PANEL DISCUSSION: BIOLOGICAL MONITORING

THE CONNECTICUT RIVER VALLEY SECTION,

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION

Industrial Hygiene Conference IV April 10, 1979

Presentation by Dr. Hilton C. Lewinsohn, MB, BCh., D.I.H., MFOM

Corporate Medical Director
Raybestos-Manhattan, Inc.
100 Oakview Drive,
Trumbull, Conn. 06611

INTRODUCTION:

Stedman's Medical Dictionary defines biology as follows: "The branch of science that deals with living organisms. It consists of several branches: morphology, physiology, pathology, ecology, paleontology, etc."

The same dictionary defines monitor as follows:

"A device that records specified data for a given series of events, operations, or circumstances."

To arrive at a definition of monitoring, it is necessary to realize that a monitor has to be used in the instrumental sense, but that the term may also apply to the person responsible for its use, i.e. monitor may also mean "one that warns, an overseer." (Webster's New Collegiate Dictionary). The definition also extends to "one that monitors" or "a person or thing that warns or instructs."

Monitoring means

1. to check
2. to test for intensity
3. to watch, observe or check for a special purpose
4. to keep track of, regulate or control an operation
5. to control the quality of the process.

Biological monitoring, therefore, is composed of testing for, checking on, watching for and observing the effects of environmental factors on living organisms, taking into consideration at all times species differences, differences in the effects on organ systems in any one given species, and keeping track of regulatory and control mechanisms which vary the environmental factors involved.

The aim of biological monitoring is to allow the quality of the process being monitored to be controlled to produce the desired effect on the living organism involved.

A01095

When the living organism is man, a number of philosophical, ethical and moral issues have to be given serious consideration. Biological monitoring only serves a useful purpose if the effects measured are reversible and are not already an indication of damage to the organism. Measurements or observations made in persons exposed to substances, or radiation, in the workplace, if they are to be used to monitor controls on the release of those substances into the workplace, must be possible at levels which are below those considered harmful and must correlate with exposure levels measured in the workplace. This implies an accuracy of technique of the highest order and must involve population groups of adequate size to provide meaningful statistical correlations. Individuals differ in many respects, and therefore only clinical use can be made of measurements where a single individual is involved.

I do not propose to dwell on these issues, and I am sure you will want to discuss them later. In my personal experience I have not relied upon biological monitoring to tell me what to do about the workplace. I have, however, realized that it is necessary to monitor the workplace and the workers in it to establish a number of parameters which can eventually lead to the development of hygiene standards. What I am concerned with is a known hazard and its control, with the aim of preventing it from causing harmful effects by limiting exposure to a level which appears to produce no effect. There is no absolute safety in this world, and, therefore, no matter how well we are able to control a process, there will theoretically always be a person who reacts differently from the rest. We all take risks in living, and we all try to avoid unnecessary risks as well. Society decides which risks are acceptable, and governments legislate according to the will of the people.

MONITORING

I would like to deal specifically with the question of exposure levels and their biological effects, taking asbestos as my example. The monitoring of an asbestos factory or process consists of:

1) Static sampling of the workplace
2) Personal sampling of employee exposure
3) Medical surveillance.

I am sure I do not have to dwell upon 1 & 2 as far as this audience is concerned, except to say that static sampling is valuable to the engineer who has to know where the dust is coming from and to the biologist who wants to know how much dust is in the workplace. This background level will influence each individual employee's exposure and may sometimes explain differences in results between two people, both doing the same type of job, but perhaps in different areas of the plant or on different shifts. Personal sampling results must be recorded in the employee's medical record.

