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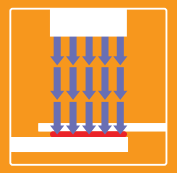
Top tips for getting the best from your UV curing process



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In these tips, the term 'adhesive' also covers coatings, encapsulants, potting compounds, temporary masking materials and form-in-place gaskets, where applicable.

Mercury Arc Lamp

Broad Spectrum

<2,000 hour bulb operational life

Intensity degrades over time

5 minute warm-up time

High operating temperature

Higher energy costs

LED Lamp

Narrow Spectrum

>20,000 hour operational life

No bulb, no degradation

No warm-up time

Low operating temperature

Lower operating costs

UV curing lamps can be based on two types of quite different technology:

Mercury arc lamp – used successfully for decades, and still the predominant lamp type, it produces a **broad spectrum** of light

LED lamp – a much newer technology, it produces a **narrow spectrum** of light

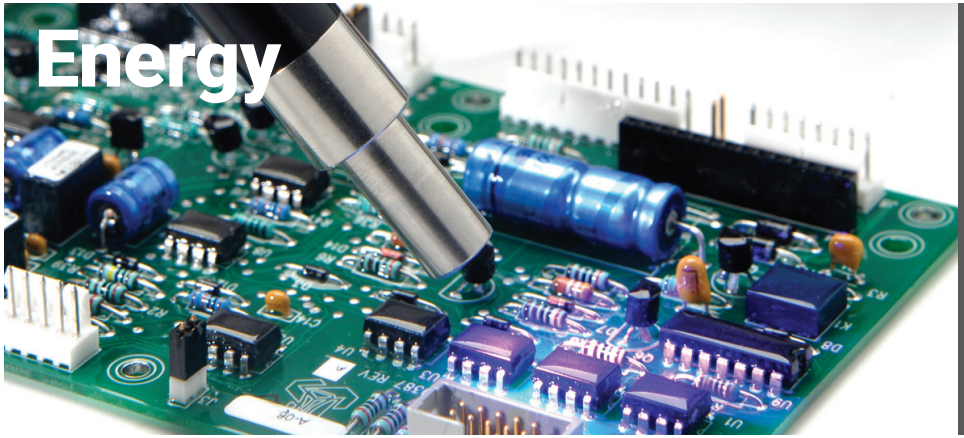
The output from UV curing lamps based on LEDs does not appreciably degrade over time. There are no bulbs to replace in LED lamps, they require no warm up time, they emit cooler light radiation and they are more electrically efficient. They also meet the increasingly stringent regulations regarding the use of mercury.

LED UV curing lamps will not work optimally with all UV curing adhesives, many of which are designed to cure with broad spectrum UV light.

Dose

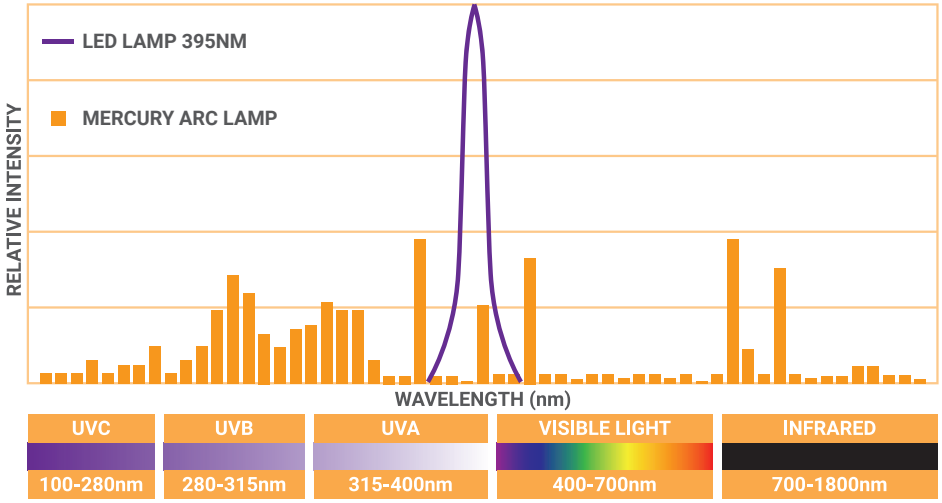
The key to success is ensuring that the adhesive or other light curing material receives the correct dose (J/cm²), which is a combination of light intensity and time of exposure (W/cm² x seconds), at the appropriate wavelengths for the material.

