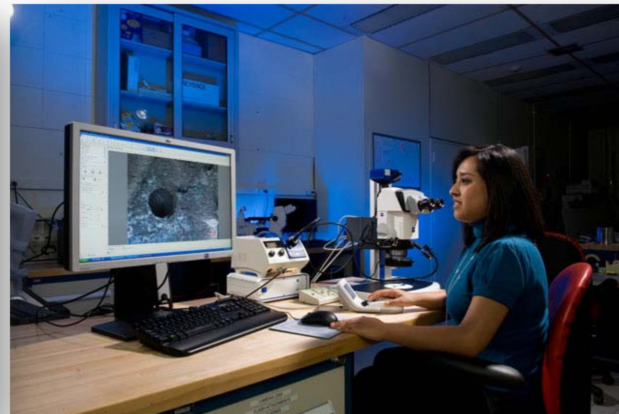
Materials and Nondestructive Evaluation Laboratories

User Test Planning Guide




National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

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1.0 Materials and Nondestructive Evaluation Laboratories

The Johnson Space Center (JSC) Materials and Nondestructive Evaluation Laboratories provide science and engineering services to JSC, industrial organizations, the National Aeronautics and Space Administration (NASA) and other government agencies, and educational and research institutions, including those supporting NASA spaceflight and technology development programs. Test and evaluation capabilities include metallography, Nondestructive Testing (NDT), material properties testing, microscopy, and analytical chemistry. A complete list of laboratory equipment is included in Appendix A.

Scanning Electron Microscopy

The Scanning Electron Microscopy (SEM) Laboratory contains a Cold Field Emission SEM and a Variable Pressure Schottky SEM capable of imaging electrically conductive and nonconductive specimens to 1 nm resolution.

Services Provided

- Secondary/backscatter imaging
- Energy Dispersive Spectroscopy (EDS)
- Electron Backscatter Diffraction (EBSD)
- Scanning Transmission Electron Microscopy (STEM)
- Carbon and precious metal thermal/sputter coaters

Metallography

The Metallography Laboratory conducts investigations of material microstructures and provides overall photography in support of various failure analyses and materials evaluations. During failure analysis, a broken part is documented with digital photography in the as-received condition before a section of the material is cut into a manageable size and mounted in a resin disk. The disk is polished to a mirror finish that can be analyzed for grain size, flaw detection, and coating thickness in the metallograph.

Services Provided

- Mounting, polishing, and etching
- Hardness testing
- Inverted, stereo, and upright microscopy
- Field metallography
- Reflective brightfield, darkfield, DIC, C-DIC, polarized, and transmitted microscopy
- Imagery and dimensional analysis

Analytical Chemistry Laboratory

The Analytical Chemistry Laboratory contains analytical instruments that are used to determine different material properties and nonmaterial characterizations. The laboratory performs chemical analysis of materials and contaminant identification, including identification of unknown solids and liquids.

Services Provided

- Chemical analysis
  - Fourier Transform Infrared (FTIR) Spectrometry
  - Pyrolysis Gas Chromatography/Mass Spectrometry (Py-GC-MS)
  - Ultraviolet Visible Near Infrared (UV-Vis-NIR)
  - Raman spectrometry
  - Near infrared photoluminescence
- Thermal Analysis
  - Differential Scanning Calorimetry (DSC)
  - Thermogravimetric Analysis (TGA)
  - Dynamic Mechanical Analysis (DMA)
  - Laser flash technique (thermal diffusivity)
  - Rheology
- Other Analysis
  - Surface area porosity analysis
  - Optical instruments
  - Wet chemistry techniques
  - 4-point probe conductivity meter

Polymer Laboratory

The Polymer Laboratory has the capability of performing tensile, lap shear, and compressive testing of materials and structural components at elevated or cold temperatures (¯250 – 800 °F). The Laboratory also has the capability to perform tape and adhesive peel tests, textile tension and tear resistance tests, and to mix, degas, compound, cure, and fabricate polymer and composite test specimens.

Services Provided

- Tensile, lap shear, and compressive testing
- Structural testing at elevated or cold temperatures
- Cutting and bonding of nonmetallic materials
- Bandsaws to cut ceramic and composites
- Shore hardness testing
- ARAMIS 3-D Image Correlation Photogrammetry

Nondestructive Evaluation (NDE) Laboratory

The Nondestructive Evaluation (NDE) Laboratory provides surface and volumetric evaluations using various NDT methods and techniques that do not destroy the hardware. We assist in failure analysis investigations, reverse engineering, and manufacturing of metallic and nonmetallic materials.

Services Provided

- Radiographic Testing (RT)
  - Computed Tomography (CT)
  - Digital Radiography (DR)
  - Standard Film Radiography
- Ultrasonic Testing (UT)
  - Phased Array Ultrasonic Testing (PAUT)
  - C-scan UT
  - Conventional UT
- Infrared (IR) Thermography Inspection
  - Flash Infrared (FIR)Thermography Testing
  - IR Thermography Testing
- Remote Evaluation Techniques
  - Laser Shearography
  - High Speed Imagery
- Eddy Current Testing (ET)
  - Array Eddy Current Testing (AET)
  - Conventional ET
- Liquid Penetrant Testing (PT) and Magnetic Particle Testing (MT) Inspection
  - Fluorescent and visible mediums for both methods

