Statement of Work
Noncontact Video Extensometer

Introduction

Creep is the slow deformation of a material due to an imposed load. For the purposes of this work, it involves the tensile elongation of metallic samples tested at temperatures between 200°C and 1650°C for periods of time ranging from one hour to five years or longer. During that time the samples will deform at minimum rates between 10^{-3} inches per inch per second (s^{-1}) for the shortest tests to $<10^{-11}$ s^{-1} for the longest tests. The total strain (change in length divided by initial length) will be between less than 1% and 25%.

Long-term, creep testing at the NASA Glenn Research Center has shown a need for an improved methodology for measuring the specimen elongation. Currently, optical cathetometers, Linear Variable Resistors (LVRs), Linear Variable Differential Transformers (LVDTs) and encoders are utilized to make such measurements, but operator-to-operator and unit-to-unit variation along with poor resolution sensitivity lead to large amounts of error and inconsistency in the measurements. This translates into a poor assessment of the true creep response of the material and requires many man hours to acquire the desired data. A better, automated method for acquiring creep data is required.

As a general guideline, a typical creep test is outlined below. It is meant as a guide to help the Offeror understand the general elements and flow of a creep test and is not meant to be all inclusive.

Prior to testing two fiduciary marks are placed on the sample. Typically these are small indents, scratches or holes. Yttria paint and platinum wire flags have also been used. The distance between the fiduciary marks varies depending on the length of the reduced gauge section, but they are typically between 0.5 inches and 1.5 inches apart. The distance is measured to precisions of 0.001" using an optical comparator, micrometers, calipers or other similar devices.

A sample is loaded into a vacuum chamber. The vacuum chamber is evacuated. The sample is heated by a high temperature resistance furnace, typically tungsten, molybdenum or tantalum. To improve heating and reduce the heat flux to the chamber walls the heaters and sample are surrounded by heat shields. A load is applied to the sample to introduce a tensile stress along the length of the sample. The sample slowly elongates or stretches due to creep.

The vacuum chamber has a window to observe the sample. A slit or gap in the heater and heat shields allows a limited but unobstructed view of the sample. Currently an optical cathetometer is used to measure the displacement between the two fiduciary marks.

In addition, LVRs. LVDTs and encoders located on the load train are used to measure the total elongation of the sample. These measurements are less accurate, but data acquisition can be automated for continuous, frequent recording of the displacement during the test.

The test continues until the sample reaches a predefined length of time, a predefined elongation, or breaks in two.

The data collected are used to plot creep strain against time. A typical creep curve for a copper-based alloy is shown in Figure 1.

Upon loading the load train moves significantly as the slack is taken out of the system. After the initial application of the load, the sample undergoes a rapid creep regime called primary creep. These two phenomena are highlighted in Figure 1b. Primary creep continues until the sample stabilizes and enters a constant creep rate regime called the secondary or steady-state creep regime.

During steady-state creep the creep curve is a straight line and has the minimum creep rate (strain per unit time). This straight portion is used to calculate the steady-state creep rate. The steady-state creep rates are typically 10^{-3} to $<10^{-11}$ s^{-1} (10^{-1} to $<10^{-9}$ percent per second) depending on the material and test conditions.

Finally the sample can undergo an increasing creep rate as the sample necks (decreases cross-sectional are) and becomes unstable. Tertiary creep can be either a slow, gradual change or a sudden, rapid transition. While it is desirable to capture as much of the details of the third stage creep as possible, it may not be possible. The other measurement techniques currently in use will be the primary data source to capture this information.

Additional information on creep and creep testing can be found in metallurgical references such as **Physical Metallurgy Principles, Second Edition** by R.E. Reed-Hill (Nostrand Co., New York, NY, 1973, pp. 827-887)) and **Mechanical Metallurgy, Principles and Applications** by M.A. Meyers and K.K. Chawla (Prentice-Hall, Englewood Cliffs, NJ, 1984, pp. 659-687).

Figure 1a – Typical Creep Curve

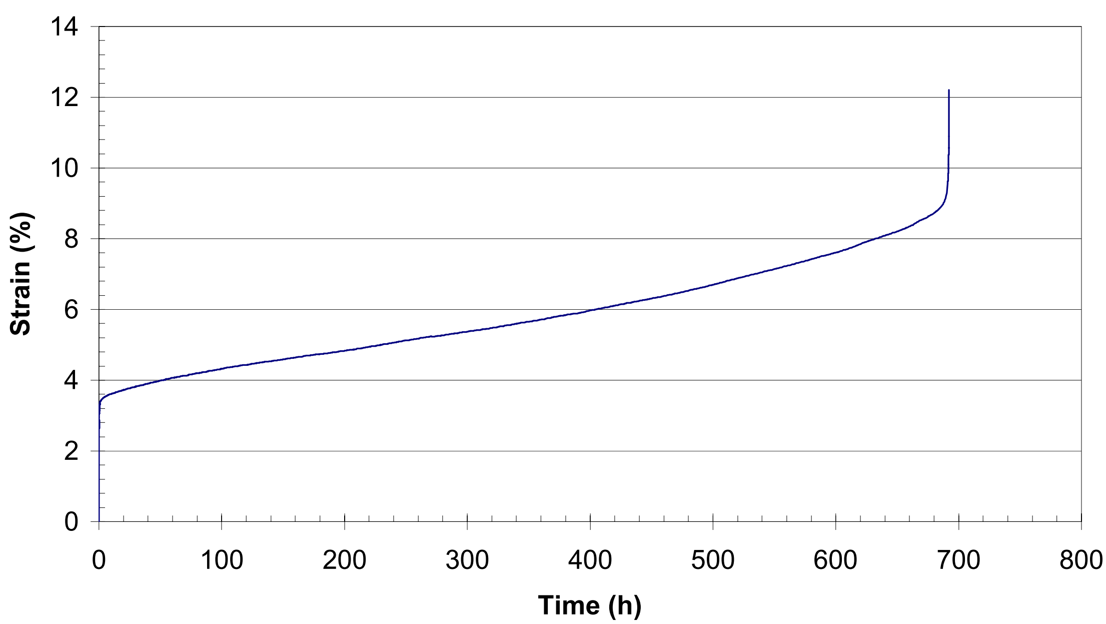
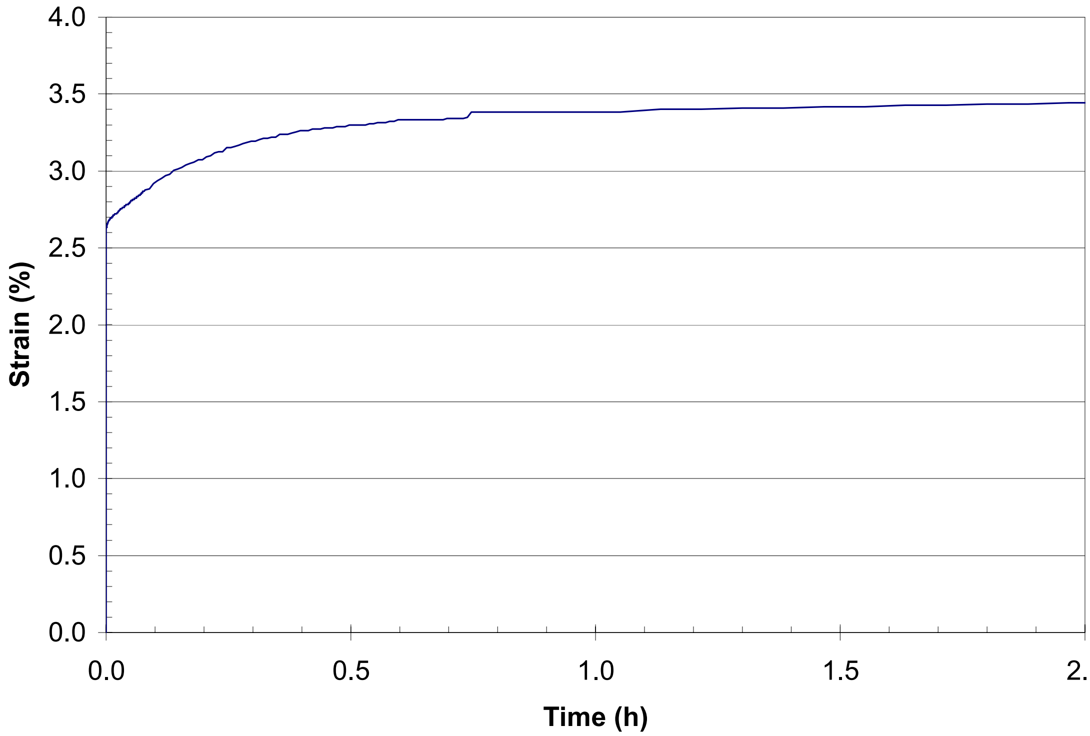


Figure 1b – Detail of Initial Loading (Primary Creep)



System Requirements

The Offeror shall be solely responsible for providing a complete system for measuring the strain of a sample undergoing creep. The system will consist of all software and hardware required to meet the specifications for measuring the strain of the sample. The Offeror shall also provide in writing any exceptions taken to these specifications and any options that they have or requirements that they can meet.

Under the Base Contract the Government shall purchase two systems for evaluation. The period of performance for the Base Contract shall be six (6) months after receipt of award. Under Options I through V up to four more systems may be purchased during a period up to one year after the receipt of the Base Contract systems. Under Option VI an additional on-site training session may be purchased within one year after receipt of the Base Contract systems.

