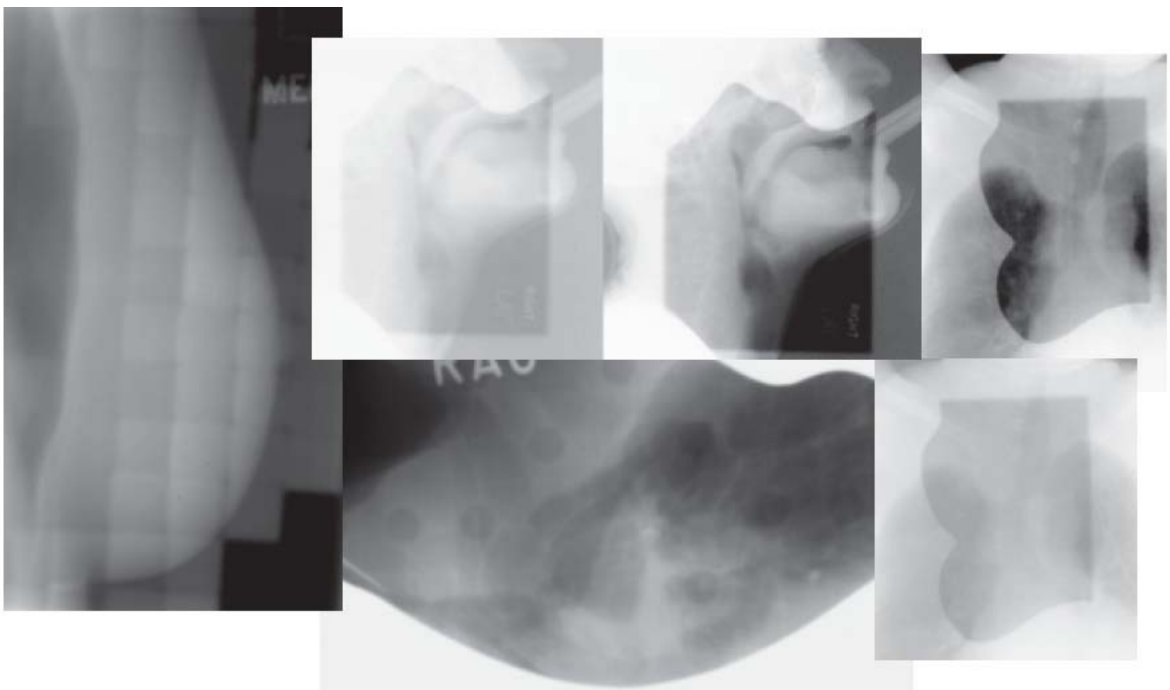
Carestream Oncology Film Systems



Carestream Oncology Film Guide

Carestream

PURPOSE OF THIS GUIDE

The following information is intended to be a useful guide to understanding and optimizing the use of Carestream films for oncology. Imaging applications for Oncology EC Film include both portal localization and verification imaging. Oncology EDR2 Film is used for dosimetry and quality control. For optimum results, it is recommended that EC Film/screen components be used together. Oncology Portal Pack for Localization / PPL film is used for verification and portal localization. Oncology Simulation / SIM film is used for simulation.

Consult the Carestream Web site: http://www.carestream.com/oncoFilm.

HOW TO USE THIS GUIDE

This Carestream Health guide includes the following sections to provide information and to help optimize image quality:

- Localization imaging applications
  - For Cobalt 60, radiosurgery, radiotherapy, and intensity-modulated radiation therapy (IMRT)
  - Technical considerations and technique recommendations for CARESTREAM EC-L Film Systems
    - Using multiple energies
    - Image geometry
    - Patient thickness
    - Field size
    - Film processing
  - CARESTREAM EC-L Film System technique charts
- Verification
- KODAK EC Lightweight Cassette for localization and verification imaging
- Dosimetry and Quality Control
  - CARESTREAM Oncology EDR2 Film for dosimetry/QA/equipment calibration
- Troubleshooting
- Other CARESTREAM Oncology Products
  - CARESTREAM Oncology Simulation / SIM Film
    - Simulator exposure chart
  - CARESTREAM Oncology Portal Pack for Localization / PPL Imaging
- Questions and answers
- Reference

LOCALIZATION IMAGING APPLICATIONS

Through the use of different phosphor screens with varying speeds, cassettes designed for localization imaging are available to fit a wide range of equipment types, energy levels, and patient body part treatment areas. Faster cassette/film systems are ideal for fields such as the lateral pelvis, for example. Slower-speed cassette/film combinations may be appropriate to compensate for beam energies higher than 6 MV, particularly 18 MV or higher.

Using CARESTREAM Oncology EC FILM with Cobalt 60 sources

CARESTREAM Oncology EC Film can be used with Cobalt 60 sources for better visualization of key landmarks near the center of the treatment field. However, because of the high contrast of this film, the penumbral region may be more difficult to image with CARESTREAM Oncology EC Film.

Using CARESTREAM Oncology EC FILM for stereotactic radiosurgery and radiotherapy patients

The CARESTREAM EC-L Film Screen System allows unprecedented verification and enhanced quality assurance of stereotactic radiotherapy and radiosurgery. The very low image noise and high-contrast characteristics of CARESTREAM Oncology EC Film allow for high-resolution, digitally scanned images, vital to this application. Visualization of the small localization markers used in stereotactic procedures can be seen more easily. The low image noise of a digitized Oncology EC Film allows clinicians to utilize software tools identifying the 3-D position of the patient and the treatment beam.

