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    This presentation covers the technical background of the subjects of dissemination as well as redissemination and fiber life. These subjects were defined in the overview presentation. Dissemination, as shown in figure 1, is the first release of the
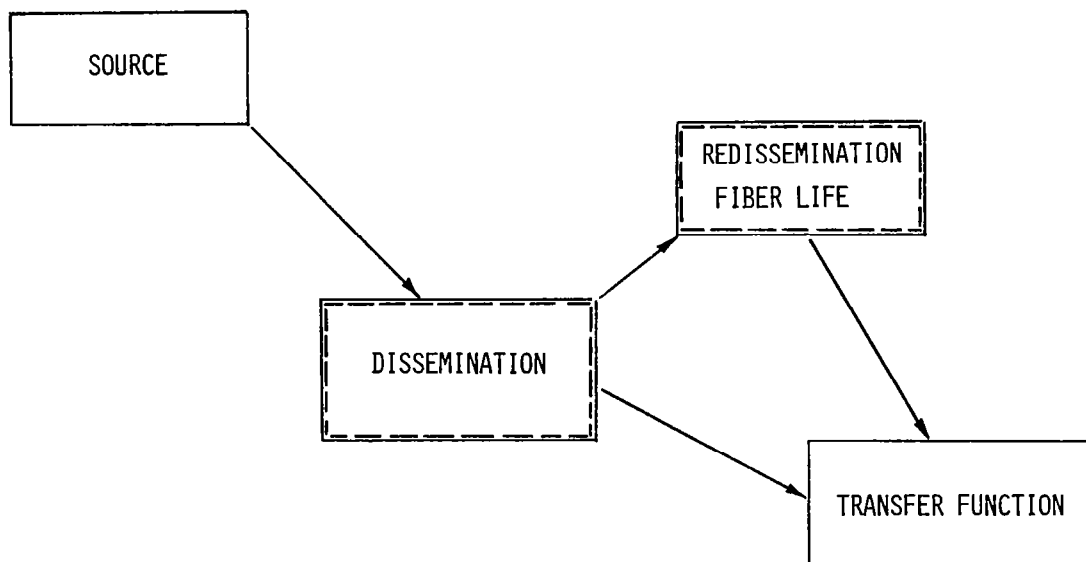
OUTLINE OF PROBLEM

Figure 1

fiber and the drift of the fibers, or clumps, or fragments in the pollutant cloud downwind from the accident scene. Those fibers will of course deposit somewhere and there is a possibility that they are either stirred up by wind or traffic to be redisseminated. If they are not redisseminated, then they might be buried in the ground or destroyed. That's the subject of fiber life.

    I want to treat first the dissemination portion of the problem and give you a basic introduction. I want to leave you with a qualitative idea of how the fibers are disseminated and some quantitative feel for the range and the amount of dissemination.

    In figure 2 you see a typical accident scene. Above the aircraft accident we consider having a fire plume, which as long as
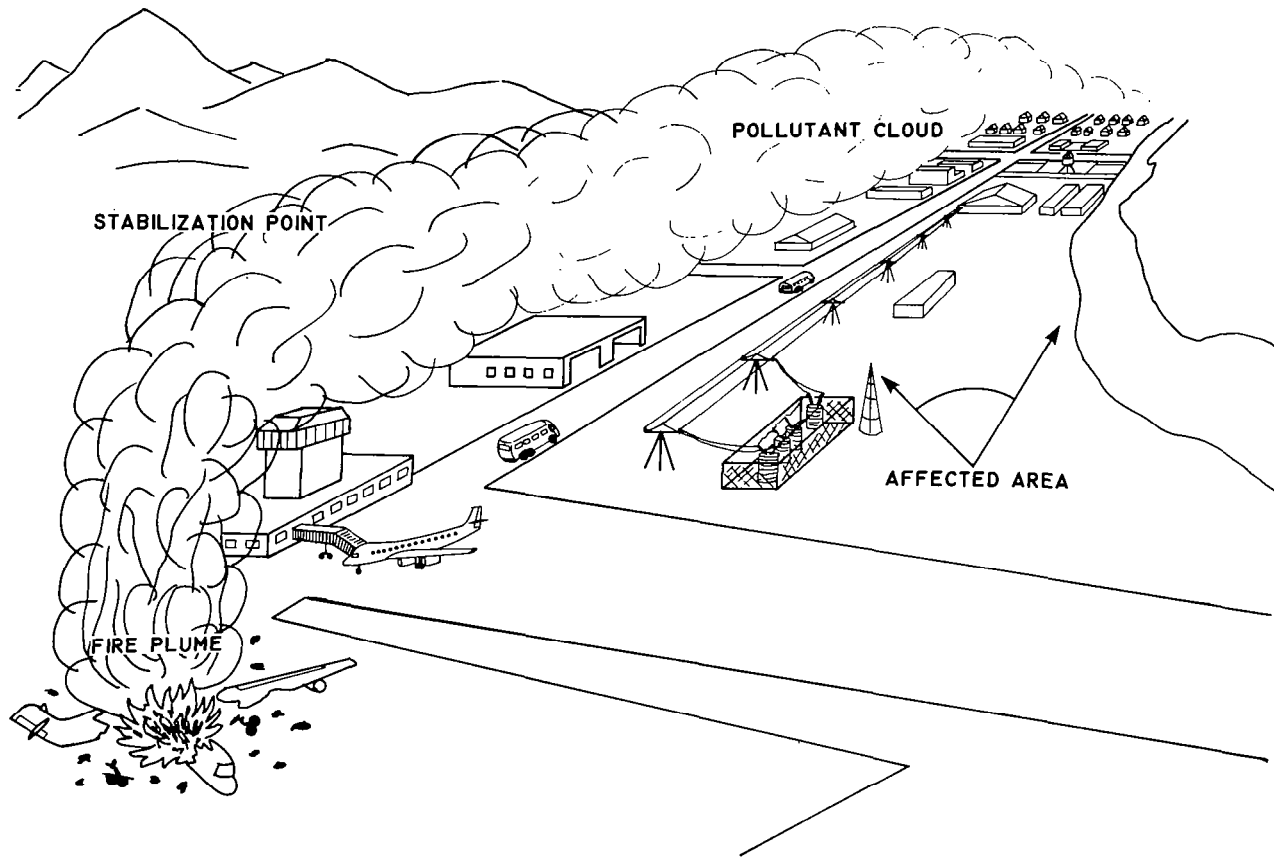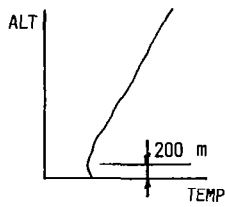
ACCIDENT SCENE

Figure 2

it has thermal energy also has buoyancy and therefore a vertical velocity. After a while it mixes with the ambient air and it will stabilize. After that we consider the next phenomenon which is the drift of the pollutant cloud downwind over industry, domestic areas, and possibly out to sea. The whole process is very strongly dependent on the weather. One of the first characteristics of a certain weather situation is the vertical temperature profile in the atmosphere, because mixing of aerosols occurs only in the convective band, i.e. below the inversion.

In this first case, in figure 3, which is typical of a night-time situation, we have an inversion at about 200 m. So the mixing occurs over a relatively shallow layer. If there are any winds, they are typically very low, so that the cloud drifts slowly. This nighttime weather would be categorized as an E or F Pasquill-Gifford stability class. As you can see on the sketch below this first case, the moon is shining, and the plume is spreading at a relatively shallow angle that is characteristic of stable weather conditions. The spread angle is of the order of 10 degrees, sometimes even less.
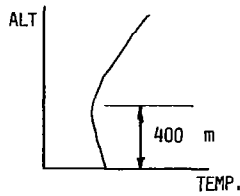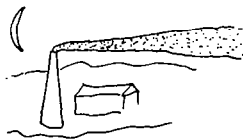
PLUME SPREAD AND WEATHER

ALT | 200 m | TEMP

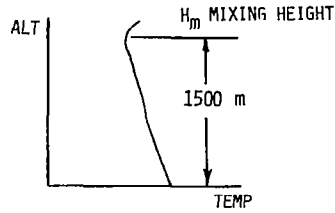TYPICALLY: LOW WINDS
           NIGHT

CATEGORY:

STABLE   E

ALT | 400 m | TEMP.

