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SMR.803 - 6

TRAINING COURSE ON DOSIMETRY AND DOSE REDUCTION TECHNIQUES IN DIAGNOSTIC RADIOLOGY

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"PHOTOGRAPHIC QUALITY CONTROL"

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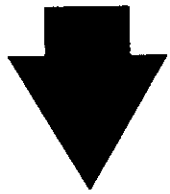
These are preliminary lecture notes, intended only for distribution to participants.

PHOTOGRAPHIC QUALITY CONTROL

Photographic film is quite sensitive to changes in the processing system



QC for photographic processing equipment demands more attention than other areas in medical imaging

U.S.A. STUDY

Survey of 479 film-chemistry-processor systems in medical x-ray facilities

RESULTS

Relative speed: from 35 to 210 (with 100 being the "normal" speed).

Base+fog: from 0.09 to 0.53 (with a range of 0.15 to 0.20 being considered optimum).

Only **48%** of the darkrooms did NOT significantly fog the film in 1 minute.

IS YOUR DARKROOM IN A FOG?

DARKROOM FAILURES

1. Either faded or improper safelight filters are being used

2. The light bulb in the safelight is of too high a wattage for the conditions being used

3. "Unsafe" light is reaching the film

DARKROOM FOG CHECK

PRECAUTIONS

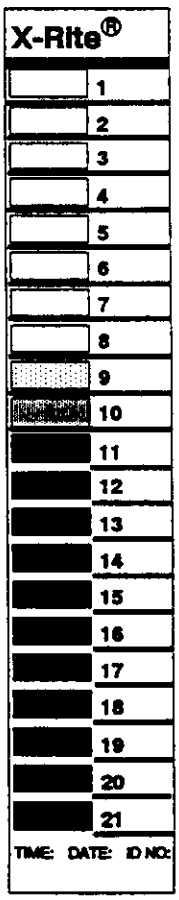
1. You should test every type of film you use in the darkroom

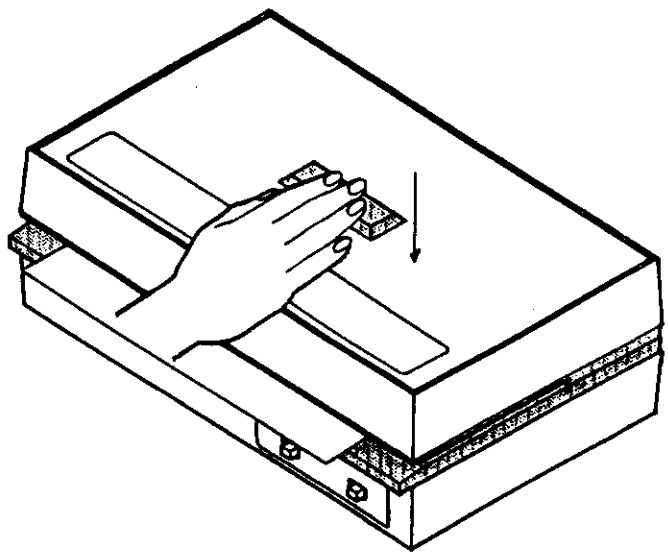
2. All film tested must be preexposed to light as it would be in use. For example, expose it in a cassette with screens to a density of approximately 1.0

3. Direct x-ray exposed film does not have the same sensitivity as film exposed with light from screens

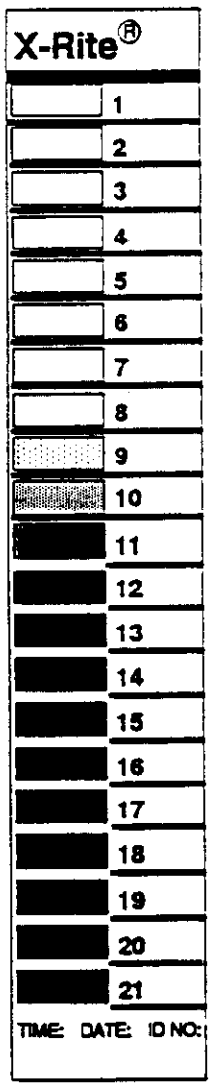
PHOTOGRAPHIC PROCESSOR QUALITY CONTROL PROGRAMME

The basic method to evaluate film processor quality makes use of the sensitometric strip. This is a step wedge exposed with a sensitometer





EXAMPLE OF SENSITOMETRIC STRIP



Each successive step emits 70.7% of the light emitted from the step adjacent to it (0.15 log exposure).

