MILITARY SPECIFICATION

FILTER (COATINGS), INFRARED INTERFERENCE: GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope.- This specification establishes general performance and durability requirements for thin film coated optical elements which are used in the spectral region from 0.7 um to 50.0 um (See 6.1).

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or requests for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

L-T-90	Tape, Pressure-Sensitive Adhesive Cellophane and Cellulose Acetate
CCC-C-440	Cloth, Cheesecloth, Cotton Bleached and Unbleached

Military

MIL-E-12397	Eraser, Rubber-Pumice for Testing Coated Optical Elements
MIL-I-45607	Inspection Equipment, Acquisition, Maintenance and Disposition of

STANDARDS

MIL-STD-105	Sampling Procedure and Tables for Inspection by Attributes
MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-1241	Optical Terms and Definitions

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, U. S. Army Armament Research & Development Command, ATTN: DRDAR-TST-S, Dover, N. J. 07801 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

DRAWINGS

U. S. Army, Frankford Arsenal

D7680606 Coating, Eraser Abrasive Tester

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

AMERICAN SOCIETY FOR TESTING AND MATERIALS

B117 - Standard Method of Salt Spray (fog) Testing

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103. Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal Agencies.)

3. REQUIREMENTS

3.1 Specification sheets.- Infrared filters and coatings shall comply with the requirements of this specification and the applicable specification sheet except as further defined in applicable drawings or procurement document.

3.1.1 Optical terms and definitions.- Terms and definitions are as used herein and defined in MIL-STD-1241 and 6.3 herein.

3.1.2 Detail specifications.- Specification sheets are categorized as shown in the supplement. As additional specification sheets are generated they will be placed in the appropriate class eg. the first additional specification sheet applicable to the class "Filter, Wide Bandpass, 7.7 to 11.7 Micrometers, Special Requirements for" shall be inserted as MIL-F-48616/301. Additional class designations, when necessary, shall be assigned outside this initial allocation in ascending order i.e. MIL-F-48616 - 700 to 799 would be allocated to the first class addition required.

3.2 Spectral.- The minimum spectral requirements for infrared filters and coatings are specified in the specification sheets. The spectral values for the wavelengths specified herein are given as measured in vacuum. (See 6.4). When specified on the component drawing or the procurement document (See 6.2c) the coated element shall meet the spectral requirements after environmental and durability testing.

3.3 Substrate.- As a minimum, when the substrate material is indicated on the component drawing or procurement document (See 6.2d), the requirements of 3.3.1, 3.3.2 and 3.3.3 shall be specified. When the substrate material and quality (internal and surface defects) are not specified, the substrate shall be chosen so that the optical component shall meet the requirements of 3.2 and 3.4.

3.3.1 Internal defects.- Prior to coating, substrate materials which are transparent or semi-transparent to visible radiation shall be evaluated for internal defects, such as bubbles and other defects which are essentially round in nature. These defects shall not exceed the dig requirements specified for surface defects specified in 3.4.1.3. The substrate materials shall also be evaluated for other internal defects such as striae, fractures, inclusions, etc. The limits on these defects shall be specified by the procurement agency (See 6.2e). For substrate materials which do not transmit visible radiation, the method for evaluation of the internal quality of the materials (See 6.4d) shall be specified by the procurement agency.

3.3.2 Surface defects.- Surface defects on the substrate shall be such that the coated component does not have defects in excess of the surface quality requirements of 3.4.1.2 and 3.4.1.3.

3.3.3 Dimensions.- The substrate shall meet the dimensional requirements of the applicable drawings or procurement document prior to coating (See 6.4e).

3.4 Coated component.- As a minimum, the coated component shall meet the following requirements.

3.4.1 Surface quality.

3.4.1.1 Coating.- The coating shall show no evidence of flaking, peeling, cracking, fingerprints, brush marks, out gassing, blistering, back-coating, crazing, etc. Spatter and holes on or in the coating shall be considered as a dig and shall not exceed the allowable dig size and quantity. (See 3.4.1.3).

3.4.1.2 Scratches.- Surface scratches (coating and substrate) shall not be in excess of the values specified on the component drawing or procurement document (See 6.2f). Scratches are permissible provided the width does not exceed that specified by the scratch letter. The accumulated length of all maximum scratches shall not exceed 1/4 of the average diameter of the element. The scratch letter and corresponding width are shown in Table 1.

3.4.1.2.1 Integrating scratches.- Where the scratches (coating and substrate) do not exceed the requirements of 3.4.1.2, each surface shall be evaluated further by integrating scratches. All scratches of widths less than or equal to the maximum allowable scratch width, and greater than or equal to the minimum scratch width to be considered, (See Table 1) shall be included in the integration. The length of each scratch shall be

multiplied by the scratch width. These products are to be added and the sum divided by the average diameter of the element. If a maximum scratch is present, this resulting value shall not exceed 1/2 the maximum allowed scratch width. If no maximum scratch is present, this value shall not exceed the maximum allowed scratch width.

3.4.1.3 Digs.- Surface digs (coating and substrate) shall not be in excess of the values specified on the component drawing or procurement document (See 6.2g). Digs are permissible on a surface provided the average diamter does not exceed that specified by the dig letter and no more than (1) maximum size dig occurs in any 20mm (0.80") diameter circle on the substrate. The dig letter and corresponding average diamter are shown in Table II.