TYPICALLY HIGH WINDS

TYPICALLY OVERCAST

CATEGORY

NEUTRAL   C

ALT | H_m MIXING HEIGHT | 1500 m | TEMP

TYPICALLY SUNNY

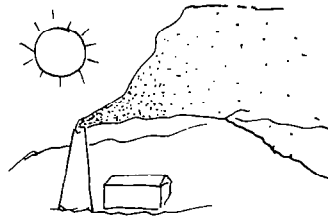LOW WINDS

CATEGORY

UNSTABLE   A

Figure 3

In the second weather situation, called a neutral weather
category, we have typically very high winds, typically it is over-
cast and the mixing depth is very much deeper, on the order of
400 meters. The sketch shows overcast weather and a spread angle
of the plume cloud on the order of 20 degrees, somewhat larger
than for the stable weather. In the third category, that's the
weather we all like to have, and don't often get, it's the
typically sunny weather, low winds, and Pasquill-Gifford category
unstable A. If ever you see cumulus clouds in the sky, you know
you have unstable weather, usually B sometimes A. The mixing
layer is typically more like 1500 meters. The atmosphere is mixed
over very great depths and of course, that means also that the
pollutants are mixed over those depths. The sketch shows the sun
shining and the plume spreading at an angle of about 40 degrees.
When it encounters the inversion the plume will not penetrate that
inversion because there is no vertical turbulence up there. It
will stay below the inversion, or reflect.

Next I want to define the measures of pollution shown in
figure 4. One thing that is of course important is the concentra-
tion of the pollutant, the number of particles over the volume, or
volumetric density. Usually, more important than the

MEASURES OF POLLUTION

1. CONCENTRATION, C = $\dfrac{\text{NUMBER OF PARTICLES}}{\text{VOLUME}}$

2. EXPOSURE OR

   DOSAGE   , E = CONCENTRATION X TIME

   $= \int C\ dt$

3. DEPOSITION, D= $\dfrac{\text{NUMBER OF PARTICLES}}{\text{AREA}}$

Figure 4

concentration is the exposure, which is the concentration times
the time of exposure, or the time integral of concentration. In
some instances, the number of particles that get deposited on
the ground, or the number of particles per unit area would
be a suitable measure of pollution. Measure of pollution is
not quite the same, of course, as the measure of potential damage.
We have to measure the potential damage. We also need to know
the area over which we get certain exposures. Therefore we plot
an area-exposure diagram. For each exposure such as exposure E4,
in figure 5, we calculate and plot the area A4, over which that
level of exposure is exceeded. The integral $\int$ E dA is a signif-
icant measure of potential damage. The others are just a mea-
sure of pollution. One important point, at this time you've
seen this morning that the vulnerability or the damage is a
continuous proportional function of exposure, so that even at
extremely low values of exposure, you still have a very small
probability of failure. Now if you have a very large area, at a
given small exposure, the product of that large area and exposure
contains a lot of equipment and may cause just as much damage
as having exposure over a small area. That is peculiar to this
situation which we have - a probability of damage continually
defined as a function of exposure, whereas in other pollution
problems we talk about a critical value below which we're safe,
above which we're unsafe.

MEASURE OF DAMAGE POTENTIAL
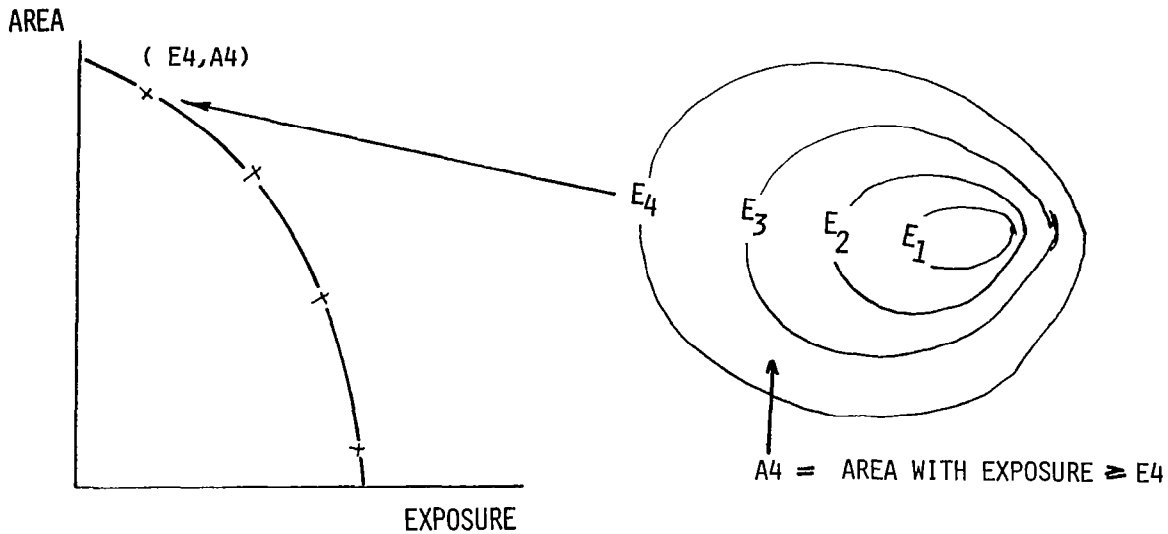## AREA COVERAGE DATA

Figure 5

Many of you have seen the type of footprints that have been used in the studies of the last few years to show the range over which we can affect the countryside. Figure 6 is drawn basically to give a qualitative feel for how strong the exposure effects can be. In the top left hand figure, I've drawn an exposure profile where the outermost exposure profile represents about 5% of the maximum exposure in that area. For the weather condition which was an overcast weather or night, in other words, a stable weather situation, the exposure pattern is a very narrow streak, and it could extend the five percent level 100 kilometers from the accident scene. In the unstable, sunny weather, the dispersion is very much wider, the dilution of the pollution is much stronger so the 5% level is very much closer in. In this case I've shown it as about 50 kilometers but the area is roughly the same as in the previous case because the streak is now wider. Those cases are for single fibers with fall velocity of 0.02 meters per second. Let's look at the heavier particles. Looking at lint, which was characterized as being a group of fibers typically 20 or more, it has a fall velocity one order of magnitude larger, or 20 centimeters per second. Now, that would mean it would take approximately a half a minute to fall from the ceiling to the floor in this room, whereas a single fiber would take on the order of 300 seconds, or six minutes. Thus for the

lint, the 5% level might occur out at 10 kilometers in the over-
cast weather and at about half that distance in the strong sun
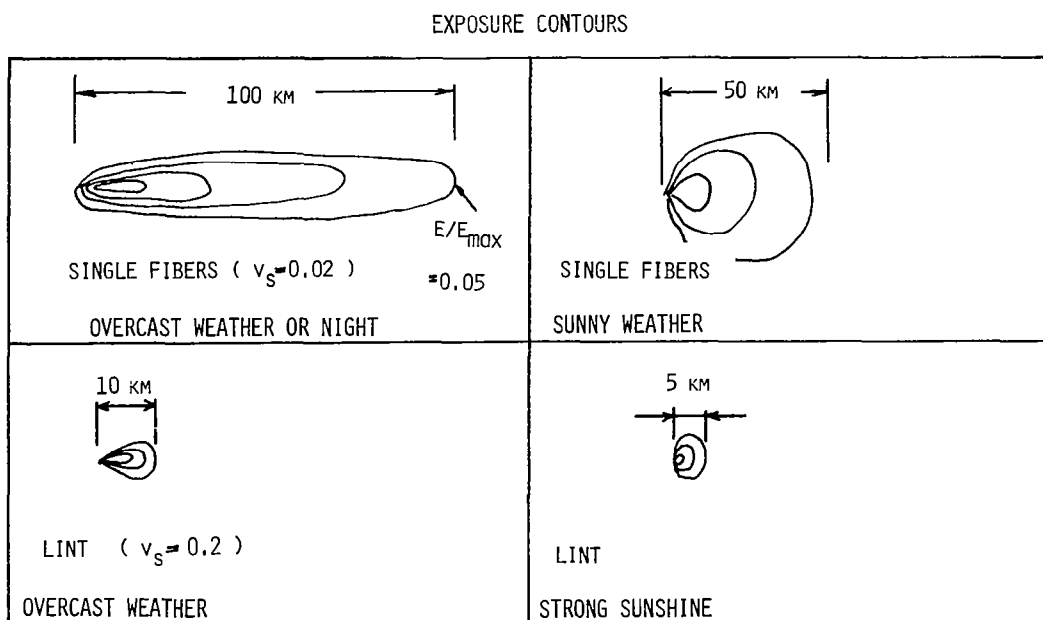shine with the wider exposure field.

EXPOSURE CONTOURS

Figure 6

Figure 7 lists the parameters controlling the dissemination
patterns. The fire starts the dissemination problem, and is
influenced by the amount of fuel, the burning rate, the pool size,
and maybe some other factors, like the pool shape, or the number
of individual pools of fuel. The exposure levels of course are
controlled very strongly by the source, that is, how many fibers
do we get out, what length fibers do we get out and what fragments
do we get out? We want to characterize those by distribution of
size and fall velocity. The weather strongly influences the
dissemination pattern. The effect of the vertical stability con-
ditions and mixing layer depths has been discussed. The wind
velocity influences how far the material drifts down range in a
given time, and fibers can be precipitated with rain or snow.
Figure 8 shows the logic for two fire plume model types: empiri-
cal models and physical models. The first model is the empirical
model which consists basically of the Briggs' equations. Those
equations are based on observations of smoke stacks and provide
reliable answers for the stabilization height and location.