Point of Contact

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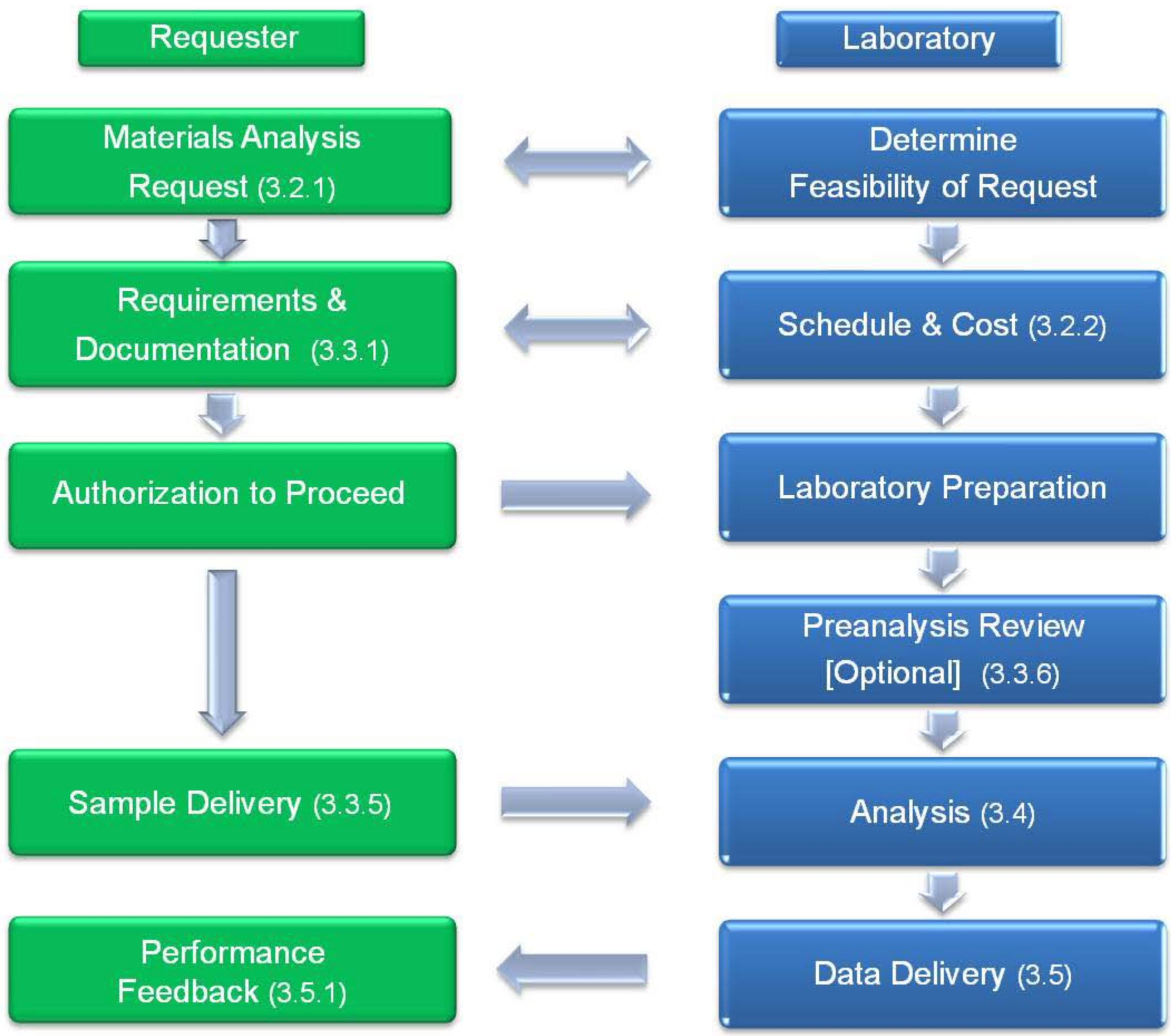
2.0 Safety and Health

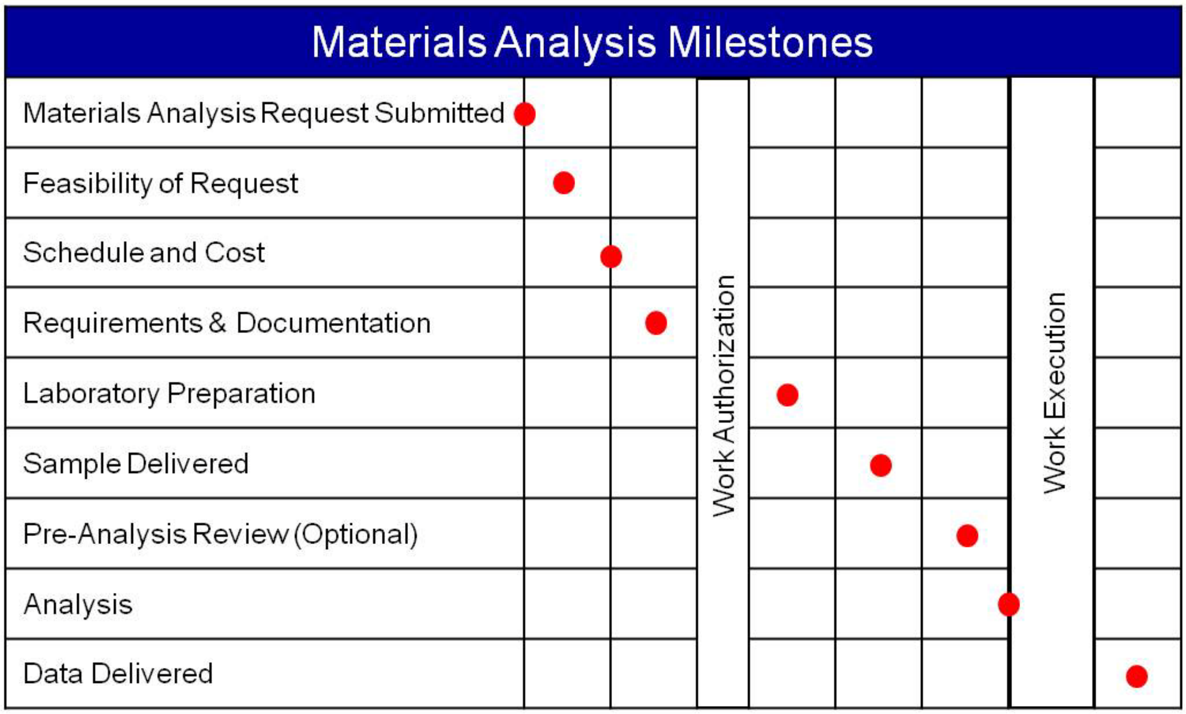
Safety is an integral part of the culture at NASA. Management, leadership, and employee involvement from all organizations is critical to the success of NASA's safety program. In order to ensure personal safety and a safe environment throughout the analysis process, vistors must be escorted through the laboratories at all times. The requester shall follow all facility-specific safety and health requirements during site visits. Safety glasses with side shields must be worn while touring JSC's Materials Evaluation Laboratories (MEL) and the NDE Laboratory.

