

DIGITAL QUALITY ASSURANCE IN PRACTICE

The National Radiological Protection Board's *Guidance Notes for Dental Practitioners on the Safe Use of X-Ray Equipment* document states that essential procedures tested within a quality assurance (QA) programme should include:

- Image quality;
- Patient doses and x-ray equipment;
- Darkroom, films and processing;
- Training;
- Audits.

Approximately 25% of practices are now using digital radiography systems

- QA tests, involving film and film processing, are becoming redundant and need replacing with tests more relevant to digital detectors.

The Institute of Physics and Engineering in Medicine (IPEM) have produced a document suggesting the tests that should be carried out for dental radiography and image display devices

Types of image receptor

- Photostimulable phosphor plates (PSPs) and
- Solid-state detectors (SSDs),

Photostimulable phosphor plates (PSPs)

PSPs are composed of a polyester base with a phosphor layer (europium activated barium fluorohalide) on one side. After the PSP is exposed it is scanned in a reader before the image is displayed on a monitor. The phosphor layer is relatively delicate and any damage to it can degrade the image significantly.

Solid-state detectors (SSDs)

SSDs contain solid state materials such as amorphous silicon or amorphous selenium in their construction

The detectors contain either a charge coupled device (CCD) or complementary metal oxide semiconductor (CMOS). The intra-oral systems generally have a flexible cable connecting the detector directly to the PC, although wireless systems are available.

Quality assurance tests

The Institute of Physics and Engineering in Medicine (IPEM) has divided the quality assurance tests into two categories, according to the level of expertise required to undertake them:

- Level A - these tests are quick and do not require complicated test equipment or analysis. Dentists who undertake these should be suitably trained. The equipment for level A tests should be readily available in the dental practice setting.
- Level B - these are specialist tests, normally carried out by Medical Physics staff.
 - Priority 1. These tests are the recommended minimum standard, and should be regarded as good practice.
 - Priority 2. These tests are regarded as best practice. However, the frequency with which these tests can be carried out is influenced by many factors, including workload and cost.

Frequency of testing

- The tests are undertaken at different time intervals. The recommended frequency for each test is given as a range, eg 1-3 months. This is related to the clinical workload. Thus, the higher the radiographic workload, the shorter the frequency between testing.

Responsibility for quality assurance testing

- The Ionizing Radiations Regulations 1999 (IRR99) stipulate that overall responsibility for quality assurance testing falls upon the employer.⁹ The radiation protection supervisor (RPS) is a suitably trained member of staff appointed by the employer who helps to ensure compliance with IRR and the local rules
- The QA tests should be carried out by suitably trained members of staff and it is essential that formal records of all the tests are maintained and checked
- A Medical Physics Expert (MPE) is a state registered clinical scientist with corporate membership of the IPEM The Institute of Physics and Engineering in Medicine who will give advice on a number of matters including equipment QA.

Condition of the Image Receptor

Photostimulable phosphor plates (PSPs)

- Each PSP ideally should have a marker on it so it can be identified if there are faults
- PSPs should be stored in a dust-free environment.
- PSPs should be visually checked for scratches and dust particles.

- The IPEM recommend the condition of the PSPs is checked monthly
- the receiving tray (if applicable) of the PSP reader should be wiped and cleaned on a daily basis.
- On a monthly basis (or earlier if visible scratches are seen on the surface of the PSP), the PSP should be exposed to see if there are significant scratches.

The PSP should be placed on a flat surface, at a set distance from the end of the spacer cone, and given a short exposure. The PSP should be read and then graded

Example:

- Category 1: No scratches or a small number that do not interfere with the diagnostic use of the image.
- Category 2: Scratches and marks that would render the image non-diagnosti

PSPs falling into Category 2 should be removed from circulation and disposed of appropriately.

Solid state detectors CCD or CMOS

- The casing should be inspected on a monthly basis for cracks/damage. The cable should also be inspected for damage

- If there is any damage to the casing, the SSD should be exposed in the same way as described for the PSPs to ensure that there is no damage to the enclosed detector. If damaged, the SSD should be taken out of clinical use. In many cases, damage to the underlying detector or the cable will require the purchase of a new SSD.

Image quality

- On a monthly basis, images (produced using either a PSP or a SSD) should be compared with a good quality reference image. If there is a visual deterioration in image quality, corrective action should be taken.

Image uniformity for intra-oral radiographs

- should be performed on a 1-3 monthly basis.
- the image receptor is placed at a fixed distance from the spacer cone and exposed to a short exposure.
- The image is inspected for areas of non-uniformity (lines or rectangular areas) and other artefacts (such as scratches in the case of PSPs). Any lines or rectangles seen on the image should be investigated.
- If there are gross areas of non-uniformity, the image receptor should not be used until the issue is resolved

Panoramic radiography –

Reproducibility and beam alignment and synchronization of the exposure with tube

These two tests are carried out together and are necessary to ensure that there are no regions of non-uniformity or artefacts on the image, to check that the panoramic exposure is entirely within the area of the image receptor and that there is no disruption in the motion of the mechanical components.

