GK Batchelor Laboratory
Laboratory Manual

Issue 2.0
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Overview

Target: All

This manual is intended as a reference and guide for those undertaking or supervising research in the GK Batchelor Laboratory. The manual contains information about the facilities and equipment available within the Laboratory, where to find help and information, standard procedures, issues relating to Health and Safety, and guidance for those preparing grant applications for laboratory work.

This manual is available both electronically (from the 'guidelines' link at http://www.damtp.cam.ac.uk/lab/) and in hard copy. A paper copy is issued to everyone working in the Laboratory when they first arrive, with the requirement that they familiarise themselves with its contents.

Policy summary

In line with the University's Health and Safety Policy, and the Centre for Mathematical Sciences Safety Policy (CMS), the GK Batchelor Laboratory aims to ensure, so far as reasonably practicable, the health, safety and welfare of all staff, students and visitors. Where practicable, by seeking appropriate procedures and safety features, the Laboratory attempts to ensure that the needs of Health and Safety do not hinder the research needs.

Further details of the Policy may be found in §2.

Review

The manual is reviewed and revised on a yearly basis and at such other times as changes in facilities or procedures call for, and laboratory users are expected to be familiar with the most recent issue. Users will be notified when a new version is issued but will not automatically receive a new hard copy. A history of the revision is contained in Appendix E.

Structure

The manual is subdivided into a number of parts. At the start of each part is a brief description, including an indication of who should be familiar with the material it contains. It is important to note that supervisors/PIs/hosts (referred to here collectively as Supervisors) have a responsibility towards their Researchers (*i.e.* students/postdocs/visitors) that requires them to have some familiarity not only with the scientific aspects of their work but also that the necessary health and safety procedures are being followed.

The intended readership is indicated at the start of each section and is summarised in the table below.

Section	Supervisors	Researchers	Technicians	Comments
1 Introduction		Optional		General background
2 Policy	Required	Required	Required	Policy, responsibilities and staff
3 Health & Safety	Required	Required	Required	Risk Assessment and basic rules
4 Research Projects	Required			Guidance for preparation of

				proposals
5 Hazards		Required	Required	Principal hazards, procedures and rules
6 Hi-risk Facilities	If to be used	If to be used	Required	These facilities will only be relevant to a subset of Laboratory users.
7 Electrical Testing		Required	Required	Procedures
8 Equipment		Suggested		Brief details of main items of equipment held by Laboratory.
Appendix A		Required		Induction check list
Appendix B		Required		Risk Assessment form
Appendix C				Temporary Use Card
Appendix D				Density table
Appendix E				Revision history

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1. Introduction

Target: General interest

The GK Batchelor Laboratory combines the cultural inheritance of Sir G.I. Taylor FRS, arguably one of the greatest experimentalists of the twentieth century, with the vision of G.K. Batchelor, DAMTP's founding head. Batchelor began his career under Taylor in the Department of Physics in Cambridge, working closely with experimentalists as he developed his many theoretical contributions to our understanding of turbulence. Although he perceived a great need to bring together into a single department many of those working on the mathematics of a broad range physical problems, he also recognised the critical role experiments played in such research and the huge benefits that could be gained by having a constant, daily interaction between theoretician and experimentalist.

The Fluid Dynamics Laboratory was founded in 1964 as soon as DAMTP moved into its first permanent home in the old University Press buildings (between Silver Street and Mill Lane) in 1964. Since that time the Fluid Dynamics Laboratory has gone from strength to strength. Under its first Director, the late T.B. Benjamin FRS, the Laboratory soon developed an international reputation for its experimental research into fundamental fluid dynamics. The subsequent leadership of J.S. Turner FRS and P.F. Linden, and the world-class research projects undertaken by the many fluid dynamics research groups in DAMTP, have continued this tradition, giving the Laboratory a strong international standing. During the late 1980s and 1990s the Laboratory underwent a number of refurbishments as it gradually expanded to fill the 520m^2 available in the basement of the Silver Street site. Despite the refurbishments, the Laboratory remained plagued by a lack of floor-level drains, cramped conditions and low crumbling ceilings.

Since the current Director, S.B. Dalziel, took over in 1997 the Laboratory has undergone its most radical change. The development of the Centre for Mathematical Sciences in the west of Cambridge led not only to a substantial increase in the office accommodation available to DAMTP, but also provided the opportunity to construct a modern purpose-built laboratory with better services and facilities, and more space. The new Laboratory in CMS, constructed using a combination of charitable donations and funds raised from two large infrastructure grants, increased the available research space to approximately 810m^2. This new laboratory, the GK Batchelor Laboratory, is supported by a new and expanded 120m^2 workshop. Further funding from a variety of sources (principally the Newton Trust and Research Councils) has enabled the new Laboratory to be fitted out with a range of new facilities and enhanced services.

1.1 Activities

The GK Batchelor Laboratory is primarily a research laboratory. Over recent years the research activities have expanded from a base in geological, geophysical and environmental fluid dynamics to include industrially motivated problems, biological fluid dynamics, granular materials, and cellular mechanics. It is anticipated that this range of interests will continue to grow.

The majority of users of the Laboratory are research students, postdoctoral research associates/fellows and University Teaching Officers. The Laboratory also plays host to a steady stream of senior visitors, some of whom return repeatedly to make use of the facilities available, and by project and summer students. The facilities are also used from time to time by members of other departments within the

University, short-term exchange students, and Part III students as part of essay projects.

Teaching activities within the Laboratory are more limited, but have been expanding in recent years. These activities include the annual Geophysical and Environmental Fluid Dynamics Summer School held each September, and fluid dynamics demonstration classes for both Part II and Part III students.

1.2 Personnel

One of the keys to the success of the Laboratory is that it has been able to maintain a critical mass of researchers for the extended period necessary to build up the necessary level of scientific, technical and practical expertise. This section lists those who play a central role in the Laboratory and provides some pointers to where their contribution lies.

1.2.1 Director: Stuart Dalziel

Stuart joined the Laboratory as a PhD student in 1985 and has been there ever since. He took charge in 1997 and has been responsible for much of the fundraising and development of the Laboratory on the CMS site. Stuart is a University Teaching Officer within DAMTP, although with an undergraduate engineering degree has shown himself to have a wealth of practical and technical knowledge. In addition to his own research in geophysical, environmental and industrial fluid dynamics, he has a keen interest in experimental diagnostics and image processing.

Stuart has overall control of the laboratory resources (physical and human), and should be consulted before any major development. Stuart is willing to discuss all aspects of work in the laboratory – both scientific and technical – and has an in-depth knowledge of the resources available within the Laboratory. Stuart is also the Safety Officer, Laser Safety Officer and Biological Safety Officer for the Laboratory, and spends much of his time in his office H.0.11, phone 337911, e-mail s.dalziel@damtp.cam.ac.uk .

1.2.2 Deputy Director

At present (since Lent 2005) the position of Deputy Director of the Laboratory is vacant.

1.2.3 Head Technician: David Page-Croft

David took over as Head Technician in 1996, moving from the Cavendish Laboratory where he was working on precision manipulators and other items used with electron microscopes. David adapted rapidly to the change of environment and has taken the lead in the workshop, transforming many of the techniques and work practices in a way that have considerably increased the productivity while maintaining the highest quality.

David manages the workshop and most aspects of the day-to-day functioning of the Laboratory. He is responsible for all ordering of equipment and supplies, allocating technician time, and designing the equipment in most cases when there is no suitable off-the-shelf solution. David also liaises closely with external suppliers and contractors whom we may commission to manufacture all or part of the equipment required.

David is also a University First Aider and one of the Fire Managers for the CMS site. David's office is located just outside the workshop in Pavilion C, but he is often to be found in the workshop, or around the Laboratory. Phone 337842, e-mail d.pagecroft@damtp.cam.ac.uk .

1.2.4 Chief Electronics Technician: John Milton

John joined the Laboratory in 2002 and comes from a background with a major optical component supplier/manufacturer. Although John has not previously worked in a laboratory like ours, he has worked extensively on projects requiring many overlapping technologies. John is responsible for the electrical testing of laboratory equipment and also has some responsibility for the day-to-day maintenance of the computer network in the Laboratory. John can normally be found in the Electronics Workshop located within the main workshop in Pavilion C, phone 337828, e-mail j.milton@damtp.cam.ac.uk .

1.2.5 Instrument Maker: Neil Price

Neil joined the Laboratory in 2008 following a long background in mechanical engineering in the private sector. Neil will normally be found in the workshop in Pavilion C, phone 337840.

1.2.6 Instrument Maker: Colin Hitch

Before joining the Laboratory in 2010, Colin worked for many years as an instrument maker for a Cambridge-based consultancy. He will normally be found in the workshop in Pavilion C, phone 337840.

1.2.7 Senior Technical Officer: Mark Hallworth

Mark has been a member of the Institute of Theoretical Geophysics (ITG) since it was set up in 1989, but has been working in the Laboratory since 1983. Although most of his effort is dedicated to research activities within the ITG, he willingly lends a hand and offers advice to other users of the Laboratory. Mark’s office is located within the Laboratory in H.L.09, although he may often be found in H.L.08, one of the sub-laboratories within Pavilion H. Phone 337841, e-mail hallwort@esc.cam.ac.uk .

1.3 Accommodation

As a consequence of the modular nature of the CMS development, the GK Batchelor Laboratory is divided into four separate areas. Each of these areas has been designed with a different set of characteristics to allow maximum flexibility and diversity within the Laboratory as a whole. All areas are supplied with the basic services of electricity (single- and three-phase), and compressed air. Water comes in multiple flavours: fresh raw, fresh softened, hot and salt water are common throughout the Laboratory, with the addition of highly-purified water available via a pair of relocatable Reverse Osmosis units. Non-slip safety flooring and floor-level drains add to the convenience, while high ceilings (painted black) improve access and visualisation with larger experiments. Safety features such as individual RCD (Residual Current Detectors) and emergency knock-down switches are provided for the electrical circuits, with wide doorways and corridors facilitating the movement of equipment between different areas. The Laboratory is wired up with category 5 network cabling connected to private Gigabit switches (connected together with dedicated optical fibres) giving the ultimate in bandwidth.

The Laboratory is situated at the lower ground level of CMS. Lifts within Pavilions C and H provide disabled access to all areas (except the lower level of the Ambient

Flow Facility), and natural light is used wherever feasible (with blackout blinds providing the ability to shut it out).

1.3.1 Pavilion A

The Pavilion A Laboratory, with around 170m^2 of research space located beneath the serving area of the main Common Room, is intended to accommodate a range of bench-top and larger experiments that are not overly sensitive to their surroundings. The space is subdivided with blackout curtains to allow ready reconfiguration of the space to house experiments up to four metres in size, with a ceiling height of nearly five metres. Water is available both around the perimeter and from a series of manholes beneath the floor, while power poles bring electrical and data outlets to the interior of the Laboratory. The space is naturally ventilated through a series of vents and windows controlled by the computerised building management system.

Two of the bays within this space are utilised as service areas, containing the main store of instrumentation, video, electronic, and electrical equipment. These bays also contain other standard items such as tubing and retort stands. The only large, relatively fixed, item of equipment in Pavilion A is a bi-directional flume The working section of this flume is a channel 2m long with a cross-section 1.2×0.2m and is capable of very high flow rates.

1.3.2 Pavilion C

The Pavilion C Laboratory, sitting alongside the workshop, is the smallest of the components, providing approximately 90m^2 for research. Part of this space is dedicated to storage of the Laboratory's extensive stock of tanks and related experimental equipment, but a key feature is the 4×3m Temperature Controlled Laboratory (TCL; also referred to as the Cold Room) with a working range of –40°C to +30°C (see §6.1 for further details).

The remainder of the space is in a single long, relatively narrow bay, equipped with power poles and central under-floor water supplies. The space is naturally ventilated through a series of vents and windows controlled by the computerised building management system.

Alongside the Pavilion C Laboratory is the main chemical store. This is equipped with a large fume cupboard, shared between the Laboratory and workshop. Immediately adjacent to this is an emergency drench shower and 'wash-down area', intended for cleaning and testing equipment in conjunction with the workshop.

Pavilion C also provides the main route in for supplies and equipment. A 2 tonne pillar and jib crane aids access to the lower ground level, with access to the Laboratory through the workshop store.

1.3.3 Pavilion H

To meet the needs of experiments that are more sensitive to their surroundings, and the requirements for the use of lasers within the Laboratory, the 220m^2 of research space in the Pavilion H Laboratory is subdivided into five separate smaller rooms. Each of these spaces is fitted with a higher level of security, door interlock circuits to manage the use of lasers, mechanical ventilation and comfort cooling, and broad availability of three-phase power. A small emergency shower is provided to one side of the broad connecting corridor.

At present, four of the five rooms within Pavilion H are devoted to Biological Physics. Within this space are wet-labs, preparation areas, growth chambers, a 'clean room' facility and a microscope suite.

1.3.4 Ambient Flow Facility

The Ambient Flow Facility (AFF) was the last area of the Laboratory to gain funding and the only area where the design was not compromised by the needs of the building above. Whereas the other three areas had to be designed around the architecture of the rest of the Pavilions, the AFF is a completely independent and dedicated laboratory unit. The AFF is also the largest of the areas providing 330m^2 of usable laboratory space.

The fundamental purpose of the AFF is to house the Laboratory's largest experimental installations, providing them with adequate space to obtain top quality visualisations. Entry to the AFF is at lower ground level, but the AFF extends down a further level to give around 6.5m headroom over part of the area. The lower level is open-plan and structure-free, with blackout curtains providing reconfigurable divisions. A suspended mezzanine floor is provided over part of the space to both provide vantage points when working with the largest apparatus, and to provide additional laboratory space over areas that did not require the full headroom. Each of the four experimental bays on the mezzanine floor is suspended separately, thus providing good structural isolation between neighbouring bays. Blackout curtains again allow control of ambient light levels and reconfiguration of the space within the AFF. The AFF is generously provided with three-phase outlets and is mechanically ventilated (with heating and cooling circuits).

Permanent and long-term installations within the AFF include:

- A large granular flow chute (see §6.2).
- A simple small flume with a 300×570mm cross-section and a 2.6m long working section.
- The Stratified Shear Flume can generate complex shear profiles in a stratified flow passing through a 400×250 mm cross-section arrange as a 4×2m 'racetrack'.
- The 10m Solitary Wave Tank is ideal for flows in channels or low-aspect ratio nearly two-dimensional flows.
- Two of the Laboratory's 1m diameter precision turntables are located on the mezzanine floor, and a third turntable, is housed on the lower level. These are capable of rotation rates up to 60 rpm (2π rad/s).

Space is also available for other experiments requiring the full headroom. A 1 tonne two-axis gantry crane and a goods lift for smaller items allow ready relocation of equipment and supplies between the different levels.

2. Policy

Target Audience: All groups

The GK Batchelor Laboratory aims to ensure, so far as reasonably practicable, the health, safety and welfare of all staff, students and visitors. Where practicable, by seeking appropriate procedures and safety features, the Laboratory attempts to ensure that the needs of Health and Safety do not hinder the research needs.

The Laboratory Safety Policy operates as a policy beneath the Safety Policy for the Centre of Mathematical Sciences. Activities in the Laboratory form two standing items in the CMS Safety Committee agenda, one biological safety, and the other covering all other areas not included in other standing items. The Laboratory policy provides the overall framework for working in the Laboratory. Beneath this are a number of specific policies for certain activities and types of equipment, as outlined in the following sections.

http://www.damtp.cam.ac.uk/lab/safety/
http://www.cms.cam.ac.uk/safety/safetypolicy/

2.1 Aim

The aim of the Laboratory is to foster internationally competitive experimental research in a variety of research fields.

This aim is achieved by

- Maintaining a suitable and safe physical environment with access to the required services.
- Designing, implementing or procuring appropriate mechanical, optical and electronic solutions to meet the experimental and diagnostic requirements.
- Providing appropriate and timely assistance.
- Sustaining a critical mass of scientific and technical expertise.
- Training and advising Researchers and Supervisors as required.
- Advising those preparing research grant applications on feasibility and cost.
- Enabling, advising and training on safe working practices.
- Responding to changes in focus and direction of experimental research.
- Adhere to legal requirements for activities, use of organisms and equipment, and the disposal of waste.

2.2 Responsibilities and duties

2.2.1 Researcher

For the purposes of this manual, a ‘Researcher’ is a student, postdoc, academic, visitor, assistant or other similar person who is undertaking work in the Laboratory. This work may be performing or helping perform experiments, setting up experiments, cleaning or tidying, or analysing samples or data.

