**NORTH ATLANTIC TREATY ORGANIZATION**
**ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD**

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20 April 2000 MAS/0461-LAND/4361

**STANAG 4361 LAND (EDITION 1) - STANDARDISED PROCEDURES FOR EVALUATING THE EFFECTIVENESS OF OBSCURANTS**

Reference:
AC/225-D/1426 dated 26 November 1997 (Edition 1) (Ratification Draft)

1. The enclosed NATO Standardization Agreement which has been ratified by nations as reflected in page iii is promulgated herewith.

2. The reference listed above is to be destroyed in accordance with local document destruction procedures.

3. AAP-4 should be amended to reflect the latest status of the STANAG.

ACTION BY NATIONAL STAFFS

4. National staffs are requested to examine page iii of the STANAG and, if they have not already done so, advise the Defence Support Division through their national delegation as appropriate of their intention regarding its ratification and implementation.

for A. GRØNHEIM
Major General, NOAF
Chairman MAS

Enclosure:
STANAG 4361 (Edition 1)

STANAG No. 4361
(Edition 1)

# NORTH ATLANTIC TREATY ORGANIZATION
# (NATO)

## MILITARY AGENCY FOR STANDARDIZATION
## (MAS)

# STANDARDIZATION AGREEMENT
## (STANAG)

SUBJECT: STANDARDIZED PROCEDURES FOR EVALUATING THE EFFECTIVENESS OF OBSCURANTS

Promulgated on 20 April 2000

for A. GRØNHEIM
Major General, NOAF
Chairman, MAS

*(AW/ABR)0461E-LAND-4361*

## RECORD OF AMENDMENTS

| No. | Reference/date of amendment | Date entered | Signature |
|---|---|---|---|
| | | | |

## EXPLANATORY NOTES

### AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Chairman MAS under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

### DEFINITIONS

4. Ratification is "In NATO Standardization, the fulfilment by which a member nation formally accepts, with or without reservation, the content of a Standardization Agreement" (AAP-6).

5. Implementation is "In NATO Standardization, the fulfilment by a member nation of its obligations as specified in a Standardization Agreement" (AAP-6).

6. Reservation is "In NATO Standardization, the stated qualification by a member nation that describes the part of a Standardization Agreement that it will not implement or will implement only with limitations" (AAP-6).

### RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page iii gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page iv (and subsequent) gives details of reservations and proprietary rights that have been stated.

### FEEDBACK

8. Any comments concerning this publication should be directed to NATO/MAS - Bvd Leopold III - 1110 Brussels - BE.

STANAG 4361
(Edition 1)

# NATO STANDARDISATION AGREEMENT
# (STANAG)

## STANDARDISED PROCEDURES FOR EVALUATING THE EFFECTIVENESS OF OBSCURANTS

Annexes A: Glossary of the definitions applicable to standardised procedure for evaluating the effectiveness of obscurants.
B: Details of the standardised procedures for evaluating the effectiveness of obscurants.
C: Procedure for generating a field trials plan.

Related documents:

| | |
|---|---|
| STANAG 4161 | The optical transfer function of imaging systems. |
| STANAG 4183 | NATO metrication policy |
| STANAG 4347 | Definition of nominal static range performance of thermal imaging systems. |
| STANAG 4349 | Measurement of minimum resolvable temperature difference of thermal cameras. |
| STANAG 4350 | Calculation of minimum resolvable temperature difference (MRTD) of thermal imaging systems. |
| AAP6 | NATO glossary of terms and definitions |

STANAG 4361
(Edition 1)

**AIM**

1. The aim of the agreement is to define standardised procedures intended for evaluation of the effectiveness of obscurants.

**AGREEMENT**

2. The participating countries agree to use the standardised procedures for evaluation and the terminology contained in the present STANAG in accordance with the definitions and procedures of this STANAG in order that the documentation relating to the evaluation of the effectiveness of an obscurant emanating from one of these countries may be clearly interpreted, understood and recognised by the other countries with no ambiguity.

**VALIDITY**

3. Many variables affect the performance of obscurants. In order to facilitate comparison of the effectiveness of obscurants, a standardised set of procedures has to be defined to serve as the basis for future evaluations.

4. These procedures describe the two phases of tests which produce an evaluation that is acceptable to the various NATO countries:

- laboratory tests (measurements of a scientific nature)
- tests in the field:
  - measurements of a scientific nature)
  - characterisation by military systems.

The two test phases are complementary and it is essential that they are both conducted to provide an evaluation of the effectiveness of obscurants. In no case should the tests be limited to the "laboratory test phase" since the parameters used show considerable variation in the field, particularly as a result of meteorological fluctuations.

It is acceptable for the field test phase to be limited to the actual needs of the evaluation: scientific measurements and/or characterisation by military surveillance systems, electro-optic sensors and/or radars.

**WARNING**

5. Because of the toxic nature of some obscurant materials, before handling these in connection with the evaluation of their effectiveness, the user must ensure he understands:

- the identification and nature of the products employed
- the way these products change in the atmosphere (volumetric change and transitory or stabilised nature of the decomposition products)

**DEFINITIONS**

6. The terms and definitions presented in Annex A are to be used for the purposes of this agreement. At the user's discretion this annex may be supplemented by the document NATO AC/225 P.VI / SP 6. D/8 - Manual for evaluating smoke and smoke screens for military use - Part 1: Terms, Concepts and Definitions.

**DETAILS OF THE AGREEMENT**

7. Annex A is a glossary of definitions applicable to the standardised procedures for evaluating the effectiveness of obscurants.

Annex B deals with the procedures and includes the following parts:

- PART 1: Principles and descriptions of laboratory measurements.

- PART II: Principles and description of static measurements of a scientific nature in the field.

  II-1 Transmission measurements
  II-2 Electro-optical measurements
  II-3 Measurements using laser equipment
  II-4 Measurements using radar equipment

- PART III: Principles and description of the characterisation of the effectiveness of obscurants agents against military systems

- PART IV: Minimum measurements of micro-meteorology.

Annex C presents the procedure for generating a field trials plan.

8 Countries having ratified the present standardisation agreement undertake to apply the described terms, definitions and procedures in every respect, for the evaluation of obscurants in order that the information may be transmitted between countries without there being any possible doubt about its significance and validity. Any waivers should not be agreed without rigorous examination of the argument justifying the request.

## IMPLEMENTATION OF THE AGREEMENT

9. Application of the present STANAG by each ratifying country will be effective when:

(a) each country has revised its relevant national documents in order to make them conform with the provisions of the STANAG.

(b) each country has given the orders and instructions necessary to the departments affected regarding the entry into force of the procedures detailed in the present agreement.

ANNEX A to
STANAG 4361
(Edition 1)

# GLOSSARY OF THE DEFINITIONS APPLICABLE TO THE STANDARDISED PROCEDURES FOR EVALUATING THE EFFECTIVENESS OF OBSCURANTS

## INTRODUCTION

The effectiveness of obscurants is dependent on many physical factors which relate both to the material forming the obscurant and to the immediate environment in which they are disseminated.

In order to evaluate this effectiveness, it is necessary to define many of these parameters since they are not part of normal language.

## GLOSSARY

### Aerosol

Entity composed of solid or liquid particles in suspension in a gas where the size of the basic particles lies between 0.1 and 5μm.

### Absorption

Physical phenomenon which characterises the capability of an obscurant to retain within itself a part of the energy received by radiation.

### Attenuation

Reduction of the original amplitude of electromagnetic radiation when passing through the atmosphere.

### Camouflage

Countermeasure with the object of reducing the probability of detection, recognition, identification, sighting or target acquisition, by reducing the signature.

ANNEX A to
STANAG 4361
(Edition 1)

**PASQUILL classification**

System of listing atmospheric stability according to the following categories:

| | |
|---|---|
| 1. Very unstable | Category **A** |
| 2. Moderately unstable | Category **B** |
| 3. Slightly unstable | Category **C** |
| 4. Neutral | Category **D** |
| 5. A small degree of stability | Category **E** |
| 6. Moderately stable | Category **F** |

**Optical path**

The route taken from transmitter to receiver by electromagnetic radiation through the atmosphere whether disturbed or otherwise.

**Extinction Coefficient**

Parameter characterising the effectiveness of an obscurant. The symbol in current use is $\alpha$. It is expressed in $m^2\ g^{-1}$

**Concentration**

Parameter characterising the density of obscurant in a given volume.

**Dissemination**

Action enabling the obscurant to be distributed in the atmosphere or into a given volume of gas. Different modes of dissemination are described in Section 10 of Annex B.

**Dosimeter**

Instrument intended for measuring the characteristics of an obscurant. It gives the number of particles per unit volume and their total mass for the duration of a test.

**Monodispersed sample**

An obscurant is considered to be monodispersed when the standard deviation of the particle size distribution divided by the mean dimension of the particles is less than or equal to 0.2.

**Smoke**

All of the solid particles resulting from combustion which disperse into the atmosphere to form an aerosol intercepting electro-magnetic radiation.

**Complex refractive index**

The complex refractive index is the square root of the complex permittivity composed of a real part and an imaginary part.

**Nephelometer**

Instrument intended for determining the mass density or concentration of particles in an aerosol by measuring transmission and back-scattering of radiation.

**Obscuration**

Modification of the atmospheric transmission which results in reduction and alteration of an electromagnetic signature.

**Obscurant**

A material producing a concentration of particles in the atmosphere, encompassing smoke and aerosols, whose effect on atmospheric transmission produces obscuration.

**Complex permittivity**

Complex coefficient of proportionality between the amplitudes of the electrical excitation and the electric field of an electromagnetic wave.

**Polarisation**

Polarisation describes the orientation of the electric vector of an electromagnetic wave (vertical, horizontal, circular, elliptical, etc.), and is invariant over time but may be modified by the interaction of particles.

**Back-scattering**

Physical phenomenon shown by the return towards the transmitter or sensor of reflected radiation consisting of a part of the initial radiation.

**Scintillation**

Rapid change in amplitude, phase and angle of the incident radiation on a sensor resulting from interference on the optical paths. This phenomenon is due to the small, rapid fluctuations of non-uniformities in the refractive indices. It results in a speckled image.

**Transmissometer**

Instrument intended for the measurement of atmospheric transmission at certain wavelengths or defined working spectral band.

COMMENTS

This glossary constitutes a limited set of definitions useful in the evaluation of the effectiveness of obscurants.

It would be useful to supplement it with the manual for evaluating smoke and smoke screens for military use - Part 1: Terms, Concepts and Definitions, published by NATO under the number AC/225 (PanelVI/SP.6) D/8: together with AAP6 - NATO Glossary of Terms and Definitions.

# DETAIL OF THE STANDARDISED PROCEDURES FOR EVALUATING THE EFFECTIVENESS OF OBSCURANTS

## INTRODUCTION

1. Obscurants constitute a suitable countermeasure against the threat presented by sensors on the air/land battlefield. In particular, the performance of these sensors is altered by the phenomena of absorption, attenuation, back scattering, polarisation and scintillation which are the effects of a countermeasure based on the screening properties of obscurants.

Part I of the present Annex B describes laboratory measurements of the parameters influencing the performance of an obscurant.

Part II describes static field techniques, using measurements of a scientific nature, for evaluating the effectiveness of an obscurant screen:

- II-1: Transmission measurements
- II-2: Electro-optical measurements
- II-3: Measurements using laser equipment .
- II-4: Measurements using radar equipment

Part III deals with characterisation in the field, using military sensors, of the essential performance of the obscurant screen obtained with a defined dissemination system.

Part IV sets the minimum micro-meteorology measurements in order to provide a detailed description of the climatic conditions for conducting a test in the field.

ANNEX B to
STANAG 4361
(Edition 1)

## PART 1: LABORATORY TESTS

### OBJECTIVE OF LABORATORY TESTS

2. The objective of the laboratory tests is to evaluate the screening of small samples (of the order of 100g) of the obscurants. under controlled and reproducible conditions.

The effectiveness of an obscurant material is quantified by gathering laboratory data on the significant parameters. These measurements supplement and are used to validate the theoretical evaluation of this product. They characterise its performance without linking the results to the means of dispersion used in the test chamber. The results may be used as input data during modelling.

