University of Reading
Infrared Multilayer Laboratory

Quality Manual

Document Reference - PA-RDU-397C

Quality Assurance

All the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity will fulfil requirements for quality.

(ISO 8402:1994 Quality management and quality assurance -- Vocabulary)

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Quality Manual

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1 Introduction

This plan describes and controls the Product and Quality Assurance activities to be implemented by the University of Reading during the design, manufacture, testing and supply of infrared optical filters and coatings.

Also defined are expanded performance assurance requirements in areas of reviews, spectroscopic and environmental testing, contamination control, materials control, parts control, safety and reliability.

1.1 Quality System

This Quality Manual describes the University of Reading system for accomplishing the assurance activities in compliance with customer's requirements. The Quality Assurance Officer shall be responsible for developing and executing the plans at the University of Reading.

The University of Reading ensures that quality is an integral part of the design, development, and fabrication of all products and services. The University of Reading emphasises the use of problem prevention and correction in order to supply quality products and services to its customers.

The activities governed by the Quality System are identified and documented. These documented procedures are controlled and effectively implemented to ensure that the University of Reading products meet customer requirements. The Quality System is defined in the following controlled documents:

- The Quality Manual (PA-RDU-397)
- The Laboratory Manual (PA-RDU-398)
- System Level Procedures (as defined in the Laboratory Manual)
- Quality Control Records

The Quality Manager shall identify activities governed by the Quality System and ensure that they are documented. The Quality Manager shall perform quality planning to relate specific customer requirements to the Quality System and to ensure that quality documentation and records are properly identified, maintained, and controlled.

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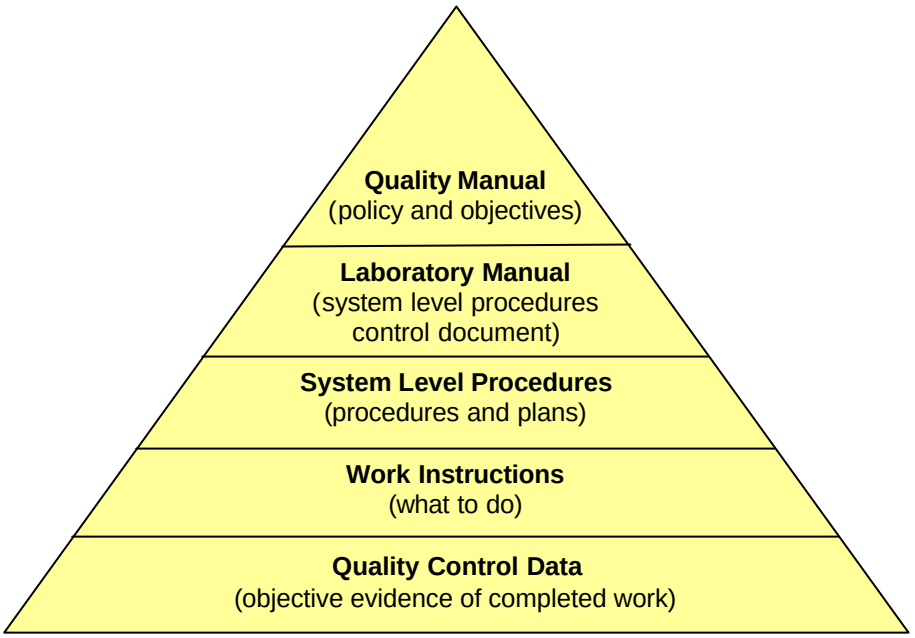
The documentation hierarchy for the University of Reading Quality System is summarized below.

Structure of Quality System Documentation



1.2 Reference Documents

The following documents are called up in this plan and used for guidance and information; selected sections of the individual documents may form part of this plan and will be followed to the extent specified.

Document Reference	Description
PA-RDU-398	University of Reading Laboratory Manual
MIL-F-48616	Military Specification Filter (Coatings), Infrared Interference General Specification For
ISBN 07049 04098	University of Reading Space Exposure of Infrared Filters and Materials on the NASA Long Duration Exposure Facility (LDEF)
Patent Specification Number 1425941	"Improvements relating to the manufacture of coated substrates" - Published 25 Feb. 1976.
Patent Specification Number 1285567	"Improvements in or relating to the manufacture of multilayer interference filters" - Published 16 Aug. 1972

For a complete list of all publications produced by the University of Reading Infrared Multilayer Laboratory see Appendix B - Publications.

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2 General Requirements

The University of Reading will conduct an organised program to demonstrate that the optical filter coating design and manufacture meets the functional requirements of the customer. This requirement will be accomplished by conducting relevant analyses, reviews, tests, and inspections defined in this plan at all stages of the manufacturing process.

Implementation and maintenance of the quality assurance program shall be conducted at the University of Reading to encompass all manufactured components. This program shall also apply to all work accomplished by sub-contractors and suppliers who provide parts, materials and support to the University of Reading.

2.1 Previously Designed and Manufactured Hardware

No previously designed or manufactured hardware will be used, unless specifically agreed on by the customer/project. The hardware to be supplied will be designed, built and tested specifically for the customer/project

However, the design and manufacture will follow established design principles developed for previous customers/projects.

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2.2 Responsibilities

The University of Reading will implement the following system for effective management control and audit of the quality assurance program. Responsibility and authority for managing the quality assurance activities shall be assigned to the University of Reading personnel having unimpeded access to higher management. The quality assurance personnel shall have timely unimpeded access to all products in order to perform pertinent assurance functions and participate as appropriate in planning and review activities.

General responsibilities for the University of Reading personnel regarding work affecting quality are summarised in the following table:

Who	Responsibility
Quality Assurance Manager	A Quality Assurance (QA) Manager appointed from the University of Reading group will be responsible in collaboration with all participating groups in the project, for developing and executing product assurance plans. The QA Manager will be the formal interface on all product assurance related matters and shall be responsible for the following activities : • Define the Quality Policy • Ensure the communication and understanding of the Quality Policy throughout the organisation • Ensure that the Quality System is established, implemented, and maintained • Obtain and communicate customer requirements to the appropriate personnel or functional organisation, • Ensure that personnel comply with applicable standards, regulations, specifications, and documented procedures
Quality Assurance Officer	A Quality Assurance (QA) Officer appointed from the University of Reading group will be responsible in collaboration with all participating groups in the project, for developing and executing product assurance plans. The QA Officer will be the formal interface on all product assurance related matters and shall be responsible for the following activities : • Document and maintain the Quality System • Ensure that products and services satisfy customer requirements including quality, safety, cost, schedule, performance, reliability, durability, accuracy, and maintainability • Witness tests • Ensure deliverable documents prepared

All personnel responsible for implementing this programme shall be fully trained in the interpretation of product assurance procedures and process control. Training programmes shall be developed, documented, implemented, and maintained for personnel who may have an effect upon, or who are responsible for reliability and quality.

