Designation: D 4024 – 9400

An American National Standard

Standard Specification for Machine Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Flanges[1]

This standard is issued under the fixed designation D 4024; 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 specification covers reinforced-thermosetting resin flanges other than contact-molded flanges. Included are requirements for materials, workmanship, performance, and dimensions.

1.2 Flanges may be produced integrally with a pipe or fitting, may be produced with a socket for adhesive bonding to a pipe or fitting, or may be of the type used in conjunction with either a metallic or nonmetallic backup ring.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are given for information only. In cases where materials, products, or equipment are available only in SI units, inch-pound units are omitted.

1.4 The following precautionary caveat pertains only to the test methods portion, Section 11, of this specification: *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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—Contact molded flanges are covered in Specification D 5421 and referenced in Specification D 5685.
NOTE 2—There is no similar or equivalent ISO standard.
NOTE 3—For purposes of this specification, polyester includes vinylester resins.

2. Referenced Documents

2.1 *ASTM Standards:*

[1] This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.23 on Reinforced Plastic Piping Systems and Chemical Equipment.

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

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]
D 883 Terminology Relating to Plastics[2]
D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings[3]
D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]
D 1898 Practice for Sampling of Plastics[4]
D 5421 Specification for Contact Molded "Fiberglass'' (Glass-Fiber-Reinforced Resin) Flanges[3]
D 5685 Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings[3]
F 412 Terminology Relating to Plastic Piping Systems[3]
2.2 *ANSI Standards:*
B 16.1 Cast Iron Pipe Flanges and Flanged Fittings[5]
B 16.5 Pipe Flanges and Flanged Fittings[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—Definitions are in accordance with Terminology D 883 or Terminology F 412. Abbreviations are in accordance with Terminology D 1600, unless otherwise indicated. The abbreviation for reinforced-thermosetting-resin pipe is RTRP.

4. Classification

4.1 *General*—This specification covers machine-made reinforced-thermosetting-resin flanges defined by type (method of manufacture), grade (generic type of resin), class (configuration of joining system), and pressure rating. Flanges complying with this specification are also given numerical classifications relating to rupture pressure, sealing test pressure, and bolt torque limit.

4.1.1 *Types*:

4.1.1.1 *Type 1*—Filament-wound flanges manufactured by winding continuous fibrous glass strand roving or roving tape, either preimpregnated or impregnated during winding, into a flange cavity under controlled tension.

4.1.1.2 *Type 2*—Compression-molded flanges made by applying external pressure and heat to a molding compound that is confined within a closed mold.

4.1.1.3 *Type 3*—Resin-transfer-molded flanges manufactured by pumping a thermosetting resin into glass reinforcements that have been cut to size and clamped between matched molds.

4.1.1.4 *Type 4*—Centrifugally-cast flanges are made by applying resin and reinforcement to the inside of a mold that is rotated and heated, subsequently polymerizing the resin system.

4.1.2 *Grades*:

4.1.2.1 *Grade 1*—Epoxy resin.

4.1.2.2 *Grade 2*—Polyester resin.

4.1.2.3 *Grade 3*—Furan resin.

4.1.3 *Classes*:

4.1.3.1 *Class 1*—Integrally-molded flange manufactured directly on a pipe section, pipe stub, or fitting.

4.1.3.2 *Class 2*—Taper to taper adhesive joint flange manufactured with a tapered socket to be used in conjunction with a pipe or fitting with a tapered spigot section and a suitable adhesive. This joining method provides an interference fit over the entire length of the bond line.

4.1.3.3 *Class 3*—Straight-taper adhesive joint flange manufactured with a tapered socket to be used with a pipe or fitting with an untapered spigot section and a suitable adhesive. This joining method provides an interference fit at the bottom of the socket.

4.1.3.4 *Class 4*—Straight adhesive joint flange manufactured with an untapered socket for use with a pipe or fitting with an untapered spigot and a suitable adhesive. This joint provides no interference fit.

4.1.4 *Pressure Rating*—Pressure rating shall be categorized by a single letter designation. Pressure designations are shown in Table 1.

4.1.5 Rupture pressure, sealing test pressure, and bolt torque limit shall be categorized by single arabic number designations as indicated by the cell classification system of Table 2.