3.4.1.3.1 Integrating digs.- Where the digs (coating and substrate) do not exceed the requirements of 3.4.1.3, each surface shall be evaluated further by integrating digs. All digs of diameters less than or equal to the maximum allowable dig diameter and greater than or equal to the minimum dig diameter to be considered (See Table II) shall be included in the integration. All digs shall be accumulated such that the sum of the diameters does not exceed twice the diameter of the maximum allowed dig for any 20mm (0.80") diameter circle on the surface. All digs of size B or small shall be separated by 1.0mm (0.04") minimum.

TABLE I

SCRATCH IDENTIFICATION
(See 6.3.1)

Scratch Letter	Scratch Width		Disregard Scratch Widths less than	
	Millimeters	Inches	Millimeters	Inches
A	.005	.00020	.0010	.0000
B	.010	.00039	.0025	.0010
C	.020	.00079	.0050	00020
D	.040	.00157	.0100	.00039
E	.060	.00236	.0100	.00039
F	.080	.00315	.0200	.00079
G	.120	.00472	.0200	.00079

TABLE II

DIG IDENTIFICATION
(See 6.3.1)

Dig Letter	Average Dig Diameter		Disregard Digs Smaller Than	
	Millimeters	Inches	Millimeters	Inches
A	.05	.0020	.010	.0004
B	.10	.0039	.025	.0010
C	.20	.0079	.050	.0019
D	.30	.0118	.050	.0019
E	.40	.0157	.100	.0039
F	.50	.0197	.100	.0039
G	.70	.0276	.200	.0079
H	1.00	.0394	.250	.0099

3.4.1.4 Cosmetic.- No blemishes (coating and substrate) such as streaks, smears, stains, blotchiness, discoloration, etc. shall be permitted on an optical component lying in a focal plane. Unless otherwise specified on the component drawing or procurement document (See 6.2h), blemishes on a component which lies outside the focal plane in an optical system shall be acceptable when it can be shown that these blemishes do not impair the spectral performance and durability requirements.

3.4.1.5 Coated area.- Optical components shall be coated over their entire clear aperture. In those instances where the clear aperture is not specified on the component or procurement document, the following allowable uncoated area shall apply:

Diameter or Maximum Diagonal Dimension of Optical Element	Maximum Width of Uncoated Area
Up to 2"	0.040"
Greater than 2"	0.040" plus additional width of 0.015" for each inch in diagonal greater than 2"
or	or
Up to 5CM	1MM
Greater than 5CM	1MM plus additional width increasing at the rate of 0.15MM for each CM over 5CM

Tooling marks are measured perpendicular from the edge of the components. In those instances where the clear aperture is specified, areas outside the clear aperture may be coated at the discretion of the contractor.

3.4.2 Surface durability (coating and substrate).

3.4.2.1 Environmental and physical durability.- The coated optical surface shall meet the following service conditions in the order specified:

3.4.2.1.1 Adhesion.- The coated optical surface shall show no evidence of coating removal when cellophane tape is pressed firmly against the coated surface and quickly removed at an angle normal to the coated surface:

3.4.2.1.2 Humidity.- After exposure in an atmosphere at 120° ± 4°F (49°C) and 95 to 100% relative humidity, the coated optical surface shall meet the requirements of 3.4.1.1 and 3.4.1.4.

3.4.2.1.3 Moderate abrasion.- The coated optical surface shall show no signs of deterioration such as streaks or scratches when abraded with a dry, clean cheesecloth pad.

3.4.2.2 Thermal and cleaning durability.- The coated optical surface shall meet the following conditions:

3.4.2.2.1 Temperature.- The coated optical surface shall be exposed to temperatures of -80°F and +160°F (26°C and 71°C) for 2 hours at each temperature. The rate of temperature change shall not exceed 4°F (2°C) per minute. Subsequent to these exposures, the coated optical surface shall meet the requirements of 3.4.1.1 and 3.4.2.1.1.

3.4.2.2.2 Solubility and cleanability.- After immersion in trichloroethylene, acetone and ethyl alcohol and wiping with cheesecloth, the coated optical surface shall show no evidence of coating removal or scratches and shall meet the requirements of 3.4.1.1 and 3.4.1.4.

3.4.2.3 Optional durability requirements.- When specified on the component drawing or other documents (See 6.2j) the following requirements shall be added or substituted:

3.4.2.3.1 Severe abrasion.- There shall be no visible damage, such as evidence of abrasion or coating removal, to the coated surface when abraded by an eraser conforming to MIL-E-12397.

3.4.2.3.2 Salt solubility.- After immersion in a saline solution, for a period of 24 hours, the coated optical surface shall meet the requirements of 3.4.1.1 and 3.4.1.4.

3.4.2.3.3 Water solubility.- After immersion in distilled water, for a period of 24 hours, the coated surface shall meet the requirements of 3.4.1.1 and 3.4.1.4.

3.4.2.3.4 Salt spray fog.- After exposure to a salt spray fog for a continuous period of 24 hours, the coated surface shall meet the requirements of 3.4.1.1 and the applicable abrasion resistance requirements of 3.4.2.1.3 or 3.4.2.3.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 General provisions.- Definitions of inspection terms shall be as listed in MIL-STD-109 and 6.3 herein.