PARAMETERS CONTROLLING DISSEMINATION
PATTERNS

FIRE: AMOUNT OF FUEL
           BURNING RATE
           POOL SIZE

SOURCE: AMOUNT OF LOFTABLE DEBRIS
           SIZE AND FALL VELOCITY OF PARTICLES

WEATHER: CATEGORY: STABLE, NEUTRAL, UNSTABLE
           WIND VELOCITY
           MIXING LAYER DEPTH
           PRECIPITATION

Figure 7

FIRE PLUME MODELS

INPUT: EMPIRICAL MODEL: OUTPUT:

FUEL AMOUNT	→	BRIGG'S	→	STABILIZATION
BURN RATE		EQUATIONS		HEIGHT
WEATHER				CLOUD SIZE
				CLOUD LOCATION

FUEL AMOUNT	→	SAI	→	CLOUD HEIGHT
BURN RATE		PHYSICAL		SIZE
WEATHER		MODEL		LOCATION
				FLAME TEMPERATURE
				VELOCITY
				CHEMISTRY
				POTENTIAL FIBER
				BURN-UP

STATUS: UNDER DEVELOPMENT

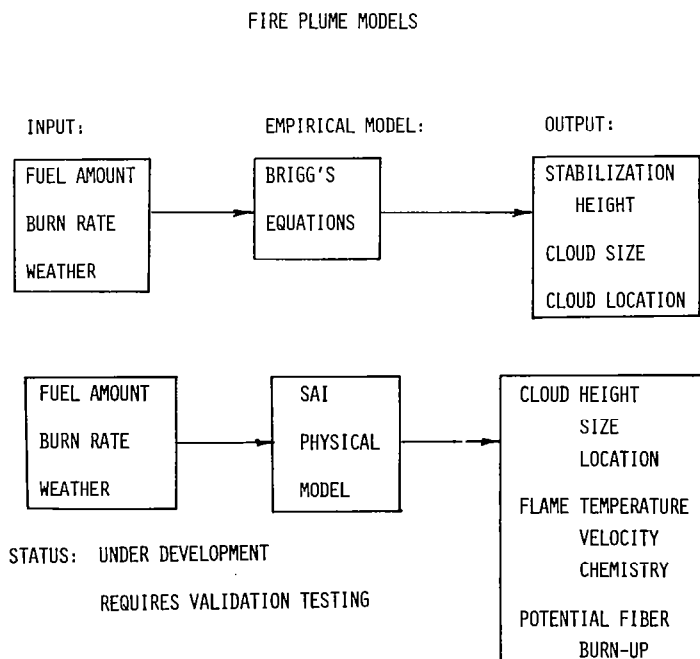REQUIRES VALIDATION TESTING

Figure 8

The growth of a fire plume is somewhat different from a smoke
stack, so that an empirical expression was derived for the type
of fire of interest. In most cases the fire plume will grow at
an angle of approximately 40 degrees, as shown in Figure 9, so
that the cloud location and stabilization height can be obtained
from the Briggs equations, the cloud size from the 40 degree esti-
mate. The second type of models are the physical models. Some
work was done under contract to develop a model which takes the
input conditions - fuel amount, burn rate, and weather - to obtain
a physical representation of a fire including cloud height, size,
location, flame temperature, flame velocity, flame chemistry,
and the potential fiber burn up, which may be of importance. Some
preliminary flame velocity data from this model are presented in
figure 10 showing flame velocities up to about 15 meters per
second. For the two fires shown here, a 7.5 meter pool and a 30
meter pool, you see that as a function of nondimensional radius
from the center at a height 5 meters above the ground, both fires
have about the same peak, but the little pool has already
developed a more uniform plume shape. Another output from that
type of model is the temperature distribution inside those
fires, shown in figure 11. We see some results that were
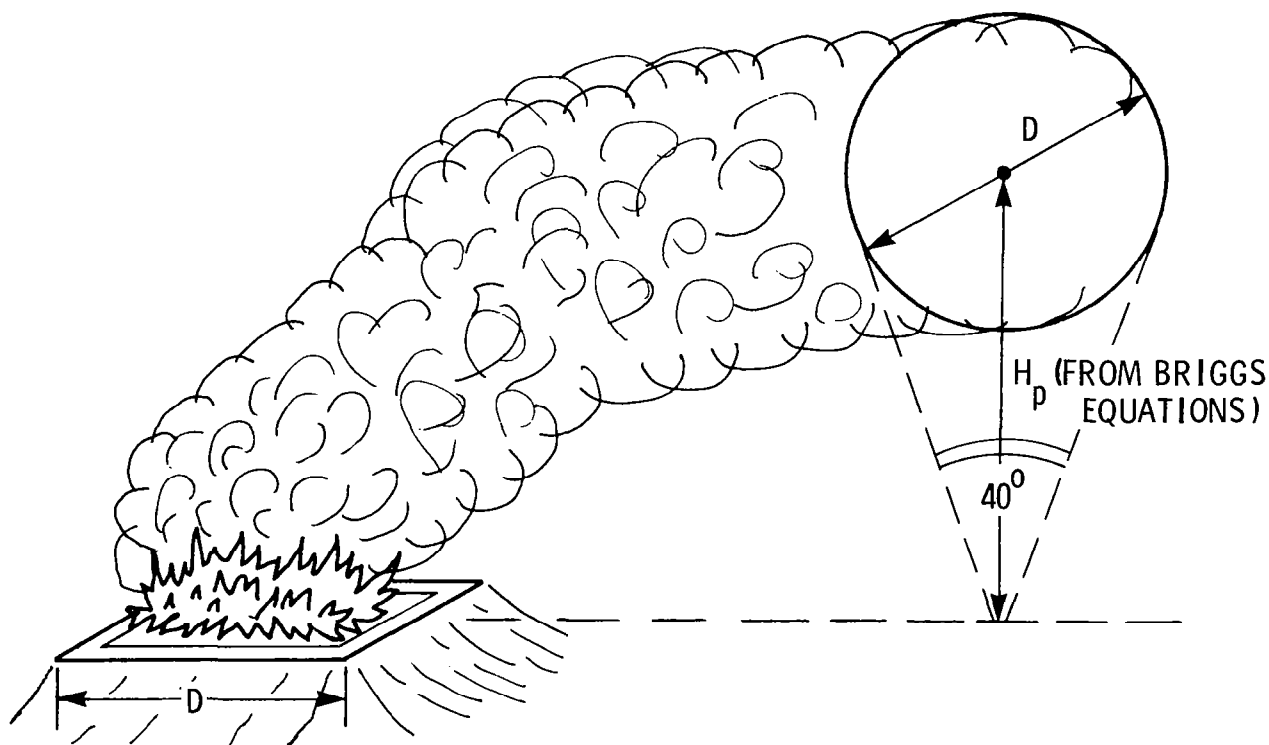
FIRE PLUME CHARACTERISTICS