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2.3 Performance Assurance Status Report

Reporting on the progress and status of product assurance related matters will form part of the project reporting procedure.

Reports will provide information on:

- Progress and accomplishments for each major product assurance task
- Current problems
- Status of materials and processes control programme
- Status list for major non-conformances
- Overview of major events in the forthcoming period
- Status of procurements and sub-contractor product assurance programmes

2.4 Audits

The University of Reading will conduct audits of their assurance activities and those of their sub-contractors and suppliers to ensure compliance with all provisions of this Quality Manual. To verify the effectiveness of the performance assurance systems, each audit shall include examination of facilities, operations and documents as well as examination of articles and materials.

A documented account of audits shall be provided to the customer's management of the audited organisation as necessary with recommendations for correction of any deficiencies. Management action shall be taken to ensure correction of the deficiencies, and reviews shall be conducted to ensure that the corrections are accomplished.

2.5 Assurance Review Requirements

The University of Reading will support design reviews that are conducted by the customer's project review team. The University of Reading shall also conduct reviews at the component and sub-system levels of all hardware in their area of responsibility in the project.

2.5.1 System Safety

System safety will be an agenda item for each review in which the University of Reading participates and as such shall serve to support the total system safety review program specified in section 3.21 - Safety.

2.5.2 Review Requirements

The University of Reading will conduct internal reviews at the component and sub-system level. The review shall evaluate the ability of the component or sub-system concept and design to successfully perform its function under operating and environmental conditions during both testing and flight.

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2.6 Performance Verification Requirements

A performance Verification Program will be conducted by the University of Reading to ensure the optical filters and coatings meet the specification requirements. This program shall consist of a series of functional and environmental tests, as specified herein, that simulate the environments encountered during handling, transportation and operation. All components destined for delivery to the customer shall undergo qualification testing to demonstrate compliance with the requirements of performance verification. All other components shall undergo acceptance testing in accordance with the requirements of performance verification unless specific modifications are permitted.

The performance verification program will commence with functional testing of the optical filters to verify compliance with the specification requirements, followed by environmental testing, supported by appropriate measurements to verify compliance.

Military specification MIL-F-48616 entitled "Filter (Coatings), Infrared Interference: General Specification For" (29 July 1977), establishes the general provisions of environmental testing requirements for infrared filters and coatings.

2.7 Configuration Control

A configuration control system will be employed by the University of Reading to control and monitor the status of all optical components and ensure all parties are informed of changes to specifications, designs, documentation etc.

The QA Officer shall be responsible for the planning and implementation of the University of Reading Configuration Control management. This will involve:

- Design and organisation of the Configuration Control system,
- Defining a documentation scheme for monitoring and controlling all aspects of the design, fabrication and testing of all optical components manufactured at the University of Reading,
- Assigning configuration identification numbers,
- Ensuring all in-house documentation is compatible and suitable for project traceability and requirements,
- Identifying release authorities for each document and/or process during each phase of component manufacture.

Detailed designs, drawings, specifications etc. will only be released to other organisations only after checking and approval by at least two members of the University of Reading team.

Changes to any previously defined specification, drawing, design etc. will be controlled by a Document/Engineering Change Request Report which shall contain the following details:

- Title of change
- Affected items
- Change classification (routine/urgent)

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- Documents affected
- Description of change
- Related factors (cost/schedule/performance/testing etc.)
- Justification for change
- Approval signatures
- Personnel to carry out change

A register of all the changes made to the program shall be maintained at the University of Reading after the final specification is frozen.

2.8 Design Assurance and Reliability Requirements

The following design assurance and reliability programme has been implemented by the University of Reading to ensure compliant design of optical filters with the customer's requirements.

2.8.1 Design Assurance

Designs shall be based on past experience and recommended practice. The designs shall be capable of:

- Functioning properly during the required mission lifetime
- Minimising or eliminating potential sources of human-induced failures
- Permitting ease of assembly, test, fault isolation, repair, servicing, and maintenance without compromising safety, reliability, quality, and performance

The QA Officer will ensure that:

- The quality, reliability, safety, and maintainability considerations are factored into the design
- The performance, safety, and interface characteristics that require verification by analysis, inspection, and test are identified and reflected in appropriate documentation
- All processes and operations in which consistent high quality cannot be assured by inspection alone are identified and controls are established to ensure hardware integrity

All detailed coating designs and manufacturing records will be retained at the University of Reading, but can be made available for review by the project/customer and/or their designates at the University of Reading in accordance with the standard University of Reading confidentially agreement.

2.8.2 Reliability

Infrared interference filters supplied by the University of Reading have been employed in many atmospheric research and weather forecasting satellite radiometer projects and planetary research probes to investigate the temperature and chemistry of atmospheres by remote sensing techniques. Projects to which the laboratory has supplied coatings include: NIMBUS 4,5,6,7, ITOS, TIROS-N, PIONEER (Venus), GALILEO (Jupiter), LDEF, UARS

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(ISAMS), ERS-1 & 2 (ATSR), MARS OBSERVER (PMIRR), CASSINI (Saturn), ENVISAT POEM-1 (MIPAS / AATSR), VHRR, EOS (HIRDLS).

Over the years, various tests have been performed to demonstrate spectral performance and mechanical reliability:

- Reliability against ionising radiation has been tested and confirmed for similar multilayer components as part of testing for TIROS-N satellite series (Marconi specification SP-0703-01 and SP-0700-00).
- Filter materials produced by the University of Reading have also under gone rigorous space testing with no deleterious effects on the NASA LDEF mission (1984-1990) at altitudes between 478km (257nmi) and 320km (179nmi) as defined in ISBN 07049 04098 "Space exposure of infrared filters and materials on the NASA Long Duration Exposure Facility".
- Reliability against electron irradiation of HIRDLS filters was carried out in a Van De Graaff Accelerator situated at the University of Reading, as described in "The Resistance of Infrared Multilayer Filters to High Energy Particle Irradiation".