Medical surveillance, my main field of interest, serves three important purposes:

1. Establishes a pre-exposure biological data baseline
   a) for an individual
   b) for a "non-exposed" group of individuals
2. Enables an immediate cross-sectional survey to be made of
   a) non-exposed individuals
   b) exposed individuals at any point in time
3. Enables data to be maintained for use in
   A) longitudinal studies using each person as his own control
   B) prospective morbidity studies
   C) Prospective mortality studies

A01097

Although this form of monitoring is not immediately productive of biological data allowing the environment to be controlled, it nevertheless forms part of the whole spectrum of information considered in the setting of standards to prevent occupational disease. The most important consideration is the long lapsed period between first exposure and the earliest detectable effect. The biological effect produced, even though its perception is "early" in the clinical sense, may of course be too late in the real sense because it indicates irreversible damage. It is then to be hoped that removal from further exposure will allow the process to regress, will delay further progression and will not produce pain, suffering, misery and disability or shorten life.

DOSE-RESPONSE AND THE ASBESTOS STANDARD

The data upon which the present standard is based extrapolates the results of high exposures "backwards" in attempting to predict effects of low exposure. The graph in Figure 1 illustrates this, and clearly, the slope of the line is critical. It is obvious that the further removed the new exposure level is from the known points on the graph, the less reliable will the estimate be.

Asbestosis is the condition which was first recognized as being caused by exposure to asbestos dust, but which should begin to decline in incidence following the introduction of controls.

There is a mass of epidemiological evidence to confirm that asbestosis is dose related. It is usual to reckon accumulated exposure in fiber years, which represents the number of years a worker has spent in the industry multiplied by the average fiber count to which he was exposed during this time. It is the basis on which the 2 fiber per c.c. standard was made. This standard is based upon the assumption that a cumulative exposure of 100 fiber/cc years would present a less than 1% chance of an individual developing the earliest signs of asbestosis. Graphically, the line representing the dose response will cut the horizontal axis at a point to the right of zero.

Malignant mesothelioma of the pleura or peritoneum presents us with a different problem. This tumor, even at high exposure levels, is a rare event in any exposed population, so that predictions of future incidence have less chance of being accurate. There is, furthermore, a natural incidence of this tumor, so unlike asbestosis, it is impossible to be 100% certain in any case of mesothelioma that it has resulted from exposure to asbestos dust. Recent evidence definately suggests that the risk of mesothelioma is dose-related, i.e. it usually occurs in people who have had a heavy exposure to asbestos dust, albeit sometimes for only brief intervals. Since there is a natural incidence of mesothelioma, there will be a number of cases occurring even at zero exposure, and the line on the graph will meet the vertical axis at a point above zero. What we cannot predict from current evidence is whether the line meets the vertical axis (as in A) or flattens off first (as in B). In other words, is there a threshold dose of dust below which the risk of developing mesothelioma is no greater than that for the non-exposed population.

The problem is not as clear-cut with lung cancer. Although there is an increased risk of an asbestos worker developing lung cancer than a non-asbestos worker, a confounding factor in the equation is cigarette smoke. In cigarette smokers there is no doubt that asbestos dust increases the risk of lung cancer, multiplying it by an amount quoted as being in the region of 90x's in comparison with non-exposed non-smokers.

Time does not permit me to go into the subject in depth. In the evaluation of asbestos workers in the light of a known quantitative exposure level, many parameters are used to monitor their health experience. The recognized minimum requirements include:

(a) Standardized respiratory symptoms questionnaire
(b) Physical examination to look for
    (i) breathlessness
    (ii) bilateral basol r'ales (crackles) in lungs
    (iii) finger clubbing

(c) Chest roentgenogram

(d) Lung function measurements

(e) Additional tests may include sputum cytology.

CONCLUSIONS

1. Biological monitoring can be used to assess the degree of contamination of a workplace if the environmental and biological measurements are highly correlated.
2. Biological monitoring should only be used to measure reversible effects before tissue damage of any kind can occur.
3. Modified routine medical surveillance techniques are useful in the determination of biological effects for the purpose of establishing hygiene standards.