Using the CARESTREAM EC-L FILM SCREEN SYSTEM for intensity-modulated radiation therapy (IMRT)

In IMRT, reproducible positioning of the patient can be even more important versus traditional radiotherapy. The smaller field sizes allow less inclusion of anatomy for orientation purposes and for confirmation of treatment of the same location identified in simulation. Portal imaging with the CARESTREAM EC-L Film System can significantly increase the confidence in knowing that the immobilization system is working accurately, due to the significant increase in image contrast. Such improved clinical visibility can mean a reduction in patient positioning errors, thus improving control of tumors and reducing the risk of healthy-tissue complications.

Benefits realized from using CARESTREAM EC Film System for localization

Benefits for localization imaging include:

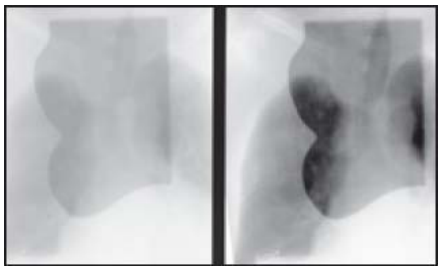
- More than 3X improvement in contrast over conventional portal imaging systems (see Figure 1)
- One film for both localization and verification imaging
- Fast and easy processing in a conventional film processor.

Different variations of KODAK localization cassettes are available to provide flexibility in matching the exposure to the imaging application. With the CARESTREAM Oncology EC Film's very high contrast, achieving the appropriate exposure is very important. The average exposure must be in the high-contrast part of the film response to achieve a high-contrast image on the view box. The different cassette/screen offerings represent a choice of different system speeds (similar to what is commonly seen in conventional x-ray imaging).

A practical example of the use of different oncology cassettes: the exposure to the patient in the localization for a lateral pelvis procedure can be reduced 30% by using the KODAK EC-L fast cassette configuration.

Figure 1

Comparison of the Carestream EC-L Film System and conventional film images AP Lung Portal Localization



Conventional film *CARESTREAM EC-L Film System*

Using different EC-L Lightweight Cassettes: slow, regular, and fast

Slow

The KODAK EC-L Lightweight Cassette Slow consists of a 0.127 -mm lead-front screen and two phosphor-coated intensifying screens inside a light weight x-ray cassette. This cassette may be appropriate to compensate for beam energies higher than 6 MV, particularly 18 MV and higher. Using the same CARESTREAM Oncology EC Film in all three cassettes, this slow cassette requires approximately 30% more exposure vs. the KODAK EC-L Lightweight Cassette Regular described next.

Regular

The KODAK EC-L Lightweight Cassette Regular consists of a 0.127-mm lead-front screen and two phosphor-coated intensifying screens. This cassette is designed for the majority of treatment images.

Fast

The KODAK EC-L Lightweight Cassette Fast differs from the slow and regular cassettes in its complement of phosphor intensifying screens. These screens offer increased speed, allowing a reduction in exposure of approximately 30% vs. the KODAK EC-L Lightweight Cassette Regular. This can be particularly useful when imaging lateral pelvis fields and when dealing with large patients.

TECHNICAL CONSIDERATIONS AND TECHNIQUE RECOMMENDATIONS FOR EC FILM SYSTEM

Technical considerations for EC-L Film Screen System

CARESTREAM Oncology EC Film and KODAK EC-L Lightweight Cassettes have been specifically designed to produce high-contrast images at the megavoltage energies of therapy radiation. The high contrast enables greater visualization of anatomical structures, which can help in ensuring the appropriate placement of the treatment beam in a portal localization procedure.

With high contrast, the latitude of the film is reduced. This puts greater emphasis on careful control of the exposure conditions to create a consistent image. The consistent production of high-quality EC-L images requires careful consideration of all the factors affecting exposure.

An estimation of the amount of radiation to expose the CARESTREAM Oncology EC Film/ KODAK EC-L Lightweight Cassette is based on the following factors:

- Energy of the radiation beam
- Geometry
- Patient thickness or separation
- Field size
- Film processing

Following a few simple steps will ensure optimal EC-L system images, and lead to greater confidence in therapy localization. At the end of a brief discussion on the factors listed above, technique charts that can be developed and used to estimate the exposure for CARESTREAM Oncology EC Film and KODAK EC-L Lightweight Cassettes are presented.

In these charts, a double exposure is specified in the form of x+y. The first number refers to the exposure to the treatment field and the second number to the exposure to the secondary or open field. Note that in these tables, only 1 MU (Monitor Units) is typically specified to the treatment field. The rationale is that this minimizes the difference between the treatment exposure relative to the total exposure and works to ensure that the treatment field is not too dark relative to the secondary or open field.

If it is necessary to manipulate the exposures specified in these charts, always add or subtract exposure from the secondary or open field. Additional exposure to the treatment field should be considered only in situations where very large exposures are necessary.

Using multiple energies

Many modern treatment machines can operate at multiple energies. The lowest energy available should be used for port filming, because the contrast between structures (i.e., the subject contrast) will be greatest at lower energies. This will result in better visualization of structures in the image. When high energies are used, in addition to lower contrast, there is greater transmission through the patient, and more energy reaching the receptor. As a result, less exposure is required. The techniques included at the end of this discussion have been separated according to the energy of the radiation beam. Note that less total exposure is required at higher treatment energies.