General Operating Conditions

1. The system shall operate at an ambient room temperature between 70°F and 80°F. The systems shall also have the ability to withstand a sixteen hour excursion to an ambient room temperature of 110°F without failure of the system in the event of loss of air conditioning. The system shall not be required to take accurate readings above 80°F, but no component shall fail at the elevated room temperature.

2. The samples will be tested between 200°C and 1650°C. Below 650°C it is expected that external illumination will be required during the test. Between 650°C and 800°C illumination may or may not be required based upon the light sensitivity of the camera. Above 800°C it is expected that the thermally induced incandescence (glowing) of the sample will provide sufficient illumination. At the highest temperatures an iris, neutral density filter, welding glass or other method of limiting the light reaching the camera sensor will be required for the test.

3. The window and chamber temperature will vary by the type of creep unit. Those with actively cooled chambers (Brew, TM-4 and VCR) will remain between 65°F and 80°F. Those that are uncooled (UHV) will have chamber and window temperatures as high as 200°C and vary by testing temperature. The camera and illumination will be mounted to the window of the cooled chambers. The camera and illumination will be placed on a table or other independent support for the uncooled chambers.

4. The specimens being tested shall be a mixture of flat specimens, typically from sheet or plate, and round specimens, typically taken from round bars, thick material and components. The system shall be capable of dealing with both types of samples through a combination of software, camera and lens.

5. 120V, 208V and 440V power is available. Additional facilities such as cooling water and shop air may be made available upon request, and other facilities may be available if required. However, it is currently not anticipated that the systems will require anything besides power.

Software Requirements

The software shall be responsible for interrogating the cameras, determining the distance between the fiduciary marks, and recording the displacement, strain and elapsed time. The software may be a single program running on a single computer or it may be subdivided into multiple programs or applets designed to run on dedicated hardware or separate computers. It shall be solely the Offeror's responsibility to determine the optimal configuration.

The software shall meet the following requirements:

1. The software and user interface for the system shall be written in Simulink and/or the MatLab programming environment and designed for real time data acquisition and real time / near real time data display.

2. All frame grabbing features shall be supported by the dynamic link libraries (DLLs) and drivers contained within the programming environment.

3. The frame grabber shall be capable of a minimum frame rate of 1 frame per second (fps). A frame rate of 10 fps or greater is desired but not required for focusing and other activities where real time images are beneficial.

4. The software shall support at least four cameras corresponding to four separate, independent tests to be connected to the system. It is desirable but not required to

develop software and a complete system capable of controlling and acquiring data for up to twenty-five (25) tests simultaneously.

5. The system shall be capable of allowing the user through the user interface to manually calibrate the initial distance between the fiduciary marks (L_o) through the software. The calibration shall allow the user to enter a distance between the fiduciary measured prior to the test and calculate a conversion factor for translating pixels into inches. The conversion factor shall be stored in the text file with the other data.

6. The system shall be capable of performing real time measurements of the distance between the fiduciaries.

7. The system shall calculate the strain associated with the displacement using the formula $\varepsilon = \frac{L_i - L_o}{L_o}$ where L_o, L_i and ε are the initial gage length, instantaneous gage length and calculated strain, respectively.

8. The system shall continuously stream the measurements collected to a text file recorded on a hard drive or other nonvolatile memory device. The measurements shall consist of the time elapsed, the distance between the fiduciary marks and the calculated strain at a minimum. The text file shall have a format suitable for importation into Microsoft's EXCEL spreadsheet program, e.g., comma separated, tabbed or otherwise suitably delimited. To ensure that the data is not lost due to file corruption, at least one backup version of the file corresponding to the last set of data readings shall be retained on the hard drive as well.

9. It shall not be acceptable to store the data collected in RAM only. The data must be retained in the event of an extended loss of power to the system.

10. The software through the user interface shall easily allow the user to select the location for storing a data file and to uniquely name the data file. Data file names entered by the operator shall follow the Microsoft Windows naming conventions including name length unless the Offeror specifically requests an exception.

11. The system shall have five operating modes – focusing, calibration, startup, normal and termination.
    a. In the focusing mode the software shall dedicate all required resources to a single camera so that the image from the camera is displayed upon the screen at the highest frame rate and largest size possible. In this mode the user shall focus the camera on the fiduciary marks without recording images or taking data from the camera. No data from the remaining cameras shall be required to be collected, but it is desirable that it be. This mode shall be operable multiple times during a test so that the focus can be adjusted during testing as needed.
    b. In the calibration mode the software shall provide an image of the sample with the centroids or other features used to calculate the distance between the fiduciary marks superimposed. The operator shall be allowed to enter a distance between

the marks in inches to calibrate the test. The calibration shall be done at room temperature and shall require illumination.

c. In the startup mode the software shall dedicate all required resources to a single camera and acquire data at a rate of one (1) data point per second. No data from the remaining cameras shall be required to be collected, but it is desirable that it be.
d. The software shall allow the user to define the duration of the startup mode through the user interface. Typically this duration is five to ten minutes, but it could last up to one hour or more if the engineer wishes a very well defined initial creep deformation (primary creep).
e. The startup mode shall be able to be terminated by the user at any time through a manual input such as clicking on a button in the user interface. The software shall confirm that the user wishes to terminate startup mode. During the time required to confirm termination the software shall continue taking data at one data point per second.
f. After the startup mode is completed or terminated by the user, the software shall automatically switch to the normal mode.
g. In the normal mode the system shall be capable of independently acquiring data from one to four cameras at regular intervals ranging from one image every five (5) seconds to one image every twenty-four (24) hours as defined in paragraph 13 and Table 1 below.
h. Termination mode shall be manually initiated through a user input such as clicking on a button in the user interface to terminate the test. The software shall confirm that the user wishes to terminate the test prior to entering termination mode.
i. In termination mode the user shall be asked to enter a comment up to 255 characters in length through the user interface. After the user enters the comment the software shall perform all housekeeping and other functions required to store the data to the hard drive and clean up the system in preparation for the next test. The software shall also stop interrogating the camera associated with the test. If the data is stored on a computer system other than the one used for data acquisition, the final data file shall also be sent to the data storage computer, and the file's integrity confirmed.

12. The system shall allow the operator to enter through the user interface the following information during the startup phase prior to starting data collection. The information shall be stored in a text file associated with the test. The file may be the same one used for the data storage during the test or a separate file that is combined with the data file during termination mode as a header for the final data file.
    a. Sample ID (Name, text up to 25 characters)
    b. Material (Name, text up to 50 characters)
    c. Sample description (text up to 255 characters)
    d. Test temperature (°C, number between 23 and 1650)
    e. Test stress (MPa, number between 0 and 1500)
    f. Engineer (Name, text up to 100 characters)
    g. Distance between fiduciary marks (Inches, number between 0.0000 and 1.6000)
    h. Additional comments (text up to 255 characters)

13. The software shall be capable of allowing the user through the user interface to select a time interval between data points for the normal operating mode using radio buttons, drop down menus or a combination of both. These may be accessed through a pop-up menu or secondary screen. The user shall be able to manually switch between different sampling intervals while in normal operating mode. The intervals between data points shall be those given in Table 1 below.

Table 1 – Sampling Intervals

Seconds	5, 10, 30
Minutes	1, 2, 3, 4, 5, 10, 15, 30
Hours	1, 2, 3, 4, 5, 6, 8, 12, 24

14. In normal operating mode, the software shall display images of the captured region used for the measurements to the screen and superimpose markings indicating the location of the centroids or other points on the fiduciary marks used to calculate the distance between the fiduciary marks. When the software is operating in focusing or startup mode the user interface shall not be required to display this information.

15. In normal operating mode, the software shall display a separate near real time graph of strain (Y axis) versus time (X axis) for each test similar to what is shown in Figure 1.

16. In normal operating mode, the software shall display the values for the time (MM-DD-YYYY HH:MM:SS or decimal elapsed time in hours), displacement and strain for the last measurement taken.

17. In startup mode the user interface shall display either a near real time table with at least the last ten data points or a near real time graph so that the operator may monitor the progress of the test and confirm that the data acquisition system is operating properly. Strong preference shall be given during the evaluation of proposals to software that is capable of displaying a graph of all data points collected during startup mode.

18. The software shall allow the user through the user interface to redefine the fiduciary marks. This feature is needed in case the sample surface changes through oxidation or other environmental interaction, the fiduciary marks change sufficiently due to creep deformation that they are no longer recognizable by the software or new features such as cracks appear on the sample surface.

19. The software shall not be required to store images for all data points. However, the software shall be required to allow the user to manually store an image and associated data point by clicking on a button on the user interface or other similar activation method. The captured image shall have the centroids or other features used to calculate the distance between the fiduciary marks superimposed on the image of the sample. The captured image shall be stored in tag image file format (TIFF) format. Lempel-Ziv-Welch (LZW) compression of the image is preferred but not required.

20. The software shall allow the startup of each test independently. The operators shall be responsible for starting up the tests sequentially and not simultaneously. Startup of a test

must be allowed at any time independent of whether any other test is already running in normal mode or not. It shall not be acceptable to require all tests be started at the same time. Likewise it shall be unacceptable to require that all tests be completed before the next test is started. The reasons for these requirements are some test frames will have short tests and require multiple starts and stops over several years while other test frames will have only a single test run during the same time.

21. The software shall allow data acquisition from one to four cameras simultaneously and independently during normal operating mode. It shall be acceptable to delay the data acquisition of one test by up to five seconds if two tests require collection of a data point simultaneously. If more than two tests require data acquisition at the same time additional time up to fifteen seconds total may be added to the time interval to allow sequential data acquisition from multiple tests.

