DEPARTMENT OF ENERGY

10 CFR Parts 429 and 431

[Docket No. EERE–2014–BT–TP–0054]

RIN 1904–AD43

Energy Conservation Program: Test Procedures for Compressors

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Final rule.

SUMMARY: On May 5, 2016, the U.S. Department of Energy (DOE) published a notice of proposed rulemaking (NOPR) to establish new test procedures for certain varieties of compressors. That proposed rulemaking serves as the basis for the final rule. This final rule establishes definitions, materials incorporated by reference, sampling plans, representations requirements, enforcement provisions, and test procedures for certain varieties of compressors. Specifically, this final rule establishes full-load package isentropic efficiency as the applicable energy metric for certain fixed-speed compressors and part-load package isentropic efficiency as the applicable energy metric for certain variable-speed compressors. Finally, this final rule incorporates by reference certain sections of the ISO Standard 1217:2009(E), (ISO 1217:2009(E)), ''Displacement compressors—Acceptance tests,'' as amended through Amendment 1:2016, as the basis for a test method for determining compressor efficiency. ISO 1217:2009(E) includes a test method for measuring compressor inlet and discharge pressures, actual volume flow rate, electrical input power, package isentropic efficiency, and other compressor performance metrics. This final rule also adopts certain modifications and additions to ISO 1217:2009(E) to increase the specificity of certain testing methods established in ISO 1217:2009(E) and improve the repeatability of tested and measured values.

DATES: The effective date of this rule is February 3, 2017. The final rule changes will be mandatory for representations starting July 3, 2017. The incorporation by reference of certain publications listed in the rule is approved by the Director of the Federal Register February 3, 2017.

ADDRESSES: The docket, which includes **Federal Register**, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov.* All documents in the docket are listed in the *www.regulations.gov* index. However, some documents listed in the index, such as those containing information that is exempt from public disclosure, may not be publicly available.

A link to the docket Web page can be found at *https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/78.* The docket Web page contains simple instructions on how to access all documents, including public comments, in the docket.

FOR FURTHER INFORMATION CONTACT: Mr. James Raba, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE–5B, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 586–8654. Email: *ApplianceStandardsQuestions@ee.doe.gov.*

SUPPLEMENTARY INFORMATION: This final rule incorporates by reference into 10 CFR part 431 the testing methods contained in the following commercial standards:

ISO 1217:2009(E), ''Displacement compressors—Acceptance tests,'' July 1, 2009, sections 2, 3, and 4; sections 5.2, 5.3, 5.4, 5.6, 5.9; paragraphs 6.2(g), and 6.2(h) including Table 1; Annex C (excluding C.1.2, C.2.1, C.3, C.4.2.2, C.4.3.1, and C.4.5). ISO 1217:2009/Amd.1:2016(E), Displacement compressors—Acceptance tests (Fourth edition); Amendment 1: ''Calculation of isentropic efficiency and relationship with specific energy,'' April 15, 2016, sections 3.5.1 and 3.6.1; sections H.2 and H.3 of Annex H.

Copies of ISO 1217:2009(E) and of ISO 1217:2009/Amendment 1:2016(E) may be purchased from ISO at Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland +41 22 749 01 11, or by going to *www.iso.org.*

See section IV.N for additional information about ISO 1217:2009(E) and ISO 1217:2009/Amendment 1:2016(E).

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I. Authority and Background

A. Authority

Title III of the Energy Policy and Conservation Act of 1975, as amended, (42 U.S.C. 6291, *et seq.*; ''EPCA'' or, ''the Act'') sets forth a variety of provisions designed to improve energy efficiency.[1] Part C of Title III, which for editorial reasons was codified as Part A–1 upon incorporation into the U.S. Code (42 U.S.C. 6311–6317), establishes the Energy Conservation Program for Certain Industrial Equipment. Under EPCA, DOE may include a type of industrial equipment, including compressors, as covered equipment if it determines that to do so is necessary to carry out the purposes of Part A–1. (42 U.S. 6311(1)(L), 6311(2)(B)(i), and 6312(b)). The purpose of Part A–1 is to improve the efficiency of electric motors and pumps and certain other industrial equipment in order to conserve the energy resources of the Nation. (42 U.S.C. 6312(a))

Pursuant to EPCA, DOE's energy conservation program for covered equipment consists essentially of four parts: (1) Testing; (2) labeling; (3) Federal energy conservation standards; and (4) certification and enforcement procedures. Specifically, subject to certain criteria and conditions, EPCA requires DOE to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each type of covered equipment. (42 U.S.C. 6314(a)) Manufacturers of covered equipment must use the prescribed DOE test procedures: (1) As the basis for certifying to DOE that their equipment complies with the applicable energy conservation standards adopted under EPCA (42 U.S.C. 6295(s) and 6316(a)) and (2) when making representations to the public regarding the energy use or efficiency of those equipment. (42 U.S.C. 6314(d))

B. Regulatory History for Compressors

Currently, no Federal energy conservation standards for compressors exist. Before today, no Federal test procedures for compressors existed.

On December 31, 2012, DOE published a Proposed Determination of Coverage (2012 NOPD) proposing to determine that compressors qualify as covered equipment under part A–1 of Title III of EPCA, as amended (42 U.S.C. 6311 *et seq.*). DOE proposed that coverage was necessary for the purposes of Part A–1 on the basis that (1) DOE may prescribe energy conservation standards only for covered equipment; and (2) energy conservation standards for compressors would improve the efficiency of such equipment more than would be likely to occur in the absence of standards.77 FR 76972 (Dec. 31, 2012). On February 7, 2013, DOE published a notice reopening the comment period on the 2012 NOPD. 78 FR 8998.

On November 15, 2016, DOE published a final rule, which determined that coverage for compressors is necessary to carry out the purposes of Part A–1 of Title III of EPCA (herein referred to as ''notice of final determination''). 81 FR 79991.

On February 5, 2014, DOE published in the **Federal Register** a notice of public meeting, and provided a framework document that addressed potential standards and test procedures rulemakings for these products. 79 FR 6839. DOE held a public meeting to discuss the framework document on April 1, 2014. At this meeting, DOE discussed and received comments on the framework document, which covered the analytical framework, models, and tools that DOE used to evaluate potential standards; and all other issues raised relevant to the development of energy conservation standards for the different categories of compressors. On March 18, 2014, DOE extended the comment period. 79 FR 15061.

On May 5, 2016, DOE published a NOPR, to propose test procedures for certain compressors (''May 2016 test procedure NOPR'' or ''test procedure NOPR''). 87 FR 27220. The test procedure NOPR proposed establishing a new subpart T of title 10 of the Code of Federal Regulations, part 431 (10 CFR part 431), which would contain definitions, materials incorporated by reference, and test procedures for determining the energy efficiency of certain varieties of compressors. The test procedure NOPR would also amend title 10 CFR part 429 to establish sampling plans, representations requirements, and enforcement provisions for certain compressors. On June 20, 2016, DOE held a public meeting to discuss the test procedure NOPR and receive comments from interested parties.

Finally, in this final rule, DOE responds to comments received from interested parties in response to the proposals presented in the May 2016 test procedure NOPR, either during the June 2016 NOPR public meeting or in subsequent written comments.[2] In response to the May 2016 test procedure NOPR, DOE received 17 written comments in addition to the verbal comments made by interested parties during the June 2016 NOPR public meeting. The commenters included: the Appliance Standards Awareness Project (ASAP); Atlas Copco AB (Atlas Copco); CASTAIR; the Compressed Air & Gas Institute (CAGI); Compressed Air Systems; Ingersoll Rand; Jenny Products; Kaeser Compressors; the Northwest Energy Efficiency Alliance (NEEA); the Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and Southern California Gas Company (SCGC), collectively referred to as the California Investor Owned Utilities (CA IOUs); the People's Republic of China (P. R. China); Scales Industrial Technologies; Sullair; Saylor-Beall Manufacturing Company and Sullivan-Palatek, collectively referred to as Sullivan-Palatek. DOE identifies comments received in response to the May 2016 test procedure NOPR by the commenter, the number of document as listed in the docket maintained at *www.regulations.gov* (Docket No. EERE–2014–BT–TP–0054), and the page number of that document where the comment appears (for example: CAGI, No. 10 at p. 4). If a comment was made verbally during the NOPR public meeting, DOE also specifically identifies those as being located in the NOPR public meeting transcript (for example: CAGI, public meeting transcript, No. 16 at p. 100). This final rule also contains certain relevant comments that were submitted in response to the compressors energy conservation standards rulemaking and the 2012 NOPD, but pertain to the topics discussed in the test procedure rulemaking. Those comments are identified with the appropriate docket numbers, EERE–2013–BT–STD–0040 and EERE–2012–BT–DET–0033, respectively.