Researchers must

- Be familiar with and observe the safety procedures relevant to their activities.
- Be familiar with all Risk Assessments relevant to their work. Where such a Risk Assessment does not exist or is no longer up to date, they ensure that an up to date Risk Assessment is completed.

- Utilise equipment correctly and seek advice where necessary.
- Identify and undertake any training.
- Ensure all equipment is in good working order and, where appropriate, carries a valid test certificate.
- Report any and all accidents, breakages, faults or potential problems.
- Ensure behaviour and activities do not put themselves or others at risk.
- Avoid activities that inconvenience other Researchers. Where this is impractical, liaise with those affected to minimise the inconvenience.
- Ensure that any visitors are accompanied whilst in the Laboratory and are warned of any unavoidable hazards to which they may be exposed.
- Instruct anyone assisting with an experiment on the procedures required and the safety implications.
- Document any special action that may be required in the event of an emergency.
- Turn off electrical equipment when it is not required, unless there is good reason to leave it switched on. This does not apply to computers and cameras, but may apply to monitors and light sources, for example.
- Keep their environment tidy and clean up after them.
- Seek advice from laboratory personnel if they have any concerns.

Note: all accidents, incidents and dangerous occurrences **must** be reported to the Laboratory Safety Officer. The standard University report form should be used; copies are available from reception or on the Health and Safety Division web site. All such reports are brought to the attention of the CMS Site Safety Committee and the University's Health and Safety Division.

http://www.admin.cam.ac.uk/offices/safety/

2.2.2 Supervisor/Principal Investigator/Host

The term 'Supervisor' will be used in this manual to mean anyone who has a supervisory role in research undertaken within the Laboratory. In some cases the Supervisor will also be a Researcher (perhaps on a different project), while in other cases they may have no direct experience with laboratory work. In the latter case it is likely that laboratory staff will play a greater role in advising the Researcher and Supervisor in technical and practical aspects of the research project. However, even in such cases, the Supervisor remains responsible for ensuring that the Researcher adheres to the various guidelines and rules within the Laboratory.

Supervisors must

- Monitor the work of their Researcher and discuss regularly the techniques, procedures and equipment being used.
- Read the Risk Assessment for the project(s) and discuss with the Researcher the Health and Safety implications and the need for any training.
- Ensure that their Researchers adhere to the necessary procedures.
- Discuss the proposed research with the Director of the Laboratory before the work starts and preferably (where appropriate) before submitting any grant application.

- Include in any grant application, in so far as practicable, the full cost of the laboratory research, including consumables, materials, equipment purchases, safety equipment and technician time.
- Seek advice from laboratory personnel if there is any cause for concern.

2.2.3 Technicians

The principal role of the Technicians is to support the research by providing, constructing, maintaining and repairing equipment. In some cases a technician may assist with the running of experiments (in which case the Researcher should provide them with any necessary training), while in others they may advise the Researcher and/or Supervisor on possible procedures.

Technicians must

- Ensure equipment is designed and constructed to meet safety targets.
- Order equipment and liaise with external contractors.
- Purchase consumables.
- Test, maintain, repair or safely dispose of equipment as required.
- Prevent equipment known to be faulty from being used.
- Ensure untrained personnel do not utilise workshop tools.

2.2.4 Cleaners

It is important that Researchers recognise that the role of cleaners within the Laboratory is not to tidy up after the Researcher. Cleaners are there to maintain a clean working environment by removing rubbish from bins, cleaning floors and surfaces of the normal accumulation of grime, and maintaining supplies of essentials such as soap and paper towels. The Researcher should not expect a Cleaner to mop or sweep up spills, clean glassware, remove general rubbish or tidy up an area. Indeed, Cleaners are explicitly told not to disturb experimental equipment as doing so may damage the equipment, ruin an experiment, or place the cleaner at risk.

Cleaners must

- Leave experimental apparatus undisturbed.
- Alert laboratory personnel to any problems or hazards they discover.
- Seek advice if they are unsure what should or should not be cleaned.

2.2.5 Facilities Staff

The role in the Laboratory of the CMS Facilities Staff is no different to that in the rest of the site. In particular, they have a responsibility for the cleaners, fire precautions, maintenance, *etc.* Much of this, however, is undertaken in consultation with the Technicians.

There will be times, however, when Facilities Staff require access to the Laboratory to fulfil this role. For example, most of the services to Pavilion H pass through that part of the Laboratory. Some disruption to research will occur from time to time, but this will be minimised and, where possible, Researchers warned in advance.

Facilities Staff should

- Avoid using the Laboratory as a thoroughfare.
- Not touch or interfere with experimental equipment except in an emergency.

- Give advanced warning, where possible, of activities within the Laboratory.
- Seek advice concerning activities in any part of the Laboratory before working in that part or commissioning contractors to work in that part.
- Introduce to the Technicians any contractors that may require access to the Laboratory.
- Maintain the integrity of the security system within the Laboratory.
- Alert laboratory personnel to any problems or hazards they discover.

2.2.6 Director

For the purposes of this manual, the term Director shall be used to refer to both the Director and the Deputy Director of the Laboratory. Moreover, the Director should be considered as distinct from the academics who hold those positions and themselves are Researchers and Supervisors.

The tasks for the Director are coordinating activities, advising on technical and procedural problems, specifying and procuring communal equipment and services, and managing the technical and physical resources available within the Laboratory. The Director should be consulted at an early stage of planning any major project, or when procedures or experiments are planned of a type not previously undertaken in the Laboratory.

While the Director will endeavour to ensure resources are made available or equipment is completed by the time specified by the Researcher, fundamental limits on the available manpower and the needs of other Researchers often prevent this. Researchers will be treated as fairly as possible with a view to keeping delays to a minimum. It should be noted, however, that some priority will normally be assigned to projects where the requested resource (human or physical) is being funded by that project.

Researchers may seek advice from the Director on scientific and technical matters, but the expectation is that the Researcher will have sought it first within their own research group.

The Director, often acting through the Technicians, should

- Oversee and prioritise the work undertaken by the Technicians.
- Coordinate the use and maintenance of laboratory space and basic services.
- Procure and maintain standard consumables, items of furniture and communal equipment.
- Maintain and enhance the technical capabilities of the Laboratory by investing in both equipment and manpower.
- Provide, in conjunction with the Computer Officers, the network and computer infrastructure required to meet the experimental needs.
- Advise Supervisors on the feasibility and cost of proposed projects.
- Advise and, in some cases, train Researchers on laboratory techniques and/or the use of specific items of equipment.
- Monitor the actions of laboratory users.
- Warn Supervisors and/or Researchers of any concerns that could affect safety or the longevity of equipment.
- Document and publicise procedures, policies and rules.
- Plan and develop strategies for future developments in the Laboratory.

- Provide appropriate and timely warnings of activities that may impact research.
- Arbitrate in the event of any conflicts that may arise.
- Provide a point of contact.

2.2.7 Safety Officer

For the purposes of this manual, the term Safety Officer will refer to the Departmental Safety Officer who is responsible for the Laboratory. This role should be considered as distinct from the academic who holds that position and is him/herself a Researcher and Supervisor. This role should also be considered as distinct from the Director of the Laboratory, although historically the same academic has fulfilled both roles.

The Safety Officer in the Laboratory exists to ensure that all research is conducted in a manner consistent with current Health & Safety legislation. This is achieved through providing advice, formulating procedures, providing or procuring training, and monitoring the implementation of Health & Safety.

The Safety Officer should

- Document and publicise procedures, policies and rules.
- Implement workable procedures for the routine testing of equipment.
- Evaluate Risk Assessment forms and highlight any additional hazards.
- Advise Researchers and Supervisors on Health & Safety issues.
- Monitor and inspect the performance and adherence to Health & Safety procedures.
- Report to the Head of Department and the CMS Safety Committee any problems or previously unrecognised significant hazards.
- Report to the University Safety Office any accidents or incidents.

2.3 Specific policies

Within this overarching policy, specific policies exist for certain activities. These include the use of electrical equipment, lasers and genetically modified organisms.

2.3.1 Electrical Safety Policy

Electrical safety in the laboratory is governed by the CMS Electrical Safety Policy. In particular, every item of equipment connected to a mains power supply, directly or indirectly and including cables and extension leads, must be tested and identified with a sticker. This applies both to equipment owned by the Laboratory, equipment brought into the laboratory by others and purchases of new equipment. In certain circumstances, battery-powered equipment must also be tested: this is always the case if voltages exceeding 50V DC are present.

Further guidance on the risks and control measures is provided in §5.1 of this manual.

http://www.cms.cam.ac.uk/safety/electricalpolicy/

2.3.2 Laser Safety Policy

The use of Class 1 devices is not restricted provided no modifications are made that would render the classification inappropriate. Class 2 devices may also be used provided straightforward measures to avoid prolonged exposure to the beam are taken. Class 2M devices may be used similarly, provided no additional optics are fitted to the device.

The Laser Safety Policy applies principally to Class 3 and Class 4 laser devices. In every case a Risk Assessment is necessary and both legal requirements and the University's Code of Practice must be adhered to. The following must also be adhered to for all Class 3 and Class 4 devices:

- Planned purchase or acquisition of any Class 3 or Class 4 laser device must be discussed in advance with the Laser Safety Officer.
- The Laser Safety Officer must review a copy of the Risk Assessment before a new laser setup is commissioned.
- Protocols regarding Personal Protective Equipment (PPE) and shielding must be observed.
- Warning signs and access restrictions must be used as appropriate.
- Laboratory users must observe access restrictions.
- Lasers must not be left on unattended unless adequate access restrictions are in place.
- Laser keys must be returned to the appropriate storage cabinet and not be left in laser control units.
- Naked laser beams must not be accessible except during essential alignment and focusing operations.
- Access controls must be put in place during all alignment and focusing operations where a naked laser beam is accessible, or may inadvertently become accessible.
- All laser users must receive suitable training before commencing unsupervised work with a laser. Training needs should be discussed with the Supervisor and/or Laser Safety Officer.

http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd013r/

2.3.3 Artificial Optical Radiation

For sources of optical radiation (including those due to lasers), the Laboratory operates within the guidance provided by the University's policy on Artificial Optical Radiation.

http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd064r/

2.3.4 Biological Safety Policy

Biological Safety forms a standing item on the Agenda for the CMS Safety Committee meeting. This meeting is convened three times a year. The Biological Safety Officer reports to this Committee on all biological safety issues.

- Only designated areas of the Laboratory located in Pavilion H may be used for biological activities. These areas of the Laboratory are classified as Containment Level 2 facilities.
- Only Hazard Group 1 microorganisms, plants and insects are permitted.
- Laboratory coats must be worn when handling organisms.
- Organisms and waste must be sterilised, as appropriate, once work with them is complete.
- Sterilisation using the autoclave facility should be logged and verified.
- Laboratory procedures should adhere to 'best practice' and be compatible with University Guidelines.

- Good 'house-keeping' practices must be maintained.
- Disposal of biological waste shall be in accordance with the University Code of Practice.
  http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd028b/
  http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd027b/

2.3.5 Genetically Modified Organisms Safety Policy

A Genetically Modified Organism (GMO) Subcommittee monitors all matters relating to the use of GMO within the Laboratory. Membership of this subcommittee includes the Biological Safety Officer, the Director of the Laboratory, the Head Technician, a co-opted representative from the School of Biological Sciences, and a representative from those University Teaching Officers undertaking research with GMOs. The GMO Subcommittee meets at least annually and reports to the CMS Safety Committee via the Biological Safety Officer.

- All use of Genetically Modified Organisms (GMO) must adhere to legal standards and the conditions of the GMO licence.
- Only Class 1 organisms falling in Hazard Group 1 may be considered.
- Plant species must be disposed of before they go to seed.
- All researchers must be trained in and adhere to the protocols for the organisms with which they are working.
- Detailed Risk Assessments must be maintained covering all classes and strains of organisms that are or have been used and/or held in storage.
- A list of organisms and their characteristics must be maintained.
- Organisms must be obtained from reputable sources with the appropriate paperwork.

3 Health & Safety

Target: Researchers, Supervisors, Technicians

Safe working practices are not only a legal requirement, but also a hallmark of high-quality experimental research. It is essential that you do not consider the rules regulating Health & Safety an unnecessary diversion, but rather that it is an integral and essential element of the environment in which we work. A Supervisor who shows no interest or actively discourages a Researcher from adhering to safety procedures is sending a strong message that the results of the study matter more than the Researcher obtaining those results. In contrast, someone who takes a proactive stance is not only showing a concern of their own well-being, but also showing a team spirit with care for others and for shared equipment and resources.

Health & Safety is a central issue in the University. At the top-most level it is governed by the University Safety Policy, which is elaborated on by the CMS Safety Policy. The procedures and requirements outlined in this document should be viewed as an elaboration on these two policies. Some specific activities within the Laboratory are covered by additional policies (see §2 for details). Use of the Laboratory is conditional on adherence to these procedures and requirements.

The policy and procedures adopted by and required in the Laboratory are mandatory under the CMS Safety Policy, which governs all categories of people accessing the CMS site. Adherence to the CMS Safety Policy is, in turn, mandatory under the University's Safety Policy.

Health & Safety legislation requires a formal induction process and that formal procedures are in place to highlight the risks involved, to develop safe working practices, and to monitor that these are observed. Central to this strategy in the laboratory context is the requirement for every Researcher to complete a Risk Assessment of his/her work. Completing a Risk Assessment helps highlight to the Researcher (and their Supervisor) that there are dangers in undertaking the research, and what measures can be undertaken to minimise these dangers. Completing a Risk Assessment need not be a lengthy process, but it will, in general, be both educational to the Researcher/Supervisor and beneficial to the project.

All work undertaken in the Laboratory must be covered by a Risk Assessment. A Risk Assessment must be filed prior to starting any project, or when there is to be a substantial change in a project. Under certain circumstances where explicit approval has been granted by the Laboratory Safety Officer, a limited amount of work under the direct supervision of an experienced researcher may be started whilst the Risk Assessment is being prepared. The completion of a Risk Assessment is a Laboratory, University and statutory requirement. Copies of all Risk Assessments must be provided to the Laboratory's Safety Officer.

For organised classes, demonstrations, open days or courses in the Laboratory, responsibility for the Risk Assessment and an Induction procedure rests with the organiser of the course. The organiser must discuss the arrangements that have been made with the Safety Officer well in advance of the course. In such cases the participants must normally have continual supervision.

The University issues Codes of Practice covering common activities and hazards from time to time. Unfortunately, only a small fraction of these may be found at the University Health and Safety Office's web site. Where a Code of Practice does exist for particular activities that may occur within the Laboratory, this Code is referred to in this document, along with an indication of the role it plays in Health & Safety implementation in the Laboratory. In most cases the Laboratory's own procedures will elaborate on the Code of Practice; in some cases the Laboratory's procedures will exceed those found in the Code of Practice. In such cases, the Laboratory's procedures take precedence.

http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd016m/hsd016m.pdf
http://www.cms.cam.ac.uk/safety/safetypolicy/
http://www.admin.cam.ac.uk/offices/safety/

3.1 Induction

All personnel wishing to use the Laboratory must undergo an induction process before commencing work. This induction process is intended to ensure the user has all the information they require to work safely in the Laboratory and to provide Laboratory personnel with the information necessary to support this work.

For research personnel the induction will take place partially within the user's own research group (typically provided by and experienced member of that group), and partly with the Laboratory Safety Officer. A check-list may be found in Appendix A to help guide this process. Completion of all the steps on the induction checklist is a precursor to being permitted to commence work in the Laboratory.

3.2 Preparation of Risk Assessment

Although this requirement for a Risk Assessment appears onerous, in most cases it will be very simple to complete and, for an experience user, require less than half an hour. This simplicity is possible where the project is restricted to the standard laboratory procedures and hazards described in §5 of this manual. In such cases, the Risk Assessment is limited to a brief description of the project and experimental methodologies, with a reference to the material in this manual describing the associated hazards and procedures.

However, if the project uses equipment or methodologies not covered by this manual, then the Risk Assessment must explore all the possible hazards and safety measures required. A more detailed Risk Assessment is also required for some types of equipment described in §5; this requirement is indicated alongside the equipment category in that section. A *pro forma* for the Risk Assessment is provided in Appendix B. This *pro forma* is relevant for work that is largely covered by the details in this manual. Risk Assessments need not use this *pro forma*, but they must be written down.