22. Prior to entering startup mode the software shall record a data point for all tests operating in normal mode. The software shall display a message in the user interface indicating it is doing so as well.

23. After startup mode ends the software shall take a data point for any test operating in normal mode that would have taken a data point during the time the system was in startup mode.

24. The software shall inform the operator through the user interface if the fiduciary marks cannot be identified or are otherwise unusable for the measurement. That information shall also be recorded to the text file.

25. The Offeror shall allow the naming of each camera with the name of the associated test frame, e.g., UHV 1, VCR 1, TM-4 and Brew 1. The name of the channel shall be displayed on-screen in such a manner that it is clearly associated with the image, the chart and the control buttons (sampling interval, terminate test, etc.).

26. The Offeror shall document the software and provide detailed operating instructions for performing data acquisition with the hardware and software.

27. The Offeror shall provide the source code and/or Simulink models to the Government along with the compiled, operational version of the software.

Hardware Requirements

The Offeror shall provide the camera, illumination, computer(s), dedicated hardware, cabling and all other hardware required to support the software and perform the required measurements. The hardware shall meet the following specifications.

1. To achieve the desired strain resolution of 0.02% or less, the camera and software combination shall meet or exceed one of the following requirements. Alternative configurations may be proposed, but the Offeror must be able to demonstrate a strain resolution of 0.02% or less. The subpixel interpolation accuracy for any alternative methods shall be taken to be ≥0.1 pixels, the minimum accuracy deemed attainable with

commercial cameras in testing by the Government, for purposes of demonstrating strain resolution. The two options defined by the Government are:

a. The camera shall be capable of acquiring grayscale images at a resolution of 3000 x 2000 pixels (approximately 6 megapixel camera). The software shall be capable of a subpixel interpolation accuracy of 0.2 pixels while operating at a frame rate of 1 frame per second.
b. The camera shall be capable of acquiring grayscale images at a resolution of 5000 x 2000 pixels (approximately 10 megapixel camera). The software shall be capable of a subpixel interpolation accuracy of 0.5 pixels while operating at a frame rate of 1 frame per second.

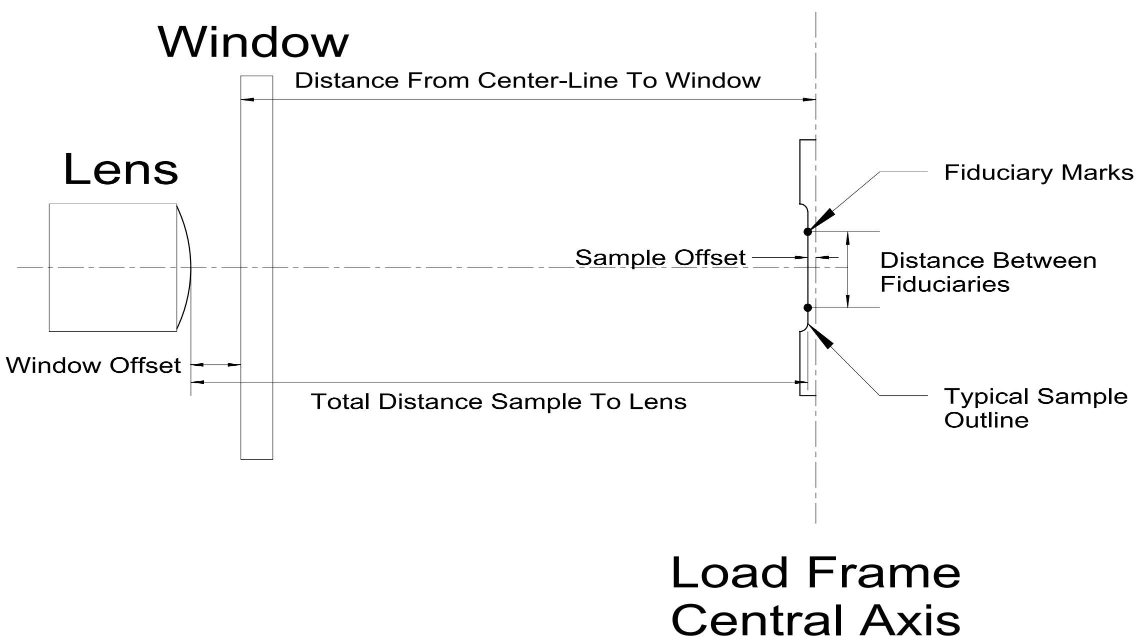
2. The camera shall have interchangeable lenses. The lenses shall use industry standard C- or F-mounts.

3. The lenses shall be able to focus properly at the working distance and have a suitable field of view for the anticipated distance between the fiduciary marks requirements listed in Table 2. Figure 1 provides the definition of the distances. Multiple lenses for a given test frame shall be allowed to meet the requirements for the field of view and focusing requirements.

Table 2 – Distances For Lens Selection

Type of Unit	Center-line to Window Distance (in)	Sample Offset		Window Offset		Total Sample To Lens		Anticipated Distance Between Fiduciaries (in)
		Minimum (in)	Maximum (in)	Minimum (in)	Maximum (in)	Minimum (in)	Maximum (in)	
VCR	7 1/16	1/16	6/16	0	2	6 11/16	9	0.75 - 1.6
UHV	10	1/16	6/16	3	5	12 10/16	14 15/16	0.75 - 1.6
UHV	8 1/16	1/16	6/16	3	5	10 11/16	13	0.75 - 1.6
UHV	8 14/16	1/16	6/16	3	5	11 8/16	13 13/16	0.75 - 1.6
TM-4	7 4/16	1/16	6/16	0	2	6 14/16	9 3/16	0.5 - 1.0
Brew	4 8/16	1/16	6/16	0	2	4 2/16	6 7/16	0.5 - 1.0

Figure 2 – Schematic View Of Test Setup Showing Distance Definitions For Table 2



4. There shall be some variability in the distance between the camera lens and fiduciary marks from sample to sample due to normal variability in machining and positioning the samples in the test frame. Typically the variability shall be ±0.010" or less but may be as large as ±0.025" for a given set of samples. To account for these differences, the Offeror shall provide one or both of the following:
    a. The lenses shall be focusable.
    b. The camera and lens shall move in and out as a unit using a manually operated horizontal translation stage for focusing.

5. The lenses shall have an iris or be able to accept neutral density filters or other filters to reduce the amount of light reaching the camera sensor so that tests at up to 1650°C may be monitored. Multiple lenses based upon the amount of anticipated light may also be provided.

6. The Offeror shall provide illumination for the sample so that the fiduciaries are visible for the room temperature calibration of the fiduciary distance and low temperature testing. The illumination shall be provided by light emitting diodes (LEDs). Incandescent lighting shall not be acceptable due to the duration of the tests and limited life of the incandescent light bulbs.

7. The camera, illumination and lens if it has a tripod mount shall be provided with a ¼"-20 threaded socket or tripod mount for attaching the parts to a mounting bracket. The mounting bracket shall be provided by the Government after receipt of the hardware and custom manufactured for each test frame.

8. The Offeror shall be responsible for determining the requirements for the data acquisition computers used in the system. The computer used for storage, if different from the one used for data acquisition, shall meet the following minimum specifications:
    a. Dual core CPU
    b. 2 GHz or faster CPU
    c. 2 GB RAM or more
    d. 2x 250 GB RAID 1 hard drive array
    e. 17" flat screen LCD monitor or larger
    f. 10/100 Ethernet connection
    g. CD-RW drive
    h. USB 2.0 port easily accessible by user, e.g., front mounted port on CPU

9. The Offeror may choose to provide separate data acquisition and data storage computers. If the Offeror chooses this option, the Offeror shall be responsible for providing all connections between the computers and ensuring that they work over the distances required. A schematic drawing of the laboratory and approximate dimensions are given in Figure 3. Figure 3 also gives the envisioned clustering of the test frames for each system.

10. Determination of the locations of the equipment within the laboratory shall be done in consultation with the Government to ensure that the equipment does not present a safety

issue (tripping, blocked access, etc.) or would be subjected to unusual conditions (high heat area, high vibration area, etc.).

11. The Offeror shall document all hardware supplied and provide operating manuals, software drivers and everything else required to operate the hardware.