### PARAMETERS TO BE MEASURED

3. For laboratory tests the parameters to be measured are as follows:

- transmission as a function of wavelength;
- concentration by mass of the product to be tested;
- particle size distribution and size of particles;
- particle descent rate;
- complex refractive index;
- ambient conditions within the measurement chambers;

    * temperature
    * pressure
    * relative humidity
    * internal turbulence (stirring).

### METHODOLOGY

**4. Transmission coefficient**

Characterisation of the screening effectiveness in a measurement chamber is based on the Beer-Lambert law:

$$T(\lambda) = \exp(-\alpha C l) \qquad \text{(for a given } \lambda)$$

in which

**T** is the transmission

$\alpha$ characterises the product to be tested (extinction coefficient per unit mass in $m^2g^{-1}$)

**C** is the concentration by mass in $g.m^{-3}$

$l$ represents the optical path in the measurement chamber in m

In order to determine the extinction coefficient per unit mass, it is necessary to measure the transmission **T** and the product **C** $l$ (concentration x length of optical path).

5. **Concentration by mass**

The concentration by mass of the product to be tested must be determined as a function of time during the experiment. This parameter is to be measured at several points within the measurement chamber by instruments such as dosimeters.

6. **Particle size distribution and shape of particles**

The width of the spectral band affected and the effectiveness of screening obtained are a function of the size of the particles, the particle size distribution and the particle shape.

The shape of the particles is characterised by their principal dimensions (for example, diameter for a disc or length for a fibre).

The distribution of the size of particles with these dimensions directly characterises the width of the spectral band in which the product is effective.

Local sampling using the measurement chamber enables this parameter to be obtained.

7. **Particle descent rate**

Minimising the particle descent rate makes it possible to optimise the period for which the screen is effective. This parameter is essential for applying the gravimetric method of §11.3.

Measuring the descent rate of fibres in an undisturbed environment is carried out by recording the time for a very small sample of the product, released into a glass tube, to fall vertically through a height of 0.5metres. A sufficient number of samples must by taken in order to determine a mean descent rate for which experimental error, equal to the standard deviation, is tolerated.

8. **Conductivity and complex refractive index**

These parameters characterise the obscurant in terms of its intrinsic optical properties.

The complex refractive index may be determined by Fourier-transform spectrometric techniques.

The direct current measurement of material conductivity only relates to large size particles.

**INSTRUMENTATION**

9. **General Matters Regarding the Test Chambers**

A measurement chamber intended for characterising the effectiveness of an obscurant must be designed in such a way as to confine the product to be tested. It must also have sufficient volume for the product to be dispersed such that the concentration obtained is naturally homogeneous or rendered homogeneous by any appropriate means.

Added to this concept of volume there is also the notion of the optical path which defines the thickness of the aerosol cloud. Finally, the internal walls must be neutral from an optical point of view and, in particular, they must not have reflecting surfaces.

The whole arrangement must be easily cleaned so that all traces of material from a previous test can be removed.

The measurement chamber must also provide guaranteed protection for the handlers from a health viewpoint, and in terms of pyrotechnic safety if necessary.

## 10. Methods of Dissemination

The various techniques used for dissemination, whose principle is closely linked to the nature of the material tested, must be perfectly controlled, defined and accurately described.

The principle techniques used for dissemination are:

- pneumatic;
- vaporisation / condensation;
- pyrotechnic;
- vibrating platform

### 10.1 *Pneumatic*

Pneumatic dissemination consists of dispersing the obscurant to be tested by means of dry clean compressed air which draws the material from its container and causes it to be diffused around the measurement chamber. The compressed air pressure is adjusted, its flow rate is known, the size and number of the orifices are defined. The quantity of obscurant to be dispersed is calculated as a function of the volume of the measurement chamber so that, during the test, the desired aerosol concentration is achieved.

### 10.2 *Vaporisation / condensation*

Dissemination by vaporisation/condensation makes it possible to produce an aerosol composed of fine droplets of the liquid to be tested. In order to do this, the liquid is vaporised by the action of a heat exchanger on fine droplets resulting from spraying the base product using carbon dioxide gas. The natural condensation of the vapour in the measurement chamber atmosphere forms the obscurant cloud to be tested. The pressure of the carbon dioxide gas and its flow rate, the flow rate of the liquid to be tested, together with the temperature of the heat exchanger may be adjusted with the aim of optimising the effectiveness of dissemination.

10.3 Pyrotechnic

Pyrotechnic dissemination involves two principles:

- expansion by bursting a pyrotechnic charge within a mass of the product to be tested, whether compacted or otherwise:
- generation of the particles or gases to be tested by pyrotechnic means, generally by combustion. The flow of gases from this combustion directly participates in dissemination.

10.4 Vibrating platform

Dissemination by vibrating platform aims to complement the means described above and, in particular, it is able to produce a homogeneous dissemination of fibres used as obscurants. The vibrating platform has a base with an adjustable grid mesh. The frequency of vibration, which is also adjustable, makes it possible to adjust the rate of dissemination.

11. **Instrumentation needed**

Comments regarding the instrumentation necessary for measuring the parameters referred to are given below.

11.1 *Transmissometers*

Transmission is measured as a function of time by means of transmissometers which generally consist of a source, opposite which a specific receiver is placed. Each transmissometer records the relative transmission through the cloud by normalising the signal detected in the presence of the screen with respect to that measured before dissemination of the material to be tested.

Transmissometers therefore enable the transmission to be determined as a function of the wavelength (or spectral band), time and the polarisation state of the received signal.

11.2 *Dosimeters*

Dosimeters make it possible to determine the concentration by mass of the material to be tested, inside the measurement chamber. The number of them in place also enables the mean value of this parameter to be obtained.

Each dosimeter extracts a small sample from the cloud over a given time interval and at a given rate. A filter placed within the dosimeter makes it possible to capture the corresponding sample.

The sample taken in this way allows the mean concentration of the product tested to be obtained and the size of the particles captured to be measured.

11.3 *Gravimetric method*

The unsuitability of dosimeters to measure the concentration of fibres has led to the development of specific methods.

The oscillating platform dissemination system produces a uniform screen by definition. A bank of sampling receptacles is placed in the flow of fibres for a given time. The mass of material sampled is recorded. This is a characteristic, as a function of time, of the particle density of the obscurant to be tested.

11.4 *Geometric optical inversion technique*

The dosimeters and gravimetric systems calculate a mean concentration on the assumption that the screen concentration is uniform. factors such as concentration, dimensional spread of the particles, and even the measurement time vary and introduce errors into the transmission measurement result.

The technique of geometric optical inversion makes it possible to determine the product 'concentration/optical path length' in real time. This technique is based on the use of a transmissometer whose measurement spectral band is centred on a wavelength which is very much less than that of the particles to be measured. The extinction effectiveness of the particle for the transmissometer working wavelength is written with the value 2 given by the extinction paradox. This technique is based on the following assumptions: monodispersion of the size of the particles; random orientation of the obscurant in the cloud; and the particle shape is convex. It is generally employed in order to characterise fibres at millimetric wavelengths.

### 12 Improvements: Introduction of Nephelometers

The use of an array of dosimeters or other methods for measuring the concentration by mass of obscurants effective in the visual and infrared wavebands does not allow the variation over time of this concentration to be recorded. In order to overcome this disadvantage, the use of nephelometers inside the measurement chamber is recommended.

Nephelometers are instruments intended for determining the density of mass or concentration of particles in an aerosol by measuring radiation transmission and back-scattering.

Each nephelometer illuminates a restricted volume of the screening cloud to be evaluated and records the signal within the illuminated volume; the value measured is proportional to the concentration of the obscurant. As the dimensions and density of the obscurant are known, integrating the nephelometer signal over the sampling time period of the array of dosimeters makes it possible to verify the assumption of constancy of concentration during the transmission measurement interval.

## DATA REDUCTION AND PRESENTATION

### 13. Description of the tests

This section must contain the following headings:

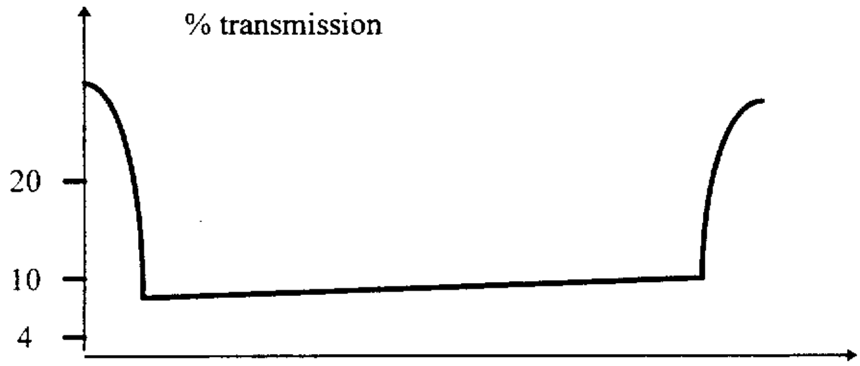
- characteristics of the test chamber.
- measurement equipment employed, layout of facilities.
- conductance of the tests (operating procedure).
- quantities of obscurant tested in each test.
- description of the type and means of dissemination.
- settings for stirring or agitation of the test chamber atmosphere.
- room meteorological settings.

- combustion temperature (if desired).

14. **Presentation of results**

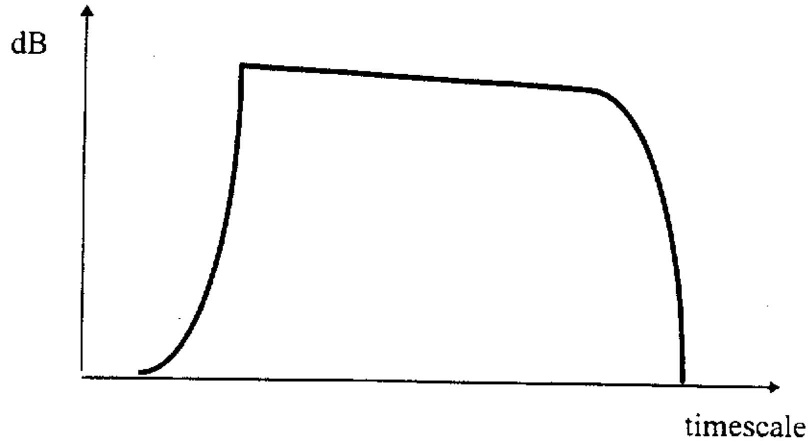
This section gathers together the results of the tests in their original form, for example:

14.1 *Transmission coefficient*



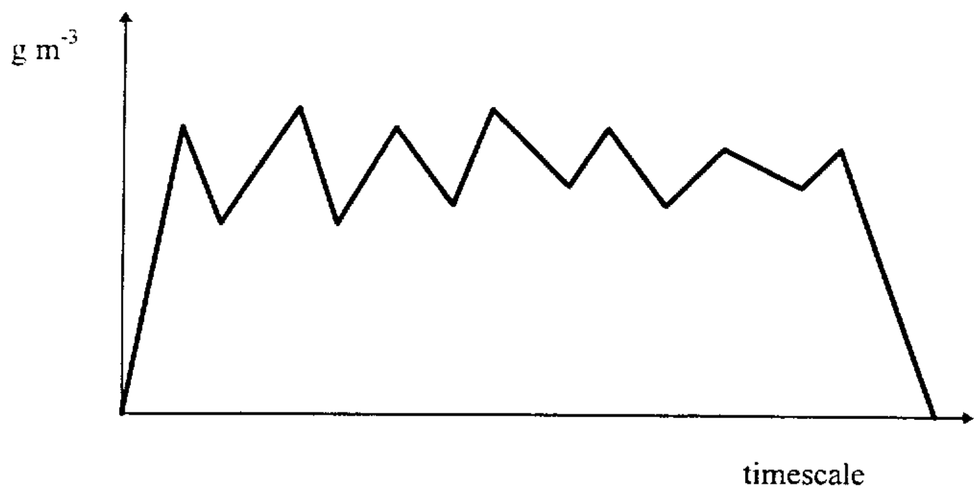

Transmission as a function of time for a given wavelength

14.2 *Attenuation*



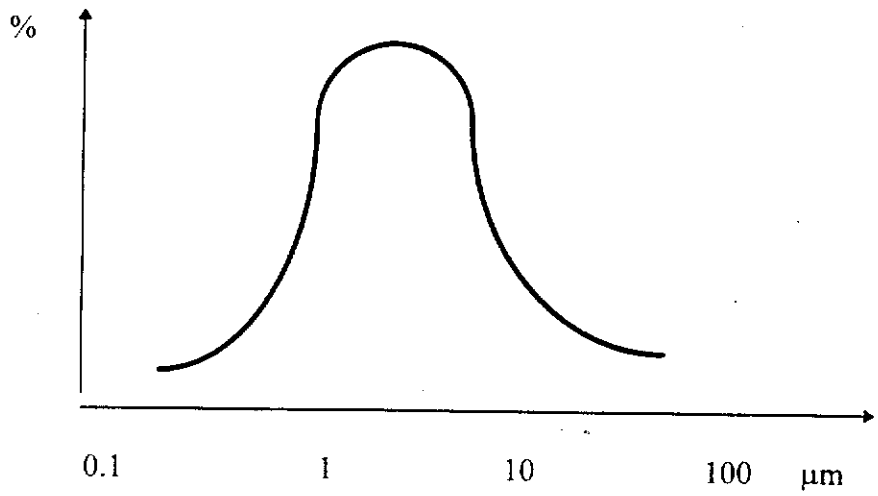

Attenuation as a function of time for a given wavelength

14.3 *Concentration by Mass*



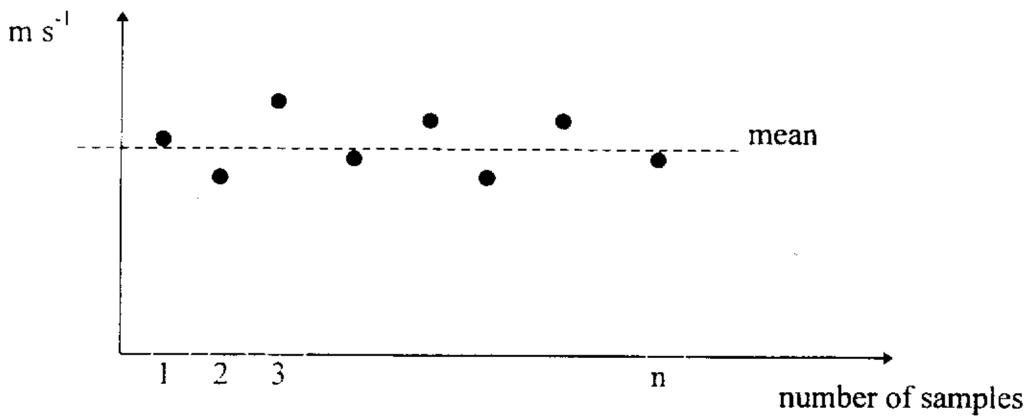

Concentration by mass as a function of time

14.4 *Particle Size Distribution*




Particle size distribution

14.5 *Mean particle Descent rate*



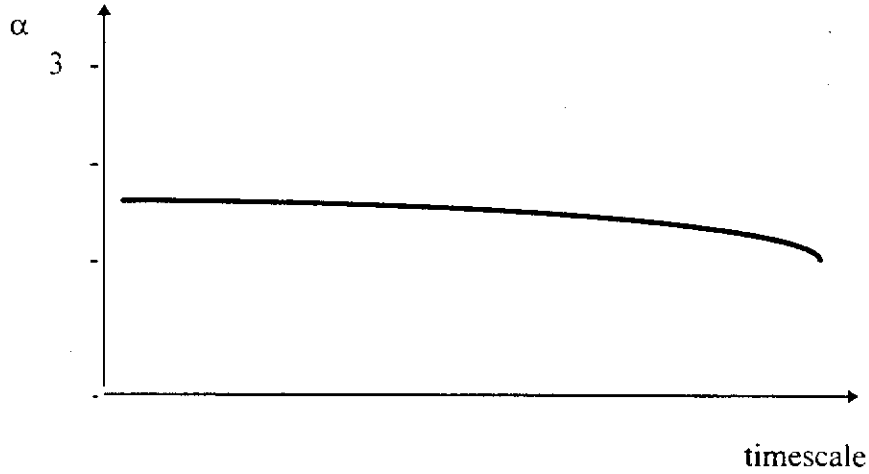

Mean particle descend rate

### 14.6 *Mass extinction coefficient*

This parameter results from a calculation according to the formula at § 4 on page B - 3:

$$\text{where } \alpha = -\frac{\ln T}{c\,l}$$

which is represented below as a function of time and for a measurement wavelength.




Change in mass extinction coefficient

### 14.7 *Local meteorological settings*

These settings correspond to the conditions inside the measurement chamber:

- temperature (°C)
- dew point (°C)
- absolute humidity (g $m^{-3}$)
- relative humidity (%)
- pressure (mbar)
- rate of extraction of air if applicable (m $s^{-1}$)
- rate and orientation of internal stirring (m $s^{-1}$; β; γ)

## PART II: STATIC TESTS IN THE FIELD

### GENERAL POINTS REGARDING FIELD TESTS FOR MEASUREMENTS OF A SCIENTIFIC NATURE

15. The principal objective of the field tests is to verify the effectiveness of the obscurants selected during the laboratory tests for the development of a screening cloud whose effectiveness extends over the whole of the electromagnetic spectrum specified.

These objectives will be met by organising tests in the field, preferably full-scale, which will enable:

- scientific measurements to be made on the physical parameters determining the effectiveness of the obscurant screen;

- the effectiveness of the obscurant screen obtained to be evaluated in the electro-optic, laser and radar wavebands.

These tests which will be organised in accordance with the procedure in the test plan described in Annex C of the present STANAG, will make it possible to evaluate the interactions between the various mechanisms involved in the sequences of deployment and dissemination of the obscurant cloud.

### OBJECTIVES OF MEASUREMENTS OF A SCIENTIFIC NATURE

16. Measurements of a scientific nature performed during tests in the field are aimed at understanding the characteristic parameters of the obscurant in a natural meteorological environment. They have much in common with those conducted in the measurement chamber and this therefore leads to the use of similar methods.

However, in order to ensure complete understanding of the obscurants in natural conditions, other experiments are proposed which employ methods and apparatus based on recent technology.

The organisation of the tests and experiments must conform to the test plan presented in Annex C.

Validation of modelling may be done following experiments containing measurements of a scientific nature.

## II-1 TRANSMISSION MEASUREMENTS

### OBJECTIVE OF TRANSMISSION MEASUREMENTS

17. Part II-1 of the section on "measurements of a scientific nature" is aimed at verifying in the field the physical characteristics of the obscurants which were determined during laboratory tests.

### PARAMETERS TO BE MEASURED

18. For tests in the field, the parameters to be measured are classified into two families:

- Fundamental parameters:
  * transmission as a function of wavelength.
  * local meteorological conditions.

- Recommended parameters:
  * concentration by mass of the material to be tested.
  * particle size distribution and shape of the particles.

### METHODOLOGY

**19. Transmission Coefficient**

Characterisation of the screening effectiveness in a measurement chamber is based on the Beer-Lambert law:

$$T_{(\lambda)} = \exp(-\alpha \, C \, l) \quad \text{(for a given } \lambda\text{)}$$

in which

| | | |
|---|---|---|
| | **T** | is the transmission |
| | $\alpha$ | characterises the product to be tested (extinction factor per unit mass in $m^2g^{-1}$) |
| | **C** | is the concentration by mass in $g\ m^{-3}$ |
| | $l$ | represents the optical path in the measurement chamber in metres |

In order to determine the extinction coefficient per unit mass, it is necessary to measure the transmission **T** and the product **C** $l$ (concentration x length of optical path).

20. **Concentration by mass**

The concentration by mass of the material to be tested must be determined as a function of time during the experiment. This parameter is to be measured by instruments such as dosimeters inside the obscurant cloud at several separate points within the generated volume.

21. **Particle size distribution and shape of particles**

The width of the spectral band affected and the effectiveness of the screen obtained are a function of the size of the particles, the particle size distribution and the particle shape.

The shape of the particles is characterised by their principal dimensions (for example, diameter for a disc or length for a fibre).

The distribution of the size of particles with these dimensions directly characterises the width of the spectral band in which the obscurant is effective.

Local sampling within the volume of the cloud enables this parameter to be obtained.

22. **Particle descent rate**

Minimising the particle descent rate makes it possible to optimise the period for which the screen is effective. This rate is linked to the atmospheric environment and it characterises the sensitivity of the obscurant cloud to wind.

23. **Conductivity and complex refractive index**

These parameters characterise the obscurant material in terms of its intrinsic optical properties.

The complex refractive index may be determined by Fourier-transform spectrometric techniques.

**INSTRUMENTATION**

24. **Instrumentation necessary**

24.1 *Transmissometers*

Transmission is measured as a function of time by means of transmissometers, which generally consist of sources placed directly opposite specific receivers across the line of the obscurant cloud. Each transmissometer records the relative transmission through the cloud by normalising the signal detected in the presence of the screen with respect to that measured before dissemination of the material to be tested.

Transmissometers therefore enable the transmission to be determined as a function of the wavelength (or spectral band), time and the polarisation state of the received signal.

24.2 *Dosimeters*

Dosimeters make it possible to determine the concentration by mass of the material to be tested, inside the measurement chamber. The number of them in place also enables the mean value of this parameter to be obtained.

Each dosimeter extracts a small sample from the cloud over a given time interval and at a given rate. A filter placed within the dosimeter makes it possible to capture the corresponding sample.

The sample taken in this way allows the mean concentration of the material tested to be obtained and the size of the particles captured to be measured.

## DATA REDUCTION AND PRESENTATION

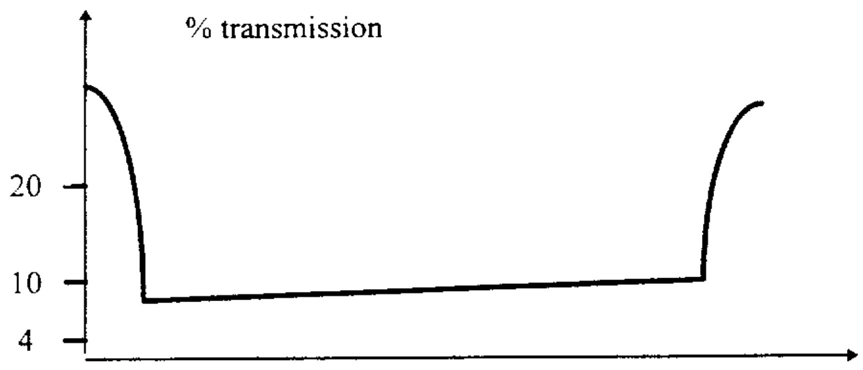
25. **Description of the test**

This section must contain the following headings:

- conduct of the test (scenario):
- number of munitions tested during the trial. quantity of product:
- layout of munitions or generator:
- topography of the site. layout of facilities:
- local meteorology on the test site (see Part IV of Annex B).