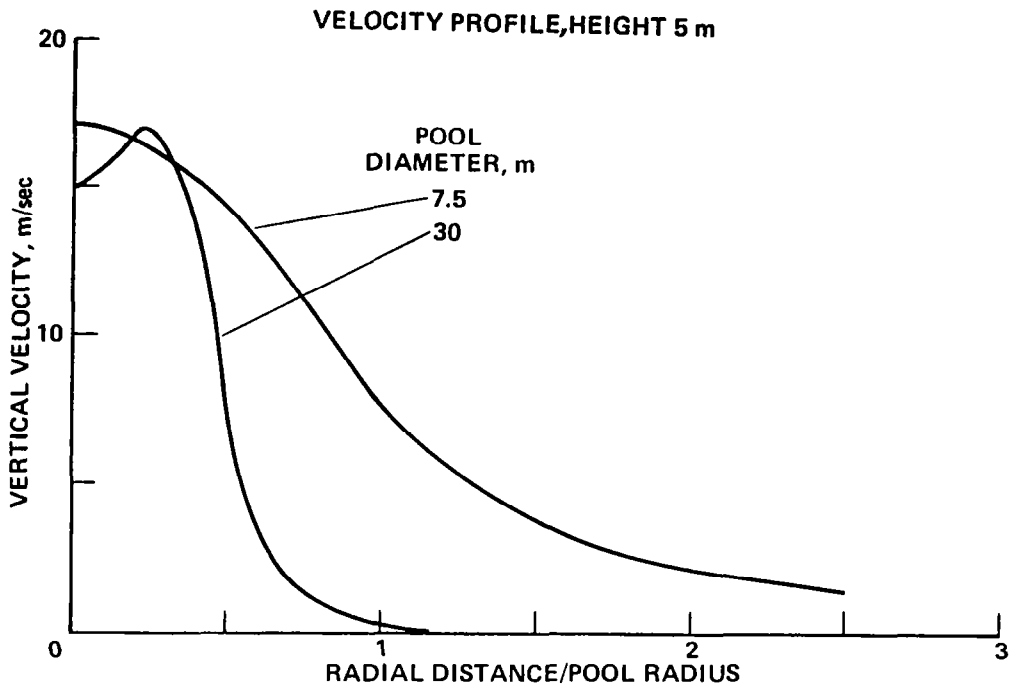Figure 9

VELOCITY PROFILE, HEIGHT 5 m

VERTICAL VELOCITY, m/sec

POOL
DIAMETER, m

7.5

30

RADIAL DISTANCE/POOL RADIUS

Figure 10

TEMPERATURE PROFILE, HEIGHT 5m

TEMPERATURE, °K

POOL
DIAMETER, m

30

7.5

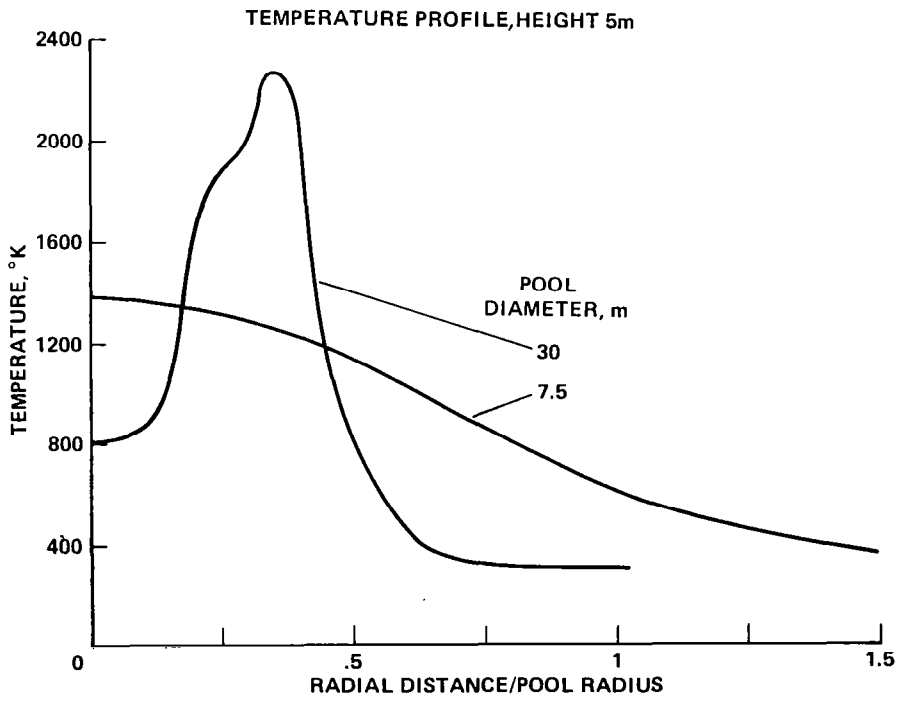RADIAL DISTANCE/POOL RADIUS

Figure 11

surprising and that were referred to earlier in a question. You
see for a small pool at the 5 meter height above the ground, the
temperatures are relatively low - the peak temperatures are about
1500 Kelvin which is in the range of temperatures we have been
talking about. But for the large pool, we have temperatures of
approximately 2300 Kelvin or 2000 degrees centigrade - very high
temperatures with a very great potential for burning up the fiber.
In this fire the influx of oxygen around the base is so strong that
stoichiometric conditions exist, and very good oxidation and very
high temperatures result.

A typical analysis of the amount of graphite fibers consumed
in a fire showed that a relatively small percentage of the fibers
is lost (figure 12). Other cases like the high temperature fire
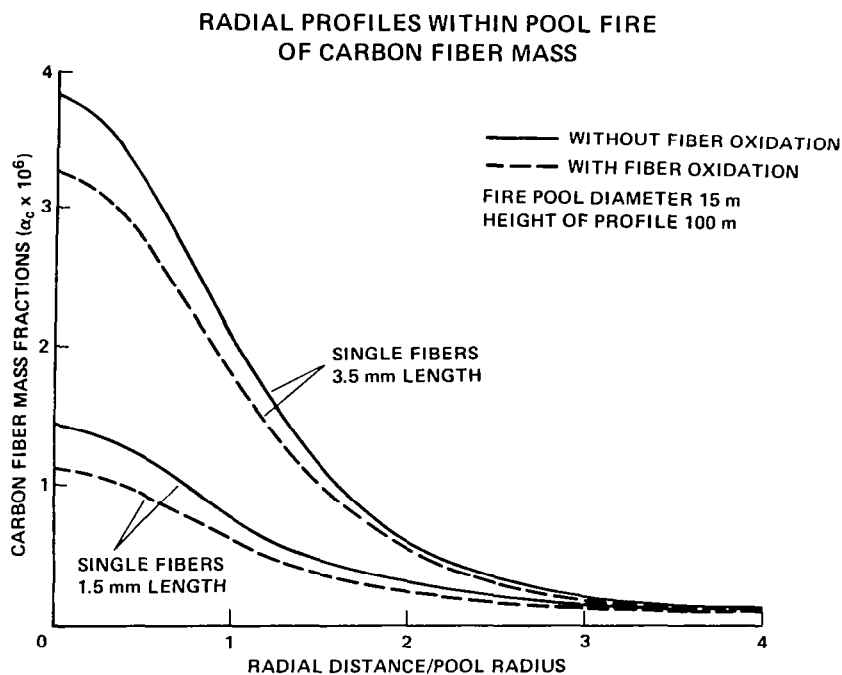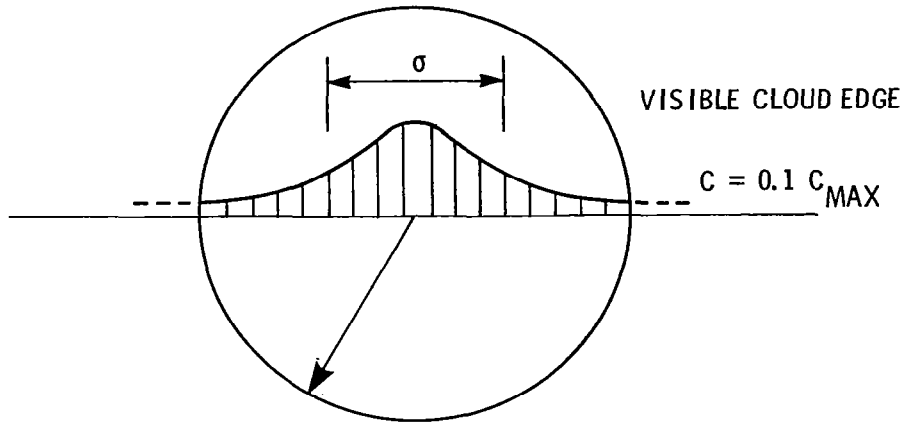of course would consume a larger percentage of fiber.

**RADIAL PROFILES WITHIN POOL FIRE
OF CARBON FIBER MASS**

Figure 12

As the fire plume rises, mixes, and cools, it reaches a sta-
bilization point. At that point the output conditions from the
plume models are transferred as input conditions into the dissemi-
nation model. Normally the pollutant is assumed distributed in a
Gaussian manner, either spherical for a short duration source or
two-dimensional for a continuous plume. The Gaussian distribution
has a minus R square exponent term so that we get the bell shaped
distribution around the center of the cloud as shown in figure 13.
That distribution shape and the size of the cloud go into the

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THE GAUSSIAN CLOUD

VISIBLE CLOUD EDGE

$C = 0.1 \; C_{MAX}$

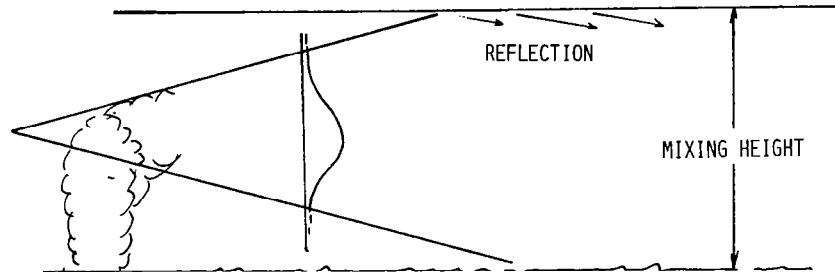$$C = \frac{N}{(2\pi)^{3/2} \sigma^3} \; e^{-\frac{r^2}{2 \sigma^2}}$$