II. Synopsis of the Final Rule

In this final rule, DOE amends subpart T of title 10 of the Code of Federal Regulations, part 431 (10 CFR part 431), which contains definitions, materials incorporated by reference, and test procedures for determining the energy efficiency of certain varieties of compressors.

While the range of equipment included in DOE's definition of compressor is broad, the test procedures established by this rulemaking are limited to only a specific subset of

[1] All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015, Public Law 114–11 (Apr. 30, 2015).

[2] DOE notes that certain comments pertaining to the definition of ''compressors'' were addressed in the November 2016 notice of final determination. 81 FR 79991, 79992–4 (Nov. 15, 2016).

compressors. Specifically, this final rule applies only to a subset of rotary compressors, as defined in section III.B of this final rule. DOE intends this test procedure final rule to apply to similar equipment for which DOE is considering adopting energy conservation standards (Docket No. EERE–2014–BT–TP–0054). However, the scope of any energy conservation standards would be established in that rulemaking.

This final rule establishes package isentropic efficiency as the applicable energy metric for compressors within the scope of the final rule. Package isentropic efficiency describes the ratio of the ideal isentropic power required for compression to the actual packaged compressor power input used for the same compression process. Specifically, this final rule establishes two varieties of package isentropic efficiency, depending on equipment configuration: (1) Full-load package isentropic efficiency for certain fixed-speed compressors, and (2) part-load package isentropic efficiency for certain variable-speed compressors. In this final rule, DOE concludes these metrics provide a representative measurement of the energy performance of the rated compressor under an average cycle of use.

In this final rule, DOE establishes test methods to measure the inlet and discharge pressures, actual volume flow rate, and packaged compressor power input, as well as calculations of the theoretical power necessary for compression—all of which are required to calculate full- or part-load package isentropic efficiency. For reproducible and uniform measurement of these values, DOE incorporates by reference the test methods established in certain applicable sections of ISO 1217:2009(E), ''Displacement compressors—Acceptance tests,'' as amended through ISO 1217:2009(E)/Amd.1:2016.[3] Specifically, the test procedure codified by this final rule references the following parts of ISO 1217 as amended by Amendment 1:2016: sections 2, 3, and 4; subsections 5.2, 5.3, 5.4, 5.6, 5.9, 6.2(g), and 6.2(h); Annex C subsections C.1.1, C.2.2, C.2.3, C.2.4, C.4.1, C.4.2.1, C.4.2.3, C.4.3.2 and C.4.4; Annex H subsections H.2 and H.3; and Table 1 of subsection 6.2. See section III.D and section IV.N of this final rule for additional information about ISO 1217:2009(E) and ISO 1217:2009(E)/Amd.1:2016. Members of the compressor industry developed ISO 1217:2009(E), which contains methods for determining inlet and discharge pressures, actual volume flow rate, packaged compressor power input, and package isentropic efficiency for electrically driven packaged displacement compressors. DOE has reviewed the relevant sections of ISO 1217:2009(E), as amended, and has determined that ISO 1217:2009(E), as amended, in conjunction with the additional clarifications and test methods and calculations established in this final rule (see section III.E), produces test results that reflect the energy efficiency of a compressor during a representative average use cycle. (42 U.S.C. 6314(a)(2)) DOE has also reviewed the burdens associated with conducting the test procedure established in this final rule, including ISO 1217:2009(E), as amended, and, based on the results of such analysis, has found that the test procedure would not be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2)) DOE presents the analysis of the burdens associated with the test procedure in section IV.B.

In this final rule, DOE also establishes, in subpart B of part 429 of title 10 of the Code of Federal Regulations (10 CFR part 429), sampling plan requirements, representations requirements, and enforcement provisions for the compressors within the scope of this final rule. The sampling plan requirements established in this final rule are similar to other types of commercial equipment (*e.g.,* pumps) and are appropriate for compressors based on the expected range of measurement uncertainty and manufacturing tolerances for this equipment. The sampling plan is intended to give DOE reasonable assurance that any individual unit distributed in commerce is at least as efficient as its basic model rating. The representations requirements established in this final rule specify the energy consumption or energy efficiency representations that, in addition to the regulated metric (part- or full-load package isentropic efficiency), may be made by compressor manufacturers, distributors, retailers, or private labelers. DOE notes that any representations of the energy efficiency or energy use of compressors to which an adopted test procedure applies must be made based on the adopted compressor test procedure beginning 180 days after the publication date of any test procedure final rule establishing such procedures. (42 U.S.C. 6314(d)) Finally, the enforcement provisions established in this final rule govern the process DOE follows when performing its own assessment of basic model compliance with any future energy conservation standards.

III. Discussion

A. Definitions

1. Definition of Covered Equipment

Although EPCA lists compressors as a type of industrial equipment, the term is not defined. (42 U.S.C. 6311(2)(B)(i)) In the May 5, 2016 test procedure NOPR, DOE proposed to define a ''compressor'' as a machine or apparatus that converts different types of energy into the potential energy of gas pressure for displacement and compression of gaseous media to any higher pressure values above atmospheric pressure and has a pressure ratio[4] greater than 1.3. 81 FR 27220, 27223–27224. Further, DOE noted that with its proposal of a pressure ratio of greater than 1.3, it intended to align the minimum pressure ratio for compressors with the maximum ratio proposed in the fans and blowers rule and to create a continuous spectrum of coverage between the two equipment types. *Ibid.*

To determine objectively and unambiguously whether equipment meets the definition of compressor, in the test procedure NOPR, DOE also proposed to define the term ''pressure ratio'' as the ratio of discharge pressure to inlet pressure, as determined at full-load operating pressure. Such a definition enables DOE to establish quantitatively which compressors meet the pressure ratio requirement proposed in the definition of the term compressor. 81 FR 27220, 27224 (May 5, 2016).

In the notice of final determination, DOE addressed all comments related to the definition of compressor, and ultimately adopted the following definition:

Compressor means a machine or apparatus that converts different types of energy into the potential energy of gas pressure for displacement and compression of gaseous media to any higher pressure values above atmospheric pressure and has a pressure ratio at full-load operating pressure greater than 1.3. 81 FR 79991, 79998 (Nov. 15, 2016).

DOE notes that in the notice of final determination, for the definition of compressor, the term pressure ratio (which was proposed in the TP NOPR), was replaced with the term ''pressure ratio at full load operating pressure.'' DOE stated that the definition of the new term, as well as methods of testing,

[3] ISO 1217:2009(E)/Amd.1:2016 is titled ''Calculation of isentropic efficiency and relationship with specific energy.''

[4] For the final rule, the term ''pressure ratio'' has been revised to ''pressure ratio at full-load operating pressure,'' as explained later in this section.

would be established in the test procedure final rule. 81 FR 79991, 79995 (Nov. 15, 2016). In this final rule, DOE addresses all comments related to the definition of the term pressure ratio. CAGI did not provide any direct comments, but commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1)

Jenny Products and Scales Industrial Technologies commented that they would prefer to use the more common term, ''compression ratio,'' in place of pressure ratio. Scales Industrial Technologies also indicated that DOE's proposed definition of pressure ratio was not sufficiently clear, and could be interpreted in multiple ways. (Scales Industrial Technologies, No. 0013, at p. 1; Jenny Products, No. 0020 at p. 2)

In response to Scales Industrial Technologies' concerns about clarity, in this final rule, DOE is clarifying its NOPR proposal and modifying the term pressure ratio to pressure ratio at full-load operating pressure. This clarification better aligns the name of this metric with its definition, which states, as proposed, that pressure ratio means the ratio of discharge pressure to inlet pressure, determined at full-load operating pressure in accordance with the test procedures prescribed in § 431.344. 81 FR 27220, 27224 (May 5, 2016). DOE is making this clarification because it understands that the ratio between the inlet pressure and the discharge pressure, measured at the discharge pipe, can vary based on the pressure of the system that the compressor is supplying. As a result, DOE concludes that the use of the general term pressure ratio to describe a pressure ratio at a specific load point (*i.e.,* full-load operating pressure), is not appropriate. Additionally, based on the general support of CAGI, Sullivan-Palatek, Ingersoll Rand, and Sullair, and the above clarification to the term pressure ratio, DOE concludes that the use of the term pressure ratio at full-load operating pressure is sufficiently clear, and DOE does not adopt the term compression ratio in its place.

Ultimately, for the reasons discussed in this section and established in the test procedure NOPR, DOE is adopting the following definition for pressure ratio at full-load operating pressure. Beyond the previously discussed terminology change from pressure ratio to pressure ratio at full-load operating pressure, this definition is unchanged from the test procedure NOPR proposal.

Pressure ratio at full-load operating pressure means the ratio of discharge pressure to inlet pressure, determined at full-load operating pressure in accordance with the test procedures prescribed in § 431.344.