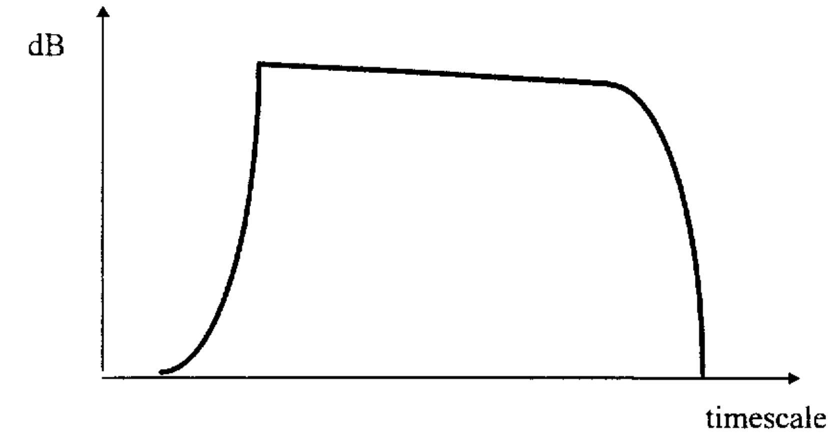
26. **Presentation of results**

26.1 *Transmission Coefficient*



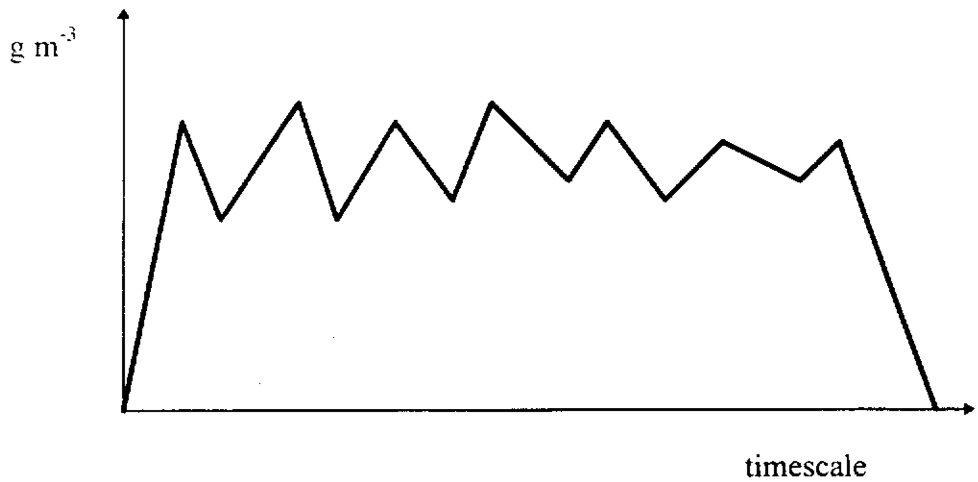

Transmission as a function of time for a given wavelength

26.2 *Attenuation*




Attenuation as a function of time for a given wavelength

26.3 *Concentration by mass*




Concentration by mass as a function of time

26.4 *Mass extinction coefficient*

This parameter results from a calculation according to the formula at § 19 on page B - 14.

$$\text{Where } \alpha = - \frac{\ln T}{c\,l}$$

which is represented below as a function of time and for a measurement wavelength


Variation in mass extinction coefficient

ANNEX B to
STANAG 4361
(Edition 1)

## II-2 ELECTRO-OPTICAL MEASUREMENTS

## OBJECTIVE OF ELECTRO-OPTICAL MEASUREMENTS

27. Part II-2 of the chapter on "Measurements of a Scientific Nature" deals with a method of evaluation using a thermal imager coupled with special processing of the data.

The principal objective of these measurements is to conduct an evaluation using data from electro-optical sensors without knowledge of the intrinsic physical properties of the material to be characterised.

## PARAMETERS TO BE MEASURED

28. In characterisation using electro-optical sensors, the parameters to be measured in making an evaluation are divided into two families:

28.1 *Dimensional parameters*

Selection of the areas of the obscurant screen of interest

* presence of the obscurant in the atmosphere
* size of the cloud
* number of component clouds
* spatial distribution
* density within the sensor field of view

Identification of the system functions:

* suitability of the obscurant screen against a threat;
* dimensions of the cloud as a function of time;
* effectiveness of screening (total screening)

28.2 *Temporal parameters*

Characterisation of the duration of effectiveness

* change in the presence of obscurant
* change in the size of the cloud
* rate of deployment (horizontal and vertical)
* rate of separation from the ground
* change in luminance
* change in transmission for the reference target

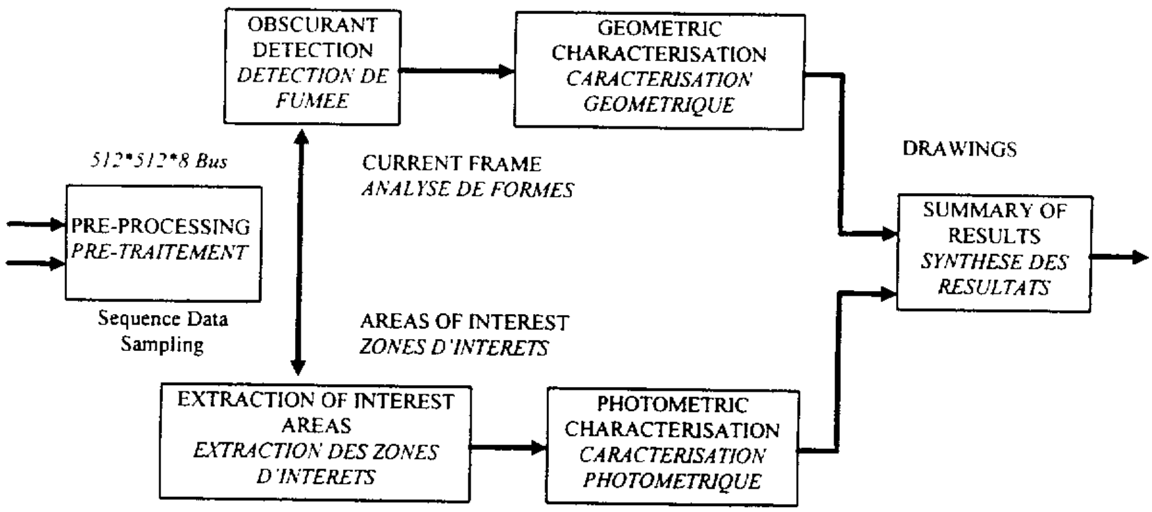
Identification of the system functions:

* time to establish the cloud
* duration of total screening
* integrity of the total screening period

## ANALYSIS METHODOLOGY

29. The definition of these parameters leads to the measurement of the attributes, presented in § 31, of the obscurant screen using the principle for processing image sequences adopted below:

**OBSCURANT CHARACTERISATION**



30. In this diagram, as an example, the input parameters are defined by a sequence of images captured at 25 Hz in 512 x 512 pixels, each pixel being digitised at 8 bits. To this image file there is a corresponding file of sensor parameters which is defined during the calibration phase. The rectangular symbol here represents a processing function. This concurrent flow of functions makes it possible simultaneously to determine the geometric and photometric attributes of the images. The output parameters are plots of these attributes as a function of time coupled with a picture showing presence obtained after labelling.

31. **List of chosen attributes**

31.1 *Geometric attributes*

- the number of extended components **(n)**
- the area of these components **(Sn)**
- the limits of extension horizontally and vertically **Hlim** and **Vlim (Slim = Hlim x Vlim)**
- the surface area density **(∑Sn/Slim)**
- the bottom limit (separation)
- the number of elementary particles
- the distance between the particles

31.2 *Photometric attributes*

- the mean internal luminance **(Lm)**
- the internal contrast

$$(1/N \sum(L(x,y) - Lm)^2)^{0.5}$$

- the horizontal and vertical texture:

$$\frac{(\sum(L(x,y) - L(x-1, y))^2)^{0.5}}{(1/N \sum(L(x, y) - Lm)^2)^{0.5}}$$

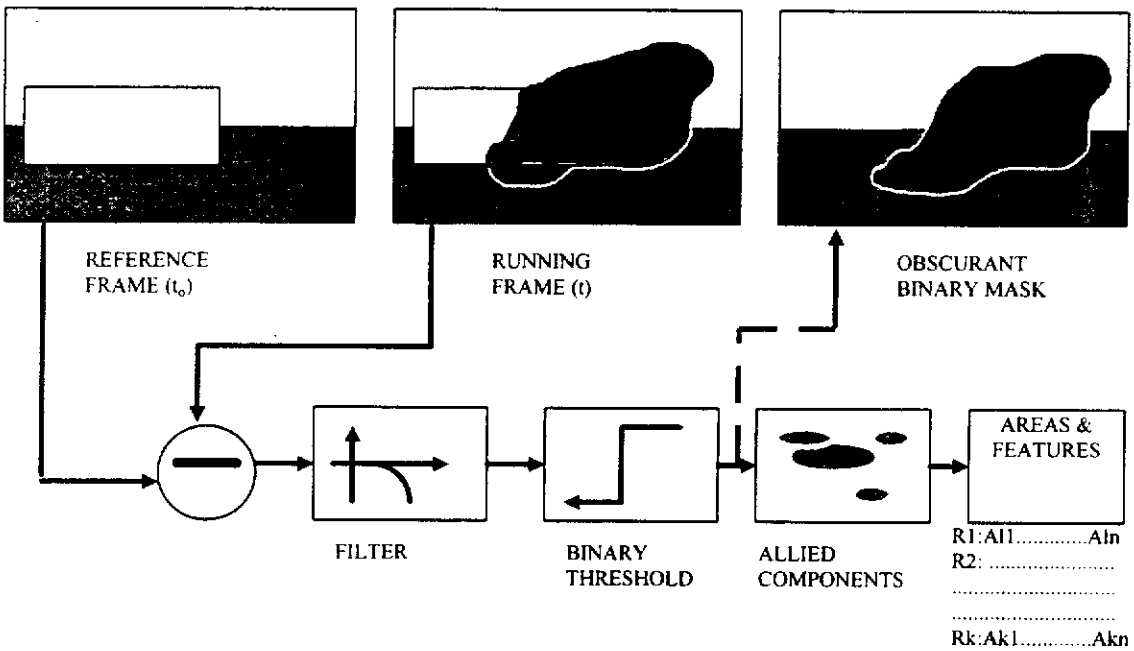
- the transmission for the reference targets

$$\tau (t) = \frac{(g(to)\ g(t)) \times (Ltgt(t) - Lbg(t))}{(Ltgt(to) - Lbg(to))}$$

$\frac{g(to)}{g(t)}$ (gain correction according to sensor).

32. These attributes, quantified from information contained in the recorded sequence of images (by digital segmentation and mapping), will enable us to arrive at the geometric and photometric characterisation of the obscurant screens. The principle is recalled below:

***SEGMENTATION PRINCIPLE***



33. The algorithm for image segmentation is carried out as follows:

- differentiation of the current image compared with a reference image (only the invariant aspects of the scene remain)
- spatial filtering (enables small and large sized areas of interest to be isolated)
- application of thresholds (eliminates false detections)
- calculation of connectivities (develops and constructs the cloud within the frame)

34. From this information it is then possible to extract a list of synthetic parameters intended for the comparative evaluation of different obscurant screens. These parameters are defined below:

| | |
|---|---|
| **Durmasq** | period during which the transmission for the reference targets is less than a pre-determined threshold |
| **TeDif** | time at the end of which transmission becomes less than the pre-determined threshold |
| **Attenint** | time integral during the period of firing of $(1 - \tau(t))$ |
| **SurfMax** | maximum area that extended adjacent components can reach |
| **DebDetec** | beginning of the image processing cloud detection time |
| **DurDetec** | duration of the image processing cloud detection time |
| **NbPartMax** | maximum number of elementary particles |
| **NbComMax** | maximum number of extended adjacent components |

## INSTRUMENTATION

### 35. Minimum instrumentation and desirable instrumentation

The devices chosen to perform image sequence acquisition are military detectors currently in service in the armed forces, or which will be introduced in the near future.