4.1.2 Witness piece.- Unless otherwise specified, witness pieces representing the actual coated component may be used for spectral and environmental testing. The witness pieces shall be positioned in the coating chamber such that they represent the whole evaporation lot (See 6.3.2). The Government reserves the right to test the actual coated component. Should a component fail, even though the representative witness pieces pass the test, the lot shall be rejected.

4.1.3 Characteristics of the witness piece.- The witness piece shall be of the same material and have a surface finish similar to that of the component to be coated. The witness piece shall be such that it presents no difficulty in measuring and testing the spectral requirements of the coating. Spectral performance of coating applied to small, thick, or curved components may be verified on convenient sized flat, thin (approximately 1.0mm, or 0.40 inch) witness piece.

4.2 First article (initial production) approval.- The requirement for first article approval and the responsibility (Government or contractor) for first article testing shall be as specified in the contract (See 6.2k). Unless otherwise specified, the sample for first article approval tests shall consist of five (5) coated components plus ten (10) coated witness pieces (See 4.1.2 and 4.1.3). The five (5) coated components shall be tested, as specified herein, for all the requirements of 3.4.1. Five (5) coated witness pieces shall be tested, as specified herein, for all the requirements of 3.4.2.1, then 3.2. The other five (5) coated witness pieces shall be tested, as specified herein, for all the requirements of 3.4.2.2, then 3.2. When an optional durability requirement is specified in the contract or order an additional five (5) coated witness pieces shall be tested, as indicated herein, for each optional durability requirement specified. In addition to the foregoing, when the substrate material is identified by component drawings or procurement documents, five (5) uncoated substrates shall be provided and tested as specified herein for all the requirements of 3.3. The Government reserves the right to subject the coated components to all the tests specified here. The sample shall be coated in the same manner, using the same materials, equipment, processes,

and procedures as used in regular production. All parts and materials including packaging shall be obtained from the same source of supply as used in regular production.

4.2.1 Government testing.- When the Government is responsible for conducting first article approval tests, the contractor, prior to submitting the sample to the Government, shall inspect the sample to insure that it conforms to all the requirements of the contract and submit a record of this inspection with the sample, including certificates of conformance for materials, as applicable.

4.2.2 Contractor testing.- When the contractor is responsible for conducting first article approval tests, the sample shall be inspected by the contractor for all the requirements of the contract. The sample and a record of this inspection, including certificates of conformance for materials, shall be submitted to the Government for approval. The Government reserves the right to witness the contractor's inspection.

4.3 Inspection provisions.

4.3.1 Submission of product.

4.3.1.1 Inspection lot size.- The inspection lot size shall consist of all components or subassemblies (unit of product) coated within one (8 through 12 hour) work shift.

4.3.1.2 Lot formation and presentation of lots.- The unit of product shall be submitted for inspection on a moving inspection lot basis where the components or subassemblies are continuously offered for inspection in the order produced.

NOTE: Each evaporation lot (coated components and witness pieces) forming a part of a moving inspection lot shall be identified for subsequent evaluation, if required.

4.3.2 Examination and tests.

4.3.2.1 Substrate material.- Uncoated substrate material, when specified on the component drawings or procurement document, shall be inspected in accordance with this specification, the inspection provisions contained in Supplementary Quality Assurance Provisions (SQAP), or other procurements documents listed in the Technical Data Package (TDP). Examination and tests related to Section 3 herein shall be performed on a class basis in accordance with MIL-STD-105 and the sampling plan specified in Table III. The tabulated classification of defects in Table III shall constitute the minimum inspection to be performed by the supplier after first article approval and prior to Government acceptance or rejection by item or lot.

TABLE III - CLASSIFICATION OF DEFECTS

CLASS	CHARACTERISTIC	REQUIREMENT	TEST PROCEDURE
CRITICAL:	NONE DEFINED		
MAJOR:	AQL 0.65% DEFECTIVE		
101.	Internal defects	3.3.1	4.6.4
102.	Surface defects	3.3.2	4.6.5
103.	Dimensions	3.3.3	4.6.6
MINOR:	NONE DEFINED		

NOTE: The inspection for the Characteristics in Table III shall be conducted at a temperature between +60° and +90°F (16°C and 32°C).

4.3.2.2 Components, subassemblies and witness pieces.- Coated components subassemblies and witness pieces shall be inspected in accordance with this specification, the inspection provisions contained in Supplementary Quality Assurance Provisions (SQAP), or other procurement documents listed in the Technical Data Package (TDP). Examination and tests related to Section 3 herein shall be performed on a class basis in accordance with MIL-STD-105 and the sampling plans specified in Tables IV and V herein. The tabulated classification of defects in Tables IV and V shall constitute the minimum inspection to be performed by the supplier after first article approval and prior to Government acceptance or rejection by item or lot.

TABLE IV - CLASSIFICATION OF DEFECTS

CLASS	CHARACTERISTIC	REQUIREMENT	TEST PROCEDURE
CRITICAL:	NONE DEFINED		
MAJOR:	AQL 0.65% DEFECTIVE		
104.	Surface quality, coating	3.4.1.1	4.6.7.1
105.	Surface quality, scratches	3.4.1.2	4.6.7.2
106.	Surface quality, digs	3.4.1.3	4.6.7.2
107.	Surface quality, cosmetic	3.4.1.4	4.6.7.3
108.	Coated area	3.4.1.5	4.6.7.4
MINOR:	NONE DEFINED		

NOTE: The inspection for the Characteristics in Table IV shall be conducted at a temperature between +60°F and +90°F (16°C and 32°C).

