Optical Technology Division: Low Background Infrared Calibration Facility Quality Manual

1. Scope

The NIST Quality System for the Low Background Infrared Calibration Facility is organized into three levels of manuals. The first level, NIST Quality Manual for Measurement Services QM – 1 (NIST QM-1) contains NIST-wide policies and procedures stemming from the executive leadership of NIST. The second level, Optical Technology Division Quality Manual, (Div844QM2), contains the policies and procedures established and maintained by Division 844, the Physics Laboratory's Optical Technology Division (OTD), to meet their technical needs. NIST-QM-1 is explicitly referenced in document Div844QM2. This quality manual, Optical Technology Division: Low Background Infrared Calibration Facility Quality Manual, (Div844QM3-LBIR), is for the Low Background Infrared Calibration Facility calibration services and is the third level. This document contains the quality-specific policies and procedures for activities such as acquisition of materials and supporting services; technical procedures for calibrations; staff qualifications, responsibilities, and training; handling and storage of calibration items; quality assurance procedures; creation, storage, and control of technical records of all types; and document development and control relevant to the Low Background Infrared quality system. These Low Background Infrared Calibration Facility services include:

1. LBIR-1 Calibration of Cryogenic Blackbodies,
2. LBIR-2 Characterization of Radiometers,
3. LBIR-3 Characterization of Detectors, and
4. LBIR-4 Special Tests at Off-Site Locations.

LBIR Project Leader Review:	Date:

Technical Manager Approval:	Date:

2. References

1. NIST Quality Manual for Measurement Services QM – 1 http://physics.nist.gov/Divisions/Div846/QualMan/QM1/nist-QM1.pdf

2. Optical Technology Division Quality Manual (Div844QM2 - For Division Internal use only- Latest update with the Division Quality Manager)

3. D. Sears, T. Marsh, T. M. Jung, A. Smith, J. Fedchak, J. Proctor and A.C. Carter, LBIR Facility Manual, 2006.

4. R. U. Datla, M. C. Croarkin, and A. C. Parr, Cryogenic Blackbody Calibrations at the National Institute of Standards and Technology Low Background Infrared Calibration Facility, Journal of Research of the National Institute of Standards and Technology, Volume 99, Number 1, January – February, 1994, p 77-86.

5. C. A. Morgan, T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, An Expanded Broadband Calibration Capability at the NIST LBIR Facility, Proceedings of SPIE Vol 3361, Thermosense XX, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona; Robert E. Sampson, I Technology Applications, April 1998

6. R. U. Datla, K. Stock, A. C. Parr, C. C. Hoyt, P. J. Miller, and P. V. Foukal, Characterization of an absolute cryogenic radiometer as a standard detector for radiant-power Measurements. Applied Optics, Vol. 31, No. 34, 1 December 1992, p. 7219-7225.

7. R. U. Datla, S. C. Ebner, J. Proctor, A. C. Parr, LBIR Facility User Handbook, National Institute of Standards and Technology Handbook 147, June 1991, 26 pages.

8. A. C. Carter, S. R. Lorentz, T. M. Jung, B. J. Klemme, R. U. Datla, NIST facility for spectral calibration of detectors: calibration of arsenic-doped silicon-blocked impurity band detectors, Proc. SPIE Vol 4028, p. 420-425, Infrared Detectors and Focal Plane Arrays VI, E. L. Dereniak and R. E. Sampson, Eds, July 2000

9. T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, NIST-BMDO Transfer Radiometer (BXR), Infrared Detectors and Focal Plane Arrays VI, Proceedings of SPIE Vol. 4028 99, 2000.

10. B. N. Taylor, *Guide for the Use of the International System of Units (SI)*, NIST Special Publication 811 (1995). (http://physics.nist.gov/cuu/pdf/sp811.pdf)

11. B. N. Taylor and C. E. Kuyatt, Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297 (1994). (http://physics.nist.gov/cuu/pdf/tn1297.pdf)

3. Definitions

The following definitions are unique to the NIST Low Background Infrared (LBIR) Calibration Facility Quality System.

a. LBIR Technical Manager - The Group Leader to which the LBIR Facility is assigned. The LBIR Technical Manager provides technical and managerial direction, and makes all the budgetary decisions for the maintenance and improvement of the facility to meet the needs of the extramural (outside NIST) and intramural (within NIST) customers. The Technical Manager works closely with the LBIR Project Leader and Project scientists to define LBIR strategic goals to meet the calibration needs of LBIR customers. Other major duties include reviewing and approving all special test/calibration reports for the Low Background Infrared Calibration Facility services under his responsibility, working with the LBIR Project Leader/LBIR Project Scientists as necessary to define special test parameters and uncertainties with Customers, and to resolve Customer complaints, resolve corrective actions, and review preventative action plans. Reviews and approves the LBIR calibration service(s) quality manual (QM3) and procedures as necessary and annually audits the LBIR calibration service(s) (technical details) to insure the correctness or validity of the calibration service's measurements.