4.2 *Designation Code*—The flange designation code shall consist of the abbreviation RTR, followed by the type, grade, and class in arabic numerals, the pressure rating category as a capital letter, and three arabic numbers identifying the cell classification designations of the rupture pressure, sealing test pressure, and the bolt torque limit, respectively. Thus, a complete flange designation code shall consist of three letters, three numerals, and one letter, and three numerals.

4.2.1 *Example*—RTR-112D-334. This designation describes a filament-wound, glass fiber-reinforced epoxy resin flange with a taper to taper adhesive joining system. The flange has a 200 psi (1.4 MPa) pressure rating, a burst pressure in excess of 600 psi (4.1 MPa), a sealing test pressure of 225 psi (1.6 MPa), and a bolt torque limit greater than 75 lbf·ft (102 N·m).

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[2] *Annual Book of ASTM Standards*, Vol 08.01.
[3] *Annual Book of ASTM Standards*, Vol 08.04.
[4] *Annual Book of ASTM Standards*, Vol 08.02.
[5] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

TABLE 1 Pressure Categories

Designation	Pressure Rating	
	psi	MPa
A	50	0.35
B	100	0.69
C	150	1.03
D	200	1.38
E	250	1.72
F	300	2.07
G	400	2.76
H	500	3.45

TABLE 2 Burst Pressure, Sealing Test Pressure, and Bolt Torque Limit

Property	0[A]	1	2	3	4	5	6	7	8
Burst pressure, psi		200	400	600	800	1000	1200	1600	2000
(MPa)		(1.38)	(2.76)	(4.14)	(5.52)	(6.89)	(8.27)	(11.03)	(13.79)
Sealing test pressure, psi		75	150	225	300	375	450	600	750
(MPa)		(0.52)	(1.03)	(1.55)	(2.07)	(2.59)	(3.10)	(4.14)	(5.17)
Bolt torque limit, lbf·ft.		20	30	50	75	100	125	150	200
(N·m)		(27.1)	(40.7)	(67.8)	(101.7)	(135.6)	(169.5)	(203.4)	(271.2)

[A] 0 = unspecified.

NOTE 4—Flanges with identical classification from different manufacturers may not be interchangeable due to nonstandardization of pipe or socket diameter, socket length, taper angle, or combination thereof.

5. Materials and Manufacture

5.1 Flanges manufactured in accordance with this specification shall be composed of reinforcement imbedded in or surrounded by cured thermosetting resin. The composite structure may contain granular or platelet fillers, thixotropic agents, pigments, or dyes.

5.2 The resins, reinforcements, and other materials, when combined as composite structure, shall produce a flange that will meet the performance requirements of this specification.

6. Performance Requirements

6.1 Flanges shall meet the following performance requirements when joined for testing according to the manufacturer's recommended practice for field installation:

6.1.1 *Sealing*—Flanges shall withstand a pressure of at least 1.5 times the rated design pressure without leakage when tested in accordance with 11.4.

6.1.2 *Short-Term Rupture Strength*—Flanges shall withstand a hydrostatic load of at least four times their rated design pressure without damage to the flange when tested in accordance with 11.5.

6.1.3 *Bolt Torque*—Flanges shall withstand, without visible sign of damage, a bolt torque of at least 1.5 times that recommended by the manufacturer for sealing of the flange at its rated pressure when tested in accordance with 11.6.

7. Content Requirements

7.1 *Percentage Extractable Material*— Flanges shall ~~have~~ contain no more than 5 % extractable material when tested in accordance with Annex A1.

7.2 *Recycled or Repprocessed Thermosetting Plastics*— Flanges shall not contain any recylced or reprocessed thermosetting plastics which might otherwise be added as fillers.

8. Dimensions

8.1 *Dimensions and Tolerances*:

8.1.1 *Flange and Bolt Dimensions*—Flanges of 24 in. (610 mm) or smaller diameter shall conform to the values given in Table 3 for bolt circle, number and size of bolt holes, and outside diameter. Flanges larger than 24 in. (610 mm) in diameter shall conform to the values for bolt circle, number and size of bolt holes, and outside diameter for Class 125 cast iron flanges in ANSI B 16.1. The tolerance for the flange dimensions provided in Table 3 shall be the same as those contained in ANSI B 16.1.