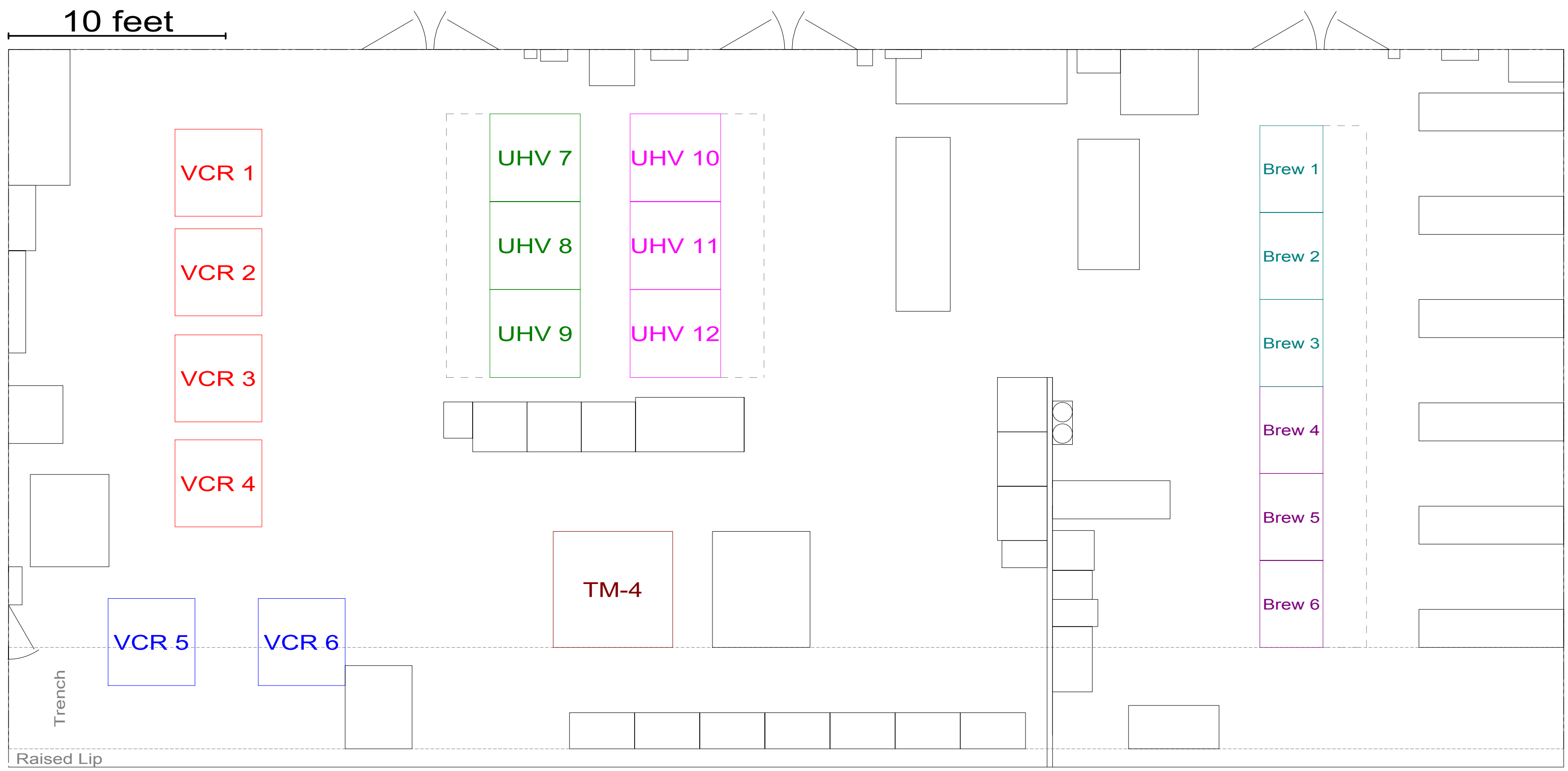
12. For purposes of this solicitation, the Offeror may assume that the fiduciary marks are one of the following:
    a. A Vickers or Knoop microhardness indent between 0.0004” to 0.010” along the major axis
    b. A scratch mark as large as 0.010” wide and the width of the region of interest
    c. A hole going through the sample up to 0.015” in diameter
    d. A drop of ceramic (yttria) paint up to 1/8” diameter
    e. A platinum wire up to 0.010” diameter attached to the sample that may either be on the sample surface or sticking off to one side as a flag

13. The ability to use other sizes and shapes of fiduciary marks shall be considered a substantial benefit when evaluating the proposals.

14. The Offeror shall provide either mounting hardware to attach the computer systems to the test frames in some manner or stand-along stands to hold the computer systems.

15. The Offeror shall provide an uninterruptible power supply (UPS) for each computer sized to provide 15 minutes of operating time. The UPS shall not be required to provide power to the camera, illumination and other hardware unless interruption of the power to these components will adversely affect the system, e.g., the computer system will lose contact with the camera and not be able to re-establish it when the power returns. Current infrastructure upgrades should limit unscheduled power outages to no more than 15 minutes, so automatic shutdown of the computers when the UPS batteries become low is not required but remains desirable.

Figure 3 –105 Vacuum Creep Test Laboratory Layout



Potential groups of test frames indicated by color
Large immovable objects indicated by outlines

Training and Support

1. The Offeror shall provide ninety (90) days of telephone support for the software and hardware after delivery of the systems.

2. The Offeror shall provide up to three (3) days of on-site support to activate the systems and train the technicians in its use.

Option I through V – Additional Systems

After evaluation of the first two systems, the Government may choose to purchase up to five additional systems. Options I through V shall each consist of one full system (software and hardware) as defined by the Base Contract. No training shall be provided, but fifteen (15) days of telephone support will be provided. The Government shall exercise these options between three (3) months and twenty-four (24) months after receipt of the first two systems under the Base Contract. The Government may exercise the options individually or as groups. Options I through V shall be exercised independent of Option VI.

Option VI – Additional Training

In the event that additional training is desired, the Government may choose to purchase one (1) additional day of on-site training at NASA Glenn Research Center. The option shall be exercised between three (3) and twelve (12) months after receipt of the Base Contract computer systems. Option VI shall be exercised independent of Options I through V.

Deliverables

Base Contract

Within six (6) months after award of the Base Contract, the Offeror shall deliver two complete systems under the Base Contract. The systems shall include all software and hardware needed to successfully conduct creep testing, full software and hardware documentation, source code and/or software models, and ninety (90) days of phone support.

In addition the Offeror shall provide within ninety (90) days of receipt of the systems up to three (3) days of on-site support at NASA Glenn Research Center including up to eight (8) hours of training for a small group of technicians and engineers (probably eight people or less) who shall be conducting the creep testing.

Options I through V

Within ninety (90) days of exercising Options I through IV the Offeror shall deliver one complete system with all software and hardware needed to successfully conduct creep testing. Any updates to the software and hardware from the Base Contract systems shall be fully documented. Up to fifteen (15) days of phone support shall be provided.

Option VI

The Offeror shall provide up to eight (8) hours of on-site training at NASA Glenn Research Center for up to eight (8) people (technicians and engineers) conducting creep testing using the systems.

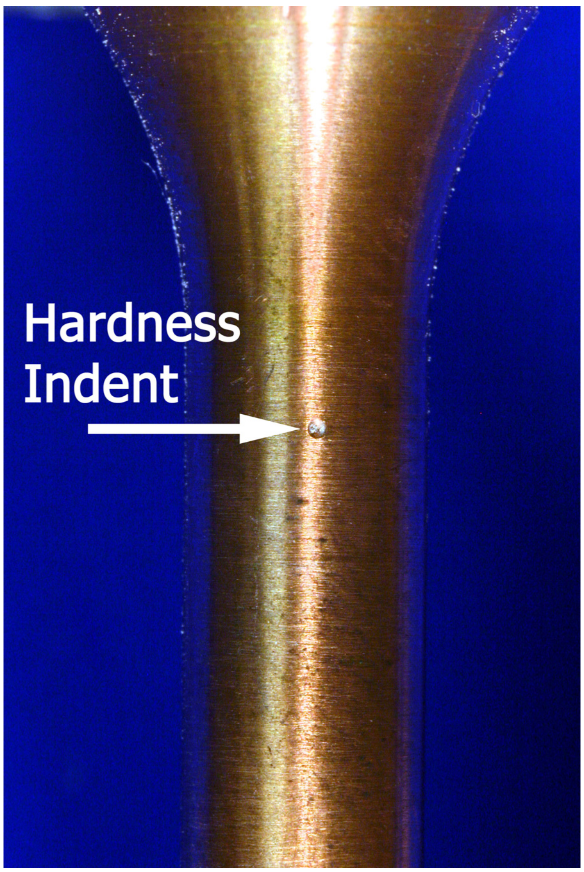
Additional Information

On Site Meetings

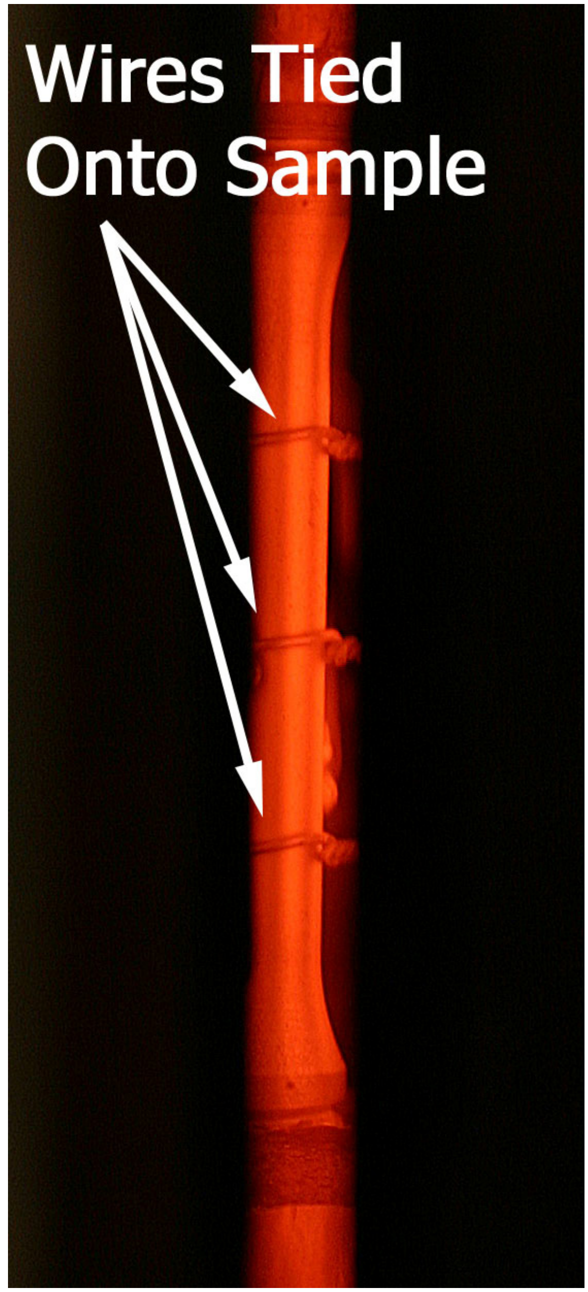
The Offeror may request one or more meetings at NASA Glenn Research Center to inspect the test frames, discuss the current creep data collection methods and needs, and oversee installation and startup of the systems beyond the requirements of the Base Contract. The Government shall attempt to schedule such meetings as quickly as possible and provide the requested access to equipment and information. On site meeting attendees shall normally be limited to US citizens. Foreign nationals including Green Card holders will require a minimum of six (6) weeks and probably more to attain clearance to enter NASA Glenn Research Center and shall not be included in on-site meetings without at least eight (8) weeks notice to the Government.