The maximum light is emitted from step 21

HOW TO READ THE STRIP: THE DENSITOMETER

A densitometer must be used to measure the densities of each step in the sensitometric strip

Print Example

step 01 = 0.15
step 02 = 0.15
step 03 = 0.15
step 04 = 0.15
step 05 = 0.16
step 06 = 0.17
step 07 = 0.20
step 08 = 0.27
step 09 = 0.49
step 10 = 0.94
step 11 = 1.44
step 12 = 1.83
step 13 = 2.15
step 14 = 2.37
step 15 = 2.57
step 16 = 2.71
step 17 = 2.78
step 18 = 2.89
step 19 = 2.94
step 20 = 3.02
step 21 = 3.06

Automatic readouts are currently available which can be connected on line to computers for subsequent management, elaboration and analysis of raw data

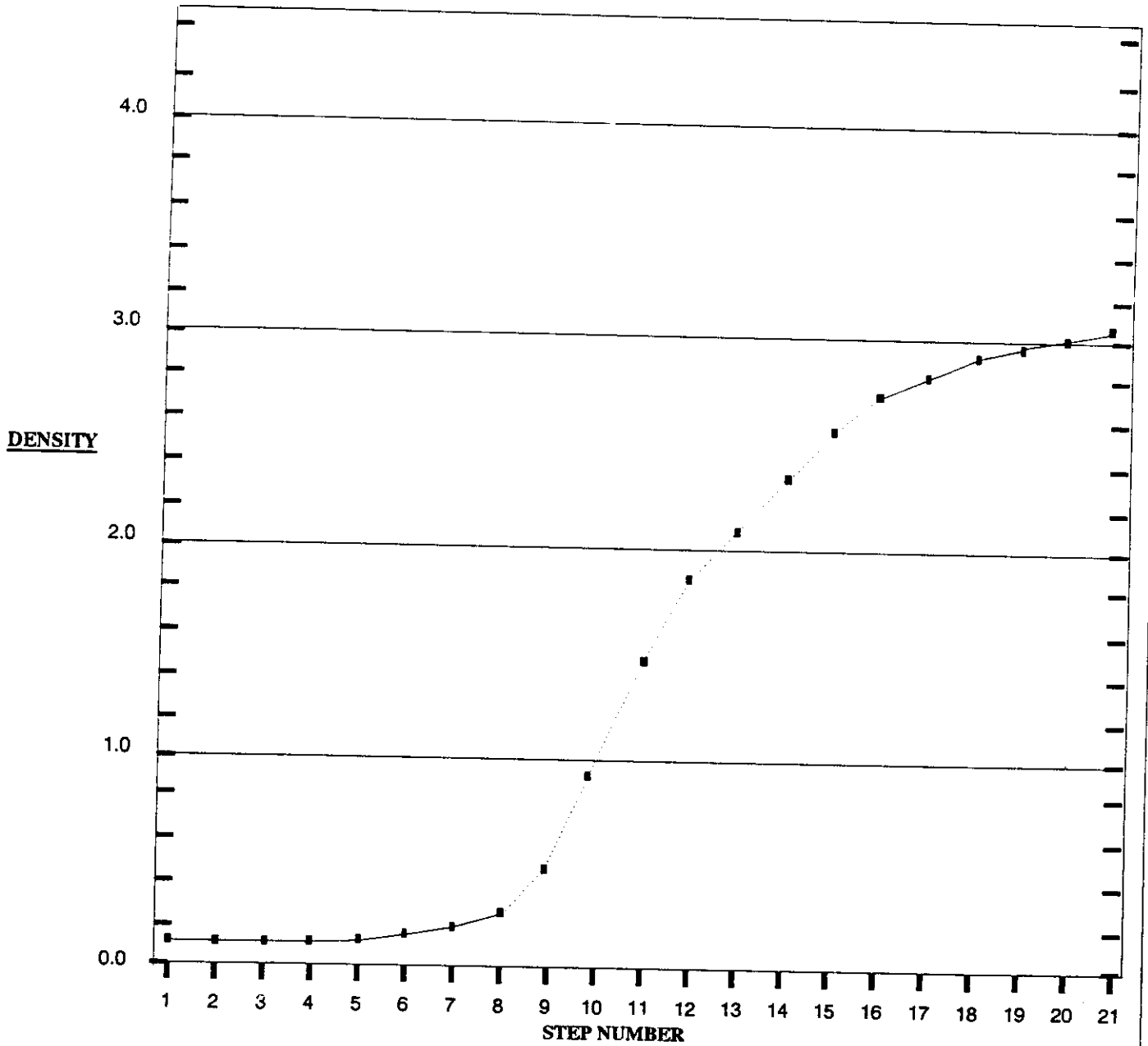
X-RITE Process Control Densitometer
METROPOLITAN HOSPITAL

