INDUSTREX Films

Film Types and Features

Film	Film Notching	Features and Customer Product Specifications	Classification	
			INDUSTREX M43ic Processor, INDUSTREX Single Part Developer Replenisher, 8 min at 26 °C (79 °F)	
			ASTM E1815	EN ISO 11699–1
DR50	1 wide trapezoidal + 1 narrow trapezoidal	• Ultra-fine grain • High contrast and excellent sensitivity • For critical radiography, especially with high voltage x-rays and gamma rays • Excellent for use in multi-films techniques	Special	C1
M100	Half-moon	• Ultra-fine grain • Medium speed, very high contrast, high definition (excellent sensitivity) • For critical radiography, such as weld inspection related to the nuclear industry	Class I	C2
MX125	Wide trapezoidal	• Ultra-fine grain • Medium speed, very high contrast, high definition • For a wide range of critical radiography such as aeroengine, weld, fabrication, investment castings and assemblies	Class I	C3
T200	Triple triangular	• Ultra-fine grain • Medium speed, high contrast • For a wide range of critical radiography such as weld fabrication, investment castings and assemblies • For use in multiple film radiography and in single film	Class I	C4
AA400	Double triangular	• Fine grain • High speed, high contrast • Suitable for weld and casting inspection • Often used in multiple film techniques	Class II	C5
HS800	Double triangle + wide trapezoidal	• Medium grain • High speed, high contrast with direct x-rays, with lead screens, with fluorescent or with fluorometallic screens • Suitable for low and high voltage equipment, and gamma sources • For concrete and heavy construction, offshore pipeline, and thick wall casting applications	Class III	C6
R400	Finished in China: Single V	• Fine grain • High speed, high contrast • Use in multiple film techniques	Class II	C5

NOTES:

- All INDUSTREX Films can be used with direct X-rays or with lead screens.
- High-speed HS800 can be used with direct X-rays, lead screens, fluorescent, or fluorometallic screens.
- Films are coated on a blue-tinted polyester support approximately 0.2 mm (7-mil) thick.

Film Types and Package Formats

The table provides the film types and suffixes, with more details below:

Sheets				Rolls			
Interleaved	Suffix 5	Pb Contactpak	Suffix 7	Ready Pack	Suffix 381	NIF Bulk	Suffix 359
Non-Interleaved	Suffix 1	READY-PACK II	Suffix 2	Lead Pack	Suffix 382		

NOTES:

- The INDUSTREX Films that are packaged in sheets are identifiable by an edge-mark/notch or embossing; **the sheets are uniquely marked for easy identification in the darkroom and after processing**. See the table on page 1 for film notches.
- Not all packaging formats are available for all INDUSTREX Films.

Sheet—Interleaved (INT) (suffix 5)

Each film is individually enclosed in a folder for extra protection during handling. For most sizes, the unit pack is 100 (2 x 50) sheets. Interleaving the film also helps prevent film sheets from sticking together if the film box has been opened in a hot or humid environment. The interleaving paper is often used to store the processed radiographs and to record relevant information such as exposure date, exposure conditions, and specimen number.

Sheet—Non-Interleaved (NIF) (suffix 1)

Supplied in packs of 100 sheets.

Sheet—Pb Contactpak (suffix 7)

This pack consists of a film placed between two 27 µm thick lead screens sealed in a light-tight, water-resistant, flexible package. A vacuum inside the pack provides superb film/screen contact. The package has a butt edge, which is invaluable for accurate positioning in difficult situations where the image needs to fall right up to the edge of the pack. Clean to use, water- and oil-resistant, and available for exposure immediately. Since the lead screens are only used once, optimal results are guaranteed.

Sheet—READY-PACK II (suffix 2)

These films are individually vacuum sealed in light-tight, water-resistant, flexible packages. The package has a butt edge, which is invaluable for accurate positioning in difficult situations where the image needs to fall right up to the edge of the pack.

Roll—Ready Pack (suffix 381)

The film is supplied in a long, light-tight roll placed between two polyethelene layers. The rolls are 90 m long in a variety of widths. The film is provided in a dispenser box and is cut to length by the user in a darkroom. A length indication in metres is printed in black on the packaging sleeve to be highly legible in the darkroom.

Roll—Lead Pack (suffix 382)

The film is placed between two 27 µm thick lead screens inside a long, light-tight paper and polyethelene sleeve. The rolls are 90 m long and are cut to length by the user in a darkroom. A length indication in metres is printed in black on the packaging sleeve to be highly legible in the darkroom. Since the lead screens are only used once, optimal results are guaranteed.

Roll—NIF Bulk (suffix 359)

The film is supplied on a cardboard core in rolls of 150 m long in various widths: 60 mm, 70 mm, 90 mm, and 100 mm. NIF bulk rolls 70 mm in width are also available in the 305 metre lengths. The film must be loaded into a cassette in a darkroom.

Storage

Unexposed:

10–24 ˚C (50–75 ˚F)

Do not refrigerate or freeze as this can cause condensation to occur.