2. Air Compressor

In the test procedure NOPR, DOE proposed to define the term ''air compressor'' as a compressor designed to compress air that has an inlet open to the atmosphere or other source of air, and is made up of a compression element (bare compressor), driver(s), mechanical equipment to drive the compressor element, and any ancillary equipment. 81 FR 27220, 27226 (May 5, 2016).

In response to the proposed definitions, DOE received comment from CAGI indicating its support of the definitions as proposed for the test procedure. (CAGI, Public Meeting Transcript, No. 0016 at p. 20) Sullivan-Palatek, Ingersoll Rand, and Sullair supported CAGI's comments. (Sullivan-Palatek, No. 0007 at p. 1; Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1)

Consequently, for the reasons established in the test procedure NOPR, DOE is adopting the definition for air compressor as proposed in the test procedure NOPR.

3. Air Compressor Components

a. Bare Compressor, Driver, and Mechanical Equipment

In the test procedure NOPR, DOE proposed to define ''bare compressor'' [5] as the compression element and auxiliary devices (*e.g.,* inlet and outlet valves, seals, lubrication system, and gas flow paths) required for performing the gas compression process. The definition does not include the driver; speed-adjusting gear(s); gas processing apparatuses and piping; or compressor equipment packaging and mounting facilities and enclosures. 81 FR 27220, 27227 (May 5, 2016).

Further, in the test procedure NOPR, DOE proposed to define ''driver'' and ''mechanical equipment'' as the machine providing mechanical input to drive a bare compressor directly or through the use of mechanical equipment, and any component of an air compressor that transfers energy from the driver to the bare compressor, respectively. 81 FR 27220, 27227 (May 5, 2016).

In response to the proposed definitions, CAGI did not provide any direct comments, but CAGI commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Scales Industrial Technologies commented that the 'bare' compressor often includes speed-increasing gears. (Scales Industrial Technologies, no. 0013 at p. 2) In response, DOE clarifies that while the definition of bare compressor does not include mention of gears, the definition of mechanical equipment does include mention of gears. Moreover, the definition of air compressor, which is the overarching term dictating the scope of applicability of equipment in this final rule, includes mechanical equipment. Consequently, for the reasons established in the test procedure NOPR, DOE is adopting the definitions for bare compressor, driver, and mechanical equipment as proposed in the test procedure NOPR.

b. Ancillary Equipment

In the test procedure NOPR, the proposed definition of air compressor included the term ''ancillary equipment.'' DOE proposed to define ancillary equipment as any equipment distributed in commerce with an air compressor that is not a bare compressor, driver, or mechanical equipment. 81 FR 27220, 27227 (May 5, 2016). Ancillary equipment would be considered to be part of a given air compressor model regardless of whether the ancillary equipment is physically attached to the bare compressor, driver, or mechanical equipment at the time when the air compressor is distributed in commerce. *Ibid.* DOE also requested comment on if a list of ancillary equipment was more appropriate than the definition. *Ibid.*

Many commenters suggested that the definition of ancillary equipment proposed in the test procedure NOPR lacked specificity. Scales Industrial Technologies, Kaeser Compressors, and Jenny Products commented that standard, but not application-specific or optional, ancillary equipment should be used as required for the safe operation of the bare compressor. Kaeser Compressors noted that the metric of isentropic efficiency is expressed relative to the theoretical power required to compress air, and thus the specified test configuration should

[5] The compressors industry frequently uses the term ''airend'' or ''air end'' to refer to the bare compressor. DOE uses ''bare compressor'' in the regulatory text of this rule, and, for the purposes of this rulemaking, it considers the terms to be synonymous.

logically reflect the equipment required to compress air, without the effect of any additional components. Scales Industrial Technologies stated that standard compressors should not include accessories beyond an aftercooler, a moisture separator, and an automatic drain cap. (Jenny Products, No. 0020 at pp. 2–3; Scales Industrial Technologies, No. 0013 at p. 2; Kaeser Compressors, Public Meeting Transcript, No. 0016 at pp. 31, 37)

ASAP commented that the definition of ancillary equipment should be clear and include equipment that is normally included with a majority of applications. (ASAP, Public Meeting Transcript, No. 0016 at pp. 25, 30) Similarly, Compressed Air Systems commented that the list of ancillary equipment should be defined, noting that safety equipment should be included as part of the list to ensure safe operation of compressors. (Compressed Air Systems, No. 0008 at p. 1) Atlas Copco agreed that the proposed definition of ancillary equipment was not appropriate, and commented that DOE should consider a definition similar to the one used in the EU Lot 31 draft standard. Atlas Copco argues that following the EU Lot 31 standard would allow for accurate comparisons of the energy consumption of similar basic models of compressors and would not penalize manufacturers who efficiently integrate optional ancillary equipment into the compressor design. (Atlas Copco, No. 0009 at pp. 10–11; Atlas Copco, Public Meeting Transcript, No. 0016 at pp. 34–35) CAGI and Ingersoll Rand also supported a clearer definition and suggested the use of a list of equipment to define the term ancillary equipment, with Ingersoll Rand further commenting that optional equipment such as ancillary air treatment equipment should be excluded from the test procedures. (CAGI, Public Meeting Transcript, No. 0016 at pp. 27–28; Ingersoll Rand, Public Meeting Transcript, No. 0016 at pp. 29, 33) CAGI provided a list that is slightly modified from the one used by the EU Lot 31 draft standard; this list is reproduced in Table III.1. (CAGI, No. 0010 at p. 3; CAGI, Public Meeting Transcript, No. 0016 at p. 37) CAGI stated that this list is limited to equipment that is required for safety or basic compressor functionality. (CAGI, No. 0010 at p. 3) CAGI further indicated that all other equipment is optional and should not be included for testing. (CAGI, No. 0010 at pp. 4–5; CAGI, Public Meeting Transcript, No. 0016 at p. 37)

TABLE III.1—CAGI-SUGGESTED LIST OF ANCILLARY EQUIPMENT TO BE INCLUDED FOR TESTING

Configuration of basic compressor	Fixed-speed rotary	Variable-speed rotary
Speed	Fixed	Variable.
Cooling	Air-cooled/Water-cooled	Air-cooled/Water-cooled.
Electric motor (driver)	Yes	Yes.
Cooling fan(s) and motors	Yes	Yes.
Compression element (bare compressor)	Yes	Yes.
Transmission (belt, gear, coupling, etc.) (mechanical equipment)	Yes (if applicable) **	Yes (if applicable) **.
Inlet filter	Yes	Yes.
Inlet valve	Yes	Yes.
Minimum pressure check valve/backflow check valve	Yes	Yes.
Oil separator	Yes	Yes.
Air piping	Yes	Yes.
Oil piping	Yes	Yes.
Oil pump	Yes (if applicable) **	Yes (if applicable) **.
Oil filter	Yes	Yes.
Oil cooler	Yes	Yes.
Thermostatic valve	Yes	Yes.
Electrical switchgear	Yes *	No *.
Frequency converter	No *	Yes *.
Compressed air cooler(s)	Yes	Yes.
Compressor control device (pressure switch, pressure transducer, electronic or electrical controls, etc.).	Yes	Yes.
Protective devices	Yes	Yes.
Moisture separator and drain	Yes	Yes.

* Electrical switchgear and frequency converter only concern the main electric drive motor, other motors (*e.g.,* fans, pumps) may still be driven by a variable-speed drive and/or include electrical switchgear and/or frequency converter.
** The term "if applicable" means that if the functionality of the basic package is achieved without the component, then it does not need to be included.