LOCATION: Xray lab A
TYPE OF FILM: _____
PROCESSOR: _____
DEVELOPER: _____
FIXER: _____
EXP. COLOR: BLUE or GREEN

EXPOSURE DATE: XX/XX/XX
EMULSION NUMBER: _____
PROCESSING TIME: _____
REPLENISHMENT: _____
REPLENISHMENT: _____
EXP. TYPE: DUAL or SINGLE

GRAPH DATE: XX/XX/XX
EXPIRATION: _____
TEMPERATURE: 95.0 F.

GRAPH OF DENSITY VS. STEP NUMBER

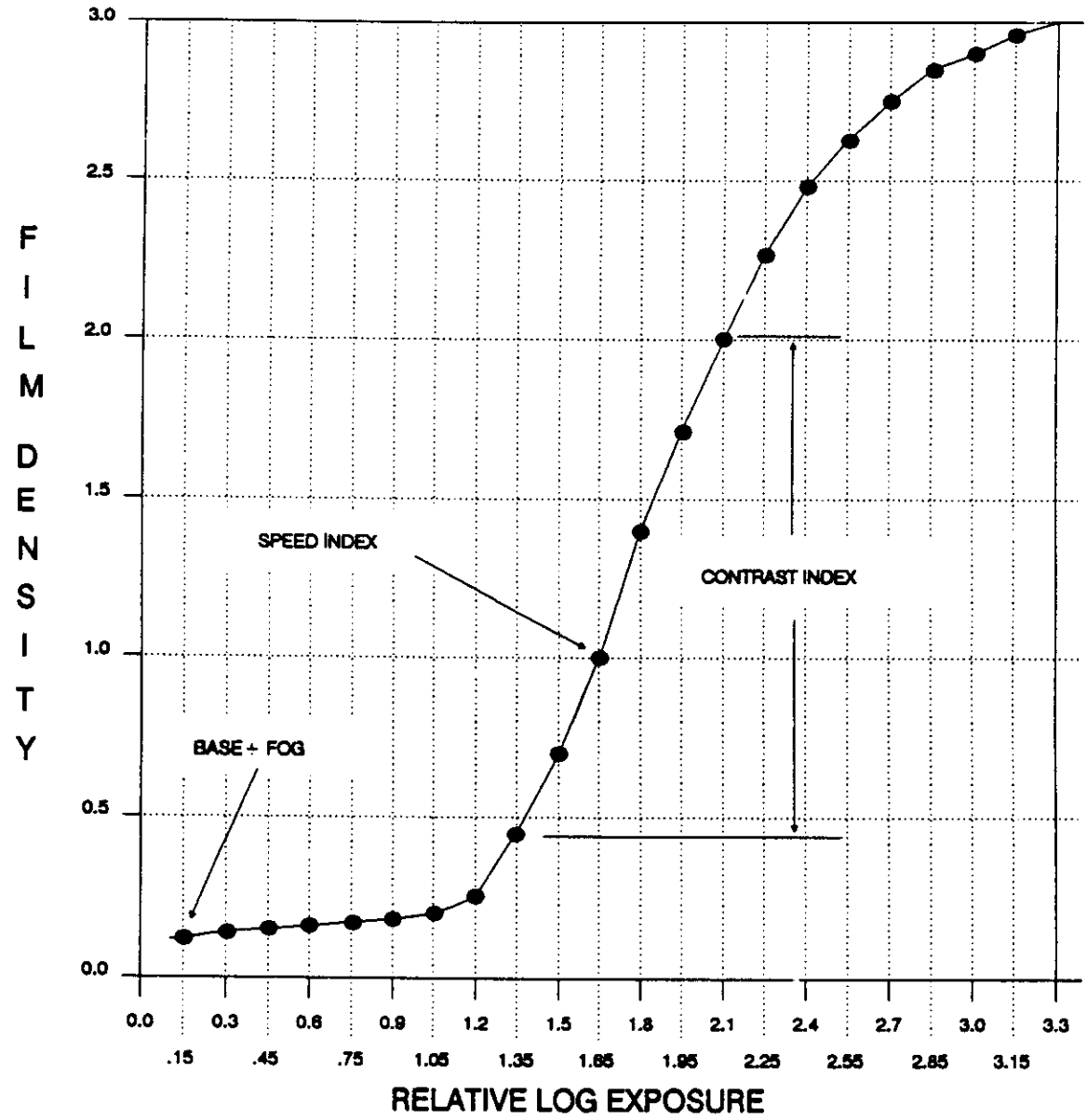


S. Indx = 1.44
C. Indx = 1.66

B+fog = .15
Dmax = 3.06

Av. Grd = 2.77

Film Response to Exposure



BASIC PARAMETERS OF D-log E CURVES

It is not necessary to plot D-log E curves to monitor automatic processors in normal laboratory environments. A simple method is to record the three values

- base+fog
- speed index
- contrast index

which can be easily obtained by the D-log E curve and contain most of the information.