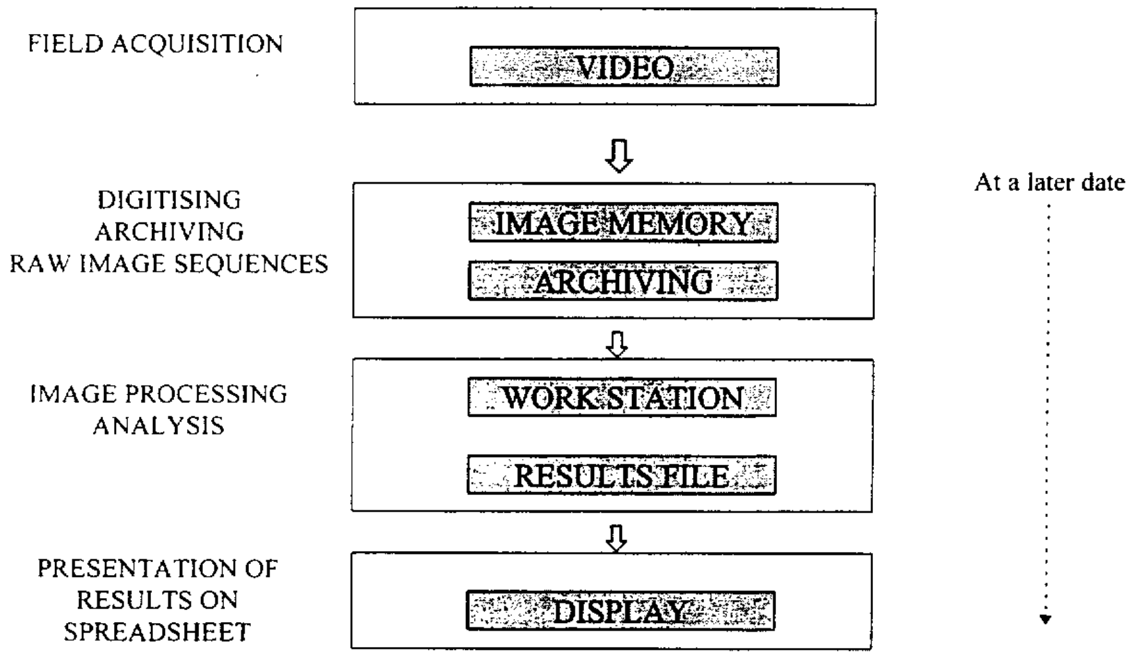
| | |
|---|---|
| CCD detector | 0.3 - 0.9 µm |
| PtSi detector | 3 - 5 µm |
| InSb detector | 3 - 5 µm |
| HgCdTe detector | 8 - 12 µm |

ANNEX B to
STANAG 4361
(Edition 1)

The military detectors used for this evaluation must cover the electro-optical spectrum from the visible domain up to far-infrared. The selection of these military detectors must be such as to make it possible to observe obscurant and obscurants at a distance in conditions which are close to those of operational use. Their performance (transfer function, offset fluctuation, gain variation, operating mode and other characteristics) must be known and easily monitored before, during and after image acquisition.

To this end, several black body type of reference targets, with dimensions suitable for the detector observation fields or even actual targets, are to be distributed logically within the scene to be observed. Knowledge of these data make it possible to conduct image analysis in retrospect using customary and reproducible image processing techniques for all recordings.

The block diagram of image analysis processing is defined below:



36. **Analysis**

Image analysis is undertaken in three phases.

36.1 *Marking and archiving the sequences to be processed*

This operation consists firstly of digitising the images to be processed using an image memory. The latter enables a sequence of images to be digitised in real time to 8 bits and then to be stored in a 128 Mbyte buffer memory. The raw image sequences are then archived. During this phase, an information file is generated for subsequent processing of these images. This file has information relating to the test conditions (environment, camera) and other information defining the observed scene more accurately, such as the position of the targets of interest (references), the position of a window not affected by the presence of obscurant throughout the entire firing (corrective offset).

36.2 *Analysis of the image sequences*

Each sequence of images is then processed on the work station using a library of image processing software. The results are gathered together in a file for output to an office spreadsheet.

36.3 *Graphical display of results*

The analysis results file is then recovered in a spreadsheet in order to display the results in graphic form and to produce a summary.

## REDUCTION AND PRESENTATION OF DATA

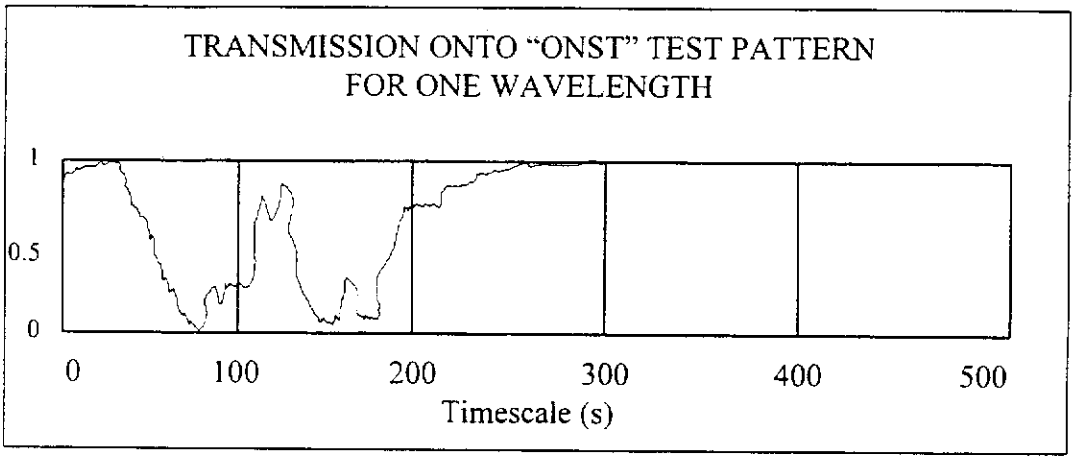
37. **Description of the test**

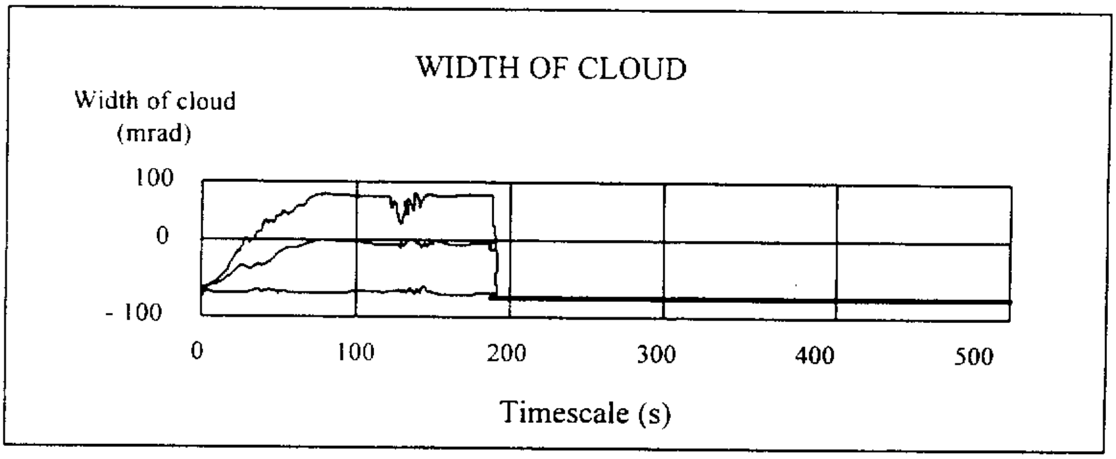
This section must contain the following headings:

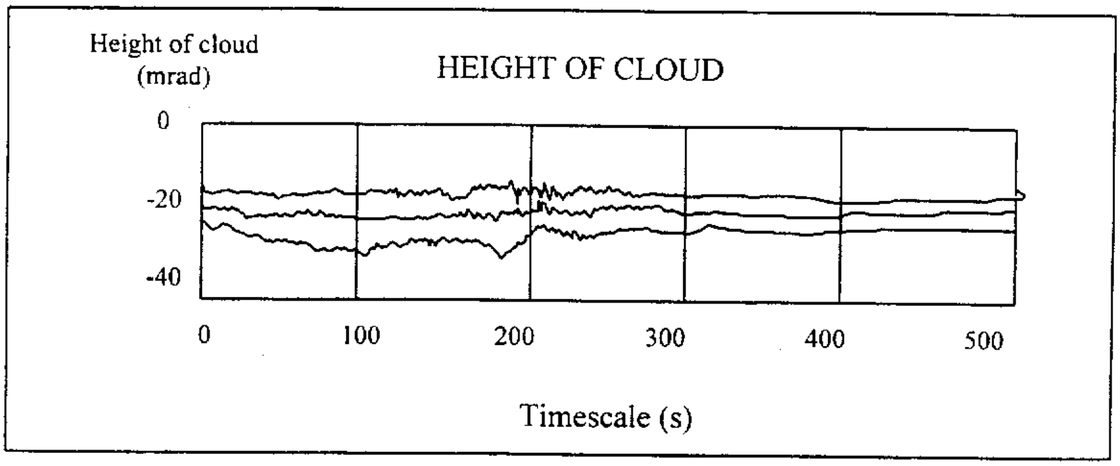
- conduct of the test (scenario)
- number of munitions tested during the trial, quantity of product
- layout of munitions or generator

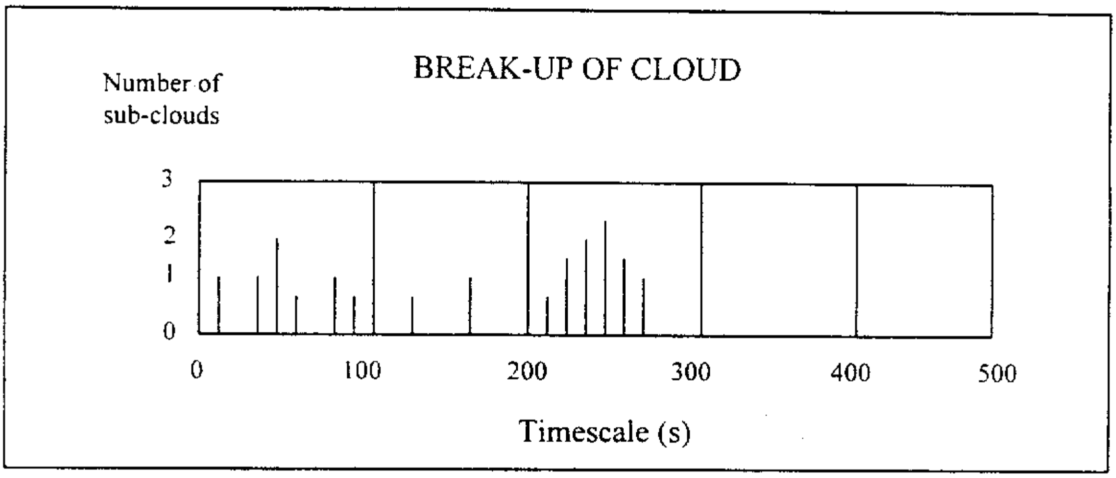
- topography of the site, layout of facilities
- local meteorology on the test site (see Part IV of Annex B)

38. **Presentation of results**






**II-3 MEASUREMENTS USING LASER EQUIPMENT**

**PRESENTATION AND OBJECTIVES**

39. Laser aided equipment is found in a variety of military applications such as:

- laser rangefinding
- target designation (including laser guiding munitions)
- active countermeasures

Understanding the effectiveness of the obscurant to degrade the performance of these systems will be obtained by means of a single scientific instrument, the LIght Detection and Ranging (LIDAR) system, which is constructed around a pulsed laser. In addition the instrumental set-up should provide information on the capability of laser warning receivers, as used by the obscurant producing units.

## PARAMETERS TO BE MEASURED

40. In evaluating obscurants, LIDAR can provide information about a variety of obscurant cloud parameters, which may be classified into three categories:

- spatial information
- temporal information
- physical parameters about the obscurant material

40.1 *Minimum information*

- range from the laser to the obscurant screen
- dimensions of the clouds (and sub-clouds)
- sharpness of the cloud edge

40.2 *Desirable information*

- relative movement of the screen in the direction of the line of sight
- change in the size of the screen as a function of time
- intensity of the backscattered radiation
- angular scattering

*40.3 Material characterisation*

- transmission through the screen (either 1 or 2-way transmission)
- diffusion characteristics
- concentration of the obscurant material
- particle size distribution

ANNEX B to
STANAG 4361
(Edition 1)

**METHODOLOGY**

41. Analysis of LIDAR signals and mathematical methods to determine information on the scattering and absorbing particles are well known from the literature. For obtaining the dimensions of the obscurant cloud, the LIDAR sensor is operating in the mapping mode. For obtaining range and sharpness, the sensor uses sharp pulses of short duration. (Cloud dimensions will be gathered at a much lower rate as with the imaging devices).