Figure 13

dissemination models. Basically, there are two types of dissemina-
tion models, the Gaussian models and the particle-in-the-cell
models. In the Gaussian models, we assume that this initial
Gaussian cloud drifts downwind and grows so that the standard
deviation (the sigma terms) keep growing in two or three direc-
tions as the cloud drifts downwind. If the cloud strikes the
inversion level, as it does in figure 14, the material in the cloud
is reflected back. Some fairly complex programming steps have to
be taken to reflect the material back in the computations. There
are several of these Gaussian models, such as the Tretheway and
Cramer models, and of course, the EPA Turner models, which are
being developed for pollution problems. The dispersion coeffi-
cient, namely, the angle at which the cloud spreads, has been
determined empirically for the various Pasquill-Gifford stability
classes, so that you have a 10 degree cone for the stable weather
and you have a 40 degree cone for the unstable weather. They
are somewhat difficult to adapt to complex terrains and wind
profiles. The Gaussian models are very cheap to run; a single
analysis on a large computer requires fractions of a second for
any one dispersion case. We use them in various forms in our
risk assessment contracts. The other model type, indicated
in figure 15, the particle-in-a-cell model, takes little particles
in a cell and by brute force solves the 3-D diffusion equations

GAUSSIAN MODELS
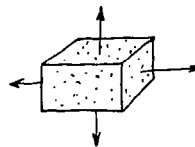DISPERSION ALONG CONICAL SECTOR   (TRETHWAY-CRAMER , EPA-TURNER)

o DISPERSION COEFFS DETERMINED EMPIRICALLY
    FOR PASQUILL-GIFFORD STABILITY CLASSES
o DIFFICULT TO ADAPT TO COMPLEX TERRAINS,
    WIND PROFILES
o CHEAP TO RUN
o USED IN RISK ASSESSMENT CONTRACTS

Figure 14

DISSEMINATION MODELS (CONT.)

PARTICLE-IN-CELL MODELS   (LAWRENCE LIVERMORE LABORATORIES)
SOLUTION OF 3-D DIFFUSION EQUATIONS

o BASED ON DIFFUSIVITIES DETERMINED
    EMPIRICALLY FOR PASQUILL-GIFFORD
    STABILITY CLASSES.
o TERRAIN, WIND PROFILE AND OTHER
    SECONDARY DETAILS INCLUDED IN
    BOUNDARY CONDITIONS
o EXPENSIVE TO RUN
o NECESSARY FOR SPECIFIC CASE STUDIES

Figure 15

including of course the fall velocity of the particles. Depending on the required precision it is a very lengthy computation. The diffusion is based on the same input data as used for the Gaussian models. The diffusivities are back calculated from the smoke plume model. In those models it is easy to adapt to a terrain for a certain wind profile and any other secondary details. Now that is important, because sometimes a cloud drifts a hundred kilometers downwind over a long time including changes in wind speed and direction as well as changes in the inversion height. These models are extremely expensive to run on computers, but to do a specific test run such as tracking a specific accident, requires the use of those models to get the precise details of where the material went.

A parametric dissemination analysis was developed to get a quantitative feel for the size of the dissemination pattern. This analysis is shown in figure 16 in a nondimensionalized form where the distance away from the source is divided by the mixing height. The fall angle (β) is the fall velocity of the particle divided by the wind speed, (N) is the number of particles and (α) is a horizontal spread angle in which all the material is contained uniformly. The exposure equation (shown) contains the source terms, proportional to the number of fibers and their fall velocity data, as an exponential term. The denominator has the weather factor term $UH^2\alpha$, which is the product of the inversion

PARAMETRIC MODEL PREDICTIONS

PARAMETERS:

$$\zeta = \frac{R}{H}$$ NONDIMENSIONAL DOWNWIND RANGE

$$\beta = \frac{v_s}{u}$$ NONDIMENSIONAL PARTICLE FALL RATE

$$N = $$ NUMBER OF PARTICLES IN THE CLOUD

$$\alpha = $$ HORIZONTAL CLOUD SPREAD ANGLE

DOSAGE EXPOSURE PROFILE:

$$E = \frac{N}{u H^2 \alpha} \times \frac{1}{\zeta} \times e^{-\beta\zeta}$$

DEPOSITION PROFILE:

$$D = N \left\{ 1 - e^{\beta\zeta} \right\}$$

Figure 16

height squares, the spread angle, and the wind velocity. Such is the influence of the weather on the exposure pattern.

The second equation is for the deposition profile. Out to the nondimensional distance ρ you have a deposition fraction given by that equation. The weather factor, $UH^2\alpha$, as listed in figure 17, in the stable weather is about 3×10^4; in neutral weather, 5×10^5; in unstable weather, 4×10^6, indicating that the exposures decreased by an order of magnitude everytime you go towards the sunny weather. Sunny weather gives you 1/100th of the local exposure values of the stable weather - the night-time conditions.

Figure 18 represents an almost scaled drawing of the dissemination pattern. Let's take single fibers with a 2 centimeter per second fall velocity and the wind at 2 meters per second and a mixing depth of 1000 meters. Only 60% of the fibers are deposited within the first 100 kilometers of the source; the others are still airborne. To drift down 100 kilometers, the cloud takes 14 hours. In that time of course, weather is going to change. You're not likely to have 100 kilometers of one weather system and even if you do, its going to change in 14 hours. Even if you were to have that stability, 40% of the particles would still be airborne, covering a wide sector of the countryside. For a case like that we can calculate the area coverage for the simple model. Once we have exposure,

THE WEATHER FACTOR

STABLE			NEUTRAL	UNSTABLE
TYPICAL:				
H	:	200 M	400	1500
α	:	0.2	0.4	0.8
U	:	4 M/S	8	2
$U\,H^2\alpha$	:	3.2×10^4	5.1×10^5	4×10^6

Figure 17

SCALE OF DISSEMINATION

FOR SINGLE FIBERS V_S = 0.02 M/s

IN A WIND U = 2 M/s

WITH A MIXING DEPTH H = 1000 M

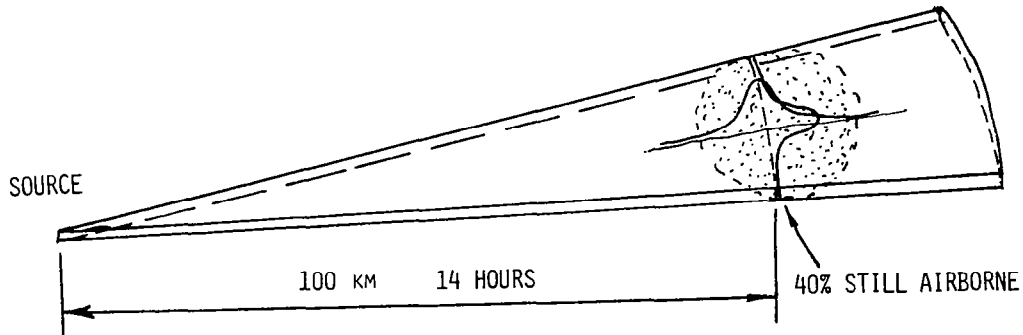60% OF FIBERS ARE DEPOSITED WITHIN 100 KM OF THE SOURCE

Figure 18

we can calculate the area over which that exposure occurred. We
have three curves, the stable, the neutral and the unstable
weather situation plotted in figure 19. You see that the stable
weather situation has the high values of exposure but over a
small area, whereas the unstable weather covers the extremely
large areas with the lower values of exposure. Surprisingly, the
total integral, which we're very interested in for vulnerability
calculations, is the same for all three. We can take those data
and plot the exposure and the area in nondimensional form -
exposure times the weather factor, divided by N, versus a
nondimensional area term. Some Tretheway-Cramer calculations for
three situations - unstable, neutral and stable-fell just about
precisely on that predicted relationship for single fibers. Their
prediction for lint fell just about precisely on our predictions
for lint as shown on figure 20. This parametric representation
for small fall velocity says that the exposure falls off as the
recipricol of the distance. This guides our thinking on how the
exposure profiles vary.