BASIC PARAMETERS OF D-log E CURVES (cont'd)

BASE+FOG:
The least exposed portion of the film is called Base+Fog. It is the base support density plus any silver emulsion density developed in the area where negligible exposure should occur.

SPEED INDEX:
The step on the exposed film with a density nearest 1.0D+Base+Fog is called Speed Index. This step is a direct indicator of film speed. Variations in processor conditions are monitored in this step.

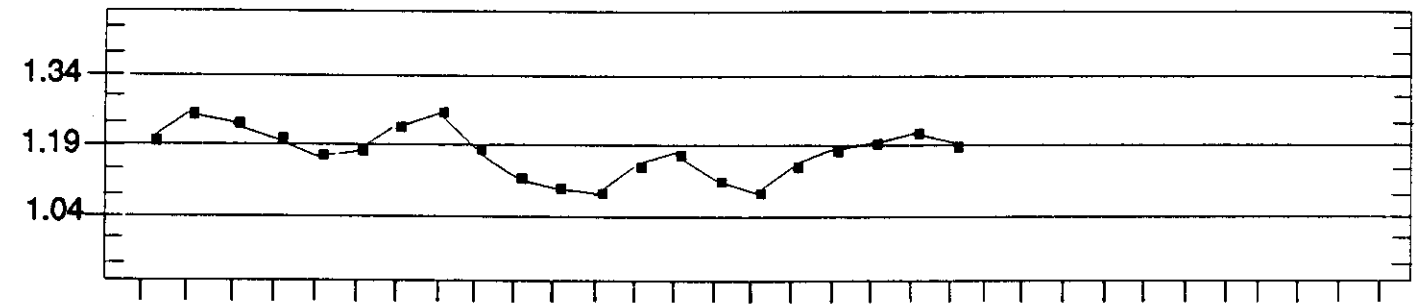
CONTRAST INDEX:
The slope of the straight-line portion of the D-log E curve is called Contrast Index. Select the step closest but not larger than 2.20D. Subtract From this step the step closest to but not lower than 0.45D. Contrast Index is used to monitor processor variations in conjunction with the Speed Index