Sullair and Sullivan-Palatek expressed support of the CAGI position and the list defined by CAGI in Table III.1; Sullivan-Palatek further argued that a consistent list of installed equipment, rather than what is included in commerce, is important such that compressors can be compared to each other consistently. (Sullair, No. 0006 at p. 7; Sullivan-Palatek, No. 0007 at pp. 3, 4; Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 28) Ingersoll Rand expanded on the importance of using a list to define ancillary equipment, noting that manufacturers independently have been self-declaring a basic compressor when representing unit efficiency, which in turn has been used by DOE to analyze standards for compressors. (Ingersoll Rand, Public Meeting Transcript, No. 0016 at p. 36) Sullair supported comments from Kaeser Compressors and CAGI, elaborating that items not included in the list of ancillary equipment developed by CAGI are customer-driven additional equipment and out of the control of a manufacturer. (Sullair, Public Meeting Transcript, No. 0016 at pp. 33–34) NEEA commented that a filter should be included as part of the definition of ancillary equipment, but would consider dropping the suggestion of adding a filter to the list of ancillary equipment if the draft EU compressor standard also does not require a filter. (NEEA, Public Meeting Transcript, No. 0016 at p. 35)

Further, CAGI commented that if a unit is offered for sale without a piece of equipment on its recommended list, the manufacturer must provide an appropriate component, and the selection and responsibility of providing and installing this component for testing shall be the responsibility of the manufacturer. (CAGI, No. 0010 at p. 5)

In response to these comments, DOE agrees with CAGI and other commenters that DOE should develop a list of equipment that must be present for testing. Further, DOE generally agrees with the list provided by CAGI. However, instead of including a specific list as part of the definition of ancillary equipment, DOE is maintaining a broad definition of ancillary equipment and adopting a list of equipment that must be present for testing in the equipment configuration section of the test method (see section III.E.3 for complete details). This approach helps avoid loopholes, as it ensures that compressors distributed in commerce with additional equipment outside this list are still within the scope of the test procedure, but such equipment is tested only with the equipment on the list. Further, this approach helps ensure that all compressors within the scope of this rulemaking are rated fairly and equitably with a consistent set of equipment present, addressing the concerns of Sullivan-Palatek. DOE concludes that this approach is consistent with CAGI's comments, which made clear that its list was the required subset of all potential equipment that it believed should be present for testing. As a result, DOE is adopting the definition of ancillary equipment proposed in the test procedure NOPR. Please see section III.E.3 for a complete discussion of specific equipment that is required for testing.

4. Rotary and Reciprocating Compressors

In the test procedure NOPR, DOE proposed the following definitions for rotary and reciprocating compressors:

Rotary compressor means a positive displacement compressor in which gas admission and diminution of its successive volumes or its forced discharge are performed cyclically by rotation of one or several rotors in a compressor casing. 81 FR 27220, 27228 (May 5, 2016).

Reciprocating compressor means a positive displacement compressor in which gas admission and diminution of its successive volumes are performed cyclically by straight-line alternating movements of a moving member(s) in a compression chamber(s). 81 FR 27220, 27228 (May 5, 2016).

To support these definitions, DOE also proposed ''positive-displacement compressor'' to mean a compressor in which the admission and diminution of successive volumes of the gaseous medium are performed periodically by forced expansion and diminution of a closed space(s) in a working chamber(s) by means of displacement of a moving member(s) or by displacement and forced discharge of the gaseous medium into the high-pressure area.

In response to the proposed definitions, CAGI agreed with the proposed compressor definitions, but stated that defining ''rotor'' would characterize the equipment more accurately, and suggested the following definition: A compression element that rotates continually in a single direction [around] a single shaft or axis. (CAGI, No. 0010 at p. 5) CAGI further commented that, beyond rotary screw compressors, other types of rotary compressors, such as rotary vane and scroll, would be covered under the definition. (CAGI, Public Meeting Transcript, No. 0016 at p. 22) However, CAGI did not specifically recommend whether these other rotary compressors should, or should not, be included within the scope of the test procedure. Sullair added that DOE should clarify which compressor technologies, such as scroll and vane, met the proposed definition. (Sullair, Public Meeting Transcript, No. 0016 at p. 23) Sullivan-Palatek, Ingersoll Rand, and Sullair supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullivan-Palatek, No. 0007 at p. 1; Sullair, No. 0006 at p. 1)

DOE agrees with CAGI and Sullair's comments that a definition of rotor and examples of rotary compressors would improve the accuracy of the rotary compressor definition. Further, DOE agrees with CAGI's recommended definition and finds it to be technically accurate. For this reason, in this final rule, DOE is adopting the definition of rotor, as recommended by CAGI. In response to Sullair's request for examples, DOE notes that rotary compressors include, but are not limited to, rotary screw, sliding vane, rotary lobe, and liquid ring. However, DOE does not believe that scroll compressors meet the definition of rotary compressors, as scroll compressors nutate (or orbit) rather than rotate continually in a single direction around a single shaft or axis.

Beyond these clarifications, DOE is making no changes to the remaining definitions discussed in this subsection, and for the reasons established in the test procedure NOPR, DOE is adopting in this final rule the definitions for rotary compressor, reciprocating compressor, and positive-displacement compressor, as proposed in the test procedure NOPR.

5. Brushless Electric Motor

In the test procedure NOPR, DOE proposed to define a ''brushless electric motor'' as a machine that converts electrical power into rotational mechanical power without use of sliding electrical contacts. Further, DOE considered brushless motors to include, but not be limited to, what are commonly known as induction, brushless direct current, permanent magnet, electrically commutated, and reluctance motors. 81 FR 27220, 27229 (May 5, 2016).

In response to the proposed definitions, CAGI did not provide any direct comments, but commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR, DOE is adopting the definition for brushless motor as proposed in the test procedure NOPR.

6. Compressor Motor Nominal Horsepower

In the test procedure NOPR, DOE proposed ''compressor motor nominal horsepower'' (''hp'') to mean the motor horsepower of the electric motor with which the rated air compressor is distributed in commerce, as determined in accordance with the applicable procedures in subparts B and X of 10 CFR part 431. 81 FR 27220, 27229 (May 5, 2016).

In response to the proposed definitions, CAGI did not provide any direct comments, but commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR, DOE is adopting in this final rule the definition for compressor motor nominal horsepower as proposed in the test procedure NOPR.

7. Volume Flow Rates

In the test procedure NOPR, DOE proposed that ''actual volume flow rate'' mean the volume flow rate of air, compressed and delivered at the standard discharge point, referred to conditions of total temperature, total pressure, and composition prevailing at the standard inlet point, and as determined in accordance with the test procedures proposed for 10 CFR 431.344. Further, DOE also proposed that full-load actual volume flow rate mean the actual volume flow rate of the compressor at the full-load operating pressure. 81 FR 27220, 27231 (May 5, 2016).

In response to the proposed definitions, CAGI did not provide any direct comments, but CAGI commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR, DOE is adopting in this final rule the definitions for actual volume flow rate and full-load actual volume flow rate as proposed in the test procedure NOPR.

8. Maximum Full-Flow Operating Pressure

In the test procedure NOPR, DOE proposed ''maximum full-flow operating pressure'' to mean the maximum discharge pressure at which the compressor is capable of operating, as determined in accordance with the test procedures proposed for 10 CFR 431.344.[6] 81 FR 27220, 27231 (May 5, 2016).

In response to the proposed definition, CAGI did not provide any direct comments, but CAGI commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR, in this final rule DOE is adopting the definition for maximum full-flow operating pressure proposed in the test procedure NOPR.

9. Lubricated Compressor

In the energy conservation standards NOPR, DOE proposed ''lubricated compressor'' to mean a compressor that introduces an auxiliary substance into the compression chamber during compression. 81 FR 31680, 31698 (May 19, 2016). Analogously, DOE proposed ''lubricant-free compressor'' to mean a compressor that does not introduce any auxiliary substance into the compression chamber at any time during operation. 81 FR 31680, 31698 (May 19, 2016). To support these definitions, DOE proposed ''auxiliary substance'' to mean any substance deliberately introduced into a compression process to aid in compression of a gas by any of the following: Lubricating, sealing mechanical clearances, and/or absorbing heat. 81 FR 31680, 31698 (May 19, 2016).

In the energy conservation standards NOPR, DOE discussed ISO Standard 8573–1:2010, ''Compressed air—Part 1: Contaminants and purity classes,'' (hereinafter referred to as ''ISO 8573–1:2010'') which is used by industry to measure and describe the purity of air.[7] DOE did not propose to use ISO 8573–1:2010, but requested comment on the suitability of using this standard to characterize compressors based on the presence of lubricant in the compression chamber. 81 FR 31680, 31698 (May 19, 2016).

In response, CAGI commented that ISO 8573–1:2010 is a standard for measuring the quality of air and, as such, is not suitable for determining the presence of lubricant in the compression chamber. (EERE–2013–BT–STD–0040, CAGI, No. 0052 at p. 10) Ingersoll Rand, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1) Beyond this commentary, CAGI provided no comments or recommendations regarding the definitions of lubricated compressor and lubricant-free compressor, as proposed in the energy conservation standard NOPR. Kaeser Compressors commented that ISO 8573–1:2010 is not suitable for defining a lubricated compressor and agreed with DOE's approach in the NOPR regarding the definition of an auxiliary substance without reference to ISO 8573–1:2010. (Kaeser Compressors, Public Meeting Transcript, No. 0044 at p. 21)

DOE agrees with the comments made by CAGI, Ingersoll Rand, Mattei Compressors, Sullair, Sullivan-Palatek, and Kaeser Compressors, and does not use ISO 8573–1:2010 in the definition of lubricated compressor in this final rule. Additionally, due to the reasons established in the test procedure NOPR, and due to support from Kaeser Compressors, in this final rule DOE is adopting the definitions for lubricated compressor, lubricant-free compressor, and auxiliary substance as proposed in the energy conservation standards NOPR.

