Practical Aspects of ACR PET Accreditation

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Objectives

- ACR PET Phantom
- Activation of ACR Phantom
- Image acquisition and processing

Accreditation Program Objective

To provide a solid foundation for continuous quality improvement through a peer review and education process for clinical facilities committed to image quality

Quality Patient Care

Accreditation Attests to a Site's High Standard of Clinical Practice

- Personnel: physicians, technologists, physicists
- Policies and procedures
- Scanning equipment

ACR Accreditation

PET Physicist Qualifications

- Board Certification (recommended):
  Nuclear Medicine Physics or Radiologic Physics
- Training (required):
  40 hrs of on-site practical experience providing PET physics support
- Continuing Education (recommended):
  150 hours every 3 years
  with 15 hours in PET

ACR Accreditation Two Part Submission

- Initial site application (online)
- Clinical review
  - Phantom images that reflect the performance of the equipment during
    routine clinical studies
  - Clinical images

Quality Patient Care

Scanner Performance

- ACR Phantom testing for clinical image quality is required for ACR accreditation and renewal
- Phantom testing recommended quarterly
- Clinical performance, not NEMA acceptance testing

Quality Patient Care

Image Submission

- Clinical images and techniques
- PET phantom images
  - Equipment quality assurance
  - FDG worksheet
  - SUV analysis worksheet

Quality Patient Care

Quality Patient Care

ACR Phantom

PET Phantom

Hot-Cylinder Cover Plate

Fillable thin-walled cylinders (8, 12, 16, and 25 mm in diameter), a Teflon cylinder and two 25 mm cylinders, one for air and one for "cold" water.

ACR PET Phantom

Hot Cylinders & Cold Rods

8, 12, 16, and 25 mm

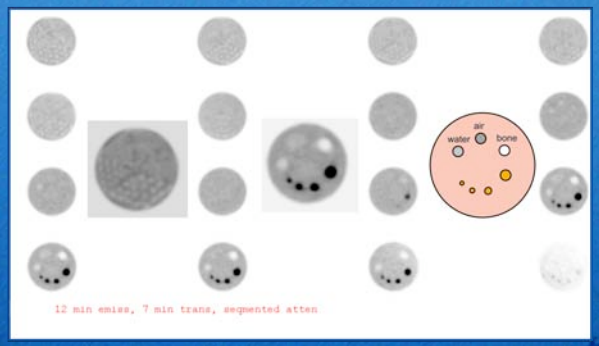
4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm

Typical Images 2.5:1 Ratio (10 mCi) Clinical Protocol

EXACT (7E, 3T) Biograph (6 min) Phantom

HR+

High Count , 12E/7T



Rods: 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm

PET Phantom Review

1 cm slices

1 - 5 Grading Scale

- Uniformity
- Contrast – Hot Cylinders
  8, 12,16, 25 mm
- Resolution – Cold Rods
  4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm

PET Phantom Review

1 - 5 Grading Scale

- 5 – Excellent, best image quality.
- 4 – Good, minor variations in quality.
- 3 – Satisfactory, some variations in image quality, but not likely to affect interpretations of clinical studies.
- 2 – Marginal, may affect interpretation of clinical studies.
- 1 – Failure, probably will affect interpretation of clinical studies. Scanner should not be used for clinical studies.

PET Phantom Review

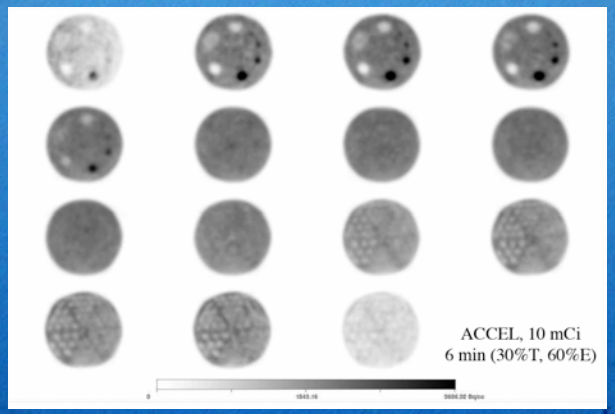
Marginal Passing Score

(2 on 1 -5 scale)

Images are reviewed by 2 reviewers (3 if tie)

- **Contrast - marginal passing:**
  16 mm vial is resolved with acceptable contrast; larger vial resolved with high contrast
- **Resolution - marginal passing :**
  11.1 mm rods are resolved with low contrast; larger rods are resolved with high contrast
- **Uniformity - marginal passing :**
  Strong artifacts are seen in a small number of slices.

