Designation: E999 – 15

Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing[1]

This standard is issued under the fixed designation E999; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide[2] establishes guidelines that may be used for the control and maintenance of industrial radiographic film processing equipment and materials. Effective use of these guidelines aid in controlling the consistency and quality of industrial radiographic film processing.

1.2 Use of this guide is limited to the processing of films for industrial radiography. This guide includes procedures for wet-chemical processes and dry processing techniques.

1.3 The necessity of applying specific control procedures such as those described in this guide is dependent, to a certain extent, on the degree to which a facility adheres to good processing practices as a matter of routine procedure.

1.4 If a nondestructive testing agency as described in Practice E543 is used to perform the examination, the testing agency shall meet the requirements of Practice E543.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of federal and local codes prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E94 Guide for Radiographic Examination

E543 Specification for Agencies Performing Nondestructive Testing

E1079 Practice for Calibration of Transmission Densitometers

E1254 Guide for Storage of Radiographs and Unexposed Industrial Radiographic Films

E1316 Terminology for Nondestructive Examinations

2.2 *ISO Standards:*[4]

ISO 11699-2 Nondestructive testing—Industrial Radiographic Film—Part 2: Control of film processing by means of references values.

ISO 18917 Photography—Determination of residual thiosulfate and other related chemicals in processed photographic materials—Methods using iodine amylose, methylene blue, and silver sulfide

2.3 *ANSI Standards:*

IT 2.26 Photography—Photographic Materials– Determination of Safelight Conditions[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, see Terminology E1316.

4. Significance and Use

4.1 The provisions in this guide are intended to control the reliability or quality of the image development process only. The acceptability or quality of industrial radiographic films processed in this manner as well as the materials or products radiographed remain at the discretion of the user, or inspector, or both. It is further intended that this guide be used as an adjunct to and not a replacement for Guide E94.

5. Chemical Mixing for Manual and Automatic Processes

5.1 Any equipment that comes in contact with processing solutions should be made of glass, hard rubber, polyethylene, PVC, enameled steel, stainless steel, or other chemically inert materials. This includes materials such as plumbing, mixing impellers, and the cores of filter cartridges. Do not allow materials such as tin, copper, steel, brass, aluminum, or zinc to come into contact with processing solutions. These materials can cause solution contamination that may result in film fogging or rapid oxidation.

5.2 *Mixing Chemicals:*

[1] This guide is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) Method.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SE-999 in Section II of that Code.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

5.2.1 Do not mix powdered chemicals in processor tanks, since undissolved particles may be left in the square corners of the tank. Mix solutions in separate containers made from materials specified in 5.1.

5.2.2 Carefully follow the manufacturer's package directions or formulas for mixing the chemicals. Start with the correct volume of water at the temperature specified in the instructions, and add chemicals in the order listed. During the mixing and use of radiographic film processing chemicals, be sure to observe all precautionary information on chemical containers and in instructions.

5.2.3 Proper mixing of chemicals can be verified with measurements of pH and specific gravity.

5.3 *Contamination of Solutions:*

5.3.1 Thoroughly clean all mixing equipment immediately after use to avoid contamination when the next solution is mixed. When mixing fixer from powder, make sure to add the powder carefully to the water in the mixing tank so fixer dust does not get into other processing solutions. When mixing any chemical, protect nearby tank solutions with floating lids and dust covers. The use of a vent hood is recommended as a safety precaution.

5.3.2 The water supply should either be de-ionized or filtered to 50 microns or better, so it is clean and sediment-free.

5.3.3 If large tanks are used for mixing, carefully mark the volume levels to be certain that volumes are correct.

5.3.4 Use separate mixers for developer solution and for fixer solution. If only one mixer is available, thoroughly rinse the mixer after each mix to avoid cross-contamination of chemicals. Use of impeller-type mixers provides rapid, thorough mixing. When positioning the impeller special caution should be taken in choosing angle and depth to minimize the amount of air being drawn into the solution. Over-mixing of the solutions can cause oxidation, especially with developers, and should be avoided. Rinse the shaft, impeller, and mounting clamp with water after use.