Sample Print-out from the 381 Densitometer

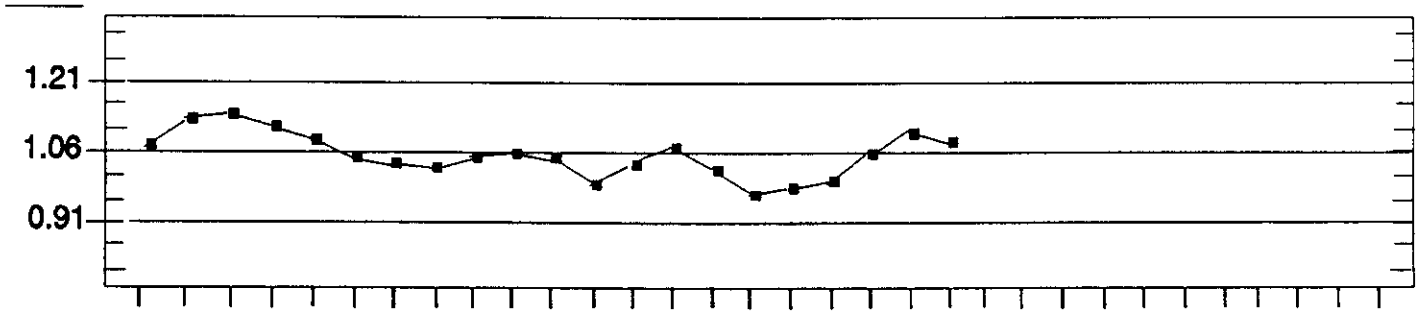
X-RITE Process Control Densitometer
METROPOLITAN
HOSPITAL

LOCATION:	Xray lab A	BEGIN DATE:	XX/XX/XX	GRAPH DATE:	XX/XX/XX
TYPE OF FILM:		EMULSION NUMBER:		EXPIRATION:	
PROCESSOR:		PROCESSING TIME:			
DEVELOPER:		REPLENISHMENT:			
FIXER:		REPLENISHMENT:			
EXP. COLOR:	BLUE or GREEN	EXP. TYPE:	DUAL or SINGLE		