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3 Product Quality System

A product quality system shall be implemented to ensure that the components supplied to the customer meet the specified requirements. This system will consist of a series of functionality and environmental tests, as specified herein, that simulate the environments encountered during handling, transportation and use of delivered components.

3.1 Contract Review

It is our policy to ensure that at the onset of manufacturing, there is a clear understanding of our customers' requirements contained in their contracts and/or purchase orders. The emphasis is on prevention of any potential issue or misunderstanding by their early identification and resolution.

A contract review procedure addresses the Commercial, International and Government business and requires that all contracts and purchase orders are reviewed prior to acceptance and until completion such that:

- Requirements are clearly defined, documented and understood;
- All requirements differing from those quoted are resolved and details recorded;
- The requirements are attainable;
- Customer "Flow-Down" requirements are properly administered;
- A contract Change Control Mechanism is established;
- Levels of authority for contract approval are established; and
- Records of all Contract Reviews are maintained.

Contract requirements are deployed through specifications, sales orders, manufacturing procedures and quality plans, as required by procedures of specific business lines.

3.2 Design Control

The University of Reading controls and verifies product design to ensure that specified customer requirements are met. This includes ensuring that:

- Service or product design documentation agrees with customer documentation,
- Designs are planned, controlled, verified, and validated,
- Requirements for design are documented,
- Design reviews are held as appropriate, and
- Design changes are made in accordance with documented procedures.

Qualified personnel equipped with adequate resources define responsibilities for design and development activities. These personnel also plan and execute the activities. A plan for each design and development project is required. Each plan will address, as appropriate:

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- Organisational and technical interfaces between groups that provide input to the design and development processes,
- Required design inputs and how they are identified, documented, and reviewed for adequacy,
- Required design outputs and how they are reviewed and approved prior to implementation,
- Required design reviews and resulting Quality Records,
- Required design verification approaches and resulting Quality Records,
- Required design validation approaches, and
- The method for review and approval of design changes and modifications prior to implementation.

The QA Manager shall ensure that appropriate design review and design verification and validation plans are implemented for all tasks.

3.3 Document and Data Control

The University of Reading will ensure that current Quality System documentation is readily available to University of Reading personnel via the Laboratory QA system. This system ensures that all Quality System documentation are reviewed and approved prior to their initial release and any subsequent modifications. Obsolete or invalid Quality System documents and data are retained but properly marked.

The QA Officer shall maintain document control procedures for Quality System documents, Quality System data, and applicable external documentation.

The QA Officer shall process, control, and co-ordinate the creation revision of the Quality Manual and the Laboratory System Level Procedures. This includes tracking, status, maintenance, and distribution of information relating to these documents.

3.4 Purchasing

The University of Reading controls the purchase of materials, products, and services incorporated into products delivered to its customers. The University of Reading ensures that all purchasing documents describe the product or service to be delivered. The University of Reading reviews and approves purchasing documents for completeness of specified requirements prior to release. This ensures that purchased materials, products, and services are verified (inspected and accepted) against documented and specified requirements.

The University of Reading evaluates and selects vendors based on their ability to deliver products that meet specified requirements. Records of acceptable vendor performance are maintained as Quality Records.

When the University of Reading decides to inspect and/or accept a purchased product at the vendor's facility, the purchasing document will specify inspection and/or acceptance arrangements and the method delivery.

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The Purchase Request Originator shall define the specifications for purchased goods and services and verify that received goods and services conform to those specifications.

Raw materials purchased by the University of Reading shall be accompanied by the traceability of results from any spectral and/or physical tests performed on the lots of material delivered. When raw material is purchased, the suppliers will furnish specimens for chemical and physical tests, if required, in the event that the materials are later used for critical design applications.

3.5 Control of Sub-contractor and Supplier Products

Manufacturers and suppliers shall be selected for their proven ability to supply materials and component parts to the required specifications together with the documentation to verify that the requirements of the procurement specifications have been met.

Only contractors with assessed capability with regard to quality control and traceability shall be used for manufacturing or carrying out processes.

Contracts, purchase orders etc. shall include a statement indicating the requirement for quality control and traceability to the appropriate standard. Conformance documentation shall be requested and act as a point of entry into the manufacturer's traceability system. If a contractor procures materials it shall be stated in the contract that only "released" materials shall be used and obtained from approved stockists.

The QA Officer or appointed deputy will ensure proper witnessing of critical processes, inspections and tests and will ensure that appropriate documentation is produced.

3.6 Sub-contractor and Supplier Surveillance

Where sub-contractors are employed to provide services or deliverables the product assurance requirements listed within this plan will be imposed on those sub-contractors appropriate to the criticality of the services or products being provided.

Surveillance of QA activities will be carried out by the QA Officer or delegated deputy who will ensure that appropriate inspections, tests and documentation are specified and completed. Sub-contractors shall be assessed on the basis of their product assurance system in addition to their technical capability.

3.7 Incoming Acceptance Tests

Incoming inspections on items procured from outside sources will be performed to check compliance with applicable requirements by one or a combination of the following activities, depending on the criticality of specific parameters for the application of the item and the quality assurance provision already carried out by or with the supplier.

- Review of the Certificate of Conformance and of deliverable documentation with inspection / test results
- Visual inspections for completeness and freedom from obvious damage or deficiencies

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- Sample testing or testing on all items for compliance to the most essential parameters

3.8 Product Identification and Traceability

The University of Reading has developed component identification and tracking system by which each component is identified by a unique identification code. Using this identification code, it is possible to retrieve all quality control records at each stage of the manufacturing and testing of the component from incoming inspection to component release. Identification codes must accompany all components at all stages of manufacture and testing.

It the responsibility of the QA Officer to ensure that appropriate product identification and traceability activities are performed throughout the product's life cycle in accordance with documented procedures.

3.9 Process Control

The University of Reading has produced a Laboratory Manual (PA-RDU-398), detailing the manufacturing process control procedures and plans for the following operations:

- Design
- Manufacture
- Measurement and Testing
- Parts and Materials Control
- Health and Safety
- Computing (Information Technology)
- Administration

These plans and procedures will not be issued to the customer but will be available for inspection by the customer and/or their designates at University of Reading.

The University of Reading product assurance personnel shall ensure that manufacturing operations are in compliance with current controlling documents.

3.10 Design

All detailed filter designs and manufacturing specification records will be retained at the University of Reading. Filter designs will not be issued to the customer but will be available for inspection by the customer and/or their designates at University of Reading.