The most basic information to be obtained from the LIDAR is the beam attenuation by the obscurant.

Assuming that as reference source a laser reflector is used with known caracteristics, albedo (laser cross section) and equal or greater than the laser beam at the given range, the LIDAR receiver, located near the laser, receives a signal dependent upon the optical geometry and the (clear) atmosphere. When the obscurant is deployed, the beam passes twice through the cloud. The signal reduction immediately provides the square of the screen transmission.

One way transmission can also be determined by means of a receiver similar to a laser warning receiver, which is capable of measuring the signal attenuation of the main beam again supposing that the forward scattering is reflected. The level attenuation provides direct information about the effectivenes of the obscurant cloud against laser range finders and laser warning receivers.

In principle the result of laser beam propagation and image-contrast propagation by the obscurant may be different because of the different nature of the beam (coherent or non-coherent; narrow beam or wide beam).

42. Scattering by the obscurant cloud in comparison with target reflection as relevant in the context of laser guided weapons, is measured by means of a sensor similar to a laser spot locator, which can simply be a radiometer with a certain offset with respect to the main laser beam. The sensor will determine the strength and direction of both scattered or reflected beams. In case of an effective obscurant, the target signal is attenuated and the cloud signal increases. In case of equal signals it is assumed that the obscurant is effective. In this part Particle size distribution of the signal analysis the integrated signals (in space and time) are taken.

This information together with the transmission properties determine the effectiveness of the obscurant cloud against laser designator systems.

43. Another analysis of the scattered signal delivers depth information. The more dense the signal and the more reflection of the obscurant material at the laser wavelength, the stronger and sharpen the backscattered pulse of light. Careful, high speed analysis of the returned signal (in the nanosecond time frame) provides the sharpness information and density of the cloud edge and particle density. Information on particle shape is obtained with cross polarisation measurement. Knowning the backscattered light from spherical particle do not depolarize the light. It is then possible to distinguish sperical particles from none sperical particles.

44. To obtain cloud images by means of a LIDAR it will be desirable to increase the laser frequency as high as possible. It may be required to add an extra laser, where working e.g. at 1kHz. In this way it is possible to move the pulsed beam more rapidly over the cloud. By means of range gated operation, the obscurant cloud is discriminated from the background. By setting a certain level in the reformed signals, the cloud edges are defined making an image with 10,000 pixels with a 1 kHz laser takes 10 seconds, estimated to be the maximum allowable frame time.

**INSTRUMENTATION**

45. For obtaining as much information as possible LIDAR sensors at various wavelengths are recommended, for example, 0.53μm ; 1.06μm ; 1.53 μm ; and 10.6μm, for smaller than 1 mrad are required to minimum multiple scattering effects.

For determination of the two-way transmission, a calibrated retro-reflector is required. For one-way transmission, a receiver on the other side of the cloud is necessary.

The scatter properties are determined by the strength of the returned signal.

45.1 *Minimum instrumentation :*

- a single LIDAR, similar to a laser rangefinder
- a retro-reflector with known laser cross-section

ANNEX B to
STANAG 4361
(Edition 1)

- an illuminating laser
- a laser seeker head
- a laser warning receiver type of radiometer
- a laser spot locator type of receiver at a certain offset from the line-of-sight

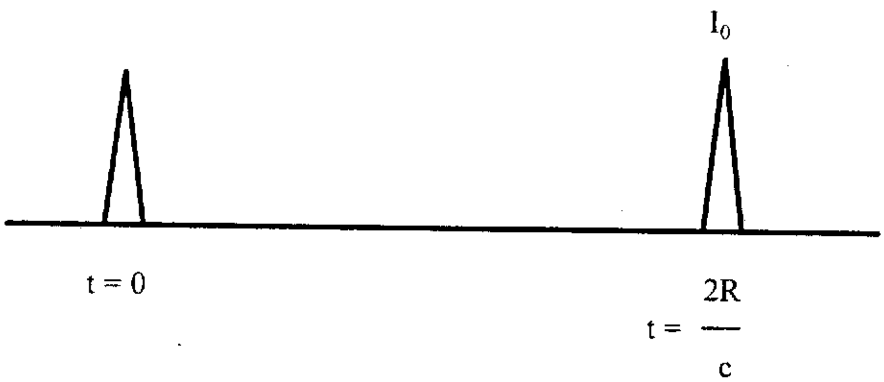
45.2 *Desirable instrumentation*:

- a multiple LIDAR, active in various spectral bands, preferably eye safe
- a high frequency laser to be added to the LIDAR platform
- scanning missions; for example, providing a picture of 10,000 pixels in about 10 seconds
- precise pulse shape analysis hardware and software
- a sophisticated laser spot locator-radiometer capable of determining the ratio of the strength and the direction of the 2 received beams.

46. **Illustrations of the Laser signal backscattering**

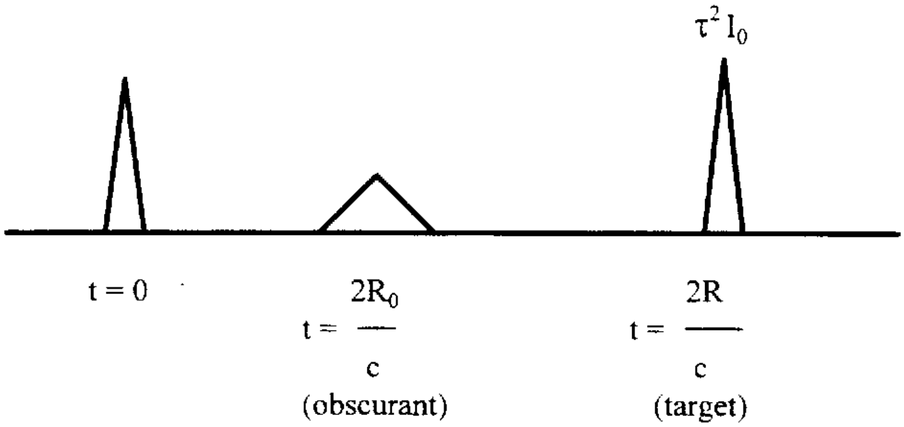
46.1 Without obscurant present

R ⇨ target distance
c ⇨ speed of light
$I_0$ ⇨ intensity of backscattered signal



46.2 With obscurant present

| | | |
|---|---|---|
| R | ⇨ | target distance |
| c | ⇨ | speed of light |
| $I_0$ | ⇨ | intensity of backscattered signal |




| | | |
|---|---|---|
| $R_0$ | ⇨ | obscurant distance |
| $\tau$ | ⇨ | transmission in the cloud |

## DATA REDUCTION AND PRESENTATION

### 47. Description of the test

This section must contain the following headings:

- conduct of the test (scenario)
- number of munitions tested during the trial, quantity of product
- layout of munitions or generator
- topography of the site, layout of facilities
- local meteorology on the test site (see Part IV of Annex B)

48. **Presentation of results**

48.1 *Minimum data*

- level of transmission through the cloud along one or two optical paths, as a function of time

- comparison of strength of the signal reflected by the cloud with that returned by the calibrated reflector, as a function of time

- comparison of the signal reflected by the cloud with the threshold level of a detector, as a function of time.

48.2 *Recommended data (in addition to those above)*

- extent of the cloud, as a function of time

- change in thickness of the cloud (optical path), as a function of time

- ratio of strength received compared with that emitted by the multispectral LIDAR, as a function of time

- change in screen dimensions in a plane perpendicular to the line of sight.

- depolarisation

## II-4 MEASUREMENTS USING RADAR EQUIPMENT

## PRESENTATION AND OBJECTIVES

49. Millimetre wave sensors deployed on the battlefield can be categorised into two distinct classes, namely active and passive systems, depending on the mode of operation.

Active systems emit electro-magnetic radiation. The analysis of the reflected signal gives information on the motion, speed and 3D characteristics of the target. Systems fielded include battlefield radars and weapon guidance sensors.

Passive systems detect radiation emitted and reflected by objects within the sensor field-of-view. Systems exploiting this mechanism include surveillance imagers, guidance sensors, and warning receivers.

50. To fully assess a millimetre wave obscurant screen, it is necessary to characterise the spatial and temporal attenuation and backscatter as a function of signal frequency and polarisation state.

Characterisation is generally undertaken by use of an active monostatic radar, using a single antenna to transmit and receive the millimetre wave radiation.

**PARAMETERS TO BE MEASURED**

51. An active radar is capable of recording spatial and temporal information on the obscurant screen, and characterise the obscurant material deployed. This may differ from that packaged due to the dissemination mechanism used to disperse the obscurant.

Spatial information to assess the effectiveness of the obscurant screen include the range and dimensions (width, height and depth) of the screen, the attenuation distribution across the extent of the screen and the obscurant backscatter distribution.

Temporal information includes the dynamics of the screen evolution, the variation of the obscurant attenuation and backscatter, and the screen duration.

Analysis of the polarisation dependence of the spatial and temporal characteristics of the screen give an insight into the dynamic properties of the obscurant material. If the screen is characterised at two or more signal frequencies, the ratio of the spectral parameters can indicate whether the particle size distribution has been modified by the dissemination mechanism.

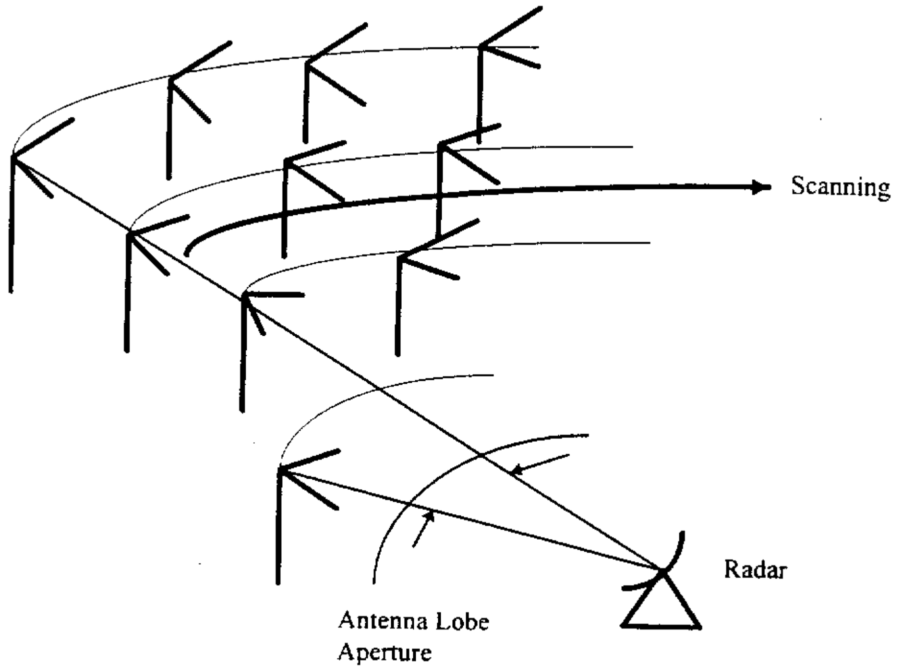
52. The current trend for millimetre wave systems is to operate close to the atmospheric windows centred on 35GHz, 94GHz, 140GHz, and 220GHz. However, future systems are likely to exploit the latest technology to operate at alternative frequencies, provided the sensor can achieve an adequate signal-to-noise ratio.

53. The two-way screen attenuation is determined by recording the change in the signal return reflected by a (calibrated) reflector, as the obscurant screen to be characterised passes between the radar and reflector. A scanning radar and an array of reflectors allow the spatial variation of the screen attenuation to be measured. The screen backscatter is dependent on the obscurant concentration within the volume element to be characterised and the amount of the screen present between the volume and the characterising radar (see Page B - 31). Since the obscurant screen is an extended target, the screen backscatter is expressed as a radar cross-section per unit volume, dBsm $m^{-3}$, where the magnitude of the reflected signal from the screen volume is equated to that of a flat plate having an area equal to the radar cross-section.