30–50 % RH

Protect from heat and radioactive sources. Film is to be properly shielded from x-rays, gamma rays, or penetrating radiation.

Expiration:

Use film before the expiration date, which is identified on each film box. Also:

- Rotate inventory to use the older film first.
- Avoid storing unexposed film boxes for extended periods.

Do not reuse:

Do not reuse. Film is a single-use device.

Exposed: Keep cool, dry, and properly shielded from penetrating radiation. Process as soon as possible.

Processed: 16–27 ˚C (60–80 ˚F), 30–50 % RH

For more information, if needed:

- ASTM E1254 gives details of storage conditions of radiographs.
- For processed films, ISO 18911 and ISO 18902 provide recommended storage conditions and specifications for their enclosure materials.

Film Handling

- Hands must be clean, dry and free of lotions.
- Handle film carefully by the edges to avoid physical strains such as pressure, creasing, or buckling. Pressure to the film's surface can cause plus-density marks to develop. To avoid handling artifacts, carry a single sheet of film by the two opposite corners, or gently bend the film, but avoid pressing the areas of the film surface together.
- Avoid luminous watches, cell phone and darkroom light leaks.

Safelight Filter

The darkroom must have suitable safelight illumination.

Use a Red Safelight Filter, such as GBX-2, with a frosted 15-watt bulb or a LED Safelight (660 nm peak) located at least 1.22 m (48 in.) from the film.

NOTE: Other safelights filters that block radiation at 550 nm and shorter wavelengths may also be suitable.

Relative Exposure

Exposure Conditions: 8 mm Copper Filtration, HVL 3.5 mm Copper (220 kV), Lead screens

INDUSTREX Films	INDUSTREX Processor / INDUSTREX Chemicals
	8 minutes, 26 °C (79 °F)
DR50	7.2
M100	4.2
MX125	2.8
T200	1.7
AA400*	1.0
R400	1.0
HS800	0.5

* AA400 Film in 8 min 26 ˚C (79 ˚F) cycle is assigned a relative exposure of 1.0.

Relative Exposure for Various Energy Levels: 8 minutes, 26 ˚C (79 ˚F)

INDUSTREX Films	Relative Exposure for Various Energy Levels			
	ISO 120 kV*	EN 220 kV√	Iridium¥	Cobalt‡
DR50	9.0	7.2	9.0	9.0
M100	4.1	4.2	5.4	6.3
MX125	2.9	2.8	3.1	3.3
T200	1.6	1.7	1.9	1.9
R400**	1.0	1.0	1.0	1.0
AA400**	1.0	1.0	1.0	1.0
HS800	—	0.5	—	—

*In accordance with ISO 7004 standard, without lead screens

√In accordance with ISO 7004 standard, EN ISO 11699-1 lead screens

¥8 mm Copper filtration. 100/200 µm lead screens

‡100/200 lead screens

** R400 and AA400 Films are assigned a relative exposure of 1.0.

Recommended Processing Chemicals

The following formulas are designed for use with all INDUSTREX Films and CARESTREAM NDT film processors. They can be used with automatic or manual processing methods and can be used in chemical auto-mixers.

INDUSTREX Single Part Developer Replenisher

This formula is a universal single-part concentrate that provides easy mixing, is compatible with existing automatic processing cycles (8 minutes and longer), and allows a shorter processing cycle (5 minutes).

The formula ensures efficiency when using a low replenishment rate and reduces or minimizes operator maintenance due to crystallization, silver deposits, or sludge.

Features:

- High chemical stability—includes consistent image quality over an extended period of time, excellent resistance to aerial oxidation, and low sludge formation
- Minimal packaging, less solid waste
- Glutaraldehyde free
- Strengthened “activation power.” High activity allows for fast processing and high productivity
- Outstanding image quality—cold (blue) image “tone” and low granularity
- Low environmental impact—low COD and BOD5 (5-days Biochemical Oxygen Demand)

INDUSTREX LO Fixer and Replenisher

This formula consists of a single-part liquid—just add water to the proper dilution.

Features:

- Low odor
- Good radiograph life expectancy (LE)
- Low environmental impact—low COD and BOD5 (5-days Biochemical Oxygen Demand)

INDUSTREX DX Developer / INDUSTREX FX Fixer

Fully compliant with REACH, these formulas deliver outstanding performance and are environmentally friendly. The hydroquinone-free developer and borate-free fixer produce excellent results while minimizing the impact on the user and on the environment.

Features:

- Odor-free processing chemicals, pleasant to use without an undesired odor
- Concentrated solution in two 5 L containers makes 40 L of solution, minimizing packaging waste
- The polyethylene containers and cardboard packaging are both fully recyclable
- Less cleaning effort for silver deposits
- Shelf life of 24 months
- Processed film life expectancy is unaffected, to ensure secure archiving
- No transportation restrictions for road, rail, water, or air; temperature stable

Storing Solutions

To maintain product quality, these chemicals must be stored in the original unopened package, at a temperature between 5-30 ˚C (41-86 ˚F). When stored in these conditions, the lifetime is two years from the date of manufacture. Discard solutions if there is evidence of contamination, dirt, over-dilution, excessive evaporation, or crystallization.