Figure 2

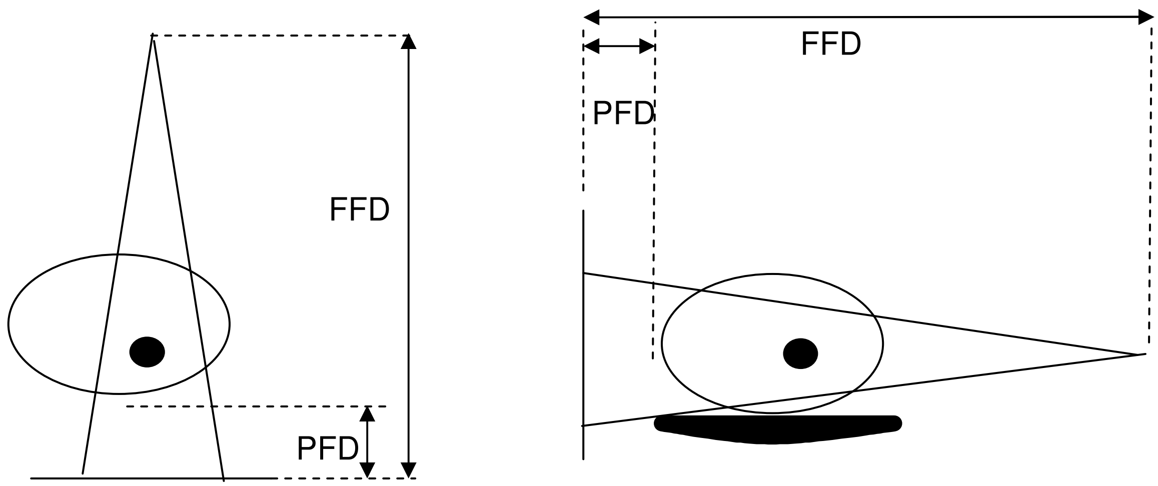


Image geometry

Geometry is an important consideration in determining the exposure for any radiographic procedure. Factors influencing geometry of the source relative to the patient and the film (image receptor) are the location of the disease, the orientation of the beam, and the access around the patient.

Typically the target volume is positioned so that it is at the isocenter of the treatment device, which is commonly 100 cm from the source. The position of the image receptor relative to the source is referred to as the focal-film distance, or FFD. This distance is influenced primarily by the orientation of the beam and the access around the patient. Another important distance is the separation between the exit of the patient and the film, referred to in the figure as the PFD (Figure 2).

The distance from the source to the film is important, because the intensity of a projection beam, which diverges from a small source of radiation, diminishes according to the square of the distance from the source (inverse square law). Practically speaking, then, a receptor placed farther from the source will require the specification of a higher exposure technique in order to achieve adequate darkening of the film.

If the radiation originating at the source of the treatment machine were the only radiation, then the FFD would be the only important geometric consideration impacting technique. However, the intensity of radiation behind the patient has been observed to fall off more rapidly than would be predicted by the inverse square of the FFD. A dependence that is roughly related to the inverse cube of the FFD has been measured empirically. This dependence is understood in terms of two additional factors: electrons originating from interactions within the patient, and the proximity of this patient source of radiation to the image receptor.

At megavoltage energies, photons that interact within the patient produce electrons. Some of the electrons created close to the exit of the patient can escape into the gap between the patient and the image receptor. Some of these will reach the receptor and interact to expose the film. These electrons effectively act as a second source of radiation. There is a greater impact associated with the receptor placement relative to the radiation from the patient than the therapy source, due to the fractional distances involved. The prediction, which has been verified empirically, is that the optical density falls (due to the drop in intensity) much faster than would be predicted by the inverse square of the FFD alone.

Understanding the implications of the distance between the patient and the receptor (PFD) is extremely important in ensuring consistent results with the high contrast and narrow latitude of EC-L exposures. *For optimal image quality, the distance between patient and cassette should be reduced as much as is reasonably possible.* As the distance between patient and cassette increases, density decreases. CARESTREAM Oncology EC Film will amplify this effect due to its considerably higher film contrast vs. conventional films. If distance increases, a compensating increase in monitor units will need to be made.

This should be remembered if and when the cassette is placed at different distances from the patient each time the patient is treated. Changes in density due to the contrast characteristics of the CARESTREAM Oncology EC Film should be anticipated, and proper exposure techniques for each situation should be noted. *The distance between the patient and the film is more important than the distance between the source and the film for predicting the appropriate exposure technique.*

How is geometry reflected in the specification of the technique charts? *In the AP projection, where the image receptor is placed beneath the patient, the cassette is commonly rested on supports beneath the patient couch.* This is very desirable, as the cassette is placed at a fixed and reproducible distance relative to the source and the patient.

In other projections, the beam may traverse a greater distance across the patient, and the patient couch may prevent getting the image receptor close to the patient. In this case, much greater distances would be involved and exposures would be expected to increase. This is reflected in both the geometry and the recommended exposures specified in the technique charts for AP vs. lateral procedures. The increase in the exposures for the the lateral geometry is due to both the increases in radiation from the source (FFD) and radiation from the patient (PFD).

The charts provided in this section are for use with the geometry specified. Other geometries are possible; however, it will be necessary to customize the techniques accordingly. The discussion above should be used as a guide: pay close attention to the PFD. Using a smaller PFD will minimize the exposure required. *As PFD increases, an increase in exposure will be required (i.e., add exposure to the open field of 1 MU for each additional foot of PFD).*

It is very important to note that once a geometry is chosen, the reliable production of consistent high-quality Oncology EC film images requires careful attention to and consistent use of that geometry. Many facilities have improved their consistency by using a short ruler or piece of string to ensure a consistent separation between the patient and the film.

Patient thickness

The thickness of the patient will affect the amount of radiation reaching the image receptor. As patient thickness increases, more exposure is needed to compensate for the increased attenuation. This is reflected in the technique charts in this guide, in that the techniques for some anatomical parts have been divided according to patient profile: small, medium, and large. Note that exposure has been added to the open field as the patient thickness increases. In situations where the patient is either very thick or very thin, consider adding or subtracting exposure from the secondary or open field.

Field size

The field size is not specified in the technique charts. It is important to note that field size can affect the technique selection, because the amount of scattered radiation will increase as field size increases. This will cause the overall density of the image to increase. If large fields are being used, then the exposure should be reduced in the secondary or open field.

This relationship between field size and image density is more apparent with imaging systems that use intensifying screens, such as the EC-L Film System, coupled with the approximately 3X contrast amplification delivered by CARESTREAM Oncology EC Film. Small adjustments or changes in radiation intensity are translated into more pronounced image density changes, due to the combination of intensifying screens and the very-high-contrast film.

