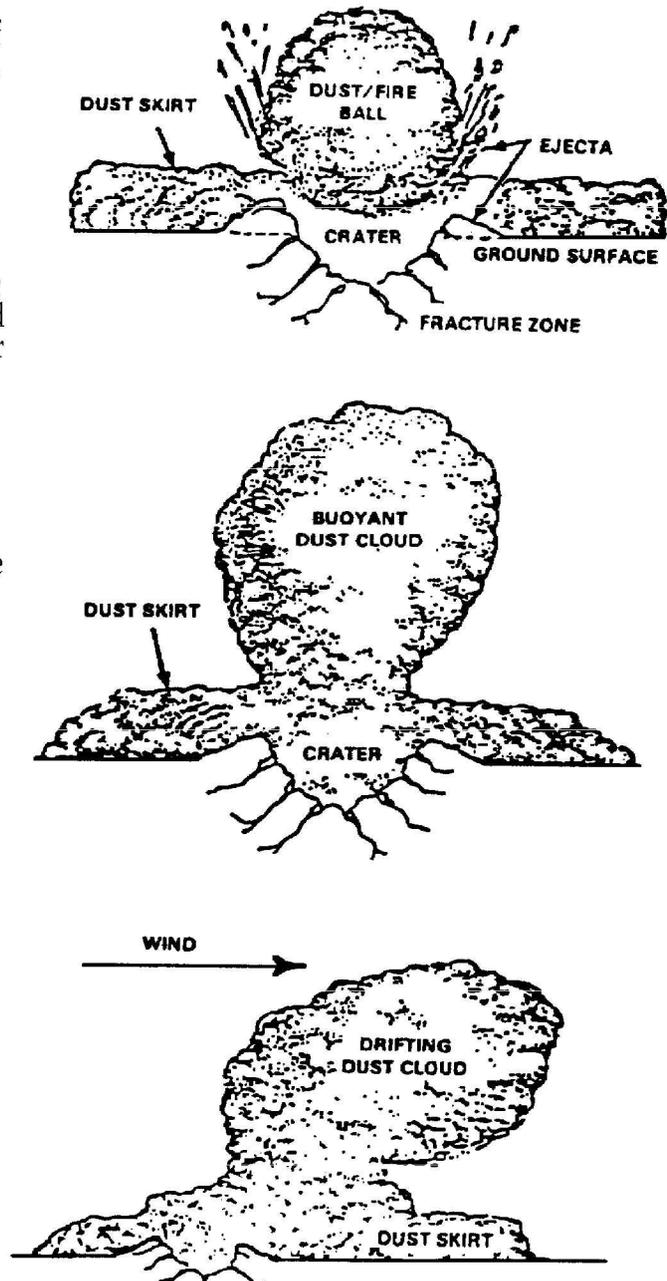


Figure 20. Phases of munition-produced dust cloud.

## Munition-Produced Dust

When HE munitions are used, dust will be produced. The amount produced depends on the size of the munition, its point of detonation (above or below the surface), and the state of the soil. The initial explosion throws up a variety of crater materials. From small clumps down to individual soil particles, obscuration will occur at all frequency bands of the electromagnetic spectrum (assuming the explosion is on or near the line of sight).

Obscuration times are generally 3 to 10 seconds in the millimeter wave portion of the spectrum; this is the amount of time required for the small clumps and large particles to fall back to the ground. The remaining airborne dust that forms the drifting dust cloud continues to provide obscuration in the visible

and infrared portions of the spectrum.

As a rule of thumb for drier soils, dust generally has less effect on IR sensors than on visual sensors such as the eye. For moist or very sandy soils, the two sensors are often affected equally, and under some conditions the IR sensors are obscured more than the visual sensors. In general, infrared sensors will usually offer some advantage over visible-radiation sensors when looking through dust.

Figure 20, at left, shows the phases of a munition dust cloud. The initial phase lasts only a few seconds and quickly blends into the rise phase that lasts about 10 seconds or less. The degree and time of obscuration depend on the dust cloud drift and dissipation phase of the dust cloud with respect to the line of sight and the

weather conditions. Dust clouds created by HE have three successive phases: impact, rise, and drift and dissipation.