4.3.2.3 Acceptance and rejection.- Rejected lots shall be screened for all defective characteristics. Removal of defective units and resubmittal or rejected lots shall be in accordance with "Acceptance and Rejection" as specified in MIL-STD-105.

4.3.2.4 Special sampling.- A minimum of three coated witness pieces, or coated components (when required), shall be selected as samples from each evaporation lot. Each sample shall meet the requirements and tests in Table V. The sequence of test shall be as delineated in Table V.

TABLE V - CLASSIFICATION OF DEFECTS

NO.	CHARACTERISTIC	REQUIREMENT	TEST PROCEDURE
301.	Spectral	3.2	4.6.3
302.	Adhesion	3.4.2.1.1	4.6.8.1
303.	Surface quality, coating (post humidity)	3.4.2.1.2	4.6.8.2, 4.6.7.1
304.	Surface quality, cosmetic (post humidity)	3.4.2.1.2	4.6.7.3
305.	Moderate abrasion	3.4.2.1.3	4.6.8.3

NOTE: The inspection for the Characteristics in Table III shall be conducted at a temperature between +60° and +90°F (16°C and 32°C).

4.3.2.5 Failure of sample.- Should any one item of a special sampling fail to meet the specified test requirements, acceptance of the represented inspection lot shall be suspended by the Government until necessary corrections have been made by the contractor and the resubmitted items have been approved. (See 4.3.2.3).

4.4 Inspection equipment.- Except as otherwise provided for by the contract, the contractor shall supply and maintain inspection equipment in accordance with the applicable requirements of MIL-I-45607.

4.4.1 Government furnished inspection equipment.- Where the contract provides for Government furnished test equipment, supply and maintenance of test equipment shall be in accordance with applicable requirements specified in MIL-I-45607.

4.4.2 Contractor furnished inspection equipment.

4.4.2.1 Government design.- All inspection equipment specified by drawing number in specifications or SQAP forming a part of the contract shall be supplied by the contractor in accordance with technical data included in the contract.

4.4.2.2 Contractor equipment.- The contractor shall supply inspection equipment compatible with the "Test Methods and Procedures" specified in 4.6 of this specification. Since tolerance of test equipment is normally considered to be within 10% of the product tolerance for which it

is intended, this inherent error in the test equipment must be considered as part of the prescribed product tolerance limit. Thus, concept, construction, materials, dimensions and tolerances used in the test shall be so selected and controlled as to insure that the test equipment will reliably indicate acceptability of a product which does not exceed 90% of the prescribed tolerance limit, and permit positive rejection when nonconforming. Construction shall be such as to facilitate routine calibration of test equipment.

4.4.2.3 Inspection equipment design requirements.

4.4.2.3.1 Spectrophotometric equipment.- The spectrophotometer utilized for spectral measurements of finished components, or witness pieces, shall have an optical system collimated to f/4.0, or a larger "f/-" number.

4.4.2.3.2 Spectrophotometric measurement accuracies.

4.4.2.3.2.1 Wavelength resolution, scanning speed and time constant.- The wavelength resolution of the spectrophotometer shall be better than that required by the applicable detailed specification sheet. The scanning speed and time constant shall be compatible with the resolution requirement of the item under test.

4.4.2.3.2.2 Wavelength and photometric accuracy.- When not specified in the applicable detailed specification sheet, the spectral parameters shall be measured to the following accuracies in the region from 0.7 um to 50.0 um:

a. Wavelength accuracy.- Plus or minus ($\pm$) 0.5% of the wavelength being measured, or in the case of narrow bandpass filters, $\pm$ 20.0% of the filter's half-band width.

b. Transmittance (T) accuracy.

TRANSMITTING REGION	ACCURACY
(T 1.0% absolute)	$\pm$ 1.5% of full scale
ATTENUATED REGION	ACCURACY
(T 1.0% absolute)	$\pm$ 0.1%

c. Reflectance (R) accuracy.

HIGH REFLECTANCE REGION	ACCURACY
(R 80.0%)	± 1.5% of full scale
MID-REFLECTANCE REGION	**ACCURACY**
(5.0% R 80.0%)	± 2.0% of full scale
LOW REFLECTANCE REGION	**ACCURACY**
(1.5% R 5.0%)	± 0.1%
(R 1.5%)	± 0.05%

4.5 Inspection documentation.

4.5.1 Spectral.- A copy of the spectral test results shall be supplied with each coating lot and shall contain sufficient data to show compliance with the spectral requirements for the parts being shipped. This data should include as a minimum the following:

a. Type of spectrophotomer used.

b. Properly labelled axes with spectral reference lines (e.g. where appropriate, zero reference and/or full scale reference lines).

c. Test conditions.

d. Actual measured values plus any theoretical or measured corrections to the measured values.

4.5.2 Physical.- Inspection records shall be available which show compliance with all physical requirements.

4.5.3 Environmental.- Inspection records shall be available which show compliance with all environmental durability requirements.