This same principle operates to a lesser extent among the typical choices of low-contrast, medium-contrast, and high-contrast general radiographic films in conventional medical radiography. The very-high-contrast films currently used in film-screen mammography imaging also place similar demands on the accuracy of exposure parameters, attention to body part thickness, field size, and collimation.

The size of the treatment field will be determined in the treatment plan. Some additional consideration should be given to the size of the secondary or open field. Using a large secondary field in the hopes of seeing more anatomical landmarks will increase the scatter, and reduce the contrast of the image. *The secondary or open field should be defined according to a fixed increment from the dimensions of the treatment field, rather than using a very large field, or one corresponding to the maximum opening of the port. A 5-cm increment is recommended to allow increased visualization of the regional anatomy, without excessive increase in the amount of scattered radiation.*

Film processing

Proper film processing is important with any medical imaging film. Processing conditions can change exposures by as much as 50 to 100%. The technique charts listed on the following pages assume that Carestream recommendations for processing of CARESTREAM Oncology EC Film are being followed. These recommendations are summarized in Carestream service bulletin #30. Local processing conditions can influence the speed and contrast. If speed is affected (the images are dark or light), manipulate (reduce or increase exposure) the exposure recommended for the secondary or open field to achieve the desired appearance. (See page 20).

CARESTREAM EC-L FILM SCREEN SYSTEM TECHNIQUE CHARTS

Using the Charts

1. First, identify the energy for which filming will be performed (remember, the lowest energy available will produce the best results).
2. Pay particular attention to the distance between patient and film. If this distance needs to be increased due to the access of the cassette and holder around the patient, then it may be necessary to add exposure to the secondary or open field. If different distances are used, then the techniques may have to be adjusted.
3. Next, refer to the anatomical area to be imaged. The technique indicated is based on standard considerations for thickness and field size. If the patient thickness differs from a standard thickness, add or subtract exposure from the open field accordingly. For particularly large treatment fields, decrease the exposure in the open field to account for increased scatter.

Customizing the charts

1. The charts are presented here as a guide. The previous discussion in this section describes how geometry and the local processing conditions can impact the exposure required for CARESTREAM Oncology EC Film in KODAK EC-L Cassettes, which also includes the KODAK EC-L Lightweight Cassettes. The exposures in the secondary or open field should be modified to account for local preferences in these factors. Once a technique is worked out, new charts should be produced, and careful attention to using those techniques consistently is recommended.
2. Unlike imaging at diagnostic energies, there is not a substantial difference in tissue attenuation at megavoltage energies. For this reason, the biggest factors affecting the exposure required are not specifically dependent on the anatomy. Once the energy and geometry have been determined, patient thickness and field size would be the important factors. As an alternative to the technique charts presented here which provide exposure recommendations according to anatomy, a technique chart based on thickness and field size for a given geometry and energy could be created.

Fractional MUs

The charts provided express exposures in integer increments (MUs). Integer increments are common on most machines. Some manufacturers have provided for fractional increments of exposure. If this is available, then techniques can be fine-tuned for even greater optimization of exposure. The points raised in this discussion can be used to guide the fine-tuning according to patient thickness, field size, geometry, and processing.

CARESTREAM EC-L Film System Technique Chart
Common Techniques for 6-MV Beams

Assumes source-to-film distance of: **105–115 cm for AP/PA; 100 cm SAD**
115–125 cm for Obliques; 100 cm SAD
130–140 cm for Laterals; 100 cm SAD

LUNG/CHEST		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+3	
OBLIQUE	Most	1+4	or 1+3
PELVIS		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+3	
OBLIQUE	Most	1+4	
LATERAL	Small	2+7	1+5
LATERAL	Most	2+8	1+6
LATERAL	Large	2+10	2+7
BREAST		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
TANGENTS	Most	1+3	
TANGENTS	Single Exposure	4	
HEAD/NECK/BRAIN		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+3	
LATERAL	Most	1+3	
SHOULDER/CLAVICLE		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+3	
ABDOMEN		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+3	
OBLIQUE	Most	1+5	1+3
LATERAL	Most	2+8	1+6

Technique Tips:

• Generally, adjust the technique to darken or lighten films by adding or subtracting to the 2nd number (e.g., if an oblique pelvis is too light at 1+4, change technique to 1+5).

• Increasing the distance between patient and cassette will require additional MUs (e.g., a lateral lung at an angle of 270º will require more MUs than an oblique lung [1+4] at 210º).

• Poor processing conditions affect image quality and decrease image contrast and density. Recommended replenishment rates for EC film: 100 ml of developer and 120 ml of fixer.

• The dimensions of the surrounding (i.e., open) field can affect image quality.

CARESTREAM EC-L Film System Technique Chart
Common Techniques for 4-MV Beams

Assumes source-to-film distance of: **105–115 cm for AP or PA; 100 cm SAD**
130–140 cm for Laterals; 100 cm SAD

LUNG/CHEST		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+4	
OBLIQUE	Most	1+6	
PELVIS		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Small/Medium	1+4	1+3
AP/PA	Large	1+6	1+4
LATERAL	Small		1+7
LATERAL	Medium		1+9
LATERAL	Large		1+10
LATERAL	Small/Medium (Single Exposure)		9
LATERAL	Large (Single Exposure)		10
BREAST		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
TANGENTS	Small	1+3	
TANGENTS	Medium/Large	1+4	
TANGENTS	Single Exposure	4 or 5	5
HEAD/NECK/BRAIN		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP	Most	1+3	
LATERAL	Most	1+4	
SHOULDER/CLAVICLE		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+4	

ABDOMEN		EC-L Regular Cassette	EC-L Fast Cassette
	Patient Profile	Monitor Units	Monitor Units
LATERAL	Medium	2+12	2+10
OBLIQUE	Medium	2+6	2+5

Technique Tips:

• Generally, adjust the technique to darken or lighten films by adding or subtracting to the 2nd number (e.g., if an oblique pelvis is too light at 1+4, change technique to 1+5).