One key element of the Risk Assessment is governed by the COSHH (Control Of Substances Hazardous to Health) regulations. In most cases the COSHH form will need to be completed as a part of the assessment. If any chemicals or materials are used that require a specific entry in the Risk Assessment (*i.e.* if the references in §5 do not cover all the necessary details) then the Risk Assessment should include a copy of the relevant datasheet on the substance.

The Risk Assessment *pro forma* in Appendix B also includes a section on emergency procedures that details the action(s) required should there be a major incident and the person in charge of the experiment is not on scene. This section must note the course of action in such an event. Typically this will include using the knock-down button to cut the electric supply, and details of how to disconnect from other services. In many cases an answer of 'do not care' is appropriate, indicating the person dealing with the incident can take whatever action they deem necessary without exposing themselves or others to an increased risk.

The *pro forma* is also available electronically at http://www.damtp.cam.ac.uk/lab/safety/.

Once completed, the Risk Assessment must be passed to the Laboratory Safety Officer or the Senior Technical Officer for approval. If there is a Supervisor associated with the project, then the Risk Assessment should first be viewed and signed by them. Once approved, a copy of the Risk Assessment must be deposited in the wallet labelled 'Risk Assessments' found at the main entrance to each of the laboratory areas. The researcher should also retain a copy, and the original must be given to the Laboratory Safety Officer.

3.3 Maintenance and monitoring

Equipment will remain safe only so long as it is used within its design parameters, it is regularly maintained, and the operators are competent to use it. It is the responsibility of the individual Researcher, and of their Supervisor, to ensure these conditions are met.

To monitor satisfactory Health & Safety performance, all equipment and experimental setups in the Laboratory are subject to a regular review. This review exists both as a paper exercise, and as inspection of the state of the equipment, its setup, conformity of tests (*e.g.* electrical or pressure), and other related areas.

Risk Assessments must be reviewed annually (more frequently for high-risk activities) or when there is a significant change in the setup or operating procedures. Any faults found in the equipment must be logged in the Risk Assessment, and the cause of any recurring fault analysed and eliminated.

3.4 Ordering, borrowing and receiving equipment

The majority of equipment and supplies used in the Laboratory are ordered and received by the Head Technician (or in some cases the Electronics Technician). As equipment is received it is tested for safety and logged, as appropriate.

However, some equipment may arrive through a different route, either ordered from a mail order/internet supplier, or possibly borrowed from another institution. In all cases the Head Technician, Electronics Technician or the Safety Officer must be informed before the equipment is used, and any tests/checks must be performed.

3.5 Access to Workshop

3.5.1 Entry to workshop

Access to the workshop is restricted to authorised personnel only. While members of the Laboratory are welcome to enter the workshop to seek assistance or advice from one of the technicians, they should not proceed beyond the assembly bench area unless invited to do so by a technician. Visitors should not normally be brought into the workshop without first consulting the technicians.

3.5.2 Use of workshop facilities

Laboratory users should not attempt to use any of the facilities or machines within the workshop without first seeking permission from the Head Technician. You may be permitted to use hand tools and the drilling machines if you are able to demonstrate your competence to the Head Technician. You will not be permitted, under normal circumstances, to use the other machine tools.

3.6 Working after hours

Special care should be taken if working in the laboratory after hours or during the weekends. In most cases the level of risk is not altered significantly, but the consequences of an accident could be substantially greater. Before undertaking any work after hours, you should consider the following:

1. Are there other people also working in the laboratory who could offer assistance or summon aid in the event of an accident? If the answer to this is "no", then you should avoid high-risk activities. For example, experiments on the rotating tables requiring direct manual interaction with the turntable should not be undertaken if you are the only person in the laboratory.
2. You should familiarise yourself with how to summon the University Security Patrol. This may be essential if you need to summon an ambulance, for example, as they may not otherwise be able to gain access to the laboratory.
3. If you are undertaking experiments and you are the only person working in the laboratory, you should arrange a regular telephone check-in with a friend or colleague so that an alarm may be raised if you can no longer be contacted due to an accident. You should be aware that mobile phones do not work reliably in the Laboratory.

Any intention to work alone should be indicated in your Risk Assessment, along with the additional measures you will take to minimise the associated risk.

3.7 Hygiene

1. Do not eat or drink food in the laboratory.
2. Do not drink water from taps in the laboratory.
3. Do not store food in the laboratory, even in sealed containers.
4. Do not dispose of food in the laboratory.
5. Do not use the laboratory sinks for cleaning glasses, plates or cutlery.
6. Always wash your hands after working in the laboratory.

The University has issued guidance on these matters.

http://www.admin.cam.ac.uk/cam-only/offices/safety/eating/

Note that a water chiller may be found in the corridor within Pavilion H. While it is not permissible to bring food or drink into this corridor, you may drink water from this chiller whilst remaining in the corridor. Under no circumstances may you take a drink from here into other areas of the laboratory. You must also wash your hands before making use of the water chiller.

3.8 Fire

The issues here apply wherever you are working (in the laboratory, your office or elsewhere in the department).

3.8.1 Preparation

1. Determine all the escape routes open to you.
2. Locate the nearest call point (fire alarm switch).
3. Familiarise yourself with the location of the nearest fire extinguisher and their instructions.

4. Fire doors are **not** to be wedged open, except as a temporary measure to facilitate the moving of equipment.

3.8.2 If there is a fire

The fire alarm is a single, continuous electronic tone.

1. If the fire alarm sounds, switch off all equipment and leave the building immediately. You may leave the computers and printers running.
2. Do not run.
3. Do not lock the doors.
4. Do not return to the building until you have been advised that it is safe.
5. Never use water to extinguish electrical or chemical fires.
6. Do not place yourself at risk attempting to extinguish a fire.

Although each of the Pavilions at CMS is a separate fire compartment, it is recommended that on hearing the alarm you go outside from the building you are in. Subsequently, if the alarm is not sounding in one of the other Pavilions, and you are given approval to do so by a fire monitor, you may enter one of the other Pavilions where the alarm is not sounding.

3.9 Children

The University and its Insurers discourage the presence of children on University premises, except on Open Days and social events. Moreover, they require the Department to have its own policy that is repeated below:

1. Children brought into the Department should **never** be left unaccompanied
2. Children should **never** be allowed into hazardous areas **like the laboratory** (except under the special conditions of Open Day) or workshops - and remember that children like exploring
3. Children should not be brought into the Department routinely - the building is not designed and above all it is not used with their safety in mind (*e.g.* building work, doors with automatic closers, congested car park, large adults hurrying along narrow corridors or stairs and not expecting to see small persons in their path.). If you need to bring a child in, remember the factor of the unexpected and take special care accordingly.

If any member of the Department needs to bring a child/children in on more than a very occasional basis, please contact the head of department’s secretary beforehand to see if special arrangements need to be and can be made. At parties to which parents may bring their children, the organiser of the party should consider this question carefully.

3.10 People at risk

Some medical conditions may make it inadvisable for you to undertake certain activities within the laboratory, or to restrict such activities to the daytime where assistance is available. Conditions and activities that may be incompatible may include:

1. The use of the turntables if you suffer from dizzy spells or uncontrolled epilepsy.

2. The use of certain chemicals if you suffer dermatitis or respiratory problems.
3. Moving equipment if you suffer back problems.
4. Lifting or using ladders if you are pregnant.

If you are an expectant mother, it is recommended that you discuss at any early stage any changes or restrictions to your work with either the Laboratory Safety Officer or the Departmental Administrator. Any discussions will be treated with strict confidentiality.

The University has issued specific guidance for pregnancy and nursing mothers.

http://www.admin.cam.ac.uk/cam-only/offices/safety/misc/pregnancy.html

4. Research Projects

Target: Supervisors

The need to take Health and Safety issues into account must be remembered at all stages in the life of a research project in the Laboratory.

4.1 Preparation of proposal

Successful research benefits greatly from an adequate resources being available. This is particularly true of experimental work where the work may not be able to progress if a critical piece of equipment is missing or broken. Key questions that must be addressed at an early stage in planning a piece of research include

1. How much of the necessary equipment already exists? Is this equipment going to be available for the project?
2. What funds are required to procure or construct new equipment?
3. What funds are required to modify new or existing equipment?
4. Are funds required to maintain, test or calibrate equipment?
5. What is the cost of any safety equipment or training required?
6. What are the costs of consumables, chemicals, *etc*.?
7. What level of technical support is required to construct/assemble the equipment?
8. What level of technical support is required to keep the equipment running?

It is strongly recommended that you discuss your plans with the Director of the Laboratory and/or the Head Technician before submission.

It is important that, in so far as practicable, research grant applications meet all the direct costs of the research. This includes funding all new equipment, the cost of consumables, and technical support. While the Laboratory accepts that such funding is not available for some categories of researcher (particularly research students and those on some fellowship schemes), the required funds should be raised from the sponsor wherever possible. The Laboratory does have access to some funds to support projects where there is no mechanism for raising the funds, but these are very limited and cannot absorb the high costs of some projects.

This issue is particularly important with respect to technical support. The demands on technical support significantly exceed the number of technicians supported on central funding. All the other technicians are supported on a combination of research grants and overheads. Over most of the history of the Laboratory, the demand for technical support has far exceeded the funds available to provide that support. An inadequate level of technical support in one project tends to cause delays, not only to that project, but also to all the other projects.

Wherever possible, funds should be requested for technical support. Typically this should be between 20% and 30% of a full time equivalent over the entire period of the project. These funds are pooled together from all the projects within the Laboratory and are used to fund the technicians to provide the best possible level of support.

It is important to note that when technician time is taken into account, it is normally more cost effective (and definitely more time effective) to purchase ready-made equipment, where that is available. It should also be noted, however, that even the ordering, safety testing and installation of ready-made equipment requires some technician time. Moreover, it is frequently necessary to modify the equipment in some way, or to provide ancillary devices in order that it may be mounted and/or used.

Issues such as whether a proposed piece of research can be conducted safely should also be addressed before submitting a research proposal or making other plans to undertake the work. While it is not necessary to solve all problems at this point, the fact that there are problems that will need solving should be recognised. Moreover, it is important to incorporate in any budget for the work an allowance (both time and money) to allow a satisfactory solution to be developed.

In many cases careful design or detailed procedures are all that are required, and existing equipment can be adapted to avoid many of the issues. However, in other cases, considerable care must be exercised and a significant cost must be met in order to achieve safe working practices. Where the project requires safety measures beyond those for a 'standard' experiment, it is essential that funds are available for these measures. Failure to secure such funds may prevent the work from being undertaken.

4.2 Detailed planning and setting up

The development of detailed designs and procedures must adhere to the general guidelines found in this document and in the University's various Codes of Practice. Anything falling outside these guidelines must be discussed with suitably qualified and experienced individuals in order to both assess the risk and determine any appropriate safety measures that should be incorporated. In such cases, full documentation of the risks and preventive measures, and the operating procedures, should be produced prior to the associated equipment being commissioned. This documentation, and the experimental setup, should also be reviewed both by the project Supervisor and by the Laboratory Safety Officer (or someone nominated by him) prior to use.

5. Hazards

Target: Researchers, Technicians

All laboratories are inherently dangerous places. It is essential to maintain safe working practices in order to prevent injury to people and damage to property. The hazards in the GK Batchelor Laboratory may be less obvious than in many other laboratories yet can be just as dangerous. The main hazards fall into a number broad categories:

- Electrical – water and electricity make a lethal combination
- Mechanical – rotating tables, the wave maker, pumps and other moving equipment have the potential of jamming, tearing or throwing other equipment around
- Chemical – while the majority of substances used in the laboratory are relatively harmless, some can promote dermatitis and related skin conditions, may be poisonous if ingested and can damage your eyes
- Biological – infection and toxicity may be less of a problem than sensitisation, allergy or simply being scratched
- Optical – powerful visible light sources are used in many of the experiments
- Heat – hot water, heating elements, heat baths and light sources producing high temperatures
- Cold – freezers, cooling baths and cryostatic circulators can cause cold burns and embrittlement of many materials
- Breakages – thermometers, glassware and metals
- Lifting – many items of equipment are heavy or cumbersome to lift or may require special lifting equipment
- Falls and injury –wet floors can be slippery
- Clutter – can cause tripping, promote fire or hide other more serious hazards.

These main issues are dealt with in the following subsections. You should familiarise yourself with these and re-read them at least annually. If you are unsure about something, please **ask**. If you see something you believe to be dangerous, please **tell** either the Head Technician or Director of the Laboratory.

Most of the safety procedures are based on “common sense”. Remember that a tidy working environment will reduce the chance of accidents.

All accidents, incidents and “near misses” must be reported to either the Head Technician or the Director of the Laboratory, no matter how insignificant they may seem. In addition, when injury occurs or in other cases when so instructed, those involved should complete an Accident Report Form and return this to the Director of the Laboratory. Blank copies of the Accident Report Form may be obtained from reception.

http://www.admin.cam.ac.uk/cam-only/offices/safety/accidents/

It is also important, both from a safety and environmental view point that materials, equipment and other waste is disposed of in a suitable manner. Please consult with the Head Technician and/or Laboratory Safety Officer for any non-standard items or materials needing to be disposed of. The University has issued guidance on this through the Environmental Office:

http://www.admin.cam.ac.uk/offices/environment/guidance/

5.1 Electrical

Spills of water are inevitable in the laboratory. If such spills occur over or close to electrical or electronic equipment then this represents a serious risk of electrocution. The following checklist will help reduce this risk to acceptable levels:

1. Never position mains-operated equipment or plugboards where there is a danger of it getting wet through splashes or leaks.
2. Do not overload sockets or plugboards by connecting excessive electrical loads.
3. Do not daisy chain plug boards so that there are more than two plugboards connected to any given power socket.
4. If the equipment is located above a tank or where it may be knocked into a tank, then ensure the equipment is securely attached. If necessary, the technicians will make suitable brackets or other attachment mechanisms.
5. Ensure all equipment used near liquids is protected by an RCD (Residual Current Detector). This device will automatically shut of the mains supply if the current returning along the neutral wire is not equal to that supplied along the live wire. You should **not** assume the use of an RCD removes the danger of electrocution: it does not, but it does lessen the risks. All single-phase (*i.e.* 13A plugs) outlets within the research areas of the GK Batchelor Laboratory are protected by a local RCD. In most cases this is incorporated into the socket front, but for power poles the RCD forms a separate unit. Sockets in other areas, such as the corridors or IT cupboards, are not necessarily RCD protected. If you are using equipment outside the Laboratory, then you should use either a RCD adapter, or a plug fitted with an integral RCD.
6. Never turn on or off, or alter in other ways, any mains-operated equipment when you have wet hands, unless it is specifically intended for use in wet environments.
7. Never operate mains equipment when standing on a wet floor.
8. In emergencies, use the red knock-down button to cut power to all sockets in your area. You should familiarise yourself with the location of the knock-down switch before you start work on your project. Knock-down switches are positioned to allow easy access in emergencies and are typically adjacent to passageways or doors. In larger spaces (such as the AFF and Pavilion A), the power outlets are divided into zones, with one or more knockdown switch per zone. Each socket and knock-down switch is labelled to identify the zone to which it belongs. Resetting the knock-down button will in most cases immediately restore power to all single-phase outlets (but not three-phase outlets).
9. Check visually all equipment for loose or damaged wires, or other features which may represent an electrical hazard.
10. All electrical equipment must have a valid test sticker attached. These stickers show both the date the equipment was last tested, and the date the next test is due. The equipment must not be used if the date due has passed, but should instead be referred to the technicians for testing. Additionally, do not use equipment that does not have a safety sticker, the sticker was issued by someone other than the Department, or the equipment has any visible damage.
11. Never operate equipment from outside the laboratory until it has been safety checked. This includes both electrical testing (see above), and a visual check of

other features (*e.g.* mechanical or optical) by a suitably qualified person. Note that it may be necessary to extend the Risk Assessment for the project to include this equipment.

12. Electrical equipment should be turned off when not in use, unless there is a good reason to keep it turned on. This rule does not apply to video cameras, computers and some types of instrumentation. Older computer monitors that do not power down automatically should be turned off, except if the computer is left processing results.
13. Any equipment that must be left on should have a label stating ‘Do not turn off’ (or similar) adjacent to the relevant switch(es).

Refer to the CMS Electrical Safety Policy for further details.
http://www.cms.cam.ac.uk/safety/electricalpolicy/ElectricalPolicy.pdf
The University has issued guidance on electrical safety.
http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd001p/

5.2 Mechanical

Electric motors are used in a number of large and small apparatus. In addition to the electrical safety noted above, these represent a hazard due to possible entanglement, crushing, abrasion and movement of insecure loads. Similar risks exist in other equipment with moving parts, whether activated by compressed air or manually.