B. Scope of Applicability of the Test Procedure

In the test procedure NOPR, DOE proposed to limit the scope of applicability of the compressors test procedures to compressors that meet the following criteria:

- Are air compressors;
- are rotary or reciprocating compressors;
- are driven by a brushless electric motor;
- are distributed in commerce with a compressor motor nominal horsepower greater than or equal to 1 hp and less than or equal to 500 hp; and
- operate at a full-load operating pressure of greater than or equal to 31 pounds per square inch, gauge (''psig'') and less than or equal to 225 psig;

The proposed test procedure NOPR scope directly aligned with the scope of compressor equipment that DOE analyzed for the May 5, 2016 energy conservation standards NOPR for compressors. 81 FR 27220, 27224–5. Similarly, in this final rule, DOE intends to directly align the scope of the compressors test procedures with the scope of the forthcoming energy conservation standards final rule. However, while DOE intends the scope of the test procedures adopted in this final rule to be consistent with that of any energy conservation standard that may eventually be established for compressors, DOE notes that the scope of any energy conservation standards will be established as part of a separate rulemaking.

As such, based on comments received in response to both the test procedure and energy conservation standards NOPR, the scope of this test procedure final rule is limited to compressors that meet the following criteria:

- Are air compressors;
- are rotary compressors;
- are not liquid ring compressors;
- are driven by a brushless electric motor;
- are lubricated compressors;
- have a full-load operating pressure of 75–200 psig;
- are not designed and tested to the requirements of The American Petroleum Institute standard 619, ''Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries;'' and
- have a capacity that is either:

o 10–200 compressor motor nominal horsepower (hp), or

[6] A discussion of the test procedure to determine the maximum full-flow operating pressure can be found in section III.E.9.

[7] Available at: *http://www.iso.org/iso/catalogue_detail.htm?csnumber=46418.*

o 35–1,250 full-load actual volume flow rate (cfm).

Detailed discussion of each of the scope limitations, associated benefits and burdens, and interested party comments, are in the subsections that follow.

1. Air Compressor Limitation

In the test procedure NOPR, DOE proposed to limit the scope of the compressors test procedure to air compressors, as defined in section III.A.2.

In response to the 2012 NOPD, Ingersoll Rand commented that losses in efficiency are often attributable to system-level losses as opposed to package-level losses. Ingersoll Rand stated that, therefore, little benefit would be achieved by regulating the compressor package alone without providing guidance for the overall compressed air system. (Docket No. EERE–2012–BT–DET–0033, Ingersoll Rand, No. 0004 at p. 2) CAGI argued that estimating compressor energy consumption, alone, is difficult because it is often operated in an ensemble of accompanying equipment, including other compressors. (Docket No. EERE–2012–BT–DET–0033, CAGI, No. 0003, at pp. 5–6)

In response to the more recent 2016 test procedure NOPR, CAGI and Ingersoll Rand provided updated positions on the subject, and agreed with DOE's proposal for items on which they did not directly comment. (CAGI, No. 0010 at p. 3; Ingersoll Rand, No. 0011 at p. 1) Sullivan-Palatek and Sullair supported CAGI's comments. (Sullivan-Palatek, No. 0007 at p. 1; Sullair, No. 0006 at p. 1) CASTAIR disagreed with the notion of efficiency standards for air compressors, arguing that DOE should only regulate the manufacturers of bare compressors, as air compressor assemblers have very little control over efficiency. (CASTAIR, No. 0018 at p. 1)

In response to CASTAIR, the efficiency of an air compressor is not solely a function of the bare compressor. As DOE discussed in the test procedure NOPR, opportunities exist to select high efficiency motors, drives (if applicable), mechanical equipment, and ancillary equipment that affect efficiency. Further, proper sizing and integration of this equipment also influences efficiency. In the test procedure NOPR, DOE specifically evaluated the option of regulating at the bare compressor and packaged compressor level. For the reasons just mentioned, DOE concluded that regulating a bare compressor would result in significantly lower energy savings opportunity compared to the packaged compressors. Further, DOE concluded that determining the energy performance of the bare compressor alone would not be representative of the energy consumption of the equipment under typical use conditions. 81 FR 27220, 27225 (May 5, 2016).

Based on these reasons and the support of many interested parties, DOE maintains its NOPR proposal, and is limiting the scope of the compressors test procedure final rule to air compressors as defined in section III.A.2 of this final rule.

2. Rotary and Reciprocating Compressors

In the test procedure NOPR, DOE proposed to include only rotary and reciprocating compressors within the scope of the test procedure, and not to include dynamic compressors. 81 FR 27220, 27228 (May 5, 2016).

In response to the test procedure NOPR, the CA IOUs supported the inclusion of reciprocating compressors in the scope of the test procedure and recommended that DOE require testing and performance data reporting for reciprocating compressors, noting that making their performance data publicly available would be helpful for future rulemakings and utility incentive programs. The CA IOUs recommended a phased approach for reciprocating compressors to reduce the burden on manufacturers, in which testing and reporting of performance data would be required over a long period of time. (CA IOUs, No. 0012 at p. 4)

Sullair commented that any equipment covered by the test procedure and not the standard presents a significant burden to the manufacturer and a competitive advantage to competing unregulated technologies without a resulting improvement in unit efficiency. (Sullair, No. 0006 at p. 3)

DOE agrees with the CA IOUs that establishing test procedures and public reporting requirements for reciprocating compressors could be helpful in future rulemakings and utility incentive programs. However, in the energy conservation standards NOPR, DOE concluded that energy conservation standards for reciprocating compressors are not economically justified at this time; as such, DOE did not propose energy conservation standards for reciprocating compressors. 81 FR 31680 (May 19, 2016). As discussed previously, and in agreement with Sullair's comments, DOE concludes that in the absence of existing or proposed energy conservation standards for reciprocating equipment, establishing a test procedure to measure performance of such equipment is not warranted at this time. Further, DOE concludes that the burdens associated with such a test procedure, as discussed by Sullair, outweigh any potential benefits at this time. Consequently, in this final rule, DOE is adopting test methods applicable only to certain rotary compressors and is not adopting any testing requirements for reciprocating compressors at this time.

In response to the concurrent energy conservation standards rulemaking, ASAP, NEEA, NWPCC, CA IOUs, and Sullivan-Palatek suggested that DOE's consideration of reciprocating compressors as one, monolithic category may be inappropriate, as reciprocating compressors are built to a wide range of efficiencies, intended duty cycles, and configurations based on capacity. Further, Sullivan-Palatek suggested that a fraction of compressors in the reciprocating market are likely to be used in industrial settings and may be worth considering separately from the rest. (EERE–2013–BT–STD–0040, NEEA and NWPCC, No. 0057 at pp. 1–2; Docket No. EERE–2013–BT–STD–0040, ASAP, Public Meeting Transcript, No. 0044 at pp. 151–152; Docket No. EERE–2013–BT–STD–0040, CA IOUs, No. 0059 at p. 3; Docket No. EERE–2013–BT–STD–0040, Sullivan-Palatek, Public Meeting Transcript, No. 0044 at pp. 67–68, 84–85, 87, 112–113, 114, 115–116) DOE acknowledges these suggestions and concludes that separately reassessing certain segments of the reciprocating marketing may lead DOE to a better informed assessment of the burdens and benefits of test procedures and energy conservation standards for reciprocating compressors. However, at this time, insufficient data exists to perform such a specific characterization of the reciprocating market, as noted by NEEA. (Docket No. EERE–2013–BT–STD–0040, NEEA, Public Meeting Transcript, No. 0044 at pp. 123–124) Consequently, DOE concludes the most suitable path forward is to explore the appropriateness of test procedures and energy conservation standards for reciprocating compressors in a future, separate rulemaking.

As a point of clarification, DOE notes that compressors that combine more than one type of compression principle (*e.g.,* rotary and reciprocating elements within a single compressor package) do not meet DOE's adopted definition of rotary compressor, and, therefore, are subject to the test procedures adopted in this final rule.

As noted in section III.A.4, liquid ring compressors meet the definition of a rotary compressor. Specifically, ISO

1217:2009(E), as amended,[8] defines ''liquid ring compressor'' as a machine with a rotating impeller with protruding blades eccentrically mounted in a stationary round housing or centrally mounted in a stationary elliptical housing.

In this final rule, DOE is explicitly excluding liquid ring compressors from the scope of applicability of this test procedure. Although liquid ring compressors are rotary compressors, they provide a unique utility for applications that require a durable compressor tolerant of dirty input air and ingested liquid. Due to this utility and construction, liquid ring compressors require test methods different from those proposed in the test procedure NOPR. Specifically, ISO 1217:2009(E), as amended,[9] specifies that due to their configuration, liquid ring compressors should be tested to Annex A, which provides testing methods and accuracy tolerances that differ from those contained in the sections that DOE proposed to incorporate by reference in the test procedure NOPR. As a result, DOE concludes that it is not appropriate to include liquid ring compressors in the scope of this test procedure final rule. However, DOE retains the authority to evaluate and propose appropriate test methods for liquid ring compressors in future rulemakings.