We've got some interesting field data for some heavy parti-
cles in the fire test at China Lake. We actually recorded the
coordinates of all the strips that we found as shown in figure 21.
For the purpose of this exercise, I categorized them within
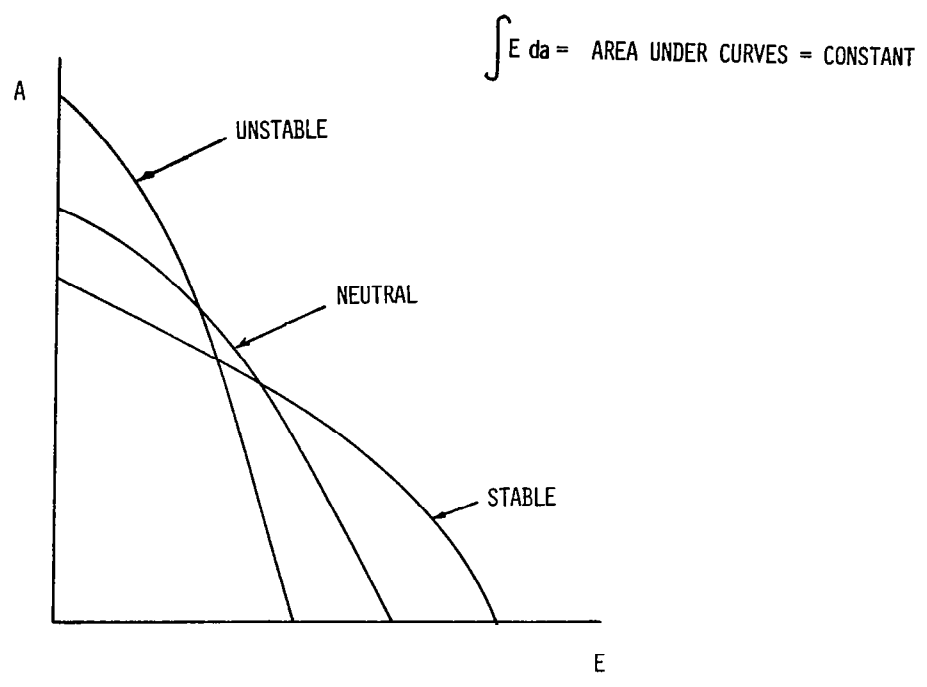certain sections of range. Figure 22 shows the number of strips

AREA COVERAGE

$$\int E\,da = \text{AREA UNDER CURVES} = \text{CONSTANT}$$

A

UNSTABLE

NEUTRAL

STABLE

E

Figure 19

NONDIMENSIONAL AREA COVERAGE

$\dfrac{2\,A}{\alpha\,H^2}$

NONDIMENSIONAL
AREA

——————— TRETHEWAY- CRAMER MODEL

— — — — PARAMETRIC EQUATIONS

SINGLES

LINT

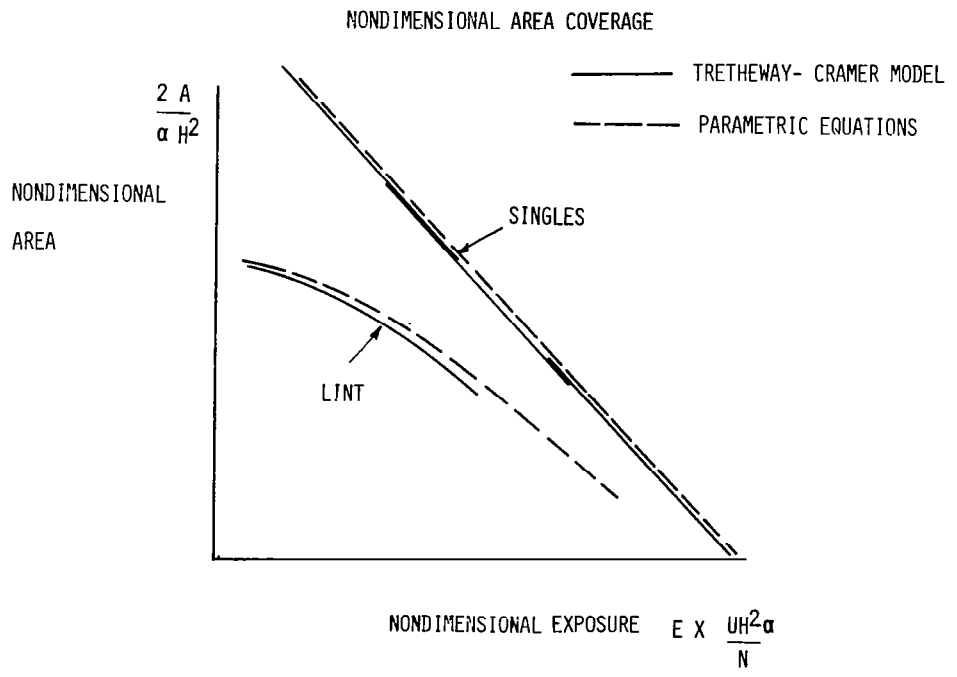NONDIMENSIONAL EXPOSURE   E X $\dfrac{UH^2\alpha}{N}$

Figure 20

within each interval, as well as the cumulative deposition within each interval. Assuming a wind velocity of about 5 m/s, a fall velocity of about 5 m/s (because they were very heavy fragments), an average mixing depth at that time of 700 meters, and 130 particles, we can plot both the data and the equation for the deposition. At least in this case we see in figure 23 that the exponential profile of total deposition as a function of range is approximately valid.

Last, I want to calculate the pollution effects for a possible scenario. Assume a source of 1000 kilograms - a metric ton of composites on an airplane. If we were to destroy that airplane in a fire, we could assume 5% would be released as singles, 5% would be lint, 20% airborne fragments, and 70% residue on the ground, as listed in figure 24. From the mass of any one of those fragments, we know the number of particles for each one of those fragments per kilogram of material, we know the total particles of each category and we know their fall velocities. Now we want to calculate the exposure patterns from that source. First of all let us take the data for the singles, and we find that in stable weather, an area of approximately 1 city block will be covered at an exposure of about 10^5 particles, as shown in figure 25. Whereas in unstable weather, that same area would be covered at an exposure of about 10^4. In the unstable case, for an exposure of 10^1, an area equivalent to a full state would be covered, whereas in the stable case, for that value of exposure, an area of

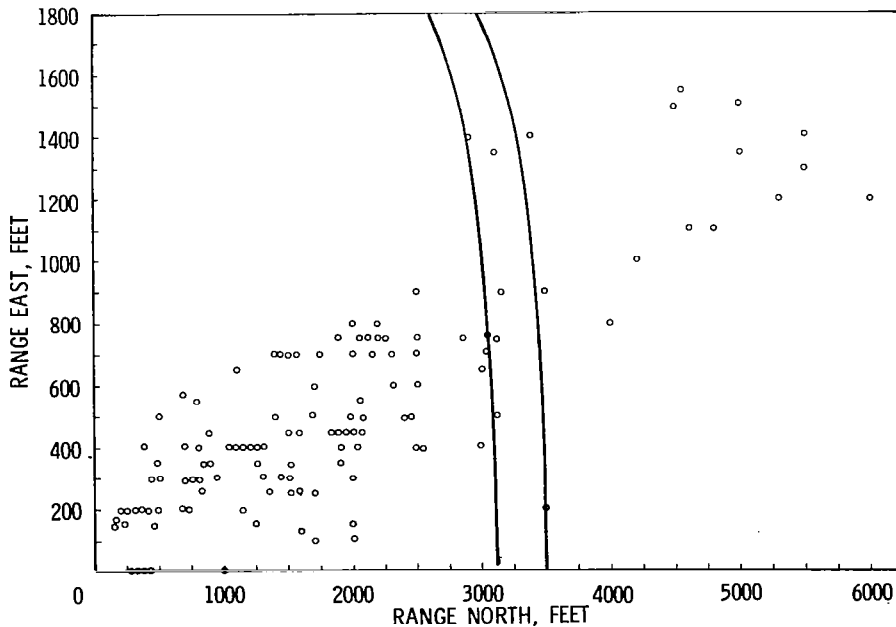## SPOILER TEST 11 - STRIP DEPOSITION LOCATIONS

Figure 21

TEST II - CUMULATIVE DEPOSITION

INTERVAL	DEPOSITION IN INTERVAL	CUMULATIVE DEPOSITION
0 - 500	17	17
500 - 1000	16	33
1000 - 1500	22	55
1500 - 2000	22	77
2000 - 2500	19	96
2500 - 3000	5	101
3000 - 3500	9	110
3500 - 4000	1	111
4000 - 4500	2	113
4500 - 5000	5	118
5000 - 5500	3	121
5500 - 6000	1	122

Figure 22

CUMULATIVE DEPOSITION OF FIBER STRIPS
FROM SPOILER BURN TEST

$U = 5$ M/S

$V_S = 5$ M/S

$H = 700$ M

$N = 130$

WEIGHT FRACTION OF STRIPS

DISTANCE FROM SOURCE, M

Figure 23

RELEASE AND DISSEMINATION EXAMPLE

ASSUME SOURCE: 1000 KG OF COMPOSITE

	%	MASS	PARTICLES / KG	TOTAL PARTICLES, N	V_S
SINGLES	5	50	10^9	5×10^{10}	0.02 M/S
LINT	5	50	10^6	5×10^7	0.2 M/S
FRAGMENTS	20	200	10^3	2×10^5	2 M/S
RESIDUE	70	700			

