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Ideas and Inspiration supporting Science & Technology for all Local Authorities

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The 'hole truth and nothing but...'

When last did you change the speed on your pillar/pedestal drill? Have you settled for some mid-range speed in the hope that the drill copes with all drilling requirements? Have we lost the art of matching the correct drill speed to the drill diameter?

Modern pedestal drills typically have 12 speeds ranging from about 180 rpm to 2740 rpm, this adequately covers the correct speeds for drilling ferrous, non ferrous metals, acrylics, hard and softwoods. But what is the correct speed for drilling materials found in school workshops taking into consideration the material, the drill type and drill diameter?

Setting up drilling areas

You should ask yourself the following:

- Is there an easy reference 'drill diameter, material and drill speed chart' available at each pedestal drill in our department?
- Has each chart speed displayed been personalised to suit the nearest drill speed available from your drill?
- Would a graphical illustration of the pulleys and belts position aid quick speed changing?

Twist Drills

Table 1 shows typical correct speeds (in rpm) for drilling steel and aluminium in relation to the diameter of the twist drill.

Twist drill diameter (mm)	drilling speed (rpm)	
	steel	aluminium
3	1820	2580
4	1350	2580
5	1290	2580
6	970	2580
7	830	2580
8	830	2580
9	500	1820
10	500	1820
11	500	1820
12	420	1820
13	420	1350
14	420	1350
15	320	1290
16	320	1290

***Table 1** - Correct twist drilling speeds (rpm) for steel and aluminium, the two most commonly used metals in technology departments in schools.*

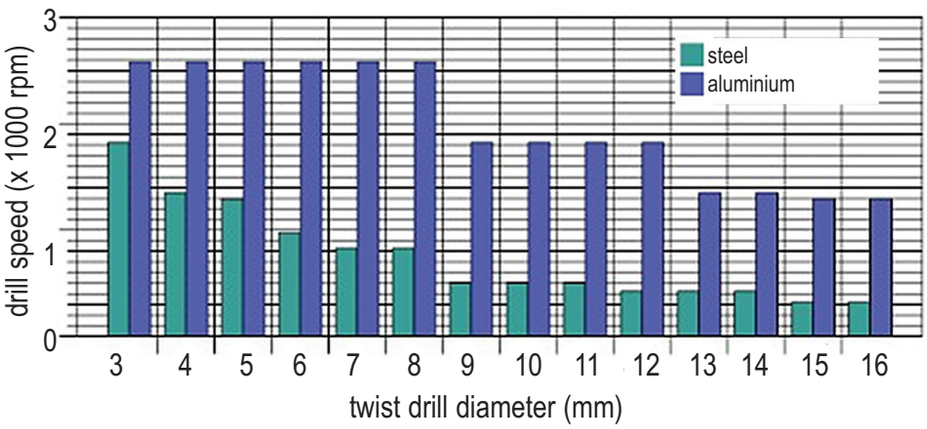

***Figure 1** - Graph results from Table 1.*

Depending on the source of information you may see some variation in the speeds from those stated here. Generally, when the drill diameter increases, the drill speed decreases. Table 1 shows that a particular speed is suitable for a range of diameter of drill.
Most twist drills/bits are manufactured from either High Speed Steel (HSS) or from Carbon Steel. HSS type should be used for drilling metals as they are able to withstand higher working temperatures. Carbon steel twist drills should never be used for drilling metals as they are more brittle, tend to be less flexible compared with HSS drills and they are not able to withstand the higher temperatures involved in drilling metals.

Today, it is common to see twist drills with a gold colour coating, this is titanium nitride (TiN). This coating has two functions, firstly to improve the drill's hardness and secondly to provide a self-lubricating property when drilling metals.

You can see that the drilling speed of aluminium for a 3 mm twist drill is about 1.4 times faster than that required for steel. For a 16 mm diameter drill, the relationship of the correct drilling speed for aluminium is over 4 times faster than for drilling steel. Steel and aluminium are the two most commonly used metals in school technology departments. The speed range for twist drills (3 to 16 mm dia.) from 320 to 2580 rpm is typically found in our 12 speed pedestal drills. Each drilling speed should be utilised when deemed necessary.

Drilling timber

Care must be taken when using twist drills with hardwoods and woods which are 'green' They tend to clog quickly, particularly if deep holes are required and must be withdrawn regularly and the waste removed.

Hole Saws

When drilling metals, lubrication is essential. The pilot drill should never extend past the teeth of the saw any more than the drilled material thickness. The pilot hole should be drilled at around 970 rpm.

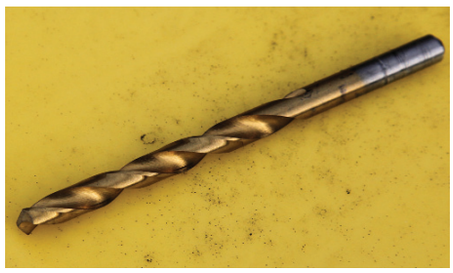

***Figure 2** - Twist drill.*

***Figure 3** - Hole saw.*

Figure 4 *- Forstner bit.*

Figure 5 *- Flat bit.*

Figure 6 *- Countersink bit.*

The range of drilling speeds varies from 85 rpm to 530 rpm for steel and 125 to 900 rpm for aluminium.

Notice that the speed for drilling aluminium with a hole saw is faster than that required for steel by a factor in the range 1.4 – 1.7, depending upon the diameter.

Further drilling of the main hole, after the pilot hole has been drilled, should be in keeping with the speeds shown in Table 4.

Conclusion

Drilling too fast can cause overheating, while drilling too slow may cause poor quality holes. When drilling in the end grain of timber, reduce speed. In order to operate safely, produce the best quality of work and efficiently use drills, check the tables and change the speed!

