Designation: E2669 – 22

Standard Digital Reference Images for Titanium Castings[1]

This standard is issued under the fixed designation E2669; 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 The digital reference images provided in the adjuncts to this standard illustrate various types and degrees of discontinuities occurring in titanium castings.[2] Use of this standard for the specification or grading of castings requires procurement of the appropriate adjunct digital reference images, which illustrate the discontinuity types and severity levels. They are intended to provide the following:

1.1.1 A guide enabling recognition of titanium casting discontinuities and their differentiation both as to type and degree through digital radiographic examination.

1.1.2 Example digital radiographic illustrations of discontinuities and a nomenclature for reference in acceptance standards, specifications and drawings.

1.2 The digital reference images consist of twenty-five digital files each illustrating eight grades of increasing severity. The Volume I files illustrate seven common discontinuity types representing casting sections up to 1 in. (25.4 mm). The Volume II files illustrate five discontinuity types representing casting sections over 1 in. (25.4 mm) to 2 in. (50.8 mm) in thickness.

1.3 All areas of this standard may be open to agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization. These items should be addressed in the purchase order or the contract.

NOTE 1—The digital reference images are available from ASTM International Headquarters. Order number RRE2669 and RRE266902. Each of the digital reference images contain an image of a step density scale and two duplex-wire gauges. Refer to Practice E2002 for wire pair details. Originally, only Volume I images were available and some sets may identify these only as RRE2669 without a volume designation. They remain valid for use as Volume I images.

1.4 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 These digital reference images are not intended to illustrate the types or degrees of discontinuities when performing film radiography. If performing film radiography of titanium castings, refer to Reference Radiographs E1320.

1.6 Only licensed copies of the software and images shall be utilized for production inspection. A copy of the ASTM/User license agreement shall be kept on file for audit purposes.

1.7 *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 regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E1316 Terminology for Nondestructive Examinations

E1320 Reference Radiographs for Titanium Castings

E2002 Practice for Determining Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy

2.2 *SMPTE Practice:*[4]

RP133 SMPTE Recommended Practice Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard-Copy Recording Cameras

[1] These digital reference images are under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and are the direct responsibility of Subcommittee E07.02 on Reference Radiological Images.

Current edition approved Dec. 1, 2022. Published January 2023. Originally approved in 2010. Last previous edition approved in 2016 as E2669 – 16ε1. DOI:10.1520/E2669-22.

[2] The digital reference images are considered to be applicable to all titanium castings, requiring close tolerances. Castings for which these images are applicable generally include those made by the lost wax, frozen mercury, ceramicast or shell mold processes.

[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 Society of Motion Picture and Television Engineers, 3 Barker Avenue, White Plains, NY 10601; or www.smpte.org/smpte_store/

*A Summary of Changes section appears at the end of this standard

2.3 *ASTM Adjuncts:*
Digital Reference Images for Titanium Castings:
Volume I: Applicable for Thicknesses up to 1 in. (25.4 mm)[5]
Volume II: Applicable for Thicknesses over 1 in. (25.4 mm) to 2 in. (50.8 mm)[6]

3. Terminology

3.1 *Definitions*—Definitions of terms used in this standard may be found in Terminology E1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 The terms relating to discontinuities used in these digital reference images are described based upon radiographic appearance when viewed in the negative polarity such that the images appear in the same sense as they would when viewed on X-ray film. If images are viewed in the positive polarity, the terms lighter and darker will need to be reversed.

3.2.2 *aliasing, n*—artifacts that appear in an image when the spatial frequency of the input is higher than the output is capable of reproducing. This will often appear as jagged or stepped sections in a line or as moiré patterns.

3.2.3 *contrast normalization, n*—the adjustment of contrast between the production image and the reference image that makes the change in digital driving level versus change in thickness equal for both images.

3.2.4 *foreign material, less dense, n*—appear as dark indications in a variety of shapes and sizes on a digital image. Inclusions may be found in groups or appear singularly. Less dense inclusions can be caused by contaminants in the molten titanium, residual materials left on the surface of the mold, or broken pieces of the mold becoming entrapped during solidification.

3.2.5 *foreign material, more dense, n*—appear as light indications in a variety of shapes and sizes on a digital image. More dense inclusions can be caused by contaminants introduced in the same manner as less dense inclusions, or tungsten introduced during weld repairs.

3.2.6 *gas, n*—gas in its various forms is usually caused by the reaction of molten titanium with the mold or residual material left in the mold. Gas tends to migrate to the upper portions of the casting. The formation of clustered or scattered gas holes results from the generation of larger amounts of gas than a single gas hole. Whether the larger amount of gas spreads out or is confined to a small area is dependent upon a number of factors including casting process, reaction area, solidification rate, wall thickness, and geometry.

3.2.6.1 *clustered gas holes, n*—a closely nested group of dark round voids concentrated within a self-defined boundary area.

3.2.6.2 *gas holes, n*—spherical voids formed through the release and subsequent entrapment of gas during solidification. A gas hole will appear as a dark round spot on the digital image.

3.2.6.3 *scattered gas holes, n*—multiple voids appearing as dark round spots on the digital image. They are randomly spread throughout a part or area of a part to a lesser concentration than clustered gas holes but with the potential to degrade the casting through their interaction which precludes their evaluation on an individual basis.

3.2.7 *shrinkage, n*—while at times the appearance of shrinkage in titanium may be radiographically similar to shrinkage in steel, the faster solidification rate of titanium has a dramatic effect on the conditions under which each shrinkage type will occur in titanium. Other factors which influence the formation of shrinkage are wall thickness and thickness transition gradients, gate size and orientation, mold design, casting configuration, metal/mold temperature, and pouring rate and method. All the types of shrinkage described in 3.2.7.2 through 3.2.7.3 have a degree of overlap. However, each is most likely to occur under a specific set of conditions primarily influenced by metal feed, section thickness, and cooling rate.

3.2.7.1 *scattered shrinkage, n*—appears on a digital image as dark fine lacy or filamentary voids of varying densities. These voids are usually uniformly spread throughout the area of the casting where shrinkage is occurring and are relatively shallow.

3.2.7.2 *shrinkage cavity, n*—appears as a dark void with smooth sides taking an appearance very similar to a gas hole. A shrinkage cavity, particularly in thicker wall sections, is usually larger than a single gas hole would be. The cavity is formed during the cooling process due to a lack of feeding metal. The cavity compensates for the rapid solidification taking place at the surface of the casting, thereby forming the cavity in the center area of the wall. Shrinkage cavity has a definite tendency to occur near hot spots where walls are ½-in. (12.7-mm) thick or more.

3.2.7.3 *shrinkage, centerline, n*—characterized by a more discrete dark indication than scattered shrinkage. The indication has definite borders consisting of a lacy network of varying density or a network of interconnected elongated voids. Centerline shrinkage is located primarily in the center of the material cross section with a tendency to orient toward gates or risers.

4. Significance and Use[7]

4.1 Personnel utilizing reference radiographs to this standard shall be qualified to perform radiographic interpretation in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties. If assistance is needed with interpreting specifications and product requirements as applied to the reference radiographs, a certified Level III shall be consulted before

[5] Available from ASTM International Headquarters. Order Adjunct No. RRE2669.

[6] Available from ASTM International Headquarters. Order Adjunct No. RRE266902.

[7] A study was performed that compared film to digital modalities for the classification of aluminum casting discontinuities. Results of this study are available from ASTM as RR:E07-1004. A subsequent study was performed that compared film to digital modalities for the classification of titanium and steel casting discontinuities. Results of this study are available from ASTM as RR:E07-1006.