3.0 Process Flow

The flowchart presented below outlines the basic roadmap and significant milestones between the initial Materials Analysis Request (MAR) and delivery of the data. The flow is separated between Requester actions and Laboratory actions, highlighting interactions and inputs between the Requester and the Laboratory.



The schedule is highly dependent on the complexity of the analysis, facility availability, and sequence of work. For time-critical analyses, this schedule may be accelerated. A detailed schedule shall be developed following a review of objectives and requirements. Major milestones are presented below:



3.1 Export Controlled and Proprietary Information

JSC provides for protection of export controlled and proprietary information and hardware throughout the analysis process. The Requester shall clearly mark all export controlled or proprietary samples and data provided with a notice of restriction on disclosure or usage. The Laboratory staff shall safeguard export controlled or proprietary items from unauthorized use and disclosure and ensure that samples remain secure within the facility and are properly sequestered. Access to the facility is restricted to facility personnel and escorted visitors. Samples shall be returned to the Requester or disposed of in accordance with the Requester's instructions upon product acceptance.

3.2 Materials Analysis Request Phase

The materials analysis request phase establishes the relationship between the Requester and the Laboratory Manager. The Requester shall provide a Materials Analysis Request Worksheet to the Laboratory Manager, which will be used to determine feasibility of the analysis and to develop an estimated cost and a preliminary schedule. An initial materials analysis requirements review shall define the scope of the work, quantities, and desired delivery dates

Inputs: Requester provides materials analysis request, identifies Technical Expert

Activities: Laboratory Manager reviews request to determine feasibility

Outputs: Laboratory Manager delivers estimated cost and schedule to Requester

3.2.1 Materials Analysis Request

The materials analysis request outlines the scope of the work, quantities, desired delivery date, and sample disposition. A Materials Analysis Request Worksheet is provided in Appendix B. This worksheet addresses the basic requirements for utilizing JSC's MEL and NDE services. It is suggested that the Requester complete this worksheet to facilitate the development of a preliminary cost and schedule estimate. At a minimum, the materials analysis request should include the following information:

Scope of Work

A description of the product(s) to be fabricated, including, but not limited to, the following:

- Technical point of contact
- Statement of work
- Quantities
- Target delivery date(s)

Materials Analysis Requirements

A description of the materials analysis requirements, including, but not limited to, the following:

- Analytical techniques to be utilized
- Process specifications (e.g., military specifications, standards)
- Material specifications
- Sample of known materials (materials or contamination identification request)
- Special considerations (e.g., hazards, cleanliness requirements)

3.2.2 Schedule and Cost Estimate

Following receipt of a completed Materials Analysis Request Worksheet, the Laboratory Manager will provide a cost and schedule estimate, including major milestones, to the Requester.

3.3 Materials Preparation Phase

The materials analysis requirements and schedule are finalized during the materials preparation phase. The Requester shall provide detailed requirements and documentation to the Laboratory Manager.

Inputs:	Requester provides requirements and documentation
Activities:	Laboratory staff begins planning the materials analysis
Outputs:	Requester approves schedule
	Laboratory staff begins analysis

3.3.1 Requirements

A complete understanding of materials analysis requirements is mandatory. Requirements must be defined and reviewed so that the Laboratory Manager can properly prioritize, plan, and schedule the work. The Requester shall provide a detailed list of requirements, including, but not limited to, the following:

- Material Safety Data Sheets (MSDS)
- Hazards
- Analytical techniques
- Materials specifications
- Process specifications
- Drawings

3.3.2 Documentation

Material Safety Data Sheets

NASA must ensure that all materials do not present a hazard to personnel or the laboratory. The Requester shall deliver MSDS for materials to be analyzed. The MSDS shall be delivered along with the Materials Analysis Request Worksheet. The Laboratory Manager will review the MSDS for compatibility with the laboratory environment and determine protective measures for personnel, if required.

Hazard Identification

The safety of the Laboratory staff and equipment is imperative to NASA. Potential hazards and material compatibility will be reviewed with the Laboratory staff prior to the analysis. In certain instances, special precautions must be taken due to the severity level of these potential hazards. The Requester may be asked to provide further information to clarify or mitigate a potential hazard. It is highly recommended that the Requester provide a hazard analysis or complete the Hazard Checklist included in Appendix B.

Materials Specifications

Materials specifications may be required for materials supplied by the Requester. The materials specifications contain standard reference data for specific materials. Reference material data includes the measured physical property allowable, material-specific safety precautions, and material-specific processing parameters. This data may be necessary to perform NDE of the provided material.

Process Specifications

The Requester shall provide a list of processes required for NDE. It is recommended that the Requester reference the process specifications in any drawings provided.

Drawings

Drawings may be required for some NDE services. We encourage you to submit electronic copies of your drawings. We can accept files through a File Transfer Protocol (FTP) site, by e-mail, or via standard mail. Instructions for submitting drawings are included as part of the Materials Analysis Request Worksheet (Appendix B).

3.3.3 Analysis Plan (If Requested)

An analysis plan may be prepared if required by the Requester. The final analysis plan shall be approved by the Requester with concurrence from the Laboratory Manager. The analysis plan will be the controlling document, with respect to scope and approach of the work. The analysis plan will include, at a minimum, the objectives, scope of work, safety considerations, and data requirements.

3.3.4 Schedule

A detailed schedule shall be developed by the Laboratory Manager and approved by the Requester. The schedule shall allow adequate time for review and approval of requirements, preparation for the analysis, and delivery of the sample. The schedule of other work and maintenance activities will be reviewed and potential conflicts shall be addressed by the Laboratory Manager.