Automatic Processing

Cycle Times and Temperatures

NOTE: Observe precautionary information on product labels and Material Safety Data Sheets.

Cycle	Time (Minutes)	Development Time (Seconds)	Temperature
M37 Plus Processor			
Normal	8	110	28 ˚C (82 ˚F)
Short	6	90	30.5 ˚C (90 ˚F)
M43ic Processor			
Normal	8	100	26 ˚C (79 ˚F)
Short	5	70	30 ˚C (86 ˚F)

Mixing the Chemicals

Follow the instructions on the packaging to mix the processing chemicals.

Auto-mixer Mixing

Remove the bottle caps (leaving the seal intact) and place the bottles in the auto-mixer template. The auto-mixer will add water to achieve the proper volume or a specific gravity, depending on the type/model of the auto-mixer. See the packaging for details.

Film Characteristics (Sensitometric)

Exposure Conditions—200/220 kV, ISO/EN Conditions, INDUSTREX Chemicals, INDUSTREX M43ic Processor

Cycle	DR50		M100		MX125		T200		AA400		HS800	
(Minutes)	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*
8 m, 26 ˚C (79 ˚F)	0.19	5.40	0.19	5.40	0.20	5.15	0.19	4.70	0.20	4.70	0.22	4.40
5 m, 30 ˚C (86 ˚F)	0.20	5.55	0.19	5.25	0.20	5.05	0.20	4.70	0.20	4.65	0.23	4.30

*Contrast calculated between net densities of 1.5 and 3.5.

Washing

Use a filtered water supply of proper water temperature, pressure and flow. Follow the processor manufacturer's recommendation for wash flow rate.

NOTES:

- Insufficient wash flow can adversely affect the life expectancy of processed radiographs. For best results, and to prevent development of bio-slime/algae, drain the wash tank daily and leave it empty when not in use.
- Proper installation is a critical component to the success of any processor. Benefits of proper installation include:
  - Film and image quality
  - Increased productivity, e.g. less time spent on repairs

- Refer to the INDUSTREX Processor Site Specifications, especially the environmental requirements.

Drying

Follow the processor manufacturer's recommendation for dryer settings. In general, the dryer should be set to a temperature slightly above the lowest temperature required to eliminate any signs of tackiness in films exiting the dryer (3 ˚C/5 ˚F).

Replenishment

The consistency of the radiographic quality is related to the accurate adjustment of the replenishment rate.

Replenishment should maintain the chemical equilibrium, replacing the components used by the film.

Solution	**Per 35 x 43 cm (14 x 17 in.) Sheet**	**Per m^2**
Developer	100 mL	665 mL
Fixer	180 mL*	1200 mL*

*For optimum radiograph life expectancy (LE), a 10 % increase in fixer replenishment rate may be desirable.

Manual Processing

To reach the desired optical density on a radiograph while achieving optimal radiographic image quality, it is important to follow recommended processing conditions and to use proper exposure (dose) for the selected film type and for the object being examined. Film characteristic curves can be used to:

- Adjust the X-ray exposure that is used to produce a radiograph with a certain optical density to an exposure that will produce a second radiograph of higher optical density.
- Relate the X-ray exposure produced with one film to the exposure needed to produce a radiograph of the same density with another radiographic film.

When using a Gamma source, you can use the INDUSTREX Film R-Factor Table to determine the correct exposure (based upon density desired – see the table on page 15). By removing the processing variable, you will get better consistency and higher productivity in the darkroom. INDUSTREX Films incorporating T-grain emulsion technology provide stable contrast and a relatively stable speed over a wider range of developer temperatures—unlike older film technologies that have highly variable speed, relative to developer temperature and immersion time.

Cycle Times and Temperatures

NOTE: Observe precautionary information on product labels and Material Safety Data Sheets.

Temperature	Development Time (Mins)	Stop Bath	Fixer	Wash
20 ˚C (68 ˚F)	5	30--60 seconds (Continuous moderate agitation)	3-6 mins or twice the time to clear film (Vigorous agitation for 15 seconds, then 5 seconds every 30 seconds)	10-30 mins in running water (8 volume changes per hour)
22 ˚C (72 ˚F)	4			
24 ˚C (75 ˚F)	3			
26 ˚C (79 ˚F)	2			

Stop, Fix and Wash Steps

	Temperature	Recommended Time	Agitation
Indicator stop bath, diluted 3.5% acetic acid solution, or running water rinse	16-30 ˚C (60-85 ˚F)	30 seconds	Moderate
INDUSTREX LO Fixer and Replenisher or INDUSTREX FX Fixer and Replenisher	16-30 ˚C (60-85 ˚F)	3-6 minutes, or twice the clearing time	Vigorous for 15 seconds, then intermittent (5 seconds) every 30 seconds)
Running water wash (8 volume changes per hour)	16-30 ˚C (60-85 ˚F)	10-30 minutes	

NOTES:

- If it is necessary to process film at temperatures around 24 ˚C (75 ˚F) and higher, then the fixer solution should be renewed frequently. The film should be fixed to provide maximum hardening and the washing time should be limited to 15 minutes.
- A rinsing (wetting) solution is recommended after washing to reduce water spots and drying marks.
- A stop bath checks development, prevents most spots and streaks, and prolongs the life of the fixing bath.

