Digital Pathology

What to look for when specifying monitors in your digital pathology workflow

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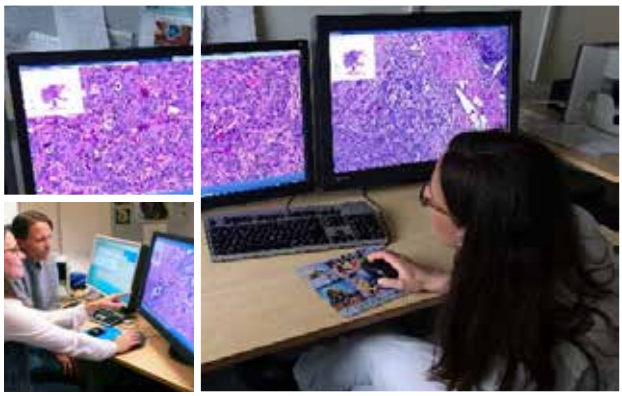
Introduction

As it currently stands, there are no set standards for Digital Pathology in the UK, or indeed across most of the world. This can prove problematic for users who are trying to research the best solution and balancing budgets whilst providing a clinically safe solution; as well as providing consideration to how long they need to future-proof these purchases for. Without specialist help, this is a complex and lengthy task.



Our UK team, have started to have many conversations with the major Digital Pathology PACS providers to understand preferred monitor specifications, for the optimum performance of their software.

EIZO is the expert in visual technology solutions with over 50 years' experience in specialist monitor technologies and displays covering colour workflows, clinical applications and image integrity. We are the UK market leader of monitor solutions in Radiology and PACS. Our UK team, have started to have many conversations with the major Digital Pathology PACS providers to understand preferred monitor specifications, for the optimum performance of their software, and have also had many educational and advisory conversations with end user sites over a period of 10+ years. EIZO already supplies monitors for diagnosis to large parts of the NHS Pathology estate, including Oxford University Hospitals, and major health departments around the globe.

While EIZO is unable to certify a monitor, specifically to meet Pathology requirements or standards, due to the lack of RCPath standards, we are extremely well placed to help and guide your teams' considerations, and demystify any jargon around the technology.

Our wide exposure to market requests and conclusions from monitor testing at a range of sites including, Royal Wolverhampton, Calderdale & Huddersfield, Glasgow, Lancashire, Royal Devon & Exeter, Plymouth University Hospitals, North Bristol NHS and several London trusts has further enhanced our Pathology specific understanding. Our gathered knowledge and experience enables us to advise on what your peers in Pathology seems to be reporting as the preferred features, size and functions, which also meets the software providers expectations of performance.

This guide has been put together to help you understand the relevant areas for consideration, and we would welcome a conversation to understand which software provider, area of Pathology and other Trust specific factors you have to further guide you on what is necessary, what is absolutely not, and what you will need to make a local decision on.

Please feel free to contact our team on 01344 317480

Advantages of Digital Pathology

The adoption of Digital Pathology can increase the safety of the diagnostic process in a number of ways. Examples of this include:

Reducing the risk of patient misidentification	Reduced risk of losing slides	Increasing access to second opinions

Overcoming these risks leads to greater short and long-term cost and resources savings.

Within a digital world, images and video streams can be shared in real-time. As a result, physical location and distance limitations between local hospitals, colleges (for education and second-opinions) and between workplace and home office (remote working) can be eliminated, resulting in greater efficiency in both diagnosis and review. Telepathology becomes an accessible practice due to Digital Pathology. There is also no degradation of an image over time, once stored.

Basic measuring, counting and advanced machine learning tasks are more efficient and easier to perform as digital images are well suited to Computational Pathology (CPATH).

Resolution

The higher the monitors resolution, the more level of detail will be seen. Images are smoother, with sharper edges and also display more content at one time.

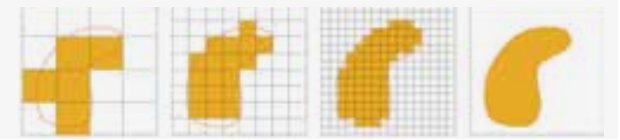
The resolution of a monitor describes the number of pixels which make up the image on the screen. A pixel is the smallest element of a digital picture that make up the dots which create the image. Resolution is measured as the number of pixels wide multiplied by the number of pixels high (width x height) used to produce the monitor image.