Twist drill diameter (mm)	Softwood (rpm)	Hardwood (rpm)
2 – 5	3000	3000
6 - 10	3000	1500
11 - 16	1500	750
17 - 25	750	500

Table 2 *- Drilling speeds using a twist drill for drilling timber.*

Twist drill diameter (mm)	Drill speed (rpm)
2 – 5	2500
6 - 10	2000
11 - 16	1500
17 - 25	not recommended

Table 3 *- Drilling speeds using a twist drill for drilling acrylic.*

Hole saw diameter (mm)	Drilling speed (rpm)	
	steel	aluminium
16	530	900
20	460	690
25	350	525
30	285	425
35	250	375
40	220	330
50	170	255
75	115	165
100	85	125
175	115	165

Table 4 *- Drilling speeds using a hole saw for steel and aluminium.*

Drilling timber with other bits

Forstner Bit (mm)	Figure 4	
6 – 10	2400	700
11 -16	2400	500
17 - 25	1500	500
26 - 32	1000	250
33 - 50	500	250
Flat Bit (mm)	Figure 5	
6 - 12	2000	1500
15 -25	1750	1500
26 - 38	1500	1000
Countersink	Figure 6	
2 – flute	1400	1400
5 - flute	1000	750

Table 5 *- Drilling speeds for timber using various types of bit.*

Drilling acrylic with other bits

Forstner Bit (mm)	
6 – 10	not recommended
12 – 32	250 rpm
35 – 50	not recommended
Hole Saw (mm)	
25 - 62	not recommended
Flat Bit (mm)	not recommended
Countersink (mm)	
2 – flute	not recommended
5 – flute	not recommended

Table 6 *- Drilling speeds for acrylic using various types of bit.*

Useful Websites

www.ultimatehandyman.co.uk/DIY_Metalworking/drilling_metal_technique.htm
www.diydata.com/tool/drillbits/drillbits.php
www.raygirling.com/dpspeed.htm

Polymerase Chain Reaction: Don't assume

Background

Since the first description of the technique [1], the polymerase chain reaction (PCR) has become an indispensible tool with applications in virtually all biological, biomedical and biotechnological areas of science [2-6].

As many readers will be aware there has been considerable debate over the content of the new Higher Biology. However, one thing is certain; PCR will be one of the topics covered when the Arrangements Document is published in November 2010. So, what resource might one use to support teaching and learning? A number of animations and digital images are available [7] but we believe that there is no substitute for practical work.

We have previously described [8] the development of a PCR protocol suitable for use in secondary schools and colleges. More recently our colleagues at the *National Centre for Biotechnology Education* (*NCBE*) have refined the protocol [9] and made it available in the form of a self-contained kit. The current (July 2010) cost of the full kit from *NCBE* is £140 [10]. The PCR kit, as marketed by *NCBE*, allows students to extract chloroplast DNA from plants and identify possible evolutionary relationships between different species. What the protocol, as written, does not demonstrate is that increasing the number of amplification cycles during PCR will increase the amount of DNA present for staining in the electrophoresis stage. Clearly for PCR to work this increase in the amount of DNA present must be happening but we thought it would be both interesting and useful to have a protocol which could be utilised to show that this is the case. So, there is one key aim of the experiment we describe here – *viz* to show that an increase in the number of PCR cycles leads to an increase in the amount of DNA which can be observed.

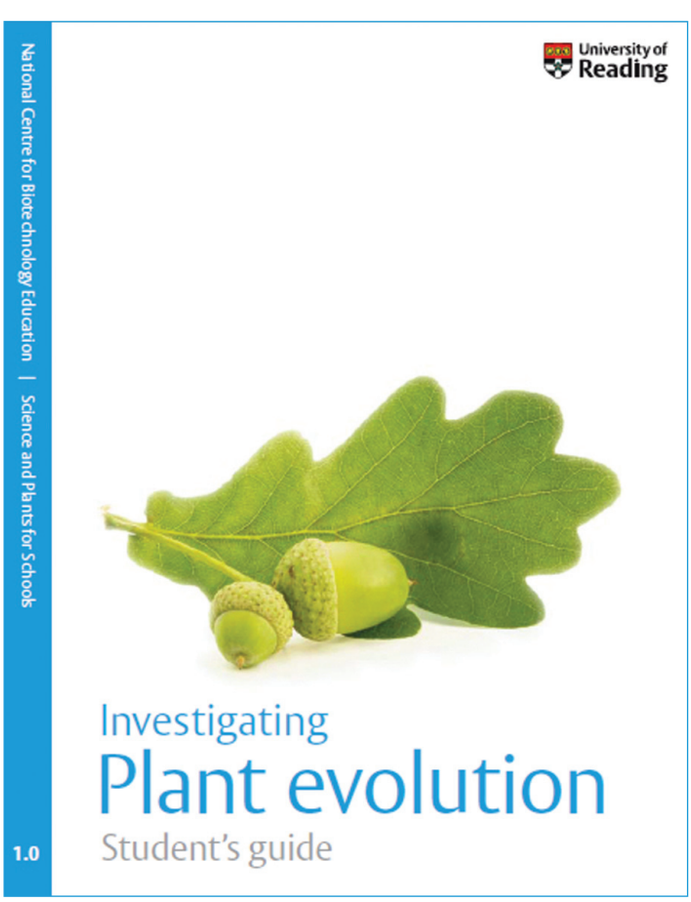

Figure 1 *- See the Student's Guide for full information.*

Methodology

We utilised the *Investigating Plant Evolution* kit from *NCBE* for this practical. The DNA that is amplified is a highly variable non-coding region of chloroplast DNA (cpDNA). In addition to the items in the kit you will need to supply the following:

1. some fresh plant material – any soft, thin leaf will do (we used spinach and red chard)

2. a thermal cycler or three water baths maintained at 94°C, 55°C & 72°C

3. apparatus for gel electrophoresis

It is not our intention here to rewrite the method involved since it is more than adequately covered in the Student Guide booklet accompanying the kit (Figure 1) [9]. We believe that the learning experience for your students will be enhanced if the following are emphasised:

1. the PCR bead contains (i) equal amounts of dATP, dTTP, dCTP, dGTP, (ii) the heat-stable enzyme *Taq* polymerase, (iii) buffer, and (iv) $MgCl_2$

2. the primers provided have been synthesised so as to be complementary to the 5' end of the targeted cpDNA

3. the three steps in a PCR cycle involve:

   (i) denaturation (94°C)
   (ii) annealing (55°C)
   (iii) extension (72°C)

Clear diagrams explaining each step of the PCR process are given in the Student Guide accompanying the kit [9]. Although thermal cyclers are beyond most school budgets the protocol works equally well when performed manually using water baths (we are aware of a UK-based supplier that markets 'PCR' water-baths which incorporate 3 chambers into a single housing [11]). Since it is unlikely that your students will undertake PCR on many occasions during their period in school or college one could make a strong case to suggest that the learning process will be enhanced if the amplification is done manually. If you have emphasised what happens at each temperature the students will be able to envisage the step each time they transfer the tubes from one water bath to the next.