- Impact phase. Upon munition impact, two parts of a dust cloud are created instantaneously. One part is the hot dust or fire ball, which has an initial size of 4 to 6 meters and is close to the surface. The dust or fire ball is initially several hundred degrees hotter than its surroundings. Most of the dirt and dust are contained in this initial dust or fireball. The second part is the dust skirt, which has a greater horizontal extent of 6 to 10 meters high, and has nearly the same temperature as its surroundings.

- Rise phase. The initial dust or fireball begins to rise and expand, cooling as it rises. The dust cloud top may reach heights of 10 to 30 meters in less than 10 seconds. The dust skirt does not rise but will continue to diffuse outward.

- Drift and dissipation phase. The entire dust cloud, both the buoyant part and the nonbuoyant dust skirt, begin to drift. Wind causes the upper portion to move out ahead while the lower dust skirt lags behind. As the dust cloud drifts, it diffuses, becoming thinner and gradually dissipating.

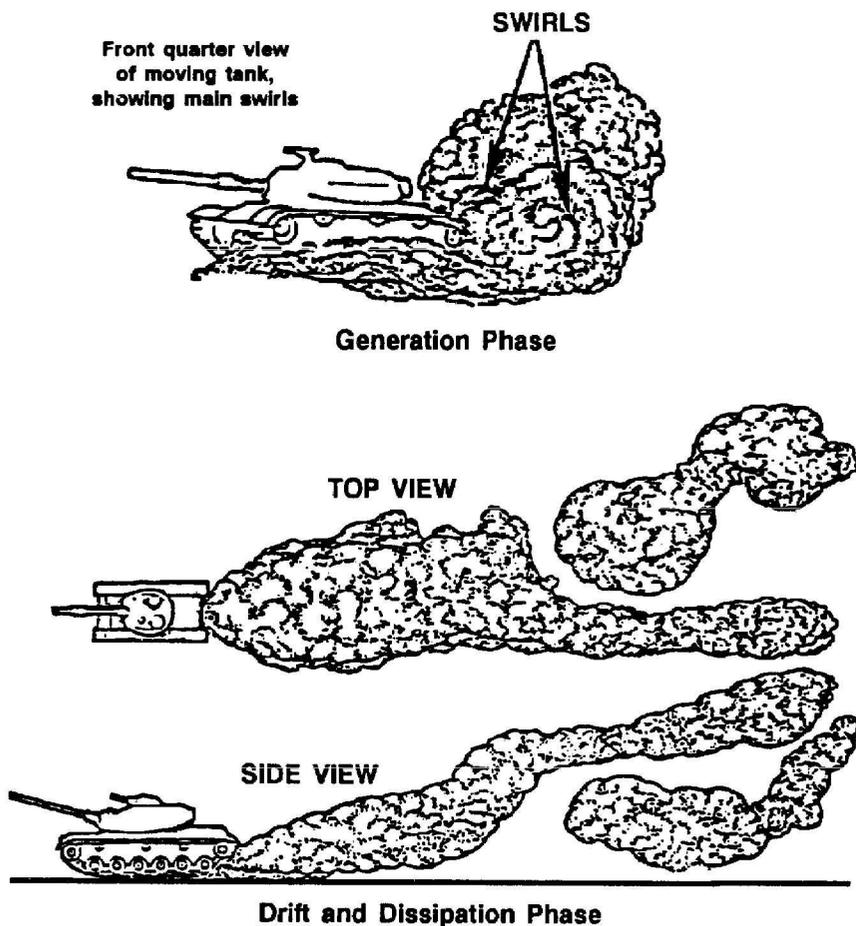


Figure 21. Vehicular dust cloud generation phase and drift and dissipation phase

## Vehicular Dust

The amount of dust produced by vehicular traffic depends on the weight of the vehicle, the number of wheels (or tread area), the speed of the vehicle, and the state of the soil. Because vehicles kick up the smaller particles present on the soil surface, vehicular dust does not effectively attenuate the radar or the millimeter wave portions of the spectrum. However, vehicular dust clouds can provide effective obscuration in the visible and infrared portions of the spectrum. Vehicular dust can be divided into two phases: generation and drift and dissipation (Figure 21).

- Generation phase. In this phase, the dust is thrown up or lifted off the surface by the vehicle's wheels

or treads and is swept up in the turbulent air under and behind the vehicle. The total amount of dust produced increases with the speed of the vehicle.

- Drift and dissipation phase. After the dust has been swept up behind the vehicle, it begins to drift and diffuse with the wind. As before, the degree and duration of obscuration

depend on the position of the dust trail with respect to a line of sight and the weather conditions.