8.1.2 *Flange Face*—The flange face shall be perpendicular to the axis of the fitting within ½ °, and shall be flat to ±1⁄32 in. (1 mm) for sizes up to and including 18 in. (457 mm) diameter and ±1⁄16 in. (2 mm) for larger diameters.

8.1.3 *Washer Bearing Surface*—Washer bearing surface shall be flat and parallel to the flange face within ±1°.

8.2 *Pipe Stop*—Each adhesive joined flange shall provide sufficient taper or a diametral constriction to act as a stop during adhesive joining so that the pipe stub cannot project beyond the face of the flange.

9. Workmanship, Finish, and Appearance

9.1 Flanges shall be free as commercially practical of defects, including indentations, delaminations, bubbles, pinholes, foreign inclusions, and resin-starved areas.

TABLE 3 Flange Dimensions, in. (mm)[A]

Nominal Pipe, Size[B]	Outside Diameter of Flange	Drilling			
		Diameter of Bolt Circle	Diameter of Bolt Holes	Number of Bolts	Diameter of Bolts
12 ½	3.50 (88.9)	2.38 (60.5)	0.62 (15.75)	4	½ 12(12.70)
½	3.50 (88.9)	2.38 (60.5)	0.62 (15.75)	4	½ (12.70)
34 ¾	3.88 (98.6)	2.75 (69.9)	0.62 (15.75)	4	½ 12(12.70)
¾	3.88 (98.6)	2.75 (69.9)	0.62 (15.75)	4	½ (12.70)
1	4.25 (107.9)	3.12 (79.2)	0.62 (15.75)	4	½ 12(12.70)
1	4.25 (107.9)	3.12 (79.2)	0.62 (15.75)	4	½ (12.70)
114 ¼	4.62 (117.3)	3.50 (88.9)	0.62 (15.75)	4	1 / 2½ (12.70)
1¼	4.62 (117.3)	3.50 (88.9)	0.62 (15.75)	4	½ (12.70)
112 ½	5.00 (127.0)	3.88 (98.6)	0.62 (15.75)	4	½ 12(12.70)
1½	5.00 (127.0)	3.88 (98.6)	0.62 (15.75)	4	½ (12.70)
2	6.00 (152.4)	4.75 (120.6)	0.75 (19.0)	4	5 / 8⅝ (15.9)
2	6.00 (152.4)	4.75 (120.6)	0.75 (19.0)	4	⅝ (15.9)
212 ½	7.00 (177.8)	5.50 (139.7)	0.75 (19.0)	4	⅝ 58(15.9)
2½	7.00 (177.8)	5.50 (139.7)	0.75 (19.0)	4	⅝ (15.9)
3	7.50 (190.5)	6.00 (152.4)	0.75 (19.0)	4	⅝ 58(15.9)
3	7.50 (190.5)	6.00 (152.4)	0.75 (19.0)	4	⅝ (15.9)
312 ½	8.50 (215.9)	7.00 (177.8)	0.75 (19.0)	8	⅝ 58(15.9)
3½	8.50 (215.9)	7.00 (177.8)	0.75 (19.0)	8	⅝ (15.9)
4	9.00 (228.6)	7.50 (190.5)	0.75 (19.0)	8	⅝ 58(15.9)
4	9.00 (228.6)	7.50 (190.5)	0.75 (19.0)	8	⅝ (15.9)
5	10.00 (254.0)	8.50 (215.9)	0.88 (22.4)	8	¾ 34(19.0)
5	10.00 (254.0)	8.50 (215.9)	0.88 (22.4)	8	¾ (19.0)
6	11.00 (279.4)	9.50 (241.3)	0.88 (22.4)	8	¾ 34(19.0)
6	11.00 (279.4)	9.50 (241.3)	0.88 (22.4)	8	¾ (19.0)
8	13.50 (342.9)	11.75 (298.4)	0.88 (22.4)	8	¾ 34(19.0)
8	13.50 (342.9)	11.75 (298.4)	0.88 (22.4)	8	¾ (19.0)
10	16.00 (406.4)	14.25 (361.9)	1.00 (25.4)	12	⅞ 78(22.2)
10	16.00 (406.4)	14.25 (361.9)	1.00 (25.4)	12	⅞ (22.2)
12	19.00 (482.6)	17.00 (431.8)	1.00 (25.4)	12	⅞ 78(22.2)
12	19.00 (482.6)	17.00 (431.8)	1.00 (25.4)	12	⅞ (22.2)
14	21.00 (533.4)	18.75 (476.2)	1.12 (28.4)	12	1 (25.4)
14	21.00 (533.4)	18.75 (476.2)	1.12 (28.4)	12	1 (25.4)
16	23.50 (596.9)	21.25 (539.8)	1.12 (28.4)	16	1 (25.4)
16	23.50 (596.9)	21.25 (539.8)	1.12 (28.4)	16	1 (25.4)
18	25.00 (635.0)	22.75 (577.8)	1.25 (31.7)	16	118⅛ (28.6)
18	25.00 (635.0)	22.75 (577.8)	1.25 (31.7)	16	1⅛ (28.6)
20	27.50 (698.5)	25.00 (635.0)	1.25 (31.7)	20	118⅛ (28.6)
20	27.50 (698.5)	25.00 (635.0)	1.25 (31.7)	20	1⅛ (28.6)
24	32.00 (812.8)	29.50 (749.3)	1.38 (35.1)	20	114¼ (31.7)
24	32.00 (812.8)	29.50 (749.3)	1.38 (35.1)	20	1¼ (31.7)

