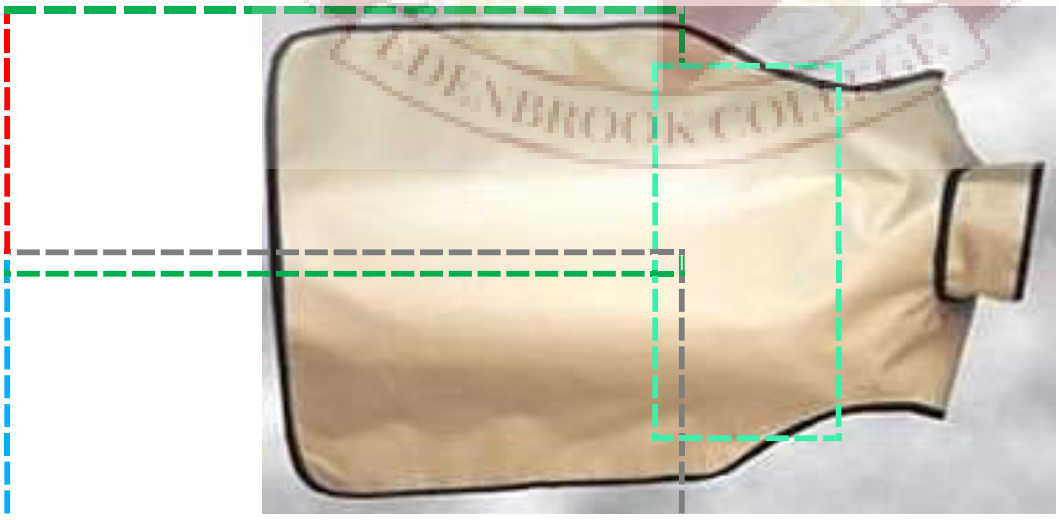
Accessory Equipment

Learning Outcome: Evaluate the performance of the accessory equipment according to Safety Code 35 requirements.

Objectives 4.1-4.7

Testing Lead Apparel (Test 7) – Papp 6th Edition pg 102, SC 35 pg 35: Section 4.1

- Inspection of lead apparel is usually performed at the same time as the visual inspection
- This includes all types of equipment used: aprons, gloves, shielding, lead sheets
- This is important because this equipment protects patients and staff
    - If there is a large crack right through the middle of a lead apron, how will thatapron offer sufficient protection?
        - What if the lead equivalent in the apron is insufficient, will that affect anyone?
    - There are two main methods of testing aprons, fluoroscopically and radiographically.
    - Cracks will appear:
        - Black – radiographically
        - White – fluoroscopically
- Method:
    - First, confirm the presence of a permanent label (must include ID, lead equivalency)
    - Lay the apron on the table
        - Collimate to the size of the IR
        - Label each image taken, using lead markers
        - Ensure overlap for each image, including areas where the marker was
        - Expose until the entire apron has been imaged



5 images would be required for this apron to be assessed properly (as shown above with colors)

- This test is typically performed annually, but every 6 months is preferable
- Results must be included in QC test records
- Typically results are recorded in a chart, with an area to note any comments
    - i.e. location/size of a defect, areas to be aware of, date of inspection, any corrective action/recommendations
    - If there is a defect, it is site specific protocol for what action to take
        - Commonly, if the defect is small and not located over a radiation sensitivearea when worn (i.e. bottom edge), it will stay in circulation with a note to check it more frequently
        - If the defect is large and located over radiation sensitive areas (pelvis), itis typically removed from use.
- Defective equipment must be removed from clinical use
    - Must be disposed of appropriately
    - Recycling is common, lead can be reused
- Common issues that may be encountered are:
    - Labels missing
    - Improper storage and care
        - Lead must be properly hung in order to prevent cracks
    - Need to confirm that the lead equivalency meets the criteria in the SC 35
        - Pg 35 Section 4.1 Protective Equipment