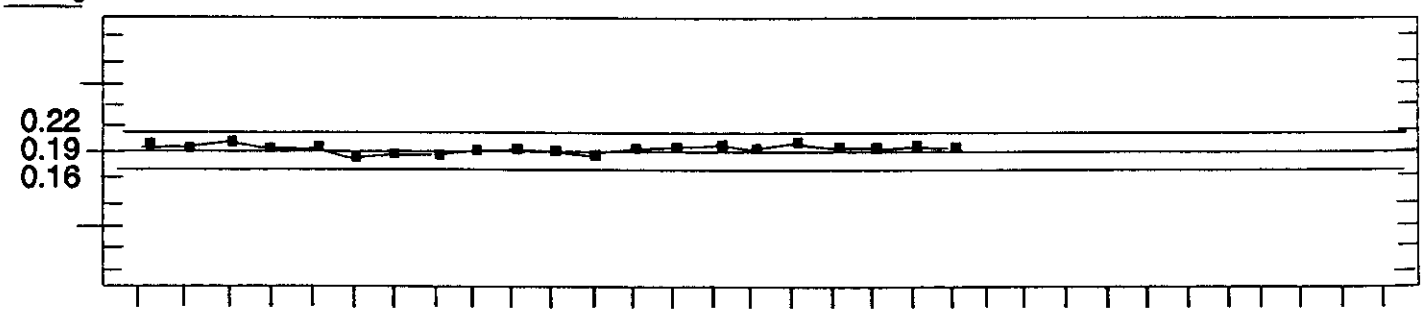
S. Indx



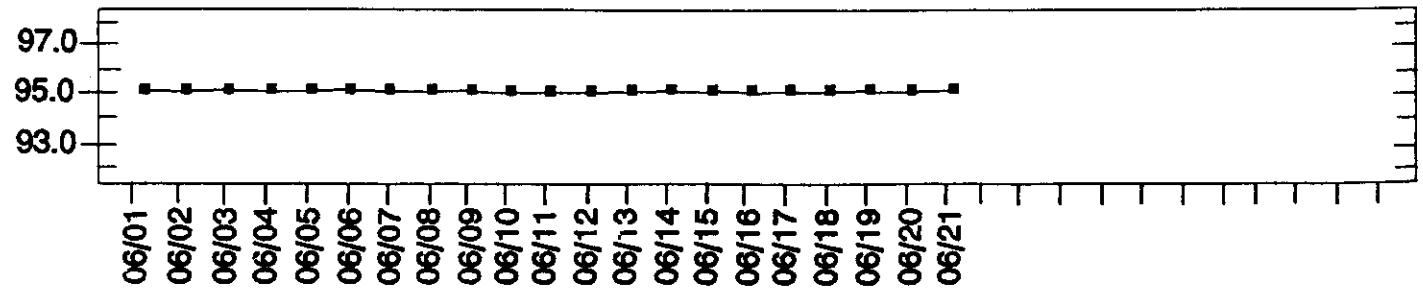
C. Indx



B+fog



Developer Temperature



ESTABLISHING A DAILY PHOTOGRAPHIC PROCESSOR QUALITY CONTROL PROGRAM

Purpose

To determine the operating levels for all photographic processors in the department. (The operating levels should be the same for all processors processing the same type of film.)

Equipment Needed

1. Sensitometer
2. Densitometer
3. Digital thermometer or metal-stemmed dial thermometer
4. Stopwatch
5. Control emulsion
6. Fresh chemicals

ESTABLISHING A DAILY PHOTOGRAPHIC PROCESSOR QUALITY CONTROL PROGRAM

Procedure

1. Drain the developer and fixer tanks in the processor and flush the tanks and racks with fresh water. [***Note:*** **Do not** use systems cleaner at this time.]
2. Replace the developer recirculation filter with a new filter and assure that the processor is functioning normally.
3. Drain and flush the replenisher tanks and hoses with fresh water.
4. *Carefully* mix fresh developer-replenisher and fixer.
5. Refill the replenisher tanks, operating the replenisher pumps temporarily to assure that all fresh water is flushed out of the replenisher lines and to assure that the replenisher pumps are functioning properly.
6. Flush the processor fixer tank again with fresh water.
7. Fill the fixer tank in the processor with fresh fixer and replace the fixer rack.
8. Again flush the developer tank.
9. Fill the developer tank with fresh developer-replenisher and add the correct amount of starter as noted in the manufacturer's instructions.
10. Carefully replace the developer rack, crossover racks, etc.
11. Allow the processor to operate for 30 minutes.
12. Check the developer temperature, fixer temperature, and wash water temperature. The chemistry temperatures should be within 0.5° of those recommended.
13. Check the replenishment rates and the time it takes a film to pass through the processor (the time it takes from when the leading edge enters the processor until the leading edge exits the dryer).
14. Allow the processor to be used until 50 14 x 17-inch (35 x 43-cm) films, or the equivalent, *per gallon of developer* have been processed.
15. Expose six sensi-strips. If you are using a double emulsion film and a sensitometer that exposes only one side you should expose strips on both sides of the film, i.e., three sheets of film with two exposures each.
16. Wait at least 30 minutes before processing the strips.
17. Process the sensi-strips—**thin end leading, same side of the feed tray.**
18. Zero and calibrate the densitometer.
19. Read the densities on the six strips. Be sure to read the densities in the center of each strip, not near the edges. (Check the zero and calibration of the densitometer after reading each strip.)
20. Determine the average of the densities of the six strips for each step.
21. Select and mark the steps producing the densities nearest to 0.25, 1.0, and 2.0 above the base-plus-fog level of the film (Figure 5.3).
22. Determine the appropriate values and record these values and the control limits on the control chart (Figure 3.2). Three values should be recorded:

    DD (Density Difference) = high – low (± 0.10)
    MD (Medium Density) = mid (± 0.10)
    B + F (Base-Plus-Fog) = B + F (± 0.05)

23. Adjust *all* processors using the same film and chemistry to produce the same values.

ESTABLISHING A DAILY PHOTOGRAPHIC PROCESSOR QUALITY CONTROL PROGRAM

Acceptance Limits

The control or acceptance limits for daily processor control should be ±0.10 for both the medium density and density difference. Until you are familiar with the procedures and have your processors in good control you may wish to use wider limits of ±0.15 for the MD and DD but you should maintain the limit of +0.05 for the base-plus-fog. If you use the wider limits initially you should be able to shift to the tighter limits within not more than 1 month after you start your quality control program.

Corrective Action

If you have difficulties with any of the above procedures, contact the technical service representative from the firm that manufactures your film and chemistry.