4.6 Test methods and procedures.

4.6.1 Cleaning.- Before and after subjecting a coated sample (component or witness piece) to any inspection or test, the coated sample shall be thoroughly and carefully cleaned to remove dirt, finger marks, smears, etc. The cleaning solution shall be acetone, ethyl alcohol, isopropyl alcohol, or mixtures thereof. Following the cleaning, the coated sample shall be carefully dried with lens tissue or a soft clean cloth. The temperature of the cleaning solution shall not exceed +80°F (27°C).

4.6.2 Temperature conditions.- Unless otherwise specified the testing equipment and coated components, or witness pieces, shall be stabilized at a temperature between +60° and + 90°F (16°C and 32°C), and maintained at that temperature during all spectral testing.

4.6.3 Spectral.- Perform the test for spectral requirements utilizing the test equipment specified in 4.4.2.3. The measured spectral performance of infrared filters and coatings shall conform to the requirements of 3.2. Unless otherwise specified the measured spectral values for the applicable wavelengths shall be recorded as measured in vacuum.

4.6.4 Internal defects.- Substrate materials which are transparent, or semi-transparent to visible radiation, shall be visually examined by transmission with the unaided eye for the requirements of 3.3.1. The examination shall be performed using two 15 watt cool white fluorescant light tubes as the light source. The viewing distance from the substrate surface to the eye shall not exceed 18.0 inches (45.7 cm). The substrate material shall be viewed against a black matte background. The only illumination in the inspection area shall be from the light source used for examination. This method of examination is as depicted in Figure I. The quality of the substrate material shall not exceed the dig tolerance specified in 3.3.1. The method of inspection and the evaluation of transparent and semi-transparent material for internal defects, other than defects which are essentially round in nature, shall be as specified by the procurement agency. The overall internal quality of the substrate material shall conform to the requirements of 3.3.1. The method of inspection to evaluate the internal quality of substrate materials which do not transmit visible radiation shall be as specified on the component drawing, or procurement document (See 6.2e).

4.6.5 Substrate surface defects.- The component substrate shall be examined for scratches and digs by reflection or transmission, where applicable using the inspection technique specified in 4.6.4. Magnification shall be used as needed in these examinations. The length and width of scratches, and the dig diameters shall be determined by use of interferometer, microscopic measuring devices, calibrated precision comparators, or similar applicable precision measuring devices. The width, length and density of all scratches on the substrate surface shall conform to the requirements of 3.4.1.2 and 3.4.1.2.1. The diameter and density of all digs in the substrate shall conform to the requirements of 3.4.1.3 and 3.4.1.3.1. The quality of each substrate surface shall meet the requirements of 3.3.2.

4.6.6 Substrate dimensions.- The substrate shall be inspected by use of standard measuring equipment (See 6.3.3). The substrate dimensions shall conform to the requirements of 3.3.3.

4.6.7 Surface quality of coated components.

4.6.7.1 Coating.- The coating on the component surface shall be examined for evidence of flaking, peeling, cracking, etc by reflection or transmission, where applicable, using the inspection technique

specified in 4.6.4. The coating shall conform to the requirements of 3.4.1.1.

4.6.7.2 Scratch and dig.- The coated substrate shall be examined for scratches and digs by reflection or transmission, as applicable, using the inspection technique specified in 4.6.4. Magnification shall be used as needed in these examinations. The length and width of scratches, and the dig (hole) diameters shall be determined by use of interferometer, microscopic measuring devices, calibrated precision comparators, or similar applicable precision measuring devices. The width, length and density of all scratches in the coating or substrate shall conform to the requirements of 3.4.1.2 and 3.4.1.2.1. The diameter and density of all digs (holes) in the coating or substrate shall conform to the requirements of 3.4.1.3 and 3.4.1.3.1.

4.6.7.3 Cosmetic.- The coating and substrate shall be examined by transmission or reflection, where applicable, using the inspection technique specified in 4.6.4. Blemishes on the coating or substrate shall conform to the requirements of 3.4.1.4. Coatings or substrate that exhibit evidence of discoloration shall be inspected for conformance to the applicable spectral requirements (See 4.6.3) specified on drawing, contract or purchase order. The blemished area on the coated substrate shall then be subjected to the moderate abrasion test of 4.6.8.3. The coating and substrate shall conform to the requirements of 3.4.1.4.

4.6.7.4 Coated area.- The coated area of the component shall be inspected by use of standard measuring equipment. The coating of the component shall conform to the requirements of 3.4.1.5.

4.6.8 Environmental and physical durability.- The coating on the component, or witness piece shall withstand exposure to the following conditions in the order specified.

4.6.8.1 Adhesion.- The coated component or witness piece shall be subjected to an adhesion test using 1/2" (12.7mm) wide cellophane tape conforming to Type I of L-T-90. Press the adhesive surface of the cellophane tape firmly against the coated surface so as to cover the stained area, then quickly remove it at an angle which is normal to the coated surface. Immediately following the removal of the adhesive tape, the coated surface of the component, or witness piece, shall be examined by reflection using the inspection technique specified in 4.6.4. The coating shall conform to the requirements of 3.4.2.1.1. Subsequent to this test the coated component, or witness piece, shall be subjected to the test in 4.6.8.2.