[A] Dimensions conform to ANSI B 16.5 for Class 150 steel flanges.
[B] For larger sizes, see 8.1.1.

10. Sampling

10.1 The rate of sampling of flanges for pressure rating verification shall be in accordance with Annex A2.

10.2 For individual orders, only those additional tests and number of tests specifically agreed upon between the purchaser and seller need be conducted.

11. Test Methods

11.1 *Conditioning*—When conditioning is required, and in all cases of disagreement, condition the test specimens at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h prior to test, in accordance with Procedure A of Practice D 618.

11.2 *Test Conditions*—The tests may be conducted at ambient temperature and humidity conditions. When controlled environment testing is specified, tests shall be conducted in the Standard Laboratory Atmosphere of 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity. When elevated temperature testing is specified, the tests shall be conducted at the design operating temperature ±5.4°F (±3°C).

11.3 *Dimensions and Tolerances*—Flange dimensions shall be measured with a micrometer of vernier calipers, or other suitable measuring devices accurate to within ±0.001 in. (±0.02 mm). Diameters shall be determined by averaging a minimum of four measurements, equally spaced circumferentially.

11.4 *Sealing*—Flanged components in general arrangement with Fig. 1 shall be bolted together using the gasket and bolt torque recommended for standard field installation by the flange manufacturer. The assembly shall then be pressure tested and be required to hold the test pressure for a period of 168 hours without leakage. Retorquing to the manufacturer's specified level after initial pressurization is permitted.

Ⓐ-END PLATE, END CAP OR QUICK CLOSURE WITH COUPLING FOR PRESSURE SOURCE/VENT LINE.
Ⓑ-REINFORCED THERMOSETTING RESIN PIPE (RTRP).
Ⓒ-TEST FLANGE SET.
Ⓓ-END PLATE, END CAP OR QUICK CLOSURE.

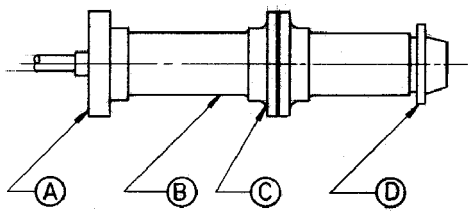

FIG. 1 Test Assembly Configuration

11.5 *Short-Term Rupture Strength*—Flanged components shall be tested in accordance with Test Method D 1599 with free-end closure except as herein noted. The pressure in the specimen shall be increased until failure of the flange occurs. Pressure testing in an atmospheric environment is permissible. Minimum failure time shall be 60 s; no restriction shall be placed on maximum time-to-failure. Leaking past the gasket interface is permissible during this test. Bolt torque may be increased as necessary during the test in order to minimize gasket leaking and to achieve the pressure necessary to cause flange failure. The assembly used for the test in 11.4 may be used for this test.