MONITORING

THE MONITORING OF AN ASBESTOS FACTORY OR PROCESS CONSISTS OF:

1) STATIC SAMPLING OF THE WORKPLACE

2) PERSONAL SAMPLING OF EMPLOYEE EXPOSURE

3) MEDICAL SURVEILLANCE

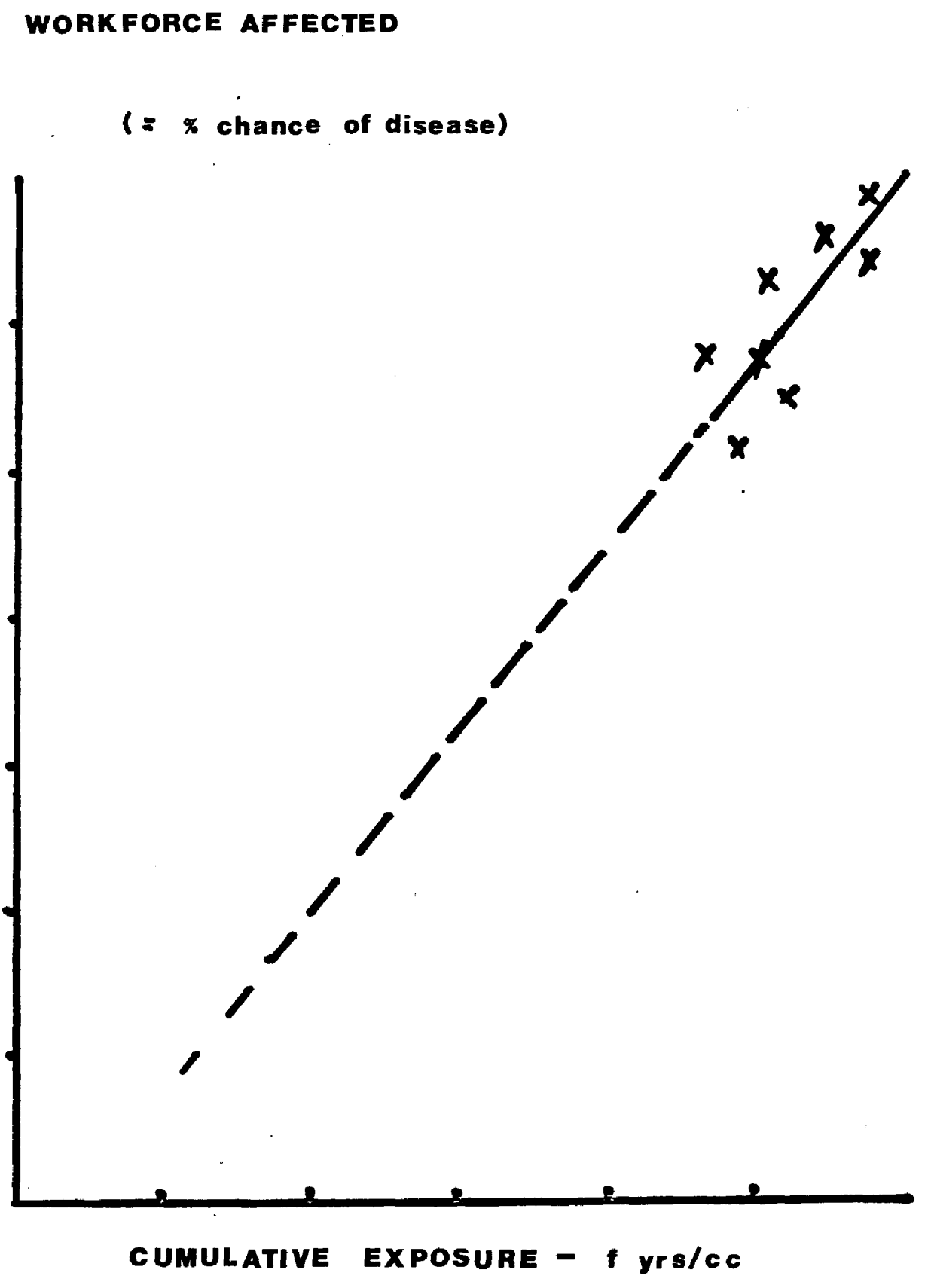
MEDICAL SURVEILLANCE

1. ESTABLISHES A PRE-EXPOSURE BIOLOGICAL DATA BASELINE
   (A) FOR AN INDIVIDUAL
   (B) FOR A "NON-EXPOSED" GROUP OF INDIVIDUALS

2. ENABLES AN IMMEDIATE CROSS-SECTIONAL SURVEY TO BE MADE OF
   (A) NON-EXPOSED INDIVIDUALS
   (B) EXPOSED INDIVIDUALS AT ANY POINT IN TIME

3. ENABLES DATA TO BE MAINTAINED FOR USE IN
   (A) LONGITUDINAL STUDIES USING EACH PERSON AS HIS OWN CONTROL
   (B) PROSPECTIVE MORBIDITY STUDIES
   (C) PROSPECTIVE MORTALITY STUDIES

FIG. 1.