3.11 Manufacture

At the University of Reading we have three Balzer 510 deposition plants which are fitted with chamber furniture especially designed to manufacture the precision infrared filters your specification requires. The layer thickness of the filters is measured during deposition by an optical monitoring method; temperature control of the filter substrates during deposition is achieved by thermally clamping them into the coating jig which in turn is clamped to a temperature controlled heater. The filters are deposited at an elevated

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temperature resulting in hard adherent coatings that are capable of meeting the general provisions of MIL-F-48616.

Selection of materials and processes used in the fabrication of infrared coated optics is based on past experience and performance. These components are considered to be of a conventional nature.

For engineering models, components shall be used which are equivalent in form, function, materials and with the capability of operating in the thermal and vibration environment of the qualification test programme but otherwise may be of agreed lower quality.

3.12 Inspection and Testing

The University of Reading ensures that inspection and testing activities prove that product requirements are met consistently.

Inspection and testing occurs throughout the product's life cycle as required by a customer agreement or project plan. Review and approval procedures ensure that the product or its components meet requirements at each stage of development.

The University of Reading demonstrates final product inspection and testing in accordance with documented procedures. Products are inspected and tested per customer requirements before release and are released to the customer when they either meet documented acceptance criteria or when acceptance criteria are otherwise waived. Records of product authorised for urgent release prior to verification are maintained as Quality Records.

Inspection and test records provide evidence of the test and/or inspection, detail the results of the test and/or inspection, and identify the Inspection Authority responsible for product release. These records will be maintained as Quality Control Records.

3.12.1 Spectral Testing

Spectral testing of the qualification and test components will involve room temperature and cryogenic transmission measurements as well as room temperature reflection measurements.

Measurements will be performed on two spectrophotometers:

- PerkinElmer spectrum 2000 Optica Fourier Transform Spectrophotometer. The spectrophotometer has a wavelength range between 7000cm^{-1} (1.4µm) and 30cm^{-1} (333µm) and a maximum resolution of 0.2 cm^{-1}.

- Hitachi U-3400 short wavelength (UV-VIS-NIR) spectrophotometer will be used to measure over the wavelength range from 190 to 2600nm to establish short wavelength blocking performance.

Low temperature transmission measurements will be performed using an Oxford Instruments Optistat Bath Cryostat fitted with KRS-5 windows placed in the sample compartment. The Cryostat contains a 2.5 litre liquid helium reservoir, a liquid nitrogen reservoir and a 49mm sample space known as a variable temperature insert (VTI). Liquid helium is supplied from the reservoir to the VTI through a needle valve, allowing the flow to be optimised to suit the operating requirements. The Optistat Bath Cryostat has a temperature range of 4K (-269°C) to 450K (+177°C).

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All spectral tests performed are recorded in the Laboratory Database. This includes set-up conditions, test description and results. Each spectral measurement set is assigned a unique process identification number.

Specific details of spectral testing procedures are documented in the Laboratory Manual (PA-RDU-398).

3.12.2 Environmental Testing

Environmental testing of the qualification and test components will involve humidity, thermal cycling, moderate abrasion and adhesion testing.

Environmental testing will be performed according to the general provisions of MIL-F-48616 military specification or agreed testing requirements described in the customer's specification.

- Military Specification: "*Filter (Coatings), Infrared Interference: General Specification For*", MIL-F-48616; Section 3.4.2 - Surface Durability (coating and substrate).

All Qualification and Test samples environmentally tested will be stored at the University of Reading, unless otherwise required by the customer/project.

All environmental tests performed are recorded in the Laboratory Database. This includes set-up conditions, test description and results. Each environmental test set is assigned a unique process identification number.

Specific details of environmental testing procedures are documented in the Laboratory Manual (PA-RDU-398).

3.12.3 Physical Testing

Physical testing of the qualification and test components will involve dimensional, flatness and surface quality testing.

Dimensional and Flatness testing will be performed according to the agreed testing requirements described in the customer's specification.

Surface quality testing will be performed according to the general provisions of MIL-F-48616 military specification.

- Military Specification: "*Filter (Coatings), Infrared Interference: General Specification For*", MIL-F-48616; Section 3.4.1 - Surface Quality.

All dimensional tests performed are recorded in the Laboratory Database. This includes set-up conditions, test description and results. Each dimensional test set is assigned a unique process identification number.

Specific details of environmental testing procedures are documented in the Laboratory Manual (PA-RDU-398).

3.12.4 Life Test

Coated components shall be subjected to life testing in accordance with the customer's specification. The life-test procedure will be to expose test samples to controlled conditions as specified by the customer. Spectral measurements and visual inspections from these samples at regular intervals and will be compared with control samples stored under a continuously room temperature / desiccated environment. All samples subjected to the life test will be retained at the University of Reading.

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3.13 Control of Inspection, Measuring, and Test Equipment and Software

The University of Reading will ensure that the measurement standards and equipment meet the requirements for the inspections and tests to be performed.

Inspection, test, gauging, measurement equipment and software will be checked for accuracy and reproducibility with appropriate standards traceable to national standards prior to use.

3.13.1 Inspection, Measuring, and Test Equipment

Instruments, tools, gauges and jigs used to measure optical filter performance and dimensions will be checked for accuracy prior to use using standards traceable to national calibration standards.

3.13.2 Software

Software used in the design, manufacture and testing of all optical components will be will be checked for accuracy prior to use.

3.14 Inspection and Test Status

The University of Reading ensures that only materials and products that have passed required inspections and tests are released. Documented procedures specify that the inspection and test status of materials and products is identified during receipt and throughout the material or product life cycle. The material or product status indicates conformance or non-conformance to inspection and test procedures.

The QA Manager shall ensure that the method for identifying inspection and test status as identified in a customer agreement, project plan, or other documented procedure is implemented effectively.

3.15 Non-conformance Control

The University of Reading shall operate a closed-loop non-conformance control system for failures and discrepancies. When a non-conformance or failure is detected during fabrication, inspection, testing or during any other activity it shall be recorded on a suitable form and a disposition made with respect to : stopping or continuing of ongoing activities, use-as-is, rework to original requirements, scrapping of defective items or other appropriate dispositions to be determined by a Material Review Board (MRB).

Non-conformances shall be listed in the NCR register within the Laboratory Quality Control Database, each occurrence being assigned a unique and sequential number. The NCR register of major non-conformances and waivers with current status and copies of non-conformance reports and waiver reports shall be supplied with the delivery documentation.