• Increasing the distance between patient and cassette will require additional MUs (e.g., a lateral lung at an angle of 270º will require more MUs than an oblique lung [1+4] at 210º).

• Poor processing conditions affect image quality and decrease image contrast and density. Recommended replenishment rates for EC film: 100 ml of developer and 120 ml of fixer.

• The dimensions of the surrounding (i.e., open) field can affect image quality.

CARESTREAM EC-L Film System Technique Chart

Common Techniques for 10-MV Beams

Assumes source-to-film distance of: **105–115 cm for AP or PA; 100 cm SAD**

130–140 cm for Laterals; 100 cm SAD

LUNG/CHEST		EC-L Regular Cassette	EC-L Fast Cassette
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+2	
OBLIQUE	Most	1+4	
PELVIS		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Small/Medium	1+2	
AP/PA	Large	1+3	
LATERAL	Small		1+4
LATERAL	Medium		1+5
LATERAL	Large		1+6
LATERAL	Small/Medium (Single Exposure)		6
LATERAL	Large (Single Exposure)		7
BREAST		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
TANGENTS	Small	1+2	
TANGENTS	Medium/Large	1+3	
TANGENTS	Single Exposure	3	
HEAD/NECK/BRAIN		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units

AP	Most	1+2	
LATERAL	Most	1+3	
SHOULDER/CLAVICLE		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+2	
ABDOMEN		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
LATERAL	Medium		1+5
OBLIQUE	Medium	1+3	

Technique Tips:

• Generally, adjust the technique to darken or lighten films by adding or subtracting to the 2nd number (e.g., if an oblique pelvis is too light at 1+4, change technique to 1+5).

• Increasing the distance between patient and cassette will require additional MUs (e.g., a lateral lung at an angle of 270º will require more MUs than an oblique lung [1+4] at 210º).

• Poor processing conditions affect image quality and decrease image contrast and density. Recommended replenishment rates for EC film: 100 ml of developer and 120 ml of fixer.

• The dimensions of the surrounding (i.e., open) field can affect image quality.

CARESTREAM EC-L Film System Technique Chart
Common Techniques for 18-MV Beams

Assumes source-to-film distance of: **105–115 cm for AP or PA; 100 cm SAD**
130–140 cm for Laterals; 100 cm SAD

LUNG/CHEST		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+2	
OBLIQUE	Most	1+3	
PELVIS		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Small/Medium	1+2	
AP/PA	Large	1+3	
LATERAL	Small		1+2
LATERAL	Medium		1+3
LATERAL	Large		1+4
LATERAL	Small/Medium (Single Exposure)		4
LATERAL	Large (Single Exposure)		5
BREAST		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units

TANGENTS	Small	1+2	
TANGENTS	Medium/Large	1+2	
TANGENTS	Single Exposure	3	
HEAD/NECK/BRAIN		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP	Most	1+2	
LATERAL	Most	1+3	
SHOULDER/CLAVICLE		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
AP/PA	Most	1+2	
ABDOMEN		**EC-L Regular Cassette**	**EC-L Fast Cassette**
	Patient Profile	Monitor Units	Monitor Units
LATERAL	Medium		1+3
OBLIQUE	Medium		1+2

Technique Tips:

- Generally, adjust the technique to darken or lighten films by adding or subtracting to the 2nd number (e.g., if an oblique pelvis is too light at 1+4, change technique to 1+5).
- Increasing the distance between patient and cassette will require additional MUs (e.g., a lateral lung at an angle of 270º will require more MUs than an oblique lung [1+4] at 210º).
- Poor processing conditions affect image quality and decrease image contrast and density. Recommended replenishment rates for EC film: 100 ml of developer and 120 ml of fixer.
- The dimensions of the surrounding (i.e., open) field can affect image quality.

VERIFICATION IMAGING APPLICATIONS

The CARESTREAM EC-V Film Screen System for verification imaging builds upon the innovative technology introduced with the CARESTREAM EC-L Film System for portal localization imaging.

The difference between localization and verification cassettes is the exposure required to produce an image. This is underlined by the intended application. In verification, the imaging system will be exposed for the entire prescribed dose for a specific treatment field, compared to localization that involves a short collimated exposure and a short open field exposure, to confirm patient positioning. Thus the verification systems must necessarily be much slower than localization systems—hence slower screens (less light output) are used.

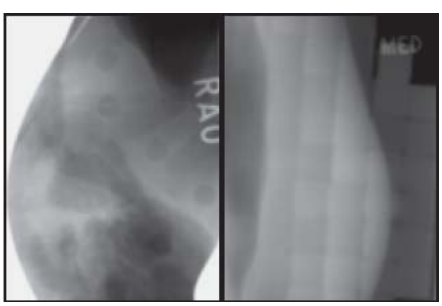
To use the CARESTREAM EC-V Film System, therapists position the KODAK EC-V Lightweight Cassette before beginning a patient's treatment. The CARESTREAM Oncology EC Film records the radiation delivered during the treatment. This provides an accurate record of the irradiated area, because the film is exposed by the treatment beam.

There is also typically a 2- to 5-minute reduction in the treatment process, due to the elimination of technologist travel into and out of the treatment room to prepare the field for the double exposure. This streamlining of the treatment process offers radiation therapy departments an opportunity for improved productivity. It also can mean the elimination of non-prescribed radiation from double-exposure localization, which may not be counted in treatment prescriptions.

The CARESTREAM EC-V Film System works particularly well for breast, whole brain, and head and neck images (see Figure 3). The resulting sharp, high-contrast images enable radiation oncologists to more confidently identify anatomy and verify that the appropriate area is being treated.