% WORKFORCE AFFECTED
(= % chance of disease)
CUMULATIVE EXPOSURE – f yrs/cc

A01103

FIG. 2.

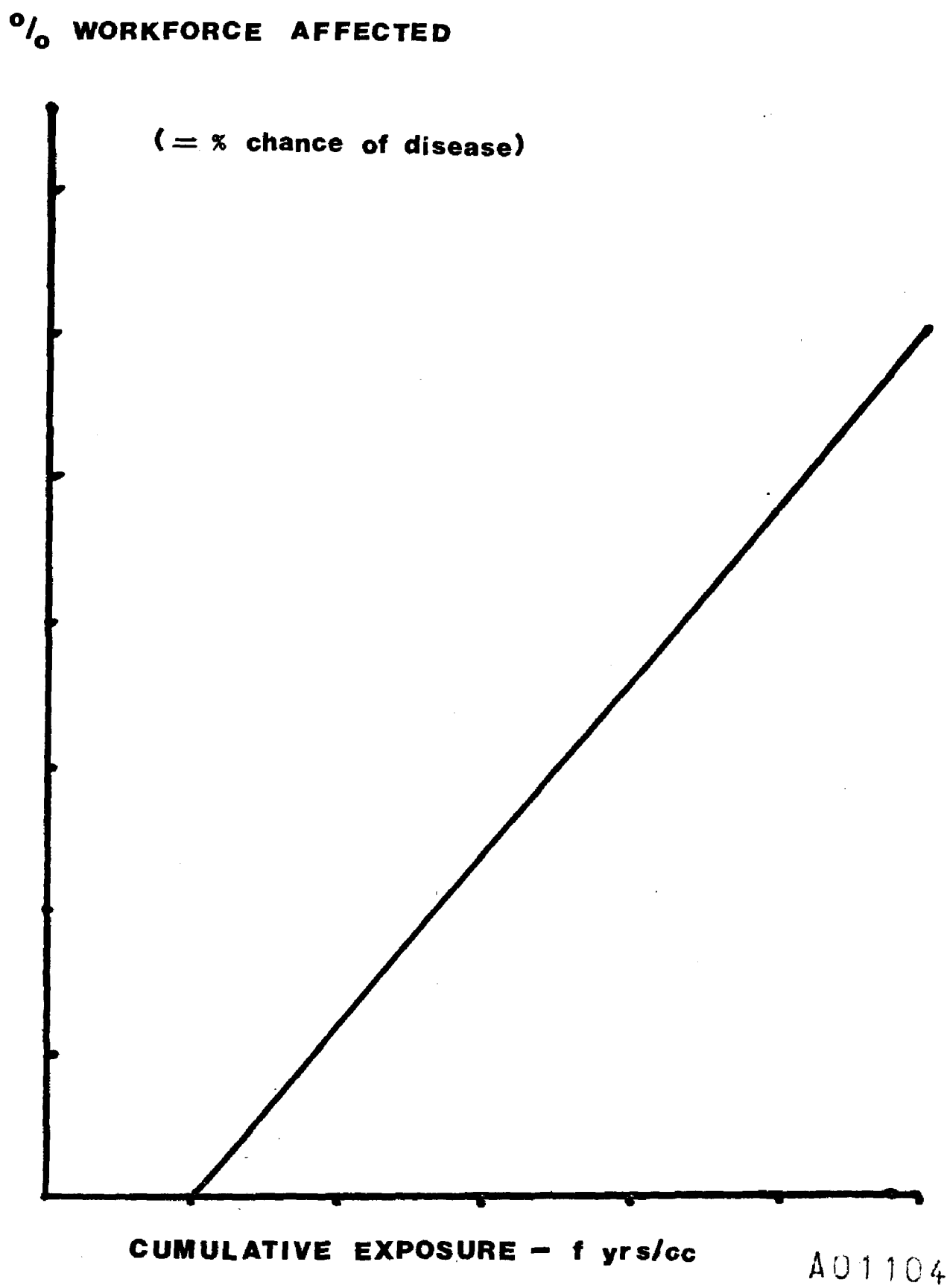

% WORKFORCE AFFECTED