Example: When viewing a digitally captured image obtained from a device such as a WSI (Whole Slide Image) scanner a high resolution of 4MP (2560x1600) or higher on a 27" monitor, 6MP (3280x2048) on a 30" monitor or 8MP (3840x2160) or higher on a 32" monitor is recommended to retain an optimum level of detail and information for pathological diagnostics.

6MP Example: 3280 x 2048

This example of a
6MP resolution,
(6 Megapixel / 6 Million Pixels) monitor

(3280 x 2048= 6,717,440 ≈ 6,000,000)



Higher screen resolution has been found to decrease time to diagnosis.

The higher the monitors resolution, the more level of detail will be available to be seen. Images are smoother, with sharper edges and also allow the system to display more content at one time. However, increasing the resolution, but not the physical monitor size, can lead to text, images and tools being too small to read and use effectively.

To combat this, users tend to adjust the scaling in the operating system settings resulting in inaccurate images and unwanted imaging artefacts.

A Pathologist will pan around a slide a lot in the process of producing their report, which means moving a lot of pixels. Current graphics cards can struggle to do this smoothly on large full slide images. A lower resolution monitor can often give a much better performance on an ordinary level of graphics card. For example a 6MP monitor can be a great compromise between graphics card speed and resolution.

Screen size

The screen size of a monitor is an important consideration when taking into account the physical working area and field of vision of the user. At a normal desk working position it is recommended to use monitors between the size of 27″ and 32″ for Digital Pathology to fill a users natural field of vision.

A smaller screen size, for example a 24″, will not fill the user's natural field of vision, whereas a larger screen size, 55″ for example, would require users to constantly move their head to view the image without the ability to view the entire image at once.

Our experience tells us from customers working in Pathology that they are most comfortable with a 30″ monitor, this will also reduce the need for image scaling, which would then lead to inaccurate images and unwanted imaging artefacts.

Linked to resolution is the aspect ratio of a monitor. The aspect ratio is the ratio of an image width to its height with two numbers separated by a colon, such as **4:3**, for example.

The closer these numbers are to each other, the more 'square' the image will be **(e.g. 4:3)**.

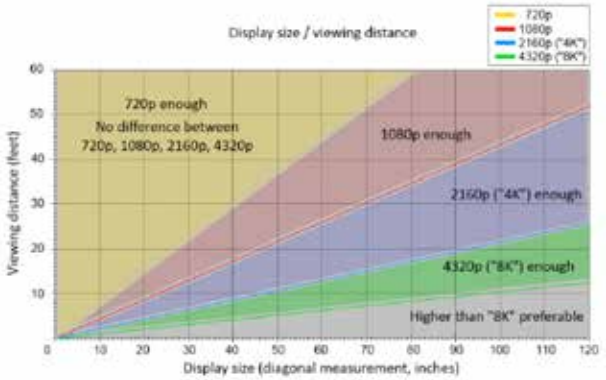
The further apart these numbers are to each other, the more 'wide screen' the image will be **(e.g. 16:9)**.

30″

24″

Workstation setup

Monitor screen size and resolution are equally important when it comes to picking the perfect solution. Increasing the resolution, but not the physical monitor size, can lead to text, images and tools being too small to read and use effectively.



The human eye is only able to perceive a limited amount of data, and when choosing any monitor, consideration needs to be given to screen size, pixel resolution and distance between the monitor and the user to get the best data from any image. As explained in the opposite diagram, a user needs to be closer than the stated distances to be able to confidently perceive all parts of the monitor screen.

As mentioned using an optimum screen size of 30" will reduce the need for image scaling, which could then lead to inaccurate images and unwanted imaging artefacts. However, if the monitor resolution is not increased in relation to the screen size, this can lead to a loss in image smoothness, and sharpness, therefore leading to the possibility of misdiagnosis.

Monitor brightness

A monitor with a luminance of 350cd/m^2 will be better suited to normally lit rooms that have a large amount of ambient light.

Monitor brightness, or luminance, is a measurement of the amount of light the LCD monitor produces.

These values are usually measured in candelas per metre squared (cd/m^2) (one candela is the luminous intensity, in one direction, roughly equivalent to that of one candle).