5.2.1 Turntables:

1. Never operate wearing loose clothing or jewellery that may become entangled. Similarly long hair should be tied back if there is a danger of snagging.
2. Ensure your footwear is suitable for walking around the table without slipping or tripping.
3. Ensure all apparatus is mounted securely on the table and that there are not dangling wires. The technicians will construct suitable mounting brackets if none are available.
4. Never have sharp objects protruding from the table, or other items overhanging the table edge to any great extent.
5. Where possible, set up experiments to avoid the need to walk around the turntable while it is in motion.
6. Ensure there is adequate space to move freely around and past the turntable while it is in motion.
7. Position a security barrier to prevent others from walking past the turntable while it is in motion.
8. Keep members of the public well clear of the table when rotating.
9. Never operate the table in complete darkness.
10. Do not rotate in speeds in excess of 30rpm (~3rad/s) without first seeking clearance from the Director of the Laboratory.
11. Do not use a turntable if you are in the third trimester of a pregnancy or your movements are otherwise impaired.

5.2.2 Other

Specific Risk Assessment: Mandatory

1. Ensure guards are properly installed.
2. Do not place hands or objects in the way of any moving parts.
3. Turn off and, where appropriate, disconnect before making any adjustments.
4. Do not tamper with any limit switches or cut-offs.
5. Ensure the "off" switch is located in an easily accessible and obvious place.

5.3 Chemical

The main chemical substances used in the laboratory are salts, dyes, water and alcohol. A small supply of other chemicals is also kept for specific applications. Regardless of the chemical, you should check the current safety information before use. Copies of the COSHH materials safety data sheets may be obtained from the Head Technician. Your Risk Assessment must contain a copy of the data sheet for any substance that is not covered by this manual or where its use is regulated.

The notes below are only for additional guidance. In all cases:

1. Do not leave open or unlabelled containers lying around.
2. Label all containers using insoluble pen and suitable labels.
3. Make yourself fully aware of the potential hazards involved.
4. Never be tempted to determine the contents of an unknown container by smell, taste or chemical reaction.
5. Never establish flow through a tube/siphon using your mouth.
6. Never use your mouth to fill a pipette.
7. If you are uncertain of the correct method of disposal, please check first. Even chemicals that can be flushed down the drain separately can react violently if brought together. The Head Technician will arrange for disposal of any chemicals that may not be disposed of via normal routes.
8. Avoid the possibility of any chemicals coming in contact with electrical or other equipment.
9. Chemicals labelled R40, R45, R46, R47, R61, R63 and R64 must not be used if you are pregnant. Special assessment of other chemicals should be made.
10. Flammables and solvents should be stored in one of the 'flammables' cupboards when not in use, although small quantities of propan2ol may be kept in suitably marked containers in the Laboratory.
11. Liquid containment wadding and other materials used for containing or cleaning up a spill are located in the chemical store. In some cases it may be appropriate to have this form of material closer to a particular experiment.

The University also has a code of practice concerning chemical safety. The notes given here are in accordance with that code and provide supplementary information.

http://www.admin.cam.ac.uk/cam-only/offices/safety/chemical/
http://www.admin.cam.ac.uk/cam-only/offices/safety/chemical/guidance.shtml

The University has issued specific guidance to the completion of COSHH forms (available electronically), including examples.

http://www.admin.cam.ac.uk/cam-only/offices/safety/chemical/risk.html
http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd030c/

The University has also issued guidance for the disposal of chemicals and discharges to drains.

http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd018c/
http://www.admin.cam.ac.uk/cam-only/offices/environment/guidance/effluent.html

There are many web-based sources of additional information available, including electronic access to many of the Material Safety Data Sheets that are required for completion of COSHH forms. Good starting places for this information are listed below.

http://msds.chem.ox.ac.uk/
http://www.msdssolutions.com/en/
http://www.ilpi.com/msds/
http://www.cds.dl.ac.uk/cds/cds.html
http://www.dow.com/webapps/msds/msdssearch.aspx
http://www.bandj.com/
http://chemfinder.cambridgesoft.com/
http://www.msdsonline.com/

The Material Safety Data Sheets are also supplied whenever we order chemicals. These are held by the Head Technician and are available on request.

A fume cupboard is available within Pavilion C for any work requiring such facilities. A detailed risk assessment will be mandatory in all cases where the fume cupboard is required. The University has issued some guidance on the use of fume cupboards.

http://www.admin.cam.ac.uk/cam-only/offices/safety/publications/hsd029c/

5.3.1 Water

The main dangers from water by itself are contributing to electrocution and making the laboratory floor slippery.

1. Avoid splashes and spills wherever possible.
2. Always mop up spills immediately. Squeegees, which are available in every part of the laboratory, are the most effective method of sweeping water into the drains. Take care, however, not to sweep the water into areas containing other equipment.
3. If you are unable to clean up the spill quickly, cordon off the area affected or erect "Slippery Floor" signs.
4. Do not operate electrical equipment (unless specifically designed for operating "wet") while there is water on the floor.
5. It the spill is sizeable, it may be necessary to isolate all power outlets using the knock-down button.
6. Ensure that the shutoff valves feeding the apparatus remain accessible at all times.
7. Never drink water from the laboratory.

Note that a drinking fountain is provided in the corridor in Pavilion H. You may drink directly from this, but should not use it to fill any form of container. Moreover, you may not bring or consume food or other drinks within the corridor.

In the event of major problems, it may be necessary to shut off the water to the whole of the Laboratory in which you are working. For the laboratory components in Pavilions A, C and H, this can only be achieved in the adjoining plant rooms, and so must be done by a technician or a member of the facilities staff. In the Ambient Flow Facility, isolation valves are located alongside the main stairs between levels -1 and -1.5.

5.3.2 Solvents

This section deals with the most commonly used solvents (liquids) used in experiments.

http://www.bandj.com/

Note that the use of volatile solvents is restricted and in many cases a Volatile Solvent Permit is required before they can be used. This Permit system operates in parallel with the need for a Risk Assessment. With the exception of undiluted propan-2-ol, a Permit is not required for the solvents listed here.

http://www.damtp.cam.ac.uk/lab/safety/SolventPermit.pdf

5.3.2.1 ALCOHOL

Volatile Solvent Permit: May be required

Propan-2-ol (isopropyl alcohol; $CH_3CHOHCH_3$) is often used for cleaning laboratory equipment and may be used to match refractive indices or reduce the density of water solutions. Do **not** use either ethanol or methanol for any purposes without prior consultation. In addition to the safety issues, it also damages most of our tanks.

The guidance given in §5.3.1 for water applies also to alcohol. However, in addition:

1. Avoid breathing vapours.
2. Dilute spills with water before mopping or wiping up.
3. Do not use in enclosed spaces.
4. Do not use the pure liquid for experiments.
5. Do not use solutions more concentrated than 30% by volume in experiments requiring more than 50ml of propan2ol without prior approval of the Laboratory Safety Officer. Approval will require careful assessment of the dangers and control measures in your Risk Assessment.
6. Do not leave dilute solutions in open experimental apparatus for extended periods.

Note: a Volatile Solvent Permit is required whenever in excess of 50ml per hour is released from solutions stronger than 30% by volume.

5.3.2.2 GLYCERINE

Glycerine is frequently used when a high viscosity fluid is required, sometimes diluted with water. Glycerine can also be used in low concentrations to adjust the refractive index if a solution. Glycerine is relatively safe to use: it is frequently a component of foods.

The guidance given in §5.3.1 for water applies also to glycerine. However, in addition:

1. Minimise contact with skin. Can cause dehydration of skin.
2. Dilute spills with water if necessary, and always rinse with clean (preferably hot) water at the end.
3. Dispose of glycerine down the drain, diluting with copious quantities of water. Paper towels used to mop up glycerine may be disposed of via the normal laboratory rubbish bins.
4. Be aware that glycerine can be extremely slippery as it acts as a lubricant.
5. Handle glycerine drums with care. The weight of these drums often exceeds the limits that may be handled safely by one person.

http://www.dow.com/glycerine/resources/physicalprop.htm

5.3.2.3 Golden syrup and treacle

Golden syrup and treacle are sometimes used when a high viscosity fluid is required, sometimes diluted with water. These sugar products are relatively safe to use: it is frequently a component of foods.

The guidance given in §5.3.1 for water applies also to golden syrup and treacle. However, in addition:

1. Dilute spills with water if necessary, and always rinse with warm soapy water at the end.
2. Dispose of golden syrup and treacle down the drain, diluting with copious quantities of water.
3. Failure to clean up a spill adequately may attract insects and other pests.

5.3.2.4 Silicon oil and silicon fluid

Specific Risk Assessment: Mandatory for low viscosity oils

Unlike glycerine, golden syrup and treacle, silicon oil is insoluble in water and has a viscosity that is only weakly dependent on temperature. It comes in a broad range of different viscosities, ranging from fluids comparable with water, to ones that are extremely viscous. The low viscosity fluids have low boiling and flash point, while the higher viscosity fluids are relatively inert.

1. Avoid prolonged contact.
2. Do not dispose of silicon oil/fluid down the drain. Instead, all waste oil/fluid must be placed in a sealed container and the Head Technician informed that it needs to be disposed of.
3. Mop up spillages using absorbent material such as paper towels, and place these in a rubbish bag.
4. Clean surfaces using detergent and hot water. Note that even after vigorous cleaning a thin film of silicon oil/fluid is likely to remain.
5. Do not use low viscosity silicon oil/fluid without adequate ventilation and precautions against ignition.

5.3.2.5 OTHER SOLVENTS

Specific Risk Assessment: Mandatory

Do not use any solvents without prior consultation.

5.3.3 Salts and sugars

5.3.3.1 SODIUM CHLORIDE

The majority of the salt used in the laboratory is sodium chloride (common salt).

1. Avoid spillages and sweep up any accidental spills immediately.
2. Salt solutions are highly corrosive and may render previously safe equipment unsafe, so avoid splashes *etc.*
3. Do not use salt solutions with equipment not designed for such uses. Failure to observe this will lead to damage to the tank, potential spills and electrolysis reactions. If in doubt, please **ask**.
4. Always rinse with fresh water any tanks, pumps, pipes or other equipment used with salt solutions.
5. If you are using electrolysis for any reason, do not collect the evolved hydrogen and chlorine gas in a container.

5.3.3.2 SUCROSE

Sucrose (sugar) is sometimes used as a less diffusive alternative to salt for changing the density of the fluid. Sugar is also optically active (*i.e.* it changes the angle of the polarisation vector of polarised light). As it is a foodstuff, sugar is relatively safe to use.

1. Avoid spillages and sweep up any accidental spills immediately. Rise with fresh water to remove any sticky residue.
2. Always rinse with fresh water any tanks, pumps or other equipment used with sugar solutions.
3. Failure to clean up a spill adequately may attract insects and other pests.

5.3.3.3 OTHER SALTS

Specific Risk Assessment: Mandatory

Do not use salts other than sodium chloride without prior consultation.

1. Avoid spillages and sweep up any accidental spills immediately.
2. Salt solutions are highly corrosive and may render previously safe equipment unsafe, so avoid splashes *etc.*
3. Do not use salt solutions with equipment not designed for such uses. Failure to observe this will lead to damage to the tank, potential spills and electrolysis reactions. If in doubt, please **ask**.
4. Always rinse with fresh water any tanks, pumps or other equipment used with salt solutions.
5. If you are using electrolysis for any reason, do not collect the evolved gases.

5.3.4 Dyes

The main dyes used in the laboratory are food colourings, sodium fluorescein and potassium permanganate.

5.3.4.1 Food colouring

1. Avoid spillages and mop up any accidental spills immediately.
2. Avoid contact with hands or clothes. Disposable gloves are available by the entrance to the main laboratory.
3. Do not use bleach to try to remove dye from skin.
4. Where possible, avoid using in high concentrations.

5.3.4.2 Sodium fluorescein

1. Avoid spillages and mop up any accidental spills immediately.
2. Avoid contact with hands or clothes. Disposable gloves are available by the entrance to the main laboratory.
3. Do not use bleach to try to remove dye from skin.
4. Where possible, avoid using in high concentrations.

5.3.4.3 Potassium permanganate

Specific Risk Assessment: Mandatory

Potassium permanganate ($KMnO_4$) is often used to create streaks of dye by dropping the crystals through the water column. It is also often used in dye absorption measurements as it is of a consistent quality and, when used in conjunction with green light, has close to the ideal exponential behaviour.

However, potassium permanganate is harmful (it is readily absorbed through the skin) and an oxidising agent under the definitions of COSHH. Refer to the COSHH data sheet for further details.

1. Avoid spillages and mop up any accidental spills immediately.
2. Avoid contact with hands or clothes. Disposable gloves are available by the entrance to the main laboratory.
3. Do not use bleach to try to remove dye from skin.
4. Where possible, avoid using in high concentrations.

5.3.4.4 Other dyes

Specific Risk Assessment: Mandatory

Do not use without prior consultation. A thorough Risk Assessment including COSHH documentation is required.

5.3.5 Cleaning agents

5.3.5.1 Wetting agent

It is often necessary to add wetting agent in an experiment, either to change the contact angle (and, for example, allow particles to be suspended within a flow), or to reduce the surface tension.

Normally, dishwasher rinse aid or household detergent is used. These products are formulated in a similar manner and do not represent a significant health hazard.

1. Dilute spills with water if necessary, and always rinse with clean water at the end.
2. Avoid using excessive quantities.
3. Be aware that the wetting agent can act as a lubricant.

5.3.5.2 Bleach

Bleach may be used to remove the colour from an experiment where food colouring has been used. Note that this is most effective with red food colouring.

1. Avoid using too much bleach: the oxidation reaction to remove the colour takes some time.
2. Avoid splashing bleach onto clothes, skin or other equipment. For clothing and skin, remove splashes immediately with fresh water. For equipment, wipe the bleach off, disconnecting from electric supply if appropriate.
3. Do not use bleach to clean your hands.
4. Do not use concentrated bleach to clean work surfaces or equipment.
5. Do not use bleach, even when diluted, to clean aluminium components.

5.3.6 Other chemicals

Specific Risk Assessment: Mandatory

Do not use without prior consultation. Explicit note of the dangers and control measures must be made in the Risk Assessment, and COSSH details must be provided.

1. Always ensure you are familiar with the requirements for safe handling and disposal.
2. Kits for dealing with chemical spills are located in each laboratory.
3. Containers are available for the safe disposal of excess or used chemicals. Notify the Head Technician or Director or the Laboratory who will arrange for the safe disposal of the residue.
4. Use hazard warning labels.
5. Lab coats, chemical aprons, long trousers and impervious footwear must be worn when handling hazardous chemicals.

5.4 Particles

Specific Risk Assessment: Mandatory for particles not covered explicitly in this section

Particles have two main uses in the Laboratory: as passive tracers for measuring velocity, and as an additive to change the density in multi-phase flows. Most particles used are relatively inert, with the chief hazard arising from breathing in dust.

Basic safety measures are outlined below, with additional measures for specific types in the subsequent subsections.

1. Carefully sweep or mop up any spilt particles.

2. Be aware that spills can be very slippery, particularly if the particles are approximately spherical in geometry.
3. Avoid the creation of dust.
4. If the handling of the particles is liable to create a dust, use a protective mask and goggles. Always use such protection when transferring particles from the sieves to containers.
5. Ensure that dust cannot enter other equipment.
6. Keep the particle storage and handling areas tidy, sweeping up any spillages.

The Granular Flow Chute can represent a significant source of dust and warrants a more detailed analysis and Risk Assessment. The use of this facility is covered in greater detail in §6.2.

5.4.1 Pliolite

The main use for Pliolite is as a neutrally buoyant tracer for PIV and PTV measurements. Pliolite comes in a broad range of different types, each of a different chemical composition and specific density (in the range 1.02 to 1.05). The commercial use for Pliolite is as the resin in solvent-based paints. We use Pliolite before it has been dissolved in a solvent. At this stage, the resin is in the form of friable granules that are an opaque white in appearance and are readily dispersed in water with the aid of a little wetting agent. Pliolite particles are normally sieved to obtain the correct size range; sometimes it is necessary to sieve them first. Follow the basic safety measures as outlined at the start of §5.4.

http://www.eliokem.fr

5.4.2 ChemiGum

The use of ChemiGum is very similar to that of Pliolite (see §5.4.1). While optically it is less good (being slightly off-white in colour), the density close to that of fresh water makes it particularly valuable in some circumstances. Follow the basic safety measures as outlined at the start of §5.4.

http://www.eliokem.fr

5.4.3 Polystyrene

Polystyrene particles are used in both their unexpanded (dense) and expanded (low density) forms for a variety of purposes. In their unexpanded form they are slightly denser than fresh water and can be used as a substitute for Pliolite, or for glass ballotini. The particles are commonly approximately spherical, which can make them very slippery when spilled. The low density expanded polystyrene particles are very mobile and can easily spread throughout the laboratory, so good housekeeping is essential. Follow the basic safety measures as outlined at the start of §5.4.