3.3.5 Sample Delivery

The sample delivery date will be determined on a case-by-case basis. An agreed-upon delivery date shall be captured as a milestone in the schedule. The Requester shall provide detailed handling instructions prior to delivery of the sample, including handling hazards, cleanliness, and storage requirements. The sample shall be secured within the laboratory, unless directed to provide another means of storage.

3.3.6 Preanalysis Review (If Required by Laboratory Manager or Requester)

The Laboratory Manager or Requester may request a Preanalysis Review, which is typically required for off-nominal situations or for hazardous operations that are outside of the experience base of the laboratory. The Preanalysis Review will include the Laboratory Manager, Requester, Chemical Hygiene Officer (if chemicals are used in the analysis), and Safety Engineer. The Preanalysis Review will include the following:

- Review of the analysis plan, procedures, and other required documentation
- Facility readiness
- Confirmation that controls are in place to mitigate risks or hazards identified in the Hazard Analysis

Approval to proceed with the operation is granted by the Laboratory Manager.

3.4 Analysis Phase

Following receipt of the sample(s), the Laboratory staff will complete the materials analysis.

Inputs: Laboratory receives sample(s)

Activities: Laboratory begins materials analysis

Outputs: Materials analysis completed

3.4.1 Anomalies

When analysis anomalies occur, the Requester shall have the authority to decide whether to continue, based on results, or whether the activity should be terminated when objectives cannot be met.

3.4.2 Change Request

Changes to the scope of the analysis shall be approved by the Requester. Deviations that result in a major change to the scope of the analysis may require a delta requirements review or a change to the cost and schedule. Changes should be coordinated through the Laboratory Manager.

3.5 Closeout Phase

Data shall be delivered to the Requester within 10 business days following completion of analysis. The Requester shall notify the Laboratory Manager upon receipt of the data. Acceptance of the data concludes the activity.

Inputs:	Materials analysis completed
Activities:	Facility returns sample to Requester
	Laboratory Manager delivers data to Requester
Outputs:	Requester accepts data
	Requester completes Customer Feedback form

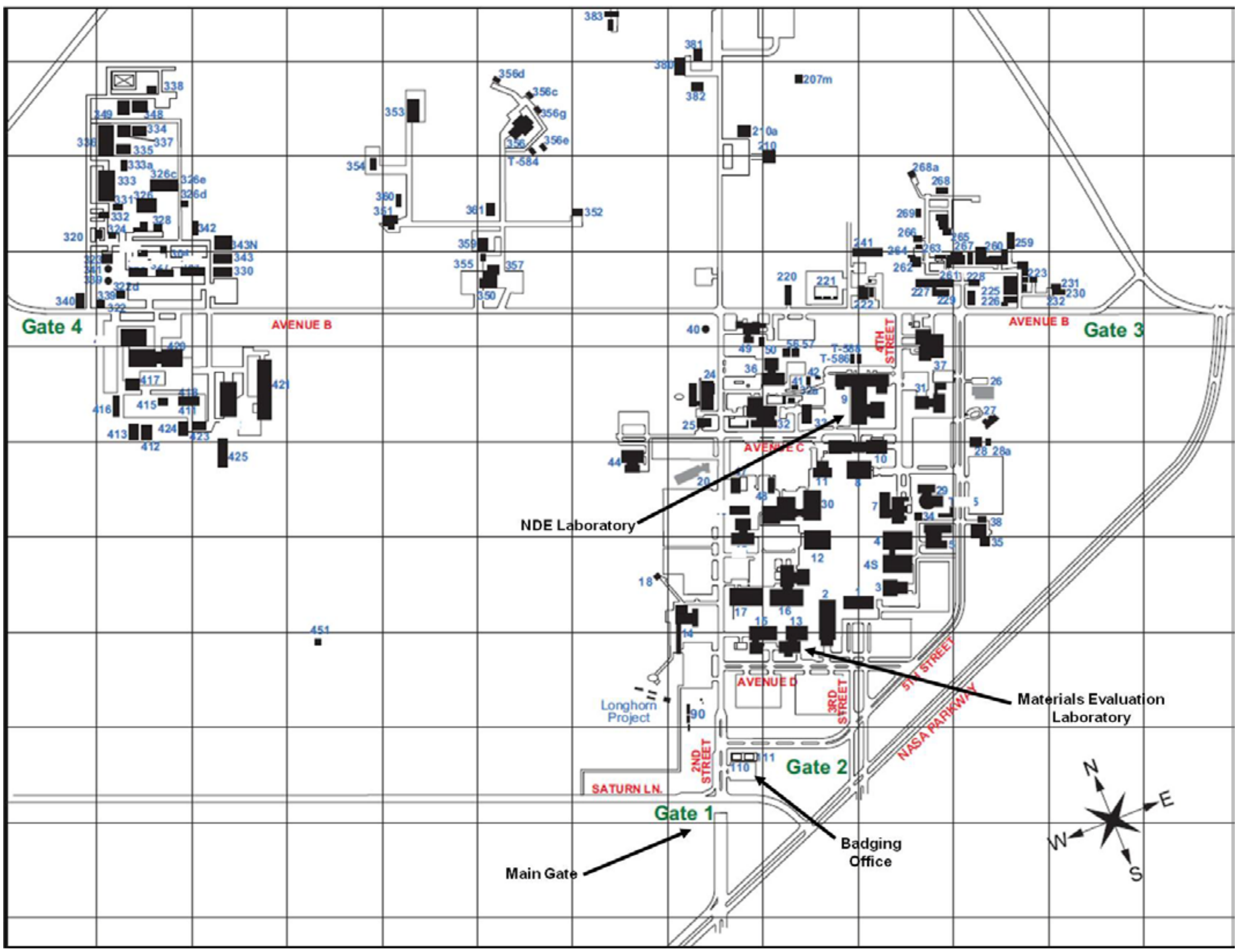
3.5.1 Customer Feedback

The MEL and NDE Laboratory request feedback from our customers. Evaluation of the services we provide enables continued improvement to our process. A Customer Feedback form is included in Appendix C. You are encouraged to complete the Customer Feedback form and return it to the Laboratory Manager, following receipt of the data. Your participation is greatly appreciated.