<u>IP cleaning</u>

- Screens that are dirty or dusty can result in creating image artifacts
- In cases where an artifact is suspected to be caused by a dirty cassette, the technologistshould open it and clean it
    - Screens are delicate and must be handled gently to avoid damage
    - This is why they are not cleaned and handled regularly – handle the IP asminimally as possible
    - Otherwise, only the exterior of cassettes is cleaned and disinfected on a regularbasis
- Procedure:
    - Use the tip of a pen to open the CR cassette lock release
    - Keep the black side of the cassette facing up, and carefully pull the IP oursideways
    - Do not touch the white surface with fingers, and keep it facing up
    - Using a manufacturer approved cleaning wipe or cleaner, gently wipe the plate in<u>one direction</u> only. Avoid excessive rubbing and pressure. Do not use a back and forth motion as debris can be dragged back onto the surface.
    - Allow it to air dry completely before use
    - Place IP back inside of the cassette, and reset the lock.

Automatic Exposure Control – Density Control, Uniformity/Field Balance, Reproducibility, Sensitivity

Papp 6th Edition pg 118-121, SC 35 pg 53 (Y7), pg 78 (24.1-3)

Automatic Exposure Control - review

- When an appropriate quantity of radiation is received, the exposure will be terminated
  - AEC controls the exposure time
- Main advantage: helps to ensure that the appropriate amount of radiation is used toachieve acceptable image quality
  - Especially useful for varying thickness of anatomy, pathology, patient conditions
- When should AEC be avoided?
  - Anatomy that is smaller than the cell, difficult patients, prosthetics
- Testing is done on acceptance, annually, whenever service to the AEC is performed andwhenever there is an indication that the AEC is malfunctioning.

AEC Reproducibility (Test 8)

- Purpose of this test: to ensure that the exposure is being terminated at the appropriatetime after a predetermined quantity of radiation has been detected, thereby producing the same output from exposure to exposure when the same kVp and mA are used.
  - If it is not, images will be consistently over/under exposed
  - Ensures the same radiation output is being produced when exposures with thesame kVp, mAs and part thickness are taken
    - Remember: AEC controls time
- Refer to the QUAL 370 Procedures manual for the equipment and sample procedure toperform this test and analyse results.
- Use the following sample data results to perform the calculations. Formulas andcalculation sheets are provided in the QUAL 370 Procedures manual.

AEC Reproducibility

AEC Cell: Center	kVp: 80	SID (cm): 110

Exposure	mA	Time (ms)	Exposure (mR)
1	100	12.54	12.39
2	100	12.55	12.42
3	100	12.56	12.47
4	100	12.54	12.41
5	100	12.54	12.42
6	100	12.55	12.39

This guided calculation is for the **exposure time. Please complete calculations for the full data set.*

$$\% \text{ Variation} = \frac{(mR_{max} - mR_{min})}{(mR_{max} + mR_{min})} \times 100$$

$$\% \text{ Variation} = \frac{(12.56 \text{ ms} - 12.54 \text{ ms})}{(12.56 \text{ ms} + 12.54 \text{ ms})} \times 100$$

= 0.0797% variance in exposure time

Compare the results to the standard in SC 35 pg 53

- The SC 35 recommends that the variance does not exceed 20%

Acceptance criterion are user defined and site specific, the SC 35 recommends manufacturerspecifications should be used.

Based on results, exposure time for center cell = PASS

Please ensure all calculations are completed in full for the remaining mA settings. Check youranswers for accuracy.

% variance for mR = 0.322%

AEC Uniformity/Field Balance (Test 9)

- Purpose of this test: To confirm that the exposure is being terminated at the proper timeafter a predetermined quantity of radiation has been detected, thereby producing the same output from exposure to exposure when the same kVp and mA are used, regardless of the combination of AEC cell(s) selected.
- The ideal result is minimal variance between exposure times when using different combinations of AEC cells and all other factors staying constant
- Acceptance criteria is manufacturer specific.
- Refer to the QUAL 370 Procedures manual for the equipment and sample procedure toperform this test and analyse results.
- Use the following sample data results to perform the calculations. Formulas andcalculation sheets are provided in the QUAL 370 Procedures manual.