3. Driver Style

a. Electric Motor- and Engine-Driven Compressors

In the test procedure NOPR, DOE proposed to limit the scope of the compressors test procedure to only compressors driven by electric motors. In response, EEI expressed disappointment that the scope of the proposed energy conservation standard for compressors and, by extension, the test procedure was not fuel-neutral, noting that there are compressors driven by natural gas. (Docket No. EERE–2013–BT–STD–0040, EEI, Public Meeting Transcript, No. 0044 at p. 5)

In response to EEI's comment, DOE considered engine-driven compressors in the February 5, 2014 Framework document for compressors and discussed these extensively in the May 5, 2016 test procedure NOPR. 79 FR 6839 and 81 FR 27220. Specifically, in the test procedure NOPR, DOE concluded that the inclusion of engine-driven compressors was not appropriate for various reasons, including their differing utility as compared to electric compressors, their existing coverage under the U.S. Environmental Protection Agency's Tier 4 emissions regulations, and the limited test data available under Annex D of ISO 1217:2009(E) to verify suitability as a DOE test procedure. For these reasons, DOE noted that engine-driven compressors would more appropriately be considered as part of a future rulemaking. 81 FR 27220, 27229 (May 5, 2016). DOE continues to conclude that engine-driven compressors are unique equipment with different performance, applications, and test requirements from air compressors driven by electric motors. However, as noted in the test procedure NOPR, DOE currently lacks the performance data and product information to develop and validate such procedures. Therefore, DOE continues to conclude engine-driven compressors would be more appropriately addressed as part of a separate rulemaking specifically considering such equipment. As such, DOE is limiting the scope of this compressors test procedure final rule to only compressors driven by electric motors.

b. Electric Motor Varieties

In the test procedure NOPR, DOE proposed limiting the scope of the compressors test procedures to only compressors driven by brushless electric motors, as defined in section III.A.5. Further, DOE discussed the differences between brushed and brushless motors and noted that brushed motors are uncommon in compressors with significant operating hours due to higher maintenance requirements, lower efficiency, acoustic noise, and electrical arcing. However, DOE noted that compressors with brushed motors could be considered in the future as part of a separate rulemaking. 81 FR 27220, 27229 (May 5, 2016).

In response to DOE's test procedure NOPR, NEEA stated that manufacturers may avoid regulation by changing the motor technology. (NEEA, Public Meeting Transcript, No. 0016 at p. 56) In response, DOE reiterates that brushed motors are uncommon in compressors with significant potential energy savings (*i.e.,* high operating hours) due to higher maintenance costs, short operating lives, significant acoustic noise, and electrical arcing. For these reasons, DOE concludes that brushed motors are not a viable substitution risk for compressors within the scope of the compressor test procedures.

In a joint comment, ASAP and NEEA recommended that DOE expand the scope of the test procedures so that it includes all kinds of electric motors, rather than exclusively covering brushless motors. ASAP and NEEA reasoned that the test procedures should be broad so that they could be applicable to possible future energy conservation standards and could be used to collect a wide range of compressor performance data. (ASAP and NEEA, No. 0015 at p. 1)

In response, DOE acknowledges the potential benefits of standardized test procedures and reporting requirements in making available consistent performance information for utility programs and consumers. However, with these potential benefits come potential burdens. If DOE were to include this equipment in the scope of the test procedures and require reporting of performance data, the burden would be significant, as most brushed motor compressors are not currently tested for efficiency. Consequently, manufacturers of this equipment, many of which are small, would face significant third-party testing costs or test lab development costs. Alternatively, DOE could adopt *optional* testing and certification requirements for brushed motor compressors. However, doing so may not have the desired effect of making more certified performance data available, as this equipment is not currently tested and energy performance is not currently represented. Therefore, based on this discussion, at this time, the burden associated with establishing testing requirements for brushed motor compressors outweigh the associated benefits.

4. Compressor Capacity

In the test procedure NOPR, DOE proposed to limit the scope of the test procedures to compressors that met the following capacity criteria:

- Compressor motor nominal horsepower of 1–500 hp.
- full-load operating pressure 31–225 psig.

81 FR 27220, 27230 (May 5, 2016).

In the test procedure NOPR, DOE did not propose scope restrictions based on the actual volume flow rate (expressed in cfm).

As noted in the test procedure NOPR, the intent of the compressor capacity criteria used to establish the scope of the test procedures was to encompass the majority of the rotary and reciprocating compressor market

[8] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic. For details on ISO 1217:2009(E) and Amendment 1:2016, see III.D and IV.N.

[9] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic.

intended for use in non-specialty applications. 81 FR 27220, 27224–27230 (May 5, 2016). However, in the test procedure NOPR, DOE noted that most equipment operating at an output pressure of greater than 215 psig is highly engineered equipment, primarily used in specialty applications. DOE also recognized that there are relatively few compressed air applications in the 31 to 79 psig range. 81 FR 27220, 27230 (May 5, 2016).

a. Compressor Motor Nominal Horsepower Limitations

In response to the proposed compressor motor nominal horsepower scope of 1–500 hp, CAGI recommended limiting the scope of the test procedures to compressors with compressor nominal motor horsepower of 10–200 hp. CAGI suggested that the inclusion of larger compressors (*i.e.,* greater than 200 hp) would be burdensome and cause problems with certification and enforcement as they are infrequently built and often customized. Further, CAGI noted that while the test procedures are technically appropriate for 1–500 hp compressors, the data upon which the energy conservation standard regression curves were developed is not readily available for smaller and larger compressors. (CAGI, No. 0010, p. 6) Kaeser Compressors, Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's scope suggestion, while Scales Industrial Technologies suggested a horsepower scope of 15–200 or 250 hp. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at pp. 1–8; Sullivan-Palatek, No. 0007 at pp. 1, 3; Scales Industrial Technologies, No. 0013 at pp. 3, 7; Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 46; Sullair, Public Meeting Transcript, No. 0016 at pp. 40–41, 47; Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 56; Ingersoll Rand, Public Meeting Transcript, No. 0016 at p. 53)

Compressed Air Systems commented that there are few 1-hp rotary compressors manufactured and suggested that the test procedures burden would outweigh the energy savings potential. (Compressed Air Systems, No. 0008 at p. 1) Sullair agrees that the test procedure for low horsepower compressors would be burdensome, but commented that the volume of compressors manufactured in the low horsepower range are high. (Sullair, No. 0006 at pp. 5–6) P. R. China also commented that the DOE did not provide adequate justification to include low horsepower compressors in the scope of the test procedure. (P. R. China, No. 0019 at p. 3) P. R. China further stated that, in accordance with Article 2.5 of the TBT Agreement, they are entitled to an explanation for the justification for a technical regulation that may impact the trade opportunities of those in the agreement. (P. R. China, No. 0019 at p. 3) DOE interprets P. R. China's comments as challenging the rationale of including small capacity compressors with small nominal horsepower motors in the scope of the test procedure NOPR.

Sullair suggested that the testing burden associated with including rotary compressors less than 10 hp and greater than 200 hp in scope would create an unfair competitive advantage for non-regulated competing equipment; specifically, reciprocating or scroll compressors on the low end and centrifugal compressors on the high end. Sullair indicated that such burden may completely eliminate the larger rotary screw compressors from the market and significantly hurt the sales of the smaller ones. (Sullair, No. 0006 at pp. 2–3, 5–6) Kaeser Compressors indicated similar concerns of product substitution, citing 350 hp, rather than 200 hp. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 51) Beyond the financial burden, CAGI and Sullair commented about the difficulty of testing large compressors over 200 horsepower. Specifically, Sullair stated that the test equipment and environmental chamber required for compressors above 200 horsepower are unreasonably costly. (Sullair, No. 0006 at p. 4; CAGI, Public Meeting Transcript, No. 0016 at p. 50)

Kaeser Compressors further stated that compressor customization, such as customer-driven motor substitutions or modifications due to unique environments, are more common on units above 300 hp. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 46) CAGI, Sullair, and Sullivan-Palatek made similar comments, noting that large horsepower compressors are more frequently customized. Sullair and Sullivan-Palatek defined large horsepower compressors as compressors with greater than 200 horsepower. (CAGI, No. 0010 at p. 6; Sullair, No. 0006 at p. 4; Sullair, No. 0006 at pp. 7–8; Sullivan-Palatek, No. 0007 at p. 3)