5.4.4 Glass ballotini

Glass ballotini are used as suspended particles, as porous media, and for a variety of other purposes. They are available in sizes ranging from around 0.1mm up to several centimetres in size. The particles are approximately spherical in shape and are available in well graded sizes. Cohesion between neighbouring particles is very small and they are readily wet. Follow the basic safety measures as outlined at the start of §5.4.

http://www.pottersbeads.com/

5.4.5 Pearlescence

Pearlescence is available in two forms in the Laboratory: natural Pearlescence (crystals of guanine extracted from fish scales and widely used as glitter in cosmetics) and artificial Pearlescence (flakes of mica coated with titanium dioxide and other relatively inert chemicals are widely used in metallic paints, as colorants for plastics, *etc.*). Both align themselves with the shear in a flow and provide a method of visualising the length scales found in the flow.

Natural Pearlescence comes as a slurry suspended in a carrier fluid such as propan2ol or glycerine, whereas artificial Pearlescence comes in the form of a dry powder. Both disperse easily in water. The natural Pearlescence will dissolve over a day or two in tap water, while the artificial varieties are immune to all solvents likely to be used in the Laboratory. The principal hazard comes from the artificial Pearlescence in that it is readily suspended in air. However, as the particles are relatively large and dense, it will quickly settle again. Follow the basic safety measures as outlined at the start of §5.4.

http://www.thornleycompany.com/Products/Pigments/Mearlmaid.htm
http://www.merck-chemicals.co.uk/

5.4.6 Silicon carbide

Silicon carbide (industrial grinding powder) is primarily used to create dense, particle-laden flows where the density of the suspended particles is dynamically important and their settling changes the concentration of particles over time. The particles, which are available in a broad range of graded sizes, are dark grey in colour, angular in geometry, and have a specific density of around $3.2\mathrm{gcm}^{-3}$. Follow the basic safety measures as outlined at the start of §5.4.

http://www.washingtonmills.com/products/types/silcarb/index.html

5.4.7 Titanium dioxide

Titanium dioxide is widely used as the white pigment in paints, toothpaste, and a broad variety of other products. It is an extremely inert material, the principal hazard arising from the potential for fine dust. Its use in the Laboratory overlaps closely with that of silicon carbide. Follow the basic safety measures as outlined at the start of §5.4.

5.5 Biological

Biological hazards fall into two groups: unintentional biological organisms and projects studying biological processes.

5.5.1 Unintentional biological organisms

The presence of unintentional organisms within the Laboratory can impose a real and significant risk. For example, the bacterium that causes Legionnaires Disease thrive in warm, stagnant water (such as an experimental tank that is not emptied, or a section of pipe work that has not been used for some time), and then dispersed in small water droplets generated by an experimental procedure (which might be simply draining/cleaning the tank). Similarly, many insects such as mosquitoes will lay their eggs in stagnant water.

Unintentional biological organisms may be present in the Laboratory for a variety of reasons. However, the most likely causes are poor housekeeping. For example, failing to clean up spills of golden syrup. Tanks and vessels of water should not be allowed to stand for longer than necessary due to the possible growth of bacteria, algae and insect larvae. Although regular testing of water outlets is undertaken, hoses and water outlets should be flushed carefully directly down the drain before use to remove any residual risk of listeria and other water-bourn pathogens.

1. Drain tanks after use.
2. Clean up spillages.
3. Take care and consider wearing a mask when draining or cleaning a tank that has been allowed to stagnate.
4. Be careful when turning on taps, especially if the tap has not been used for some time. Allow the water to flow for short time before using it to fill a tank.
5. Report any drain blockage or sewage smells.
6. Mop up spills.
7. Cover tanks that might be attractive to insects (*e.g.* golden syrup).

Note that the problem with stagnation applies to fresh water. Salt solutions, especially those with very high salt concentrations, are much less prone to biological growth. However, solutions with organic compounds (including food colouring, sugar, glycerine, *etc.*) can see much higher levels of biological growth.

Insects (*e.g.* wasps), moulds and other organisms can also represent a significant hazard to some people and are typically the result of poor house keeping and laboratory procedures.

The low level windows in Pavilion A can also provide an entry point for small animals such as frogs.

5.5.2 Biological organisms intended for experiments

Specific Risk Assessment: Mandatory

Experiments utilising biological organisms, either alive or dead, are limited to Hazard Group 1 microorganisms, plants and insects. Organisms can include both natural strains and Class 1 genetically modified strains. In all cases a Risk Assessment is required, even if the organisms are only stored in the Laboratory (see §2.3.4). Plans to move to other categories, groups or classes of organisms must be discussed with the Biological Safety Officer at an early stage.

Specific rules and generic Risk Assessments for work in this are can be found online.

https://wiki.cam.ac.uk/goldlab/Safety

5.6 Optical

Powerful light sources are frequently used in a wide range of experiments. These light sources can cause damage to eyes if viewed directly. The two categories of light sources in common use: projecting light sources and diffuse light sources. However, the lack of light is also a potential hazard.

The Control of Artificial Optical Radiation at Work Regulations, introduced in 2010, govern the use of all sources of optical radiation, not just lasers. There are four groups of source:

Exempt Group Sources such as office lighting, computer monitors and indicator lamps that are safe for normal use.

Risk Group 1 – Low Risk Only pose a risk if very prolonged direct exposure.

Risk Group 2 – Moderate Risk Safe for accidental exposure for most people, relying on normal aversion response, *e.g.* standard slide projectors.

Risk Group 3 – High Risk Sources that pose a risk even for momentary or brief exposure. Control measures are mandatory.

This section deals with the most common sources found in the Laboratory that fall into Risk Group 3 by design or application. University guidance can be found on the Safety Office web pages.

http://www.admin.cam.ac.uk/cam-only/offices/safety/radiation/nonir/optical/

5.6.1 Dark

Many of the experimental techniques used in the laboratory require very low levels of ambient illumination. The dark thus created can cause things that would normally be safe to become a significant risk.

1. Ensure your work area is kept free of clutter and trip hazards.
2. Never place open chemicals where they may be knocked in the dark.
3. Ensure your route out remains clear.
4. If necessary, use the knock-down switch to turn off equipment in an emergency rather than fumbling in the dark.
5. In some parts of the Laboratory, auto luminescent tape has been used to indicate key features.

5.6.2 Projecting light sources

Specific Risk Assessment: Mandatory for arc lamps of all powers and halogen lamps exceeding 250W

The three main types of projecting light sources are standard slide projectors, 1kW linear photographic lamps and arc lamps. Seek guidance before using other light sources.

The output from some of these far exceeds the 25W/m^2 radiant exposure limit permissible for lasers, but the regulations governing them are phrased differently. Care must therefore be taken both in the design of the experimental setup and in the operational procedures used to ensure there is no chance of looking at the beam or a specula reflection of it. It is good experimental practice, in general, to contain and mask the projected light as much as possible. This not only reduces the chance of accidental exposure, but also cuts down on stray light that might reduce the contrast or signal to noise ratio of your visualisations.

1. Never look directly at the light source.
2. Ensure others cannot accidentally look directly at the light source. This is especially important for those working in the open plan areas of the lab.
3. Prevent specula reflections by suitable shielding or masking of the light.
4. Do not locate the light sources close to flammable or delicate materials.
5. Do not impede airflow through ventilation slots.
6. The lamps should not be located closer to the tank than (a) 0.5m for slide projectors, (b) 1m for 1kW photographic lamps and (c) 1.5m for the 300W arc lamps.

7. Ensure items of clothing, hands *etc.* cannot accidentally enter the light beam closer than the distances given above as this may result in burning.
8. If masking the light beam closer than the distances given above, use only non-flammable materials (*e.g.* aluminium) and attach a warning ("Hot!") as appropriate.
9. Where feasible, use a 'cold mirror' to reduce the heat in the beam. Also consider using a coloured mirror to filter out the unnecessary wavelengths.

Arc lamps: http://optoelectronics.perkinelmer.com/products/

Specific additional guidance can be found on the Safety Office web pages.

http://www.admin.cam.ac.uk/cam-only/offices/safety/radiation/nonir/broadband/

5.6.3 Diffuse visible light sources

Typically, these take the form of fluorescent lights, either singly or in banks of multiple lights. For visible light, these sources do not represent a danger over and above those associated with their electrical and mechanical nature.

5.6.4 Lasers

Specific Risk Assessment: Mandatory for all lasers

The rooms in the Pavilion H Laboratory have been designed with the use of lasers in mind. However, substantial additional safety measures are required before lasers may be used. Please refer to the University Code of Practice for lasers and consult with the Departmental Laser Officer.

Often you will find it simpler and more convenient to use some other form of light source (*e.g.* arc lamp) rather than a laser.

Specific usage rules and generic Risk Assessments for the lasers held by the Biological Physics group may be found on the web.

https://wiki.cam.ac.uk/goldlab/Safety

The University has issued a Code of Practice governing the use of lasers.

http://www.admin.cam.ac.uk/cam-only/offices/safety/radiation/nonir/lasers/

5.6.5 Ultraviolet light sources

Specific Risk Assessment: Mandatory for all ultraviolet light sources

A full Risk Assessment must be made for any work utilising ultraviolet light sources. This Risk Assessment must consider not only the possibility of damage to skin, eyes, but also the generation of ozone and possible damage to materials and other equipment.

Specific usage rules and generic Risk Assessments for the UV sources held by the Biological Physics group may be found on the web.

https://wiki.cam.ac.uk/goldlab/Safety

The University has issued a Code of Practice governing the use of UV sources.

http://www.admin.cam.ac.uk/cam-only/offices/safety/radiation/nonir/ultraviolet/

5.7 Heat

Note that the use of mercury thermometers is strongly discouraged due to the contamination that can occur in the event of breakage (see §5.11 for clean-up procedures). Please use spirit-based or electronic thermometers wherever possible.

5.7.1 Hotplates and heat baths

Hotplates and heat baths have the potential to cause serious burns, either by direct contact, or through spillages or leaks of the fluid or other substance being heated. Care should be taken in the positioning of these, to ensure any accidental spillage or leak cannot burn anyone. Any associated equipment must be checked to ensure it can withstand the temperatures to which it is exposed. Note that the period of exposure is important as well as the temperature. Some materials (*e.g.* PVC) can withstand short periods at high temperatures (above 50°C), but will suffer creep, distortion and premature failure if exposed for longer periods.

Heat baths and hotplates must not be used to heat solutions of volatile (especially flammable) solvents, and heat baths should not be used with corrosive chemicals (*e.g.* salt water). Care must also be taken to ensure heat baths are never used under dry conditions.

5.7.2 Immersion heaters

Immersion heaters must only be used in equipment that is designed for this purpose. The use of inappropriate materials or accidental contact with surfaces incapable of withstanding the high temperatures of the heating element can both damage the equipment and gives rise to the risk of serious burns.

Immersion heaters must only be used in conjunction with a RCD, and the fluid in the tank should be independently earthed. Care must also be taken to ensure immersion heaters are never used under dry conditions, or with fluids containing corrosive or volatile components (*e.g.* potassium permanganate or alcohol).

5.7.3 Heat from light sources

Light sources provide the dual risk of direct heat from the casing and, especially in the case of arc lamps, a considerable amount of radiated heat. Refer to §5.5.1 for further details.

5.7.4 Freezers and cryostatic circulators

Cold can not only cause ‘cold burns’, but also cause materials to become brittle and prone to fracture.

1. Always wear suitable gloves when removing items from a freezer or which are cooled to less than freezing point. Note that thin latex gloves or gloves that can absorb water are not suitable.
2. Be aware that sudden changes in temperature (*e.g.* hot water into cold glass) can cause materials to fail and the contents to spill.
3. Ensure the cooling fluid in a cooling bath or cryostatic circulator has a freezing point well below the required working temperature. Inadvertent freezing of the cooling fluid can lead to leaks and equipment damage.

5.7.5 Autoclave

The autoclave, located in Pavilion H, generates very high temperatures internally to sterilise equipment and wastes from biological activities.

1. Ensure only compatible materials are placed in the autoclave.
2. Select appropriate program given materials and purpose for autoclave use.

3. Ensure that autoclave and all items it contains have cooled sufficiently before attempting to empty or refill autoclave.
4. Ensure the autoclave is tested annually.

5.7.6 Temperature controlled laboratory

Risk Assessment: Mandatory

The temperature controlled laboratory (TCL) is capable of temperatures ranging from −40 to +30°C. The TCL consists of two rooms: an outer room used for observation, and an inner room. The outer room is at normal room temperature, whereas the inner room can be well below freezing. Hazards include embrittlement of materials, cold burns, and hypothermia.

1. Wear suitable protective clothing when working in the TCL for even a short time.
2. Always wear gloves when working at subzero temperatures.
3. Do not work alone if the temperature is below freezing.
4. Do not use equipment outside the temperature range for which it was designed.
5. Be aware that sudden changes in temperature (*e.g.* hot water into cold glass) can cause materials to fail and the contents to spill.
6. Ensure the doorway to the inner room and the goods door remain clear of obstructions. These doors are fitted with heating circuits to prevent icing up.
7. Ensure the emergency call and emergency shutdown buttons remain accessible and are not iced up (they are fitted with a warming unit to prevent icing under normal circumstances).

A more complete discussion of the use of the TCL and restrictions on its use may be found in §6.1.

5.7.7 Naked flames

Specific Risk Assessment: Mandatory

Hot Work Permit: May be required

Naked flames are not permitted in the Laboratory, except in specifically designated areas. Failure to adhere to this requirement is likely to trigger the sensitive fire alarm system.

Any proposal to use naked flames must be discussed in advance with the Safety Officer. In all cases a detailed Risk Assessment will be required. A daily Hot Work Permit may also be required, depending on the control measures put in place to reduce the risk.

http://www.damtp.cam.ac.uk/lab/safety/HotWorkPermit.pdf

5.8 Pressure

Specific Risk Assessment: Mandatory if compressed air used

Although compressed air is available throughout the Laboratory, it is important to recognise that it can be very dangerous. The air is produced and distributed at 10 bar and is capable of a flow rate in excess of 140litres/s at atmospheric pressure.

Associated hazards include

- Failure of pressure vessels or tubing.
- Formation of aerosols and resuspension of particles.

- Damage to eyes or skin.
- Noise.

Compressed air may only be used with apparatus designed with it in mind. Such apparatus must be attached via a suitable regulator and gauge, and the shut off valve must remain accessible. If the apparatus is not certified for use at the production pressure (10 bar), then it must include a pressure relief valve in its design.

The shut off valve must remain readily and safely accessible, even in the event of equipment failure. In the event of major problems, it may be necessary to shut off the compressed air to the whole of the Laboratory in which you are working. In the Ambient Flow Facility, there is an isolation valve alongside the main stair between levels -1 and -1.5. For the other components of the laboratory, although there are isolation valves at high level where the airline enters the Pavilion C laboratory, and where it passes from Pavilion A to Pavilion H, the simplest route is to have a technician or member of the facilities staff shut off the air at the compressor. Note that the pipework will remain pressurised until the excess pressure is bled off through an open outlet or leak.

In all cases, a specific Risk Assessment is required before use.

5.9 Use outside design specification

Specific Risk Assessment: Mandatory if used outside design specification

Equipment should normally be used for the purpose envisaged by the manufacturer and within the manufacturer’s design specification. For equipment constructed in the Laboratory, any significant deviation from previous usage must be discussed with the Director of the Laboratory. Similarly, any use of commercial equipment outside the design specification must be discussed first with the Director of the Laboratory. Failure to do so may damage the equipment and/or render it unsafe.

Use of equipment outside its design specification will normally require a greater level of detail to be incorporated in the Risk Assessment. In some cases, a regular testing and maintenance programme may be required.

5.10 Noise

5.10.1 Low levels of noise

Most of the apparatus in the laboratory is relatively quiet and represents no direct hazard. No special provision is required, except for those items listed under sections 5.9.2 and 5.9.3.

