Performance testing for Precision 500D Classical R/F System

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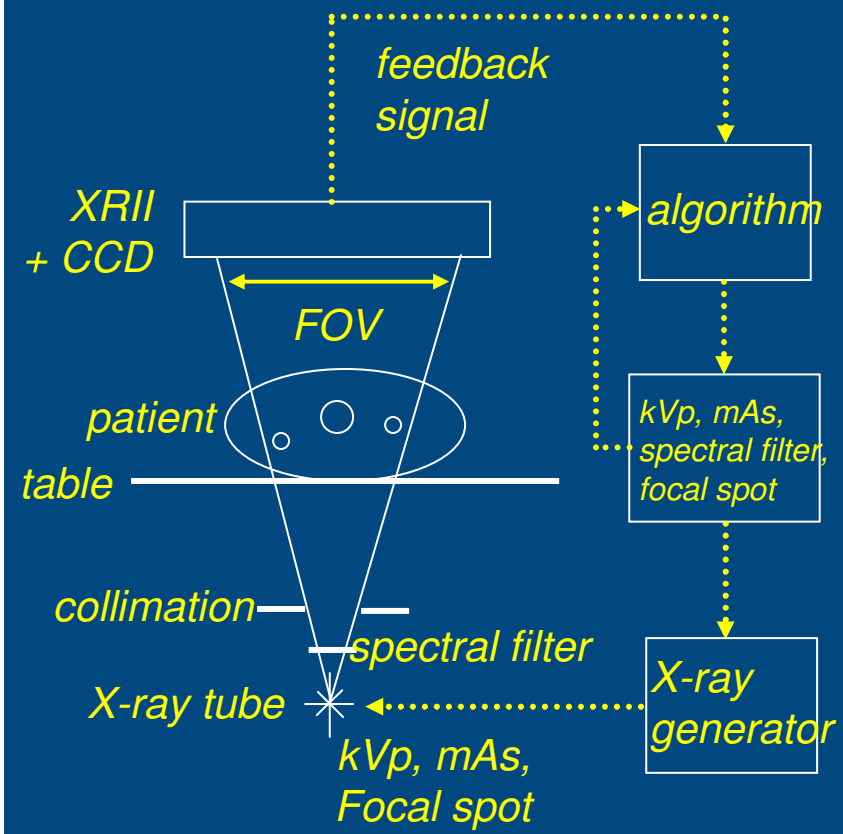
Outline

- *System background*
- *Image Quality Signature Test (IQST) tool*
- *Evaluation/debug for sites with image quality complaints*
- *Dose considerations*
- *Conclusion*
- *Appendix of tables related to system performance testing*

Precision 500D

- *Classical R/F System*
- *Focus on fluoro/digital spot*
  1. *Overtable imager*
  2. *Undertable tube*
- *Overtable imager*
  1. *X-ray Image Intensifer (XRII)*
  2. *Optics assembly (lens + iris)*
  3. *CCD camera*

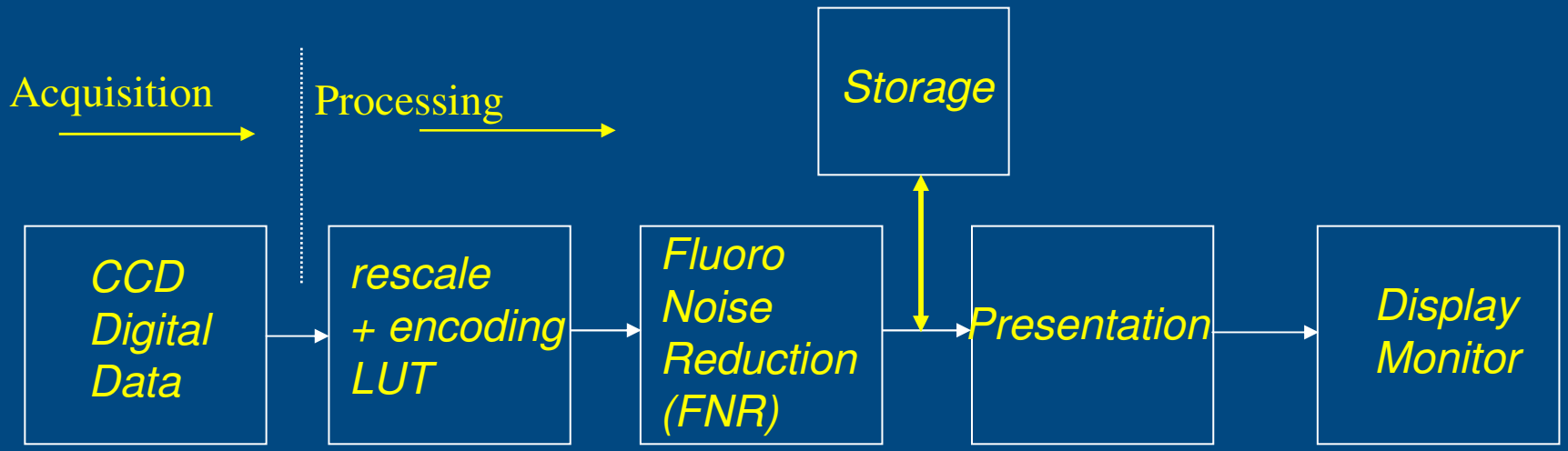
Completely Automated X-Ray Technique Selection