Images Of Potential Fiduciary Marks

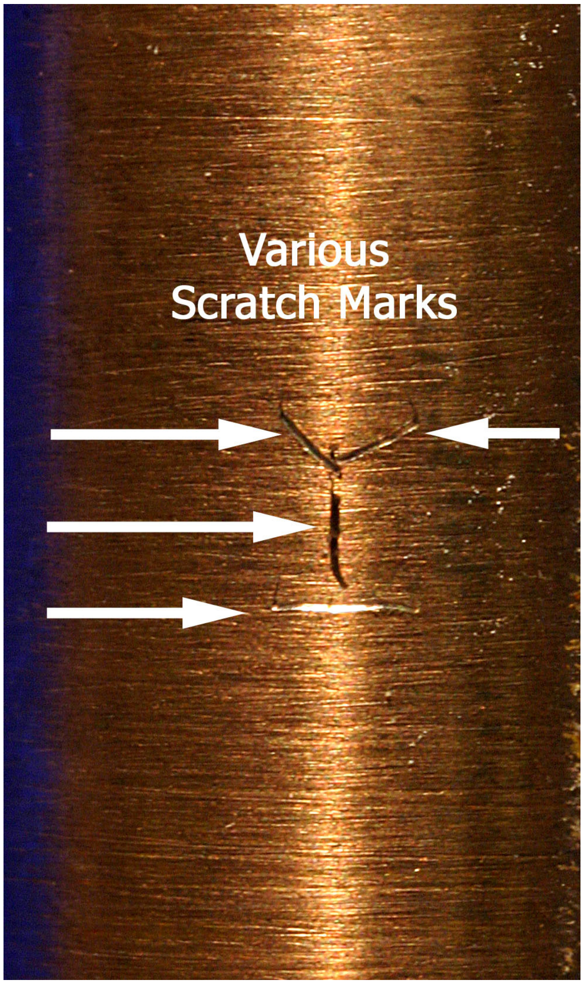
Images of potential fiduciary marks when available are provided for reference. Actual fiduciary marks will vary to some degree and may change with time during the test due to oxidation, cracking, deformation and other factors.



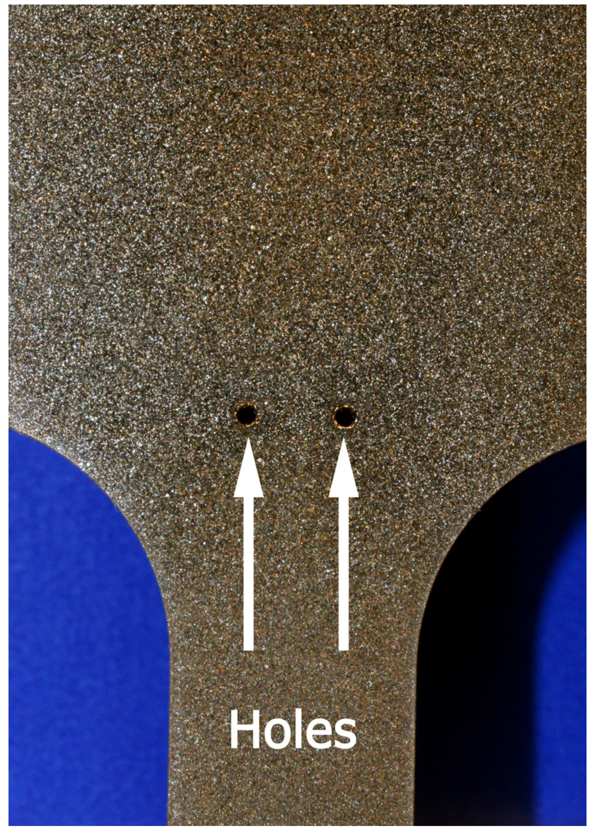
Hardness Indent



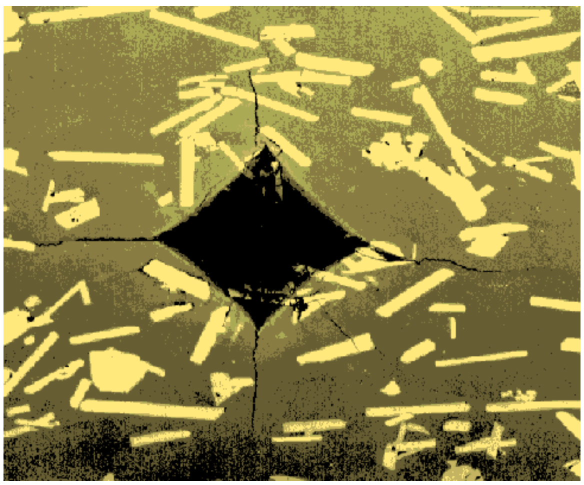
Wire



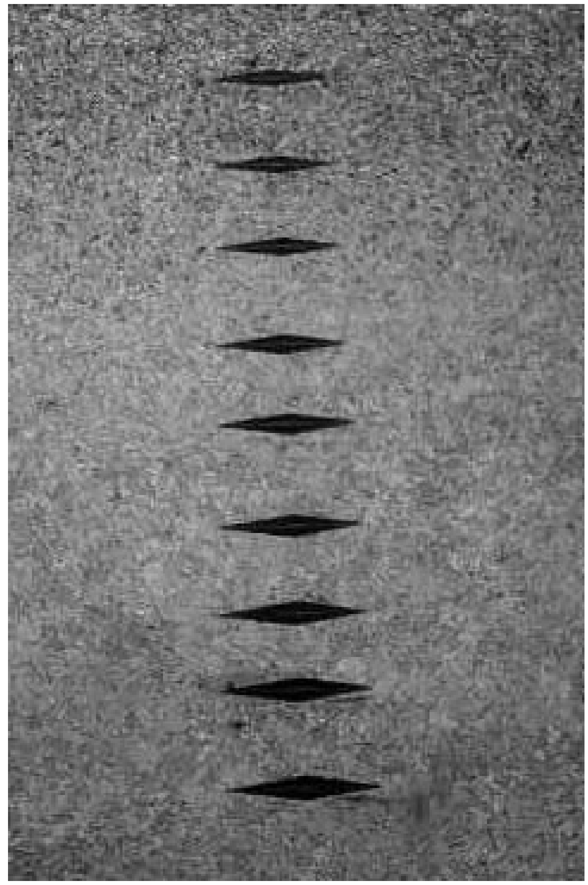
Scratch Marks



Hole



Vickers Hardness Indent
(Note cracking of sample due to indentation)



Knoop Hardness Indent

Prototype Optical Extensometer Test Beds

Two prototypical optical extensometer units have been designed and built by NASA Glenn Research Center using commercial off the shelf hardware and software where possible to demonstrate the technical feasibility of the optical extensometers and the ability to achieve the desired strain accuracy. These test beds were successfully operated in a manual data acquisition mode. Both used the MatLab programming environment for data acquisition and all calculations. Upgrades and changes are required to allow real time data collection, an improved and standardized user interface and improved hardware-software interfaces, so these test beds should be taken only as showing that the goals of the Base Contract are achievable with commercial off the shelf (COTS) hardware and MatLab, not as the expected hardware and software for the new optical extensometers.

Manual Noncontact Video Extensometer System 1 – TM-4 Optical Extensometer

The system consisted of the following components:

Dell Dimension 3000 with Pentium 4 CPU, 1 GB RAM
Matrox Meteor II frame grabber
Silicon Imaging SI-6600-RGB-CL 6.6 megapixel video camera using CameraLink
Navitar TV Zoom – Zoom 7000
Metaphase Technologies FL201-R Red LEDs (x2)
Metaphase Technologies SS120DC-2 dual DC power supply

Manual Noncontact Video Extensometer System 2 – UHV Optical Extensometer

The system consisted of the following components:

Dell Dimension 3000 with Pentium 4 CPU, 1 GB RAM
Silicon Imaging SI-6600-M-CL 6.6 megapixel video camera using Firewire
Navitar Macro Zoom 18-108mm f/2.5

Test Frame Images

Four types of test frames are used in the 105 Vacuum Creep Lab. Images of each unit and their windows are given below for reference. Images of the TM-4 camera unit and optical cathetometer unit used for the VCR, UHV and Brew test frames are also included.

In addition images of round samples being tested in a Brew unit are provided to show the approximate view of the samples during testing. While the details vary from unit to unit, all have a small slit in the heater that makes the sample visible in the window. An example of an illuminated specimen undergoing creep testing at 500°C is provided for reference of what is required for calibration at room temperature prior to testing and low temperature testing.