A JND is a **'Just Noticeable Difference'** which is the smallest amount of change in colour and brightness that an average human eye can perceive. The higher a monitor's brightness is set, the greater the number of JND's are visible. JND's are important, as the more JND's a monitor can show, the more likely a small difference will be seen within an image by a consultant.

Example: If a monitor is capable of producing a calibrated brightness of 250 cd/m^2, its brightest white is only a level of grey (half) on the way up to the brightest white on a monitor capable of producing a maximum calibrated brightness of 500 cd/m^2.

It is recommended the brightness of a monitor for Pathology diagnostics be at least 300cd/m2 in line with the paper "Pathologists light level preferences using the microscope - study to guide digital pathology display use", as this roughly matches the perception through a traditional microscope. To be able to stay at a consistent level, it is recommended the monitor is able to produce a much higher brightness (eg 1000 cd/m^2 typical) to allow for natural brightness degradation over time and future proofing for possible industry standard adoption.

Ambient light within a room also has an effect on both image quality and JND's of a monitor. Therefore, a monitor with a higher brightness than 300cd/m^2 could be better suited to normally lit rooms that have a large amount of ambient light.

Monitor contrast

Dynamic Contrast Ratio (eg 15,000,000:1) is usually used for domestic LCD televisions whilst Static Contrast Ratio (eg 1500:1) is usually used for medical grade monitors.

The contrast of a monitor is the relationship between the darkest blacks and the brightest whites which the monitor can produce. For example, a contrast ratio of 1000:1 means that the brightness of a completely white image is 1000 times greater than the brightness of a completely black image. Contrast is important to allow the Pathologist to see the detail in the image such as cell walls and interfaces.

LCD panels, by nature, will have a small amount of light leakage so there can be differences between monitors regarding how black the darkest blacks are. Monitor brightness alone, therefore, does not tell the whole story.

There are two main ways of measuring contrast ratio - these are Static Contrast Ratio and Dynamic Contrast Ratio.

Static Contrast is the ratio of white to black on an LCD monitor without any adjustment to the backlight (brightness).

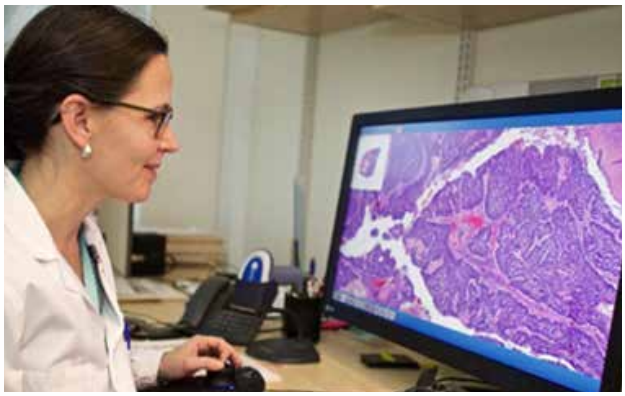
Dynamic Contrast is measured by turning the backlights all the way up then measuring the white levels, then turning them all the way down and measuring the black. Most LCD monitors cannot show an image with the backlights all the way up and simultaneously all the way down at any one time, monitors that can will often display halo artifacts as a result.

Dynamic Contrast Ratio (eg 15,000,000:1) is usually used for domestic LCD televisions whilst Static Contrast Ratio (eg 1500:1) is usually used for medical grade monitors. The measurement of Static Contrast ratio gives a much more reliable indication of achievable contrast within a single image.

It is recommended the contrast ratio of a monitor for Pathological diagnostics be at least 1500:1 (Static Contrast Ratio) to ensure a good level of difference between the darkest and lightest aspects of brightness produced by the monitor, and to allow for uniformity correction.

A brighter environment can reduce the real luminance ratio (ratio between real world black and white) due to reflected light swamping the darker tones. It is recommended that ambient light falling on the front of the monitor is kept to a minimum, if darker areas of the image are important.

Monitor uniformity



It is important that fluctuations and inconsistencies are levelled out to produce a uniform image across the viewing panel so the user is seeing the same image no matter where it is on the monitor.

Uniformity relates to the **consistency of brightness and colour** across the entire LCD panel. It is important that fluctuations and inconsistencies are levelled out to produce a uniform image across the viewing panel so the user is seeing the same image no matter where it is on the monitor. Some medical monitors have an integrated function that helps to even out these fluctuations for example the EIZO Digital Uniformity Equaliser.