Non-conforming components submitted for re-work shall be returned using established practices and documents and shall subsequently be re-submitted to the normal sequence of inspections and tests.

3.15.1 Materials Review Board (MRB)

The Material Review Board shall consist at least of one representative of the Product Assurance Organisation and one representative of the Engineering

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Organisation. Specialists may be invited and consulted and representatives of other organisations may also participate in the MRB.

The MRB shall determine:

a. The cause of the discrepancy, with the help of experts or outside organisations,

b. The disposition with corrective and preventive actions including :

- "Scrap"
- "Use-As-Is"

  If a formal specification requirement remains violated, preparation and acceptance of a Request for Waiver or a Specification Change can be recommended.

- "Repair / Rework"
- "Change / Modify The Design"

  Subject to satisfactory Engineering Change request approval.

c. Re-verification to be performed after repair or modification which may consist of re-inspection, re-test and updating of previously established design analyses.

The cause of the discrepancy and the dispositions and actions agreed by the MRB are to be documented on the Non-conformance Report or in associated MRB minutes. Quality Assurance personnel shall verify the completion of all actions and re-verification defined by the MRB and when that has been achieved successfully, the NCR can be "closed out" with reference to re-verification reports or updated documents and QA-signature on the NCR form.

3.15.2 Classification

Non-conformance shall be classified as Major or Minor. The definition of Major and Minor is as follows:

Major Non-conformances are non-conformances, or failures, which may affect:

- Approved design requirements with respect to form, fit, function,
- performance, materials and safety as specified in applicable design
- requirement specifications.
- Approved test requirements and procedures
- Approved Interface Control Documents.

A minor non-conformance is a non-conformance which does not affect any aspect in the definition of the major non-conformance. A minor non-conformance is inconsequential as regards the requirements and does not influence fitness-for-use and safety, or is trivial with regard to workmanship criteria applicable to deliverable items.

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3.16 Corrective and Preventive Action

The University of Reading emphasises the use of problem prevention or problem correction to determine the potential cause or actual cause of non-conformances (including customer complaints, non-conforming products, and non-conforming processes) and prevent their occurrence or recurrence.

The University of Reading investigates the causes of non-conformances relating to the Quality System, including Quality System products and processes. The results of these investigations are maintained as Quality Records. Investigations resulting in changes to documented procedures are processed in accordance with the document and data control system or the configuration management control system.

Preventive and corrective action is taken to eliminate potential or existing non-conformances and to eliminate or minimise the impact on safety, performance, dependability, processing cost, quality-related cost, and customer satisfaction.

The QA Manager shall ensure that requirements contained in documented procedures that implement this policy are communicated and followed by the individuals responsible for implementing the process.

The QA Manager shall collect, process, track, analyse, and report on corrective and preventive action requests.

3.17 Handling, Storage, Packaging, Marking, Labelling, Transportation and Delivery

A Handling, Storage, Packaging, Marking, Labelling, Transportation and Delivery procedure will be implemented by the University of Reading to ensure that all materials and components are treated in a consistent manner.

3.17.1 Handling

A detailed handling, cleaning and identification notice will be issued to the customer with each set of delivered components. Contained within this notice will be details on the unique identification code used to identify each component, any tools that may be required to handle or manipulate to component and solvents and temperatures to which the components can be exposed.

All packaged or bagged items will be clearly marked or labelled to identify the item and specify the environment and conditions required when the package is opened.

3.17.2 Storing, Marking, Labelling

All components will be labelled, packaged and stored during all phases of the programme in such a way as to prevent loss of marking, deterioration, contamination or damage. All optical components and materials will be identified by a unique identification number which will accompany it at all times.

The University of Reading quality assurance personnel will ensure that all stored components and materials will be periodically inspected and tested, where necessary, for the correct storage environment and packaging to prevent deterioration or damage.

Optical components will normally be stored at temperatures between 10 and 30 degrees centigrade and at relative humidities below 65%. Randomly selected

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stored components and materials will be visually and spectroscopically tested at regular intervals to ensure no deterioration or physical damage has occurred during storage.

3.17.3 Transportation

Transport containers will be used to protect the components and their packaging in transit. Prior to transportation from the University of Reading to the customer/project, quality assurance personnel will ensure that:

1. All manufacturing, inspection, testing and verification operations have been completed satisfactorily.
2. All components are identified and marked according to the requirements
3. All accompanying documentation has been reviewed for completeness, identification and quality approvals.
4. Evidence that all packaging is compliant with requirements.
5. Loading and transporting methods are in compliance with those designated in the transport documents.

Special handling instructions for receiving activities, including inspection and recording requirements are provided where appropriate.

3.17.4 Delivery

A quality assurance document set will accompany all components upon the completion of manufacture of a project or project sub-set. The quality assurance document set will:

- describe the contents of the delivery package,
- provide a summary of the work completed,
- provide certificate of conformance reports for any testing required,
- provide full spectral data for the delivered components plus any associated witness pieces,
- any other reports or documentation applicable to the particular customer/project.

The quality assurance document set will take the form of both a hard-copy (paper version) and a soft-copy (electronic version). The electronic version will be stored on a secure section of the Infrared Multilayer Laboratory website. Usernames and passwords will be issued to designated personnel only.

Both the paper and electronic versions of the quality assurance document set are automatically generated from the data obtained in the laboratory quality control database.

Master copies of all documents will be retained at the University of Reading.

3.18 Control of Quality Records

The University of Reading will maintain Quality Control records as objective evidence that demonstrates conformance to the customer's requirements.

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To this end the University of Reading has designed and implemented a comprehensive Quality Control database system. Using a system of unique serial numbers and identifiers, it is possible to provide full traceability of all parts, processes and materials within the laboratory.

Internal manufacturing records will not be delivered to the customer / project.

3.19 Internal Quality Audits

The University of Reading shall conduct internal quality audits to determine the status and effectiveness of the Quality System. Internal audit results will be documented and brought to the attention of the QA Manager. The University of Reading will ensure that timely corrective action is taken on non-conformances found during an internal audit. This includes verifying the implementation and effectiveness of corrective action and recording it as a Quality Record.

The University of Reading uses the results of internal audits to improve the effectiveness of the Quality System. This is accomplished by implementing corrective actions, improving documented procedures, or utilising a combination of the previous two items.

The University of Reading requires scheduling of internal quality audits based on the status and importance of the activity to be audited. Personnel independent of the activity being audited execute these audits.

The QA Manager shall develop an audit schedule and obtain approval from the QA Officer. The QA Manager shall ensure that audits are performed in accordance with the schedule and documented procedures.