Additionally, CAGI cited that its current Performance Verification Program covers compressors with motor power of 5–200 hp. CAGI clarified that manufacturers may publicly rate equipment beyond 200 hp with the CAGI performance data sheet; however, this equipment is not subject to the CAGI Performance Verification Program. (CAGI, Public Meeting Transcript, No. 0016 at pp. 50, 54–55) Conversely, Atlas Copco and the CA IOUs recommended that DOE expand the scope of the test procedures to equipment with compressor motor horsepower greater than 500 hp, with Atlas Copco citing harmonization with the draft EU standard for compressors and noting that the ISO 1217:2009(E) standard is applicable to compressors above 500 horsepower. (Atlas Copco, No. 0009 at p. 11; CA IOUs, No. 0012 at p. 4)

In response to the 2012 NOPD, EEI argued that large electric motors (*i.e.,* of greater than 500 horsepower), relative to other sizes, carried the greatest per-unit energy consumption and tended to be operated at high duty cycles. EEI noted that this tendency to operate at high duty cycles may simplify development of a test procedure and that, on the account of both test procedure simplicity and large unit energy consumption, DOE should prioritize large compressors and common gases. (Docket No. EERE–2012–BT–DET–0033, EEI, No. 0009, at p. 8)

In summary, one group of commenters (CAGI, Compressed Air Systems, Kaeser Compressors, Ingersoll Rand, P. R. China, Scales Industrial Technologies, Sullair, and Sullivan-Palatek) favors a significant reduction in compressor motor nominal horsepower scope (to approximately 10–200 hp, depending on commenter). This group suggests that significant test burden would be incurred if the smaller and larger horsepower range were to be kept in scope, and this burden could lead to competitive advantage for unregulated compressors. This group also cites weakness in the data used to evaluate less than 10 hp compressors in the energy conservation standards NOPR as a reason to limit the lower horsepower range. Another group (Atlas Copco, CA IOUs, and EEI) favors expansion of scope to all equipment for which the test method is technically applicable. EEI, while not outright calling to exclude lower horsepower ratings, implies that DOE's first attention should go to larger compressors.

In general, DOE agrees with the concerns that the representations, sampling, and enforcement provisions proposed in the test procedure NOPR may cause significant burden for compressors greater than 200 hp, as many of the larger horsepower models are custom or infrequently built and typically not available for testing. Additionally, DOE agrees with Kaeser Compressors and Sullair that DOE's proposed inclusion of small (less than 10 hp) and larger (greater than 200 hp) rotary compressors, could create a competitive disadvantage for manufacturers of these compressors, as centrifugal, reciprocating, and scroll compressors of the same horsepower do not have the same testing and representations requirements. Furthermore, DOE concludes that this competitive advantage may incentivize end users to switch from a regulated (rotary) to an unregulated (centrifugal and reciprocating) compressor, thus creating an unfair and undue burden on certain manufacturers.

In response to Atlas Copco and the CA IOUs suggestions to expand scope, DOE acknowledges the potential benefits of standardized test procedures and reporting requirements in making available consistent performance information for utility programs and consumers. However, DOE also recognizes that with these potential benefits come potential burdens. Based on the comments received and the discussion in this section, DOE concludes that the burden of testing requirements on compressors certain smaller and larger compressors outweigh the benefits. DOE acknowledges that multiple recommendations for horsepower limitations were put forward. Of the commenters supporting a reduction in horsepower cost, the overwhelming majority recommended the 10–200 hp range. For these reasons, DOE is limiting the scope of the test procedures to only compressors with 10–200 compressor nominal motor horsepower. DOE notes that this limitation on compressor nominal motor horsepower is coupled with a limit of compressor full-load actual volume flow rate, as discussed in section III.B.4.b.

b. Full-Load Actual Volume Flow Rate Limitations

CAGI and Sullair commented that the absence of a maximum airflow limit may encourage manufacturers of compressors to equip units with higher horsepower motors than the unit requires to avoid regulatory coverage. CAGI and Sullair then suggested that DOE adopt a hybrid scope limitation. Specifically, CAGI proposed a horsepower range of 10–200 hp or an actual volume flow rate range of 35–1,250 cfm. Sullair proposed a horsepower range of 10–200 hp or, an actual volume flow rate of 30–1,250 cfm (whichever is less). (Docket No. EERE–2013–BT–STD–0040, CAGI, No. 0052 at p. 9; Sullair, No. 0006 at pp. 2, 4–5; Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at pp. 9–10; Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at p. 11; Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at pp. 11–12; Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at p. 13) CAGI's position is supported by Ingersoll Rand, Kaeser Compressors, Sullair, and Sullivan-Palatek. (Docket No. EERE–2013–BT–STD–0040, Ingersoll Rand, No. 0055 at p. 1; Docket No. EERE–2013–BT–STD–0040, Kaeser Compressors, No. 0053 at p. 1; Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at p. 1; Docket No. EERE–2013–BT–STD–0040, Sullivan-Palatek, No. 0051 at p. 1)

DOE agrees with CAGI and Sullair that, by not limiting flow rate, manufacturers could conceivably circumvent the intent of compressor regulations by using a motor of horsepower slightly greater than 200 hp. For example, two similar compressors, one with a 200 hp motor and one with a 225 hp motor, would supply nearly identical flow rates and pressure (*i.e.,* utility) to the end user, however the compressor equipped with the 225 hp motor would not be subject to the test procedure, as proposed in the NOPR. In DOE's view, any alteration in flow rate directly impacts consumer utility. Additionally, a flow limitation is consistent with the EU Lot 31 draft standard, which proposes to regulate compressors with airflow of between 5 and 1,280 liters per second (l/s) (approximately 10.6–2,712 cfm).

A review of all available CAGI performance data sheets indicates that the flow rate ranges recommended by CAGI and Sullair are reasonable. The full-load actual volume flow rate range of 35–1,250 cfm is slightly broader than the compressor motor nominal horsepower range of 10–200 hp; *i.e.,* the flow range encompasses slightly more compressor models. This aligns with the intent of the recommendations put forth by CAGI and Sullair. Specifically, the full-load actual volume flow rate range of 35–1,250 cfm incorporates 9.2 percent more fixed-speed compressors and 2.9 percent more variable-speed compressors as subject to the test procedure than would otherwise be included with the compressor motor nominal horsepower range of 10–200 hp alone. For the reasons outlined in this section, in this final rule, DOE adopts a coupled airflow and horsepower limit, as recommended by Sullair and CAGI. DOE notes that the recommendations from Sullair and CAGI are not completely aligned, with Sullair recommending a lower limit of 30 cfm and CAGI recommending a lower limit of 35 cfm. Given general support by Ingersoll Rand, Kaeser Compressors, Sullair, and Sullivan-Palatek for CAGI's recommendations, DOE is adopting the lower limit of 35 cfm. Specifically, the test procedure applies to compressors with either a nominal horsepower of 10–200 horsepower or a full-load actual volume flow rate between 35–1,250 cubic feet per minute.

c. Full-Load Operating Pressure Limitations

In response to the operating pressure range proposed in the test procedure NOPR, CAGI suggested reducing the range to compressors with a full-load operating pressure of 75–200 psig, noting that outside this range, the package isentropic efficiency of a compressor is no longer independent of pressure. (CAGI, No. 0010 at p. 6) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's position. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1; Sullivan-Palatek, No. 0007 at p. 3; Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 40) CAGI further stated that their recommended pressure range of 75–200 psig covers the primary market for rotary compressors, which the DOE defines as 80–139 psig according to the NOPR. (CAGI, Public Meeting Transcript, No. 0016 at p. 40) Jenny Products also recommended a range of 75–200 psig and stated that nearly all of the compressors sold in commerce would be covered under this range. (Jenny Products, No. 0020 at p. 3)

Atlas Copco asserted that it is incorrect for DOE to state that isentropic efficiency is independent of pressure. Instead, Atlas Copco commented that the correct statement is that isentropic efficiency is less dependent on pressure than specific energy is dependent on pressure. To support this assertion, Atlas Copco provided a chart of pressure versus isentropic efficiency, for what DOE infers to be a single compressor. Atlas Copco further stated that the chart shows the relative independence of isentropic efficiency with respect to outlet pressure between 80–170 psig (7–15 bar),[10] which was the motivation for the air compressor industry to use isentropic efficiency in Lot 31. (Atlas Copco, No. 0009 at pp. 16–17) DOE notes that Atlas Copco's unit conversions are incorrect; 80 to 170 psig does not convert to 7 to 15 bar (g), rather this range converts to 5.5 to 11.7 bar (g) (or 6.5 to 12.7 bar absolute), which is inconsistent with the scope proposed in the EU Lot 31 draft standard.[11] In the EU draft standard, the

[10] The commenter did not specify whether it meant absolute or gauge pressure. DOE's response in the following sentence addresses both possibilities.