Timer and Thermometer

The timer and the thermometer are essential. They must be accurate and in good condition. Avoid adjusting development time (“sight developing”) to compensate for under- or over-exposed images.

Film Handling

Hands must be clean, dry and free of lotions. Do not bend the film. Handle the film only by the edges to avoid finger marks and abrasions when loading on hangers. Hangers must also be clean and dry. Separate hangers in the solutions so that the films will not touch each other or the tank wall.

Recommended Chemicals

- INDUSTREX Single Part Developer Replenisher
- New eco-friendly INDUSTREX DX Developer
- Use a stop bath to check development. A stop bath rapidly prevents most spotting or streaking and prolongs the life of the fixing bath. Use a stop bath mixed at a 3 % solution (for example, 28 % acetic acid at 110 mL/L) for 30 seconds.
  NOTE: A running water rinse for one minute may be substituted for a stop bath. However, it may not provide results equivalent to a stop-bath solution.
- Use a fixer, e.g. INDUSTREX LO Fixer and Replenisher or INDUSTREX FX Fixer.
- Use a final rinse solution/wetting agent to reduce water spots and drying marks on film.

Film Characteristics (Sensitometric)

Exposure Conditions—200/220 kV, lead screens, ISO/EN Conditions, INDUSTREX Single Part Developer Replenisher

Cycle	DR50		M100		MX125		T200		AA400		HS800	
(Minutes)	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*	Base + Fog	Con-trast*
8 m, 26 ˚C (79 ˚F)	0.20	5.10	0.19	5.00	0.19	5.00	0.20	4.80	0.25	4.20	0.23	2.60
5 m, 30 ˚C (86 ˚F)	0.20	5.00	0.19	5.30	0.19	5.10	0.20	4.80	0.20	4.30	_	_

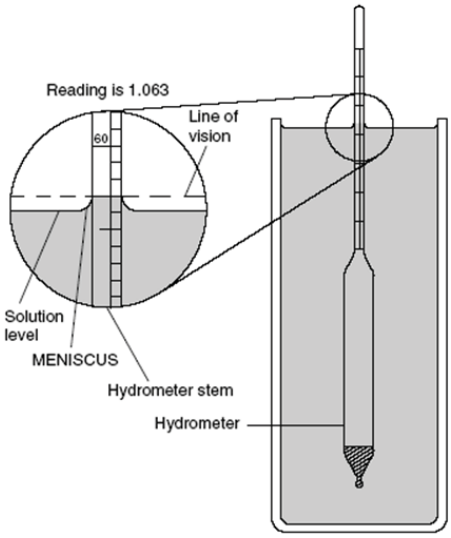
*Contrast calculated between net densities of 1.5 and 3.5.

Specific Gravity

Measurement of SpG of freshly prepared processing solutions can reveal mixing errors and can be easily accomplished with a graduated cylinder and an appropriate hydrometer.

To measure specific gravity:

1. Fill a clean, dry 250 mL graduated cylinder to within 2.5 cm (1 in.) of the top with the solution you are measuring.
2. Adjust the solution to the proper temperature (25 ˚C, 77 ˚F). Note that proper solution temperature is very important.
3. Place the cylinder in a sink or tray to catch overflow.
4. Choose the correct hydrometer to match the approximate specific gravity of the solution.
5. Be sure that the hydrometer is clean and dry. Carefully lower the hydrometer into the solution in the cylinder. Let it bob up and down slightly. When it stops, read the number at the top of the meniscus.
6. After making the measurement, discard the sample.
7. Rinse the hydrometer and graduated cylinder thoroughly with water.



Replenishment Rates

NOTE: Observe precautionary information on product labels and Material Safety Data Sheets.

Maintain the chemical activity and solution level in the tank by topping off the developer and fixer tanks daily or every 25 sheets (whichever occurs first). Stir solutions after each addition. Follow the manufacturer's instructions for the specific developer replenisher and fixer replenisher.

- When removing films from a developer tank, DO NOT ALLOW THE EXCESS SOLUTION TO DRAIN BACK INTO THE TANK. Normally, this will carry out the proper amount of solution for correct replenishment.
- Use floating covers on the developer tanks to reduce oxidation and evaporation. Store developer replenisher in a closed airtight container.
- Fill the developer and fixer tank to its original level each morning with developer or fixer replenisher solution. Periodically top off as necessary throughout the workday.
- Discard solution after adding two tank volumes of replenisher to the tank, or at least once per month, and then refill with fresh solution.
- Dry in a dust-free area at room temperature or in a suitable drying cabinet. Temperature in the drying area is not to exceed 50 ˚C (120 ˚F).