4.0 Facility Access

Identification badges are required for all persons requiring access to JSC. The Laboratory Manager or designee will initiate a badge request for all Requester personnel who require access to the MEL or NDE Laboratory. Badge requests must be submitted at least 4 days prior to the visit to prevent badge processing delays. Badge requests for non-U.S. citizens may require a minimum of 30 business days to process. Requester personnel shall arrive at JSC Building 110 to pick up temporary identification badges. Visitors to JSC must show a current picture identification (valid driver's license, U.S. passport, government ID card).

The MEL is located in JSC Building 13. The NDE Laboratory is located in Building 9. Visitors must be escorted at all times. Safety glasses are required at all times inside the high bay of Building 9 and in the MEL in Building 13. Safety glasses will be provided to visitors. Closed-toe shoes are required during normal laboratory operations.



5.0 Roles and Responsibilities

Laboratory Manager – The primary interface between the laboratory and the Requester. The Laboratory Manager has overall responsibility for all phases of the analysis process.

Laboratory Staff – One or more individuals responsible for performing the materials analysis per the requirements defined by the Requester.

Requester – The client requesting materials analysis or testing. The Requester is responsible for defining the requirements and providing authorization to proceed.

Technical Expert – A representative of the Requester with thorough knowledge of the requirements. The Technical Expert also is responsible for approving the analysis plan, verifying that objectives are met, and approving change requests.

Chemical Hygiene Officer – Reviews the MSDS and the analysis plan and participates in the Preanalysis Review for off-nominal situations or for hazardous operations that are outside of the experience base of the laboratory.

Safety Engineer – Reviews the Hazard Checklist to identify any additional hazards that could result in injury to personnel.

Responsibilities Matrix

Item	Requester	Laboratory
Materials Analysis Request	Create	Review
Cost and schedule	Approve	Create and sign off
Hazards	Identify hazards	Create Hazard Analysis
Test plan (optional)	Review and approve	Create and sign off
Pretest review (if required)	Approve	Conduct and approve
Analysis	Approve requested deviations	Perform analysis
Provide test data/results	Notify Laboratory Manager of data receipt	Deliver to Requester
Review test data/results	Approve	
Shipping	Provide instruction	Execute per request

Acronyms

3D	Three-Dimensional
AET	Array Eddy Current Testing
ARES	Advanced Rheometric Expansion System
CT	Computed Tomography
DMA	Dynamic Mechanical Analysis
DR	Digital Radiography
DSC	Differential Scanning Calorimetry
EBSD	Electron Backscatter Diffraction
EDS	Energy Dispersive Spectrometer
	Energy Dispersive Spectroscopy
ET	Eddy Current Testing
FEG	Field Emission Gun
FIR	Flash Infrared
FTIR	Fourier Transform Infrared
FTP	File Transfer Protocol
GC-MS	Gas Chromatography Mass Spectrometry
IR	Infrared
JSC	Johnson Space Center
LFA	Laser Flash Apparatus
MAR	Materials Analysis Request
MEL	Materials Evaluation Laboratory
MSDS	Material Safety Data Sheets
MT	Magnetic Particle Testing
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation
NDT	Nondestructive Testing
PAET	Phased Array Eddy Current Testing
PAUT	Phased Array Ultrasonic Testing
PT	Liquid Penetrant Testing
Py-GC-MS	Pyrolysis Gas Chromatography/Mass Spectrometry

RF	Radio Frequency
RT	Radiographic Testing
SDD	Silicon Drift Detector
SEM	Scanning Electron Microscopy
STEM	Scanning Transmission Electron Microscopy
Tg	Glass Transition
TGA	Thermogravimetric Analysis
TGA-MS	Thermogravimetric Analysis Mass Spectrometry
UT	Ultrasonic Testing
UV-Vis-NIR	Ultraviolet Visible Near Infrared
VP	Variable Pressure

Appendices

A. Laboratory Equipment

B. Materials Analysis Request Worksheet

C. Customer Feedback

Appendix A Laboratory Equipment

Nondestructive Evaluation Laboratory

Real-Time X-Ray

The microfocus X-ray system permits image magnification up to 200 times, providing an inspection capability for a variety of applications. Projects that have benefited from real-time X-ray have ranged from electronic component inspection through light metal alloy flaw detection, where the material thickness can be up to 60 mm.

X-Ray

The NDE Laboratory has four X-ray machines and two radiation protection enclosures. The high voltage range of these machines can be varied from 7.5 kV to 300 kV. This capability allows the X-rays to penetrate a great distance and provide readable film results from low-density composite materials and aluminum and steel products.

Computed Tomography (CT) – Creates three-dimensional (3D) reconstructed images used for volumetric evaluation and reverse engineering.

Digital Radiography (DR) – A nontraditional film radiography technique that converts radiation energy into immediate digital images.

Standard film radiography – A chemically processed film used to inspect hardware.

Fluorescent Dye Penetrant

Fluorescent dye penetrant is used as a technique for detecting surface cracks in nonporous, nonmagnetic, and ferromagnetic materials. The material is cleaned, etched, and sprayed with a fluorescent green solution. This solution will wick into the cracks and, after treatment with a developer, will produce a bright green color under a fluorescent light, pinpointing the surface flaw.

Flash Infrared (FIR) Thermography Testing

FIR thermography testing induces a brief pulse of light used to heat the surface of a sample, while an infrared (IR) camera records changes in the surface temperature. As the sample cools, the surface temperature is affected by internal flaws that obstruct the flow of heat into the sample.

Infrared Thermography Testing

IR thermography testing is a noncontact method of measuring the thermal energy emitting from an energy source.