There are two different cassette offerings: a KODAK EC-V Lightweight Cassette Regular (90 cGy) and a KODAK EC-V Lightweight Cassette Fast (45cGy). The regular cassette contains a single phosphor intensifying screen; the fast cassette has a pair of screens. Both use the CARESTREAM Oncology EC Film.

Figure 3



Oblique lung view (left) and breast view (right) using CARESTREAM Oncology EC Film

Benefits for verification imaging include:

- More than 3X improvement in contrast over conventional portal imaging systems
- Reduction in time required to image one treatment field, resulting in an average of 2 minutes' savings per

film. This can deliver increased capacity without adding resources (CARESTREAM EC-V Film System)

- An image record of the entire treatment dose (CARESTREAM EC-V Film System)
- Elimination of non-prescribed radiation (CARESTREAM EC-V Film System)
- One film for both localization and verification imaging
- Fast and easy processing in a conventional film processor.

DOSIMETRY AND QUALITY CONTROL

CARESTREAM Oncology EDR2 FILM for dosimetry/ QA/ equipment calibration

CARESTREAM Oncology EDR2 Film is a member of the CARESTREAM READY PACK product family which consists of Oncology EDR2 film and PPL.

Oncology EDR2 Film is a convenient means for calibration and monitoring of exposures.

- Two sizes available: 35 x 43 cm and 10 x 12 inches
- Widely available through distributors of CARESTREAM medical imaging products
- Excellent for relative dosimetry (e.g., field uniformity, equipment characterization: field shapes, port openings, MLCs)
- With appropriate calibration, film may be applicable to absolute dosimetry (e.g., high-dose treatment strategies such as IMRT)

Oncology EDR2 is intended for direct exposure applications only. Its features include:

- Wide response range
- Approximately linear (see Figure 4)
- Robust processing
- Available in convenient READY PACK format

Dose response evaluation

Exact dose responses depend on processing conditions (processing time, processing temperature, processing equipment, processing chemistry); the density sampling (digitizer equipment and calibration) and exposure monitoring equipment. The exact response relationship should be measured and verified for the local conditions.

Protocol

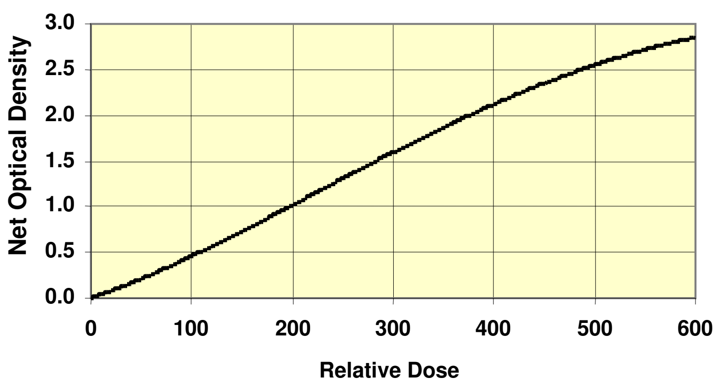
Medical physicists or other personnel should perform measurements of the dose response of a film using appropriate amounts of buildup and backscatter material, with a range of field sizes and energies. The films should be processed using the conditions given in Carestream's service bulletin #30. Task Group 69: "**Radiographic film for megavoltage beam dosimetry"** from the American Association of Physicists in Medicine discusses protocols in detail [12]. Many authors have also discussed methodologies for measuring the response of a film. Some references are listed at the end of this section [5–24].

Dose Response

The curve in Figure 4 shows the approximate relative dose response for EDR2. The curve is representative only—the exact results will depend on the exposing, processing, and scanning conditions at each facility. EDR2 film will saturate in direct exposure at ~700 cGy.

Figure 4

Extended Dose Range Film (EDR2)



TROUBLESHOOTING

When images are too light

Light images are typically the result of processing and exposure.

Exposure

If you are exposing two fields on one film and the treatment field is too light, then the secondary field should be too light as well. Increasing the monitor units on the secondary field also darkens the treatment field. Adding one or two units to the technique, using the charts provided in this publication, should be all that is required to account for differences in normal chemistry and film fluctuations.

If the exposure guidelines in this publication do not provide satisfactory results, you should seek help from your regional Carestream account manager. Do not add monitor units to the treatment field. This will only make the secondary field appear lighter. Single-field users should never require an increase of more than one or two MU from the exposure guidelines recommended in this publication.

Does field size affect image density?

Yes. There is a direct relationship between field size and image density. The underlying cause is scattered radiation. The larger the field size, the more scatter is created. This adds density to the image. The significant increase (over 3X) in image receptor contrast provided by the CARESTREAM EC-L Film System "amplifies" exposure differences into more pronounced density differences.

The practice of enlarging the field size to facilitate visibility of anatomic landmarks can introduce **less desirable** image results, including variable densities and reduced image contrast. The significantly higher image contrast level of CARESTREAM Oncology EC Film should help decrease or even eliminate the need for a large field size in many instances, providing improved image quality.

What about intermittent density shifts or density variations on films?

This can happen for multiple reasons, including:

- Inconsistent cassette-to-patient distance
- Scatter radiation exposure
- Loss of safelight integrity
- Processing

Different cassette to patient distance positioning can produce density variations. Differences in image magnification on comparison films should alert the film interpreter that inconsistent cassette to patient distance is a possible reason for image density variations.

Processing

Check the working chemistry inside the processor for possible oxidation. If oxidized solutions exist, replace with fresh chemistry. If chemical replenishment rates are insufficient for the film type, volume, and/or film mix, processed films can appear to have a green tint. Certain types of processing chemicals can sometimes produce similar shifts in image tone with some films. Insufficient fixer strength and/or under replenishment can also affect the image tone of processed films, giving films a milky or greenish appearance. In addition, film drying can be adversely affected in such circumstances, and there can be an increased propensity for film artifacts due to insufficient emulsion "hardening" in the fixer stage.