Energy



By testing, understand the minimum dose needed for your application – how much energy do you need to achieve an optimal cure? Establish a curing process at the minimum dose plus a recommended 25% safety factor.

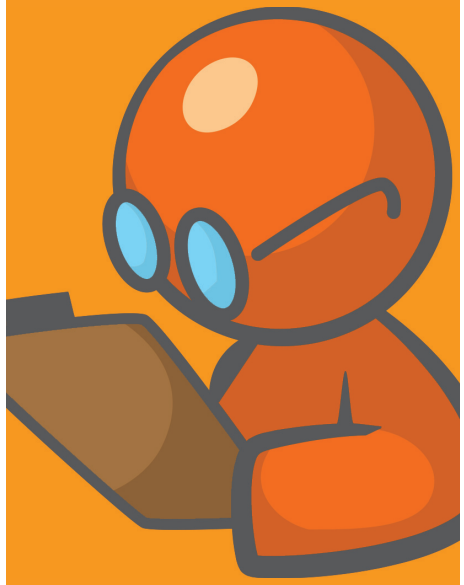
Wavelength



Make sure the spectral output (UV and/or visible light wavelengths) of your curing lamp is correctly matched with the material you're curing. Remember that not all materials cure optimally with all lamps, and a mismatch can result in non-optimal or poor bonds. If you're considering taking advantage of the benefits of LED UV curing technology, remember that it is not a simple like-for-like replacement for broad spectrum lamps.

Variables

Understand and control the process variables in order to get repeatability and consistency. Ideally, you would like to fix each process variable i.e. time of exposure, distance, intensity, adhesive quantity and location, etc.

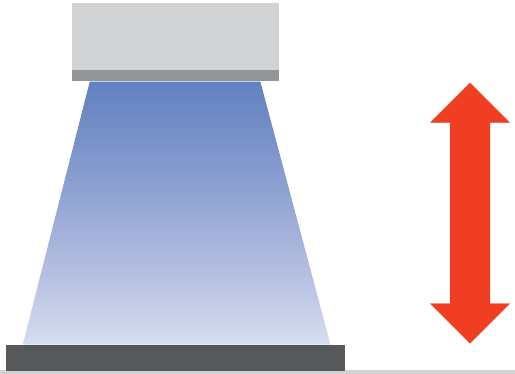


Minimum Intensity

As a rule of thumb, we recommend a minimum curing intensity of about 50 mW/cm². Higher intensities should give better cure and therefore better performance – and shorter process time. It is not recommended to use very low power UV lights (or the sun!) for extended times, as this is likely to result in non-optimal or incomplete curing for most industrial grade products, which may have a minimum activation energy level.

Distance

Fix the distance between the light source and the bondline. This is a critical variable, because the light intensity falls off with the square of the distance – so at twice the distance, you will have only one quarter of the energy. For faster cures, get as close as you can.