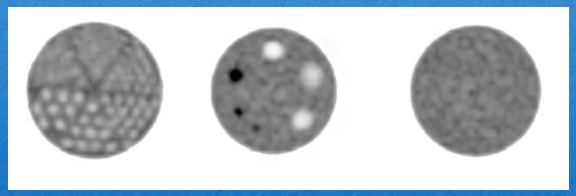
Siemens ACCEL



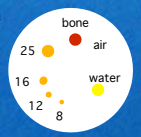
1 cm slice Rods: 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm

GE Discovery: LightSpeed 4

16 mCi, 6 min per bed, 1 cm slices

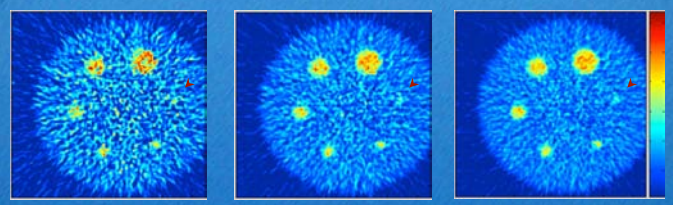


Rods: 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm



PET Contrast:
^{11}C Spheres/ ^{18}F Background

HR+ (resolution ~ 6 mm at 10 cm), 3D (FBP)



5 min 15 min 25 min

Typical brain scan (10 mCi): ~ 0.5 µCi/ml, 35 min acquisition

^{18}F (1.2 µCi/ml) and ^{11}C spheres (ratio to background = 2.6)

Sphere diameters (volumes): 31.3 (16.0), 24.8 (8.0), 15.6 (2.0), 19.7(4.0), 12.4 (1.0), 9.85 (0.5 ml) mm.

PET Statistics: Resolution

Activity:
1.6 µCi/ml FDG

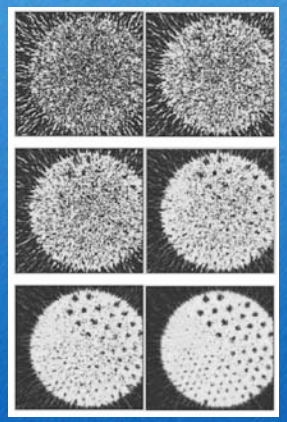
Scanner:
HR +, 3D
Single slice

Rods (mm):
4.8, 6.4, 7.9,
9.5, 11.1, 12.7

5 10

15 30

60 min 90 min



Phantom

Activation

Required Supplies

- 1,000 ml bag of saline solution
- Two tuberculin syringes and FDG doses
  1) Activation Dose A - added to 1,000 ml bag,
  2) Activation Dose B - added to phantom, background activity
- Three 60 ml syringes
  1) Test Dose #1 (60 ml) - vial activity from saline bag
  2) Test Dose #2 (60 ml) - background from phantom
  3) Vial doses from saline bag (40 ml)

Required Supplies

Dose Dilution

Patient Dose	Dose A mCi	Dose B mCi
4 mCi	0.140	0.330
6 mCi	0.210	0.495
8 mCi	0.280	0.660
10 mCi	0.350	0.825
12 mCi	0.420	0.990
14 mCi	0.490	1.154
16 mCi	0.560	1.319
18 mCi	0.630	1.484
20 mCi	0.700	1.649