b. LBIR Project Leader – Responsible for providing technical support in measurement science, instrumentation design, development, improvement, repair, and testing. Provides logistic support in scheduling routine and special tests/calibrations, low background infrared calibrations units realizations, and maintenance of the units. Provides liaison to intramural and extramural customers. Ensures that the quality system is implemented and followed at all times.

c. LBIR Project Scientist – Responsible for providing theoretical/technical support in infrared measurement science, instrumentation design, development, improvement, repair, and testing. Provides logistic support in scheduling routine and special tests/calibrations, analysis of data, low background infrared calibrations units realizations, uncertainty analysis and maintenance of the units.

d. LBIR Service Personnel – Responsible for day-to-day operation, modification, repair, and testing of the LBIR measurement systems.

4. Management Requirements

4.1 Organization

NIST QM-I section 4.1 covers the organizational structure of NIST from its description as a non-regulatory federal agency within the U.S. Commerce Department's Technology Administration to the Division Chief level. Document Div844QM2 section 4.1 covers the organizational relationships from the Division Chief to the calibration service personnel. These two documents cover areas including legal responsibilities, NIST core values, ethical conduct, impartiality, objectivity, protection of confidential or proprietary information and the statement that the NIST Quality System is in conformity with the international standard ISO/IEC 17025.

The following sections describe the organizational structure of the Low Background Infrared Calibration Facility including the physical location of laboratories and the personnel with authority and responsibility for measurements and support work.

4.1.1 Physical Location

The Low Background Infrared services are performed at the NIST Gaithersburg Campus in the Physics Building (Building 221) in room A26. The management system described in documents NIST-QM-I, Div844QM2, and, in this document (Div844QM3-LBIR) shall cover the work carried out in these designated laboratories. Additional calibration services are performed at off-site locations as required by the client.

4.1.2 Responsibilities and Authorities

As stated in document Div844QM2, the Division Chief maintains the overall authority and responsibility of the calibration services offered by the Optical Technology Division (844). Within Low Background Infrared services, the LBIR Technical Manager working with the LBIR Project Leader maintains the overall authority and responsibility of the calibration and test services offered and ensures that the quality system presented in this document is implemented and followed at all times. The LBIR Project Leader has direct, uninterrupted communication to the Division Quality Managers and Technical Managers. The LBIR Project Scientists and the LBIR Service Personnel have direct, uninterrupted communication with the LBIR Project Leader.

The management personnel are designated in Section 4.1 of the Optical Technology Division Quality Manual (Div844QM2). The following list designates the personnel

specific to Low Background Infrared services with their position. Any temporary changes are designated by a memorandum to the Division Chief.

LBIR Technical Manager	Joe Rice
LBIR Project Leader:	Simon Kaplan
LBIR Project Scientist:	Timothy Jung
LBIR Project Scientist:	Soloman Woods
LBIR Project Scientist	Adriaan Carter
LBIR Project Scientist	Raju Datla
LBIR Project Scientist:	James Proctor
LBIR Service Personnel:	Dale Sears
LBIR Service Personnel:	Greg Ly
LBIR Service Personnel	Tomoya Ohno

4.2 Quality system

This section documents the Low Background Infrared Calibration Facility quality system. This documentation shall be available for use by the LBIR Project Scientists and Service Personnel. This section documents the Low Background Infrared policies and objectives for, and its commitment to, good laboratory practice and quality of calibration services. The LBIR Project Leader shall ensure that these policies and objectives are documented and maintained current in the Low Background Infrared Calibration Facility Quality Manual (Div844QM3-LBIR). The LBIR Project Leader shall ensure that these policies and objectives are communicated, understood, and implemented by all LBIR Project Scientists and Service Personnel.

The NIST policies and operational procedures related to quality management are documented in NIST QM-I. The Division 844 policies and operational procedures related to quality management are documented in Div844QM2. The services offered by the Low Background Infrared Calibration Facility include:

1. LBIR-1 Calibration of Cryogenic Blackbodies,
2. LBIR-2 Characterization of Radiometers,
3. LBIR-3 Characterization of Detectors, and
4. LBIR-4 Special Tests at Off-Site Locations.

Each of these services is procedurally documented in this manual with supporting documentation in the LBIR Facility Manual.

Quality Policy Statement. The Low Background Infrared Calibration Facility, of the NIST Optical Technology Division, maintains the Low Background Infrared Absolute Cryogenic Radiometers (ACRs) as traceable to the Absolute Cryogenic Radiometer (POWR) scale at NIST and uses them as the basis for cryogenic blackbody, radiometer and detector calibrations.