AEC Field Balance						
mA:	100	kVp:	70	SID (cm): 110		
Cell	Time (ms)	Exposure (mR)	% Diff (ms)	% Diff (mR)	Pass	Fail
Center	23.10	17.15				
Left	26.04	19.26				
Right	25.61	18.84				
Center + Left	24.56	18.07				
Center + Right	24.09	17.87				
Left + Right	25.58	19.10				
All	24.58	18.24				
Mean						

**This guided calculation is for the exposure time. Please ensure all calculations for the full data set arecompleted.*

Mean time: Add all the time values, then divide by 7. Mean = 24.79 ms

$$\% \text{ Difference} = \frac{(\text{Measured}) - (\text{Mean})}{(\text{Mean})} \times 100$$

$$\% \text{ Difference} = \frac{(23.10 \text{ ms} - 24.79 \text{ ms})}{24.79 \text{ ms}} \times 100$$

% Difference = **-6.817%** for the center cell exposure time

Acceptance criterion are user defined and site specific, the SC 35 recommends manufacturerspecifications should be used. The AHS standard for acceptance is < 20% variance.

Please ensure all calculations are completed in full for the remaining mA settings. Check youranswers for accuracy.

Mean mR = 18.36 mR

Cell	% Diff (ms)	% Diff (mR)
Center	*-6.817*	*-6.590*
Left	*5.042*	*4.902*
Right	*3.308*	*2.614*
Center + Left	*-0.928*	*-1.580*
Center + Right	*-2.824*	*-2.669*
Left + Right	*3.187*	*4.031*
All	*-0.847*	*-0.654*

AEC Density Control (Test 10)

- Purpose of this test: to confirm that the exposure is being terminated at the proper timewhen using density control settings and the same kVp and mA are used.
- The ideal result is a difference in exposure of approximately 15-25% between adjacentdensity settings
- Acceptance criteria is manufacturer specific.
- Refer to the QUAL 370 Procedures manual for the equipment and sample procedure toperform this test and analyse results.
- Use the following sample data results to perform the calculations. Formulas andcalculation sheets are provided in the QUAL 370 Procedures manual.

AEC I nsity Control

AEC Cell: Center kVp: 70 SID (cm): 110

Density Setting	mAs	mR
-2	1.7	11.32
-1	2.2	14.06
0	3.6	20.81
+1	4.1	24.19
+2	5.1	30.42

This guided calculation is mAs for -2 and -1 density setting. Complete all calculations for the full data set.

$$\% \text{ Difference} = \frac{(-2 \text{ Setting}) - (-1 \text{ Setting})}{(-1 \text{ Setting})} \times 100$$

% Difference = $\frac{(1.7 - 2.2)}{2.2} \times 100$ = **-22.727%** difference in mAs between density setting -1 and -2

Acceptance criterion are user defined and site specific, the SC 35 recommends manufacturer specifications should be used. The AHS standard states there should be a difference between15-25% between adjacent density settings.

*Based on results, mAs between density setting -1 and -2 = **PASS***

Please complete calculations for the remaining mA settings. Check your answers for accuracy.

Density Settings	mAs	mR
-2 and -1	-22.727%	-19.488%
-1 and 0	-38.889%	-32.436%
0 and +1	-12.195%	-13.973%
+1 and +2	-19.608%	-20.480%

AEC Sensitivity (Test 11)

- Purpose of this test: to confirm that the exposure is being terminated at the proper timewhen using different speed/sensitivity settings and the same kVp and thickness
- As the speed of the system is doubled, the resultant exposure should be halved. Whenthe speed of the system is halved, the resultant exposure should be doubled.
- Acceptance criteria is manufacturer specific.
- Refer to the QUAL 370 Procedures manual for the equipment and sample procedure toperform this test and analyse results.
- Use the following sample data results to perform the calculations. Formulas andcalculation sheets are provided in the QUAL 370 Procedures manual.