Figure 24

RELEASE AND DISSEMINATION EXAMPLE
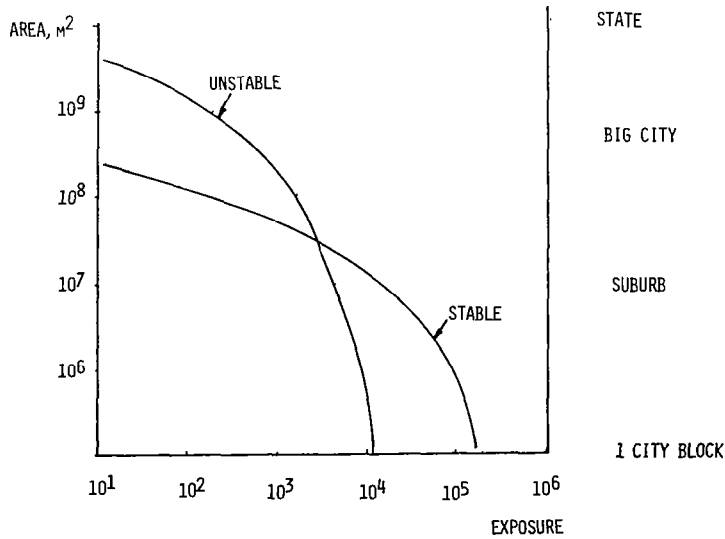
AREA COVERAGE - SINGLES

Figure 25

a big city could be covered. That is the range of exposure from
this metric ton release of composite. Let's look now at the
other fractions in figure 26, and instead of calculating what
exposure levels occur, since we don't know vulnerability in terms
of exposure for those fractions, I plotted the deposition density.
For the lint, we have 5 times 10^7 particles released. In the
stable case, at about 1 kilometer out, we have 50 particles per
square meter deposition density, and in the unstable case
approximately an order of magnitude less. For the fragments at
500 meters out we have about 0.4 particles per square meter, and
in the unstable case, again, significantly less. Those data are
not used in the risk assessment because we haven't qualified the
vulnerability of equipment to that type of particle.

     In summary, as listed in figure 27, we know the following
about dissemination. We have the simple fire plume models
available. The differences between all of them affect only the
short range immediately around the fire. We have the complex
fire plume models under development, they will be most useful to
use in determining the oxidation potential of the fibers. We
have cloud dissemination models available; we have the simple
Gaussian models, which we're using in the very many repetitive
runs that we need to do for a risk assessment, and we have the
complex models which we could use if we ever needed them for
specific tracing of an event. We have the parametric analysis
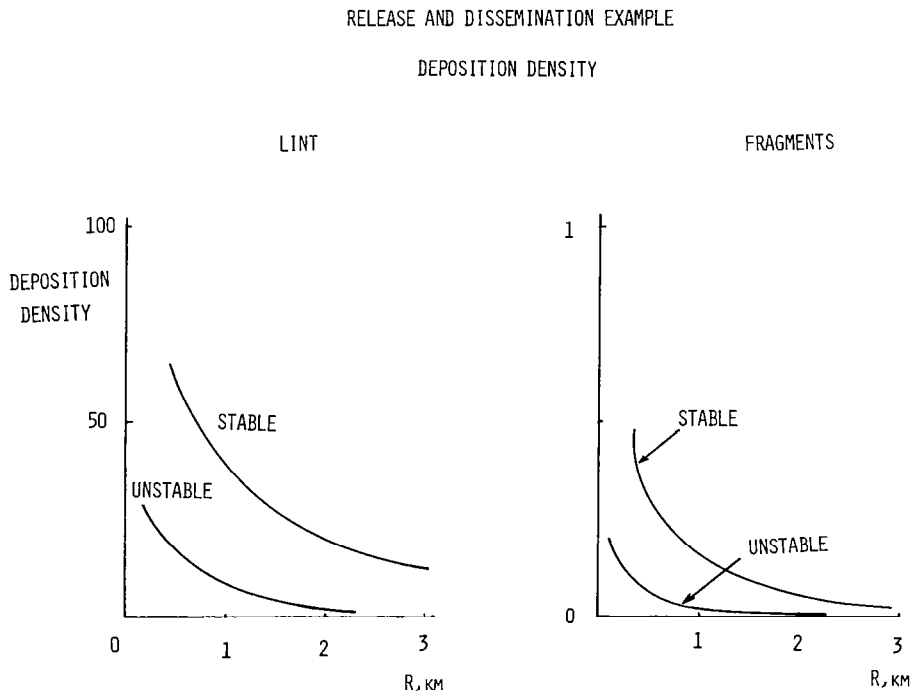which gives us a little more quantitative insight into the

RELEASE AND DISSEMINATION EXAMPLE

DEPOSITION DENSITY

LINT   FRAGMENTS

Figure 26

SUMMARY FOR DISSEMINATION MODELS

. SIMPLE PLUME MODELS AVAILABLE

    . DIFFERENCES AFFECT SHORT RANGE ONLY

. COMPLEX PLUME MODELS UNDER DEVELOPMENT

    . PREDICT TEMPERATURES, OXIDATION POTENTIAL

. CLOUD DISSEMINATION MODELS AVAILABLE

    . SIMPLE, SUITABLE FOR REPETITIVE APPLICATIONS

. PARAMETRIC ANALYSIS SHOWS THAT AREA COVERAGE IS INSENSITIVE TO UNCERTAINTIES IN MODELS

. SUFFICIENT TEST DATA AVAILABLE TO VALIDATE DISSEMINATION MODELS

Figure 27

interrelations between the very many parameters involved. But it also shows that the total area coverage, which we're using as a measure of our damage potential, is rather insensitive to a lot of parameters that go into the fire plume model and into the dissemination model. We now feel that we have sufficient test data to validate our dissemination models to the levels of accuracy that we required for this study.

I will talk about fiber life and redissemination as outlined in figure 28. I want to talk about outdoor testing, the program direction that we have in mind, and a brief summary. In a study done in the desert in which we checked on the redissemination of some fibers that had been deposited there, we could get a measure of the significance of the redissemination of the single fibers. The data that we plot in figure 29 are the vertical deposition, which means the tuna can catch, over a 24 hour period, as a function of the time after the deposition, since June 75 to the present. After a very high initial peak the deposition falls to very low levels. Integration shows that by now, 1% of that source has been redissemination. The other data in figure 30 show that the fibers initially had a 8 mm mean length but as time went on the type of fibers collected became shorter and shorter, so that by now, three years after the event, the average fiber length