- 1 mm thick strip of copper approximately 2 cm wide-- This acts as a filter to attenuate the x-ray beam.
- The test is performed with the image receptor in the carriage on the unit and should be carried out after installation of the unit.

This result acts as the reference image to which subsequent tests can be compared.

Reproducibility and Uniformity

- The 'density' of the image should be compared with that of the reference image. There should be no areas of non-uniformity.

- the higher density band in the midline of the image is due to a programmed increase in exposure, which is required to penetrate the cervical spine
- the 1 mm copper strip is taped over the beam collimator
- A panoramic exposure is carried out using a standard adult programme and the subsequent image examined.
- The image should be visually checked to confirm that the radiation field is contained within the edges of the image receptor, with no overlap.

There should be no signs of additional vertical banding which would suggest a fault in the unit's rotational motion

- tests should be archived electronically for future reference.
- Routine testing images should be archived if significant artefacts are observed.
- These test images should be kept for Medical Physics staff

Image display

The Royal College of Radiologists provide guidance on the specification of image display devices

- The images being displayed are for diagnostic purposes and therefore the screen resolution needs to be at least 1280 x 1024 (~1.3 megapixels).
- The maximum luminance (the amount of light produced from the display device) should be at least 170 cd/m²

(The candela per square metre is the derived SI unit of luminance) and the luminance contrast ratio (ratio between the higher luminance, L_H , and the lower luminance, L_L) should be at least 250:1
- Discuss with Medical Physics expert before purchase as this would be useful to ensure appropriate equipment is ordered and is fit for purpose.

Tests recommended by the IPEM

- Image display monitor condition;
- Greyscale;
- Distance and angle calibration;
- Image monitor resolution.

Image display monitor condition

- The monitor should be kept clean using appropriate cleaning materials

- Test patterns that can be used to check monitor condition.
- Society of Motion Pictures and Television Engineers known as SMPTE
- Technical Group 18 QC known as TG18-QC

These images should be viewed full-screen for all tests.

- Whichever test pattern is used, the 5% detail superimposed on the 0% square and the 95% detail superimposed on the 100% square should be visible (Figure 9). If they are not visible, the monitor settings should be adjusted until they become visible.

Greyscale

- A photometer is suggested to measure the luminance within the 100% (white) and the 0% (black) squares (Figure 10). If the ratio of white:black is below 250 it should be investigated
- It may be appropriate, if possible, to include this test within the service level agreement within the local medical physics service.

Distance and angle calibration

Distance calibration

- could be carried out using a metal ruler with the measurement scale etched on the surface. The metal ruler is

placed on the detector and exposed using exposure factors that allow the scale on the ruler to be visualized

- The dental digital software distance measuring tool is then used to measure a known distance, as large as possible on the ruler.
- A second exposure with the ruler placed at 90° to the original position should also be carried out and measurements made.
- Measurements have now been carried out both in the horizontal and vertical planes.
- The IPEM suggest changes more than ± 5 mm need investigation.

Angle measurement

If the same ruler has been cut at a right angle- at the end .

- A radiograph of the end of the ruler is acquired and the angle at the end of the ruler measured using the angle measurement tool in the software. The IPEM suggest any changes that vary by more than $\pm 3^\circ$ need investigation.

Image monitor resolution

- The high and low contrast resolution patterns on the Test (SMPTE or TGIS-QC) patterns should be examined, making

sure that resolution at the centre and periphery is similar to that of the baseline image .All the patterns should be resolvable.

Low contrast sensitivity; and limiting spatial resolution

Testing is suggested for direct digital radiography systems (SSD systems) and computed radiography systems (PSP systems).

These are designated level A tests which should be carried out every 4-6 months. One test object, or phantom, called the Tor Den Digital produced by Leeds Test Objects is designed for use on intra-oral, panoramic and cephalometric units

- It contains a lead test pattern for measuring both the spatial resolution (using groups of lead lines separated by air gaps of different frequencies) and the low contrast resolution

For intra-oral radiography

- The phantom containing the image receptor (PSP or SSD) is placed over the open end of the spacer cone and an exposure is made. The image is viewed and the highest frequency of lead lines and air gaps is recorded
- This measures the spatial resolution and the manufacturer suggests this should be at least 5 line pairs per millimetre. The result measured at baseline should be referred to during

routine testing and any significant changes would necessitate remedial action.

The same tests can also be carried out on panoramic and cephalometric units and require the use of a tripod to hold the phantom in the required position

- positioning of the test object in the focal plane is very important.

SOURCE

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