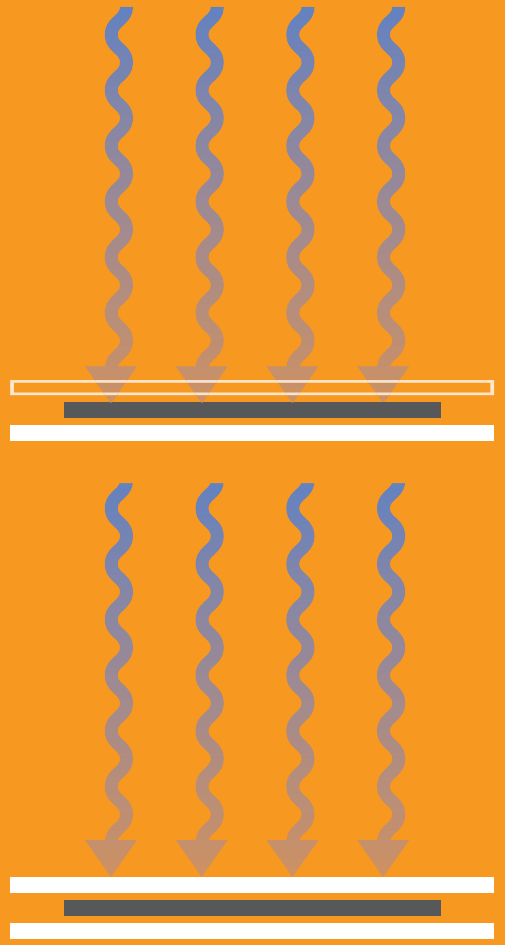


Measure Output

You can measure the light intensity using a radiometer, which gives an output in mW/cm² or W/cm². Radiometers with different spectral sensitivities are recommended for use with the different broad spectrum and LED curing lamps. Some radiometers also measure dose.

Light Transmission

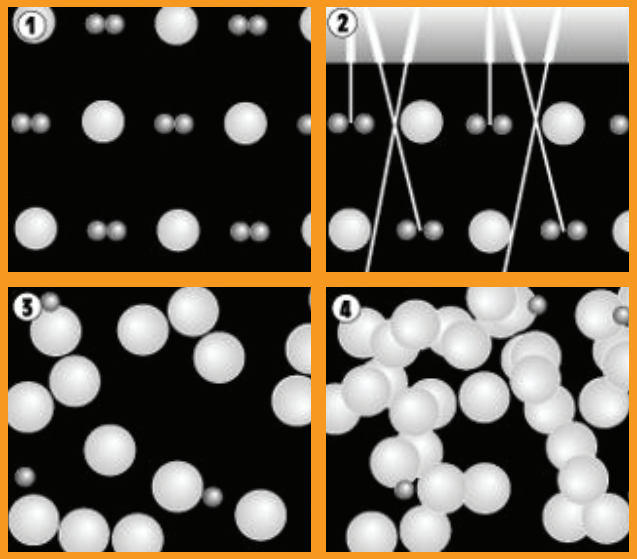
Try to understand the curing intensity at the bondline. If you are curing through a substrate, how does this affect the light transmission to the adhesive? Some plastics have UV blocking additives, which can inhibit transmission, and therefore curing. In this case, adhesives with enhanced UV and visible light cure ability can overcome this.



Bondline Exposure

All of the adhesive in the bondline must be exposed to light in order to cure, so in general at least one substrate must be able to transmit appropriate light; the ability to see through the surface is a good indication. In some cases (e.g. conformal coatings), part-shaded areas can be accommodated by using dual-cure materials, such as those that have a secondary cure capability using heat or moisture.