Results

You can clearly demonstrate that PCR amplifies DNA by dividing your students into three groups:

1. Group 1 whose task is to carry out 20 amplification cycles

2. Group 2 whose task is to carry out 25 amplification cycles

3. Group 3 whose task is to carry out 30 amplification cycles (the normal number of cycles recommended for use with this protocol [9])

   - Lanes 1 and 4 = 20 amplification cycles
   - Lanes 2 and 5 = 25 amplification cycles
   - Lanes 3 and 6 = 30 amplification cycles

We took 3 samples of both spinach and red chard and ran either 20, 25 or 30 PCR amplification cycles. Once these amplifications had been carried out we ran samples of the products using agarose gel electrophoresis followed by staining with Azure A [9]. The results are presented in Figure 2. As can be seen there is an evident increase in the intensity of colour of the dye and this reflects the increase in the amount of DNA present as we move from 20 cycles through to 30 cycles of amplification. This is a nice way of showing that increasing the number of amplifications does indeed increase the amount of DNA present.

We have made no attempt to quantify the intensity of the bands produced - perhaps a good student investigation in the making?

Acknowledgements

We would like to thank Rodger McAndrew who made important contributions to the practical work associated with this article.

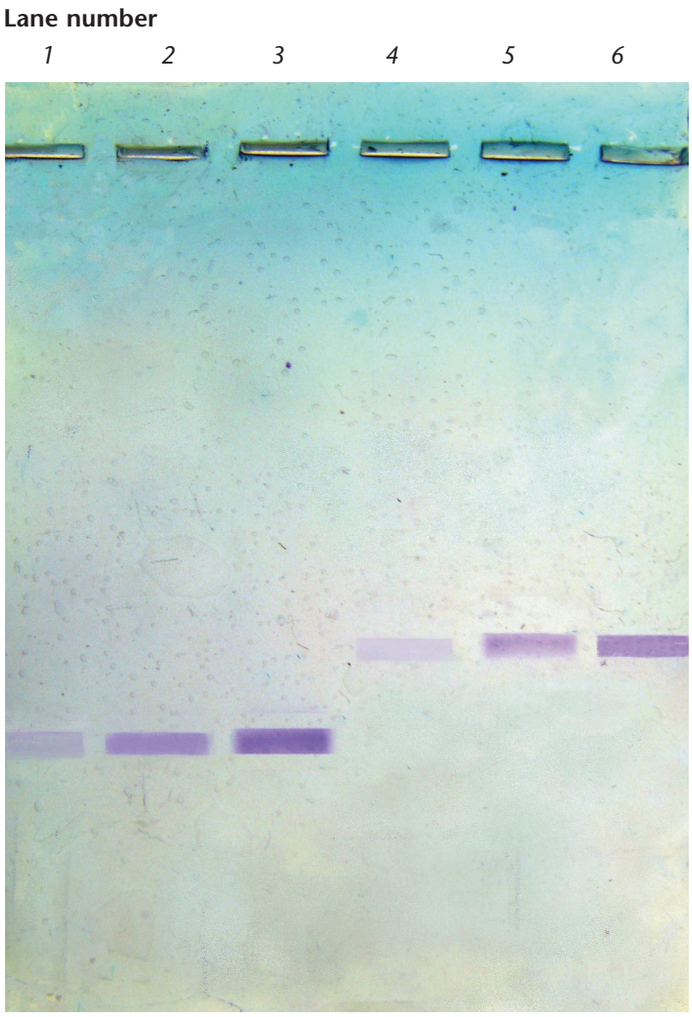

Figure 2 *– Bands of cpDNA, stained with Azure A, obtained following PCR of chloroplast DNA from spinach (lanes 1-3) and red chard (lanes 4-6).*

References

[1] Mullis K.B. (1990), The unusual origin of the polymerase chain reaction. *Scientific American*, **262**, 36-43.
[2] Gillaspy, E. (2004) The polymerase chain reaction. *Biological Sciences Review,* **16**, 10-13.
[3] Micklos, D.A. and Freyer, G.A. (2003), *DNA Science A First Course (2nd edition)*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
[4] Smith, J.E. (1996) *Biotechnology (3rd edition),* Cambridge University Press, Cambridge.
[5] Walker J.M. and Rapley, R. (eds.) (2000) *Molecular Biology and Biotechnology (4th edition),* The Royal Society of Chemistry, Cambridge.
[6] Campbell, N.A. and Reece, J.B. (2008), *Biology (8th edition),* Pearson Education Inc., Pearson Benjamin Cummings, San Francisco.
[7] Polymerase Chain Reaction, Dolan DNA Learning Center available at http://www.dnalc.org/resources/animations/pcr.html (accessed July 26th 2010).
[8] Hamilton, K., Barfoot, J., Crawford, K.E., Simpson, C.S., Beaumont, P.C. and Bownes, M. (2006), Amplification of chloroplast DNA using the polymerase chain reaction (PCR). *Journal of Biological Education*, **40**, 172-177.
[9] National Centre for Biotechnology Education (see www.ncbe.reading.ac.uk/) have produced both teacher and student guides and these are available at www.ncbe.reading.ac.uk/ncbe/MATERIALS/DNA/PDF/PlantPCRTG.pdf and www.ncbe.reading.ac.uk/ncbe/MATERIALS/DNA/PDF/PlantPCRSG.pdf respectively (accessed July 26th 2010).
[10] National Centre for Biotechnology Education price list available at www.ncbe.reading.ac.uk/NCBE/MATERIALS/PDF/NCBEpricelist.pdf (accessed July 26th 2010).
[11] Edvotek UK (http://edvotek.co.uk/) (accessed July 26th 2010).

Make your own respiration rate sensor

You will need:

- 2 x 60 cm lengths of 10 cm wide e.g. tough, non-stretch material such as deck chair canvas
- 10 x 10 cm square of material to make a pocket for the battery holder
- 2 x AA (1.5 V) batteries and a holder
- 2 x 22 Ω (22R) resistors
- 50 Ω (50R) variable resistor
- 2 x 60 cm lengths of Velcro®
- 5 cm x 1 cm strip of *ElectroLycra* [1]
- voltage sensor
- Two 6 cm x 3.2 cm lengths of elastic [2].