Ensuring Process Quality

Residual Thiosulfate Test

Use a test kit to ensure good life expectancy (LE) characteristics for radiographs. A test such as the X-OMAT Hypo Estimator Test Kit (CAT 196 5847) determines whether film has been adequately washed and provides an estimate of the archival life you can expect. The kit comes complete with testing solution, eyedropper, instructions for use, and a visual Hypo Estimator.

Residual Silver Test Solution

An overworked fixing bath contains complex silver thiosulfate compounds that cannot be removed completely from the processed film by washing. A residual silver test solution provides a quick and accurate method for determining when a fixing bath should be discarded. Prepare the test solution as follows:

Water	100 mL
Sodium Sulfide (Anhydrous)	2 g

To Use: Store stock solution in a small stoppered bottle for no longer than three months. Dilute one part stock solution with nine parts water. (Replace the working solution weekly.) Place a drop of the test solution on the margin of the processed film. Remove solution after 2-3 minutes. Any yellowing of the test area indicates the presence of silver. Refix the film in fresh fixer and rewash. The yellow stain is permanent.

Fixer Test Solution

A fixer test solution is used to check the silver content of the fixer bath. Prepare the test solution as follows:

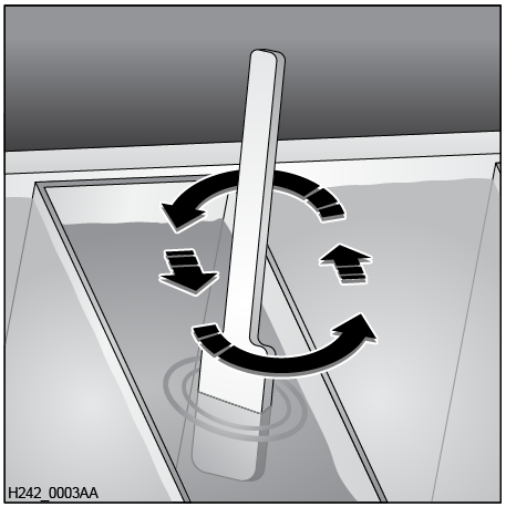
Water at 27 °C (80 °F)	750 mL
Potassium Iodide	190 g
Water to make	1 L

To five drops of the test solution, add five drops of the fixing bath and five drops of water. Discard the fixer if a yellow-white precipitate forms instantly. (You can disregard any slight milkiness.)

You can also use silver estimating test papers to measure the silver content in your fixer.

Step-by-Step Guide to Manually Processing INDUSTREX Films

1-Stir Solutions

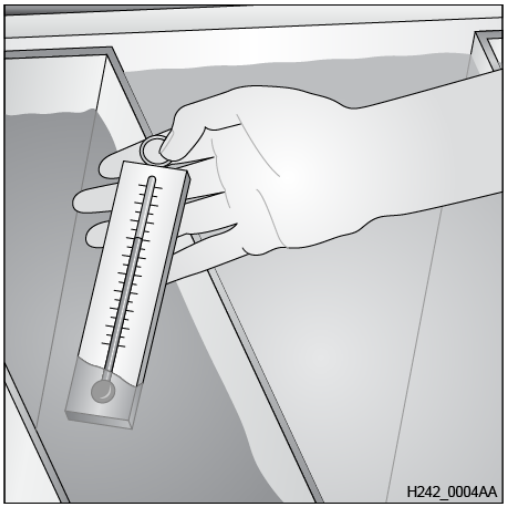


Stir the developer and fixer to equalize their temperatures.

Use separate paddles for each to avoid contamination.

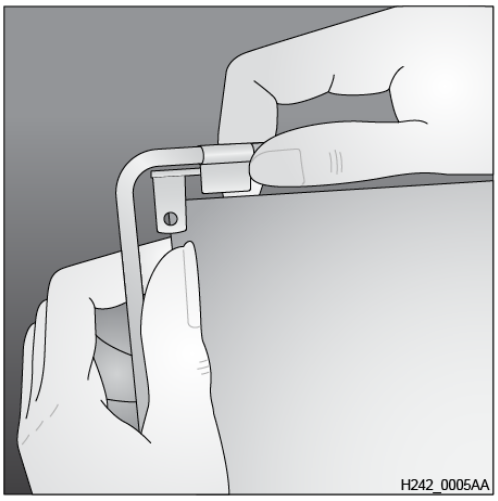
NOTE: Small amounts of fixer will contaminate developer and make it unusable.

2-Check Temperature



Check the temperature of the solutions with an accurate thermometer, rinsing it off after checking each one. Adjust the temperature as needed.