4.6.8.2 Humidity.- The coated component, or witness piece, shall be placed into an environmental controlled test chamber and exposed to a temperature of + 120° ± 4°F (49° ± 2°C) and 95% to 100% relative humidity for a minimum of 24 hours. Subsequent to this exposure the

coated component, or witness piece, shall be removed from the test chamber, cleaned (See 4.6.1), dried, and then subjected to the examinations specified in 4.6.7.1 and 4.6.7.3. The coating shall conform to the requirements of 3.4.2.1.2. The coated component, or witness piece, shall then be subjected to the test specified in 4.6.8.3.

4.6.8.3 Moderate abrasion.- Within one hour after the humidity test of 4.6.8.2 the coated component, or witness piece shall be subjected to a moderate abrasion by rubbing the coated surface with a 1/4 inch (6.4mm) thick by 3/8 inch (9.5mm) wide pad of clean dry, laundred cheesecloth conforming to CCC-C-440 affixed to an abrasion tester that conforms to Drawing D7680606. The cheesecloth pad shall completely cover the eraser portion of the tester and be secured to the shaft with an elastic band. The cheesecloth pad shall be rubbed across the coated surface from one point to another over the same path for 25 complete cycles (50 strokes) with a minimum force of 1.0 pound (0.45kg) continuously applied. The length of the stroke shall be approximately equal to two widths of the cheesecloth pad when the diameter or area of the component permits. The abrasion tester shall be held approximately normal to the surface under test during the rubbing operation. Subsequent to the rubbing operation the component, or witness piece, shall be cleaned (See 4.6.1), dried and then subjected to an examination by reflection using the inspection technique specified in 4.6.4 for evidence of physical damage to the coating. The coating on the component, or witness piece, shall meet the requirements of 3.4.2.1.3.

4.6.9 Thermal and cleaning durability.- The coated component, or witness piece, shall withstand exposure to the following test conditions:

4.6.9.1 Temperature.- The coated component, or witness piece, shall be subjected to temperatures of -80°F ± 2°F (-62° ± 1°C) and + 160°F ± 2°F (71°C ± 1°C) for a period of 2 hours at each temperature. After each exposure the coated components or witness pieces shall be stabilized at an ambient temperature between +60° and +90°F (16°C and 32°C) and subjected to the examination and test specified in 4.6.7.1 and only the adhesion test of 4.6.8.1. The coating shall conform to the requirements of 3.4.2.2.1.

4.6.9.2 Solubility and cleanability.- The coated component, or witness piece, shall be immersed, in sequence, in the following solutions maintained at room temperature (+60° to +90°F): trichloroethylene; acetone; and ethyl alcohol. The immersion time in each solution shall be a minimum of ten minutes. Upon removal from each solution, the solvent shall be allowed to evaporate to dryness without wiping or forced drying before proceeding to the next solution. Upon removal from the alcohol solution, and after drying any resultant stains on the coated surface shall be removed by wiping the coating to a clean, stain-free condition with an ethyl-alcohol-moistened cheesecloth. Subsequent to this cleaning, the coating shall be subjected to the examinations specified in 4.6.7.1 and

4.6.7.3. The coating shall conform to the requirements of 3.4.2.2.2.

4.6.10 Optional durability tests.- The coated components or witness samples shall withstand exposure to the following test conditions when specified in the contract, purchase order or on the component drawing (See 6.2j).

4.6.10.1 Severe abrasion.- The coated components, or witness piece, shall be subjected to a severe abrasion by rubbing the coated surface with a standard eraser conforming to MIL-E-12397 mounted in a eraser abrasion coating tester that conforms to the requirements of Drawing D7680606. The eraser shall be rubbed across the surface of the component, or witness piece, from one point to another over the same path for 10 complete cycles (20 strokes) with a force of 2.0 to 2.5 pounds continuously applied. The length of the stroke shall be approximately equal to 3 diameters of the eraser when the diameter or area of the component, or witness piece, permits. The eraser abrasion tester shall be held approximately normal to the surface under test during the rubbing operation. Subsequent to the rubbing operation the component or witness piece, shall be cleaned (See 4.6.1), dried and then subjected to an examination by reflection using the inspection technique specified in 4.6.4 for evidence of physical damage to the coating. The film coating on the component, or witness piece, shall meet the requirements of 3.4.2.3.1.

4.6.10.2 Salt solubility.- The coated component, witness piece, shall be immersed for a period of 24 hours in a solution of distilled water and sodium chloride (salt). The mixture shall be 6 ounces (170 grams) of salt per gallon (3.8 liters) of water at room temperature (16° to 32°C). Subsequent to this immersion the coated component, witness piece, shall be removed from the solution and gently washed, or dipped in clean running water not warmer than 100°F (38°C) to remove salt deposits. The coated component, witness piece, shall then be cleaned (See 4.6.1), dried, and then subjected to the examination specified in 4.6.7.1 and 4.6.7.3. The coated component, or witness piece, shall conform to the requirements of 3.4.2.3.2.

4.6.10.3 Water solubility.- The coated components, or witness piece, shall be immersed for a period of 24 hours in distilled water at room temperature (+60°F to +90°F). Subsequent to this immersion, the coated components, or witness piece, shall be removed from the solution, cleaned (See 4.6.1), dried, then subjected to the examination specified in 4.6.7.1 and 4.6.7.3. The coating on the component, or witness piece, shall meet the requirements of 3.4.2.3.3.