It is not unusual to add 1 MU to the larger field because the processing chemistry is not optimized. This can be more obvious on the lesser-exposed projections. In some cases, a change to fresh chemistry can bring an immediate change. In other cases, a change in chemistry brand or type could bring about similar improvements.

CARESTREAM ONCOLOGY PRODUCTS

SIM—CARESTREAM SIMULATION FILM

CARESTREAM Oncology Simulation / SIM Film and CARESTREAM LANEX Regular Screens are designed to work together to deliver excellent image quality. The system speed of this combination is 400. If CARESTREAM LANEX Fast Screens are used instead of LANEX Regular, the system speed is approximately 600. In addition, this screen-film combination may allow lower exposure techniques compared to many existing simulation imaging systems.

The wide exposure latitude of CARESTREAM Oncology Simulation / SIM Film is useful when exposure settings are difficult to control, and this characteristic provides better visualization of the full range of anatomical landmarks, including:

- Skin line and the chest wall on breast simulations
- Soft tissues of the neck and the bony details of the cervical spine
- Lung markings
- The heart and mediastinum

The film is a green-sensitive film with highly stable sensitometric properties over a wide range of processing conditions. If you currently have CARESTREAM LANEX Regular Screens or other green-light-emitting screens, this film is a “drop-in.” No changes are required to existing film processors or chemistry.

Simulator Exposure Chart

These are reasonable exposure techniques for the "400 speed" CARESTREAM LANEX Regular Screens with CARESTREAM Oncology Simulation / SIM Film, for average-sized patients. With other similar-speed, appropriately matched screen-film systems (i.e., Green-Green, Blue-Blue), these techniques may be an appropriate starting point.

	NO GRID		**WITH 8:1 GRID**		
BODY PART/VIEW	kVP	mAs	kVP	mAs	SEPARATION
LUNG/CHEST					
AP/PA	70	40	80-85	60-65	22CM
LAT	75	60	90	100	
OBLIQUE	70	75	95	85	
PELVIS					
AP/PA	80	40	85	95	23CM
LAT	90	150	90	170 (2 Exp.)	36CM
BREAST					
TANGENTS	70	10	75	35	
HEAD/NECK					
AP	75	20	80	35	
LAT	75	120	80	45	14CM
SKULL					
AP	75	25	85	45	
LAT	75	20	75	35	15CM
SPINE					
AP/PA	70	50	85	70	20CM
LAT	75	120	95	200	

CARESTREAM Oncology Portal Pack for Localization / PPL Imaging

CARESTREAM Oncology Portal Pack for Localization Imaging is available in "READY PACK" packaging in two sizes: 33 x 41 cm and 10 x 12 inches. The 33 x 41 cm film size allows the READY PACK envelope with film to fit neatly inside a 35 x 43 KODAK X-OMAT L Cassette. The READY PACK is a sealed envelope containing film that can be used with or without a metal-screened cassette. This packaging offers great convenience in handling and can eliminate carrying heavy cassettes from treatment room to darkroom and back.

CAT Nos. for PPL are 801 3963 for the 33 x 41 cm size and 801 5059 for the 10 x 12 in size.

Other CARESTREAM FILMS for direct exposure

The selection of the appropriate film depends on the application, particularly the exposure range of interest. The following films are commonly used in the oncology environment for portal simulation, localization, or verification imaging. The table below summarizes the approximate active ranges and saturation for direct exposure with commonly available films in the oncology department (Table 1). This table may be helpful when considering their use in relative and absolute dosimetric measurements.

Table 1

Film	Responsive Range	Approximate Saturation Exposure
General (e.g., SIM film)	0.5–10 cGy	20 cGy
PPL	0.25–5 cGy	10 cGy
EDR2	25–400 cGy	700 cGy

QUESTIONS AND ANSWERS

Selected product usage recommendations

Can I use CARESTREAM Oncology EC Film in metal-screened cassettes for portal localization and/or verification imaging?

No. This combination is not recommended for patient imaging. The main reason is the very slow film speed of CARESTREAM Oncology EC Film. This would make the system speed too slow for use with patients.

Can I use conventional medical x-ray film(s) in KODAK EC-L or EC-V Lightweight Cassettes?

No. This is not recommended, because the higher speed of most medical x-ray films would make the resulting combination too fast for patient use. A fraction of 1 MU might be required, and delivering this amount of exposure is typically difficult with most equipment.

What technique changes will I need to make for localization?

Please see suggested technique charts in this document.

Can I use CARESTREAM Oncology EDR2 Film for portal verification imaging?

No. Oncology EDR2 Film cannot be used for patient imaging. The main reason is the very slow film speed of CARESTREAM Oncology EDR2 Film. This would make the system speed too slow for use with patients. We recommend the EC-L and EC-V Film Systems for imaging applications.

Can I process CARESTREAM Oncology EC Film in "shallow-tank" automatic processors?

Processing CARESTREAM Oncology EC Film in "shallow-tank" automatic film processors is not encouraged. In some situations and environments with shallow tank-type processors (and with larger film processors too), it is useful to set the recommended processor up for what is called "flooded replenishment." Flooded replenishment is typically recommended for low-volume processing conditions. In such conditions, there is a greater chance of chemical oxidation and resulting impaired image quality/consistency over time. Flooded replenishment is a practice where chemistry replenishment is delivered regularly via a timer mechanism, whether or not film is being processed. In conjunction with this, there is usually a change to the normal routine of adding "starter" solution to the developer tank inside the processor upon a chemistry change. With flooded replenishment, the addition of starter solution is omitted, so both the internal processor tank and the external replenisher tank contain the same identically prepared developer. Many film processors today have built-in electronics to allow quick setup for flooded replenishment if this is needed.