3-Load Film on Hanger

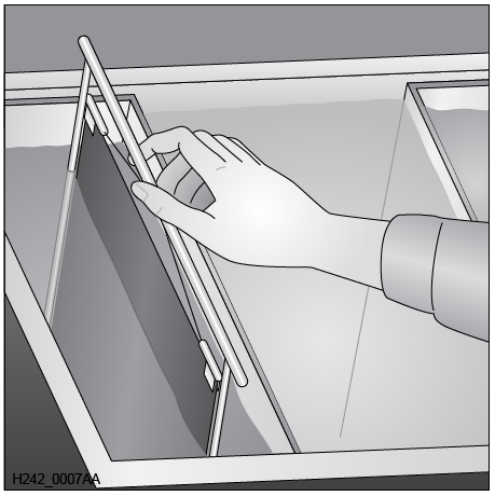


Attach the film carefully to a proper-sized hanger. Attach the lower corners first. Avoid finger marks, scratches or bending.

4-Set Timer for Developing

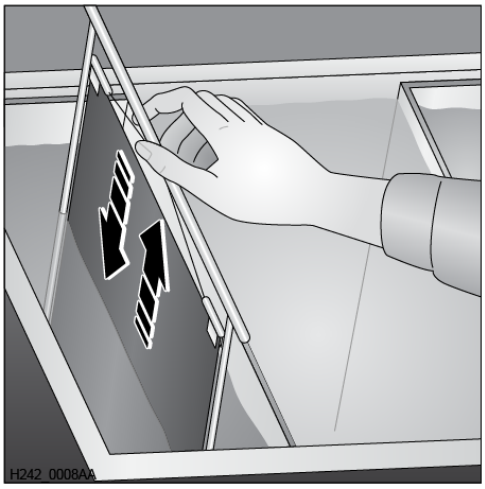
Set a timer for 4 minutes at 22 ˚C (72 ˚F). See time temperature table on page 8 for the equivalent cycle.

5-Immmerse Film in Developer



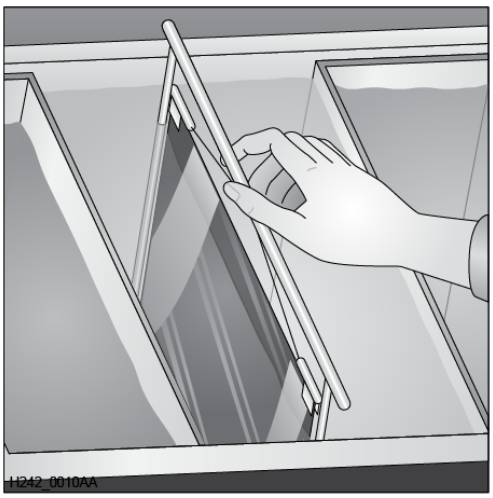
To avoid streaking, completely immerse the film smoothly and without pausing. Start the timer.

6-Agitate Film



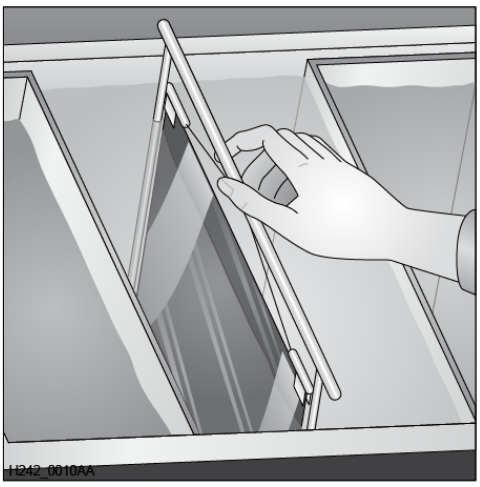
Immediately after immersion in the developer, tap the hanger to dislodge air bubbles. Do not agitate further.

7- Immerse in Stop Bath



When the timer ends, place the film in the stop bath for 30 seconds. Agitating moderately, lift from the stop bath and drain well.

8-Fix Adequately



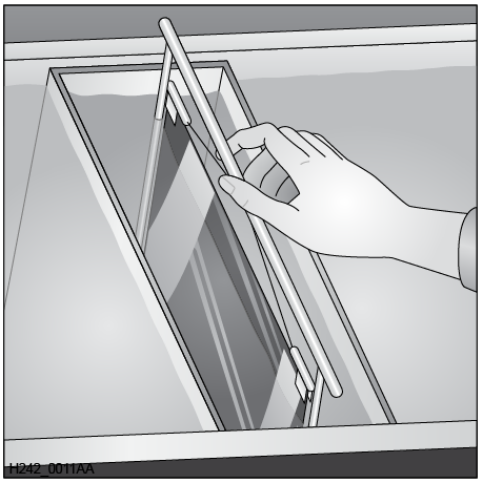
Immerse the film in the fixer for **3-6 minutes**, agitating for **5 seconds every 30 seconds**. Film should remain in fixer for twice the time it takes to "clear" it (when the milky look disappears).

Never fix film for less than 3 minutes.