4.6.10.4 Salt spray (fog).- The coated component, witness piece, shall be subjected to a salt spray fog test in accordance with ASTMB-117-73, for a continuous period of 24 hours. Subsequent to the salt spray fog exposure the coated component, or witness piece, shall be washed and dried as specified. The coated component or witness piece, shall then be cleaned (See 4.6.1), dried, and then subjected to the examination specified in 4.6.7.1. Subsequent to the visual examination for physical defects

the coated component or witness piece, shall be subjected to the test in 4.6.8.3 or 4.6.10.1, as specified in the contract or order. The coated component or witness piece, shall meet the requirements of 3.4.2.3.4.

5. PREPARATION FOR DELIVERY

5.1 Packaging and packing.- In the absence of specified packaging data in the contract, or purchase order, each thin film coated optical element shall be individually wrapped in a chemically inert paper that will not scratch, leave a residue or corrode the coated element (See 6.4g). The wrapped coated element shall be immobilized in a unit container that provides adequate protection during handling and shipment.

5.2 Marking.- Each packaging and shipping container shall be marked to show the following:

a. Lot or batch number.
b. Contract or purchase order number.
c. Part or drawing number.
d. Quantity of parts in container.
e. Manufacturer's name or trademark.

5.3 Shipping container.- Shipping containers shall be marked with words "DELICATE OPTICAL COMPONENTS REQUIRING SPECIAL HANDLING". The appropriate side of the container shall be clearly marked to indicate "TOP" or "OPEN THIS SIDE".

6. NOTES

6.1 Intended use.- This document is intended to be used for all types of infrared interference filters and coatings. It is anticipated that most of the coatings/filters covered by this document will not include specialized characteristics such as fluorescence, high energy handling properties, conduction, etc. However, specialized characteristics as those mentioned, or those in which more exacting performance capabilities are needed can be imposed by the generation of additional specification sheets that include the desired specific properties. The primary requirement on the specification sheet is the spectral characteristic of the filter or coating. However, requirements in addition to spectral requirements may be added, if needed. The specification sheet in conjunction with the general document will then adequately specify the required filter and/or coating.

6.2 Ordering data.- Purchasers should exercise any desired options offered herein, and procurement documents should specify the following:

a. Title, number and date of this specification.

b. Number and revision of the specific detailed specification sheet and dash number, if applicable.

c. Post environmental spectral evaluation (See 3.2).

d. Substrate material (See 3.3).

e. Internal defect requirement (See 3.3.1).

f. Scratch value (See 3.4.1.2).

g. Dig value (See 3.4.1.3).

h. Cosmetic requirement (See 3.4.1.4).

j. Optional durability requirements (See 3.4.2.3).

k. Requirement for first article approved (See 4.2, 4.2.1 and 4.2.2).

m. Supplemental spectral requirements (See specification sheets).

6.3 Definitions.

6.3.1 Scratch and dig identification.- This is specified by two letters separated by a hyphen (i.e. F-F). The first letter of the pair is the maximum scratch letter. The second letter is the maximum dig letter.

6.3.2 Evaporation lot.- An evaporation lot is defined as the group of parts which has the coating applied at the same time and in the same chamber.

6.3.3 Standard measuring equipment (SME).- Standard measuring equipment is defined as the common measuring devices which are usually stocked by commercial supply houses for ready supply (shelf items) normally used by an inspector to perform dimensional inspection of items under procurement. This category also includes commercial testing equipment such as meters, optical comparators, etc.

6.4 Informational notes:

a. Spectrophotometer measurements: Spectrophotometers are calibrated for wavelength using standard air (pressure =760mm Hg and temperature = 15°C). The purpose is to clearly identify the index of refraction of the medium in which the calibration is to apply and eliminate possible fluctuations in poorly defined conditions. For most applications, such details in calibration are inconsequential since the change in operating conditions affects measuring only slightly. For example, the difference between wavelengths measured in vacuum and the same wavelengths measured in standard air amount to about 0.025%. (Reference: Commission on Molecular Structure and Spectroscopy. International Union of Pure and Applied Chemistry, Table of Wavenumbers for a Calibration of Infrared Spectrometers. (Butterworths, 1961).

b. Temperature effects on coatings:

If the application for these coatings is for other than normal room temperature, the user should request from the manufacturer specific performance information. Spectral performance is temperature dependent and allowance for temperature effects can frequently be included in filter design. Coating durability is also temperature dependent.

c. Angle of incidence effects on coatings:

Normally, as the angle of incidence of the radiation increases from 0^{o} (normal incidence to the optical element) the spectral features of the thin film coating shift to shorter wavelengths with changes in transmittance and reflectance also occurring. The same holds true as the radiation changes from parallel to convergent beam. Allowance for non-normal angles of incidence and convergency angles can be included in filter design. For angles of incidence greater than approximately 20^{o}, spectral performance is influenced by the polarization state of the incident radiation. For a particular application, the user should request pertinent information from the manufacturer.

d. Internal defects of substrates:

Internal defects of spectral filter substrates can seriously deteriorate the related system performance. Techniques of various degrees of precision exist for evaluation visually opaque substrates for internal defects. Some of these are image spoiling property test, snooper scope evaluation, infrared microscope test, laser scanning, X-ray, etc.

The higher the resolution and lower the tolerance of the system to scattered radiation, the more exacting the tests that should be selected.