- *Algorithm*
  1. *Patient thickness calculation*
  2. *Technique mapping for thickness and selected contrast agent*
  3. *Technique mapping based upon:*
     - *-imaging metric (e.g., CNR, contrast)*
     - *-patient skin dose*
     - *-regulatory tube and generator limitations*
     - *-customer feedback*
- *Feedback Signal*
  1. *Average signal over a region of interest (ROI)*
  2. *Compensation for raw beam/collimated areas*
- *User controls (via a protocol editor)*
  1. *Contrast agent (5 total)*
  2. *ROI size and position*
- *All techniques (including spectral flitration) for fluoro are determined and continually updated*
- *Same for spot execpt exposure time (AEC)*

Skill of clinician (positioning, collimation, SID) still very important

Image Processing



- *User controls:*
  1. *FNR level*
  2. *Edge enhance level*
  3. *Window/level values*
  4. *Inversion*
  5. *Image "look" (for spot/fluoro and DSA)*

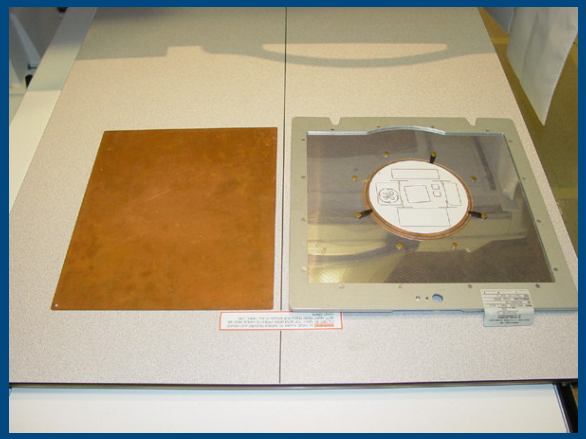
Default settings available for all user controls

- *Fluoro only*
- *Includes motion compensation*

- *edge enhance*
- *window/level*
- *inversion*
- *user "look" LUT*
- *DSA functions*
  1. *Subtraction*
  2. *Landmark*
  3. *roadmapping*
- *monitor LUT (Barten correction)*

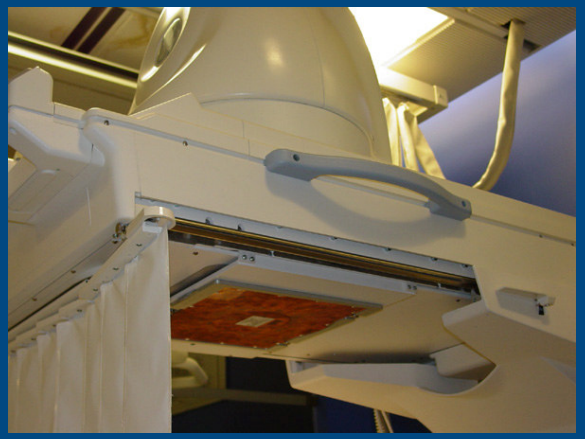
Image Quality Signature Test (IQST)