5.10.2 Moderate levels of noise

The following fixed items, however, produce noise levels which may become hazardous through prolonged exposure or if working close to the source of the noise:

- The large flume (Pavilion A)
- The small flume (AFF, level -1)
- Cold Room (Pavilion C)

The following points should be considered

1. The noise levels may cause fatigue, headaches or other signs of stress if subject to prolonged exposure.

2. The use of ear protection and frequent breaks is recommended for all use extending beyond 20 minutes if you are working in the general proximity of the noise source.
3. The use of ear protection is required for those working within 2m of the noise source.
4. Try to avoid using the apparatus while others are sharing the lab space.
5. Warn other users of the lab space and make sure they have ear protection available.

5.10.3 High levels of noise

Specific Risk Assessment: Mandatory

The following items produce levels of noise which are potentially harmful even with only short exposure:

- Recirculating granular flow chute

The following points should be considered

1. The noise levels may cause fatigue, headaches or other signs of stress if subject to exposure even for modest periods.
2. The use of ear protection is required at all times when working on the equipment. Frequent breaks are recommended.
3. Ear protection is also required for visitors viewing the equipment in operation.
4. The impact of the noise on other users of the laboratory must be considered. Do they require ear protection? What is the ‘safe’ distance? (Ear protection should be made available to other users, even if the Risk Assessment does not require them to wear it.)
5. Try to avoid using the apparatus while others are sharing the lab space.
6. Consider what measures may be made to reduce the acoustic radiation.

5.11 Breakages

The occasional breakage is inevitable in the laboratory. However you should always exercise care to avoid breakages and, if one occurs, clean up any materials spilt, or cordon off the area until remedial action has been taken.

1. In the case of broken equipment, please report this as soon as possible to the Head Technician or Director.
2. Protect any sharp or dangerous edges immediately.
3. For broken glassware, carefully sweep up all glass fragments and dispose of in the “Broken Glass” container located in the chemical store and in each of the individual laboratories.
4. Other sharp items can be disposed of in the “Sharps” container located in the chemical store and in each of the individual laboratories.
5. For broken mercury thermometers, seal the remains in a plastic bag. A kit for dealing with the spilt mercury is located in the chemical store. Follow the instructions on this kit. It is better to overestimate the size of the contaminated area than to underestimate it. Always use gloves for this operation, and avoid walking through the contaminated area; fence off if appropriate. Label all bags

appropriately and pass over to the Head Technician for disposal. **All spillages of mercury must be reported to the Head Technician and Safety Officer[1].**

6. Deal with other chemical spills in the manner stipulated in the appropriate safety literature. You should ensure you are familiar with the relevant procedures (*e.g.* those stated in the relevant COSHH data sheets, available from the Head Technician) *prior* to using any chemicals.
7. Liquid containment wadding and other materials used for containing or cleaning up a spill are located in the chemical store. High risk activities may require containment material to be kept nearby.

5.12 Lifting

Many of the items in the laboratory are heavy or awkward to move. What is meant by 'heavy' depends not only on the weight of the object, but also on its shape/size and on the individual(s) doing the lifting. As a rule of thumb, anything weighing more than 1/3 your body weight or weighing more than 25kg (whichever is lower) is considered 'heavy'. Any item that does not have good hand-holds, that you can not carry close to your body, that requires your arms to be fully extended, or that you cannot carry without bending over is considered 'awkward'.

1. Always lift with your knees bent and your back straight.
2. Never lift by sharp edges or thin parts.
3. Ensure your handhold is sufficiently strong and secure.
4. Ensure all attached items are secure and not likely to fall.
5. Always seek help to lift large or heavy items.
6. Make sure your route is clear of hazards before starting to move the item.
7. Trolleys, a mobile hoist and lifting platforms (stackers) are available from the workshop to assist in the movement of large or heavy items.
8. Consult the Technicians before attempting to move anything weighing over 50kg.

5.13 Falls and injury

As with most of the other safety issues, exercising due care will minimise the likelihood of falls and injuries. It may be best, however, on medical grounds for some people to avoid certain activities.

5.13.1 Falls

1. Never run in the laboratory.
2. Mop up any spills immediately.
3. Never position cables or equipment across access ways.
4. Never stand on chairs - ladders are available.
5. Never stand on the very top of the ladder (*i.e.* no higher than the large "platform" step).
6. Do not use a ladder if you are in the third trimester of a pregnancy.

[1] The Safety Officer keeps a record of any such spills.

The University has issued a Code of Practice governing the use of ladders.
http://www.admin.cam.ac.uk/cam-only/offices/safety/buildings/ladders.html

5.13.2 Injury

1. A First Aider may be summoned by phoning reception (65000) or (if reception is not manned) the University Security Service (101) from any internal phone.
2. The Head Technician is one of the Departmental First Aiders.
3. Wash all minor cuts under clean *running* water immediately.
4. An emergency drench shower is located in the wash-down area immediately outside the main chemical store. Smaller hand-held shower units are also to be found in Pavilion H (in the corridor around the stair well) and the AFF (just inside the main entrance). These should be used if you have a major chemical spill or contamination to your clothing.
5. An eye rinse is available in the workshop and the First Aid room in Pavilion F (accessible by a first aider). Alternatively, and often more effectively, wash your eyes using the drinking fountain in the corridor of Pavilion H or with one of the hand-held showers. You should run the fountain/shower for a few seconds before directing it at your eyes in order to remove any contamination. You should not use taps or sinks in the laboratories for this purpose.
6. Use tools correctly: use the correct size and do not force; knives should be retracted or sheathed after use; "snap off" blades should be disposed on in the "Sharps" container under the sink by the entrance to the main laboratory.
7. Report all injuries (even minor cuts) to the Head Technician.
http://www.admin.cam.ac.uk/cam-only/offices/safety/firstaid/

5.14 Clutter

Clutter and general untidiness is bad laboratory practice. While not normally a risk in its own right, it acts as a multiplying factor for other risks. The clutter can obscure other issues, moving and working around clutter can increase the likelihood of knocking equipment, prevent access to controls, or hamper 'escape' routes. Untidiness will generally get in the way of doing good science, and is frequently unfair to others with whom you may be sharing equipment or laboratory space.

The small amount of time required to keep things reasonably tidy (no one expects perfect tidiness) generally pays dividends for all working in the Laboratory. Equipment put away where it should be prevents damage and makes it easier for others to find.

5.15 Clothing

Always wear sensible suitable clothing and footwear in the laboratory.

1. Do not wear loose clothing or jewellery that might catch in equipment.
2. Do not wear tops with over-long or baggy sleeves that may drape in tanks or chemicals.
3. Do not have bare feed or use open-toed footwear in the lab.
4. Ensure long hair is restrained to avoid entanglement.
5. Lab coats are available to protect clothing if desired.

6. Lab coats, chemical aprons, long trousers and impervious footwear must be worn when handling hazardous chemicals.
7. Footwear with toe protectors must be worn when moving heavy equipment or using a crane or hoist.

The prohibition against bare feet and open toed footwear such as sandals or flip-flops is not only to protect against injuries from objects falling onto feet, but also against stubs, cuts, contamination from chemicals, slipping, *etc*.

6 High-risk Facilities

Target Audience: Users of the facilities described

This section describes the additional dangers, restrictions and procedures relevant to the use of certain fixed installations that pose a significantly higher base level of risk.

6.1 Temperature Controlled Laboratory

Specific Risk Assessment: Mandatory

Introduction

The Temperature Controlled Laboratory (TCL; frequently referred to as the Cold Room) is a unique facility offering close control over ambient temperatures between +30°C and -40°C through the use of dual cooling circuits in conjunction with heating circuits. While it is intended that the Room can be used anywhere in this temperature range, it is envisaged that the majority of usage will be at or significantly below freezing.

The thermal environment within the TCL poses a significantly greater danger than other parts of the Laboratory. In order to minimise the risk associated with use of the TCL then additional procedures must be followed. To monitor the use of the TCL and compliance with the procedures, additional documentation is also required, both as part of the Risk Assessment and on a day-to-day operational basis.

Risk

The principal risk associated with this experiment is the extreme cold conditions combined with a strong wind-chill due to the air circulation. These pose the following dangers to the experimentalist:

- Cold burns from contact with high-conductivity surfaces such as metal work
- Hypothermia due to heat loss from prolonged exposure to the low temperatures
- Slippery conditions due to the formation of ice on the floors within the TCL
- The above dangers would be significantly increased in the event of a fall or other accident that may cause the experimentalist to become trapped within the TCL.

Generic measures to reduce risk

Minimising the danger associated with the use of the TCL is achieved through a combination of built in design features and management procedures.

DESIGN FEATURES

The TCL has a number of design features to reduce the risk of accidental hypothermia, falls and becoming trapped. These include:

- Timed door interlocks that will sound an alarm if not reset within set time of entering the TCL
- If alarm sounds for more than five minutes then the TCL will automatically shutdown the chillers and activate the heaters to return the room temperature to normal room temperatures (~20°C).

- The air supply is dried to minimise ice formation within room
- The floor is heated to prevent excessive ice formation on the floor
- The door seals are heated to prevent the doors from freezing shut
- The room has two exits: one through an airlock for normal entry/exit, and the second directly outside for emergency escape (and access for equipment when the room is not running)
- The Room has heated viewing panels that allow monitoring of the experiment without entering the room, and monitoring of any researchers within the room
- A 'panic' button is installed within the TCL. This button both operates an external alarm and places the TCL into a heating mode.
- Operation of the TCL is controlled by a key switch

OPERATIONAL PROCEDURES

An extensive set of operational procedures has been developed to facilitate the safe use of the TCL. The main elements of these are summarised here.

- *Buddy system*. Work in the TCL at temperatures below +10°C requires a Buddy to oversee the ongoing safety of the Researcher. The extent of the role of the Buddy is dependent on the temperature within the TCL and the nature of the experiments being undertaken. However, in all cases it is the Buddy's responsibility to provide routine checks on the whereabouts and condition of the Researcher while the TCL is in use.
- User training. This covers both the practical aspects of controlling the TCL and the Safety Procedures that must be adhered to in the use of the TCL. The training is provided by authorised personnel (principally the Head Technician). This training is documented on an induction sheet. Both the Researcher(s) and their Buddy must receive training.
- Risk Assessment. A detailed Risk Assessment is mandatory and must be completed by the researcher and approved by the Laboratory Safety Officer (or deputy) prior to starting to use the TCL. This Risk Assessment must include a discussion of how the various generic risks and measures given here relate to the envisaged experiment. The Risk Assessment must also highlight any additional risks and measures not stated here that may impact the safety of the researcher or other personnel (including emergency personnel).
- Permission to start. This must be gained (and the permission sheet signed) from the Laboratory Safety Officer (or deputy). Permission will not be granted until the Researcher and Buddy have received adequate training and the Laboratory Safety Officer (or deputy) is satisfied all necessary measures are in place and the procedures will be adhered to. This permission will be for use only within a specific range of temperatures. Permission must be sought again if temperatures are required outside this range.
- Access to room. Access to the TCL is controlled by a key that must be signed for by both the Researcher and the Buddy at the beginning of each period when access is to the TCL is required. This key must be returned and signed back in at the end of each such period, at which point the Research must also certify that the procedures were followed and formally report any problems that arose.

- Safety equipment. The very low temperatures and strong air currents within the TCL make the use of specialised clothing mandatory over most of the temperature range:

  +30 to +15°C Normal laboratory clothing is adequate

  +15 to +5°C If working in conjunction with another Researcher (or Buddy) who is always in the locality of the TCL then indoor clothing may be worn, provided periods of work within the room are limited to a maximum of five minutes. In all other cases outdoor (winter) clothing must be warn whenever entering the room.

  +5 to 0°C If working in conjunction with another Researcher (or Buddy) who is always in the locality of the TCL then outdoor (winter) clothing may be worn, provided periods of work within the room are limited to a maximum of ten minutes. In all other cases thermal clothing must be warn whenever entering the room.

  0 to -5°C Thermal clothing must be worn whenever entering the TCL. Thermal boots and gloves are recommended, but not mandatory. Maximum exposure to be determined as part of specific Risk Assessment.

  Below -5°C Full thermal clothing, including thermal boots and gloves, are mandatory. Maximum exposure to be determined as part of specific Risk Assessment.

  Below -15°C The Buddy must always be present in the locality of the TCL when the Researcher enters the room. Maximum exposure to be determined as part of specific Risk Assessment

  Below -20°C Additional measures are required. These must be discussed with the Laboratory Safety Officer and documented before permission will be granted.
- *Noise levels.* The cooling units generate significant levels of mechanical noise. Consequently, researchers are required to wear ear defenders if remaining in the TCL for periods of more than 10 minutes.
- Medical. All Researchers wishing to use the TCL below +5°C will be asked to self-certify their fitness for working in such temperatures. Additionally, Researchers wishing to use the TCL at temperatures below -10°C will be required to fill in a medical questionnaire that will be assessed by the University’s Occupational Health Service.
- Hours of use. Access to the TCL is generally available only during normal working hours (8:00 to 17:30). Experimental programmes should be designed with this in mind (the TCL itself may remain on over night, etc.). Special permission must be sought from the Laboratory Safety Officer (or deputy) for any experimental work outside this period; additional safety measures may be required.
- Cessation of experiments. Laboratory staff are authorised to require experimentation to cease immediately if they have any cause for concern about the manner or environment in which the research is being conducted, or if conditions in the TCL give concern. It remains, however, the responsibility of the Researcher and their Buddy to ensure the maintenance of safe working practices and conditions within the TCL.

6.2 Granular flow chute

Specific Risk Assessment: Mandatory

The granular flow chute is located in the Ambient Flow Facility. Risk factors include

1. Noise. Ear protection must be warn by chute operator and those in close proximity. The impact of noise on other laboratory users must be considered. See §5.10.
2. Dust: The chute must not be operated without the dust extraction system running and the dust-curtains installed. The chute operator must wear dust overalls and a mask. Remove overalls in a manner that minimises the introduction of dust to the atmosphere. Wash hands and other exposed skin before leaving the laboratory.
3. Mechanical: Never place hands or foreign objects in the conveyers. Keep emergency stop buttons accessible at all times.

A more detailed Risk Assessment is available upon request.

7. Equipment

This section describes briefly some of the main categories of equipment available within the Laboratory. Equipment should be treated with reasonable care. This includes not only using dust covers, *etc.*, to prevent accidental damage while the equipment is not in use, but also only using equipment for the purpose for which it was intended. In general, when you have finished using an item of equipment, it should be put away in its normal storage location. Hiding it on a shelf or in a cupboard in some remote corner of the lab will make it much more difficult for others (and possibly you) to find. Please ask if in doubt about where equipment should be stored.

7.1 Furniture

The Laboratory holds a large stock of furniture of various kinds. In general you will be able to find furniture to meet your experimental needs, although it will often be necessary to relocate this to where you are working and possibly rearrange your part of the laboratory or maybe swap a specific item of furniture with another researcher.

As with all other things within the Laboratory, furniture should be treated with reasonable care. You should not, for example, paint or cut directly onto table tops, or start screwing experimental apparatus directly to benches without first consulting laboratory personnel.

Many of the benches and tables within the Laboratory have a loose cover of flooring vinyl over them. This covering makes things easier to clean and helps protect the surface of the table/bench. Although this covering can be replaced, the cost is not negligible, and it should not be considered as disposable.

A range of mobile storage units are available, as are relocatable steel cabinets for storage of experiment-specific items. In some parts of the Laboratory, mobile sinks are used in place of permanent fixed units (see §7.6.4 for further details).

7.2 Imaging

7.2.1 Film-based

Once the main stay of experimental imaging, film is now used only infrequently, although still offers advantages in terms of quality and sensitivity.

The Laboratory has a range of 35mm SLR cameras. Of these the Cannon A1 are the best and come equipped with motor drives capable of up to three frames per second. Lenses include standard 50mm, macro, wide angle, telephoto and zoom varieties. There are also bellows for ultra close work and adapters that let you use the lenses on some of the video equipment.

There are two cine cameras. The 16mm Bolex is equipped with a servo motor, allowing it to be used for time-lapse work, while the Hadland Photonics Hyspeed S2 (again 16mm) can achieve 10,000 frames per second.

7.2.2 Standard video

For many years standard video equipment provided the main method of capturing images and recording experiments within the Laboratory. Consequently, the Laboratory has an extensive array of video equipment. Most of this is based on PAL (colour) or CCIR (monochrome) video cameras using a single CCD sensor. Some cameras are colour, but many are monochrome. The monochrome cameras tend to have greater sensitivity and offer the better solution to most work in the Laboratory. Some of the cameras can operate in a 'frame integration' mode that, when combined with a mechanical shutter, provides the ability for both the odd and even fields to be exposed at the same time.