DAILY PHOTOGRAPHIC QUALITY CONTROL OF MECHANIZED FILM PROCESSORS

Purpose

To assure on a day-to-day basis that all photographic processors are operating at the same levels and producing consistent, high-quality films.

Equipment Needed

1. Sensitometer
2. Densitometer
3. Digital thermometer or metal-stem dial thermometer
4. Control emulsion

DAILY PHOTOGRAPHIC QUALITY CONTROL OF MECHANIZED FILM PROCESSORS

Procedure

1. Follow the manufacturer's start-up procedures every day.
2. Allow sufficient time for the processor temperature to stabilize—about one-half hour. Assure that the wash water temperature is adjusted properly, where appropriate.
3. Check the following:
   a. Solution temperatures
   b. Replenishment rates
   c. Water flow rates
   d. Dryer temperature
4. Run several clean-up sheets and check them for roller marks and scratches. (Use exposed but unprocessed film for cleanup sheets.)
5. Expose enough sensi-strips for a single day's use. If the film is a dual emulsion film expose a strip on both sides if you are using a sensitometer that only exposes one side.
6. Wait at least ½ hour but not more than 4 hours before running all of the sensi-strips in the processors.
7. Process the strips—two per machine, thin end leading, in the same location.
8. Zero and calibrate the densitometer.
9. Read the three density patches and the base-plus-fog level from the two strips (for sensitometers requiring two exposures) from each processor and average the pairs of readings.
10. Plot the DD, MD, and B + F on the control charts.
11. Analyze the control charts carefully.
    a. Are all three points within the control limits?
    b. Are there any apparent trends?
12. If any single point (or points) falls outside of the control limits, run two more strips and verify that your first readings were correct.

Acceptance Limits

The acceptance limits on the DD and MD should be ±0.10 in density while the limit on the B + F should be +0.05. You may wish to use a slightly wider acceptance limit (±0.15 on the MD and DD) initially (for the first month) until you have all of your processors working in a stable condition.

Corrective Action

Corrective action is *required* if one or more data points falls outside of the control limits and *remains* outside of the control limits for a second set of test strips.

1. Be sure to verify the out-of-control condition with another set of sensi-strips *before* taking any corrective action.
2. Make the adjustments that you believe will bring the processor back into control.
   If control limits are exceeded check the following:
   a. Developer temperature
   b. Replenishment rates
   c. Water flow rates
   d. Water temperature (when appropriate)
   e. Recirculation
   f. Filters
   g. Batch mix dates
   h. Recent maintenance
   i. Film fog
   j. Transport time
   k. Control emulsion

   If trends are noted in the control charts check the following:
   a. Developer temperature
   b. Replenishment rates
   c. Change in the mix, types, and number of films being processed
   d. Proper mixing of replenisher
   e. Control emulsion age or fog (base-plus-fog tends to rise gradually as the film ages)
   f. Leaks or overflow from the fixer tank getting into the developer tank
   g. Gremlins
3. Make only one adjustment to the processor at a time.
4. After each change run another set of sensi-strips.
5. For future reference keep a log of the types of changes made (the amount the temperature was changed, for example), and the resultant change in the three control parameters.
6. When the processor is back in control, plot the new data points, circle all three of the points from the out-of-control strips, and record the adjustment made directly on the control chart in the space provided.

DAILY PHOTOGRAPHIC PROCESSOR QUALITY CONTROL

Problems and Pitfalls

Photographic processor quality control is probably the most difficult program to establish and operate properly. The photographic process is full of its own quirks, idiosyncracies, and pitfalls. Extreme care must be taken to follow the steps described exactly and to keep in mind all of the problems and pitfalls listed below. For further information and a more detailed discussion of photographic processor quality control and the associated problems, you should refer to the two-volume Bureau of Radiological Health publication on the topic (Gray, 1976, 1977).