Responsibility for implementing this policy has been delegated to the LBIR Project Leader and the LBIR Project Scientists and Service Personnel through the technical management chain. This manual contains the quality objectives endorsed by the entire technical management chain and service personnel. Therefore, it is a requirement that all LBIR Project Scientists and Service Personnel familiarize themselves with this quality documentation and implement the policies and procedures in their work. As stated in document Div844QM2, the management in the Optical Technology Division is committed to providing each calibration service with the time, resources, and materials necessary to carry out these services, in compliance with this quality manual.

4.3 Document control

Procedures for control and maintenance of quality documents are described in detail in the document Optical Technology Division Quality Manual (Div844QM2).

4.4 Review of requests, tenders and contracts

Procedures for review of requests, tenders and contracts are described in detail in the document Optical Technology Division Quality Manual (Div844QM2).

All communication with the customer relating to the customers requirements or the results of the work during the period of measurement shall be documented and included in the Test Folder.

4.5 Subcontracting of tests and calibrations

As stated in the NIST Quality Manual for Measurement Services (NIST QM-I) tests and calibrations are not subcontracted.

4.6 Purchasing services and supplies

Purchases of consumable materials needed to provide calibration services are procured in accordance with the Federal Acquisition Reform Act (FAR) (http://www.arnet.gov/far/).

4.7 Service to the client

In addition to the services documented in the Optical Technology Division Quality Manual (Div844QM2) under section 4.7, the customer has the right to monitor and clarify the Low Background Infrared Facility services performance and timeliness in relation to the services performed.

The LBIR Service Personnel are available for discussion through e-mail or telephone before the customer submits a calibration request. The NIST LBIR Website (http://physics.nist.gov/Divisions/Div844/facilities/lbir/lbir.html) provides service and contact information. The customers have reasonable access to relevant areas of the laboratory for witnessing examples of calibrations. The customers are allowed to be present during the time of actual measurements.

After the completion of a calibration service, the customer is welcome to contact the LBIR Project Leader to clarify or discuss calibration procedures and results.

4.8 Complaints

Procedures for assessing and resolving customer complaints are described in detail in the documents NIST QM-I and Div844QM2.

4.9 Control of nonconforming testing and/or calibration work

Procedures and policies for control of nonconforming testing and/or calibration work are described in detail in the documents NIST QM-I and Div844QM2.

4.10 Corrective action

Procedures for corrective action when discrepancies are detected or departures from documented policy occur are described in detail in the documents NIST QM-I and Div844QM2.

Any corrective action shall be noted in the appropriate laboratory notebook. Final determination of the effectiveness of the corrective action is the responsibility of the LBIR Project Leader and the LBIR Technical Manager.

4.11 Preventive action

As stated in NIST QM-I, excellence, a NIST core value, relies on continual improvement. All NIST employees are encouraged to identify needs and opportunities to improve our technical and quality procedures and policies. The

appropriate levels of technical and quality management will respond to staff suggestions by examining the opportunity or need and develop action plans to implement any changes required. The outcome will be communicated to the employee whose suggestion stimulated the actions.

4.12 Control of records

The document NIST QM-I discusses the NIST wide policies with regards to control of quality system documents and laboratory records and data. The document Div844QM2 discusses the OTD division policy on control of quality system and technical records.

Low Background Infrared Calibration Facility service has many controls of technical records. Laboratory notebooks are maintained according to the "Physics Laboratory Policy on Laboratory and Research Notebooks" which is very similar to the NIST Research Responsibilities (http://www-i.nist.gov/div222/newweb/InventorHandbook/responsibilities/notebooks.htm) for laboratory notebooks presented in the NIST Inventor Handbook. The information recorded in a notebook for a particular calibration is:

Customer name
Folder number
Dates
Experimental setup
Experimental parameters
Filenames

When recording mistakes occur, each mistake is crossed out, not erased, made illegible or deleted, and the correct value is entered alongside the original. The notebook is confidential and is not to be accessed by anyone except LBIR scientists and service personnel, and management. The notebooks remain in the LBIR locations, which are listed in section 4.1 of this document.

Details of the procedures for the record-keeping associated with a calibration and data storage and handling are given in the document LBIR Facility Manual.

4.13 Internal audits

Procedures and policies for conducting assessments and internal audits are described in detail in the documents NIST QM-I and Div844QM2.

4.14 Management reviews

Reviews by management at the NIST-wide level are described in detail in the document NIST QM-I and at the Division level in the document Div844QM2.