REDISSEMINATION

- DESERT STUDY SHOWS SOME REDISSEMINATION OFF HARD-PAN SURFACE

  - REDISSEMINATION RATE DECREASES WITH TIME

  - FIBER LENGTH DECREASES WITH TIME

- REDISSEMINATION FROM VEGETATED LAND INSIGNIFICANT

- SUBJECT UNDER CONTINUED STUDY

Figure 28

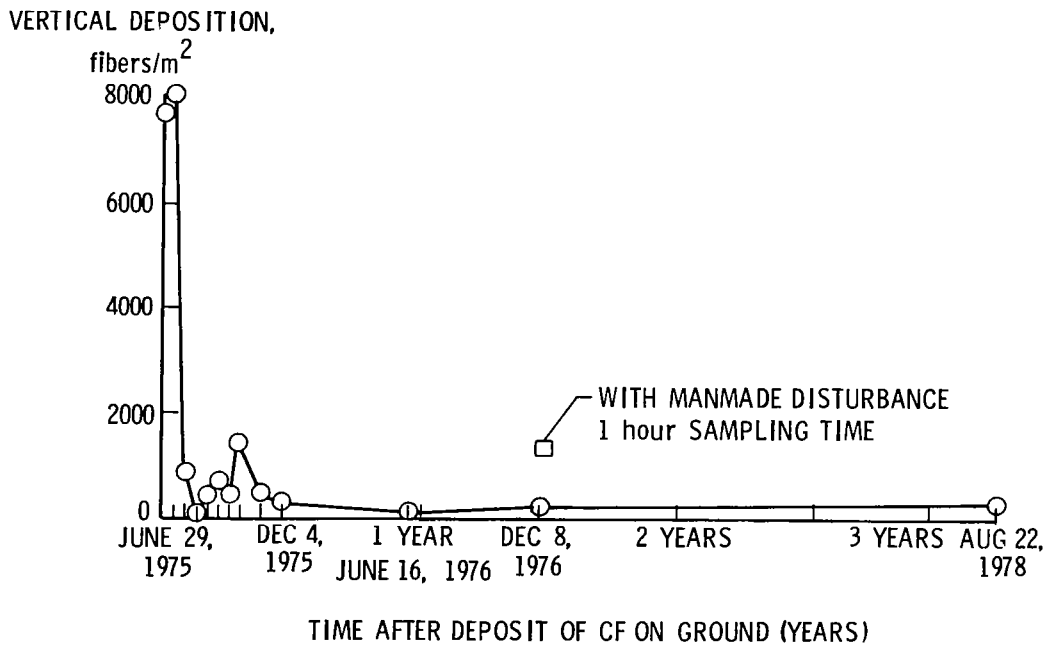VERTICAL DEPOSITION OF FIBERS AS A FUNCTION OF TIME

Figure 29

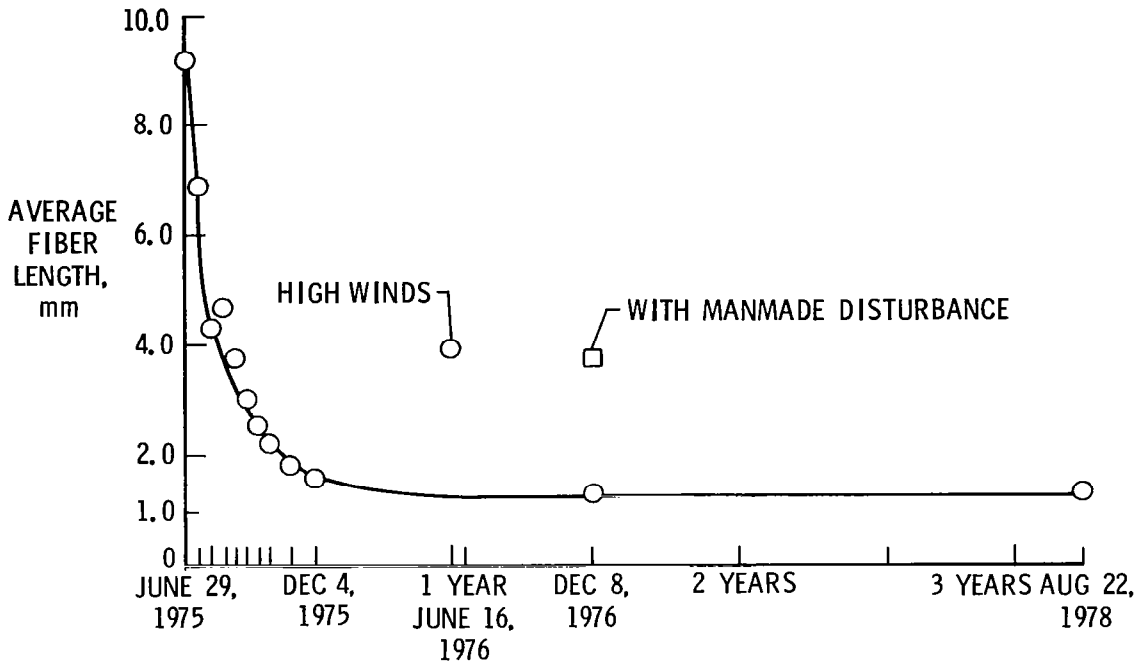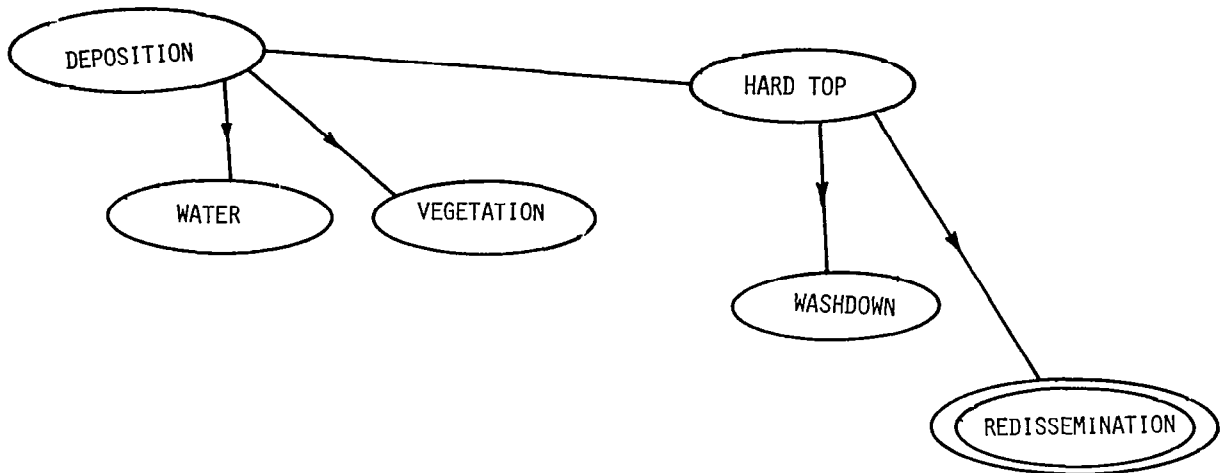## MEASURED AVERAGE LENGTH OF FIBERS AS A FUNCTION OF TIME

Figure 30

collected is approximately 1 millimeter. The residual fibers are caked into the desert crust. Some of them stick out, and the only time any of those fibers are released is when saltating particles rolling along the ground strike pieces of graphite off the clumps that are lying there. That's the mode that we currently feel is in operation out there, and the reason for the shorter fibers. The conclusion is, that the dissemination rate decreases with time, and the fiber lengths decrease with time, or to be more precise, the spectrum of size has its maximum at a shorter length. The desert country out there can be classified as hard pan surface which has a very short roughness length that makes it possible for the singles to be picked up. In a vegetated country, like even short grass, agricultural lands, or forests, it would be impossible to redisseminate singles back out of those depths because the boundary layer is so thick and laminar. Therefore, we feel that we won't get much redissemination from anything except a hard surface. That subject of course is under containued study.

Let me show you on figure 31 the road map for what we have in mind. This is the problem for single fibers. Starting with the deposition, they can fall into water, vegetation, or they can fall on hard top. On the first two, those fibers must be considered as dead, the resuspension rates are very very small. From
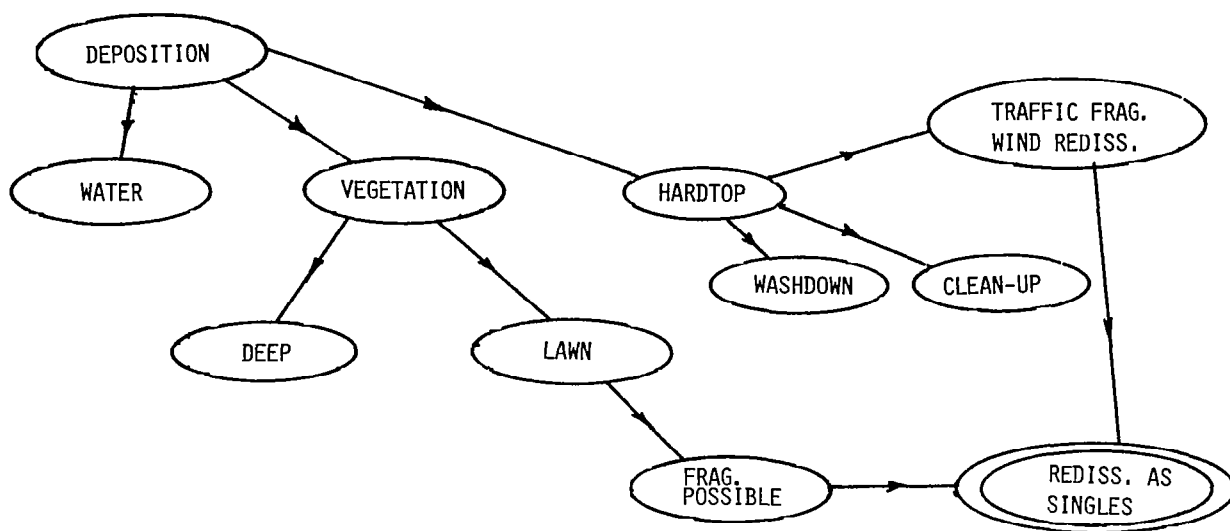
REDISSEMINATION OF SINGLE FIBERS

● SMALL FRACTION FROM SMALL AREA.

Figure 31

the hard top, which might be typical of a city area, concrete,
asphalt, roofs, much of it could be washed down into the drainage
system of a large city. The rest might be available for
redissemination. But on the whole, the amount available for
redissemination represents a small fraction from a very small area.
Let's look at the larger fragments in figure 32, where we just
calculated a deposition density. Those fibers could again be
deposited in water, where they would be immediately lost. In
vegetation, with deep vegetation forests, they would be lost. The
big particles however are going to sit on top of shallow
vegetation, like lawns. They could essentially be fragmented by
wind action or other disturbances. They could land on the hard top
where some could be lost to washdown. We could clean up the area
and get rid of some of them once and for all. Traffic could
fragment those remaining particles providing a source of single
particles. Now that would remain the main study issue, because
the large clumps and fragments contain most of the mass of the
debris and could act as a substantial source of singles. However,
again you're looking at the possibility of resuspending from only
a very small area.

In conclusion, we need to continue working this issue of
redissemination, but are relatively confident with the other

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REDISSEMINATION FROM CLUMPS AND FRAGMENTS

● MAIN STUDY ISSUE

Figure 32

models of dissemination and the fire plume models. We are working on advanced models to get oxidation state.

Question: How did you test the parametric model?

Response: I took the strip data set from the spoiler burn test and analyzed the deposition, and found that it was an exponential distribution.