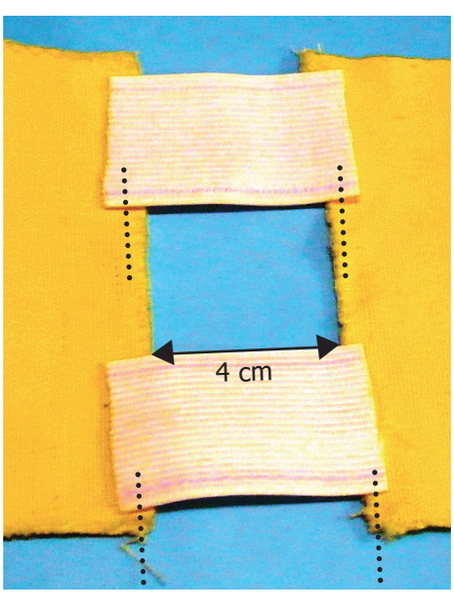

Figure 1 *- Place the 2 strips of fabric 4 cm apart and stitch the elastic to it.*

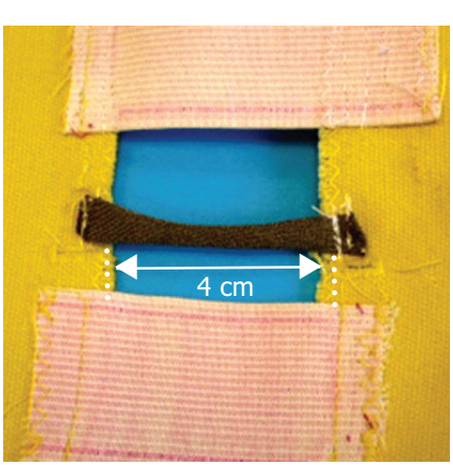

Figure 2 *- Place the ElectroLycra between the 2 pieces of material and stitch together.*

Figure 3 *- Insert one jaw of the croc clip through the buttonhole.*

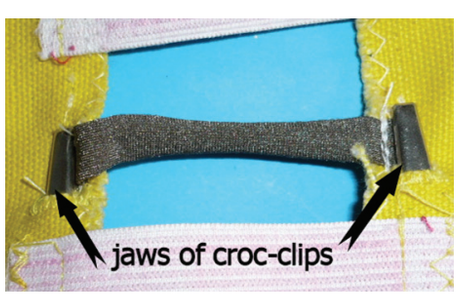

Figure 4 *- Ensure the croc cilps grip the ElectroLycra.*

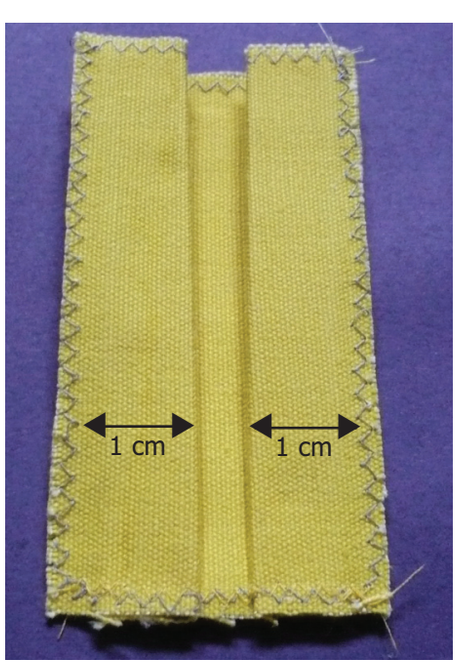

Figure 5 *- Fold the material as shown.*

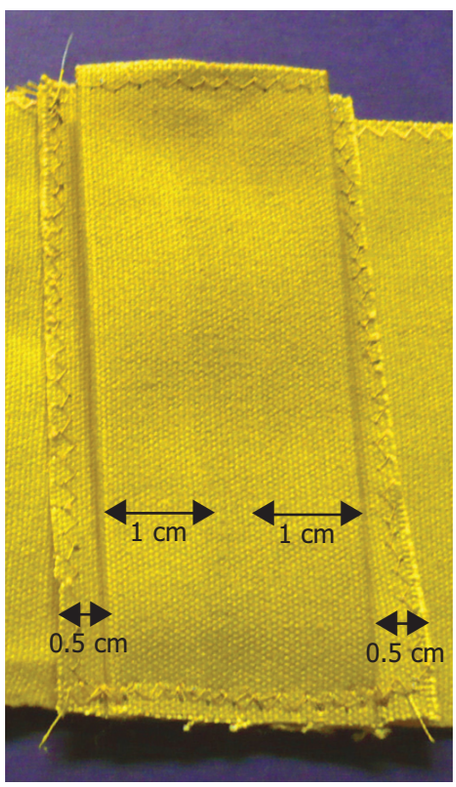

Figure 6 *- Stick the pocket in place as indicated.*

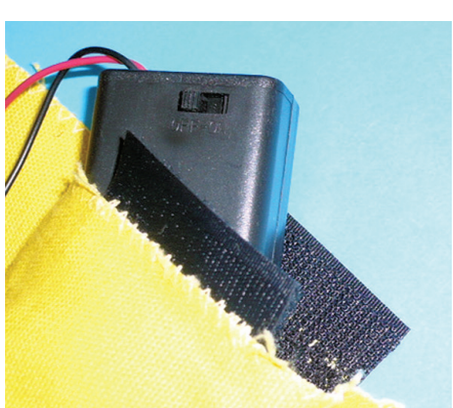

Figure 7 *- Stick the pocket in place as indicated.*

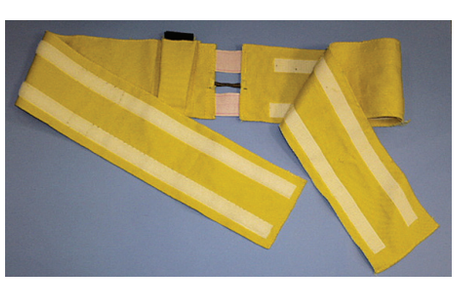

Figure 8 *- Strips of Velcro on top on one side and underneath on the other side.*

Lay the two strips of material out with a gap of 4 cm between each piece (Figure 1). Place one strip of elastic at the top of the gap and the other at the bottom of the gap. Sew the elastic to the material using a straight stitch as indicated by the dashed lines in Figure 1. Place the strip of ElectroLycra across the centre of the gap and sew it to either side of the gap with a straight stitch as indicated by the dashed lines in Figure 2, ensuring there is a 4 cm piece of ElectroLycra free across the gap. Just under the ElectroLycra make a buttonhole each side 0.5 cm in length for one jaw of the croc clip to fit through, see Figure 3, ensuring the croc clip will close holding the ElectroLycra on the other side, see Figure 4.