Precision 500 D System



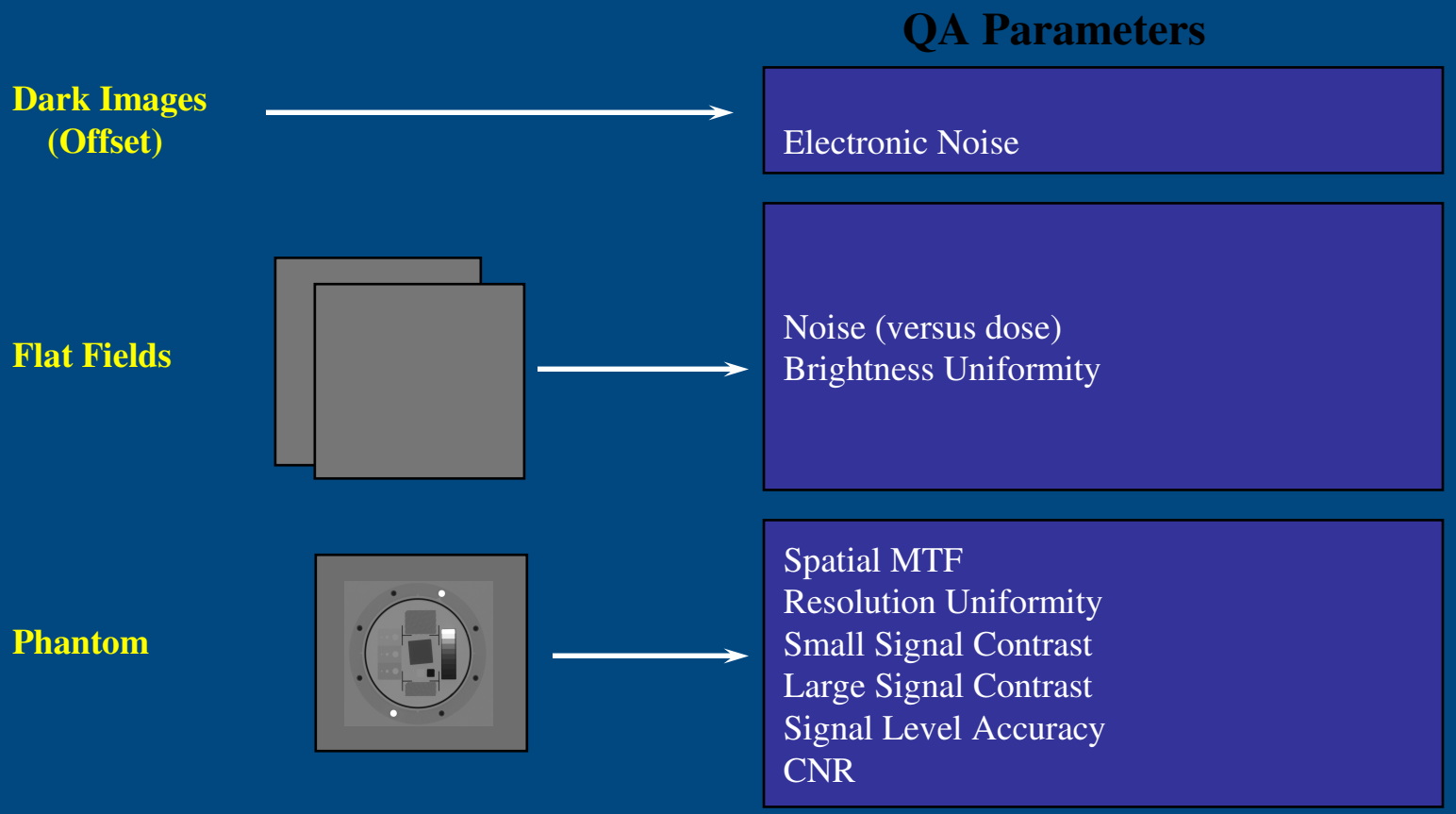
Phantoms

- *Copper sheet (placed on table)*
- *Composite (mounted)*

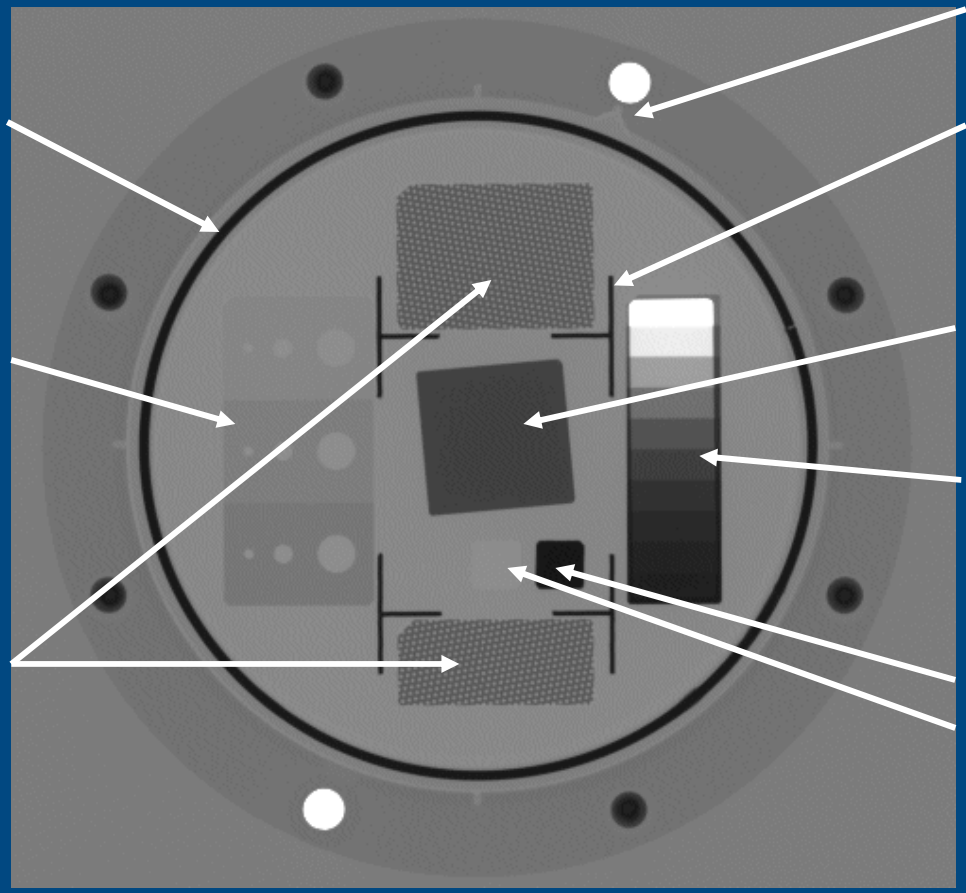


Mounted composite phantom

Measures and QA Parameters



Quality Assurance Phantom



Position Tab

Lead Ring (phantom detection)

Lead Fiducial Markers (feature location)

Aluminum Steps w/ Holes (contrast, CNR)

Tungsten Coupon (MTF)

Copper Steps (level accuracy)

Steel Mesh Coupons (resolution non-uniformity)

Lead Slug & Through Hole (large signal contrast)

IQST - Other Points

- *Data is analyzed post CCD (tests primarily XRII, optics, and CCD)*
- *Frequency of use is up to the user (monthly is o.k.)*
- *GE service CD required for display of numerical values for individual test results (otherwise, gives a global PASS/FAIL)*
- *Recommend trending data*

Evaluation/debug for sites with image quality complaints

Three Step Process

1. *Definition of imaging issue*
   -issue with images acquired in the room or with PACs image or printed film

2. *Verify the system is operating to design*
   -processing parameter check
   -protocol check
   -calibration check

3. *Adjust processing (if necessary)*

Processing Parameter Check

Procedure

1. Check processing parameters
   - -user preferences screen
   - -via service interface, config -> digital -> setup