11.6 *Maximum Bolt Torque*—Using the gasket and hardware recommended by the flange manufacturer, bolt the flange against a flat face steel flange. Tighten the nuts by hand until they are snug. Prior to fit-up, the nuts, bolts, and washers should be well lubricated, using a nonfluid thread lubricant. Establish uniform pressure over the flange face by tightening bolts in 5 lbf·ft (7 N·m) increments according to the sequence shown in Fig. 2. For flanges with more than 20 bolts, similar alternating bolt tightening sequences shall be used. Increase the bolt torque uniformly until flange failure occurs or until all bolts have been torqued to five times the level recommended by the manufacturer for field installation practice to establish the bolt torque cell classification of the flange. Any sign of flange damage (crumbling, flaking, cracking, or other breaking) shall constitute failure.

NOTE 5—The torque limits determined by 11.6 apply only to flanges bolted up against a flat sealing surface. Significantly lower bolt torque value will normally be obtained when RTR flanges are bolted up against raised-faced flanges. When RTR flanges must be used against raised steel flange face, the flange manufacturer should be contacted for his torquing and installation recommendations.

12. Product Marking

12.1 Each flange shall be marked with the following information:

12.1.1 The designation "ASTM D 4024" indicating compliance with ~~which the flange complies,~~ this specification,

12.1.2 Identification of the flange in accordance with the designation code in 4.2,

12.1.3 Nominal flange size, and

12.1.4 Manufacturer's name (or trademark) and product designation.

12.2 All required markings shall be legible and so applied as to remain legible under normal handling and installation practices.

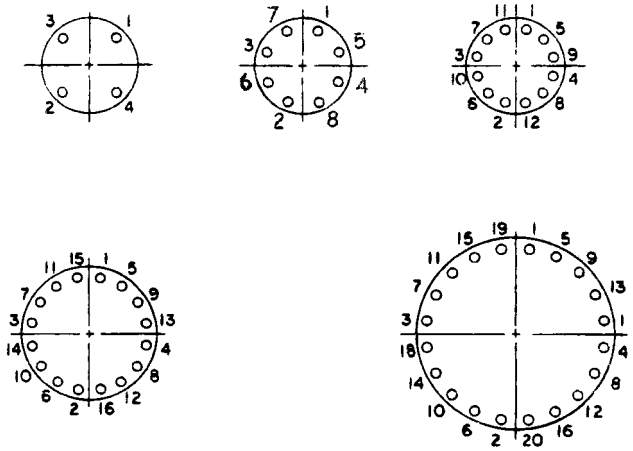

FIG. 2 Bolt Torquing Sequence

13. Precision and Bias

13.1 No precision and bias statement can be made for this test method, since controlled round robin test programs have not been run.

NOTE 6—Thw wide variation in raw materials and constructions allowed in this specification make round robin testing difficult to apply.

14. Keywords

134.1 centrifugally-cast; compression-molded; filament-wound; furan; machine-made; polyester; resin-transfer; vinylester

ANNEXES

(Mandatory Information)

A1. TEST METHOD FOR PERCENTAGE EXTRACTABLE MATERIALS

A1.1 Scope

A1.1.1 This test method covers the procedure for determining the percentage extractable materials in RTR flanges.

A1.2 Summary of Test Method

A1.2.1 The test method consists of filing material from the flange, immersing this material in a solvent (methylene chloride), extracting the unreacted material and, by means of gravimetric analysis, determining the quantity of unreacted resin and residual solvent.

NOTE A1.1—For certain classes of resins, it may be necessary to select a different solvent in performing this test.

A1.3 Significance and Use

A1.3.1 This test method measures the amount of extractable material which includes unreacted resin and residual solvent.

A1.4 Apparatus

A1.4.1 *Beakers*, 100-mL
A1.4.2 *Beakers*, 50-mL
A1.4.3 *Graduate*, 25-mL
A1.4.4 *Magnetic Stirrer* and capsule (dental amalgam shaker).
A1.4.5 *Funnel* and filter paper (type) Grade 950, size 15 cm.
A1.4.6 *Hot Plate*.
A1.4.7 *Oven*.