References

1. Hammoudah MM, Henschke U. Supervoltage beam films. *Int J Radiat Oncol Biol Phys.* 2: 571-577, 1977.

2. Droege RT, Bjarngard BE. Influence of metal screens on contrast in megavoltage x-ray imaging. *Med Phys*. 6: 486-493, 1979.

3. Droege RT, Bjarngard BE. Metal screen-film detector MTF at megavoltage x-ray energies. *Med Phys*. 6: 515-518, 1979.

4. Holmes TW, McCullough EC. Acceptance testing and quality assurance of automated scanning film densitometers used in the dosimetry of electron and photon therapy beams. *Med Phys*. 10: 698-700, 1983.

5. Williamson JF, Khan FM, Sharma SC. Film dosimetry of megavoltage photon beams: a practical method of isodensity-to-isodose curve conversion. *Med Phys*. 8: 94-8, 1981.

6. Haus, AG. Through the Portal. *Advance for Administrators in Radiology & Radiation Oncology.* 10: 63-67, 2000

7. Eastman Kodak Company. Health Imaging. In Focus Information for Medical Physicists. Vol. 7/1, 1999

8. Eastman Kodak Company. Health Imaging. In Focus Information for Medical Physicists. Vol. 6/1, 1998

9. Haus AG, Dickerson RE, Huff KE, et al. Evaluation of a cassette-screen-film combination for radiation therapy portal localization imaging with improved contrast. *Med Phys*. 24: 1605-1608, 1997.

10. Dickerson RE, Haus AG, Huff KE. Development of a novel high-contrast cassette/film/screen system for radiation therapy portal localization imaging. *Proc SPIE.* 3032: 520-529, 1997.

11. Eastman Kodak Company. Health Imaging. *Film Artifact Diagnostics Guide for KODAK X-OMAT Automatic Film Processors*. CAT No. 132 7246, 4-23, 1996

12. TG-69: Radiographic film for megavoltage beam dosimetry. *Med Phys.* 34: 2228. 2007

13. Inhwan, Jason Yeo, Akbar Beiki-Ardakani, Young-bin Cho, Mostafa Heydarian, EDR2 film dosimetry for IMRT verification using low-energy photon filters, *Med Phys*. 31: 1960, 2004.

14. Childress, Nathan L, Rosen, Isaac I, Effect of processing time delay on the dose response of Carestream EDR2 film, *Med Phys.* 31: 2284, 2004.

15. Palm, Asa, Korov, Assen S, LoSasso, Thomas, Predicting energy response of radiographic film in a 6 MV x-ray beam using Monte Carlo calculated fluence spectra and absorbed dose, *Med Phys.* 31: 3168, 2004.

16. Olch, Arthur J., Dosimetric performance of an enhanced dose range radiographic film for intensity-modulated radiation therapy quality insurance, *Med Phys.* 29: Sept. 2002, pg 2159.

17. Esthappan, Jacqueline, Mutic, Sasa, Harms, William B, Dempsey, James F, Dosimetry of therapeutic photon beams using an extended dose range film, *Med Phys*. 29: 2438, 2002.

18. Dietmar, Georg, Kroupa, Bernhard, Winkler, Peter and Potter, Richard, Normalized sensitometric curves for the verification of hybrid IMRT treatment plans with multiple energies, *Med Phys*. 30: 1142, 2003.

19. Gerbi, Bruce J, Dimitroyannis, Dmitri A, The response of Carestream EDR2 film in high-energy electron beams, *Med Phys.* 30: 2703, 2003.

20. Yan, Yulong, Papanikolaou, Nikos, Weng, Xuejun, Penagaricano, Jose, Ratanatharathorn, Vaneerat, Fast radiographic film calibration procedure for helical tomotherapy intensity modulated radiation therapy dose verification, *Med Phys*. 32: 1566, 2005.

21. Cheung, Tsang, Butson, Martin J., Yu, Peter K N, Measurement of high energy x-ray beam penumbra with Gafchromic™ EBT radiochromic film, *Med Phys*. 33: 2912, 2006.

22. Wilcox, Ellen, Daskalov, George, and Nedialkova, Lucy, Comparison of the Epson Expression 1680 flatbed and the Vidar VXR-16 Dosimetry PRO™ film scanners for use in IMRT dosimetry using Gafchromic and radiographic film, *Med Phys.* 43: 41, 2007.

23. Novotny, Josef, Bhatnagar, Jagdish P, Quader, Mubina A, Bednarz, Greg, Lunsford, L. Dade, Huq, M. Saiful, Measurement of relative output factors for the 8 and 4 mm collimators of Leksell Gamma Knif Perfexion by film dosimetry, *Med Phys.* 36: 1768, 2009.

24. Peter Munro, Ph.D., and Matt Mulligan, B.SC.**:** Reducing the Weight of the ECL Cassette**;** *Int. J. Radiation Oncology Biol. Phys.*, 54: 290–299, 2002

25. Nathan L. Childress, Mohammad Salephpour, Lei Dong, and Charles Bloch, R. Allen White, and Isaac I. Rosen, Dosimetric Accuracy of Carestream EDR2 film for IMRT Verifications, *Med Phys*. 32, pg. 539, 2005.

Carestream Health's analog technical support team can be reached at 1-800-328-2910.

Technical Data Sheets for Carestream Oncology films are available at http://www.carestreamhealth.com/oncoFilm.

Carestream Health, Inc.
150 Verona Street
Rochester, NY 14608
U.S.A.

Carestream Health Canada Company
6 Monogram Place
Suite 200
Toronto, Ontario M9R 0A1
CANADA

N2-106 Printed in U.S.A. 2014-3 ©Carestream Health, Inc., 2014 CAT No. 127 1030

Carestream