Inaccurate uniformity can result in an image looking different depending on where it is on the monitor. This means Consultants may need to move the image around the screen of the monitor to get the best information from it, reducing efficiency and increasing the chances of misdiagnosis.

Most monitors do not have any form of digital uniformity correction. Standard monitors used in an 'office' environment are typically not uniform and have patches or halos depending on the monitor design.

Whilst this is not a significant consideration for text based back-office work, **uniformity is essential for critical image analysis** and so it is important to ensure the right monitor is used.

Without DUE

With DUE

Refresh rate

The EIZO team currently recommends a refresh rate of 60Hz is used for all medical grade monitors.

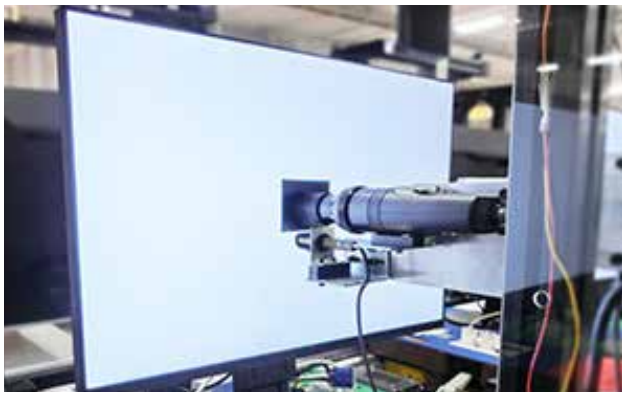
The refresh rate of a monitor refers to how many times per second the display is able to draw a new image and this is measured in Hertz (Hz).

Example: **a 60Hz monitor will refresh sixty times per second. A higher refresh rate than 60Hz is usually more advisable for continuously moving images (such as video gaming) as it will result in smoother motion.**

Most WSI devices typically capture a single image plane of a physical slide in a very high resolution. Some scanners also have the capability of capturing a number of images in different focal planes and putting them together to produce a "Z-stack" of images across the entire slide. Panning around the image and moving between different images in the Z-stack can benefit from a faster pixel response and refresh rate, however, once the image is static and being viewed by the consultant, refresh rate and pixel response times no longer play a part in image quality.

The EIZO team have found a refresh rate of 60Hz is suitable for digital pathology reporting.

Calibration & QA



You calibrate a microscope, so why wouldn't you calibrate a monitor?

Medical devices should undergo appropriate quality control and calibration before leaving the factory and ongoing quality assurance (QA) thereafter. **Performing regular performance and health checks on a monitor** ensures the pathological diagnoses are consistent and reliable, giving the user trust in the information provided and reducing the chances of misdiagnosis and litigation. Calibration also allows any new standards to be added to the monitor/QA regime as and when they are published.

There are two types of calibration; hardware, and software. With hardware calibration, the monitor's calibration characteristics are adjusted inside the monitor itself, providing a more accurate calibration. Software calibration uses look-up tables that are applied within the computer driving the monitor. This means the monitor must always be used with the specific computer, otherwise the settings will be lost, and accuracy may also be lost due to the limitations of your system's graphics capabilities.

The brightness and performance of any monitor will naturally degrade over time through both general and intense use. It is important the brightness and gamma curve of a monitor is kept at a consistent level – regular QA testing and calibration (when required) will ensure the digital image is kept to the highest standard and will also provide indications on when a monitor may be coming to the end of its life.

The act of calibration returns aspects of the monitor back to factory, or pre-designated, settings. Calibration to advised industry benchmarks can also be performed to ensure the image being seen across multiple locations is identical.

Ideally a proper colour workflow should be used within the digital pathology process, similar to those used in digital imaging for creative industries (e.g. photography, pre-press, moving image production).

With a non-hardware calibrated monitor there is the potential that after the first 6 months, the brightness can be greatly reduced compared to its starting brightness, and the value specified by the manufacturer. This can mean a **monitor that was within a certain specification can sometimes fall outside of that specification within a few months**, rendering it useless for diagnostic work. If monitors without internal self QA are used, regular manual measurements should be carried out to ensure the monitors remain within the required specification. The time and cost of manual measurement usually outweighs the cost of in-built calibration long before the full lifetime of the monitor is realised.