AEC Sensitivity		
AEC Cell: Center	kVp: 70	SID (cm): 110
Sensitivity/Speed	**mAs**	**mR**
S200	6	36.52
S400	2.8	16.59
S800	1.4	9.44

This guided calculation is for the **mAs. Please ensure all calculations for the full data set are completed.*

S200 and S400

$$= \frac{(6\ mAs - 2.8\ mAs)}{2.8\ mAs} \times 100$$

$$= 114.286\%$$

$$____\% = \frac{(S200) - (S400)}{(S400)} \times 100$$

S800 and S400

$$= \frac{(1.4\ mAs - 2.8\ mAs)}{2.8\ mAs} \times 100$$

$$= -50\%$$

$$____\% = \frac{(S800) - (S400)}{(S400)} \times 100$$

S400 is used as the standard setting for most departments. If the system is adjusted to S200,the exposure needs to increase by 114.286% (approximately double). If the system is set to S800, the exposure decreases by -50% (approximately half).

Please ensure all calculations are completed in full for the remaining mA settings. Check youranswers for accuracy.

mR

S200 and S400 = 120.133%

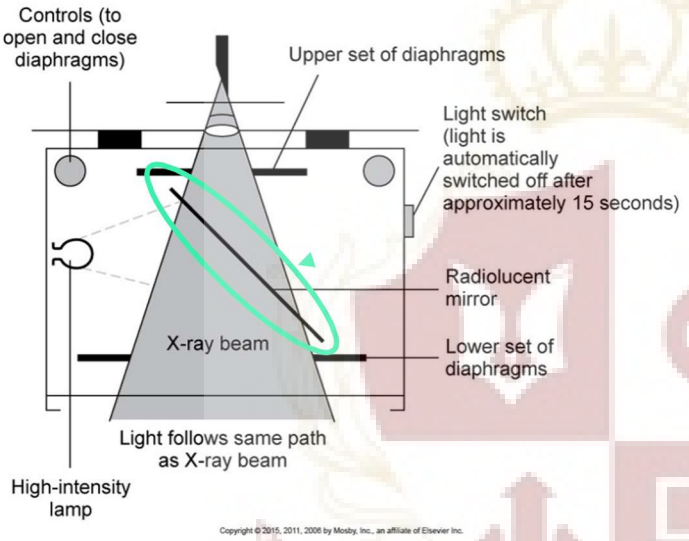
S800 and S400 = -43.098%

Positive Beam Limitation (Test 12) Papp 6th Ed. Pg 113, SC 35 pg. 53: Y9(b), pg. 75: 12. (1)

- A system in the x-ray unit that detects IR size and adjusts collimation to match
- There are sensors inside the cassette holder (Bucky) to detect the IR size
- So why is this important?
    - Helps to prevent the radiation field from being larger than the IR
    - Decreases unnecessary dose – what is the purpose of having a large field size ifthe IR cannot capture the entire radiation field?
- Two tests performed
    - Test the amount of time for the field size adjustment to be made
    - Test the accuracy of the field size and the corresponding IR that was inserted
- Use a timer to determine how long it takes for the field size to adjust after IR insertion
    - SC 35 states that adjustment should occur within 5 seconds
- To test the accuracy of the size detection
    - Place an 18 x 24 cm cassette into the Bucky and visually confirm that the lightfield has been adjusted by the PBL.
    - Center a 24 x 30 cm cassette in the light field on the table top, do not adjust collimation.
    - Expose and evaluate the image on the 24 x 30 cm IR – remember to account for magnification from the OID
    - Repeat with all common IR sizes
- Purpose of this test: to confirm that the PBL quickly and accurately adjusts to theappropriate field size required
- Testing is done on acceptance, semi-annually, before/after any work is done on x-raytube, collimator or bulb
- Troubleshooting Considerations
    - Mechanism that detects the IR size can malfunction with age and wear
    - Shutters may malfunction
        - Should have an override switch
- Refer to the QUAL 370 Procedures manual for a more detailed sample procedure andadditional information.
- **Note: Acceptance criteria is **different** from the collimation light field test in the SC 35:
    - The dimensions of the x-ray field do not exceed those of the IR by more than 3%of the SID
    - The sum of the width and length of the radiation field shall not exceed the sum ofthe length and width of the IR by more than 4%.
    - The PBL will automatically adjust the dimensions of the radiation field within 5seconds of the IR being inserted into the cassette holder.