## Artificial Obscurants

We cannot control the behavior of natural and by-product obscurants with the degree of certainty required to defeat enemy RSTA efforts. While natural and by-product obscurants block or attenuate portions of the electromagnetic spectrum, we must produce obscurants artificially to attack enemy electro-optical systems. We classify US obscurants as visual, bispectral, multispectral, and special.

While 98 percent of all current battlefield viewers operate in the visual portion of the spectrum, future systems will acquire and engage, using IR and millimeter wave technologies. This will require integration of each class of US obscurant to attack and defeat these systems. The following portions of this appendix describe the militarily significant, artificially produced obscurants.

### Visual Smoke

Many years of experience with smoke technology has shown white smoke to be superior to black smoke for most applications. Currently we have no black smoke production agents, although the US Navy does have black smoke production capability. The three principle agents for producing white smoke are oils (SGF2 and diesel), HC, and phosphorous.

### Oil Smoke

We make oil smoke by vaporizing fuel oils in mechanical smoke generators or engine exhausts. The generator or engine exhaust vaporizes either SGF2 or diesel fuel and for-

ces into the air where it condenses into a dense white smoke. This smoke can produce effective obscuration of the visual through near-infrared portions of the electromagnetic spectrum.

### Hexachloroethane Smoke

HC is a pyrotechnic composition of hexachloroethane, zinc oxide, and aluminum powder. A pyrotechnic starter mixture usually ignites the burning reaction. The smoke produced is zinc chloride during burning. This zinc chloride reacts with the moisture in the air to form a zinc chloride solution in tiny droplets: smoke. When first produced, HC smoke is very hot but cools rapidly and has little tendency thereafter to rise. HC munitions generally have definite burn times, which are useful for planning purposes.

### Phosphorous Smoke

#### Caution

HC is carcinogenic. Soldiers must wear respiratory protection (for example, a protective mask) while in HC smoke.

Phosphorus is a flammable solid that burns to form solid particles of phosphorous pentoxide in the air: smoke. The phosphorous pentoxide then reacts with moisture in the air to form phosphoric acid. We use phosphorous smokes in instantaneous-burst munitions (for example, artillery and rifle grenades), with the showers of burning phos-

phorous particles being highly incendiary. This makes phosphorous smoke excellent for harassing enemy personnel and starting fires, as well as its having excellent smoke properties.

Phosphorous smoke burns so hot

#### Caution

Phosphorous smoke produces phosphoric acid. Soldiers must wear respiratory protection, such as protective masks, if exposed to phosphorous smoke.

that it tends to form a pillar of smoke, which rises rapidly. While this pillaring reduces the efficiency of phosphorous smoke, the by-product of the heat is that it obscures from the visual through the far-infrared portions of the electromagnetic spectrum. The three phosphorous smokes are WP, PWP, and RP.

WP is a spontaneously flammable natural element. It ignites on contact with air and is relatively unstable in storage. WP burns at 5,000 degrees Fahrenheit, making it the most effective smoke agent to defeat thermal imagery systems.

PWP is a formulation of white phosphorus and some other agents (for example, butyl rubber) to stabilize the smoke agent fill and slow the burning. This slowed burning tends to produce a more coherent smoke cloud with less pillaring.

RP is not spontaneously flammable, requiring ignition to burn and make smoke. RP burns at a lower temperature – 4,000 degrees Fahrenheit – which produces a

more coherent smoke cloud with less pillaring. It is less incendiary than either WP or PWP, making it safer for use in smaller cartridges (for example, 40-millimeter grenades). Some munitions such as the M825 155-millimeter howitzer cartridge use felt wedges saturated with KP to produce an even distribution of smoke agent around the point of burst.

## **Bispectral Obscurants**

Bispectral obscurants defeat or degrade two portions of the electromagnetic spectrum simultaneously. As previously stated, phosphorous smokes defeat both

the visual and infrared portions of the spectrum. Other bispectral capabilities include type III IR obscurant, which is a micropulverized metal compound. Currently we use this bispectral obscurant in self-defense systems only (for example, the M76 smoke grenade for armored vehicle grenade launchers). In the near term we will have and use a large-area bispectral obscurant capability.

## **Multispectral Obscurants**

As implied by the name, multispectral obscurants will defeat or

degrade multiple portions of the electromagnetic spectrum. Challenges associated with this technology include preventing the inadvertent suppression of friendly force EO systems. In the mid-term we will have and use multispectral obscurants.