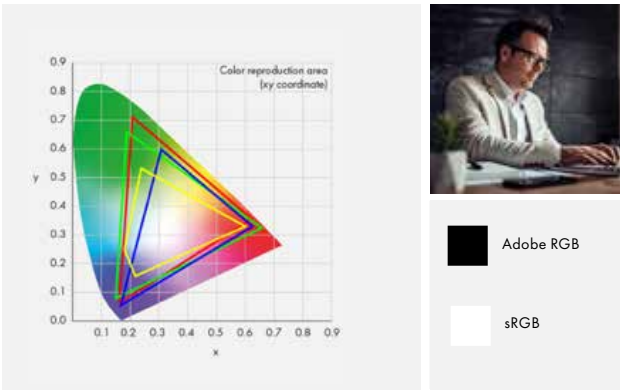
However, a hardware calibrated display is designed to keep the brightness and gamma curve consistent and stable across the whole life cycle of the monitor.

Colour

Due to the nature of Pathologists work, it is important all monitors are accurate to specified colour standards.

Whilst imaging standards for the reproduction of colour are still in development for digital pathology, it is important that alterations to colour are controlled and minimised throughout the entire digital pathology process. **It is also important all monitors are accurate to specified colour standards** (e.g. sRGB) and can be calibrated, sometimes taking into account differing lighting conditions. This can be conveniently achieved by self-calibrating monitors. Colour deviations can be corrected at the point of origin (WSI scanner) through the use of software profiles (e.g. ICC – International Color Consortium – Profiles). A truly managed colour workflow is essential if an open system is going to be used to share images between NHS Trusts, doctor's offices and home working environments. Additionally, this provides consistency, no matter when or where pathology images are viewed.

The numerical values are different because the Adobe RGB colour space (the numbers of colours you can see) is larger than the sRGB colour space. For example, a tone of purple often used in pathology images, could have RGB (Red, Green, Blue) values of 79, 51, 111 in sRGB however, these numbers would be 74, 54, 109 if working in AdobeRGB, while still representing the same colour shade.



The primary gamuts used for image capture and reproduction are sRGB, Adobe RGB, BT.2020 and DCI P3. In most cases, products like LCD monitors, printers, digital cameras and various applications are configured to reproduce the sRGB colour gamut as accurately as possible. In the event of two pieces of equipment using differing colour gamuts (e.g. a WSI scanner and LCD monitor), the shades of colour will differ. The photo below has been converted from Adobe RGB to sRGB where you can clearly see the difference in tone of some of the colours within the picture, such as the green of the trees and the colours of the water in the lake.

sRGB

Adobe RGB

Longevity & consistency

Medical grade monitors have been designed and produced to be used intensively for long periods of time, as opposed to other domestic and commercial grade monitors. As a result, alongside the ability to consistently perform to a high standard, the replacement of monitors can coincide with the replacement of other digital pathology equipment, such as the WSI scanner, for example. Non-medical grade monitors are more likely to need to be replaced a number of times within the equivalent lifespan of a medical grade monitor, thus saving on economic resources and physical waste over a longer term.

Additionally, having a higher brightness than necessary means it will easily be able to conform to any standards, for example if a brightness of 500cd/m2 was required.

Industry leading warranty

All EIZO RadiForce monitors come with a industry leading, five-year, double swap, next business day, onsite warranty.

The RadiForce RX range of monitors come with a 7-year warranty, covered from the point of dispatch by EIZO Limited , for a period of either 7 years or 20,000 hours of usage, whichever occurs first.

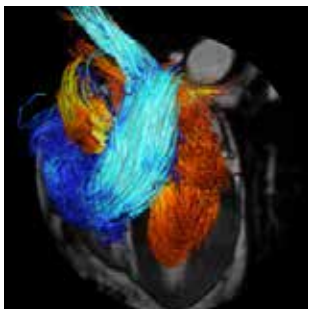
Management software

Some medical grade monitors have specific software available to manage elements such as quality assurance testing, monitor health status reporting, calibration, and the ability to configure to international and local compliancy tests. This will ensure compliance with expected performance standards and the overall longevity of the monitor.

Another consideration is the type of management software, Cloud-based solutions allow all of the gathered information to be pulled together in a central location for easy reporting and trouble shooting.

The ability to push calibration targets, setting updates, software and firmware upgrades remotely provides a simple solution to implement any future standards, when they come in to force. Making the process seamless for all end users and ensuring the monitors are working to current standards at all times.

