# Specifications for Computer Tomography System

## 1) Introduction:

The microtomography (CT) system is a complex system that should provide a great deal of capability to perform diverse analyses. Specifically, it should be a turnkey microtomography petrochemical, oil, gas and core analysis CT system that includes core accommodation, modeling of core structures, petrophysical tune-up/calibration, post-processing data analysis for petrophysics, and training by a system user who has demonstrable skills in performing petrophysical analysis to ensure a seamless integration of data sets and image reconstruction. This multi-disciplined system shall include very high spatial resolution, narrow energy bands and core analysis tuneability. The system shall provide porosity and saturation calculations for a histogram of a single image. The scanner shall provide three-dimensional characterization of core material that can be used as input to property transport simulation models. The system shall also be flexible to accommodate defect analysis.

The microtomology (CT) system is a combination of several different components that need to fulfill the basic requirements that are listed in the following paragraphs to fulfill NRL's needs for volumetric data collection of sediment cores, gas hydrates, polymers, metal welds that have large size and weight ranges while still providing exceptionally high resolution of the imaged material. The basic requirements for the system that it accommodate a range of sizes and provide ultra high resolution and enable the determination void (pore), grain and crack sizes on the order of 10um. It is anticipated that the system be a combined computer tomography and real-time radiography system that consists of a 225mm image intensifier, CCD camera, camera interface, Pentium workstation, an image processor, color image display, multi-axis manipulator with linear drives, video monitoring system, cabling, software, installation, raining, documentaion and a one- year warranty that commences upon completion of installation. The system shall have the capability to provide both single-slice images and volumetric images of up to 100 slices in a single rotation.

## 2) Specifications:

1) The CT shall be able to accommodate objects up to 25cm and 50 kg in a horizontal orientation and 15cm and 20 kg in a vertical orientation. The CT shall also be able to accommodate objects that are 1-2mm in diameter.
2) CT image slice width shall be variable from at least 10um for the small objects to 10.0 mm for the large objects to successfully image sediment grains and pore spaces as well as larger scale objects such as shrimp and crab burrows. The spatial resolution for objects <5 mm diameter shall be $\leq$10 um, for 10 mm diameter should be $\leq$ 25 um, for 45 mm diameter should be 100 $\leq$ um and for 90 mm diameter should be $\leq$ 200 um.
3) Image display matrix shall be adjustable to 256 squared, 512 squared or 1024 squared for either 8 or 12 bits with a contrast scale of 4096.
4) X-ray system comparable to the Fein Focus FXE-225.50 X-ray System: Operate at voltages of 10-225kV with a current of 0-1mA. The spot size vs. power requirements are 3µm @1.5 watts, 10µm @ 10 watts, 50 µm @50 watts and 100 µm @100 watts. Power requirements should be 230/400 V, 3-phase, and 50/60Hz. This will require a

continuously pumped tube, a roughing pump and a turbo pump, a high voltage power supply, a high voltage cable and a control cable.

5) Simultaneously, the scan time should be relatively quick, on the order of minimum 18 seconds for 500 views, minimum 33 seconds for 1000 views and 60 seconds for 1800 views. Data sampling shall enable up to 2400 views per scan, with up to 4 TV frames per view operating in standard mode to produce 512 samples per view. The data reconstruction shall proceed quickly; a minimum 18 seconds for 512 views in standard mode, minimum 35 seconds for LFOV, minimum 28 seconds for 1,000 views in standard mode and minimum 45 seconds for LFOV, 45 seconds for 2,000 views in standard mode and 130 seconds for LFOV.
6) The Image Intensifier shall have a minimum spatial resolution of 4.4 1p/mm with a quantum detection efficiency of at least 85% at 60 keV monochromatic.
7) The video camera shall be a solid state 2/3" CCD with signal format being NTSC video, having a horizontal resolution of .430 lines and a signal to noise ratio of >43dB.
8) The system shall be built on an optical grade table or equivalent, for precision, stability and to be isolated from vibration. Source and receiver shall be fixed in place with a mechanism to manipulate the core or sample in the space between the source and receiver. Two separate manipulators shall be provided for the core and core holders. One for the vertically aligned cores shall have a horizontal turntable and a vertical slice axis and for the horizontally aligned cores a vertical turntable and a horizontal slice axis. These manipulators shall be adjustable to accommodate objects of maximum size, 25 cm diameter or to enable maximum resolution 10 um.
9) The sample stage shall have a vertical and horizontal travel distance of at least 50 cm, with a feed rate of at least 1 mm/sec and an accuracy of at least 5 um. The Magnification Linear Axes shall provide at least 50 cm travel. This will enable alignment with the x-ray tube and the detector so that position adjustments can be accurately made providing alignment of centerlines, orthogonal rotation axis and level turntable surface.
10) A computer system shall be provided as part of the overall system. The computer system shall be the same as or equal to the following: UNIX Workstation with ISA/PCI Passive Backplane, an industrial Intel Dual Pentium III 850 Mhz CPU with 512 Mbytes of main memory, an 18 Gbyte Hard Drive with a 4.0 Gbyte DAT Tape Drive and a 1.44 Mbyte 3.5" Floppy Disk Drive with Multi-axis servo control board and a camera interface board, an Ethernet Interface and a 1600 x 1280 accelerated display controller. The monitor shall be at a minimum, a 50 cm Multi-sync 1600 x 1280, 70 hz non-interlaced color display.
11) Image processing functions shall enable CT reconstruction, dimensional analysis capabilities, window level/width control and ROI statistics processing, zooming, panning, density profiling, smoothing, edge detection, noise reduction, rotation, registration, subtraction, reverse engineering with spline filtering and IGES format export.
12) The system shall have at a minimum the following safety features; the x-ray system shall have interlocks for the vacuum system, the door for the enclosure and the operator's key switch, warning lights and a horn that are actuated before the x-rays are energized, panel indicator light that provides notification that the "x-rays are on" during x-ray exposure, emergency shutdown switches, and a close circuit TV system to monitor the scan area from a separate location.
13) System installation and testing to provide verification that the system is at operational status.

14) Minimum one-year warranty.
15) Training provided to at least 3 government system managers on the system operation and software.
16) Shipping and installation to the Naval Research Laboratory- Stennis Space Center, MS.
17) Documentation shall be included in the form of operation and maintenance manuals.