Make a pocket to take the battery holder using the 10 cm square of material and taking a 1 cm tuck at each side leaving 0.5 cm for the seam, see Figure 5, and stitching it to the belt 4 cm from the gap with the ElectroLycra with the tucks facing the belt, as shown in Figure 6. Attach a 4 cm strip of Velcro to the top of each side of the top of the pocket, see Figure 7, so they will stick together and prevent the battery holder from falling out of the pocket. Attach two strips of Velcro to each side of the belt as shown in Figure 8. Make sure the Velcro is attached on the top of one side and on the bottom of the other side so when the belt is put on the strips of Velcro stick to each other.

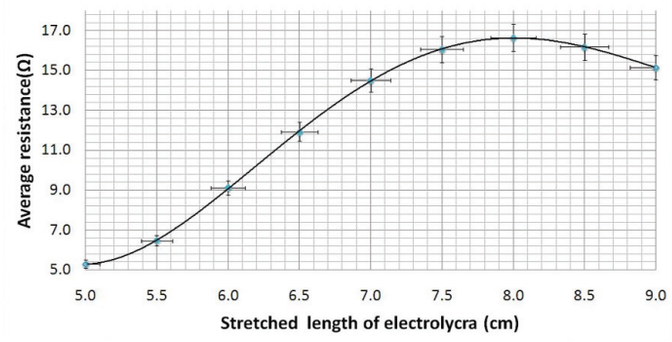

Figure 9 *- Change in resistance of a 5 cm strip of ElectroLycra on stretching.*

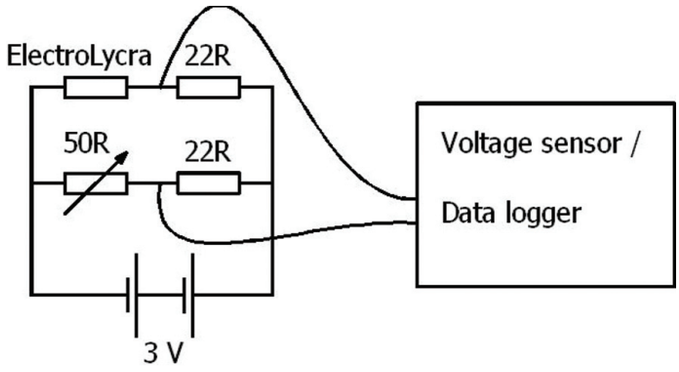

Figure 10 *- Wheatstone Bridge circuit with ElectroLycra as sensor, 22Ω resistors and 50Ω variable resistor.*

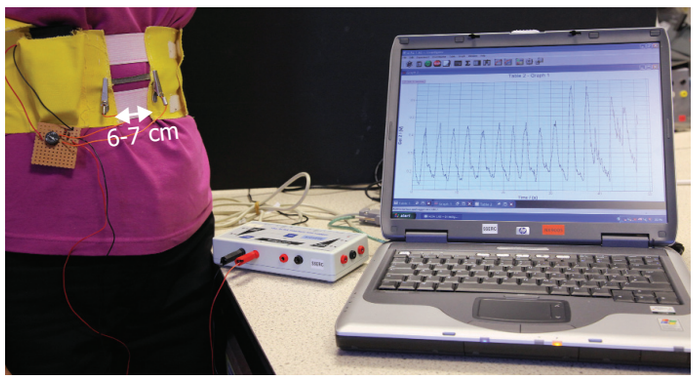

Figure 11 *- Ensure ElectroLycra operates in stretching range of 6-7 cm. A typical set of results are shown.*

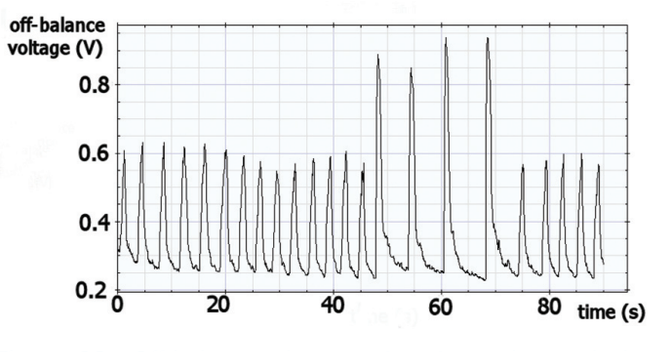

Figure 12 *- Off-balance voltage against time – the graph shows normal breathing at the start, followed by deep breathing for 20 s.*

The ElectroLycra's resistance changes with length as shown in Figure 9. It forms a branch of a Wheatstone Bridge as shown in Figure 10.

The change in length of the ElectroLycra is detected by measuring the off-balance voltage in the Wheatstone bridge using a voltage sensor connected to a data logger.

Put the belt around your chest so it fits tightly enough to stretch the ElectroLycra to about 6 cm, see Figure 11. The ElectroLycra must be operating in the range of stretching between 6 cm and 7 cm to give the best response. Connect the leads measuring the off balance voltage to the voltage sensor. If necessary adjust the variable resistor to get the output voltage to about 0.1 V. Typical graphs of breathing are shown on the laptop on Figure 11 and the graph of Figure 12.

References

[1] *ElectroLycra* - http://www.mutr.co.uk/product_info.php?products_id=1009614
[2] elastic - http://www.supplydivision.co.uk/elastic.htm#Double

Health & Safety – Optical Radiation

– when common sense isn't enough

In the physics lab, the teacher is demonstrating the photoelectric effect using a UV sterilising wand (Figure 1) bought for a few pounds from the internet. Her colleague prefers to use a halogen car headlight bulb. Next door, a biology colleague uses a blacklight (Figure 2) clamped in a stand to examine the effect of ultraviolet light on yeast. Downstairs, an English teacher looks on as a third year delivers her solo talk, illustrated by slides projected on to an interactive whiteboard. Nearby, a geographer uses a laser pointer to indicate the area on a map where an earthquake recently occurred. It's an everyday story of optical radiation in schools, but which of the above teachers are putting themselves or their pupils at risk?

The answer could be "all of them" or "none of them", depending on the control measures adopted by the teachers. One problem is that common sense isn't always enough when it comes to keeping safe and meeting legal directives [1]. For example, halogen headlights produce UV light but this is not usually a safety issue because they are generally behind glass covers in cars. If they are not, they need to be shrouded so that observers are not irradiated by light that is potentially damaging to their skin or eyes. A blacklight (*Figure 2*), which is often used to show up security markings, gives out a different type of radiation from that emitted by a sterilising wand. The latter is far more hazardous to the skin or cornea.