Test

1. Compare fluoro and spot techniques with expected values (listed at end of talk)

1. Investigate any values which significantly vary from default
   - -e.g., W/L values more than 50 counts away. Other values more than 2 settings away

Protocol Check

Procedure

1. *Enter protocol editor*
2. *For each protocol, investigate:*
    a. *contrast agent selection*
    b. *ROI selection for 'digital' steps of protocols*

Test

1. *ROI should be either the large, centered square or the large, centered rectangel*
2. *Contrast agent should be relevant for the protocol, e.g.*
    Barium --> most penetration --> higher kVps
    Ba/Air --> less penetration --> lower kVps

Calibration check - monitor check

Procedure

1. Perform 'Monitor LUT' calibration

What this does

1. Verifies luminance for white and black levels are set correctly so that the monitor is calibrated
   - -jnd versus DDL is linear
   - -contrast ratio is 'fixed' (white ~ 375 Cd/m^2; black ~ 0.8 to 1.2 Cd/m^2)

Calibration check - "load" test

Setup

1. Put 15 cm stack of lucite on table (area should be >= 25 x 25 cm^2)
2. MAG = 0
3. Grid = 'in'
4. Contrast Agent = Ba/Air
5. SID = min
6. Open collimator blades to full FOV
7. Center lucite stack

Test

1. Compare fluoro and spot techniques with expected values

In case of failure, redo:

1. Iris Calibration
2. Fluoro CF Calibration
3. Record CF Calibration
4. mR/mAs calibration

Procedure

1. Apply continuous fluoro until techniques settle (1 to 2 s)
2. Note down fluoro techniques (kVp, mA, spectral filter)
3. Take 1 fps spot exposures and record actual techniques of last image

Calibration check - limiting resolution test

Suggested Setup

1. Tape resolution wedge to the input of the XRII at a 45 degree angle to the table axis
2. Grid = 'in'
3. SID = min
4. Open collimator blades to full FOV
5. Set FNR = 3, Edge = 1 or 0

Procedure

1. For a given MAG, apply fluoro
2. Verify limiting line pairs are near the center of the field
3. While applying fluoro, record limiting resolution perceived
4. Repeat for each MAG

Test

1. Compare limiting resolution values with expected values

In case of failure, redo:

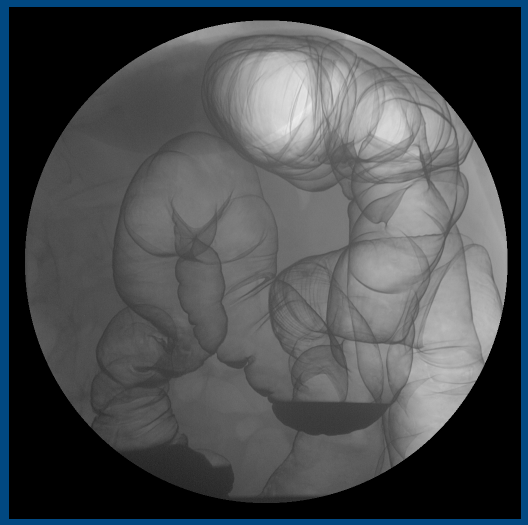
1. Camera focus calibration
2. II Sizing and focus calibration

Processing Adjust - Image "Appearance"

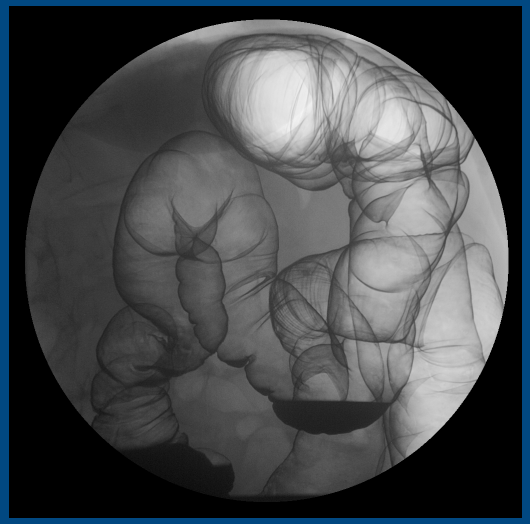
- *Five settings are available*
- *Most common adjustment; usually done in conjunction with edge enhance*
- *Not designed in isolation (based upon customer feedback and x-ray technique selection)*
- *Each trades off various parameters*
  - *-contrast at nominal dose,*
  - *-detail in higher dose regions of the image (near skin line, for example)*
  - *-noise*
  - *-blackness of contrast agent*
- *In addition, for each image appearance, one can double the anatomic over-range by setting the dynamic range parameter to 'extended' (not common)*

Image Appearance Examples

"detail plus"

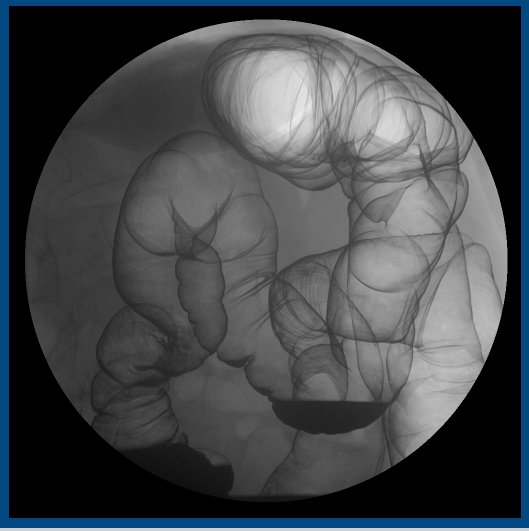


default ("contrast detail")



"contrast"

"detail"



"contrast plus"

Edge enhancement - examples

smoothed

Smoother edges (less noise)

enhanced

Crisper edges (more noise)

Dose considerations

- *Compared to previous GE system (Legacy), Precision 500 D offers two features for dose reduction:*
  - *-use of spectral filtration (to filter out low energies)*
  - *-pulsed fluoro*
  - *-improved FNR*
  - *-inclusion of spectral filter in automated technique design*