Cure

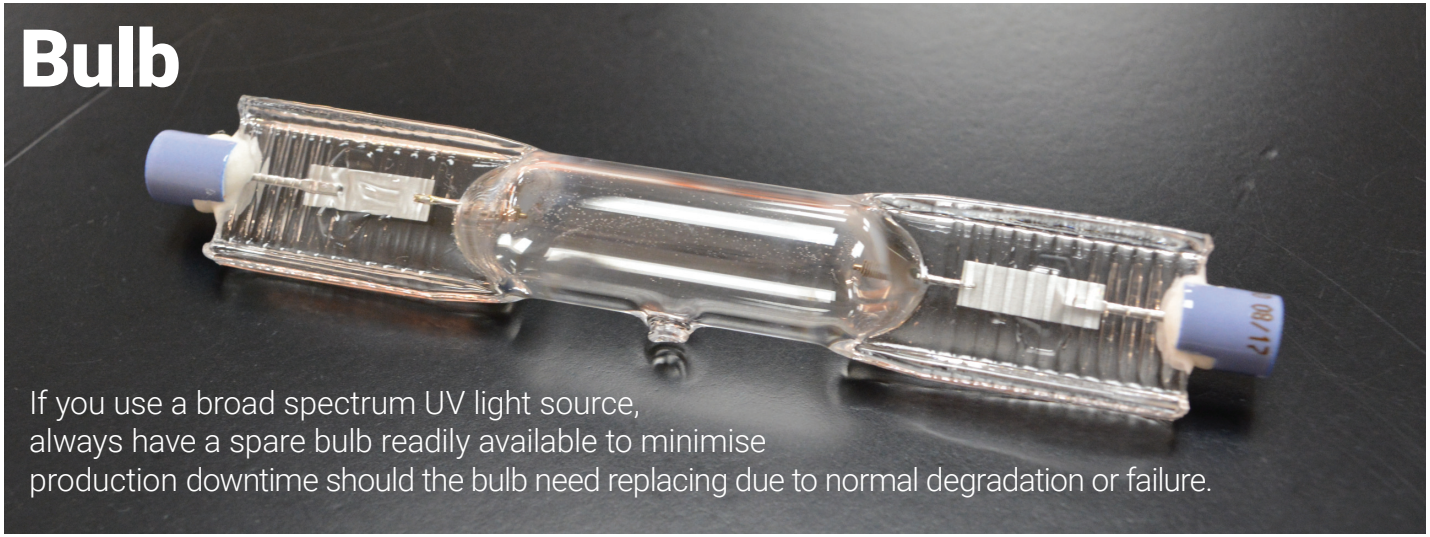


With most UV curing adhesives (i.e. those based on free radical polymerisation), curing starts with exposure to light, and stops when the light is removed. So, the production process should ensure a full cure during the time of exposure. If possible, expose all adhesive in one dose of UV light. Multiple exposures are not normally recommended as they could affect the integrity of the bond.

Variable Output

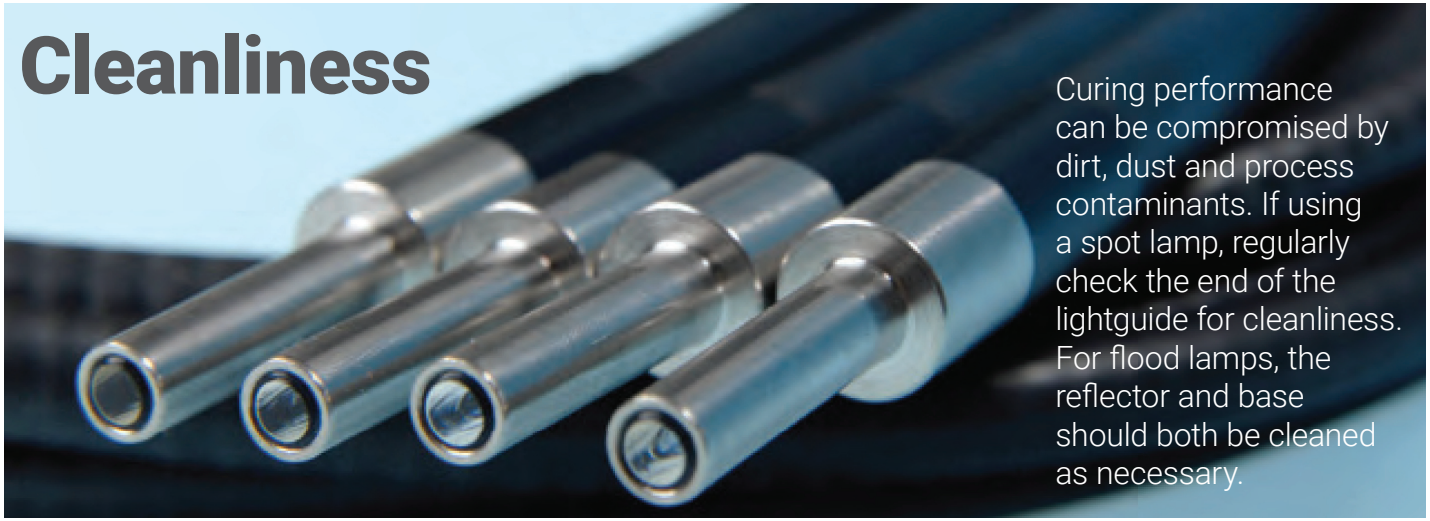
The output intensity of arc lamp broad spectrum UV light sources degrades over time, so it is recommended that you carry out regular output checks with a radiometer to ensure a minimum dose is achieved. These lamps normally have hour meters, to facilitate the recording of intensity against "on" time. With arc lamp broad spectrum UV light sources, bulb life is shortened by frequent turning on and off. It is recommended that the lamp is left on during a normal shift if curing is expected to take place. Allow broad spectrum lamps five minutes to attain full intensity before you use them to cure, and fifteen minutes after turning off to reach room temperature before re-ignition. LED-based curing lamps are instant on/off, requiring no warm-up/warm-down time.