5.4 *Maintaining Equipment:*

5.4.1 Immediately clean all mixing equipment after use.

5.4.2 In addition to cleaning equipment immediately after use, wash any mixing apparatus that has been idle for a long period of time to eliminate dust and dirt that may have accumulated.

5.4.3 Processing hangers and tanks should be free of corrosion and chemical deposits. Encrusted deposits that accumulate in tanks, trays, and processing equipment which are difficult to remove by conventional cleaning, can be removed by using the specially formulated cleaning agents recommended by the chemical or equipment manufacturer.

6. Storage of Solutions

6.1 *In Original Containers*—Follow the manufacturer's storage and capacity recommendations packaged with the chemicals. Do not use chemicals that have been stored longer than recommended.

6.2 *In Replenisher or Process Tanks*—Wherever possible, protect solutions in tanks with floating lids and dust covers. In addition to preventing contaminants from entering solutions, floating lids and dust covers help to minimize oxidation and evaporation from the surface of the solutions. Evaporation can concentrate solutions and reduce temperatures causing precipitation of some of the solution constituents.

6.2.1 Store replenisher solutions for small volume operations in airtight containers. The caps of these containers should be free of corrosion and foreign particles that could prevent a tight fit.

6.3 *Temperature*—Store all solutions at normal room temperature, between 40 to 80°F (4 to 27°C). Storing solutions, particularly developer, at elevated temperatures can produce rapid oxidation resulting in loss of activity and a tendency to stain the film. Storage at too low a temperature, particularly of fixer solutions, can cause some solutions to crystallize, and the crystals may not redissolve even with heating and stirring.

6.4 *Deterioration*—Radiographic film processing chemicals can deteriorate either with age or with usage. Carefully follow the manufacturer's recommendations for storage life and useful capacity. Discard processing solutions when the recommended number of films has been processed or the recommended storage life of the prepared solution has been reached, whichever occurs first.

6.5 *Contamination:*

6.5.1 Liquid chemicals are provided in containers with tight-fitting tops. To avoid contamination, never interchange the top of one container with another. For this reason, it is common practice for radiographic film processing chemicals manufacturers to color code the container tops, that is, red for developer and blue for fixer.

6.5.2 Clearly label replenisher storage tanks with the solution that they contain and use that container only with that solution. If more than one developer or one fixer formulation are being used, a separate replenisher tank should be dedicated to each chemical. Differences in developer or fixer formulations from one manufacturer to another may contaminate similar solutions.

7. Processing

7.1 *Manual Processing:*

7.1.1 Follow the temperature recommendations from the film or solution manufacturer. Check thermometers and temperature-controlling devices periodically to be sure the process temperatures are correct. Process temperatures should be checked at least once per shift. Keep the temperature of the stop (if used), fixer, and wash water within ±5°F (±3°C) of the developer temperature. An unprotected mercury-filled thermometer should never be used for radiographic film processing applications because accidental breakage could result in serious mercury contamination.

7.1.2 Control of processing solution temperature and immersion time relationships are instrumental considerations when establishing a processing procedure that will consistently produce radiographs of desired density and quality. The actual time and temperature relationships established are governed largely by the industrial radiographic films and chemicals used and should be within the limits of the manufacturer's recommendations for those materials. When determining the immersion time for each solution ensure that the draining time is

included. Draining time should be consistent from solution to solution. The darkroom timers used should be periodically checked for accuracy.

7.1.3 Agitate at specified intervals for the times recommended by the film or solution manufacturer.

7.1.4 As film is processed, the components of the processing solutions involved in the radiographic process are consumed. In addition, some solution adheres to the film and is carried over into the next solution while bromide ions and other by-products are released into the solutions. Replenishment is carried out to replace those components which have been consumed while, at the same time, reducing the level of by-products of the process. The volume of replenishment necessary is governed primarily by the number, size, and density of films processed. Manufacturer's recommendations for replenishment are based on these criteria and will generally provide suitable results for the expected life of the solution. In any case, maintain solution levels to ensure complete immersion of the film.