9- Wash Completely

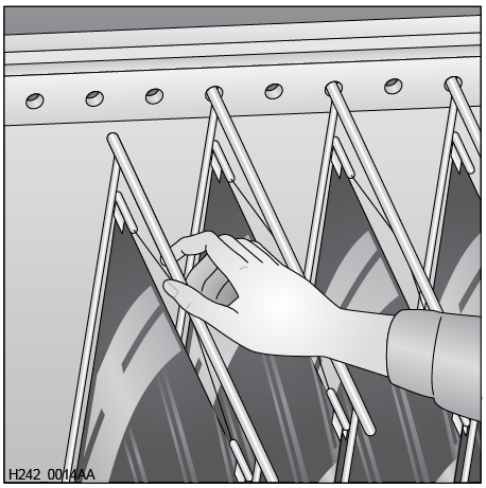
Place the film hangers in a tank of running water for **10-30 minutes**. Keep ample space between the hangers (water must flow over the top).

10-Final Rinse



If facilities permit the use of an additional tank, use a final rinse with a rinsing (wetting) agent to speed drying and prevent water marks. Immerse film for about 30 seconds, and then drain for several seconds.

11- Place in Dryer



Dry the film at room temperature in a dust-free area or suitable drying cabinet. The temperature must not exceed 49 ˚C (120 ˚F). When the film is dry, remove from hangers and insert into envelopes.

INDUSTREX Film R-Factor Table for Gamma Exposures

Reference the table to determine the correct exposure, based on desired density:

	Desired Densities:	2	2.5	3	3.5
Selenium	M100	3.6	4.6	5.5	6.5
	MX125	2.2	2.9	3.6	4.4
	T200	1.4	1.8	2.2	2.6
	AA400	0.8	1.2	1.6	2
	HS800	0.3	0.6	0.8	1
Iridium	M100	3.2	4.3	5.5	6.6
	MX125	2.3	3.1	3.9	4.7
	T200	1.1	1.5	2	2.4
	AA400	0.8	1.1	1.5	1.9
	HS800	0.2	0.5	0.7	0.9
Cobalt	M100	7.3	9.3	11.4	13.4
	MX125	3.9	5.3	6.7	7.9
	T200	2.3	3.1	3.9	4.7
	AA400	1.2	1.8	2.4	2.9
	HS800	0.1	0.6	1	1.4

Typically, film R-factors are used with a film exposure calculator tool to estimate the duration of exposure to achieve the desired film density. The above set were based on development time of 4 minutes and a developer temperature of 22 ˚C (72 ˚F).

NOTE: These film factors are starting points only. Users should adjust these factors as differences in processing temperature, chemical age, and other conditions can introduce variability.

Characteristic Curves – INDUSTREX Films

Film characteristic curves can be used to:

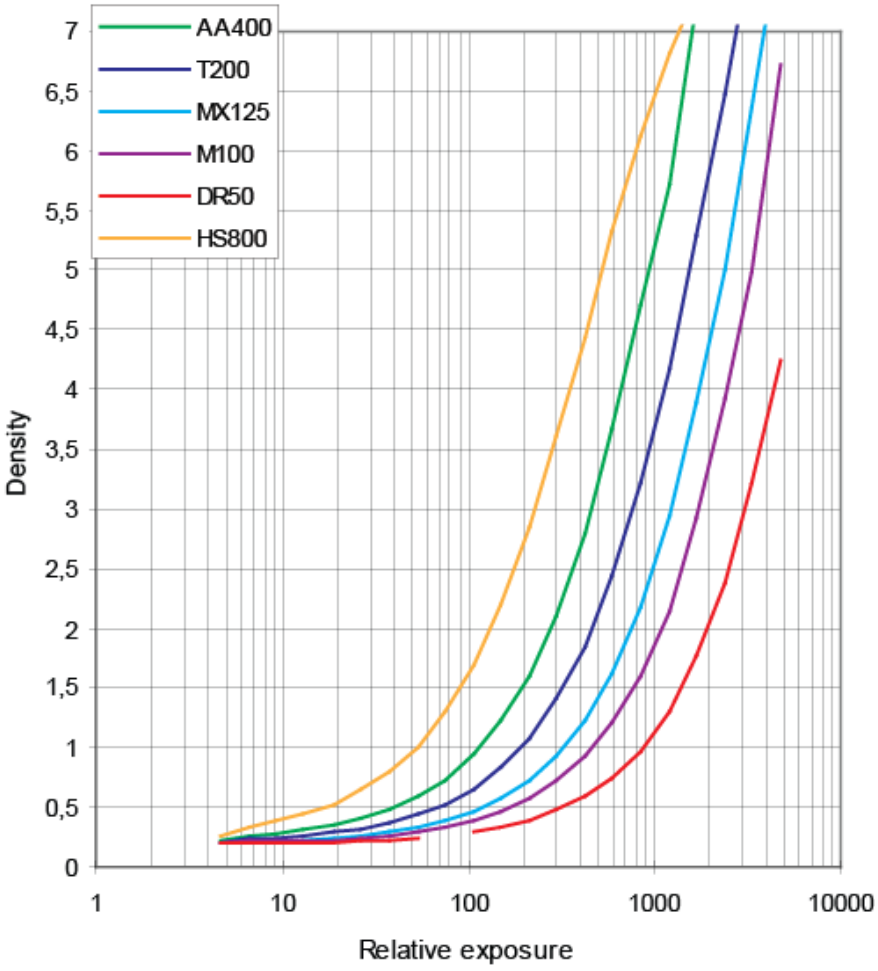
- Adjust the X-ray exposure that is used to produce a radiograph with a certain optical density to an exposure that will produce a second radiograph of higher optical density.
- Relate the X-ray exposure produced with one film to the exposure needed to produce a radiograph of the same density with another radiographic film.