(= % chance of disease)
CUMULATIVE EXPOSURE – f yrs/cc
A01104

FIG. 3A

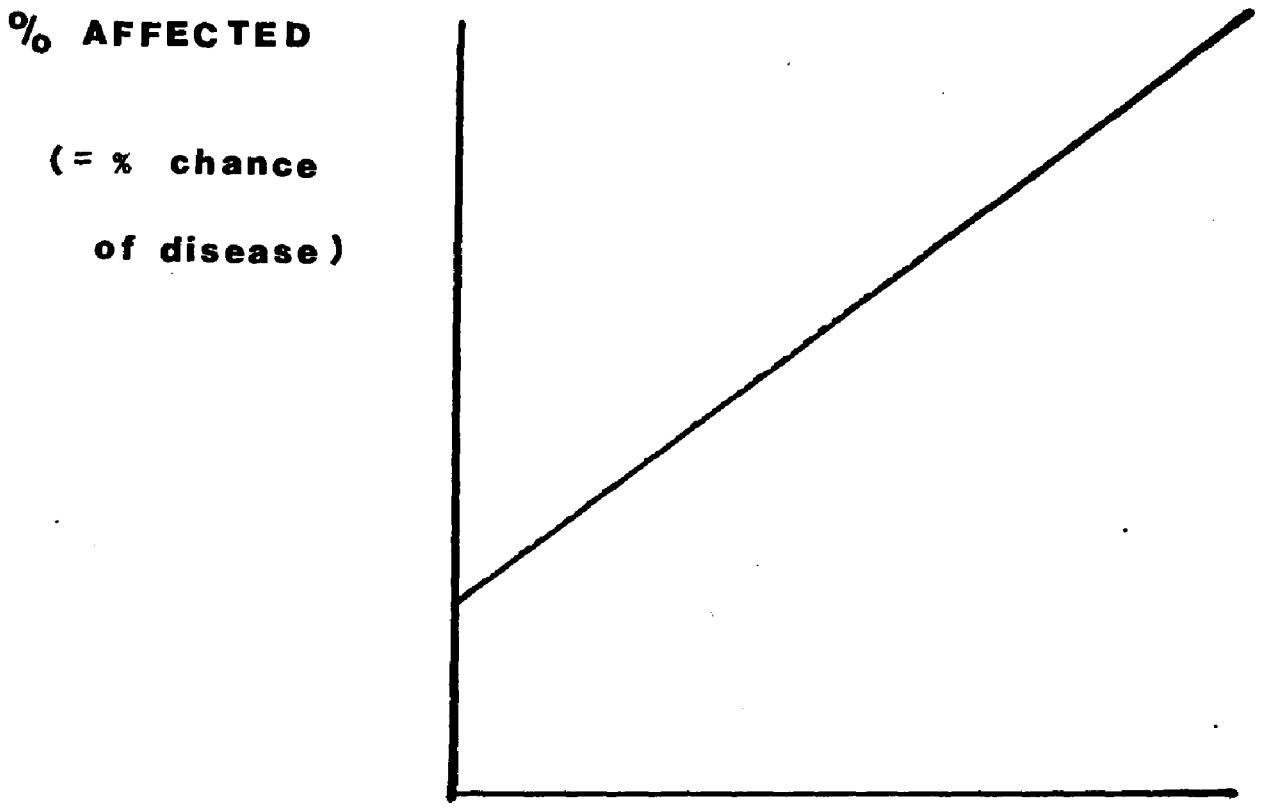
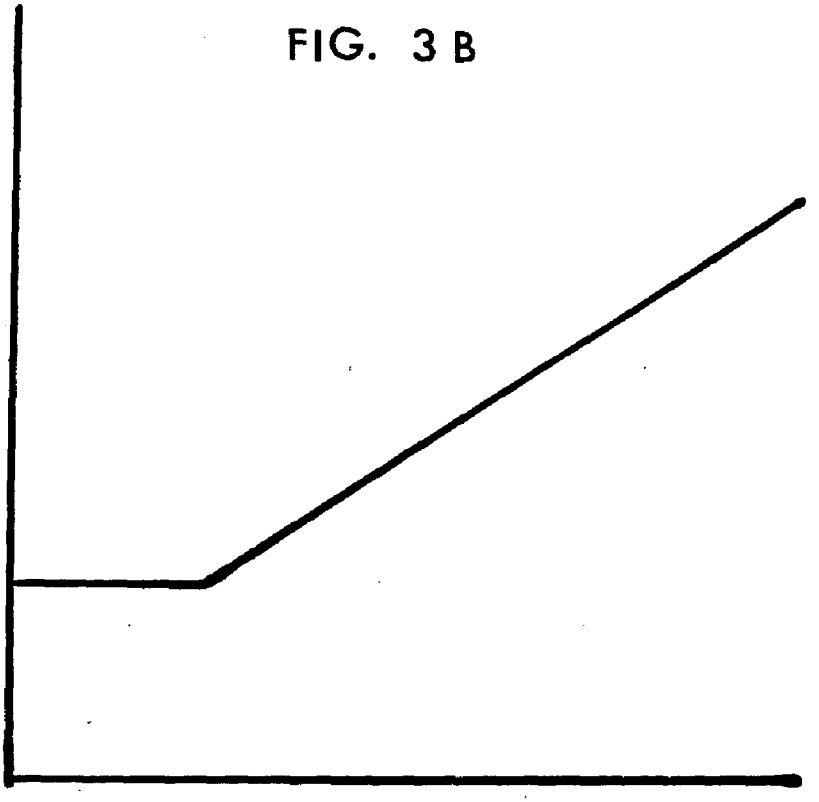