Bulb



If you use a broad spectrum UV light source, always have a spare bulb readily available to minimise production downtime should the bulb need replacing due to normal degradation or failure.

Cleanliness



Curing performance can be compromised by dirt, dust and process contaminants. If using a spot lamp, regularly check the end of the lightguide for cleanliness. For flood lamps, the reflector and base should both be cleaned as necessary.

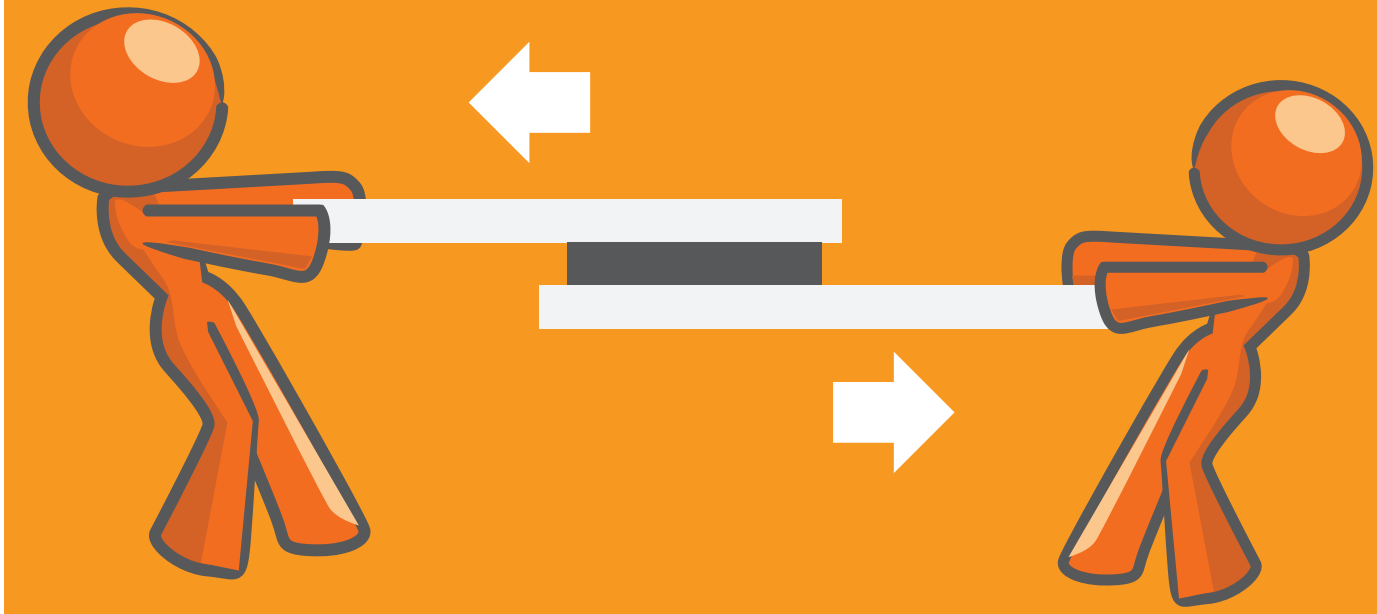
Storage

Make sure UV/light curable materials are stored in light-proof containers away from direct sunlight.

Viscosity

UV and light curable materials are available in a range of viscosities, from water-like to paste. If available, choose a viscosity which is optimal for your dispensing and application process, taking into account desired flow and wicking characteristics.