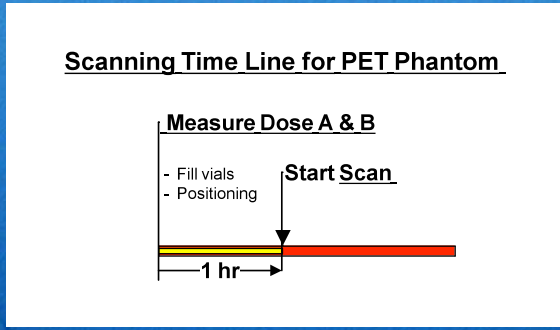
Phantom Doses

Two required doses (from Dilution Chart)

- **Activation Dose A** will be added to 1000 ml bag (or bottle) to diluted activity for the 4 test vials
- **Activation Dose B** will be added to the phantom as background activity.

Radiation Safety

Scanning Time Line for PET Phantom



Measurement of Doses

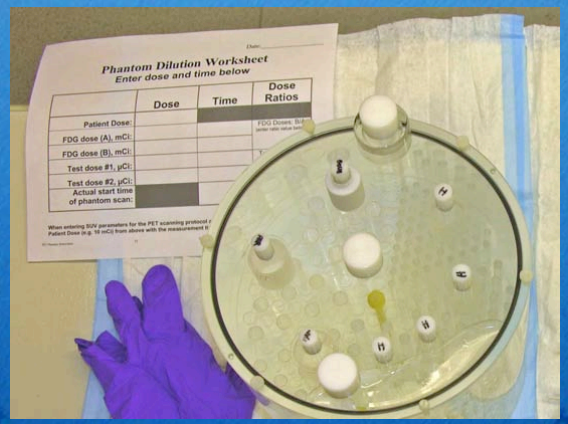
- Measure and record the activity of Activation Dose A and Activation Dose B (tuberculin syringes) with time on the work sheet.
- Scanning begins 1 hr after the Activation Dose A measurement time.

Background Correction

Measurement of Dose

Dose and Time

Enter Dose and Time



Activation of Vials

Add **Activation Dose A** to the 1000 ml bag or bottle and mix well. Then with the first 60 ml syringe withdraw 60 ml — this is **Test Dose #1** (set aside).

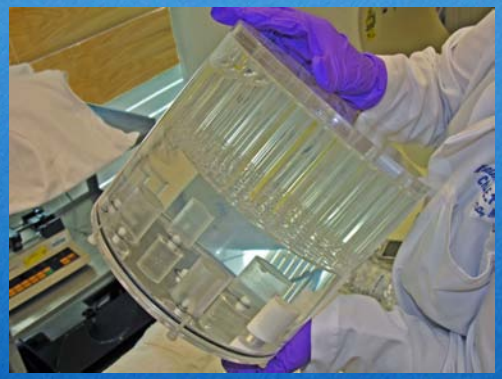
Next, using the second 60 ml syringe withdraw 40 ml from the bag and fill the 4 appropriate chambers in the phantom top.

Vial Activation

Withdraw 40 ml from the saline bag using the second 60 ml syringe and fill the 4 appropriate chambers in the phantom top

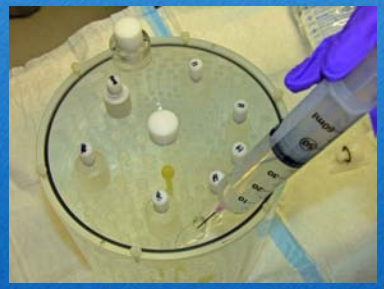
Phantom Background Activation

Thoroughly mix **Activation Dose B** into the main chamber of the PET phantom (a bubble of air will help ensure a well-mixed solution).



Test Dose #2

After mixing, using the third 60 ml syringe, withdraw 60 ml from the phantom — this is **Test Dose #2** (set aside).



Measurement of Test Doses with Time

- Measure and record the activity of **Test Dose #1** and **Test Dose #2**.
- Inject **Test Dose #2** back into the phantom. Fill any remaining air-space in the phantom with water and mix again.
- Scan at the specified time. Dispose of syringes appropriately.