Eddy Current Inspection

Eddy current inspection refers to the use of an electromagnetic transducer placed on the surface of the test object. A variety of probes and frequencies are employed to vary the depth of penetration into the material. This technique detects debonding, voids, cracks, and other anomalies in metallic, nonferrous materials.

Phased Array Eddy Current Testing (PAET) – A contact surface/slightly subsurface inspection method that is primarily used on thin nonferromagnetic material, consisting of several coils within a shoe to cover large surface areas.

Conventional Eddy Current Testing (ET) – A single coil surface/slightly subsurface inspection method used to inspect small areas, including radii, bolt holes, and critical dimensions.

Laser Shearography

Laser shearography provides full-field, noncontact, nondestructive testing of a wide range of composite materials and bonded structures. Shearography is an optical video strain gauge, and an appropriately applied stress is used to locate strain concentrations caused by internal defects.

Shearography allows for a noncontact inspection of complex materials and geometries for deformation and strain during loading. The system is well suited for measuring 3D deformation and strain of actual components under static or dynamic loads. The ARAMIS system measures 3D deformation, using stereo high-resolution video cameras or high-speed video cameras.

Ultrasonic Inspection

Ultrasonic inspection, by definition, uses sound wave frequencies too high for the human ear to hear. Ultrasonic testing usually employs mechanical vibrations at ultrasonic frequencies from 0.1 to 25 MHz. The type of transmitter/receiver used for ultrasonic testing is usually an electromechanical transducer that converts energy into electrical energy and back. As with the eddy current testing technique, ultrasonic testing detects debonding, voids, cracks, and other anomalies below the surface of the material.

Phased Array Ultrasonic Testing (PAUT) – A contact subsurface inspection method that utilizes several piezoelectric transducers within a single shoe to create C-scan images on small metallic hardware.

C-Scan Ultrasonic Testing (UT) – A noncontact inspection method used to inspect large-scale metallic and nonmetallic materials, generating a C-scan image map.

Conventional UT – Standard contact UT used on small hardware with transducers ranging from 0.125- to 1.0-inch diameter.

Scanning Electron Microscopy (SEM)

The SEM Laboratory possesses two scanning electron microscopes. One SEM is fitted with a Shottky Field Emission Gun (FEG) and the other with a Cold FEG as the source of electrons. Both SEMs offer resolution down to 1 nm at 15 kV. The Shottky FEG SEM also has the added capability of operating at Variable Pressure (VP). Both SEMs are fitted with Energy Dispersive Spectrometers (EDSs). The Shottky FEG SEM EDS has a Silicon Drift Detector (SDD), which permits count rates in excess of 300,000 cps.

Additionally, the SEM Laboratory possesses two plasma sputter coaters and a thermal deposition chamber for depositing conductive films (Pt, Au/Pd, C) on samples for SEM preparation.

Metallography Laboratory

The Metallography Laboratory contains cutting saws, specimen preparation presses, polishing wheels (manual and automated), hardness testers, upright and inverted optical microscopes, an optical comparator, and a photography studio. The main function of this laboratory is failure analysis, where a broken part is documented with digital photos in the as-received condition, and a section of the material is cut into a manageable size and mounted in a resin disk. The disk is polished to a mirror finish that can be analyzed for grain size, flaw detection, and coating thickness in the metallograph. The hardness testers determine the hardness of a metallic sample, and the optical comparator can measure larger samples to 0.0005 inch precision.

<u>Hardness and Microhardness Testers</u>

The hardness tester performs Rockwell A, B, and C and Superficial N and T at 15, 30, and 45 kg loads. The microhardness can be performed on the Vickers and Knoop scales with 25, 50, 100, and 200 gm loads.

<u>Automatic Mounting Press</u>

The 1.5-inch diameter mounts can hold an approximately 1.25-inch specimen.

<u>Automatic and Manual Grinding Wheels</u>

These grinding wheels are capable of polishing both mounted and unmounted samples to a mirror finish.

<u>Cutoff Machines</u>

The Exotom cutoff wheel is used for larger samples (approximately 1 sq. ft), depending on thickness, and the small diamond cutoff wheels are used for smaller samples.

<u>Low Power Optical Microscopy</u>

Stereoscope capabilities range from 8X to 50X with digital photo capturing capability. Digital optical microscopy ranges from 25X to 5000X with photo capturing capabilities. The optical comparitor includes 10X, 50X, and 100X.

<u>Digital Photography</u>

Digital photography is capable of capturing overall sample views at low magnifications.

Polymer Laboratory

Electromechanical Load Frame

The Polymer Laboratory has the capability to perform tensile, lap shear, and compressive testing of materials and structural components at elevated or cold temperatures using electromechanical load frames and an environmental chamber.

Specifications

Parameter	Value
Load Capacity	35,000 lb_f
Actuator Capacity	1,000 – 20,000 lb_f
Stroke Range	± 2″
Temperature Range	–300 – 800 °F

ASTM Methods

The Polymer Laboratory has the capability to perform extensive ASTM methods for polymer/composite properties including, but not limited to, the following:

ASTM Standard	Test Method
C297/C297M	Flatwise Tensile Strength of Sandwich Construction
C364/C364M	Edgewise Compressive Strength of Sandwich Constructions
C365/C365M	Flatwise Compressive Properties of Sandwich Cores
C393/C393M	Core Shear Properties of Sandwich Constructions by Beam Flexure
D2344/D2344M	Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
D3039/D3039M	Tensile Properties of Polymer Matrix Composite Materials
D3171	Constituent Content of Composite Materials
D3410/D3410M	Compressive Properties of Polymer Matrix Composite Materials with Unsupported
D3518/D3518M	In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a 645° Laminate
D5379/D5379M	Shear Properties of Composite Materials by the V-Notched Beam Method
D6415/D6415M	Measuring the Curved Beam Strength of a Fiber-Reinforced Polymer-Matrix Composite
D6484/D6484M	Open-Hole Compressive Strength of Polymer Matrix Composite Laminates
D6641/D6641M	Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture
D7028	Glass Transition Temperature (DMA Tg) of Polymer Matrix Composites by Dynamic Mechanical Analysis (DMA)