Improperly oriented birefringent substrates can seriously deteriorate higher resolution performance. A favorable orientation should be specified.

e. Physical thickness of coatings:

Coatings in the infrared spectral region can be several thousandths of an inch thick. Consequently, allowance must occasionally be made for coating thicknesses as well as substrate thickness when designing filter holders.

f. Test conditions:

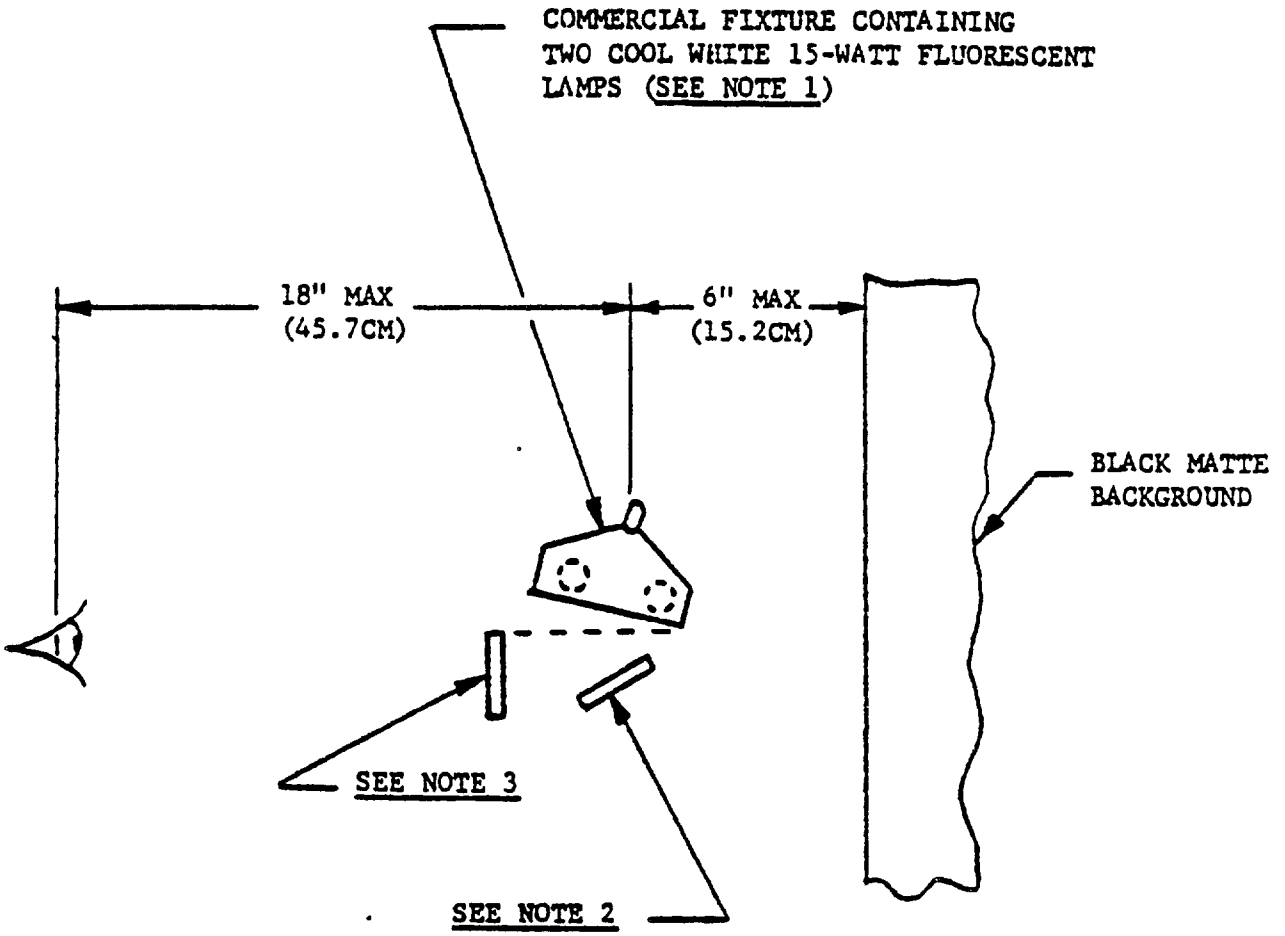
Should in-use conditions differ from these test conditions, the customer should request from the manufacturer the pertinent adjusted parameters either by theoretical calculation or change in the test conditions. Adjustments that may be required shall include the effects of temperature, angle of incidence, convergence angle of the incident radiation, and polarization of the incident radiation. The optical component or witness may absorb energy during spectrophotometric tests thus causing a temperature change. Controlled temperature during testing should be specified by the customer.

g. Wrapping tissue:

Papers which contain certain chemicals, or are fabricated of bleached wood pulp, may cause deterioration of optical coatings. Care must be exercised to insure that chemically inert paper made from unbleached wood pulp is used to wrap optics.

Custodians:
Army - AR
Navy - SH
Air Force - 99

Preparing activity:
Army - AR
Project No. 6650-0091



NOTES

1. THE ONLY ILLUMINATION IN THE TEST AREA SHALL BE FROM THE LIGHT SOURCE USED FOR TEST.
2. RELATIVE POSITION OF COMPONENT FOR INSPECTION BY REFLECTION.
3. RELATIVE POSITION OF COMPONENT FOR INSPECTION BY TRANSMISSION.

FIGURE 1