The QA Manager shall inform personnel of audit time and scope, assign a guide to accompany audit personnel, provide necessary access for audit personnel, and take timely corrective action regarding deficiencies found during the audit.

3.20 Training

The University of Reading will ensure that personnel have the training needed to do their jobs safely and effectively and to produce quality products. The University of Reading views training and developing personnel as an essential management responsibility that is vital to meeting the Laboratories missions and future requirements. The University of Reading is therefore committed to providing relevant training and development opportunities to optimise personnel effectiveness in an environment of changing programs, technologies, and mission requirements. Records of training are maintained as Quality Records.

The QA Manager together with the QA Officer shall identify personnel training requirements, ensure all personnel receive required training, and maintain appropriate records.

3.21 Safety

The University of Reading has developed a safety program for infrared optical filters and coatings as defined in the Laboratory Manual (PA-RDU-398). This involves identification and control of any hazards to personnel, facilities and equipment during all stages manufacturing, testing and delivery.

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3.21.1 Safety Implementation Plan (SIP)

A safety implementation plan is prepared by the University of Reading (PA-RDU-398), describes the safety requirements in control of hazards to personnel and hardware during fabrication, testing and transportation.

The plan addresses safety issues associated with: responsibilities, laboratory safety, safety during manufacturing, safety review processes, accident investigation and reporting and operator training.

The safety implementation plan is written in accordance with the University of Reading, Department of Cybernetics, Area Safety Code Handbook - November 1996.

3.21.2 Hazard Analyses

Identifying potential hazards affecting personnel or components forms part of the safety implementation plan (PA-RDU-398). A hazard report will be generated for the hazards identified and will document causes and controls for the hazards. Measures to eliminate or minimise the effects of hazards will be taken and reported where necessary.

3.21.3 Safety Compliance Data Package

A safety compliance data package describing safety issues appropriate to the delivery of optical filters to the customer will be submitted with the quality assurance data at the time of delivery (where appropriate).

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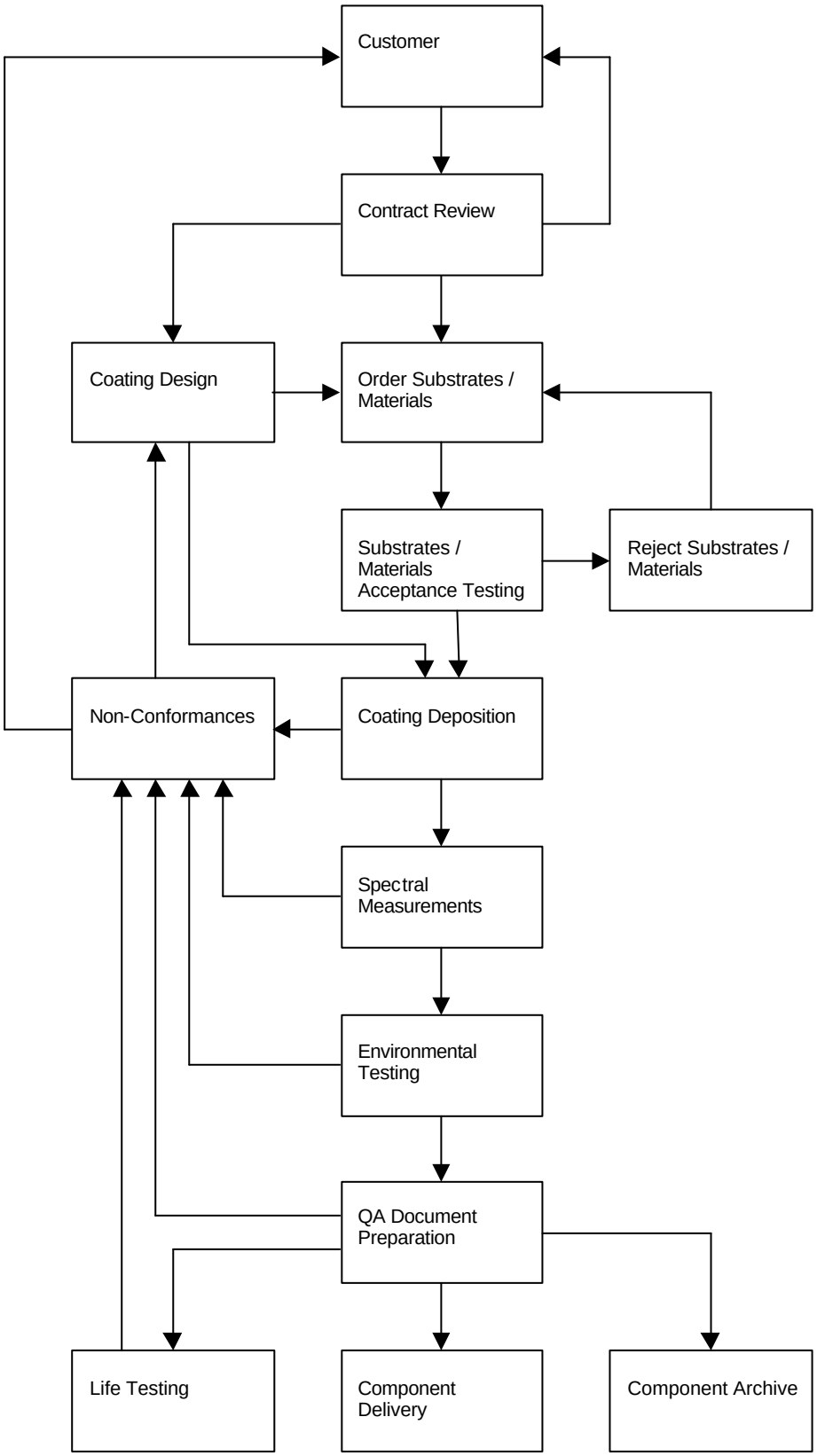
Appendix A - Design, Manufacture and Test Flow Plan



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Appendix B - Publications

J W Bowen, P Edwards, G J Hawkins : "*Filters for Astronomy and Atmospheric Sciences in the 15-40µm Range*", 28th International Conference on Infrared and Millimetre Waves, Otsu, Japan, Sep 29 - Oct 3, 2003, pp. 117-11 (2004)

G J Hawkins, R Hunneman : "*The temperature dependent spectral properties of filter substrate materials in the far-infrared (6-40µm)*", Infrared Physics & Technology, Vol 45, Pages 69-79 (2003)