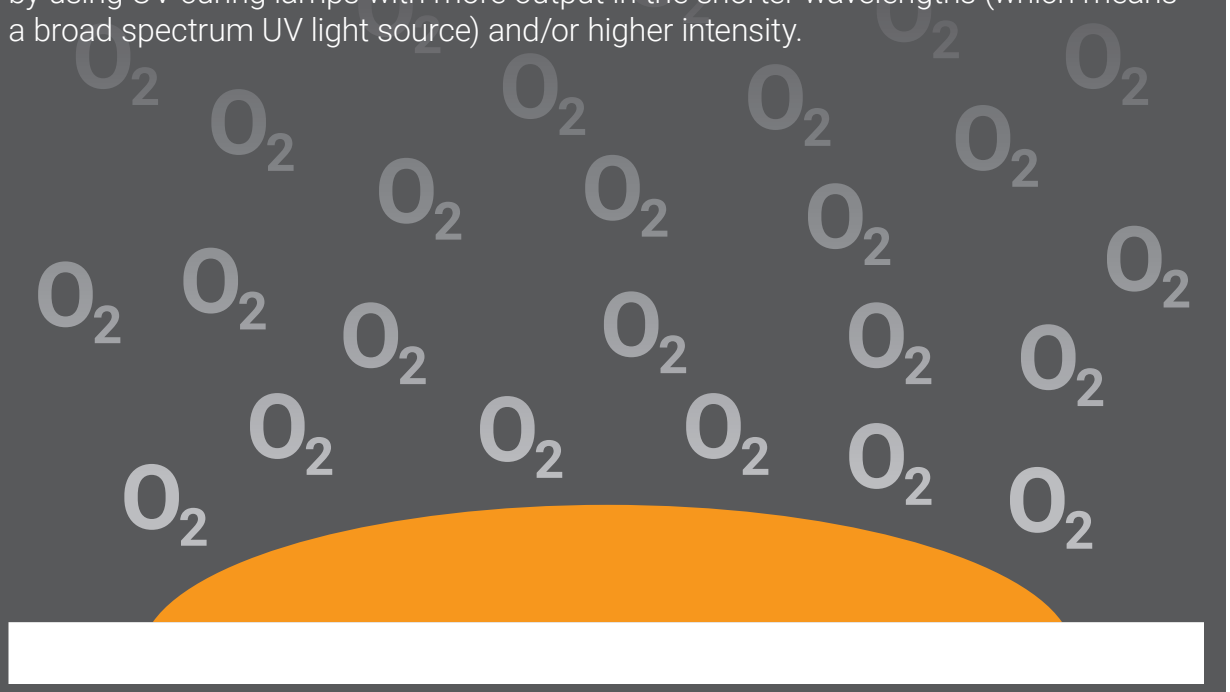
Full Cure



The determination of whether or not a full cure has been accomplished is best achieved by empirical tests. Full cure is the point at which more UV exposure no longer improves cured properties. For an adhesive, pull or lap shear tests against a range of process variables like time or intensity should help determine the optimal cure. Other cured properties like hardness or tackiness can also be indicators. In addition, some materials which indicate an effective cure are available (e.g. Dymax See-Cure colour change technology).

Oxygen Inhibition

If you get a slightly sticky or tacky surface after curing, this could be a result of oxygen inhibition. This is a well understood phenomenon of free radical cure chemistry, where the presence of normal atmospheric oxygen at the surface of the adhesive can inhibit the cure at that surface, resulting in a very thin layer of an adhesive constituent remaining – the bulk of the adhesive is cured. Tackiness can be reduced or prevented by using UV curing lamps with more output in the shorter wavelengths (which means a broad spectrum UV light source) and/or higher intensity.



Fluorescence

In order to assist with inspection, some materials will strongly fluoresce under UV black light (e.g. conformal coatings, some plastic bonding adhesives).

Health & Safety

Observe health & safety rules/best practice, as exposure to UV/visible light can be hazardous. What would you do on the beach in high summer? Protect your eyes and skin. Follow the equipment operation manual to ensure that it is installed and used safely. Make sure appropriate personal protection equipment is used at all times. Occupational UV light exposure in Great Britain is subject to the Control of Artificial Optical Radiation at Work Regulations 2010, which came into force on 27th April 2010, the European Physical Agents (Artificial Optical Radiation 2006/25/EC) Directive. Read the safety data sheet for the material which you are working with, and follow the personal protection equipment recommendations for that as well.

Light Levels

A radiometer is very useful for checking the levels of UV light in and around the curing equipment. Understanding this is recommended for health & safety and risk assessments, and useful for operator training.

Waste

Unused, uncured or residual material should be disposed of in accordance with the European Directives on waste and hazardous waste, local regulations and in conjunction with the SDS. Unused material can be cured and disposed of as a plastic.

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And remember...

The technical staff at your UV equipment or materials supplier should be willing and able to advise you on achieving the optimum results from your process.

Contact us

For more information about any of the tips described in this guide, please email **info@intertronics.co.uk** or call **01865 842842**.

Complete information on our products is available at **intertronics.co.uk**

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