- Cohu 4910: good quality monochrome; may be locked to mains frequency and used with mechanical shutter. Suitable for most experiments.
- Sony XC-77R: good quality monochrome; very compact. Suitable for most experiments.
- Panasonic F10 & F15: medium quality colour; F15 has SVHS output. Not suitable for quantitative measurements.
- Canon XM1: very good quality colour; digital camcorder; three-CCD; fire-wire. Suitable for experiments where colour required.

Output from these video cameras may be digitised directly (see §7.2 below), or recorded on a Super VHS (SVHS) video tape recorder. The SVHS standard provides a much improved spatial resolution over domestic VHS recorders, while still providing the facility to play and record the standard VHS format.

- Panasonic AG7350: good quality; SVHS; can be controlled by DigImage. Suitable for most experiments.
- JVC BRS-822: excellent (broadcast) quality; SVHS; can be controlled by DigImage. Suitable for most experiments, but fiddly to use.

http://www.cohu-cameras.com/
http://bssc.sel.sony.com/
http://www.panasonic.com/PBDS/
http://www.panasonic-broadcast.com/
http://www.canon.co.uk/digitalcamcorders/
http://www.jvc.co.uk/

7.2.3 Digital video cameras

The Laboratory sports a range of modern digital video cameras. These include

- AtmelGrenoble Camelia 8M: Ultra-high resolution (2.7fps; 2300×3500, 12-bit)
- JAI CVM4 and CVM4+: High-resolution (24 to ~120fps; ~1280×1024, 10-bit)
- UniqVision 1830CL-12: 1MPixel 12bit mono and colour at up to 30 fps.
- Dalsa 4M60: 4MPixel, 12 bit at up to 62 fps.
- Photron FastCam SA1.1: 1MPixel 12bit mono at up to 5400 fps (faster at reduced resolutions).

With the exception of the Photron cameras, these digital cameras use either LVD or CameraLink interfaces. In the Laboratory these connect to an appropriate BitFlow R-series digital frame grabber. The systems are configured to allow full frame rate capture directly to hard disk, thus allowing an individual image sequence to extend to more than 100GBytes. The Photron cameras capture the images using internal memory and provide an ethernet interface for subsequent transfer to a computer.

http://vfm.dalsa.com/
http://www.atmel.com/products/Cameras/
http://www.jai.com/camera/
http://www.uniqvision.com/
http://www.photron.com/

7.2.4 Scanner

Images and art work may be captured using a scanner: there are a number of these around the Department.

7.3 Image processing

7.3.1 DigiFlow

DigiFlow is the principal software used to capture and process images from digital cameras. It is written and maintained in-house, but is also used in a number of other laboratories around the world.

DigiFlow provides a convenient route to capture sequences from all the digital cameras listed in §7.1.3, offering full bandwidth capture direct to hard disk. DigiFlow also provides an extensive array of image processing functions which may be used to manipulate images or extract quantitative information from them.

http://www.dalzielresearch.com/digiflow/
http://www.bitfow.com/

7.3.2 DigImage

DigImage is the predecessor of DigiFlow and was at one time used in 36 leading laboratories around the world. At its peak, the GK Batchelor Laboratory had seven operational systems, but this number is declining some of the necessary hardware no longer being in production. It was developed specifically for fluid dynamics experiments and offers an extensive array of useful functions. While DigiFlow has taken over most of this role, DigImage still has some uses for simpler experiments. DigImage also provides frame-accurate control of an attached video recorder (Panasonic AG7350 or JVC BRS-822R).

DigImage only functions properly on computers running Windows 95 or 98. The computer must also have a Data Translation DT2861 or DT2862 frame grabber installed.

http://www.damtp.cam.ac.uk/lab/digimage/
http://www.datx

7.4 Instrumentation

7.4.1 Densitometer

http://www.paar-scientific.com/

7.4.2 Refractometers

Refractometers are designed to measure the refractive index of a solution by looking at the angle for total internal reflection. For single component solutions there is generally a one-to-one relationship between refractive index and density, consequently, refractometers provide a convenient method of determining the density.

The Laboratory has two types of refractometer: optical and digital. Details of the use of these devices are given below.

http://www.atago.net/

7.4.2.1 Optical refractometer

These may be identified as a tubular black device, about 15cm long with an eyepiece at one end and a flat glass surface near the other end. A drop should be placed on the glass face and the cover held down gently with a finger. To avoid scratching the glass face, do not touch it with glass or metal. The reading gives the refractive index n. The density ρ may then be calculated using the table in Appendix C.

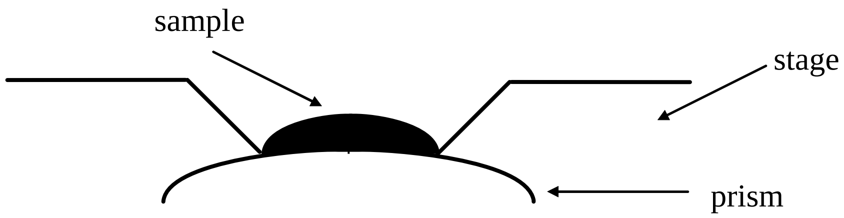
Example

$$n = 1.3384 \Rightarrow \rho = 1.0203.$$

Most of the optical refractometers have more than one scale. Other scales can include ‰ NaCl, %Brix, and urea concentration.

7.4.2.2 Digital refractometer

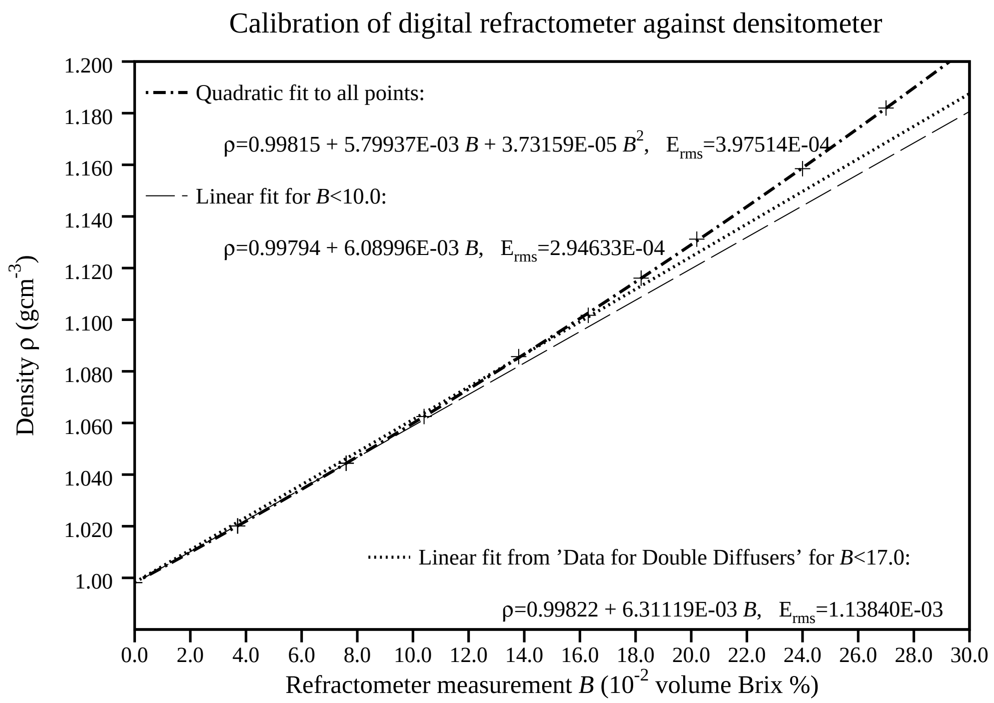
This is a grey plastic box about 15cm long, 7cm wide and 2cm thick. On the top surface is a small glass plate with a metal surround, an LCD display and two buttons. The reading on the display is in Brix%, a scale used for measuring the strength of glucose solutions.



1. Drip solution onto prism at centre of stainless steel stage until prism is covered.
2. Press START/OFF button.
3. Read measurement.
4. Mop up test solution with tissue, wipe prism with clear damp tissue, dry.
5. Either wait 5 minutes for display to switch off or hold down START/OFF button until display switches off or take another measurement.
6. The relationship between density of salt water and Brix% is given in the table in Appendix C. For convenience, it is also plotted below and is well approximated by

$$\rho = 0.9982 + 5.799x10^{-3}B + 3.732x10^{-5}B^2.$$

As with the optical refractometer, to avoid scratching the glass face: do not touch it with glass or metal.


Calibration of digital refractometer against densitometer
Quadratic fit to all points:
ρ=0.99815 + 5.79937E-03 B + 3.73159E-05 B2, Erms=3.97514E-04
Linear fit for B<10.0:
ρ=0.99794 + 6.08996E-03 B, Erms=2.94633E-04
Linear fit from 'Data for Double Diffusers' for B<17.0:
ρ=0.99822 + 6.31119E-03 B, Erms=1.13840E-03
Density ρ (gcm-3)
Refractometer measurement B (10-2 volume Brix %)
1.200
1.180
1.160
1.140
1.120
1.100
1.080
1.060
1.040
1.020
1.00
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0

7.4.3 Conductivity probes

Conductivity probes measure the electrical resistance of a solution by passing a small current between two electrodes. The current must be AC in order to prevent electrolysis of the electrodes.

http://www.omega.com/green/gsc.html

7.4.4 Temperature probes

The Laboratory has three main types of temperature probe: conventional mercury thermometers, thermistors and thermocouples. For safety considerations, the use of mercury thermometers is discouraged.

http://www.omega.com/temperature/tsc.html

7.4.4.1 Thermistors

Thermistors are semiconducting devices whose resistance is a sensitive function of temperature.

7.4.4.2 Thermocouples

A small electrical potential is produced whenever two dissimilar metals are brought into contact. This potential depends not only on the types of the two metals, but also on the temperature. Thermocouples work by measuring this potential.

7.5 Computers

7.5.1 Safe use of computers

Computers should be used in accordance to the University's guidelines on the safe use of VDU screen equipment. Most of this is common sense, but includes issues such as posture, lighting, breaks, *etc.*

http://www.admin.cam.ac.uk/cam-only/offices/safety/vdu/
http://www.admin.cam.ac.uk/cam-only/offices/safety/vdu/vdus.html

7.5.2 Copyright

Computers in the Laboratory may only be used if you agree to abide by the University's Policy and its Code of Conduct concerning copyright software. The Code of Conduct is based on the one produced by CHEST (Combined Higher Education Software Team), but applies to all software, regardless of the route through which it was obtained.

http://www.cam.ac.uk/cs/docs/handouts/h12/
http://www.chest.ac.uk/conduct.html

7.5.3 Network infrastructure

The Laboratory is fully wired with 'category 5' twisted pair network cabling and a generous number of network ports. While in principle any of these ports could be used, only a subset of them is patched to the switch at any one time. Moreover, the ports are arranged in pairs and it is a site convention that the right-hand one is for data, while the left-hand one is for analogue communications (*e.g.* telephone). The Departmental Computer Officers will be able to advise you or activate an inactive port, should you require this.

The physical network within the Laboratory has a higher performance than that in most of the rest of CMS. Some of the data ports are connected to standard 100Mbit switches linked directly to the CMS network, while others are connected via one of three gigabit switches (for 4gigabit fabrics) connected by optical fibres. Only one of these is connected to the main CMS network. This architecture has been developed to provide the bandwidth necessary for streaming live high-resolution and/or high-speed video across the network.

Ports within the Laboratory are distinguished by

- Inactive ports: Red RJ45 connector in the adjacent phone port or an RJ45 connector in the port.
- 100Mbit ports: Yellow RJ45 connector in adjacent phone port.
- 1Gbit ports: Blue RJ45 connector in adjacent phone port.
- Telephone ports: A telephone is attached.

For active ports, the RJ45 connector in the adjacent phone port that identifies the port speed is also marked with the corresponding switch number to which the port is connected.

7.5.4 Workstations

All the workstations in the Laboratory have some form of data-capture capability. In most cases this includes image capture either through DigiFlow or DigImage (see §§7.2.1 and 7.2.2). In the former case the workstation will be running Windows NT or XP, while in the latter case the workstation will be running an old version of Windows (95 or 98). Those machines equipped with a frame grabber supported by DigiFlow are fitted with gigabit network cards. Other machines will have 10 or 100Mbit cards.

Additionally, some machines have other forms of data acquisition hardware (normally some form of analogue to digital conversion card).

The following points should be observed:

- User-ids must be obtained from the Director or Electronics Technician. While these will normally be the same as those for the Departmental network, and you may use your normal password, authentication of the user is provided by the Laboratory's own server rather than the main linux network.
- Do not attempt to install any software without first seeking permission.
- Do not keep excessive amounts of data on-line. Archive data onto CD, DVD, MO-disk or tape when no longer required (see §7.4.4).
- Not all data is backed up automatically. Refer to §7.4.4 for details on how to request specific datasets be backed up.
- For workstations running NT or XP:
- D:\ is local to your machine. You should store any files under D:\Users\xxx.
- You may store files on Z:\Users*xxx* (located on \\lab\server).
- V:\ is used during image capture (normally to V:\Cache\). You should not leave files on this drive any longer than essential as it will compromise your (and others') ability to capture.
- Do not store any information on the boot drive (C:\).
- For workstations running Windows 95 or 98
- You may store files under C:\Users*xxx* or, if it exists, D:\Users*xxx*.
- You may store files on Z:\Users*xxx* (located on \\lab\server).

7.5.5 Servers

The Laboratory maintains a Windows 2003 server: \\lab. This, along with the more recent workstations, is fitted with gigabit network card.

\\lab provides the main storage disk array, account verification, printer access, software, licence management, and most of the rest of the facilities normally found on a network. A 200GByte (native; ~400GByte compressed) Ultrium II tape streamer is attached to provide network backup.

The main disk array (\\lab\server) should normally be mapped to Z: on laboratory workstations.

The simplest way to set up your machine to access the disk array and the printers is to type \\lab\server\batch\networksetup.bat at a command prompt.

7.5.6 Software

Software should not be installed on computers owned by the Laboratory without first seeking permission from the Director. This includes commercial software, public domain and shareware, and open source software. If the computer is owned by an individual research group, you should seek permission from whoever is in charge of the computer before installing software. In all cases, you must adhere to the University's software policy (see §7.4.1).

7.5.7 Backup and archive

Experiments have the potential to generate huge volume of data, particularly when using high-speed or high-resolution digital video. Moreover, remote access to a workstation while it is controlling an experiment or capturing data can disrupt these processes and lead to the experiment needing to be repeated. As a consequence, there is no automated backup of laboratory workstations. The responsibility lies with the Researcher to ensure that critical data is backed up or archived, as appropriate. The most cost efficient and convenient approach to this at present is the use of external hard disk drives.

7.5.8 Printers

Printers within the Laboratory are accessible from Windows, Mac and unix machines.

7.5.9 Laminator

A laminator, capable of laminating all sizes up to and including A2, is located in the printer cupboard just out side the workshop in Pavilion C. Instructions on use may be found on the laminator. Please be careful to feed the laminating pouches in closed end first, and remember to turn the laminator off when finished. If you are unfamiliar with the laminator, it is advisable to discuss its use with one of the Technicians first.

7.6 Services

7.6.1 Softened water

Softened water, where the majority of the calcium salts that cause lime scale have been removed by an ion exchange process, is available in all components of the laboratory. In Pavilions A and C, softened water is only available at some of the outlets, whereas in Pavilion H and the AFF, every outlet has the option of raw or softened water.

For the majority of uses, softened water is preferable as it prevents any build-up of lime scale in the experimental apparatus. However, when very large quantities of water are required, it may be more convenient to use raw water as this is available at a much higher flow rate. In cases when higher purity water is required, a reverse osmosis unit may be used to remove in excess of 90% of all contaminants (see §7.6.2).

7.6.2 Hot water

Hot water is available in all parts of the laboratory, although the method through which it is produced varies. In Pavilions A and C, hot water is provided by means of small local hot water cylinders mounted on the walls within the laboratory. Each of these cylinders has its own on/off switch plus an adjustable thermostat.

In Pavilion H and the AFF, the hotwater is piped from a central boiler. In Pavilion H electrical trace heating is run along the distribution pipes to ensure the water within the pipes remains hot. In the AFF, the water is continually circulated around the network of pipes. It is not possible to adjust the temperature of this water.