## **Special Obscurants**

Special obscurants will defeat specific portions of the electromagnetic spectrum.

Appendix H  
**PROBABILITY OF DETECTION**

**PROBABILITY OF DETECTION**

AIR STABILITY	WIND SPEED (MPH)	SOURCE STRENGTH (6 GENERATORS)	DOWNWIND DISTANCE (KM)	PROBABILITY OF DETECTION
<b>UNSTABLE</b>	5	5 lbs/min	1	55%
			3	75%
			5	95%
	5	10 lbs/min	1	35%
			3	60%
			5	80%
	10	5 lbs/min	1	85%
			3	100%
			5	100%
	10	10 lbs/min	1	55%
			3	85%
			5	100%

**PROBABILITY OF DETECTION**

AIR STABILITY	WIND SPEED (MPH)	SOURCE STRENGTH (6 GENERATORS)	DOWNWIND DISTANCE (KM)	PROBABILITY OF DETECTION
NEUTRAL	5	5 lbs/min	1	25%
			3	50%
			5	80%
	5	10 lbs/min	1	15%
			3	40%
			5	55%
	10	5 lbs/min	1	40%
			3	65%
			5	80%
	10	10 lbs/min	1	10%
			3	25%
			5	40%

**PROBABILITY OF DETECTION**

AIR STABILITY	WIND SPEED (MPH)	SOURCE STRENGTH (6 GENERATORS)	DOWNWIND DISTANCE (KM)	PROBABILITY OF DETECTION
STABLE	5	5 lbs/min	1	0%
			3	5%
			5	10%
	5	10 lbs/min	1	0%
			3	0%
			5	5%
	10	5 lbs/min	1	5%
			3	15%
			5	25%
	10	10 lbs/min	1	0%
			3	5%
			5	5%



## References

New reference material is being published all the time. Present references, as listed below, may become obsolete. To keep up to date, see DA Pam 25-30 (on microfiche).

### Required Publications

Required publications are sources users must read to understand or comply with this publication.

#### Field Manuals (FMs)

3-6, Field Behavior of NBC Agents (Including Smoke and Incendiaries)  
100-5, Operations  
101-5, Staff Organization and Operations

### Related Publications

Related publications are sources of additional information. They are not required to understand this publication.

#### Army Regulations (ARs)

310-25, Dictionary of United States Army Terms  
310-50, Authorized Abbreviations and Brevity Codes

#### Field Manuals (FMs)

3-100, NBC Operations

3-101, Chemical Staffs and Units  
6-20, Fire Support in the AirLand Battle  
17-95, Cavalry Operations  
25-100, Training the Force  
34-1, Intelligence and Electronic Warfare Operations  
71-3, Armored and Mechanized Infantry Brigade  
71-101, Infantry, Airborne, and Air Assault Division Operations (HTF)  
100-2-1, Soviet Army Operations and Tactics  
100-2-2, Soviet Army Specialized Warfare and Rear Area Support  
100-2-3, The Soviet Army Troops Organization and Equipment  
101-5-1, Operational Terms and Symbols

#### Soldier Training Publications (STPs)

3-54B1-SM, Soldier's Manual, MOS 54B, Chemical Operations Specialist, Skill Level 1  
3-54B2-SM, Soldier's Manual, MOS 54B, Chemical Operations Specialist, Skill Level 2  
3-54B34-SM-TG, Soldier's Manual, Skill Levels 3/4 and Trainer's Guide, MOS 54B, Chemical Operations Specialist