5. Technical requirements

5.1 Introduction

The policies and procedures with respect to the technical requirements for Low Background Infrared Calibration services are found in this section. NIST QM-I covers the policies and procedures for those that apply across the institute. The technical aspects considered are personnel, accommodation and environmental conditions, test and calibration methods and method validation, equipment, traceability, and handling of test and calibration items. All of these factors contribute to the total uncertainty of a measurement. Low Background Infrared services take into account these factors in developing test and calibration methods and procedures, in the training and qualification of personnel, and in the selection and calibration of the equipment it uses.

5.2 Personnel

The document NIST QM-I describes the policy for assuring competent service personnel and also describes the continuing education and training goals for its staff. NIST employee records are maintained by the Human Resources Management Division. Low Background Infrared services also use several contractors to perform calibration services.

All of the LBIR staff, scientists and service personnel listed in section 4.1.2 are qualified to perform all the required services and support work. Current resumes for all the LBIR personnel are maintained by the LBIR Technical Manager.

5.3 Accommodation and environmental conditions

Low Background Infrared services are performed in Room A24 in Building 221. These laboratory rooms contain the permanent facilities needed to produce Low Background Infrared services. The environment in the laboratory rooms is consistent with those found in research laboratories, and so are free of excessive dust, electromagnetic disturbances, radiation, and sound and vibration levels. If any of these conditions change from nominal levels, calibration activity ceases until the condition is corrected.

The temperature nominally remains at 24° C ± 2 °C. The relative humidity nominally remains in the range of 20 % to 70 %. Service personnel have no control over the laboratory humidity and little control over its temperature. The temperature and humidity typically have no effect on Low Background Infrared services.

The laboratory rooms accommodate only activities that relate to the Low Background Infrared Calibration Facility services or research and development efforts for LBIR calibrations and characterizations. The laboratory rooms are kept locked when LBIR personnel are not present. Other measures to control access to the laboratories are covered in Optical Technology Division Quality Manual (Div844QM2).

5.4 Test and calibration methods and method validation.

The calibration services that are offered have been documented in proceedings and peer reviewed journal articles. The calibration methods and procedures for all calibrations and related activities are documented in these documents. Included are measurement theory and scale realization, assessment of uncertainties, and data analysis. The personnel charged with the research shall present the developments to the scientific community for approval through talks and lectures. The LBIR Facility Manual also contains references to all these sources of documentation for LBIR services.

Low Background Infrared services use appropriate methods and procedures for all calibrations, which are listed below. The four major areas of calibrations are:

a. LBIR-1 Calibration of Cryogenic Blackbodies.

The calibration of cryogenic blackbodies utilizes the Broadband Calibration Chamber. The radiant power of the blackbody is measured with the ACR I radiometer. The temperature of the blackbody is calculated from the radiant power with the use of known geometric factors affecting the radiation from the blackbody to the ACR I. This method is documented in the following documents.

1. R. U. Datla, M. C. Croarkin, and A. C. Parr, Cryogenic Blackbody Calibrations at the National Institute of Standards and Technology Low Background Infrared Calibration Facility, Journal of Research of the National Institute of Standards and Technology, Volume 99, Number 1, January – February, 1994, p 77-86.

2. C. A. Morgan, T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, An Expanded Broadband Calibration Capability at the NIST LBIR Facility, Proceedings of SPIE Vol 3361, Thermosense XX, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona; Robert E. Sampson, I Technology Applications, April 1998

b. LBIR-2 Characterization of Radiometers

The characterization of radiometers in a cryogenic environment is performed in the Broadband Calibration Chamber. Radiation from the source blackbody is collimated through a 10 cm collimator and then directed onto either the ACR II radiometer or the radiometer under test. The ACR II radiometer determines the radiant power at the monochromator settings being utilized. Several calibration methods are available and are explained in the following documents.

c. LBIR-3 Characterization of Detectors

The characterization of detectors in a cryogenic environment is performed in the Spectral Calibration Chamber. Radiation from the source blackbody is focused through the monochromator and is then focused again onto either the ACR II radiometer or the detector under test. The ACR II radiometer determines the radiant power at the monochromator settings being utilized. Several detectors can be mounted on a detector paddle and several lenses are available to calibrate a variety of detector configurations and sizes. Several calibration methods are available and are explained in the following document.

1. A. C. Carter, S. R. Lorentz, T. M. Jung, B. J. Klemme, R. U. Datla, NIST facility for spectral calibration of detectors: calibration of arsenic-doped silicon-blocked impurity band detectors, Proc. SPIE Vol 4028, p. 420-425, Infrared Detectors and Focal Plane Arrays VI, E. L. Dereniak and R. E. Sampson, Eds, July 2000

d. LBIR-4 Special Tests at Off-Site Locations

The BXR radiometer is currently the primary instrument used for special tests at off-site locations.