The SSERC team has just finished drafting guidance to schools on using optical radiation safely [4]. All common school sources are covered. Our advice is based on information in British Standards [2] and from the Health Protection Agency's work [3]. Assessments have involved examining not just the irradiance of sources, but also the spectral distribution (*Figure 3*) of the light emitted and the dimensions of the lamp too.

The results of this work will be available in a downloadable document on our science3-18.org website [4]. Some of the advice may be surprising. When we repeated the HPA's assessment of a blue Lumiled LED, for instance, we too found that, were a pupil to stare directly at it, the exposure limit for retinal damage would be reached in around 30 seconds. Not only that, the effect is cumulative, so the limit would be breached, for example, by two exposures of 20 seconds each within an 8 hour period. We say this not to instil panic, rather to encourage teachers to have a look at our advice and continue to do safe, engaging, intriguing work with optical radiation.

Figure 1 *- A UV sterilising wand. It's cheap, but is it safe?*

Figure 2 *- Don't do this if the black light is switched on!*

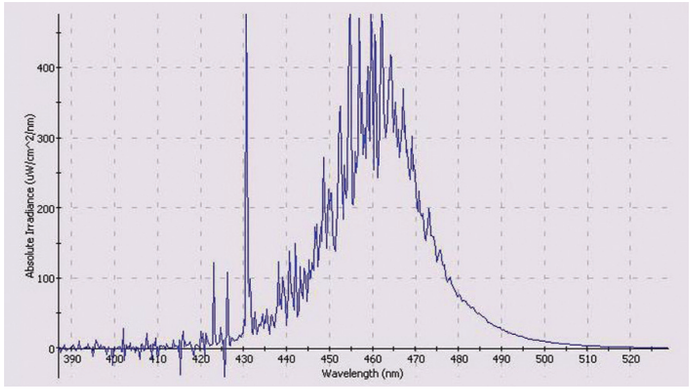

Figure 3 *- Spectral distribution of light from a blue Lumiled LED.*

References

[1] DIRECTIVE 2006/25/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation)

[2] BS EN 62471:2008 Photobiological safety of lamps and lamp systems

[3] A Non-Binding Guide to the Artificial Optical Radiation Directive 2006/25/EC, Radiation Protection Division, Health Protection Agency

[4] http://www.sserc.org.uk/members/SafetyNet/Physics/SSERC_Optical_radiation_safe_use.pdf

SSERC Annual Conference and AGM

Friday 3rd December 2010

A key date in the SSERC calendar is the Annual Conference and AGM which in 2010 will be held at the Carnegie Conference Centre, Dunfermline, on Friday 3rd December. A major theme for this year's conference is the important and continuing role which SSERC plays in offering professional development for teachers, technicians and student teachers. Speakers at this year's conference include Heather Reid who, in her capacity as consultant to LT Scotland, will be giving us an overview of the school science professional development landscape. Miranda Stephenson, Programme Director at the National Science Learning Centre in York, will be sharing her perspective on the key role which SSERC plays in delivery of NSLC programmes of activity in Scotland. A review of the impact of professional development delivered by SSERC will be the focus of the final presentation by Kevin Lowden and Stuart Hall from the Scottish Council for Research in Education at the University of Glasgow.

The Conference will provide opportunities for you to meet with the SSERC team and discuss recent developments in the design of materials in support of the science and technology curricula across all phases. Coupled with an update on health and safety legislation, we are once again offering a rich and diverse programme.

So, make a note of the date in your diary and come and join us at this important event in the education calendar!

There is no charge for attending the conference. Refreshments, including lunch, together with conference papers will be provided.

In order to reserve your place, please contact Charlie Stoddart (Tel. 01383 626070 or email sts@sserc.org.uk). Alternatively you can register online at:

http://www.science3-18.org/index.php?option=com_web2crm&view=web2crm&residential=0&Itemid=1992

Free CPD for Local Authorities

For many years, SSERC has helped local authority employers to fulfil their legal obligation to provide adequate health and safety training for staff. To date, this has been done by SSERC delivering courses at the request of the local authority or individual school.

Alternatively we have run open courses to which a school or local authority can send delegates.

At SSERC, there is an awareness that structures have changed within schools. Heads of physics, chemistry and biology have, in many local authority schools, been replaced by a single faculty head who may not be a scientist. Beyond the school, it is becoming increasingly common to have Quality Improvement Officers with cross-curricular duties rather than traditional advisers. The post of senior technician is also disappearing in many areas.

We are responding to these changes by running a rolling programme of free full day courses for local authorities.

Each authority will be entitled to a course once every two to three years. We expect that the authority will wish to use this to ensure that faculty or departmental heads receive appropriate training, or that recently employed staff are trained. Local Authorities and schools are, of course, still welcome to arrange further health and safety training from SSERC in addition to this free entitlement.

All aspects of the courses will be directly applicable to work in a school science or technology department. Feedback from teachers and technicians on previous courses has indicated that this is hugely preferred over general courses designed for a variety of council employees. The programme should ensure that science and technology staff are kept abreast of their duties and responsibilities.

Local authorities should contact: sts@sserc.org.uk to book training.