7.1.5 Newly mixed chemicals are often referred to as "fresh." "Seasoning" refers to the changes that take place in the processing solutions as films are processed after fresh chemicals have been added to the processor. As the processing solutions season, provided they are replenished appropriately, they will reach chemical equilibrium and the film speed and contrast will be consistent and stable. To bring freshly mixed solutions to a seasoned state very quickly, a chemical starter can be added or exposed films can be processed. When using developer starter solution follow the manufacturer's recommendations for the product. When using seasoning films expose the films with visible light and then develop three 14 by 17-in. (35 by 43-cm) films, or equivalent, per gallon (3.8 L) of developer, following the manufacturer's recommended processing cycle, replenishment, and wash rates.

NOTE 1—Seasoning films may be new films or films that may not be generally suitable for production purposes due to excessive gross fog (base plus fog) density, expiration of shelf life, or other reasons.

7.1.6 Handle all films carefully during the processing cycle and allow adequate time for the film to sufficiently drain before transferring it to the next solution. The use of a stop bath or clear water rinse between developing and fixing may also be appropriate. The stop bath or clear water rinse serve to arrest development and also aids in minimizing the amount of developer carried over into the fixer solution. Insufficient bath-to-bath drain time may cause excessive solution carryover which can contaminate and shorten the life of solutions in addition to causing undesirable effects on processed radiographs.

7.1.7 When washing films, a wetting agent may be appropriate to use to prevent water spots and streaking during drying. Prior to placing films in the dryer, ensure that the dryer is clean and that adequate heat and ventilation are provided. During drying, visually examine the films to determine the length of time required for sufficient drying.

7.2 *Automated Processing:*

7.2.1 Immersion time and solution temperature relationships can be more closely controlled with automatic processing since the equipment provides external gages for monitoring purposes. As a general guideline, follow the manufacturer's recommendations for industrial processing materials. However, the actual procedure used should be based on the variables encountered by the user and his particular needs. Check solutions daily or with established frequency based upon usage to ensure that temperatures are within the manufacturer's recommendations. Check the processor's thermometer with a secondary thermometer during normal maintenance procedures to verify correct processing temperatures within the manufacturer's specifications.

7.2.2 Transport speed should be checked during normal maintenance procedures by measuring the time it takes for a given length of film to pass a specific point. (For example, if the indicated machine speed is 2 ft/min, place two marks on a length of film 1 ft apart. The second mark should pass a specific location, such as the entrance to the processor, exactly 30 s after the first mark has passed the same point.) An optional method for measuring processor speed is to install a tachometer on the main drive motor and determine desired RPM/processing speed relationships.

7.2.3 Agitation is provided by the action of the processor rollers, recirculation pumps, and wash water flow. No external agitation is needed.

7.2.4 For processors with replenishment systems, use the replenishment rates recommended by the film or solution manufacturer.

7.2.4.1 Accurate replenishment increases the useful life of solutions to a great extent by replacing ingredients that are depleted and maintains the process at a constant, efficient level.

7.2.4.2 Replenishment rates should be verified during normal maintenance procedures to ensure that the correct volumes are being injected into the solutions. For installations processing very large amounts of film (in excess of two tank turnovers of solution per week), checks on replenishment rates should be made more frequently. Processor manufacturer's recommendations will generally provide an adequate procedure for checking replenishment volumes.

7.2.5 For seasoning freshly mixed developer solution, refer to the provisions in 7.1.5.

7.2.6 Always fill the fixer tank first, following the manufacturer's instructions, then rinse and fill the developer tank. This minimizes the possibility of fixer accidentally splashing into the developer solution. When replacing or removing processor racks, always use a splash guard to further reduce the possibility of contamination.