Collimator light field congruence and Perpendicularity (Test 13) Papp 6th Ed. pg 113-116, SC 3.5 pg 25, pg 53 Y8, pg 75· 12(2)

- Collimation plays a significant role in patient dose and image quality
  - Major factor in decreasing scatter and skin exposure
- If the light field is inaccurate, it is impossible to tell where the radiation field is
  - This can result in unnecessary anatomy being exposed, or repeat exposures dueto clipped anatomy
  - In short, it is important that the light field accurately represents the area that willbe exposed to radiation
- What if the beam is not perpendicular?
  - Can result in shape distortion of image, or masking of potential pathologies

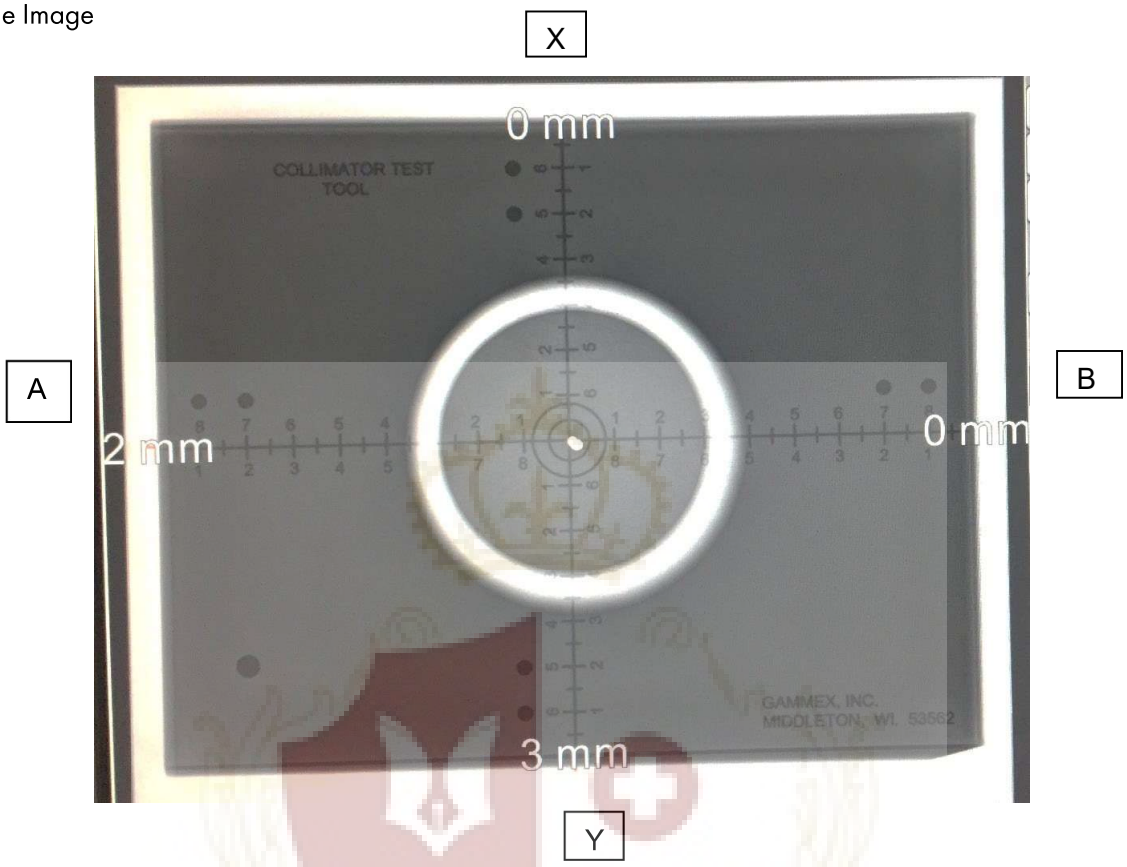


If the x-ray tube is bumped or handled roughly, the mirror that directs the light downward can become misaligned. Thiscan cause the light field to misrepresent the radiation field

- Purpose of this test: To confirm congruency of the light and x-ray field and to ensure thatthe central ray is perpendicular to the IR.
- Possible reasons that the collimation test may fail are: if the mirror has shifted or amalfunction with the collimator shutters
- Perpendicularity may fail if the tube has had a major collision or impact, disruption to thestability of the tube inside the housing caused by rough handling.
- Testing is done on acceptance, annually, after any service. Test can also be done if thereis any reason to suspect misalignment.
- Two pieces of equipment are used: the collimator alignment template (metal plate), andthe beam alignment test tool (plexiglass cylinder)
- One image is taken with both test tools
- Refer to the QUAL 370 Procedures manual for the equipment and sample procedure toperform this test and analyse results.
- Use the following sample data results to perform the calculations. Formulas andcalculation

sheets are provided in the QUAL 370 Procedures manual.

Sample Image



**Measurements are taken between the actual exposure field (collimation field) and the solid template line, measure all four sides, use positive values.*

Please ensure familiarity with all calculations and methodology for this test.

Evaluation A

Calculate 2% of SID

0.02 x 110 cm = 2.2 cm

(To convert into mm, multiply by 10). ***2.2cm x 10 = 22mm***