5.5 Equipment

The instruments used for LBIR Calibration Facility services have the necessary equipment and reference standards for performing calibration measurements of cryogenic blackbodies, radiometers, detectors and, special tests at off-site locations. All equipment is maintained in proper working order. If a piece of equipment malfunctions, that unit is taken out of service and a properly functioning replacement is used. This occurrence is noted in the notebook associated with the instrument. If the equipment cannot be replaced or repaired, further calibration services are delayed until the equipment is ready for use. If the equipment defect affects previous calibration measurements, the customers affected are notified, the calibration items are recalibrated, and a revised calibration report is issued.

Manuals provided by the manufacturer of a piece of equipment are located in the laboratory in which they are used. The manuals for the instruments contain instructions on the proper operation of the equipment.

Six major equipment systems are used in the performance of the LBIR calibration services. These systems and their operation are described in the LBIR Facility Manual. These equipment systems are:

a. Broadband Calibration Chamber (BCC)

The Broadband Calibration Chamber is contained in a stainless steel vacuum vessel 152 cm long and 60 cm in diameter. This vessel is lined with a cryogenic shroud made up of two concentric copper cylindrical shields with endplates, separated by a 2.54 cm gap. The inner shield is cooled to 20 K for the calibration environment by the Helium Refrigeration System. The BCC is used mainly to calibrate blackbodies for radiance temperature. The Absolute Cryogenic Radiometer (ACR I) radiometer is the standard for calibrations in this chamber. A copper disk partitions the interior into a source volume and a detector volume. The ACR I can be mounted in three different positions and the source can be mounted in an antechamber mounted on the front of the BCC. The distance from the blackbody to the ACR is measured with a stepper motor used with an invar rod. A bi-directional gate valve between the chambers permits access to either chamber while the other chamber is kept in vacuum. Vacuum pump-down is accomplished with a dedicated 500 L/s turbopump and a 2000 L/s cryopump.

The equipment of the Broadband Calibration Chamber is described in detail in the following documents:

1. R. U. Datla, M. C. Croarkin, and A. C. Parr, Cryogenic Blackbody Calibrations at the National Institute of Standards and Technology Low Background Infrared Calibration Facility, Journal of Research of the National Institute of Standards and Technology, Volume 99, Number 1, January – February, 1994, p 77-86.

2. C. A. Morgan, T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, An Expanded Broadband Calibration Capability at the NIST LBIR Facility, Proceedings of SPIE Vol 3361, Thermosense XX, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona; Robert E. Sampson, I Technology Applications, April 1998

b. Spectral Calibration Chamber (SCC)

The Spectral Calibration Chamber is contained in a stainless steel vacuum vessel 145 cm long and 60 cm in diameter. Access to the inside of the chamber is through a 40 x 90 cm rectangular door on a hinge. The SCC is cooled to 25 K by cold helium gas from the Helium Refrigeration system. The cryoshields are made of stainless steel in a quilted design to achieve a better defined shape for improved light tightness. The SCC is used mainly to calibrate detectors and filters. The source is an 800 K blackbody used with a two-stage monochromator. The spectral resolution of the grating monochromator is nominally 2% from 2 μm to 30 μm. The system has a grating cube with rulings on four faces to cover the selected wavelength range with a resolving power of 50 and f/4 optics. Light from the monochromator is focused onto test items by focusing lenses. The standard for the SCC is an Absolute Cryogenic Radiometer (ACR II) that can measure lower power than ACR I in the BCC. The monochromator and optics have been calibrated for throughput as a part of the calibration process. Vacuum pump-down is accomplished with a 350 L/s turbopump and two 2000 L/s cryopumps. The spectral instrument is mounted on a translation stage to move it in and out of the optical path for measuring the broadband absolute radiant power output of any test source using the ACR. The spectral calibration chamber can be operated to provide any background temperature between 20 K and 300 K.

The equipment of the Spectral Calibration Chamber is described in detail in the following document:

1. A. C. Carter, S. R. Lorentz, T. M. Jung, B. J. Klemme, R. U. Datla, NIST facility for spectral calibration of detectors: calibration of arsenic-doped silicon-blocked impurity band detectors, Proc. SPIE Vol 4028, p. 420-425, Infrared Detectors and Focal Plane Arrays VI, E. L. Dereniak and R. E. Sampson, Eds, July 2000

c. Helium Refrigeration System,

Both the Broadband Calibration Chamber and the Spectral Calibration Chamber are cooled to a temperature of 20 K by cold helium gas. The helium gas is cooled by a closed cycle Model 1620 helium refrigerator that was originally purchased from Process Systems International (PSI). PSI product line is currently owned by Linde AG company and currently all servicing and parts for the LBIR helium refrigeration system are available from Linde AG corporation. Two helium compressors drive the Model 1620 refrigerator and are located in an equipment room about 100 meters away. A storage tank and bottle racks provide ultra-pure helium reservoirs needed for the refrigerator cooling cycle. The cooled gas cools the inner shields of both chambers to 20 K and the outer shields to 40K. The refrigerator has a cooling capacity of approximately 200 watts at 10 K. The refrigerator is connected to both chambers by helium transfer lines with valving that permits the operation of either chamber or both chambers at once.