7.6.3 Saltwater

Saltwater is available on tap in parts of the Pavilion A and C laboratories, and in the AFF. The taps are identified by labels, the use of a different format of valve (diaphragm vales with a circular handle), and a different form of quick-release hose coupling (garden ‘HoseLock’ couplings, normally on yellow hoses). The saltwater is distributed at about 90% of saturation. The precise salt concentration will vary with the temperature of the mains water supply.

7.6.4 Reverse osmosis water

Reverse osmosis water is available within the laboratory by way of two relocatable Millepore™ purification units. The smaller unit, capable of producing 5litres/hour, includes a 20litre reservoir, providing small quantities of high-quality water on tap. The larger unit, mounted on a trolley, is intended for filling equipment directly and produces 60litres/hour. Additionally, the larger unit is fitted with a degassing module that effectively removes the majority of the dissolved gases normally found in our water supply.

Both units simply plug into the quick release coupling on our water outlets and a power outlet. When connecting the units, it is essential that they are connected to softened water and not raw water, hot water, or salt water. Connection to the wrong water type may do serious damage to the reverse osmosis unit.

http://www.millipore.com/

7.6.5 Sinks

Mobile sinks are provided as an alternative to fixed installations in some parts of the laboratory. These should be simply located above (or adjacent) to a floor drain, so that the sink drain pours directly into the floor drain, and connected to the hot and cold water outlets using the quick release couplings. It should be noted that the quick release couplings also provide the earth-bonding of the sink.

7.6.6 Compressed air

Compressed air is available at 10 bar at strategic locations throughout the laboratory. This should only be used following a suitable risk assessment and the drawing up of procedures. See §5.7 for details.

In Pavilions A and C, each outlet is fitted with its own regulator, although secondary precision regulators may be required for some equipment. In Pavilions H and the AFF, regulators are not fitted to the outlets, but must instead be incorporated into the experimental setup. To avoid the incorrect connection of equipment, outlets with regulators are fitted with a different type of quick release coupling from those without regulators. Mobile regulators are available to provide an interface between the two types of coupling.

Appendix A: Induction check list

This checklist is to be completed as part of inducting a new user in the Laboratory. Permission to begin work in the Laboratory will only be given once all relevant precursors have been completed.

Name	
Status	Student/Postdoc/UTO/Visitor/Other
Supervisor/Host	
Office	
E-mail	
Project	
Departure date	

	Date	**Initials**	**Comments**
Introductions			
Director of Laboratory			
Laboratory Safety Officer			
Head Technician			
Documentation issued			
Laboratory Manual			
HSD Documents (list)			
Access			
Swipe card programmed			
Lone working restrictions			

Explanation of emergency procedures			
Exits			
First aid			
Knockdown buttons			
Services			
Reporting			
Training needs/Training given			
(List)			

Unsupervised work must not commence until approved by the Safety Officer.

Approval to commence	Date	Initials	Comments
Documentation read			
Base Risk Assessment			
COSHH Assessment			
Signed by Supervisor/Host			
Hot Work approval			
Volatile Solvent approval			
Biological approval			
Permission to start			

Appendix B:

GK Batchelor Laboratory: Risk Assessment

Researcher:
Name:
Office:
Phone:
e-mail:

Supervisor/Principal Investigator/Host
Name:
Office:
Phone:
e-mail:

Project title:

Brief description of project:

Date for this revision:

Date for next revision:

Emergency measures:

Please note: This section is intended to provide others with guidance if they have to deal with your equipment in an emergency situation. In the majority of situations, the appropriate answer will be '*Do not care*', giving the freedom to react as appropriate. Only in a small subset of cases will '*No*' be an appropriate answer, and in such cases it is important to state the reasons why.

	Yes	**No**	**Do not care**	**Not applicable**
Fire alarm				
Knock down switch				
Turn off piped services				
Drain equipment				
Other				
Flood				
Knock down switch				
Turn off piped services				
Drain equipment				
Other				
Electrical fault				
Knock down switch				
Turn off piped services				
Drain equipment				
Other				
Equipment failure				
Knock down switch				
Turn off piped services				
Drain equipment				
Other				

Please explain the reasons behind any '*No*' responses in the table above.

Brief description of main hazards

Electrical

Mechanical

Chemical

Particle

Optical

Heat

Cold

Other

Which sections of the Laboratory Manual have you read? (Please tick)

§1 ☐ §2 ☐ §3 ☐ §4 ☐ §5 ☐ §6 ☐ §7 ☐ §8 ☐

Are the risks associated with the project covered by the Laboratory Manual? Yes/No

Is a COSHH form attached? Yes/No

List substances used

Are COSHH data sheets for any substances attached? Yes/No §5.3

List substances

Description of additional risks and the measures taken to minimise potential incidents. (Please continue on a separate sheet if required.)

Do you feel competent to undertake this work? Have you discussed the project with your supervisor, principal investigator or host? Please list any areas where you believe training would be beneficial.

Have all items of electrical equipment been tested for electrical safety and do they display a valid test sticker? This includes IEC mains cables, plug boards, computers and video equipment. Please list the items of electrical equipment you are using, their database number and the expiry date of the test sticker. The equipment must be re-tested if the sticker only states the date the equipment was last tested.

Do you intend to work alone in the lab out of hours? If ‘yes’, then please list any additional safety measures or procedures you will undertake to ensure your safety.

Do you agree to abide by the University’s Software Policy and Code of Conduct concerning copyright? Yes/No

Signatures:

Date:

(Researcher) (Supervisor)

For Office Use Only:
Comments:

Incidents:

Laboratory Safety Officer:
Date:

Date:	Review Date:	Assessment Reference:

UNIVERSITY OF CAMBRIDGE

CHEMICAL HAZARD RISK ASSESSMENT FORM

Completing this document fulfils the requirements of the COSHH and DSEAR Regulations relating to a written risk assessment

Experiment or Procedure (include a brief description & reaction conditions i.e. temperature, solvent, work up procedures and frequency of exposure)**:**

Risks associated with the procedure (What are the hazards and risks?)**:**

Risk implications:

Is there any substance used or formed that might give rise to explosion (e.g. flammable gases/liquids)? Yes / No

If yes, how can you ensure that no explosion occurs? ______________________________

Is it reasonably foreseeable that the lower explosive limit will be reached in the event of a leak/spillage? Yes / No

If yes, a more detailed risk assessment is required.

Is there likelihood of copious amounts of gas being released or thermal runaway? Yes / No

Can any of the substances be substituted for a less hazardous substance? Yes / No

What could happen if there was catastrophic failure of the apparatus? ______________________________

In the event of an accident, who might be exposed? ______________________________

Substances to be used (List *ALL* substances including solvents, expected products and by-products)**:**

Substances Used	**Approx. Quantity**	**Physical Form** i.e. dust, vapour, volatile liquid etc	**Hazards** i.e. flammable, corrosive, irritant, readily absorbed through skin	**Exposure Route** i.e. skin, eyes
Household bleach	5 ltrs	Liquid	Corrosive, causes burns	R31,35
Potassium permanganate	1 g	Crystals/solution	Oxidising agent/harmful	R8,22
Pliolite	200g	Particles	Not regulated	R10,25,36,37,38
Isopropanol	5 ltrs	Liquid	Highly flammable	R11
Sodium fluorescein	<1g	Powder dissolved in water		R10,25,36,37,38
Acetone	300mls	Liquid	Highly flammable, irritant	R11,36,66,67
Silicon Carbide	5 kg	Particles	Respiratory contamination	R36,37
Food colouring	<200 ml	Liquid	None known	
Salt NaCl	<20 kg	Grains/solution	None known	
Glycerine	40 ltrs	Liquid	Not regulated	

Date:	Review Date:	Assessment Reference:

Are any of the substances listed above R42, R43, R45, R46, R49, R60, R61, R64? Yes / No

(If yes, contact Occupational Health and refer where necessary to the University Code of Practice on the Safe Use of Carcinogens etc)

Control measures to be used (continue on a separate sheet if necessary)**:**

Containment:

Fume cupboard Yes / No

Glove box / isolator Yes / No

Safety cabinet Yes / No

Local exhaust ventilation Yes / No

Other (specify)

Personal Protective Equipment:

Lab coat / overalls Yes / No

Chemical apron Yes / No

Gloves Yes / No

Eye Protection Yes / No

Respiratory protective equipment Yes / No

Other (specify)

Are any additional controls required? (Consider nearby sources of ignition, formation of explosive atmospheres/mixtures, asphyxiation in confined spaces)

Disposal measures to be used during and after the procedure: (Also consider by-products and washings)

Emergency Procedures (emphasise any special hazards)**:**

Shutdown Procedures:

Action in the event of fire (type of fire extinguisher):

Action in the event of spillage or uncontrolled release:

Date:	Review Date:	Assessment Reference:

Emergency treatment for personnel in the event of contamination, exposure to fumes or other adverse effects

Eyes:

Skin:

Inhalation:

Name of assessor:	
Signature:	**Date:**
Name of co-signatory: (e.g. Supervisor / authorised deputy)	
Signature:	**Date:**

Note: This risk assessment should be reviewed at least annually and when there is any significant change in procedure.

Appendix C: Temporary Use Card

Electrical Equipment Temporary Use Card

Part A: To be given to Electronics Technician

1. Name of user:
2. E-mail:
3. Description of item:
4. Location:
5. Date of last test:
6. Can the item be turned off and tested? Yes/No?
7. If No, state how access for testing may be gained.
8. Today's date:

Issue 1, May 2003
GK Batchelor Laboratory

Electrical Equipment Temporary Use Card

Part B: To be attached to the equipment

1. Name of user:
2. E-mail:
3. I agree to abide by the conditions under which this Temporary Use Card is issued. If the equipment is not tested within two weeks, I will stop using the equipment. If I am finished with the equipment before it is tested, I will submit it for testing before returning it to stores. Furthermore, I have inspected the equipment and can see no obvious signs of damage or faults.

Signed:

Data:

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Appendix C: Temporary Use Card

Appendix D: Density Table

NaCl (wt.%)	Density (ρ)	n	Brix	Cs (g/lw)	Conductivity
0.0	0.9982	1.3330	0.00	0.0	
0.1	0.9989	1.3332	0.14	1.0	
0.2	0.9997	1.3333	0.28	2.0	
0.3	1.0004	1.3335	0.40	3.0	
0.4	1.0011	1.3337	0.52	4.0	
0.5	1.0018	1.3339	0.64	5.0	
0.6	1.0025	1.3340	0.75	6.0	
0.7	1.0032	1.3342	0.87	7.0	
0.8	1.0039	1.3344	0.99	8.1	
0.9	1.0046	1.3346	1.11	9.1	
1.0	1.0053	1.3347	1.23	10.1	
1.1	1.0060	1.3349	1.35	11.1	
1.2	1.0068	1.3351	1.48	12.1	
1.3	1.0075	1.3353	1.60	13.2	
1.4	1.0082	1.3354	1.72	14.2	
1.5	1.0089	1.3356	1.84	15.2	
1.6	1.0096	1.3358	1.95	16.3	
1.7	1.0103	1.3360	2.07	17.3	
1.8	1.0110	1.3362	2.19	18.3	
1.9	1.0117	1.3363	2.30	19.4	
2.0	1.0125	1.3365	2.44	20.4	
2.1	1.0132	1.3367	2.55	21.5	
2.2	1.0139	1.3369	2.67	22.5	
2.3	1.0146	1.3370	2.79	23.5	
2.4	1.0153	1.3372	2.90	24.6	
2.5	1.0160	1.3374	3.02	25.6	
2.6	1.0168	1.3376	3.15	26.7	
2.7	1.0175	1.3377	3.27	27.7	
2.8	1.0182	1.3379	3.38	28.8	
2.9	1.0189	1.3381	3.50	29.9	
3.0	1.0196	1.3383	3.61	30.9	
3.1	1.0203	1.3384	3.73	32.0	
3.2	1.0211	1.3386	3.86	33.1	
3.3	1.0218	1.3388	3.97	34.1	
3.4	1.0225	1.3390	4.09	35.2	
3.5	1.0232	1.3391	4.20	36.3	
3.6	1.0239	1.3393	4.32	37.3	
3.7	1.0246	1.3395	4.43	38.4	
3.8	1.0254	1.3397	4.56	39.5	
3.9	1.0261	1.3398	4.68	40.6	

NaCl (wt.%)	Density (ρ)	n	Brix	Cs (g/lw)	Conductivity
4.0	1.0268	1.3400	4.79	41.7	
4.1	1.0275	1.3402	4.90	42.8	
4.2	1.0282	1.3404	5.02	43.8	
4.3	1.0290	1.3405	5.15	44.9	
4.4	1.0297	1.3407	5.26	46.0	
4.5	1.0304	1.3409	5.37	47.1	
4.6	1.0311	1.3411	5.48	48.2	
4.7	1.0318	1.3412	5.60	49.3	
4.8	1.0326	1.3414	5.73	50.4	
4.9	1.0333	1.3416	5.84	51.5	
5.0	1.0340	1.3418	5.95	52.6	
5.2	1.0355	1.3421	6.19	54.9	
5.4	1.0369	1.3425	6.41	57.1	
5.6	1.0384	1.3428	6.65	59.3	
5.8	1.0398	1.3432	6.87	61.6	
6.0	1.0413	1.3435	7.11	63.8	
6.2	1.0427	1.3439	7.33	66.1	
6.4	1.0442	1.3442	7.57	68.4	
6.6	1.0456	1.3446	7.79	70.7	
6.8	1.0471	1.3449	8.02	73.0	
7.0	1.0486	1.3453	8.26	75.3	
7.2	1.0500	1.3456	8.48	77.6	
7.4	1.0515	1.3460	8.71	79.9	
7.6	1.0530	1.3463	8.94	82.3	
7.8	1.0544	1.3467	9.16	84.6	
8.0	1.0559	1.3470	9.39	87.0	
8.2	1.0574	1.3474	9.62	89.3	
8.4	1.0588	1.3477	9.83	91.7	
8.6	1.0603	1.3481	10.06	94.1	
8.8	1.0618	1.3484	10.29	96.5	
9.0	1.0633	1.3488	10.52	98.9	
9.2	1.0647	1.3491	10.73	101.3	
9.4	1.0662	1.3495	10.96	103.8	
9.6	1.0677	1.3498	11.19	106.2	
9.8	1.0692	1.3502	11.41	108.6	

NaCl (wt.%)	Density (ρ)	n	Brix	Cs (g/lw)	Conductivity
10.0	1.0707	1.3505	11.64	111.1	
10.5	1.0744	1.3514	12.19	117.3	
11.0	1.0781	1.3523	12.74	123.6	
11.5	1.0819	1.3532	13.30	129.9	
12.0	1.0857	1.3541	13.86	136.4	
12.5	1.0894	1.3549	14.40	142.9	
13.0	1.0932	1.3558	14.95	149.4	
13.5	1.0970	1.3567	15.50	156.1	
14.0	1.1008	1.3576	16.05	162.8	
14.5	1.1047	1.3585	16.60	169.6	
15.0	1.1085	1.3594	17.14	176.5	
16.0	1.1162	1.3612	18.22	190.5	
17.0	1.1240	1.3630	19.30	204.8	
18.0	1.1319	1.3648	20.39	219.5	
19.0	1.1398	1.3666	21.46	234.6	
20.0	1.1478	1.3684	22.53	250.0	
21.0	1.1558	1.3702	23.60	265.8	
22.0	1.1640	1.3721	24.68	282.1	
23.0	1.1721	1.3739	25.73	298.7	
24.0	1.1804	1.3757	26.80	315.8	
25.0	1.1887	1.3776	27.86	333.3	

Appendix E: Revision History

Version 1.0 (May 2003)

- The previous guidelines, developed for the Silver Street site, have been rewritten and extended to cover the new features and facilities in CMS.

Version 1.1 (March 2004)

- Minor additions.

Version 1.3 (September 2004)

- Section on clothing and footwear added (§5.15).

Version 1.4 (February 2005)

- Induction procedures (§3.1) and check-list (Appendix A).
- Permits to Work for heat (§5.7.7) and volatile solvents (§5.3.2).
- Ordering and receiving goods (§3.4).
- Personnel changes (§1.2).

Version 1.5 (August 2006)

- New section on High-risk Facilities (§6).

Version 1.6 (August 2007)

- Issues of biological safety
- Updated Cold Room safety

Version 1.7 (July 2008)

- Updated electrical safety

Version 1.8 (August 2009)

- Updated laser safety

Version 2.0 (July 2011)

- Section on Policies extended.
- Redundant information removed
- Various sections updated.