7.2.7 *Drying:*

7.2.7.1 Make sure the dryer is clean and that no foreign material has settled on the rollers. Routinely examine the ventilation system to ensure that air paths are not blocked and that films are uniformly dried. There are two types of dryer systems used in automatic film processors for industrial radiographic films:

(1) Convection dryers are circulating air systems with thermostatic controls. Normal drying temperatures range from 80 to 120°F when relative humidity (RH) conditions are approximately 40 to 75 %. Relative humidities above 75 % may require higher temperatures.

(2) Infrared (IR) dryers are based principally on absorption rather than temperature. Relative humidity has no adverse affect on infrared drying. Infrared energy levels are preset by the manufacturer and provide a range of dryer settings.

7.2.7.2 The dryer efficiency can be tested by processing six consecutive 14 by 17-in. (35 by 43-cm) production films, or equivalent and examining them immediately after the drying cycle is complete. If damp or undried areas are observed, increase the dryer setting. Should an increase in dryer temperature for convection dryers or an increase in energy for infrared dryers not dry the film, the following conditions should be investigated:

(1) Wash water that is too warm will cause excessive emulsion swelling. This can adversely affect film drying in convection dryers.

(2) Incoming dryer air that is either too humid or too cold can adversely affect film drying in the convection dryer.

(3) Check if oven-temperature devices or IR radiators, or both, are operational in infrared dryers.

(4) The fixer solution activity may not be in accordance to manufacturing recommendations and should be tested in accordance with 8.6.

8. Activity Testing of Solutions for Manual and Automatic Processing

8.1 *Certified Pre-exposed Control Strips*—The processing system can be controlled by use of certified pre-exposed control strips as specified by ISO 11699-2. Certified pre-exposed control strips are commercially available. Certified pre-exposed control strips are exposed to X-rays and are accompanied by a certificate from the film control strip manufacturer. Certified pre-exposed strips should be the same brand used in the facilities processing system. After processing, speed and contrast indexes are determined and compared to the reference speed and contrast values provided on the certificate.

8.2 Electronic sensitometers that expose film to white light are also commercially available. The user of electronic sensitometers should be aware that such usage, when accompanied by an appropriate white-light sensitive industrial film, results in greater response. Consequently, maintenance of developing parameters must be at a higher and more frequent level.

8.3 *Radiographic Monitoring Films*—To establish a reliable procedure for determining the activity of processing solutions, it will be necessary to provide a minimal amount of equipment and the proper selection and storage of radiographic control films. Radiographic films are made in batches where the characteristics may vary slightly between batches. These changes from emulsion to emulsion may be detectable and could be confused with the changes in the radiographic processing system.

8.3.1 *Sensitometric Step Tablets*—A metallic step wedge or other suitable object(s) of uniform material and varying thickness(es), of either aluminum or steel can be used with a given X-ray or gamma-ray exposure to create a sensitometric control strip. ISO 11699-2 describes the exposure of metallic step wedges for the production of sensitometric control films and the design of metallic step wedges.

8.3.2 Monitoring films must be properly stored to ensure that the film characteristics of the first sheet will be the same as the last sheet used. See Guide E1254

8.3.3 A monitoring film should be the same brand and type predominantly used in the facility's processing system

8.3.4 The first sensitometric film processed through freshly mixed and seasoned chemicals (see 7.1.5) will become the reference or standard for a box of control film.

8.3.5 Subsequent monitoring films are then produced on an as-needed basis and compared to the reference film to determine sensitometric changes within the processor. Generally, the higher the film volume processed, the more often QA checks should be performed.

8.3.6 If a monitoring film produces unusually high or low densities exceeding the tolerance limits, then the processing and sensitometric exposure conditions should be rechecked and repeated, if necessary. If the results are still out of tolerance, the cause must be located and corrected. Generally, a small adjustment in replenishment rates is necessary until a sensitometric film processor activity balance is established

8.3.7 Whenever it becomes necessary to change a monitoring film from one emulsion to another, two films each (from the new box and the old box) should be exposed and processed simultaneously to adjust for normal film manufacturing sensitometric variations.