FIG. 3 B



CUMULATIVE EXPOSURE – f yrs/cc

A01105

IN THE EVALUATION OF ASBESTOS WORKERS IN THE LIGHT OF A KNOWN QUANTITATIVE EXPOSURE LEVEL, MANY PARAMETERS ARE USED TO MONITOR THEIR HEALTH EXPERIENCE. THE RECOGNIZED MINIMUM REQUIREMENTS INCLUDE

(A) STANDARDIZED RESPIRATORY SYMPTOMS QUESTIONNAIRE

(B) PHYSICAL EXAMINATION TO LOOK FOR

(i) BREATHLESSNESS

(ii) BILATERAL BASAL R'ALES (CRACKLES) IN LUNGS

(iii) FINGER CLUBBING

(C) CHEST ROENTGENOGRAM

(D) LUNG FUNCTION MEASUREMENTS

(E) ADDITIONAL TESTS MAY INCLUDE SPUTUM CYTOLOGY.

A01106

CONCLUSIONS

1. BIOLOGICAL MONITORING CAN BE USED TO ASSESS THE DEGREE OF CONTAMINATION OF A WORKPLACE IF THE ENVIRONMENTAL AND BIOLOGICAL MEASUREMENTS ARE HIGHLY CORRELATED.

2. BIOLOGICAL MONITORING SHOULD ONLY BE USED TO MEASURE REVERSIBLE EFFECTS BEFORE TISSUE DAMAGE OF ANY KIND CAN OCCUR.

3. MODIFIED ROUTINE MEDICAL SURVEILLANCE TECHNIQUES ARE USEFUL IN THE DETERMINATION OF BIOLOGICAL EFFECTS FOR THE PURPOSES OF ESTABLISHING HYGIENE STANDARDS.