ASTM Standard	Test Method
D7078/D7078M	Shear Properties of Composite Materials by V-Notched Rail Shear Method
D7249/D7249M	Facing Properties of Sandwich Constructions by Long Beam Flexure
D7250/D7250M	Practice for Determining Sandwich Beam Flexural and Shear Stiffness
D7264/D7264M	Flexural Properties of Polymer Matrix Composite Materials
D7291/D7291M	Through-Thickness “Flatwise” Tensile Strength and Elastic Modulus of a Fiber-Reinforced Polymer Matrix Composite Material
D7332/D7332M	Measuring the Fastener Pull-Through Resistance of a Fiber-Reinforced Polymer Matrix Composite
D7336/D7336M	Static Energy Absorption Properties of Honeycomb Sandwich Core Materials
D695	Compressive Properties of Rigid Plastics
D792	Density and Specific Gravity (Relative Density) of Plastics by Displacement
D3418	Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
D5083	Tensile Properties of Reinforced Thermosetting Plastics Using Straight-Sided Specimens
D6272	Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending
D5229/D5229M	Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
D2240	Rubber Property - Durometer Hardness
SACMA SRM-1	Supported Compression (Modified ASTM-D-695)

ARAMIS 3D Image Correlation Photogrammetry

The ARAMIS software uses the principles of photogrammetry that allows full-field displacement and strain measurements. The system requires spraying high contrast dot patterns onto a sample, which is tracked in ARAMIS by thousands of correlation areas known as facets. The center of each facet is the measurement point that can be thought of as a 3D digital extensometer. An array of these extensometers forms an in-plane strain rosette. The facet centers are tracked in each successive pair of images, with accuracy up to one-hundredth of a pixel.

Hardness Testers for Polymers and Elastomers

The Shore A and D hardness tester is for the softer polymers and elastomers.

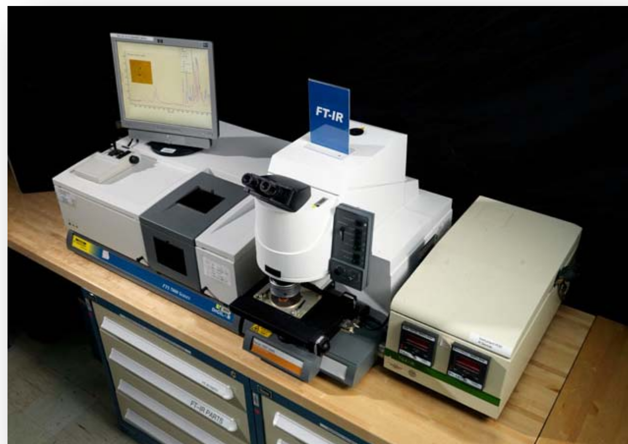
Humidity Chamber

The humidity chamber is a 32-cubic-foot working space used to create an environment that accelerates corrosion. Temperatures range from –100 °F to 375 °F.

Salt Fog Chamber

The salt fog chamber has an internal capacity of 30 cubic feet, with a temperature of 95 °F and 5% NaCl fog.

Analytical Chemistry Laboratory



Fourier Transform Infrared (FTIR) Spectrometer

The FTIR spectrometer is an instrument that measures the IR absorbance of a material in the range of 500 to 4000 cm^{-1}. The absorbance pattern obtained can be compared with a database of over 67,000 reference standards (e.g., polymers, lubricants, adhesives, waxes, oils, sealants, plasticizers, elastomers) in order to identify the sample's material.

Ultraviolet Visible Near Infrared (UV-Vis-NIR)

The UV-Vis-NIR measures the absorption properties of materials within the wavelength range of 200-3200 nm. The system utilizes a dual beam configuration and both a tungsten and deuterium lamp. The system is capable of handling both liquid and solid samples. A spectral reflectance accessory can replace the standard cuvette holder and allows for reflectance measurements, which can be utilized to determine film thickness of solid samples. This system also allows for inert gas purging for samples that may be sensitive to air. An additional component is the flow cell system, which enables chemical reactivity to be measured.

Pyrolysis Gas Chromatography/Mass Spectrometry (Py-GC-MS)

The pyrolyzing unit, a necessity for solid samples, can heat a sample to 1400 °C. The mass analyzer can detect organic molecules/fragment ions up to 800 amu. The resulting fragmentation pattern of a substance can be compared with results stored in a database that includes most known organics with mass under 500 amu.

Pyrolysis Gas Chromatography Ion Trap Mass Spectrometry

Analysis of trace-level contaminants can be performed by our Pyrolysis-GC-Ion Trap MS system. The Ion Trap instrument has a mass range up to 1000 amu and a detection level well below one microgram. The instrument can be used to desorb volatiles and semivolatiles and pyrolyze solids at temperatures as high as 1400 °C to fully characterize the composition of materials. Our instrumentation allows for the pyrolysis under both inert and reactive atmospheres.

Differential Scanning Calorimetry

Differential Scanning Calorimetry (DSC) is performed on an instrument that can detect changes in state (melting points) and determine the glass transition (Tg) of polymers. This unit measures changes in heat flow with respect to temperatures from subambient to 800 °C.

Rheometry

The Advanced Rheometric Expansion System (ARES) rheometer is a mechanical spectrometer that is capable of subjecting samples to both a dynamic or steady shear strain deformation and measuring the resultant torque produced by the sample in response to this shear strain. ARES can measure a multitude of properties in viscoelastic materials in a temperature range of –150 °C to 600 °C.

Thermogravimetric Analyses Mass Spectrometry (TGA-MS)

The TGA-MS system provides the ability to measure decomposition as a function of temperature and the ability to identify the gases that are evolved during thermal degradation. This system can detect and identify substances being released during a traditional heating/decomposition experiment.

