THE CENTRE FOR HIGH RESOLUTION TRANSMISSION ELECTRON MICROSCOPY

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A building environment to achieve atomic resolution

All scientific instrumentation has specified environmental operating conditions. In most cases the environmental conditions (within a reasonable range) are in place to protect the sophisticated electrical and mechanical components against damage. However, in the case of instrumentation which is used to measure dimensions at the atomic level (0.1nm), such as an atomic resolution transmission electron microscope (ARTEM), the environmental issues become critical and range of parameters that affect the ideal functioning of the instrument become very narrow. It is therefore clear that, since we are looking at atomic resolution, any parameter which causes a deviation greater than the dimensions of an atom will not be acceptable.

HRTEM rooms are housed within this section with special features

The parameters for the building design which need to be considered are mechanical and acoustic vibrations, air pressure pulses, magnetic fields, stable electrical supply, air flow, air temperature and humidity and stable cooling water.

Mechanical and Acoustic Vibrations:

To limit mechanical vibrations, a room within a room concept is used to satisfy the maximum vibration amplitude of 0.4 micrometre peak-to-peak at a frequency of 5 Hertz. Typical vibrations on a normal laboratory floor will be in the order of 1mm peak-to-peak (two and a half thousand times higher than the maximum vibration amplitude allowed), and will depend on the energy of the ground borne vibrations due to various factors such as passing vehicle traffic. The amplitude of vibration will depend on the energy and frequency of the ground borne disturbance as well as the density of the material in the ground. The room design consists of a large (100 metric tonnes) isolated concrete block on a specially prepared graded substrate. The block is separated by a 100mm air cavity on all four sides and an inner protective wall is built on the block.

The Centre for High Resolution Transmission Electron Microscopy

External acoustic vibrations are limited by an external wall which is surrounded by buffer rooms. Internal acoustic vibrations are limited by the use of acoustic tiles on the walls and ceiling. All noisy equipment such as vacuum pumps, compressors and water chillers are housed in the buffer room and the services are fed through an isolated trench in the concrete floor slab.

Photo of early stages of building site shows the large concrete block which reduces vibrations in the rooms

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NRF National Research Foundation | SAASTA South African Agency for Science and Technology Advancement

Magnetic Fields:

The main source of magnetic fields is the electrical cabling in the room. The variable magnetic fields produced by the electrical conductors cause a deviation in the electron beam within the instrument which results in a distortion of the image. The magnetic fields are eliminated by weaving the live/neutral pairs of electrical conductors.

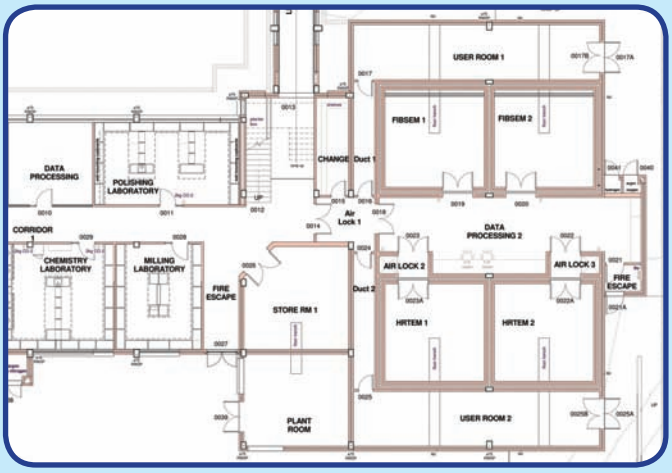
The weaving of live/neutral pairs of electrical conductors

The roof and ceiling material is fabricated from precast concrete panels with the exclusion of any metal reinforcing.

The absence of the metal components in the roof eliminates the possibility of ground induced currents which will result in unwanted magnetic fields. The same reasoning is used to avoid lightning conductors on the roof, which are substituted with lightning towers at strategic positions around the perimeter of the building.

A specified earth value of less than 1.0 Ohm, is achieved by using an independent earth mat for each laboratory. Earth loops needed to be avoided at all costs as they are probably the major cause of poor performance of the instrumentation. The earth mats are protected from lightning strikes using a spark gap arrestor. All earth connections for the microscope and auxiliary equipment are facilitated via the central earth mat connection. All other equipment such as compressors and chillers are earthed via the main building earth. A stable electrical supply is provided by the installation of an uninterrupted power supply (UPS) unit.

Images of the user rooms, housing the noisy auxiliary equipment for the microscopes. The services are fed through a trench in the floor. These are at the back of the microscope labs.



Various factors to limit environmental parameters can be seen in the floor plans

Air Flow, Humidity and Temperature:

Air that enters the laboratory goes through a double process, including filtration. It is important that air flow into the room is limited to 100mm per minute for humidity control and not is used as the primary temperature control. The ideal humidity content in the laboratory should be in the order of 50 - 60%. If the humidity is higher than 60% there is a risk of the dew point condensation of moisture on the electronic components. Working conditions for the operator are not ideal if the humidity levels fall below 50%.

The primary temperature control is maintained by the application of radiant water panels and is specified to provide a control of better than 0.1 degree per hour. Air pressure variation and environmental isolation is maintained through the installation of two airlocks, namely, one unit at the entrance into the microscope section and a second unit into the microscope laboratory. The airlocks maintain the strict internal environmental conditions and isolate the microscopes from any external environmental conditions. The first airlock has special dust removal mats as well as sticky mats used in clean room conditions. A changing room is provided for changing into clean room clothing such as dust free socks, hair covers and overalls similar to the medical staff in an operating theatre.

With thanks to Prof Michael Lee from NMMU for providing the information about the building design. This fact sheet has been reviewed by independent experts and has followed SAASTA's Scientific Editorial Process.