## Glossary

- AA – assembly area.
- AAR – after action report.
- abn – airborne
- ACR – armored cavalry regiment.
- ACRV – artillery command and reconnaissance vehicle.
- aerosol — fine particles of solids or liquid suspended in air.
- AD – air defense.
- AG – advanced guard.
- AICV – armored infantry combat vehicle.
- AirLand battle imperatives – key operating requirements for success on the battlefield to ensure unity of effort; anticipate events on the battlefield; concentrate combat power against enemy vulnerabilities; designate, sustain, and shift the main effort; press the effort; move fast, strike hard, and finish rapidly; use terrain, weather, deception, and OPSEC; conserve strength for decisive action; combine arms and sister services to complement and reinforce; understand the effects of battle on soldiers, units, and leaders.
- AMC – Army Materiel Command.
- APC – armored personnel carrier.
- arty – artillery.
- ASG – area support group.
- ASP – ammunition supply point.
- ATGM – antitank guided missile.
- attenuate — reduce the effectiveness, amount, or force of.
- bispectral obscurant – an obscurant that blocks or attenuates two portions of the electromagnetic spectrum (such as visual and infrared).
- blanket – See smoke blanket.
- BMNT – beginning morning nautical twilight.
- bn – battalion.
- BSA – brigade support area.
- build-up phase – the second stage of smoke cloud production; occurs when the individual smoke streamers start to merge.
- CAS – close air support.
- CCA – Combat Command A.
- CEOI – Communications-Electronics Operation Instructions.
- CEV – combat engineer vehicle.
- CFL – coordinated fire line.
- CFV – cavalry fighting vehicle.
- CLOS – command to line of sight.
- CMO – civil military operations.
- COSCOM – corps support command.
- CP – command post.
- CRP – combat reconnaissance patrol.
- CRSTA – counterreconnaissance, surveillance, and target acquisition.
- CSS – combat service support.
- curtain – See smoke curtain.
- DAG – division artillery group.
- decon – decontamination.
- deliberate smoke – characterized by integrated planning; may be used for extended periods for stationary or mobile missions.
- det – detachment.
- DEW – directed-energy weapon (such as high-energy microwaves, lasers).
- DISCOM – division support command.
- DPICM – dual-purpose improved conventional munition.
- DS – direct support.
- DSA – division support area.
- EA – engagement area.
- EENT – ending evening nautical twilight.
- eff – effective.
- electro-optical system — a device that detects targets by converting the electromagnetic radiation (visible, infrared, microwave) given off by the target into electric current; this current is amplified, then used to power a viewer or targeting system; this device can detect targets not visible to the naked eye.
- EMP – electromagnetic pulse.
- EO – electro-optical.
- EW – early warning.
- FA – field artillery.
- far infrared – electromagnetic energy with wavelengths of 8 to 14 micrometers.
- FASCAM – family of scatterable mines.
- FDC – fire direction center.
- FEBA – forward edge of the battle area.
- FFL – free fire line.
- flank wind – a wind that blows directly across a line between the

smoke objective and the smoke source.

FLIR – forward looking infrared.

FLOT – forward line of own troops.

fog oil – petroleum compounds of selected molecular weight and composition to facilitate formation of smoke by atomization or combustion; the resultant smoke is white.

FScell - fire support cell.

FSCOORD – fire support coordinator.

FSE – forward security element.

FSO – fire support officer.

g – gram.

gen – generator.

GS – general support.

GSR – ground surveillance radar.

G/VLLD – ground/vehicle laser locator designator.

hasty smoke – characterized by minimal planning; used for short periods to counter enemy action or anticipated enemy action of concern to the commander.

haze – a light concentration of obscuration that restricts accurate enemy observation from the air and ground. This prevents accurate enemy target acquisition, but does not disrupt friendly operations that require limited visibility, such as river crossings. A smoke haze allows limited visibility that reduces the recognition of personnel and equipment from 50 to 150 meters.

HC – a pyrotechnic smoke-producing composition of hexachloroethane, zinc oxide, and aluminum powder employed in certain smoke munitions; has a sharp, acid odor; toxic if released in sufficient quantities in enclosed places; the smoke is cool burning when contrasted to white phosphorus.

HE – high explosive.

HMMWV – high-mobility multipurpose wheeled vehicle.

head wind – wind blowing away from the smoke objective and directly toward the smoke source.

HUMINT – human intelligence.

ICM – improved conventional munition.

IFV – infantry fighting vehicle.

IMINT – imagery intelligence.

individual streamer – the initial phase of a smoke cloud, before the streamers from the point sources merge.

inversion — an increase of air temperature with increase in height (the ground being colder than the surrounding air); this condition usually occurs on clear or partially clear nights and early mornings until about one hour after sunrise, but sometimes persists longer. When stable conditions exist, there are no convection currents and, with wind speeds below 5 knots, little mechanical turbulence. Therefore, stable conditions are the most favorable for ground-released smoke.

IPB – intelligence preparation of the battlefield.

IPE – individual protective equipment.

ir – infrared.

ITV – integrated TOW vehicle.

k – knot(s)

km – kilometer(s).

kmph – kilometer(s) per hour.