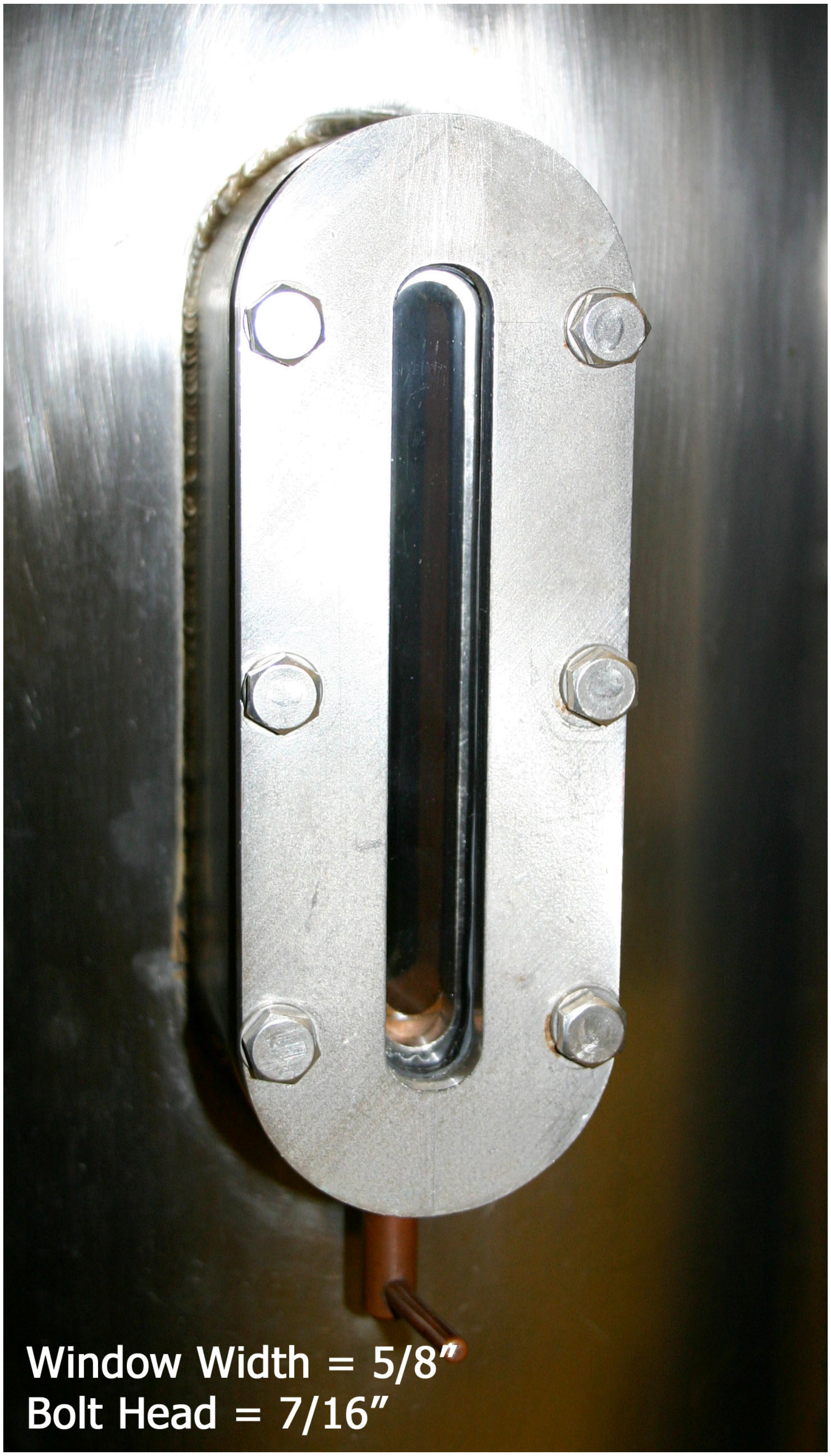
TM-4

Test Frame Overview

Heater

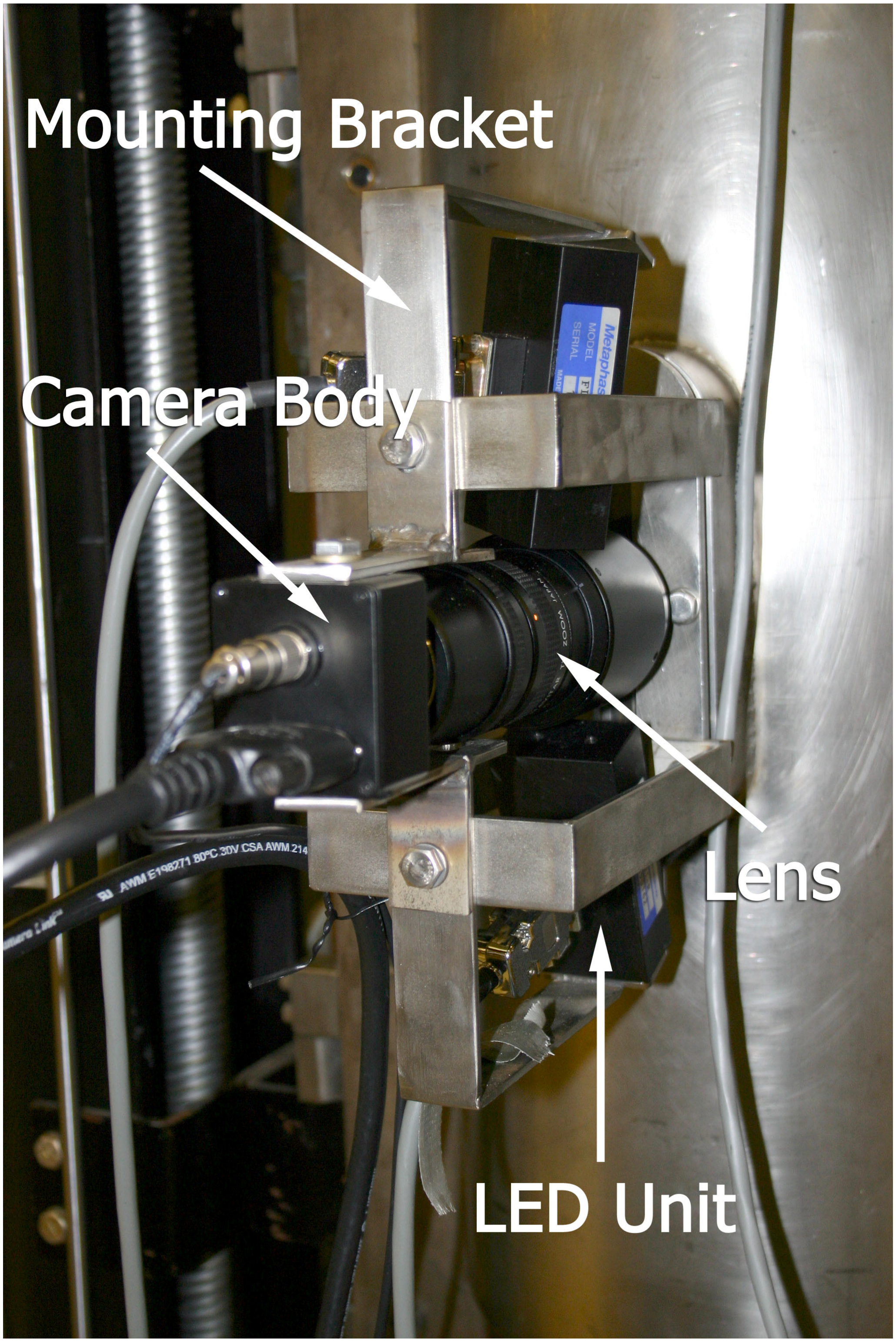
Heat shields removed for clarity of showing the approximately ¼" wide slit in the heater.

Window



The chamber and window size is the same for the VCR units.