The equipment of the Helium Refrigeration System is described in detail in the manuals of Model 1620 and its corresponding compressor units. These manuals are located in the LBIR Manual rack in Room A21 in Bldg 221. The maintenance procedures are summarized in the following document.

1. D. Sears, T. Marsh, T. M. Jung, A. Smith, J. Fedchak, J. Proctor and A.C. Carter, LBIR Facility Manual, 2006.

d. Absolute Cryogenic Radiometers (ACRs).

The standards for both the Broadband Calibration Chamber and the Spectral Calibration Chamber are Absolute Cryogenic Radiometers (ACRs). The BCC chamber uses the ACR I radiometer. The ACR I is an active cavity radiometer operated at 2 – 4 K for measuring power in the range of 20 nW to 100 μW with uncertainty of ±1% (2σ level). The accuracy of the ACR is based on thermal modeling and measurements of operational concepts. The diameter of the receiver cone is 3 cm, the time constant is about 20 seconds, and the responsivity and non-equivalence error have been measured.

The ACR II radiometer is the standard in the SSC is like that used in the broadband measurements chamber except that it has been designed to measure much lower powers. The diameter of the receiver cone is 2.5 cm, the receiver cone has a lower thermal mass to achieve a noise floor of 10 pW and the time constant is 15 seconds. It is mounted in the SCC chamber on an actively cooled optical table at the exit aperture of the monochromator.

The equipment of the Absolute Cryogenic Radiometers is described in detail in the following documents:

1. R. U. Datla, M. C. Croarkin, and A. C. Parr, Cryogenic Blackbody Calibrations at the National Institute of Standards and Technology Low Background Infrared Calibration Facility, Journal of Research of the National Institute of Standards and Technology, Volume 99, Number 1, January – February, 1994, p 77-86.

2. C. A. Morgan, T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, An Expanded Broadband Calibration Capability at the NIST LBIR Facility, Proceedings of SPIE Vol 3361, Thermosense XX, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona; Robert E. Sampson, I Technology Applications, April 1998.

3. R. U. Datla, K. Stock, A. C. Parr, C. C. Hoyt, P. J. Miller, and P. V. Foukal, Characterization of an absolute cryogenic radiometer as a standard detector for radiant-power Measurements. Applied Optics, Vol. 31, No. 34, 1 December 1992, p. 7219-7225.

4. R. U. Datla, S. C. Ebner, J. Proctor, A. C. Parr, LBIR Facility User Handbook, National Institute of Standards and Technology Handbook 147, June 1991, 26 pages.

5. A. C. Carter, S. R. Lorentz, T. M. Jung, B. J. Klemme, R. U. Datla, NIST facility for spectral calibration of detectors: calibration of arsenic-doped silicon-blocked impurity band detectors, Proc. SPIE Vol 4028, p. 420-425, Infrared Detectors and Focal Plane Arrays VI, E. L. Dereniak and R. E. Sampson, Eds, July 2000

e. BXR Radiometer

The BMDO Transfer Radiometer (BXR) is designed to measure the irradiance of a collimated source of infrared light having an angular divergence of less than 1 mrad. It is capable of measuring irradiance levels as low as 10 -15 W/cm2 over the spectral range from 2 μm to 30 μm with an uncertainty of ±5%. Spectral resolution is provided by narrow bandpass interference filters. All components of the radiometer, which include a mechanical shutter, internal calibration source and detector, a long baffle section, a spatial filter, two filter wheels, and a two-axis detector stage are cooled to below 20 K. The BXR is designed to be attached to a low background cryogenic vacuum chamber having inner shroud temperatures of 20K and below and is easily

transportable. It has a defining entrance aperture of 7 cm. The noise equivalent power is 3 x 10-16 W when used with the 1 mm2 detector BIB detector. The BXR is intended for use with a modulated signal and must be calibrated with a collimated source.