G J Hawkins, R Hunneman, R Sherwood, B M Barrett : "*Interference Filters and Coatings for Mid-Infrared Astronomy (8-30µm)*", SPIE Astronomical Telescopes and Instrumentation, Specialized Optical Developments in Astronomy, 4842-06 (2002)

G J Hawkins, R Hunneman, R Sherwood, B M Barrett : "*Infrared Filters and Coatings for the High Resolution Dynamics Limb Sounder (6-18µm)*", Applied Optics, Vol 39, No 28, pp 5221-5230 (2000)

G J Hawkins, R Hunneman : "*A Spectral Performance Model for the High Resoluti on Dynamics Limb Sounder (6-18µm)*", Infrared Physics and Technology, Vol 41, Issue 4, Pages 239-246 (2000)

G J Hawkins : "*Spectral Characterisation of Infrared Optical Materials and Filters*", PhD Thesis - The University of Reading, Department of Cybernetics (1998)

G J Hawkins, R Hunneman, M T Gardner, G T Babcock : "*An ultra-wide passband (5-30µm) filter for FTIR studies of Photosystem II*", Infrared Physics and Technology, Vol 39, Issue 5, Pages 297-306 (1998)

G J Hawkins, R Hunneman, J J Barnett, J G Whitney : "*Spectral design and verification of HIRDLS filters and antireflection coatings using an integrated system performance approach*", SPIE Proceedings, 3437, Pages 102-112 (1998)

R Hunneman, G J Hawkins : "*The manufacture and spectral assessment of the filters and antireflection coatings for use in the HIRDLS instrument*", SPIE Proceedings, 3437, Pages 378-390 (1998)

R Hunneman, R Sherwood, C Deeley, R Spragg : "*Achieving Accurate Ftir Measurements On High Performance Bandpass Filters*", CP430, Pages 435-438, ICOFTS-11, the Eleventh International Conference on Fourier Transform Spectroscopy, USA (1997)

R Hunneman, G J Hawkins : "*Infrared filters and dichroics for the Advanced Along Track Scanning Radiometer (AATSR)*", Applied Optics, Vol 35, No 28, Pages 5524-5528 (1996)

R Hunneman, G J Hawkins : "*Novel material combinations for enhanced infrared filter performance*", Applied Optics and Optoelectronics Conference, ISBN 07503 03824, Pages 188-193 (1996)

C Cole : "*Broadband Antireflection Coatings for Spaceflight Optics*", PhD Thesis - The University of Reading, Department of Cybernetics (1995)

C Cole, J W Bowen : "*Synthesis Method for Visible and Infrared Broadband Spaceflight Antireflection Coatings*", OSA Technical Digest Optical Interference Coatings, Vol 17, Pages 58-60 (1995)

C Cole, R Hunneman, W S Carter : "*Comparative Study of Barium Fluoride Thin Films Produced by Ion-Beam Sputtering and Thermal Evaporation*", IOP Conference on Applied Optics and Opto-Electronics, York, UK (1994)

G J Hawkins, R Hunneman : "*Design and Fabrication of Infrared Filters for Remote Sounding Instrumentation*", SPIE Proceedings, 2210, Pages 639-651 (1994)

R Hunneman, J J Barnett, G J Hawkins : "*High-Performance Infrared Filters for the HIRDLS 21-Channel Focal Plane Detector Array*", SPIE Proceedings, 2210-49, Pages 516-532 (1994)

G J Hawkins, R Hunneman, C Cole : "*Infrared filters for space-flight focal plane array applications*", SPIE Proceedings, 2253, Pages 333-347 (1994)

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C Cole, J W Bowen : "*Synthesis of Broadband Anti-reflection Coatings for Spaceflight Infrared Optics*", Proc. International Symposium on Space Optics: Space Instrumentation and Spacecraft Optics, Garmisch-Partenkirchen, Germany, SPIE, 2210-48, 506-515 (1994)

C Cole, R Hunneman, J W Bowen : "*Synthesis of infrared filters for use in spaceflight systems*", Proc. International Symposium on Optical Interference Coatings, Grenoble, France, SPIE, 2253-05, 42-50 (1994)

A M Zheng, J S Seeley, R Hunneman, G J Hawkins : "*Ultra Narrow Filters with Good Performance when Tilted and Cooled*", Applied Optics, Vol 31, No 22 (1992)

A M Zheng, J S Seeley, R Hunneman, G J Hawkins : "*Design of narrowband filters in the infrared region*", Infrared Physics, Vol 31, Issue 3, Pages 237-244 (1991)

G J Hawkins, R Hunneman, J S Seeley : "*Exposure to Space Radiation of High Performance Infrared Multilayer Filters and Materials Technology Experiment*", NASA Proceedings, First Post-Retrieval Symposium, Conference Publication, 3134, Pages 1479-1492 (1991)

J S Seeley : "*Far-IR multilayer filter design: manufacture and application in remote sensing*", SPIE Proceedings, CR39 (1991)

G J Hawkins, R Hunneman, J S Seeley : "*Space Exposure of Infrared Filters and Materials on the NASA Long Duration Exposure Facility (LDEF)*", University of Reading, ISBN 07049 04098 (1991)

K Q Zhang, R Hunneman, J S Seeley, G J Hawkins : "*Investigation of ultra wideband multi-channel dichroic beamsplitters from 0.3 to 52µm*", Infrared Physics, Vol 30, Issue 1, Pages 45-53 (1990)

G J Hawkins, R Hunneman, J S Seeley : "*Preliminary results from the Infrared Multilayer Filters and Materials exposed to the space environment on the NASA LDEF mission*", SPIE Proceedings, 1320, Pages 407-419 (1990)

J S Seeley, R Hunneman, G J Hawkins : "*System performance in IR atmospheric radiometry*", SPIE Proceedings, 1270, Pages 244-249 (1990)

K Q Zhang, R Hunneman, J S Seeley, G J Hawkins : "*Optical and semi-conductor properties of Lead Telluride coatings*", SPIE Proceedings, 1125, Pages 45-52 (1989)

J S Seeley, G J Hawkins, R Hunneman : "*Performance model for cooled IR filters*", Journal of Physics D. 21, S71-S74 (1988)

G J Hawkins, J S Seeley, R Hunneman : "*Spectral characterisation of cooled filters for remote sensing*", SPIE Proceedings, 915, Pages 71-78 (1988)