## METHODOLOGY

54. The dimensions of the radar antenna will determine the attenna beamwidth and the spatial resolution at which the screen elements can be discriminated. To distinguish between the signal returns from adjacent reflectors separated by less than the antenna beamwidth, the reflectors should be separated in range. The minimum range to the obscurant screen should be greater than the antenna far-field distance.

55. A scanning radar maximises the amount of spatial information that can be measured for an obscurant screen. Ideally, the radar needs to scan in a 2-dimensional raster pattern to characterise the screen width and height; however for radars incorporating a scanning pedestal, it may be necessary to restrict the radar scan to a plane to ensure a sufficient data acquisition rate to characterise the time dependence of the screen parameters. If the radar is limited to scanning in a single plane, three dimensional information for a narrow strip of the screen may be obtained by exploiting the finite antenna beamwidth of the radar. The reflector array is arranged so that at each azimuth angle, there is a set of reflectors at different elevation angles and different ranges, as shown in the figure opposite.




56. Typical millimetre wave obscurants are asymmetrical and the orientation of the disseminated obscurant is dependent on the particulate dimension and density, and the atmospheric turbulence. Atmospheric turbulence causes high aspect ratio fibres to oscillate about its stable orientation in the horizontal plane. Comparison of attenuation in the horizontal and vertical polarisation states enables fibre orientation to be characterised. For this reason, atmospheric turbulence should be one of the parameters measured by the meteorological station during a field trial.

Characterising the screen at two, or more, signal frequencies will give an indication of the obscurant size distribution. However, care must be taken with this analytical technique due to the length dependent resonant scattering of millimetre wave obscurants. Instruments such as dosimeters should be used for an unambiguous analysis of the size distribution of the disseminated obscurant.

57. The reflector array used to determine the spatial screen alternation typically comprise of reflectors selected from two basic designs. A trihedral reflector comprises three mutually perpendicular faces, and the principal return for linear polarisation states is co-polar, while the cross-polar is the principle return for circular polarisation states. A dihedral reflector comprises two perpendicular faces and the principle return for linear and circular polarisation states is co-polar.

The trihedral reflector is the preferred design used within an array because it is easier to align.

The dihedral reflector has a narrow antenna pattern in the plane common with the intersection of the two reflecting faces. Gusts of wind can move the dihedral reflector that results in a significant change in the return signal detected, that could be inadvertently interpreted as due to the obscurant screen.

## INSTRUMENTATION

58. **Minimum instrumentation**

- radar equipment which can measure temporal attenuation for a single line-of-sight.

59. **Desirable instrumentation**

- a radar system which can measure at two frequencies (antennas boresighted to characterise a common obscurant screen volume).
- a scanning radar.
- a radar with variable polarisation capability.

- radars and targets providing multiple lines-of sight.

- instrumentation for measuring temporal backscatter as a function of angle and range.

## DATA REDUCTION AND PRESENTATION

60. **Description of the test**

This section must contain the following headings:

- conduct of the test (scenario)
- number of munitions tested during the trial, quantity of product
- layout of munitions or generator
- topography of the site, layout of facilities
- local meteorology on the test site (see Part IV of Annex B)

61. **Minimum results**

- screen attenuation as a function of time.

- screen duration as a function of attenuation threshold (from an attenuation threshold from 3dB in 1dB increments)

62. **Desirable results**

- screen attenuation as a function of line-of-sight and time, for each frequency and polarisation state.

- screen duration at selected attenuation thresholds as a function of line-of-sight and time, for each frequency and polarisation state.

- relative ratio of vertical and horizontal polarized attenuation as a function of line-of-sight and time, for each frequency.

- screen dimensions at selected attenuation and backscatter thresholds as a function of time, for each frequency and polarisation.

63. **Subsequent data analysis**

- use theoretical relative spectral extinction cross-section of disseminated obscurant and screen alternation data to predict the screening at alternative signal wavelengths to those characterised.

- use of theoretical transport and diffusion models to predict changes in screen performance and dimensions as a function of meteorological conditions.

- use the range resolved backscatter data and the theoretical extinction and backscatter cross-sections of the disseminated obscurant to estimate the screen attenuation for which it was not possible to measure directly using a reflector.

## PART III: CHARACTERISATION BY MILITARY SYSTEMS

### OBJECTIVE

64. The principal objective of this characterisation is to verify the effectiveness of the obscurant using military systems to determine their operational capability.

Tests conducted in accordance with the procedure described in Annex C (field trials plan), may be used in order to confirm the overall operational performance of the obscurant system in technical/military terms.

This characterisation is therefore oriented towards an evaluation meeting the "User" need for countersurveillance by screening based on obscurants, without knowledge of the intrinsic physical properties of the product to be characterised.

**It must be noted that these tests are not strictly reproducible.**

### PARAMETERS TO BE MEASURED

65. In characterising the effectiveness of obscurant screens using military sensors, the parameters measured during an evaluation are listed under two categories:

65.1 *Minimum parameters*

- time to establish an effective screen
- duration of the effective screen
- homogeneity of the screen

65.2 *Desirable parameters*

- transmission in the principal observation axis

- initial dimensions of the effective screen
- spectral effectiveness (ultraviolet, visible, infrared, millimetre wave, laser, radar}
- sensitivity to wind
- change in dimensions of the cloud
- stability of the cloud with respect to the ground.
- apparent contrast between scene background and the cloud
- change of the cloud with respect to the principal observation axis.

**All of these parameters are to be expressed as a function of time for a given wavelength or spectral band.**

**They are only truly available when the procedures and instrumentation described in Part II of Annex B are used.**

## METHODOLOGY FOR MINIMUM PARAMETERS

### 66. Methodology for the electro-optical spectrum

The scene and progress of the test are filmed using a specific detector: ultraviolet Band A, visible, and the near, mid, and far-infrared wavebands. The data captured can be displayed on a screen for observers to use in real-time and recorded on magnetic media for storage and use at a later date.

Analysis consists of determining the moments when the reference target is lost from sight. Processing the results on a 'go - no go' basis allows the duration of initial screening or the duration of the total screening to be determined.

Preferably sensor parameters such as MRTD[1] shoud be available.

[1] (Minimum Resolvable Temperature Difference)

67. **Methodology for lasers**

The method consists, on the one-hand, of using one or more military rangefinders in order to measure, through the obscurant screen, the known distance of a reference target, and on the other-hand of illuminating the target in order to check correct behaviour of a seeker head.

Analysis consists of accounting for the incorrect rangefinder measurements and/or the times for which seeker head acquisition is in error.

68. **Methodology for radars**

The method consists of detecting a reference target situated at a known distance and having known radar cross-section through the obscurant screen.

Analysis consists of accounting for the incorrect detections for which the signal level is below a defined threshold.

## INSTRUMENTATION FOR MINIMUM PARAMETERS

69. **Military Systems**

- electro-optical systems
- laser rangefinders, designators and seeker systems
- specific detectors for the millimetre waveband
- means of recording for storing the sequence
- means of processing the results

## DATA REDUCTION AND PRESENTATION

70. **Description of the test**

This section must contain the following headings

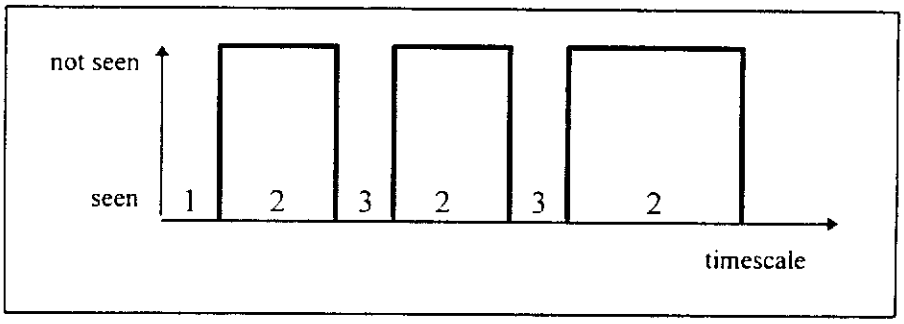
- conduct of the test (scenario)
- number of munitions tested during the trial, quantity of product
- layout of munitions or generator
- topography of the site, layout of facilities
- local meteorology on the test site (see Part IV of Annex B)

71. **Presentation of results**

This section gathers together the results of the tests in their original form, for example:

71.1 *Screening effectiveness*

Diagram of screening effectiveness




in which is seen :

- in 1 the time to establish an effective screen
- in 2 the periods in which screening is effective
- in 3 the moments when screening is ineffective (holes)

This presentation is suitable for observations performed using imagers in the UV, visible and IR wavebands.

71.2 *Laser and radar effectiveness*

With regard to effectiveness against lasers and radars, the results are expressed as the quotient of the number of incorrect laser rangefinder or radar detection readings, or the number of times loss of seeker head lock-on occurs, during the period of multispectral screening effectiveness determined in this same test.

71.3 *Sensitivity to wind*

The parameter "sensitivity to wind", which is the expression of the duration of effectiveness as a function of wind speed, can only be presented when there is a minimum of three results for the same obscuring system, tested in the same scenario with different local meteorological conditions. Sensitivity to wind is represented by the slope of the least squares straight line.

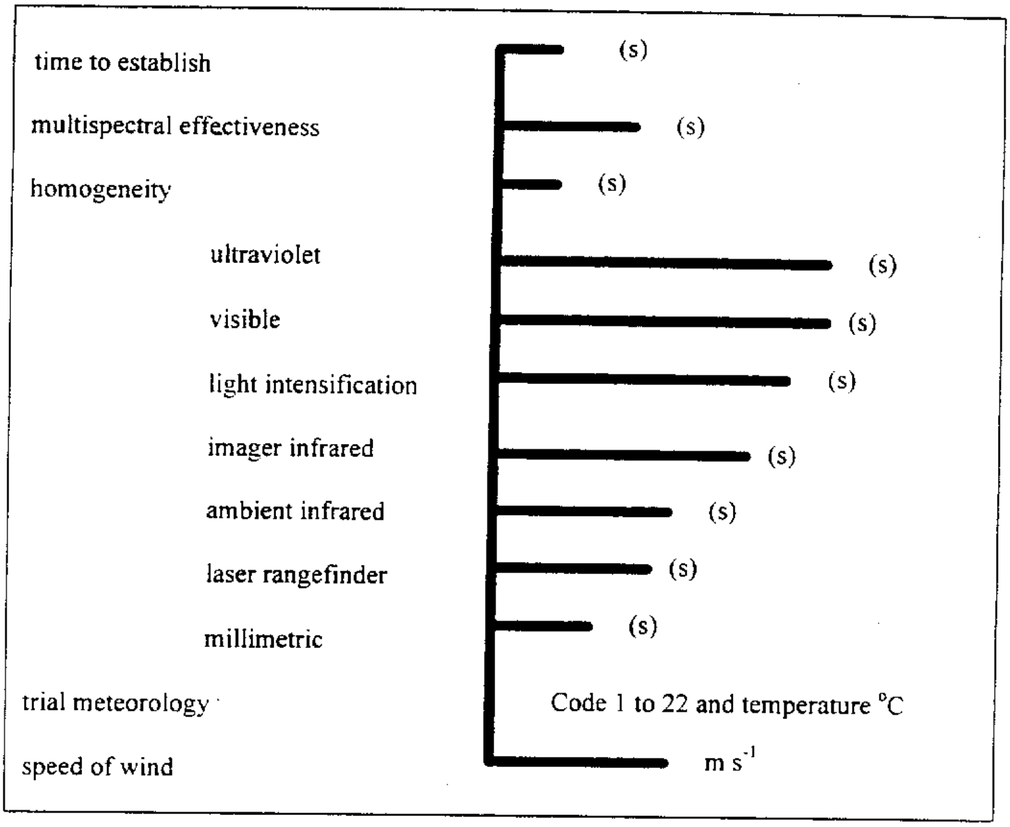
71.4 *Importance of local meteorological data*

Meteorological parameters which have a direct influence on the quality and continuity of camouflage achieved by obscuring the atmosphere are to be considered according to three basic parameters:

- aid the decision to employ obscurants.
- optimum positioning of the sources of obscurants
- probable route taken by the obscuring cloud in determining the advance of troops or equipment

ANNEX B to
STANAG 4361
(Edition 1)

## 72. Standardised global presentation




| | |
|---|---|
| time to establish: | delay in obtaining multispectral screening (1) |
| multispectral effectiveness: | duration of multispectral screening (2 or $\Sigma$ of 2) |
| homogeneity: | duration of non-effectiveness of multispectral screening (3 or $\Sigma$ of 3) |
| ultraviolet, visible, light intensification, imager and ambient infrared: | duration of effectiveness in the spectral band considered |
| laser rangefinder: | quotient of the incorrect number of rangefinder readings over the total number of rangefinder readings during the period of multispectral effectiveness, expressed by convention in seconds |
| millimetric: | quotient of the incorrect number of detections over the total number of detections during the period of multispectral effectiveness, expressed by convention in seconds |
| meteorology: | code in reference § 76.3 (Part IV below), specifying the mean ambient temperature during the trial |
| speed of wind: | measurements taken in accordance with § 76.1 (Part IV below) |

## PART IV: MINIMUM MICRO-METEOROLOGY MEASUREMENTS

### OBJECTIVE

73. The objective of micro-meteorology measurements is to provide a description of the atmospheric environment for a test of screening systems or munitions which use obscurants.