A1.5 Procedure

A1.5.1 Remove 1 to 2 g of a representative sample by means of a clean file.
A1.5.2 Pulverize the rough sample to a fine powder in a magnetic stirrer capsule. Each capsule should be pulverized for about 3 min.
A1.5.3 Accurately weigh the pulverized sample in a tared 50-mL beaker.
A1.5.4 *Gravimetric Analysis*:
A1.5.4.1 Add 25 mL of methylene chloride (or other suitable solvent) to the pulverized sample and mix.
A1.5.4.2 Place mixture on a steam bath or hot plate for 10 min.

NOTE A1.2—The solvent should not be heated above its boiling point (for methylene chloride, 104°F (40°C)).

A1.5.4.3 Let mixture cool for 10 min and filter into a tared 100-mL beaker. Wash mixture out of the 50-mL beaker and add washing to filtrate. It is very important to wash the 50-mL beaker and filter paper with methylene chloride several times to be sure all extractable material passes through the filter.
A1.5.4.4 Place filtrate in oven and evaporate methylene chloride. Oven temperature should be 194 to 212°F (90 to 100°C).
A1.5.4.5 After solvent evaporates, let beaker cool in a desiccator for 15 min.
A1.5.4.6 Weigh the beaker.
A1.5.4.7 Repeat steps 4, 5, and 6 until a constant weight is reached.

NOTE A1.3—It has been found that a 25-min drying time is satisfactory.

A1.6 Calculation

A1.6.1 Calculate the percentage extractable materials as follows:

$$\% \text{ extractable} = \frac{L}{W \times R} \times 100$$

where:
L = actual weight of residue = weight of beaker plus residue minus weight of beaker,
W = initial weight of pulverized sample = weight of beaker plus sample minus weight of beaker, and
R = resin content of the sample.

NOTE A1.4—The resin content of the sample must be known.

A2. TEST METHOD OF SAMPLING FOR PRESSURE RATING VERIFICATION

A2.1 Scope

A2.1.1 This test method describes the sampling procedure which shall be used in determining the acceptance of a given lot of flanges at the pressure rating specified according to 4.1.4 and Table 1.

A2.2 Sample

A2.2.1 Sample size and selection shall be in accordance with Practice D 1898 except as herein modified.

A2.3 Procedure

A2.3.1 Sample size shall be determined according to Practice D 1898, Appendix ~~A3~~ X3 and Table ~~A2.~~ X2.1. The Acceptable Quality Level (AQL) shall be 1.50. Inspection Level 1 shall be used in determining the sample size and acceptance constant. A flange set shall be considered to be two samples.

A2.3.2 The specification Limit Value (L) shall be the pressure rating times 4 for burst test qualification and shall be the pressure rating times 1.5 for leak test qualification.

A2.4 Results

A2.4.1 *Acceptance*— If the Quality Level of the sample is greater than or equal to the acceptance constant for both burst and leak testing, the lot shall be accepted at the specified pressure rating category.

A2.4.2 *Rejection*—If the Quality Level is less than the acceptance constant for either burst or leak testing, the lot shall be rejected unless rectification is provided as follows:

A2.4.2.1 The lot shall be resampled at a higher inspection level. The original test results shall be considered a part of the resampled lot. If the lot meets the requirements of A2.4.1 after resampling, the lot shall be accepted at the pressure category specified.

A2.4.2.2 Alternatively, the lot may be derated to a pressure rating that will bring the sample's quality level to a value equal to or greater than the acceptance constant. The lot of flanges shall be reclassified at the lower pressure rating category and appropriately marked according to the designation code in 4.2.

SUMMARY OF CHANGES

Committee D-20 has identified the location of the following changes to this standard since the last issue D4024–94) which may impact the use of this standard.

(1) Changed Note 1 to reference D 5685.
(2) Corrected grammer in 4.1.
(3) Corrected statement construction in 4.2.
(4) Added 7.2 on recycled materials.
(5) Clarified 11.2 on tolerance of operating temperature.
(6) Deleted dualism in key for drawing in 11.4.
(7) Corrected long standing error in bolt torque sequence on 8 hole flange in Fig. 2.
(8) Clarified wording in 12.1.1.
(9) Added Precision and Bias statement.
(10) Corrected references in A2.3.1 to appendix and table which no longer exsisted.
(11) Added this "Summary of Changes" section.