Third party software can be available for non-medical grade monitors, usually at an extra cost or subscription, and usually do not cover all of the above functions.



Summary

Resolution
The higher the monitor's resolution, the greater the levels of detail will be visible. Images are smoother, with sharper edges and can also display more content at one time.

Screen size
At a normal desk working position it is recommended to use monitors between the size of 27" and 32" for digital pathology images to fill a human's natural field of vision.

Brightness
It is recommended the brightness of a monitor for pathological diagnostics be at least 300 cd/m^2, as this roughly matches the perception through a traditional microscope. To be able to stay at a consistent level, it is recommended the monitor is able to produce a much higher brightness (eg 1000 cd/m^2 typical) to allow for natural brightness degradation over time and future proofing for possible industry standard adoption.

Contrast
It is recommended the contrast ratio of a monitor for pathological diagnostics be at least 1500:1 (Static Contrast Ratio) to ensure a good level of difference between the darkest and lightest aspects of brightness produced by the monitor.

Uniformity
Inaccurate uniformity can result in an image looking different depending on where it is on the monitor. This could mean consultants may need to move the image around the monitor to get the best information from it, reducing efficiency and increasing the chances of misdiagnosis.

Refresh
The EIZO team currently recommend a refresh rate of 60Hz is used for all medical grade monitors.

Calibration and QA
Performing regular performance and health checks on a monitor ensures the pathological diagnoses are consistent and reliable, giving the user trust in the information being provided and reducing the chances of misdiagnoses. Calibration also allows any new standards to be added to the monitor/QA regime if and when they are published.

Colour
A truly managed colour workflow is essential if an open system is going to be used to share images between NHS Trusts, doctor's offices and home working environments.

Longevity & consistency
Medical grade monitors have been designed and produced to be used intensively for long periods of time, as opposed to other domestic and commercial grade monitors.

All EIZO monitors come with a industry leading, five-year, double swap, next business day, onsite warranty. The RadiForce RX range of products come with a 7-year warranty, covered from the point of dispatch by EIZO Limited , for a period of either 7 years or 20,000 hours of usage, whichever occurs first..

Management software
Some medical grade monitors have specific software available free of charge to be able to manage elements such as Quality Assurance testing, monitor health status reporting, calibration, and the ability to configure to international and local compliancy tests. This will ensure compliance with expected performance standards and the overall longevity of the monitor. Additionally, the ability to upgrade software and firmware remotely provides a simple solution to implement any future standards, when they come in to force.

Industry use cases

EIZO Pathology success stories

EIZO Limited has already installed its medical grade monitors in a number of UK based Pathology Departments. Including:

- Oxford University Hospitals
- Royal Wolverhampton
- Calderdale & Huddersfield
- Glasgow
- Lancashire
- Royal Devon & Exeter
- Plymouth University Hospitals
- North Bristol NHS

And with many more in the pipeline...

For more information

product demo's or a chat to discuss your Pathology needs please call **01344 317480** or email **ukhealthcarevisuals@eizo.com**

EIZO Limited's commitment to sustainability

EIZO in the UK also works towards independent sustainability goals with our own initiatives that align to our global strategy.

Energy efficiency

The UK HQ is a new building designed to meet EIZO's needs for growth, ergonomics and sustainability. The office is equipped with LED lighting activated by motion sensors on all floors and every desk is fitted with EIZO FlexScan monitors to help to reduce energy consumption.

Waste and recycling

EIZO UK recycles and up cycles as much as possible, including donating unwanted office furniture to a local hospital and laptops and monitors to a local school. Zero waste from the UK HQ goes to landfill, with all office paper and printer cartridges recycled. At least 90% of tradeshow stands are reusable.

CSR-A Accreditation

EIZO UK's environmental impact has been audited as a part of its Silver CSR-A Accreditation which demonstrates independent validation of environmental, social and governance (ESG) compliant actions and policy.

Supply chain improvements

The UK business has committed to removing air freight from its supply chain. This is possible thanks to EIZO's resilient supply chain, production from Japan and proactive planning from operations and planning experts.

A UK-based repair centre

EIZO has a local repair centre at its UK HQ in Ascot, England to support all warranty requirements in the UK. In addition to providing excellent customer service, this minimises the environmental impact of transportation. We also stock spare parts for product repairs to keep the carbon footprint as low as possible.

EIZO

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