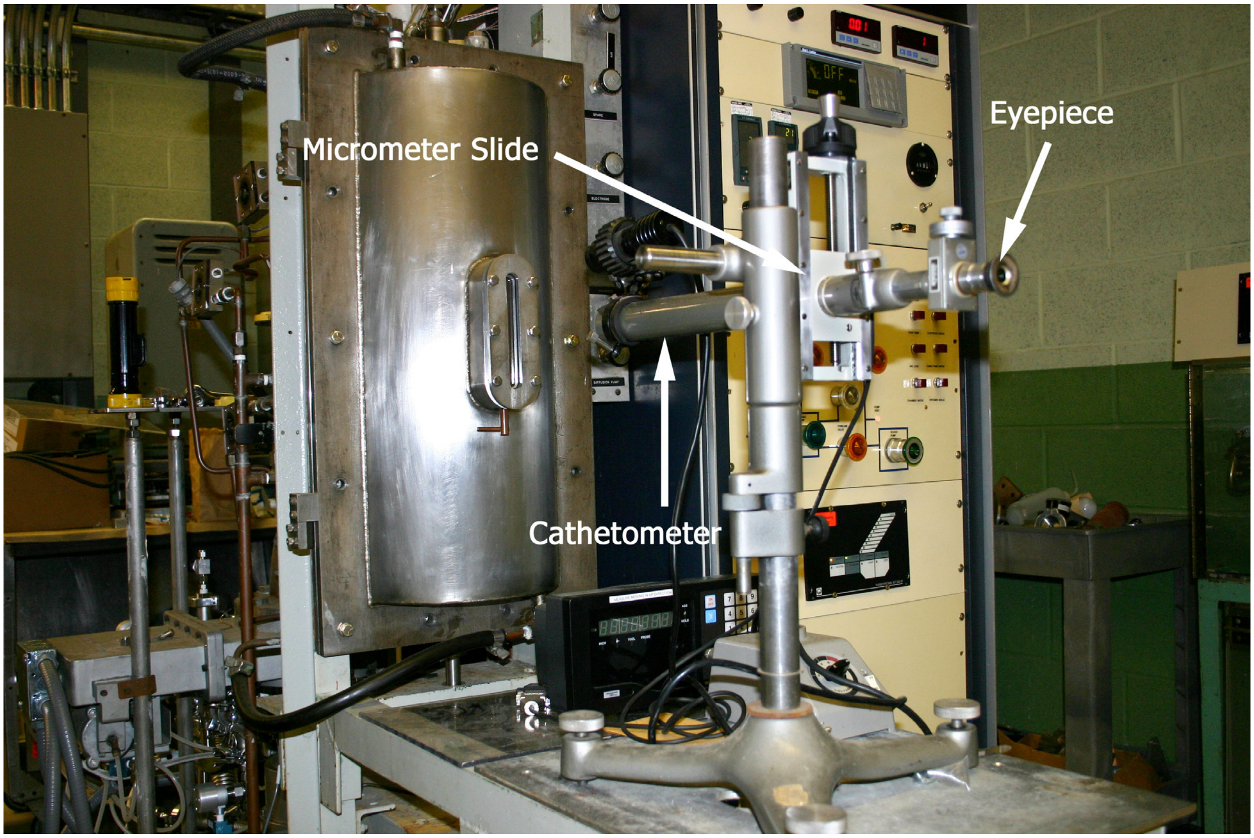
Current Manual Optical Extensometer Camera And LED Illumination