This means 22mm is the maximum amount of misalignment allowed.

A + B =_____ X + Y = _____

2 + 0 = 2 mm 0 + 3 = 3 mm Total = 5 mm

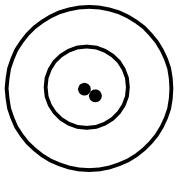
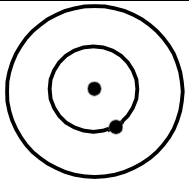
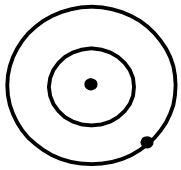
Compare the results to the standard in the SC 35 p.25

- The measured misalignment of the visually defined field and the x-ray field alongthe length or width of the x-ray field shall not exceed 2% of the SID.

Based on results, 5 mm is within 2% of the SID = PASS

Evaluation B

Compare the sample image to the chart below and record which alignment appears most similarto the results.

~0.5°	~1.5°	~3°
		
Result:	~0.5°	

Compare the results to the standard in the SC 35 p.75

- The x-ray beam axis should be within 3° of the perpendicular to the imagereceptor plane.
- Using this test tool, the upper bead must be within the outer circle to pass.

Based on results, < 3 = PASS

Half Value Layer (Test 14) Papp 6th Ed. Pg 105-106, SC 35 pg 24:

- Filtration review:
  - Filtration eliminates low energy x-rays from the x-ray beam
    - Results in 'hardening' the beam, as the average energy of the beam isincreased after removal of the low energy x-rays
  - Decreases the patient's skin dose significantly – by 80-90% with proper filtration
  - Total filtration is the combination of inherent and added filtration
  - HVL is the best method to determine if filtration of the beam is sufficient
  - HVL
    - The amount of filtration required that will reduce the intensity of theprimary beam to half of its original value
    - Does NOT measure the amount of filtration in the tube, it is only used todetermine that the beam has sufficient filtration
  - As HVL increases, so does the energy of the primary beam – higher energyphotons = less pt dose
  - ***HVL is NOT the amount of aluminum filtration in the tube, it is the amount ofaluminum that decreases the intensity of the beam by half***
  - So why is this test important?
    - If the beam does not have sufficient filtration, low energy photons willincrease the patient's dose

- Purpose of this test: to confirm that the permanent filtration is maintained at anappropriate level to minimize the exposure to the patient.