Phantom Dilution Worksheet

Enter dose and time below

	Dose	Time	Dose Ratios
Patient Dose:			
FDG dose (A), mCi:			FDG Doses: B/A (enter ratio value below)
FDG dose (B), mCi:			
Test dose #1, µCi:			Test Doses: 1/2 (enter ratio value below)
Test dose #2, µCi:			
Actual start time of phantom scan:			

When entering SUV parameters for the PET scanning protocol assume a 70 kg patient and use the Patient Dose (e.g. 10 mCi) from above with the measurement time entered for dose A

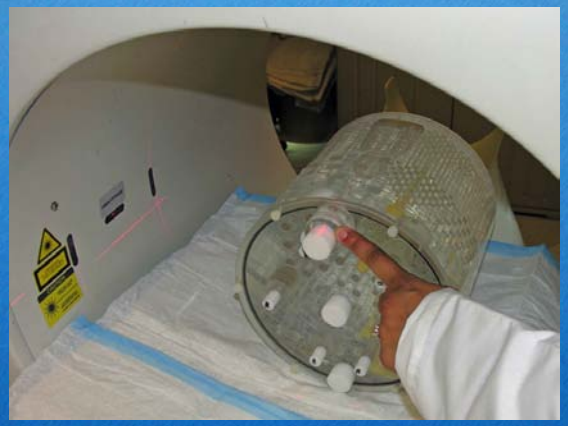
Phantom Dilution Worksheet

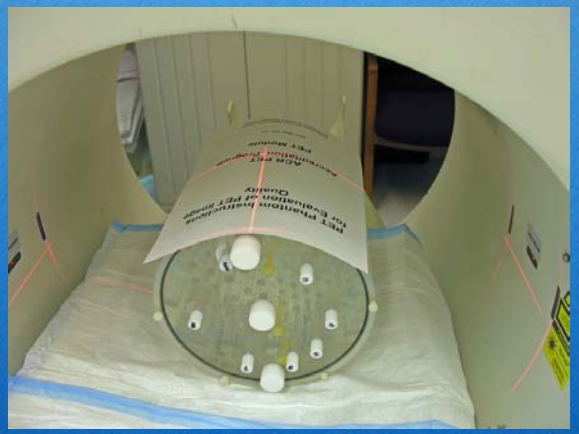
Enter dose and time below

	Dose	Time	Expected Dose Ratios
Patient Dose:	10 mCi		
FDG dose (A), mCi:	0.38	2:21:10	B/A 2.36 / 2.18
FDG dose (B), mCi:	0.83	2:21:49	
#1) 0.35 µCi X 60=21.	17.10	2:34:54	1/2 2.50 / 2.36
#2) 0.14 µCi X 60=8.4	7.25	2:35:32	
Actual start time of phantom scan:		3:21	

When entering SUV parameters for the PET scanning protocol assume a 70 kg patient and use the Patient Dose (e.g. 10 mCi) from above with the measurement time entered for dose A

Phantom Scanning

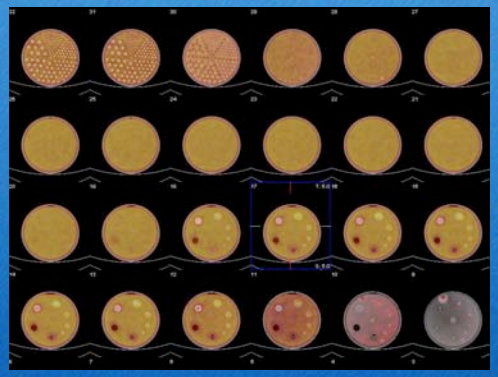




PET Phantom Image Processing

- Clinical whole-body reconstruction protocol
- 1 cm transaxial slices of phantom