VCR

Test Frame Overview

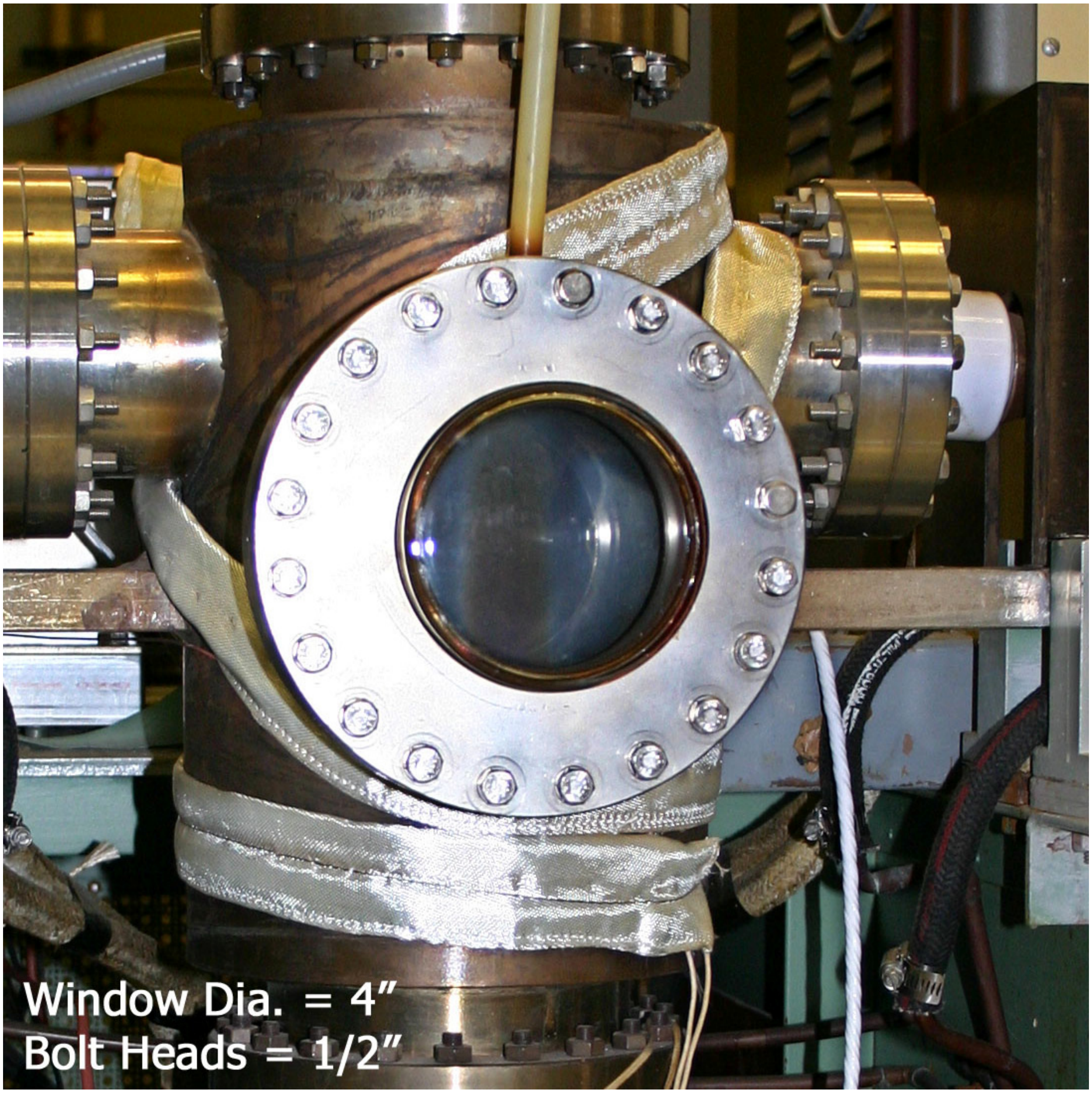
Manual Optical Cathetometer System



UHV

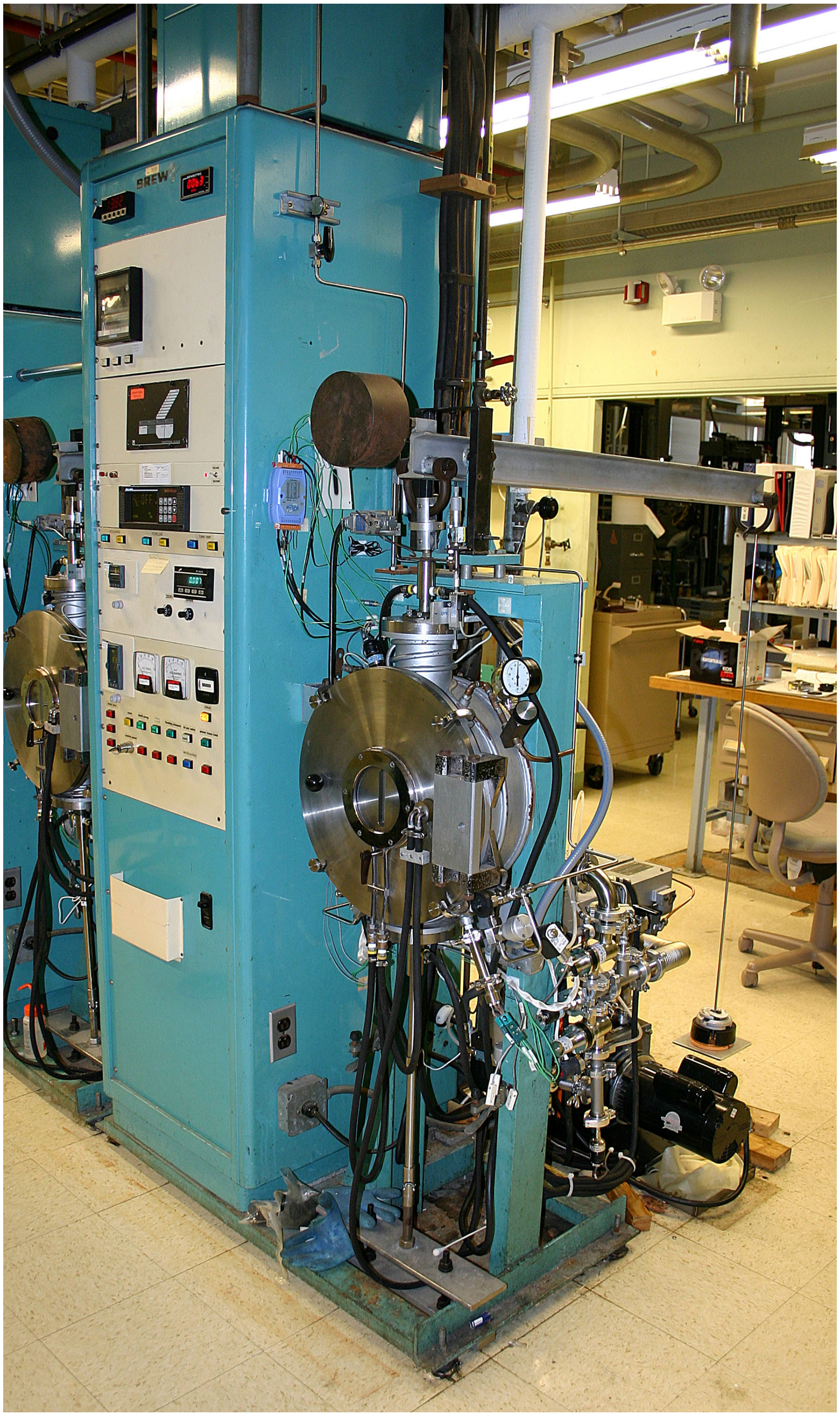
Test Frame

Window

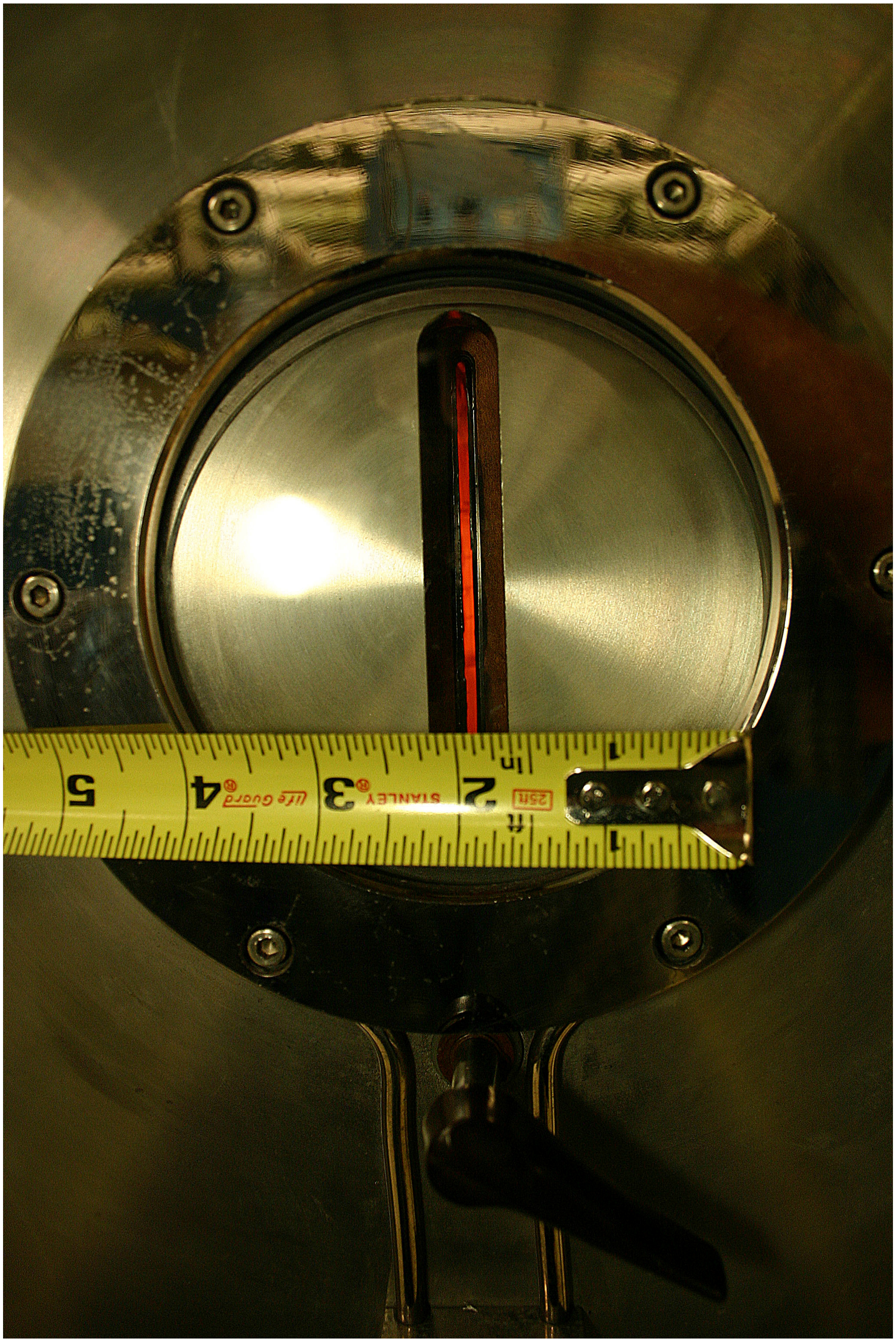


Brew Unit

Test Frame Overview

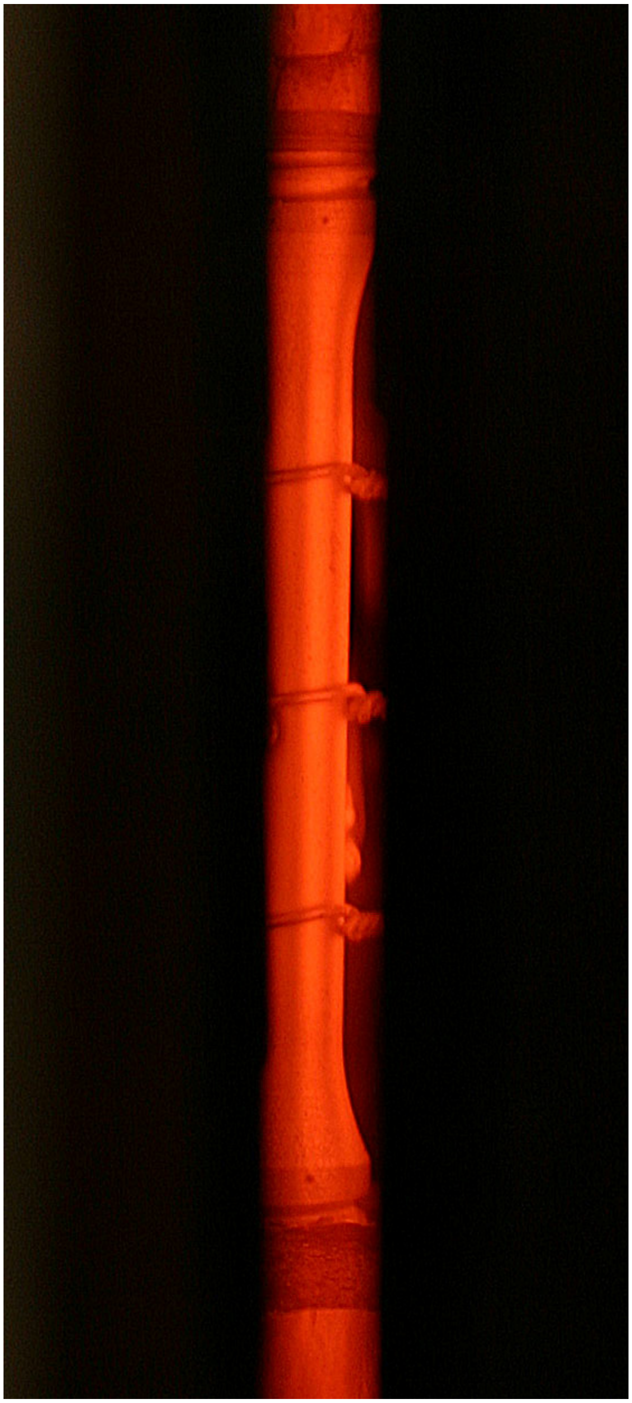


Window

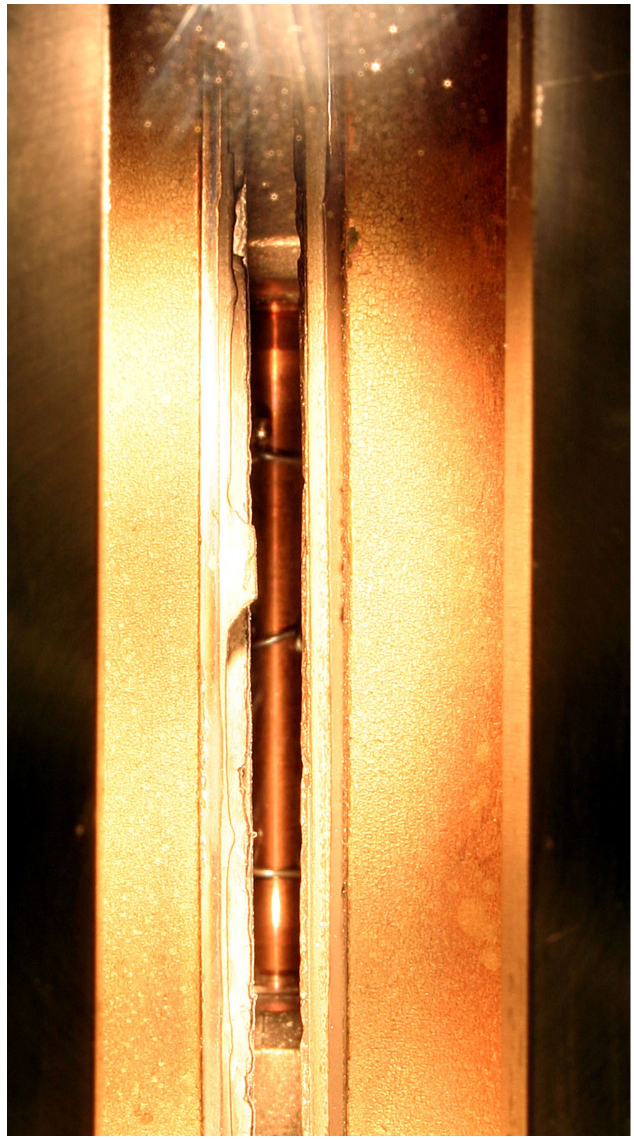


Slit is approximately 1/8" wide.

Test Specimen At 816°C



Test Specimen At 500°C



500°C sample is illuminated. Otherwise there is insufficient light to view the sample.

The 800°C sample has no external illumination. All light comes from the glowing of the sample and heater caused by incandescence. The phenomenon is the same as an incandescent light bulb filament which operates at a temperature of 2500°C to 3000°C.