- *The user can reduce dose rate by:*
  - *-working at lower magnifications and collimating (rather than mag up)*
  - *-using pulsed fluoro (7.5 fps (40 to 50%), 3.75 fps (60 to70%))*
    - *(NOTE: 15 fps is more designed for image quality (motion stopping relative to continuous) and gives only small (5 to 15%) dose reduction*
  - *-grid removal typically gives ~50% more*
    - *(recommended for newborns/toddlers)*
  - *-keeping fluoro time to a minimum*

- *No "high, medium, and low" selections (as with previous Legacy system)*

Dose considerations

- *For quality control and general performance evaluation, measure dose in applications mode (figure below)*

- *Vary as desired system variables (MAG, collimation, contrast agent, lucite thickness, grid position) and measure dose, kVp, mA, ….*

Summary

- *Precision 500D is a highly integrated and automated system*
- *Correct calibration is important to ensure the system operates to design*
  -can monitor via load test, limiting resolution test, and monitor calibration
- *In addition, the performance of the XRII can be evaluated via the IQST tool supplied with the system*
- *Adjustment to image quality is primarily achieved via processing parameters*
  -image appearance, window/level, edge setting, and FNR

Appendix

Specified Values for "Load" Test. Where applicable, typical values are in parentheses.

II Size (cm)	Mode	kVp	mA	spectral filter (mm)	ms	mAs
40	fluoro	74 +/- 3	no spec. (1)	0.3	---	---
40	spot	74 +/- 3	no spec. (45)	0.2	10 to 20 (13)	0.1 to 1.4 (0.6)
32	fluoro	74 +/- 3	no spec. (0.8)	0.3	---	---
32	spot	74 +/- 3	no spec. (50)	0.2	10 to 20 (12)	0.1 to 1.4 (0.5)

Typical Limiting Resolution Values (lp/mm)

II Size (cm)	MAG	limiting res. (lp/mm)
40	0	1.2 to 1.5
40	1	1.6 to 2.0
40	2	2.0 to 2.5
40	3	2.5 to 3.0
32	0	1.6 to 2.0
32	1	2.0 to 2.5
32	2	2.5 to 3.0
32	3	3.0 to 3.5

Appendix

Default Processing Parameters

Parameter	Value
Fluoro Window/Level	512/512
Spot Window/Level	512/512
Fluoro Edge	1
Spot Edge	1
Image Appearance	Contrast Detail
Dynamic Range	Normal
DSA Contrast	Normal
DSA Window/Level[1]	256/512
FNR - 30 fps	3
FNR - 15 fps	1
FNR - 7.5 fps	1
FNR - 3.75 fps	0

[1] For systems without a DSA Contrast setting, it is recommended to set the default window/level to: 120/532.

The chart below summarizes the impact to the image of the different image appearance settings. *Note all descriptors are relative to the default 'contrast detail' image appearance setting.*

Look	Blackness of Contrast Agent	Contrast at nominal dose	Detail in the higher dose regions	Noise
Detail Plus	Less	Less+	More	Less+
Detail	Same	Less	More	Less
Contrast	Same	More	Less	More
Contrast Plus	More	More+	Less+	More+

"Physics" or Manual Mode

- *Many tests/protocols carried out by physicists require manual control of x-ray techniques (kVp, mA, etc.)*
- *Currently, the Precision 500D does not offer such a mode*
- *However, for a few calibration units, one can control various technique factors. These are listed on the following page.*

Calibration units with manual techniques

1. Step 1 of Iris calibration
   (30 fps fluoro, 70 kVp, no spectral filter, manual mA control)
2. Step 2 of II Sizing & Focus calibration
   (30 fps fluoro, 60 kVp, 0.3 mm Cu filter, manual mA control)
3. mR/mAs cal (fixed techniques)
   Step 2: 75 kV, 50 mA, 100 msec, SF = 0
   Step 3: 75 kV, 50 mA, 100 msec, SF = 0.1
   Step 4: 75 kV, 50 mA, 100 msec, SF = 0.2
   Step 5: 75 kV, 50 mA, 100 msec, SF = 0.3
4. Fluoro CF (fixed techniques)
   Step 2 and 3: 75 kV, 0.0133 mAs, SF = 0
5. Record CF (fixed techniques)
   Step 2 and 3: 75 kV, 0.3 mAs, pw = 10, SF = 0