1. Mercury or other liquid thermometers should never be used around photographic processors since the contents may contaminate the processor if the thermometers are broken. Digital thermometers or metal-stem dial thermometers are preferred.
2. The temperature in the developer tank should be taken in the same place each time. In addition, do not trust any thermometer that may be permanently installed in your processor since it may be more variable than your good quality control thermometer and it may not be accurately calibrated. (You can check the calibration of your thermometer against the standard thermometers used in the clinical laboratories.)
3. Many processors do not have adequate agitation of the solutions on the film's surface. This results in a directional effect caused by bromide drag. Bromide, a by-product of the development process, suppresses development and, if the dense end of a sensi-strip goes into the processor first, the larger quantities of bromide liberated will suppress the processing and the densities of the following strips.
4. Only a sensitometer should be used to expose your control strips. An x-ray generator is not repeatable enough to use for this purpose.
5. Sensi-strips aged more than a few hours may lose their ability to detect changes in the processor that may be apparent on freshly exposed radiographic or sensi-strips. However, it usually helps to age the strips for at least one-half hour after exposing them since this tends to decrease the amount of variability from strip to strip.
6. Film emulsion varies from batch to batch, and such variations may be considerable. Consequently, you should select enough film from the same emulsion batch to last at least 3 to 6 months. All of this film except the box that you are using should be stored, sealed in its original packaging, in a refrigerator or, preferably, a freezer in an area where you are sure it will not be exposed to scattered radiation, chemical fumes, or radioisotopes. [***Note:*** Be sure to remove a box of film from the freezer or refrigerator at least 48 hours before you wish to use it. This allows the box sufficient time to come to room temperature.]
7. When it is necessary to change to a new emulsion batch, you must "cross-over" the old and new emulsions and adjust the control limits appropriately. This is done by exposing at least six sensi-strips on the old emulsion and six on the new emulsion. These strips are processed in a processor that is known to be in good control, their densities read, and the averages of the old and new emulsion values for the MD, DD, and B + F determined. If there is any difference in the old and new emulsions then the operating levels are adjusted appropriately.
8. In addition to a reduction in the sensitivity to changes in the process condition of an exposed sensi-strip, all photographic emulsions exhibit a certain amount of latent image failure. This means that the film appears to be less sensitive if it is processed a period of time after it is exposed, or it appears less dense overall. This can create problems not only in quality control, but on the clinical level if you use equipment with a film receiver and do not process the films frequently.
9. Low-volume processors, those machines processing less than 25 to 50 14 × 17-inch (35 × 43-cm) radiographs or their equivalent in an 8-hour period, are probably the most difficult of all processors to control properly. See the Procedure section on "Flood Replenishment" below.
10. Replenishment rates are provided by the manufacturer for a specific film-developer combination processed at a specific temperature and usually in a specific processor. In addition, the rates are provided for a specific mixture of film sizes for a set number of film sizes and for a set number of films processed in an 8-hour working day. If your conditions deviate from the ones specified by the manufacturer in any way, it will be necessary to adjust your replenishment rates—but only if your control charts indicate that the replenishment rates are either too high or too low. Watch your control charts closely for trends and only make small corrections (15–20%) in your replenishment rates at any one time. After a correction has been made in the replenishment rates, monitor the processor for at least 1 week before making further changes.
11. In most areas, water filters are essential to assure optimum photographic processing. However, the filters become clogged, reducing the flow of wash water and the amount of water available to the temperature control system of the processor. A flowmeter located in the water line immediately before it enters the processor is essential. This should be monitored on a daily basis to assure that the water flow rate is that specified by the manufacturer of the processor.

Viewing Boxes

Viewing boxes should periodically be cleaned thoroughly both inside and out and checked visually for gross mismatches in either colour or brightness . Using an exposure meter the brightness level in the centre and each quadrant of the illuminated surface is measured. Then, with the viewing box switched off the ambient level of room illumination at a point roughly 30 cm. from the viewing box is assessed. These tests are performed under normal clinical viewing conditions.

The brightness of a viewing box at all points on its surface should not be less than 5500 lux. This for a film density of 1.0 placed on the viewing box the brightness of the illuminated film will be at least 550 lux. The level of illumination in the viewing room with all viewing boxes switched off should not be greater than 100 lux. This ensures that for all film densities encountered clinically the brightness of the illuminated film will exceed the ambient background illumination This ensures that the visual acuity of the eye is not being impaired by the background illumination level.

The effect of background illumination on visual acuity is easily demonstrated using an overhead projector on which is displayed an image containing low contrast detail. In normal room illumination the image projected on a screen will be hard to distinguish. However as the room illumination is decreased image detail improves markedly.