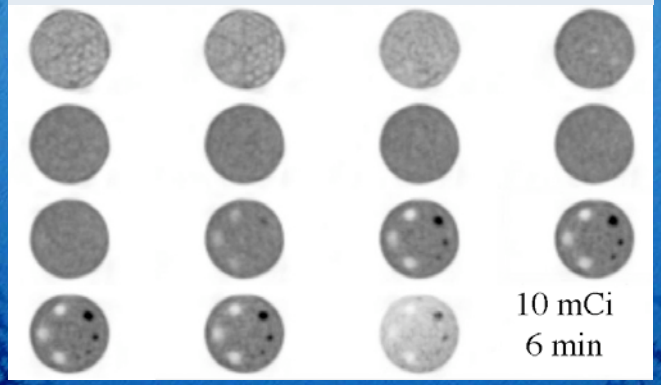
Pitfall: Merged PET/CT



Warning: merged images do not provide adequate information on PET component

Clinical Importance

Based on the evaluation of Phantom Images, patient dose increased to 12 mCi.



1 cm slice rods: 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm

Phantom Activation Objectives

- Background: SUV = 1.0
  0.14 µCi/cc for 10 mCi patient dose
- Cylinders : SUV = 2.5
  0.35 µCi/cc for 10 mCi patient dose

(for scanner SUV setup use patient dose and 70 kg patient weight)

$$SUV = \frac{\text{activity in tissue/ml}}{\text{Inj. dose/body wt (gm)}}$$

SUV Analysis Worksheet

Date: ___ / ___ / ___

Patient Dose: _____

PET/CT Model: _____

From the ROI data of minimum (min.), maximum (max.) and mean SUVs (SUV parameters: patient dose and 70 kg weight) fill in Table 1 and 2 below. If the smallest vials are not visible, leave entries blank.

A) Contrast Ð Table 1

	Hot Vial 8 mm	Hot Vial 12 mm	Hot Vial 16 mm	Hot Vial 25 mm
max. SUV				

B) Scatter/Attenuation Ð Table 2

	Background	Bone	Air	Water
mean SUV				
Min. SUV				

C) Ratio Calculations (using data from Tables 1 & 2 above):

max. vial SUV to mean background SUV e.g., Contrast = 8mm SUV / bkgd SUV	8mm/bkgd	12mm/bkgd	16mm/bkgd	25mm/bkgd

max. vial SUV to max. 25 mm vial e.g., Contrast = max16 mm SUV / max 25 mm SUV	8mm/25mm	12mm/25mm	16mm/25mm

min. air or water to min. bone e.g., ratio = min air SUV / min bone SUV	air/bone	water/bone

SUV Analysis Worksheet

Date: ___ / ___ / ___

Patient Dose: 16 mCi

Background: .22 µCi /cc, SUV = 1.0
Cylinders: .56 µCi /cc, SUV = 2.5

A) Contrast Ð Table 1

	Hot Vial 8 mm	Hot Vial 12 mm	Hot Vial 16 mm	Hot Vial 25 mm
max. SUV		1.25	1.43	1.73

B) Scatter/Attenuation Ð Table 2

	Background	Bone	Air	Water
mean SUV	0.92	0.27	0.42	0.45
Min. SUV		0.17	0.34	0.40

C) Ratio Calculations (using data from Tables 1 & 2 above):

max. vial SUV to mean background SUV e.g., Contrast = 8mm SUV / bkgd SUV	8mm/bkgd	12mm/bkgd	16mm/bkgd	25mm/bkgd
		1.36	1.56	1.89

max. vial SUV to max. 25 mm vial e.g., Contrast = max16 mm SUV / max 25 mm SUV	8mm/25mm	12mm/25mm	16mm/25mm
		0.72	0.82

min. air or water to min. bone e.g., ratio = min air SUV / min bone SUV	air/bone	water/bone
	1.92	2.26

New Reviewer Guidelines SUV Analysis Worksheet

- Pass or Fail Criteria
  - Maximum SUV for 25 mm high Contrast Vial must be > 2 and < 3
  - 16mm/25mm ≈ 0.7 or greater, other ratios should decrease in a reasonably manner
- In the future, the scoring criteria will be adjusted

Current Program Status

- Accredited Sites
  - PET: 870+
  - Nuclear Medicine: 1600+
- WEB based review process
- WEB based image sub-mission under development

Special thanks to

- Chitra Saxena, Manager, Kreitchman PET Center
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