1. T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, NIST-BMDO Transfer Radiometer (BXR), Infrared Detectors and Focal Plane Arrays VI, Proceedings of SPIE Vol. 4028 99, 2000.

f. 10 CM collimator (10CC)

The 10 cm Collimator (10CC) is designed to be a calibration source for the BXR I, as well as for any similar instruments. It is an instrument that can produce a 10 cm diameter collimated infrared beam that can be calibrated by an ACR, which is then used to calibrate the BXR I. The source for the 10CC is an internal blackbody that can be varied from 180 K to 800 K. Radiation from the source is collimated to a 2 cm beam which is passed through filter wheels to provide limited spectral capability. The 2 cm beam is then focused down to the back side of aperture wheel that contains apertures with a range of sizes. These apertures are at the focal point of the main collimating mirror that produces a beam that is approximately 12 cm, of which only the central 10 cm is specified to be used for calibration activity. By varying the aperture at the mirrors focal point, the degree of collimation from the 10CC is varied from 0.050 mrad to 1 mrad by selecting one of 6 apertures in the aperture wheel. The 10CC is a vacuum-cryogenic instrument with all components enclosed in a cryogenic shroud, such that the entire system attains a 15 K background environment. The optical system (mirrors, apertures and baffles) was designed to be easily modeled with respect to geometric optics and diffraction. This was done to maximize the potential agreement between its actual and theoretical performance, which is a necessary step in maximizing confidence in its calibration capability.

5.6 Traceability

Traceability for Low Background Infrared services is established as part of the measurement assurance program. The traceability for each of the LBIR services is documented in proceedings and peer reviewed journal articles, as well as in the calibration reports for special or unique measurements.

a. LBIR-1 Calibration of Cryogenic Blackbodies.

Calibration of blackbodies for radiance temperature is traceable to the ACR I radiometer and geometrical measurements. The traceability of these calibrations is described in the following documents.

1. R. U. Datla, M. C. Croarkin, and A. C. Parr, Cryogenic Blackbody Calibrations at the National Institute of Standards and Technology Low Background Infrared Calibration Facility, Journal of Research of the National Institute of Standards and Technology, Volume 99, Number 1, January – February, 1994, p 77-86.

2. C. A. Morgan, T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, An Expanded Broadband Calibration Capability at the NIST LBIR Facility, Proceedings of SPIE Vol 3361, Thermosense XX, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona; Robert E. Sampson, I Technology Applications, April 1998.

3. R. U. Datla, K. Stock, A. C. Parr, C. C. Hoyt, P. J. Miller, and P. V. Foukal, Characterization of an absolute cryogenic radiometer as a standard detector for radiant-power Measurements. Applied Optics, Vol. 31, No. 34, 1 December 1992, p. 7219-7225.

4. R. U. Datla, S. C. Ebner, J. Proctor, A. C. Parr, LBIR Facility User Handbook, National Institute of Standards and Technology Handbook 147, June 1991, 26 pages.

b. LBIR-2 Characterization of Radiometers

Calibration and characterization measurements of radiometers are traceable to the ACR II radiometer. The traceability of these calibrations is same as the traceability established for the LBIR ACRs.

c. LBIR-3 Characterization of Detectors

Calibration and characterization measurements of radiometers are traceable to the ACR II radiometer and measurements of the monochromator spectral throughput. The traceability of these calibrations is described in the following documents.

1. A. C. Carter, S. R. Lorentz, T. M. Jung, B. J. Klemme, R. U. Datla, NIST facility for spectral calibration of detectors: calibration of arsenic-doped silicon-blocked impurity band detectors, Proc. SPIE Vol 4028, p. 420-425, Infrared Detectors and Focal Plane Arrays VI, E. L. Dereniak and R. E. Sampson, Eds, July 2000.

d. LBIR-4 Special Tests at Off-Site Locations

The BMDO Transfer Standard Radiometer (BXR) is designed to measure the irradiance of a collimated source of infrared radiation having an angular divergence of less than 1 mrad at irradiance levels as low as 10^{-15} W/cm^2. The primary goal of the BXR is to measure these collimated sources to a standard uncertainty goal of 5%. The traceability of the calibration methods utilized is described in the following documents:

5.7 Sampling

Low Background Infrared services calibrate individual items and explicitly states that the measurement results apply only to that specific item. LBIR services perform no sampling.

5.8 Handling of test and calibration items

Calibration items for LBIR services are inspected upon receipt for possible damage or possible incompatibility with the proposed calibration. In particular, the items are tested for vacuum integrity and cleanliness suitable for a cryogenic vacuum environment. This procedure is described in the following documents:

1. R. U. Datla, S. C. Ebner, J. Proctor, A. C. Parr, LBIR Facility User Handbook, National Institute of Standards and Technology Handbook 147, June 1991, 26 pages.

5.9 Assuring the quality of test and calibration results

The quality of Low Background Infrared services is assured by the measurement assurance procedures for each the calibration services.

a. LBIR-1 Calibration of Cryogenic Blackbodies.

The quality of calibration of blackbodies for radiance temperature is assured by the quality procedures described in the following documents.

1. R. U. Datla, M. C. Croarkin, and A. C. Parr, Cryogenic Blackbody Calibrations at the National Institute of Standards and Technology Low Background Infrared Calibration Facility, Journal of Research of the National

Institute of Standards and Technology, Volume 99, Number 1, January – February, 1994, p 77-86.