### PARAMETERS TO BE MEASURED

74. The parameters to be measured in order to describe the micro-meteorology are as follows:

| | | |
|---|---|---|
| - | Temperature | °C |
| - | Dewpoint | °C |
| - | Absolute humidity | $g\ m^{-3}$ |
| - | Relative humidity | % |
| - | Visibility | km |
| - | Atmospheric pressure at sea level | mbar |
| - | Local atmospheric pressure | mbar |
| - | Wind speed | $m\ s^{-1}$ |
| - | Wind direction | ° |
| - | Cloud height | km |
| - | Cloud cover | % |
| - | Solar radiance | $W\ m^{-2}$ |
| - | Radiance of the sky | $W\ m^{-2}Sr^{-1}$ |
| - | Radiance of the ground | $W\ m^{-2}Sr^{-1}$ |
| - | Rate of dissipation of kinetic energy ($\epsilon$) | $m^2s^{-3}$ |
| - | Rate of precipitation | $mm\ h^{-1}$ |
| - | Refractive Index structure ($C_n$) | $m^{-1/3}$ |
| - | Atmospheric turbulence ($C_n^2$) | $m^{-2/3}$ |
| - | Pasquill category | $A \Rightarrow F$ |

75. This list has been drawn up by considering existing simulation models.

ANNEX B to
STANAG 4361
(Edition 1)

**METHODOLOGY AND INSTRUMENTATION**

76. The methodology for gathering meteorological data does not call for any special comment except for the measurements of parameters relating to the local wind and the prevailing wind.

76.1 *Measurement of local wind*

The local wind (immediate environment of the volume of obscurant cloud) must be known as a function of time to the greatest possible accuracy.

In order to achieve this, the local wind is to be characterised along three orthogonal axes. The measurements shall be taken at a minimum of three points, two of which are to be situated as close as possible to the test area, in the axis of the prevailing winds. The third point is to be located close to the measurement zone.

Measurement taken at the recommended repetition rate of one second make it possible to reconstitute the continual change in speed and direction of the wind during the test.

These measurements must be taken at two different heights above the ground:

2 metres and 10 metres.

76.2 *Estimation of the mean direction of the prevailing wind*

This estimate is indispensable for perfecting the organisation of the tests; it makes it possible to determine the orientation of lines of sight so that the latter may be nearly perpendicular relative to the cloud to be evaluated.

The optimal positioning of the spot(s) for releasing the obscuring product is also chosen as a function of the prevailing wind.

The measurement of the direction of the prevailing wind also determines permission to fire in accordance with § 2.8 of Annex C.

76.3 *Classification of meteorological conditions*

1 Fog, mist with visibility < 1 km
2 Fog, mist with 1 km ≤ visibility ≤ 3 km
3 Fog, mist with 3 km ≤ visibility ≤ 7 km
4 Fog, mist with visibility ≥ 7 km
5 Dust with visibility < 1 km
6 Dust with visibility ≥ 3 km
7 Drizzle, rain and thunder storms with visibility < 1 km
8 Drizzle, rain and thunder storms with 1 km ≤ visibility ≤ 3 km
9 Drizzle, rain and thunder storms with 3 km ≤ visibility ≤ 7 km
10 Drizzle, rain and thunder storms with visibility ≥ 7 km
11 Snow with visibility < 1 km
12 Snow with 1 km ≤ visibility ≤ 3 km
13 Snow with 3 km ≤ visibility ≤ 7 km
14 Snow with visibility ≥ 7 km
15 Any weather with absolute humidity < 10 $g/m^3$
16 Any weather with absolute humidity ≥ 10 $g/m^3$
17 Visibility < 1 km and cloud ceiling height < 200 m
18 Visibility < 3 km and cloud ceiling height < 1000 m
19 Cloud ceiling < 300 m
20 Cloud ceiling < 1000 m
21 No cloud ceiling
22 All conditions combined

**To this descriptive set of meteorological conditions there must be added all the information relating to local and prevailing winds which is acquired during the conduct of each test.**

ANNEX C to
STANAG 4361
(Edition 1)

## PROCEDURE FOR GENERATING A FIELD TRIALS PLAN

### INTRODUCTION

1. The generation of a plan for the preparation of a set of trials, for carrying out these trials and for analysing the result is of prime importance in any action to evaluate the effectiveness of obscurants.

### CONSTITUENT CHAPTERS OF A TRIALS PLAN

2. The constituent chapters of a trials plan are as follows:

*Presentation*

- general and specific objectives of the test
- roles and contributions of those involved
- timetable of tests
- principal experiments

*Test site*

- description of the site
- layout of facilities (observers, measurements, targets...)
- lines of sight
- reserved areas
- topography of site

*Measuring equipment*

- parameters to be measured
- description and name of equipment
- role of each of the equipments
- location of the associated target(s)
- synchronisation of the measurements

*Micro-meteorology*

- parameters to be measured
- location of meteorological equipment

*Targets*

- description and name of targets
- role of each target

*Obscurants employed*

- physical and chemical characteristics of the product(s)
- description of the munition or system
- mode of dispersion

*Test programme*

- identification of tests
- daily programme
- timing and standard scenario of a test

*Regulations*

- rules for site access
- military security
- pyrotechnic safety
- physical and chemical safety
- test authorisation conditions, limitations

*Presentation of results*

ANNEX C to
STANAG 4361
(Edition 1)

## 2.1 **Presentation of test plan**

This chapter contains all of the information relating to the objectives of evaluation, the roles of the participants and the timetable of tests and it specifies the experiments considered as the major ones for successful evaluation.

## 2.2 **Test site**

*Description of site*

This section is a general presentation of the test site specifying in geographic situation, the organisation to which it is administratively attached together with its principal geometric characteristics, geophysical, geological and vegetation.

*Layout of facilities*

This section contain the description of the positions where the measuring facilities, the targets and all logistics facilities are set up. It is convenient to add to this section a sketch of the layout specifying the logistics facilities available at each position.

*Lines of sight*

There must be a specific drawing specifying the lines of sight or axes linking the measurement instruments to the associated targets.

*Reserved areas*

This section specifies the zones where access is restricted to authorised persons for confidentiality, pyrotechnic safety or other reasons.

*Topography of site*

The topography of the site results in an accurate, three-dimensional map of the whole layout. This map must be referenced to an earth's cardinal point, a latitude and a longitude. Altitudes are to be referenced to sea level or any geodesic point. Each equipment thus a "label" specifying its position on the site exactly. All of the topographical data is to be entered in a report which will be annexed to the principal document arising out of the set of trials.

### 2.3 Measuring equipment

*Parameters to be measured*

This section relates to the parameters which qualify the effectiveness of obscurants. In this context, two families of parameters are differentiated:

- The physical parameters comparable to those determined by scientific measurements during laboratory tests (they are described in Annex B Part II):

- The technical/military parameters as defined in the military characteristics list or the performance technical specification (they are described in Annex B Part III):

*Description and name of equipments*

The aim of this section is to define the technology of the measuring instruments used. It will also specify all of the intrinsic characteristics of the equipment and in particular, the accuracy of measurements made with these equipments.

*Role of each of the equipments*

The test plan must assign to each equipment arranged around the site a precise role in the allocation of parameters to be measured, with the objective of avoiding any unnecessary redundancy.

*Location of the associated target(s)*

The test plan must also specify which target(s) is (are) assigned to each of the measuring instruments. This assignment carefully defines the different lines of sight which will be taken into account in the analysis phases.

*Synchronisation of the measurements*

There must be a common clock which provides each measurements position with a recordable timebase so as to produce synchronised timing for all of the events occurring during the conductance of a test sequence.

2.4 **Micro-meteorology**

*Parameters to be measured*

Refer to Annex B Part IV.

*Location of meteorological equipment*

Meteorological equipment must be located close to the area where the obscurants to be tested are to be dispersed.

In particular, it is important that the measurements of wind speed and direction are performed on two pylons situated on a perpendicular to the principal line of sight. Their location near to the obscuring cloud is closely linked to the safety zone defined for the test area.

2.5 **Targets**

*Description and name of targets*

the aim of this section is to define the targets used for field evaluation. It will specify the nature of each of them, in particular whether they belong to the category of targets of a scientific nature or those of a military nature. All of the technical characteristics of the scientific targets must be shown in the lists established in this way. A description of the main characteristics of military targets is desirable.

*Role of each target*

The test plan must assign each of the targets a role which links it to one or more measurement instruments. This section is supplementary to the preceding text relating to measurement equipment.

## 2.6 Obscurants employed

*Physical and chemical characteristics of the products*

This section is to be linked with the warning text in the body of STANAG 4361.

The description of the physical and chemical characteristics of the obscurants employed enables the nature of these products to be established. Classification may be made as a function of their neutrality or their reactivity.

These characteristics will make it possible to determine the expected reaction products, know their new stable states, or the continuation of their transformation within the atmosphere.

*Description of the munition or system*

This description is essential information for conducting tests in the field. It affects the safety of personnel charged with operating the munition or counter-surveillance system.

For camouflage munitions, this description takes the form of an operating procedure accompanied by pyrotechnic safety data sheets.

For system without pyrotechnics, this description is the detailed operating procedure for using them.

*Mode of dispersion*

Complementing the preceding section, the modes of dispersion will be the subject of a special description where the rate of dispersion or the rate of expansion of the obscurant(s) into the atmosphere will appear.

## 2.7 Test programme

*Identification of tests*

A system of coding obscurants or combinations of obscurants makes it possible to simplify their designation during test sequences.

*Daily programme*

This programme defines the order for conducting tests so that each munition or counter-surveillance system is tested in turn, in the same meteorological configuration, especially at different times of the day and is also tested in several types of meteorological conditions.

Test decisions are taken, and the daily programme presented, during information meetings organised before and after each of the test sessions.

The collected data will be subject to review between participants to identify any necessary changes to the trials programme.

*Timing and standard scenario of a test*

This section deals with the details of conducting a test starting from a standard scenario. Timing begins with a countdown during which the measurement systems are checked and made ready. It continues with the loading of any munitions or systems which precedes switching on instruments which present a hazard, such as lasers. The meteorological conditions are validated for authorisation to proceed with the test before the final countdown. Timing continues during the test itself up to the command to cease measuring and to stop all transmitting sources.

## 2.8 Regulations

This chapter specifies the various rules to be complied with on the test site. It also deals with the instructions for military security, pyrotechnic safety, together with physical and chemical safety. These instructions are distributed individually to each participant.

Finally, this chapter indicates the test authorisation conditions and specifies the limitations to be complied with, notable the maximum quantities of materials to be dispersed during a test and the wind directions which prevent optimal measurements from being achieved.

### 2.9 **Presentation of results**

As a reminder, this topic is the subject of specific chapters in Annex B concerning each parameter to be measured.