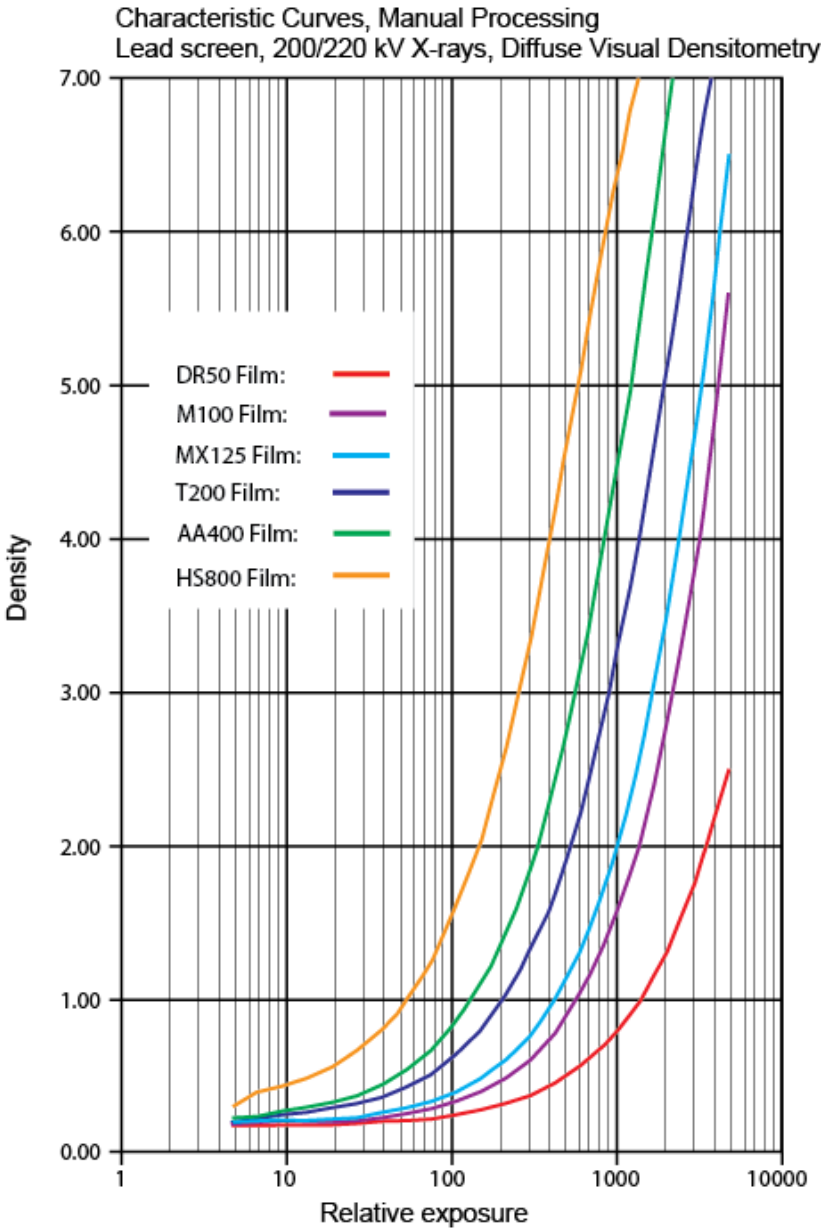
When using a gamma source, you can use R-Factors (see the table above) to determine the correct exposure.

Film Contrast is the slope, or steepness of the characteristic curve. For industrial X-ray films, the contrast increases throughout the useful density range.

- Automatic Processing: 8 minutes, 26 ˚C (79 ˚F)
- Manual Processing: 5 minutes, 20 ˚C (68 ˚F)

INDUSTREX M43IC processor (Automatic Processing)
Lead screen, EN ISO 11699-1 exposures





NOTE: While the sensitometric data in this publication are typical of production coatings, they do not represent standards that must be met by Carestream. Varying storage, exposure, and processing conditions will affect results. The company reserves the right to change and improve product characteristics at any time. The contents of this publication are subject to change without notice.

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Rev B, 2021-08: Updated the manual processing steps. Added explanation to the R-factors table. Released in PLI.
Rev C, 2024-01: Removed “no notch” and country of origin in the table on page 1.