Thermogravimetric Analysis (TGA)

TGA is a type of testing that is performed on samples to determine changes in weight in relation to changes in temperature up to 1400 °C. Such analysis relies on a high degree of precision in three measurements: weight, temperature, and temperature change. TGA is commonly employed in research and testing to determine characteristics of materials, such as polymers, to determine degradation temperatures and the absorbed moisture content of materials.

Dynamic Mechanical Analysis (DMA)

DMA is a module that will allow the testing of dog-bone shaped composites or threads. This instrument is used to determine tensile properties of composites with respect to temperature. It can measure modulus and damping; information derived includes viscosity, polymer morphology, rate and degree of cure, gelation, and vitrification.

Laser Flash Apparatus (LFA)

The LFA is an analytical instrument capable of providing information on the thermal properties of materials. Under standard operations, the instrument is capable of providing the thermal properties of materials at temperatures ranging from cryogenic (-125 °C) to extremely elevated (1100 °C). In addition these properties can be measure in air, under inert gas, or in vacuum.

Portable Solar Reflectometer

LPSR 300 is a delicate and sophisticated optical instrument that allows nondestructive measurement of surfaces. The instrument performs measurements in the spectral range of 250 nm to 2800 nm and determines the solar reflectance properties (ά) of surfaces or coatings of material samples. These measurements can be useful in calculating the thermal behavior of surfaces.

Emissivity

The ET 100 is a delicate and sophisticated optical instrument that allows nondestructive infrared measurement of surfaces. The instrument performs measurements in the spectral range of 2.5 to 30 micrometers (microns) and determines the emittance (ε) of surfaces or coatings of material samples. These measurements can be useful in calculating the thermal behavior of a surface.

Surface Area Analyzer

This system provides surface area and porosity measurements through physisorption or chemisorption of inert gases or carbon monoxide.

Raman Spectroscopy

Raman spectroscopy is another characterization tool found in the MEL. This technique can be used for chemical identification and stress measurements through the observation of vibrational modes within the material. The system utilizes laser excitations of 785, 633, and 514 nm, providing greater probing capabilities. The system also provides mapping and depth profiling capabilities.

Appendix B Materials Analysis Request Worksheet

Requester Information

Technical POC:	Contact Information (Phone, E-mail, Address):

Objectives

Purpose of Test/Analysis:	
Proposed Test Start Date:	Critical Test Start Date:
Describe Material(s):	

Handling Requirements

Cleanliness Level:	Controlled Access:
Special Moving/Handling:	

Additional Information

List any other information pertinent to this request:

Drawings

We can accept files through an FTP site, by e-mail, or via standard mail.

1. E-mail drawings to leslie.j.schaschl@nasa.gov.
2. Laboratory Manager will send invitation to NASA File Transfer Protocol Site to upload and send files.
3. Mail drawings to National Aeronautics and Space Administration, Attention: Leslie Schaschl, Mail Code: ES4, Lyndon B. Johnson Space Center, Houston, Texas 77058.

Hazard Checklist

A hazard analysis statement is required for any of the following applicable attributes of any of your provided material.

Hazard	Y	N	Comments
Explosives	☐	☐	
Peroxide Forming	☐	☐	
Flammable Compressed Gas	☐	☐	
Inert Compressed Gas	☐	☐	
Toxic Compressed Gas	☐	☐	
Flammable Liquids	☐	☐	
Flammable Gases/Vapors	☐	☐	
Combustible Liquids	☐	☐	
Flammable Solids	☐	☐	
Auto-ignition Temperature	☐	☐	
Oxidizer	☐	☐	
Organic Peroxides	☐	☐	
Poisonous/Toxic Materials	☐	☐	
Airborne Contaminants	☐	☐	
Infectious Substances	☐	☐	
Radioactive Materials	☐	☐	
Corrosive Materials (Acids, Bases, Organic or Inorganic)	☐	☐	
Reactive/Incompatible Materials	☐	☐	
Environmentally Hazardous Substances	☐	☐	

Appendix C Customer Feedback

TEST CUSTOMER FEEDBACK			
Product (Title):		**Facility:**	
File Number:	**Laboratory Manager:**	**Completion Date Req.:**	

		Yes	No
STATUS:	Were you able to obtain status in a timely manner?	○	○
ATTITUDE:	Did our employees convey a helpful and friendly attitude?	○	○
QUALITY:	Was the quality of the product or service received satisfactory?	○	○
CONVENIENCE:	Was it convenient to do business with our organization?	○	○
COMMUNICATION:	Did we furnish helpful advice and listen to your concerns?	○	○

Comments on "No" Answers:

SCHEDULE:	Poor **1**	**2**	**3**	**4**	Excellent **5**	**N/A**
1. Was the work initiated and completed to meet your requirements?	☐	☐	☐	☐	☐	☐
2. Were we able to accommodate your requested schedule changes?	☐	☐	☐	☐	☐	☐
COST:						
3. Was the work performed within the estimated budget?	☐	☐	☐	☐	☐	☐
4. Was the work cost reasonable for the work performed?	☐	☐	☐	☐	☐	☐
PRODUCT:						
5. Was the provided analytical data accurate?	☐	☐	☐	☐	☐	☐
6. Was the data provided to you in an acceptable format and a timely manner?	☐	☐	☐	☐	☐	☐
EQUIPMENT:						
7. Did our equipment capability meet the needs of the requirements?	☐	☐	☐	☐	☐	☐
8. Was the equipment reliable during the work?	☐	☐	☐	☐	☐	☐
TEAM:						
9. Did you find the team helpful and knowledgeable in meeting your objective?	☐	☐	☐	☐	☐	☐
10. Would you consider using us for future work?	☐	☐	☐	☐	☐	☐
OVERALL:						
How would you rate our service overall?	☐	☐	☐	☐	☐	☐

What was one thing that we could change or do differently to provide better service?

Customer Name and Organization:

Return to: Laboratory Manager, Leslie Schaschl (leslie.j.schaschl@nasa.gov)