8.4 *Densitometer:*

8.4.1 A transmission densitometer should be used capable of reading densities within the allowable range of optical densities utilized in production radiographs, with an aperture on the order of 1.0 to 3.0 mm in diameter. The densitometer should be calibrated in accordance with Practice E1079.

8.5 *Developer:*

8.5.1 The developer activity should be checked by processing a pre-exposed sensitometric strip, a radiograph of a step wedge, or a test part for measuring four film densities, one at base + fog (unexposed area of film) and three between 1.5 and 4.0 in three areas of interest (high, medium, and low densities). These four areas are also known as the Aim Film densities.

8.5.2 The film densities in the areas of interest being monitored should be within ±10 % of the original monitoring film density. Variations within this range are generally considered normal and should not adversely affect radiographic quality.

8.6 *Fixer:*

8.6.1 Fixer solution activity can be determined by measuring the clearing time. After the fixer solution has reached an operating temperature, place an unprocessed X-ray film into the fixer solution and measure the time required to remove the silver halide crystals; this is known as the clearing time. Removal of the X-ray film silver halide crystals can be observed when the X-ray film turns from a reflective color to a clear translucent film in the fixer. The film should remain in the fixer solution for twice the amount of time necessary for it to become clear. The film should be periodically agitated during manual processing.

8.6.2 If physical examination shows unfixed spots or areas, the fixer should be discarded. Unfixed areas may appear as

dull, nonreflective areas that may be yellowish in color depending on the actual lack of fixer activity.

8.7 *Wash:*

8.7.1 Proper washing is necessary to remove residual fixer from the film. If not removed from the film, these chemicals will cause subsequent damage (staining) and deterioration of the radiographic image, especially in low-density areas.

8.7.2 The effectiveness of washing may be checked using the *residual thiosulfate chemicals* test described in Guide E94 or ISO 18917.

8.7.3 If physical examination of the films after washing shows dirt or scum that was not present before washing, the wash tanks should be drained and cleaned. Drain wash tanks whenever they are not being used. In order to minimize washing artifacts it is recommended that *"cleanup" films* be processed at start up to clear out scum and foreign material. *"Cleanup" films* are commercially available. The use of algaecides is also recommended to retard the growth of organisms within the wash bath.

8.7.4 The newer cold-water-type processors do not require a control valve to regulate water temperatures. However, many older-type processors require that the incoming water temperature be set within certain limits of the developer temperature. Exceeding these limits may not allow the processor to adequately control the developer temperature, which may cause density variations.

8.8 *Safelights:*

8.8.1 Follow all safelight recommendations for the particular film being used. Refer to the product or manufacturer's instructions for recommended safelight filter, bulb wattage, and minimum safelight distance.

8.8.2 The sensitivity of most film emulsions does not end abruptly at a particular wavelength – most emulsions are somewhat sensitive to wavelengths outside the intended range, including wavelengths transmitted by the recommended safelight filter. Therefore, always minimize the exposure of photographic materials to safelight illumination. Safelight conditions can be tested and verified as prescribed in ANSI IT 2.26.

9. Records

9.1 Accurate records should be kept of the following items:

9.1.1 Brand name and model of processor, if used.

9.1.2 Brand names and batch number of chemicals used.

9.1.3 Time of development.

9.1.4 Temperature of processing chemicals.

9.1.5 Date new chemicals were placed in use.

9.1.6 Replenishment rates.

10. Maintenance

10.1 Maintenance schedules provided by the manufacturer for preventive maintenance should be adhered to in order to assure consistent chemical and mechanical operation as set forth by the manufacturer.

11. Keywords

11.1 automatic processing; film; manual processing; processing; radiographic; solutions