2. C. A. Morgan, T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, An Expanded Broadband Calibration Capability at the NIST LBIR Facility, Proceedings of SPIE Vol 3361, Thermosense XX, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona; Robert E. Sampson, I Technology Applications, April 1998.

3. R. U. Datla, K. Stock, A. C. Parr, C. C. Hoyt, P. J. Miller, and P. V. Foukal, Characterization of an absolute cryogenic radiometer as a standard detector for radiant-power Measurements. Applied Optics, Vol. 31, No. 34, 1 December 1992, p. 7219-7225.

4. R. U. Datla, S. C. Ebner, J. Proctor, A. C. Parr, LBIR Facility User Handbook, National Institute of Standards and Technology Handbook 147, June 1991, 26 pages.

b. LBIR-2 Characterization of Radiometers

The quality of calibration and characterization measurements of radiometers is assured by the quality procedures described in the following documents:

1. A. C. Carter, S. R. Lorentz, T. M. Jung, B. J. Klemme, R. U. Datla, NIST facility for spectral calibration of detectors: calibration of arsenic-doped silicon-blocked impurity band detectors, Proc. SPIE Vol 4028, p. 420-425, Infrared Detectors and Focal Plane Arrays VI, E. L. Dereniak and R. E. Sampson, Eds, July 2000.

c. LBIR-3 Characterization of Detectors

The quality of calibration and characterization measurements of detectors is assured by the quality procedures described in the following documents:

1. A. C. Carter, S. R. Lorentz, T. M. Jung, B. J. Klemme, R. U. Datla, NIST facility for spectral calibration of detectors: calibration of arsenic-doped silicon-blocked impurity band detectors, Proc. SPIE Vol 4028, p. 420-425, Infrared Detectors and Focal Plane Arrays VI, E. L. Dereniak and R. E. Sampson, Eds, July 2000.

d. LBIR-4 Special Tests at Off-Site Locations

The quality of calibration and characterization measurements of special tests at off-site locations is assured by the quality procedures described in the following documents:

1. T. M. Jung, A. C. Carter, S. R. Lorentz, and R. U. Datla, NIST-BMDO Transfer Radiometer (BXR), Infrared Detectors and Focal Plane Arrays VI, Proceedings of SPIE Vol. 4028 99, 2000.

5.10 Reporting the results

The LBIR staff shall promptly notify a customer in writing and, if appropriate, by phone or e-mail of:

a. any event, such as the identification of defective equipment, inappropriate procedures, or error in data reduction, which significantly effected the results given in the Report. Such notification shall quantify the magnitude of error created in the results.
b. results significantly different from previous results on the same calibration item. The customer shall be advised so that the appropriate action can be taken.

Amendments and revisions to Calibration Reports shall be made in the form of a document, which includes the statement “Supplement to Calibration Report” and the test report number shall be followed by the suffix “R” for revision. Any amendment shall contain the relevant parts of the format described. A Report may also be revised (reissued with corrections). The test report number shall also be followed by the suffix “R” in this case. A cover letter, similar to the one sent originally, shall be sent with the revised report and shall include a statement that the original report and cover letter should be destroyed.

The NIST Quality Manual for Measurement Services QM – 1 (NIST QM-1) and the Optical Technology Division Quality Manual (Div844QM2) describe the requirements for calibration reports issued by the Division. These requirements include:

a. a title (e.g. " Report of Test/Calibration");
b. the first page shall be on NIST letter head or be equivalently identified as originating from NIST;

c. the NIST Calibration Services test or calibration number, service id number ([http://ts.nist.gov/ts/htdocs/230/233/calibrations/index.htm]);
d. if required, the complete specification of a special test, either explicitly or by reference;
e. the Test Folder number;
f. all pages shall be numbered and the last page designated as the end of the report;
g. the name and address of the client;
h. a description and identification of the item(s) tested or calibrated;
i. a description of the calibration method;
j. the date(s) of performance of the test or calibration;
k. the test or calibration results with, where appropriate, the units of measurement;
l. a statement of uncertainty of each measurement result;
m. the conditions (e.g. environmental) under which the calibrations were made that have an influence on the measurement results;
n. evidence that the measurements are traceable;
o. the name(s), function(s) and signature(s) or equivalent identification of person(s)
p. authorizing the report;
q. when necessary a statement that the results apply only to the items tested or calibrated;
r. the name of the person(s) performing the measurements and analyses; and
s. an explanation of the proper use and interpretation of the reported results, as necessary (this can be in the form of an addendum).

Document History

Version	Date	Author	Approved	Page Total
1.0	11/30/2005	John Grangaard	Raju Datla	22