G J Hawkins, R Hunneman, J S Seeley : "*Design and disposition of infrared optical multilayer coatings for the Improved Stratospheric and Mesospheric Sounder (ISAMS)*", SPIE Proceedings, 868 (1987)

S Y Wu : "*Design and Manufacture of Infra-Red Bandpass Filter*", PhD Thesis - The University of Reading, Department of Cybernetics (1986)

J S Seeley : "*Optical thin films*", Pergamon Press, Encyclopedia of Materials Science and Engineering, Pages 3322-3323 (1986)

Y K Lim, J S Seeley : "*Systems analysis of absorbing media*", SPIE Proceedings, 652, Pages 83-94 (1986)

S Y Wu, J S Seeley : "*Tschebyshev optical filter design*", SPIE Proceedings, 652, Pages 57-63 (1986)

J S Seeley, R Hunneman, A Whatley : "*Physical effects in IR-coating materials*", SPIE Proceedings, 588, Pages 96-102 (1985)

Y K Lim : "*Computer Aided Design and Manufacture of Optical Multilayer Filters*", PhD Thesis - The University of Reading, Department of Cybernetics (1985)

J S Seeley, Y K Lim, S Y Wu : "*New algorithms for synthesized design of optical filters*", Applied Optics, Vol 24, No 6, Pages 875-878 (1985)

J S Seeley : "*Simple nonpolarizing high pass filter*", Applied Optics, Vol 24, No 6, Pages 742-744 (1985)

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Website : http://www.cyber.rdg.ac.uk/irfilters/

J S Seeley, R Hunneman, A Whatley : "*Exposure to space radiation of high-performance infrared multilayer-filters and materials technology experiments*", in `Long Duration Exposure Facility (LDEF) Mission 1 Experiments', NASA SP, 475, Pages 154-157 (1984)

R Hunneman, J S Seeley, A Whatley : "*Durability assessment of PbTe/II-IV infrared filters (Space Shuttle 1st LDEF)*", SPIE Proceedings, 401, Pages 55-59 (1983)

M Nixon : "*The Application of a Kalman Filter to Improve the Optical Monitoring System of a Vacuum Deposition Process*", PhD Thesis - The University of Reading, Department of Cybernetics (1983)

M Nixon, J S Seeley : "*Digital signal processing of optical monitoring by means of a Kalman filter*", SPIE Proceedings, 401, Pages 93-99 (1983)

J S Seeley : "*Synthesised design of optical filters assisted by microcomputer*", SPIE Proceedings, 369, Pages 118-129 (1983)

J S Seeley, R Hunneman, A Whatley : "*Measurement of infrared multilayer filters at temperatures down to 4 deg K*", SPIE Proceedings, 325, Pages 180-183 (1982)

J S Seeley, R Hunneman, A Whatley : "*Far infrared filters for the GALILEO-Jupiter and other missions*", Applied Optics, Vol 20, No 1, Pages 31-39 (1981)

J S Seeley, R Hunneman, A Whatley : "*Cooled filters 16-42µm for FIR astronomy*", SPIE Proceedings, 253, Pages 266-273 (1980)

J S Seeley, R Hunneman, A Whatley : "*Infrared absorption bands in multilayer thick films of some II/VI , IV/VI materials*", Nat. Bur. Stds. Spec. Publ. 574 : U.S. Govt. Printing Office, Pages 118-122 (1980)

J S Seeley, R Hunneman, A Whatley : "*Temperature-invariant and other narrow-band IR filters containing PbTe, 4-20µm*", SPIE Proceedings, 246, Pages 83-94 (1980)

J S Seeley, R Hunneman, A Whatley : "*Infrared Multilayer interference filter manufacture: supposed longwave limit*", Applied Optics, Vol 18, No 20, Pages 3368-3370 (1979)

J S Seeley, R Hunneman, A Whatley : "*Infrared partial mirror effective from 1.3 to 16 µm*", Applied Optics, Vol 18, No 20, Pages 3370-3371 (1979)

J S Seeley, R Hunneman, A Whatley : "*Spectrophotometer-Type Filters of the Highest Possible Performance, 2.5-40µm*", Infrared Physics, Vol 19, Pages 429-435 (1979)

C S Evans, R Hunneman, J S Seeley : "*Filters for the (2 band of CO2 : monitoring and control of layer deposition*", Applied Optics, Vol 15, No 11, Pages 2736-2745 (1976)

C S Evans, R Hunneman, J S Seeley : "*High performance multilayer interference filters for the region 12-50µm*", Journal of Physics D, Vol 9, Pages 309-320 (1976)

C S Evans, R Hunneman, J S Seeley : "*Increments at the interface between layers during infrared filter manufacture*", Opt. Act. Vol 23, No 4, Pages 297-303 (1976)

C S Evans, R Hunneman, J S Seeley : "*Optical thickness changes in freshly deposited layers of Lead Telluride*", Journal of Physics D, Vol 9, Pages 321-328 (1976)

J S Seeley, H M Liddell, T C Chen : "*Extraction of Tschebysheff design data for the low pass dielectric multilayer*", Opt. Act. Vol 20, No 8, Pages 641-661 (1973)

J S Seeley, C S Evans, R Hunneman : "*Deposition parameters of PbTe films in relation to infrared multilayer filters*", Journal of Vacuum Science and Technology, Vol 9, Page 397 (1972)

J S Seeley, C S Evans, R Hunneman : "*Improvements relating to the manufacture of coated substrates*", British Patent No. 1,425,941 (1972)

S D Smith, G D Holah, J S Seeley, C S Evans, R Hunneman : "*Survey of the present state of art of infrared filters*", in 'IR Detection Techniques for Space Research' (Edited: Ring and Manno), Reidel-Dordrecht-Holland, Pages 199-218 (1972)

C S Evans, R Hunneman, J S Seeley : "*New coatings and materials for the region 4-40µm*", Proceedings, Institution of Electronic and Radio Engineers, Conference 22, Pages 125-140 (1971)

C S Evans : "*Properties of Evaporated Films of Lead Telluride and their Application to Infra-Red Multilayer Filters*", PhD Thesis - The University of Reading, Department of Cybernetics (1970)

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J S Seeley, C S Evans, R Hunneman : "*Improvements in or relating to the manufacture of multilayer interference filters*", British Patent No. 1,285,567 (1969)

C S Evans, J S Seeley : "*Properties of thick evaporated layers of PbTe*", Journal de Physique, Colloque C4 No, 11-12, Pages C4-37 (1968)

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