Ocean Optics SC-500 Spectrophotometer

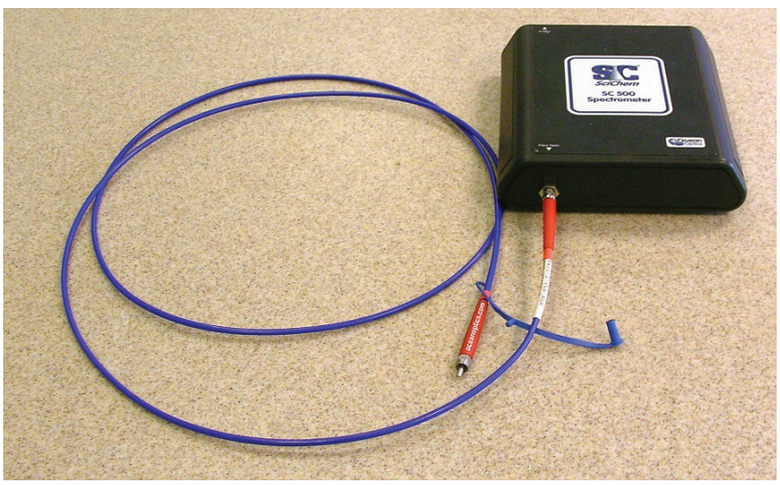

Figure 1 *- The SC-500 spectrophotometer.*

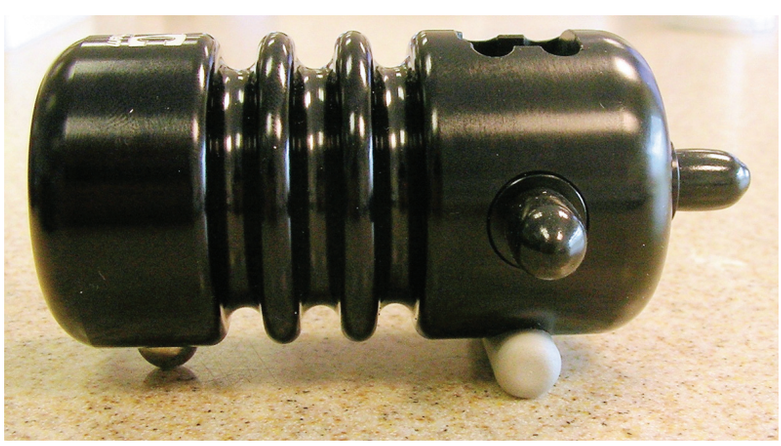

Figure 2 *- Cuvette holder, somehow redolent of a 1950s sci-fi robot.*

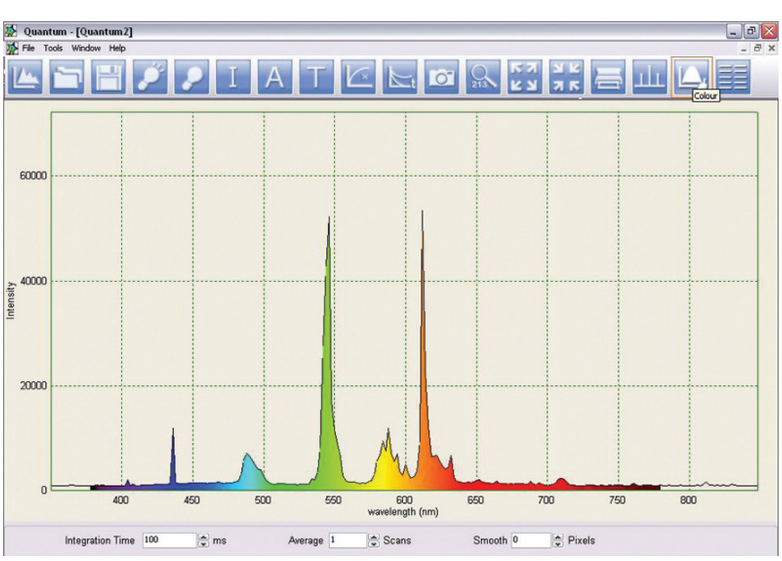

Figure 3 *- Full visible spectrum from overhead fluorescent light.*

Ocean Optics SC-500 Spectrophotometer with Quantum software

In Bulletin 228 [1] we reviewed two relatively low cost USB spectrophotometers suitable for use in schools and suggested some activities that could be carried out using these devices. We have learned of another budget model, the SC-500, made by Ocean Optics for Scientific and Chemical [2].

The SC-500 comes with an optical fibre, a cuvette holder containing a tungsten light source (Figure 2), cuvettes, connecting leads, a manual and software called Quantum. We were particularly interested in Quantum as the Spectrovis spectrophotometer we tested last time required Logger Pro to work, incurring additional cost if the school does not already have a licence. The Red Tide, also tested in Bulletin 228, could work with Logger Pro and software called Spectrasuite. Spectrasuite, whilst effective, was never promoted for school use. Users of Spectrasuite can switch to Quantum if they wish, and are unlikely to regret doing so.

The spectrophotometer has a range from 350 to 850 nm (Figure 3) and a resolution of 3 nm.

Our first test involved examining the spectrum from a sodium lamp. Figure 4 shows a peak at 590 nm. This corresponds to the well known sodium doublet, two lines at 589.0 and 589.6 nm. The measured wavelength is well within the bounds of the claimed resolution. We would not have expected this spectrophotometer, or indeed any spectrophotometer designed for the education market, to be able to distinguish the two separate sodium lines. Nick Swift, Education Sales Manager for Ocean Optics, reminds us that the potassium doublet is far easier to resolve, and that a banana in a Bunsen flame is a suitable light source of that element's spectrum.

Ocean Optics SC-500 Spectrophotometer

The Quantum software is straightforward to use. Complex procedures, such as absorbance and transmission experiments, use a "wizard" approach that guides the user through each stage. For example, to find the concentration of a sample of potassium manganate(VII) solution, the software guided us through a procedure whereby we had to place cuvettes containing known concentrations in the holder. The absorbance was measured by the spectrophotometer in each case. This produced a calibration graph that allowed an unknown concentration to be determined when it was put in the unit. An example graph is shown in Figure 5.

A feature we would like to see added to the software is the ability to zoom in on a particular part of the spectrum by dragging. As it stands, zooming is accomplished by specifying a maximum and minimum wavelength, for example in Figure 4 we specified 580 to 600 nm. The zoom buttons on the toolbar operate only on the vertical scale. We have been informed that the drag-to-zoom feature will be added by the end of 2010. Quantum and all future updates are free and can be downloaded from www.oceanoptics.eu/quantum

The cuvette holder has a mirror accessory and a port for a larger diameter fibre. The larger diameter is needed to capture light emitted through fluorescence. The Stokes Shift – the wavelength difference between the wavelength at which maximum absorbance occurs and the peak of the spectrum of light emitted when the liquid fluoresces – can be found.

The manual supplied with the SC-500 suggests a number of other experiments that can be carried out. Interestingly, it also took the trouble to explain how a spectrophotometer works, something that we feel is important in these days of black boxes that hook up to computers.

The SC-500 may not have the range of some models of budget spectrophotometer but it is a complete hardware and software package, suitable off-the-shelf for experiments in physics, chemistry and biology. The only extra required is the larger diameter optical fibre if the user wishes to perform experiments on fluorescence.