LAMPSS – large-area mobile projected smoke system.

lapse – a marked decrease of air temperature with increasing altitude (the ground being warmer than the surrounding air). During unstable or lapse conditions, strong convection currents are found. For smoke operations, the state is defined as unstable. This condition is normally the most unfavorable for the release of smoke.

LC – line of crossing.

LD – line of departure.

LIC – low-intensity conflict.

LOGPAC – logistics package.

LRP – logistics release point.

LTOE – living table of organization and equipment.

m – meter(s).

marking smoke – smoke employed to relay prearranged communications on the battlefield. Frequently used to identify targets, evacuation points, and friendly unit perimeters.

MBA – main battle area.

mech – mechanized.

METT-T – mission, enemy, terrain, troops, and time available.

mid-infrared – electromagnetic energy with wavelength in the range of 3 to 8 micrometers.

min – minute(s).

mm – millimeter(s).

MOGAS – motor gasoline.

MOUT – military operations on urbanized terrain.

MRB – motorized rifle battalion.

MRC – motorized rifle company.

MSR – main supply route.

MTOE – modified table of organization and equipment.

multispectral obscurant – an obscurant that blocks or attenuates more than two portions of the electromagnetic spectrum (such as visual, infrared, and millimeter wave).

NAI – named areas of interest.

NBC – nuclear, biological, and chemical.

NBCC – nuclear, biological, and chemical center.

NCO – noncommissioned officer.

near infrared — electromagnetic energy with wavelengths of 0.7 to 3 micrometers

neutral – a meteorological condition that exists when conditions are intermediate between lapse and inversion; neutral conditions tending toward lapse favor production of smoke curtains; neutral conditions tending toward inversion favor smoke blankets or hazes.

night-vision device — a viewer enabling an operator to see in the dark; also called night-observation device.

NFL – no fire line.

NTC – National Training Center.

OB – order of battle.

obj — objective.

obscurant – chemical agent that decreases the level of energy available for the functions of seekers, trackers, and vision-enhancement devices.

obscuration smoke – smoke placed on or near enemy positions to minimize enemy observation both within and beyond the position area.

oil smoke – see fog oil.

OP – observation point.

OPCON – operational control.

operational continuum – the strategic environment within each theater, consisting of a variety of political, military, and economic conditions and a range of threats that result in a wide range of operations conducted within a continuum; consists of three general states: peacetime competition, conflict, and war.

OPLAN – operation plan.

OPORD – operation order.

OPSEC – operations security.

PD – proximity detonator.

phases of smoke – see individual streamer, build-up phase, uniform phase, and terminal phase.

PHOTINT – photographic intelligence.

PIR – priority intelligence requirement.

PL – phase line.

plt – platoon.

POL – petroleum, oils, and lubricants.

protection smoke – smoke produced to defeat or degrade target acquisition or guidance systems or the effects of directed-energy weapons.

PWP – plasticized white phosphorus.

quartering wind – a wind that blows between tail and flank winds, toward the smoke objective.

RAG – Regimental Artillery Group.

rd – round.

recon — reconnaissance.

red phosphorus – a form of phosphorus not spontaneously flammable.

RFL – restrictive fire line.

RISTA – reconnaissance, intelligence, surveillance, and target acquisition.

RP – red phosphorus.

RPV – remotely piloted vehicle.

RSTA – reconnaissance, surveillance, and target acquisition.

S1 – adjutant.

S2 – intelligence officer.

S3 – operations officer.

S4 – logistics officer.

screening smoke – smoke employed in areas of friendly operation or in areas between friendly and enemy forces to degrade enemy ground and aerial observation; used to conceal ground maneuver, breaching, and recovery operations, as well as key assembly areas, supply routes, and logistic facilities.

selected area – as used in this manual, an area to be concealed by smoke.

SG – smoke generator.

SGF2 – smoke generator fog number 2; also called fog oil.

signature — the visible or audible effects produced when firing a weapon or operating a piece of equipment, such as noise, smoke, flame, heat, or debris; also, an electronic emission subject to detection and traceable to the equipment producing it.

silhouette – the outline or general shape of something contrasted against a lighter background.