- Testing is done on acceptance, annually, when tube is replaced, collimator removed, orany changes to added filtration.

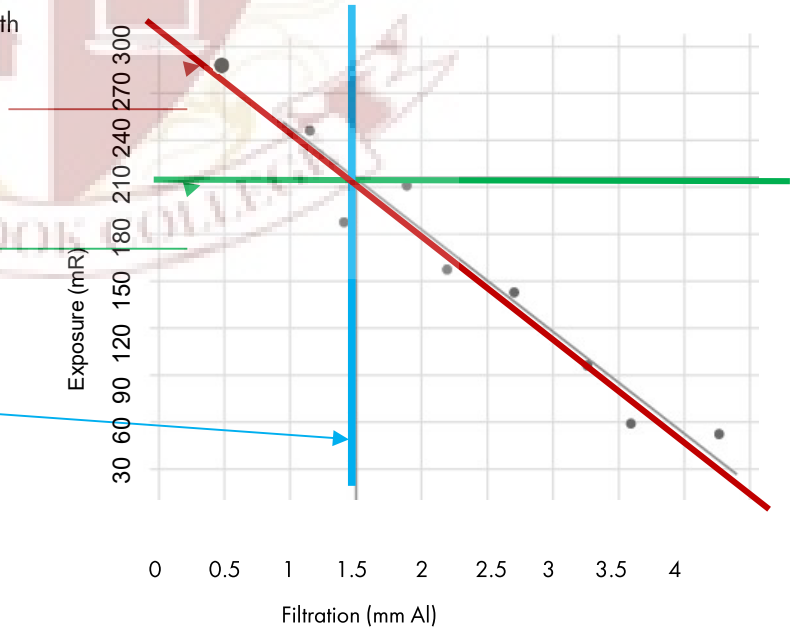
- Refer to the QUAL 370 Procedures manual for the equipment and sample procedure toperform this test and analyse results.
- Use the following sample data results to perform the calculations. Formulas andcalculation sheets are provided in the QUAL 370 Procedures manual.

Half Value Layer

kVp: 80	mAs: 50
mm Al	mR
0	298.1
0.5	258.4
1	235.3
2	190
3	157.1
4	134.3

This graph is a sample illustration to demonstrate how to use the graph. Use the data table results to plot your graph to determine HVL with the data set.

Step 1: Plot the results on the graph. Label y axiswith appropriate increments.
Step 2: Draw a best fit line. Doesn't have to intersect all the points, make a straight line following trend of data points
Step 3: Calculate 50% of the exposure withno filtration, draw a horizontal line at that exposure value.
Step 4: At the point that the line intersectswith the best fit line, draw a vertical line downwards to determine the amount of filtration used to halve the radiation.
In this example, HVL = 1.5 mm Al



Compare the results to the standard in the SC 35 p.24 Table 8

this table needs to be memorized for each of the kV settings

- At 80 kVp, the minimum HVL must be 2.9 mm Al

Based on results from data table (not the sample graph) HVL =
3.25 mm Al = PASS
Note: if the value you have gotten from your graph is drastically different, re-assess how you've drawn the best fit line.

Example Question:

Which beam is more penetrating?

Beam A: HVL= 3.5 mm Al Beam B: HVL = 2.5 mm Al

Answer: *Beam A – stronger beams will require more aluminum in order to half their intensity Physicists determine the amount of HVL required to indicate sufficient hardening of the beam to prove there is adequate total filtration present.*

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