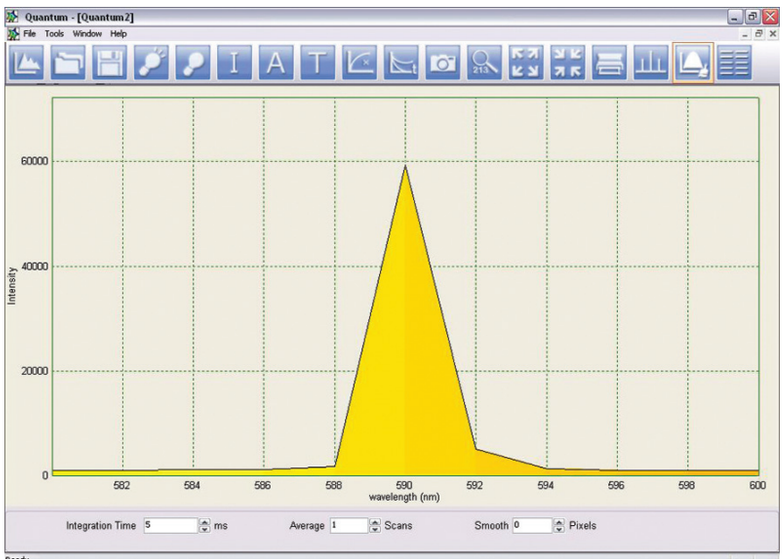

Figure 4 *- Zoomed view of sodium yellow line(s).*

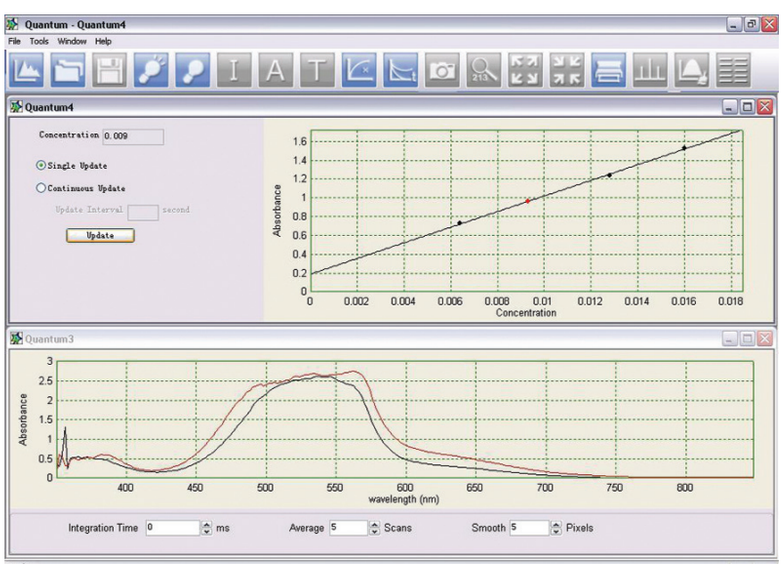

Figure 5 *- Using absorbance to determine concentration.*

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[1] http://www.sserc.org.uk/members/SafetyNet/bulls/228/Spectrophotometers_for%20Schools.htm
[2] www.scichem.com, product code – SPE400010, £450

Health & Safety – Chemical store temperatures

Introduction

Recently we have had an increasing number of queries about high temperatures in chemical stores and, whilst not questioning the reality of global warming, it seems there is more to the matter than the merely climatic.

Although it is clear that modern schools are better insulated and thus provide warmer environments than used to be the case there would appear to be more to it than that.

Why is it happening?

Some of the most common causes have been:

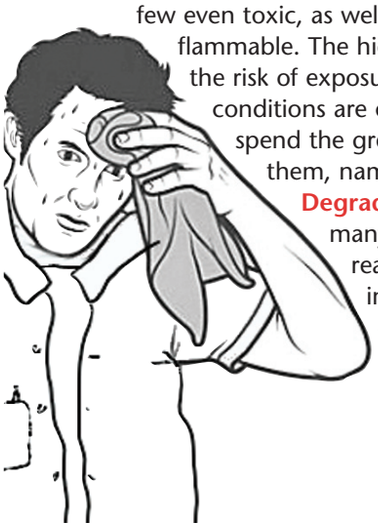
- Poor ventilation
- Badly designed ventilation:
  - air being drawn out but no intake for clean replacement air
  - fans installed in the wrong position so that fresh air is immediately taken out again.
  - air being drawn in for ventilation that is already warm as it is coming from warm corridors or rooms.
- Poor positioning of chemical stores where it is:
  - often surrounded on all sides by other rooms, which are themselves heated.
  - located on the south side of the building
  - positioned near to heating pipes etc. (and even boiler rooms) too close to the chemical store.
- Windows, especially south facing, can allow heat & light in.

Why is it a problem?

Any chemicals which have a high volatility will be even more volatile as the temperature increases. Some areas of concern are:

Corrosion - Increased levels of some vapours (particularly HCl) can cause corrosion of metal. This can lead to weakening of cupboards and, perhaps more importantly, metal shelving or brackets for shelving leading to collapse.

Poor Working Conditions - Many vapours are harmful, and a few even toxic, as well as being (highly or extremely) flammable. The higher the temperature the greater the risk of exposure. These poor working conditions are of greatest concern for those who spend the greatest amount of time exposed to them, namely technicians.



Degradation - At a higher temperature, many chemicals degrade and lose their reactivity. As well as being an inconvenience, this can represent a considerable, on-going, extra cost.

Fire/Explosion – Increased volatility of flammable liquids leads to an increased fire risk. In some cases, the high pressure due to increased evaporation might even lead to explosion – Ammonia is a case in point.

What should be happening?

Good practice would suggest that the temperature in a chemical store should be between 15 and 20°C. (i.e. as cool as possible without things freezing).

How to achieve a reasonable temperature?

Short Term

In the (very) short term, if it is practicable, open doors and/or windows to allow a through draught.

- **This must not compromise security.**
- Make sure the store does not vent into corridors, sub-floor, above ceiling or areas where people are working such as prep rooms or classrooms.

Longer Term

- Black out any windows. However, any shading would have to be on the outside or the blackout achieved on the inside with an insulating sheet otherwise the effect will be to keep the room as warm or even warmer. Many chemicals are degraded by light as well as heat so this is a sensible precaution. In addition, plastic as used in storage bottles is weakened by light. (Care should be taken though not to block off any ventilation that might be happening via the windows).

- Make sure that the ventilation system is drawing air from a cool area. Another equally warm or warmer room will not help. If there is an outside wall, high and low air bricks are often enough.

Bigger decisions

It may be that the measures above do not reduce the temperature to a safe level in which case rather more drastic measures will have to be considered, including:

- Re-routing of heating ducts/pipes that are too close to the store.
- Moving the chemical store completely; preferably to a room with an outside wall.
- Installing air-conditioning – though this can not just be a substitute for ventilation or it will simply be re-circulating the fumes.

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