SLAR – side-looking airborne radar.

smoke – a particulate of solid or liquid, part of low-vapor pressure that settles out slowly under gravity; in general, smoke particles range downward from about 5 micrometers in diameter to less than 0.1 micrometer in diameter; also means the suspension of small liquid or solid particles in air; the filling for smoke munitions, such as bombs, shells, and grenades; to produce signaling or screening smoke with any munition; generally, any artificial aerosol.

smoke blanket – a dense concentration of smoke established over and around friendly areas to protect them from visual observation from the air and visual precision bombing attack, or established over an enemy area to protect attacking aircraft from air defense fire. Blankets can also be used at night to prevent enemy-observed air attack by flare light. A smoke blanket reduces visual

recognition of personnel and equipment to less than 50 meters.

smoke control officer — the officer designated by the maneuver unit commander to coordinate and control the smoke operation.

smoke curtain — a vertical development of smoke that reduces the enemy's ability to clearly see what is occurring on the other side of the cloud; visual recognition depends on the curtain width and smoke density.

smoke generator — a mechanical device that vaporizes fog oil and releases it to condense in the air as a white smoke.

smoke haze — a light concentration of smoke placed over friendly installations to restrict accurate enemy observation and fire, but not dense enough to hamper friendly operations; density of haze is equivalent to that of light fog.

smoke munition — a device that is either discharged from a weapon or thrown and that makes smoke.

smoke point source — the point from which a smoke munition or smoke device generates an individual streamer of smoke.

smoke position — location of a smoke pot or mechanical smoke generator.

smoke pot — an expendable bucket- or pot-like ammunition that produces a dense smoke by burning a smoke mixture.

smoke projectile — any projectile containing a smoke-producing agent that is released on impact or upon bursting; also called smoke shell.

smoke shell — see smoke projectile.

smoke target analysis — the process of selecting the optimal smoke delivery system to attack specific EO systems.

smoke target development — the process of situation development and intelligence preparations of the battlefield.

SOP — standing operating procedure.

sophisticated weapons — precision-guided munitions, equipped with infrared, electro-optical, or laser seekers/trackers with or without command links; munitions with high accuracy and, hence, high probability of kill against a target.

special smoke — an obscurant that blocks or attenuates a specific portion of the electromagnetic spectrum (such as visual, infrared, and millimeter wave).

spt — support.

sqd — squad.

stable — see inversion.

streamer — the smoke cloud formed by a single smoke source.

synchronization — the coordination of activities in time, space, and purpose to achieve maximum combat power at the decisive point.

TAA — tactical assembly area.

TAACOM — theater Army area command.

TAC — Tactical Air Command.

TAI — target areas of interest.

tail wind — a wind that blows toward the smoke objective from behind the smoke source.

temperature gradient — comparison of the air temperature at .5 meters above the ground with the air temperature at 4 meters above ground; see also inversion, neutral, and lapse.

terminal phase — that stage of a smoke cloud when the cloud has thinned out and the cover is no longer effective; see also smoke blanket.

thermal infrared — electromagnetic energy with a wavelength range of 3 to 20 micrometers.

TOC — tactical operations center.

TOE — table of organization and equipment.

TOW — tube-launched, optically tracked, wire-guided.

TPU — tank and pump unit.

TVA — target value analysis.

uniform phase-phase of smoke during which the uniformly obscuring cloud exists — the streamers have joined and breakup of the cloud has not begun.

unstable — see lapse.

UTM — universal transverse mercator.

VEESS — vehicle engine exhaust smoke system.

visibility — the distance at which it is possible to distinguish a prominent object against the background with the unaided eye.

visibility criteria — the unit commander's requirement for minimum visibility in a smoke cloud. For example, in obstacle emplacement by engineers, the maneuver brigade commander may want to conceal the engineer operation without hindering their work. He establishes a visibility criteria (such as 150 meters) for the smoke.

visible spectrum — the portion of the electromagnetic spectrum lying between 0.4 and 0.7 micrometers.

white phosphorus — a spontaneously flammable solid that burns to form solid smoke particles of phosphorus pentoxide; the phosphorus pentoxide then reacts with moisture in the atmosphere to form droplets of phosphoric acid; the dilution depends on the relative humidity.

WP — white phosphorus.

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Change  
No. 1

Headquarters  
Department of the Army  
Washington, DC, 11 September 1996

## Smoke Operations

1. Change FM 3-50, 4 December 1990, as follows:

Remove old pages:	Insert new pages (attached)
3 through 4	3 through 4
97 through 98	97 through 98
	54-A through 54-D

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