[11] Available at: *http://www.regulations.gov/contentStreamer?documentId=EERE-2013-BT-STD-*

European Commission proposed to establish a scope of 7 to 14 bar (g), which converts to 101.5 to 203.1 psig.

In response, DOE acknowledges the commenters concerns that package isentropic efficiency may not be pressure independent at the lower and upper regions of the 31 to 225 psig full-load operating pressure scope, as DOE had originally assumed in the test procedure and energy conservation standards NOPR. As discussed previously, CAGI, Ingersoll Rand, Sullivan-Palatek, and Sullair suggested 75 to 200 psig as the range over which package isentropic efficiency can be considered relatively independent of pressure. Alternatively, Atlas Copco suggested that 80 to 170 psig (7 to 15 bar) [sic] as the range over which the dependence of isentropic efficiency on outlet pressure is limited. However, as discussed previously, Atlas Copco's unit conversions were inaccurate and their suggested range does not align with the scope proposed in the EU Lot 31 draft standard. Based these ambiguities, DOE cannot directly consider Atlas Copco's recommendation when considering the range for which package isentropic efficiency can be considered independent of full-load operating pressure. As such, DOE defers to the recommendation of CAGI, Ingersoll Rand, Sullivan-Palatek, and Sullair, and concludes that package isentropic efficiency can be considered independent of full-load operating pressure at full-load operating pressures between 75 and 200 psig. DOE notes that the EU draft standard proposed to establish a scope of 101.5 to 203.1 psig,[12] and concluded that isentropic efficiency is independent of pressure within this range of full-load operating pressure. Part of DOE's rationale for selecting package isentropic efficiency as a test metric for compressors, as explained in the test procedure NOPR, was that package isentropic efficiency was believed to be pressure independent—meaning that attainable package isentropic efficiency varies as function of flow, but not pressure. 81 FR 27220, 27232 (May 5, 2016) and 81 FR 31680, 31705 (May 19, 2016). DOE values dependence on one parameter (flow) rather than two (flow and pressure), as it reduces the complexity (and ultimately the burden) of the related energy conservation standards and analyses. DOE's intent in the test procedure NOPR was to limit the scope to those compressors for which package isentropic efficiency and pressure are independent. However, given the new information (*i.e.,* pressure dependence at certain full-load operating pressures), DOE acknowledges that package isentropic efficiency may not be the most appropriate metric to describe the energy performance of such equipment, and further investigation is necessary. Therefore, in this final rule, DOE is limiting the scope of the test procedures to compressors within a full-load operating pressure range of 75–200 psig. However, in the future DOE may further investigate package isentropic efficiency and other metrics to determine if they are appropriate for compressors outside this range. Further discussion related to DOE's selection of package isentropic efficiency as a metric can be found in section III.C.1.

DOE notes that Scales Industrial Technologies commented that the scope should be limited to a narrower range of 80–125 psig, commenting that a narrower range may provide more meaningful results and have less effect on isentropic efficiency. (Scales Industrial Technologies, No. 0013, p. 4) While Scales Industrial Technologies may be correct that a narrower range would have less effect on isentropic efficiency, DOE concludes, based on the input of CAGI, Ingersoll Rand, Sullivan-Palatek, Sullair, and Atlas Copco, as well as the precedent established by the draft EU Lot 31 regulation, that isentropic efficiency can be considered comparable and meaningful beyond the 80 to 125 psig range.

5. Lubricant Presence

As discussed in section III.A.9, in this final rule DOE adopts the definition proposed in the energy conservation standards NOPR for lubricated compressor as one that introduces an auxiliary substance into the compression chamber during compression. In this final rule, DOE also defines lubricant-free compressor and auxiliary substance. In the test procedure NOPR, DOE did not propose limiting scope based on lubrication; as such, the proposed scope implicitly included both lubricated and lubricant-free compressors. 81 FR 27220 (May 5, 2016).

In response to DOE's proposal, Atlas Copco, CAGI, and Kaeser Compressors noted that other technology options that are outside the scope of the test procedure, such as turbo compressors, centrifugal compressors, and other styles of dynamic compressors, will present themselves as viable alternatives to lubricant-free compressors and are risks for unregulated product substitution. (EERE–2013–BT–STD–0040, Atlas Copco, Public Meeting Transcript, No. 0044 at p. 58) Furthermore, Kaeser Compressors noted that the draft EU standard for compressors excluded lubricant-free compressors due to the risk of product substitution and lack of available data. CAGI and Kaeser recommended that DOE exclude lubricant-free compressors so that the DOE can harmonize with the draft EU compressor standard's approach for lubricant-free compressors. (EERE–2013–BT–STD–0040, CAGI, No. 0052 at p. 12; EERE–2013–BT–STD–0040, Kaeser Compressors, No. 0053 at p. 1)

DOE agrees with comments made by Atlas Copco, CAGI, and Kaeser that there is a risk of product substitution to unregulated technologies, which do not have the burden of representing efficiency in accordance to the proposed test procedure. DOE acknowledges that, in effect, the inclusion of lubricant-free rotary compressors gives unregulated technologies a competitive advantage in the marketplace in that they are free to represent efficiency in a less burdensome fashion. DOE also acknowledges an argument made by CAGI, which point out that the shipments volume of lubricant-free rotary compressors and dynamic compressors are approximately equal, yet DOE excluded centrifugal compressors from the scope of the test procedure on the basis of low shipment volume. (EERE–2013–BT–STD–0040, CAGI, No. 0052 at p. 12) 81 FR 27220, 27228 (May 5, 2016).

DOE also received many comments related to the appropriateness and applicability of the variable-speed compressors test method and metric (part-load package isentropic efficiency) to lubricant-free compressors. In general, commenters expressed concern that many lubricant-free compressors are unable to operate at the 40 percent flow load point, and as such, suggested that the test procedure, as proposed in the test procedure NOPR is not appropriate or applicable to lubricant-free compressors. A full discussion of these comments and their relationship to scope is found in section III.C.1, which discusses, in the depth, the metric and load points proposed in the test procedure NOPR. As a result of the discussions provided in section III.C.1, DOE is limiting the scope of the test procedure final rule to lubricated compressors only.

6. Specialty-Purpose Compressors

In the test procedure NOPR, DOE made no specific scope exclusion for

0040-0031&disposition=attachment&contentType=pdf.

[12] For copies of the EU Lot 31 draft regulation: *www.regulations.gov/contentStreamer?documentId=EERE-2013-BT-STD-0040-0031&disposition=attachment&contentType=pdf.*

what the compressor industry refers to as ''customized'' or ''specialty-purpose'' compressors. In response, DOE received many comments recommending that it expressly exclude specialty-purpose compressors from the scope of the test procedure. Additionally, many commenters suggested that DOE establish criteria to exclude customized compressors that are created by modifying a standard compressor.

Sullivan-Palatek commented that compressor products usually start with the basic package, but often substitute non-standard electric motors, controls or coolers and add numerous other options and features specified by the customer or required by the location in which the compressor is installed. (Sullivan-Palatek, No. 0007 at p. 22)

Sullair provided examples of custom requirements, such as sump heating, extra fans, and special marine applications for which motors have to be built (American Bureau of Shipping), and noted that these frequently increase package energy consumption. (Sullair, Public Meeting Transcript, No. 0016 at p. 113)

Atlas Copco commented that the test procedures proposed in the NOPR applied to both standard compressor packages and custom compressor packages, and the latter often have unusual combinations of ancillary equipment. Atlas Copco provided examples of custom equipment, including customized liquid cooling systems, drive systems, safety systems, filtration systems, dryers, heaters, and air receiver/surge tanks. Atlas Copco also noted that each type of customization can have a significant impact on the energy efficiency of the total compressor system. Ultimately, Atlas Copco suggested that applying the proposed test procedure to custom orders for compressor packages was unduly burdensome to conduct and inappropriate under section 343(a)(2) of EPCA. (Atlas Copco, No. 0009 at pp. 4–7)

To address the industry concerns over the testing of customized and specialty-purpose compressors, CAGI recommended that the list of ancillary equipment they provided (see section III.A.3.b and Table III.1) should exclude all options or modifications required to meet specific customer requirements or other codified standards where these options or modifications are made to an existing tested model and do not create in and of themselves a new model. Examples may include options or modifications required to meet hazardous locations, breathing air, marine environments, ambient conditions above 45 °C or below 0 °C, weather protection, etc. (CAGI, No. 0010, p. 4)

Sullair agreed with CAGI's recommendation and provided additional examples of custom requirements, including hazardous locations or corrosive environments (as specified by the standard known as Atmosphères Explosibles, or ''ATEX'') [13] or issued by the American Petroleum Institute (''API''), the Mine Safety and Health Administration (''MSHA''), etc.), marine environments, alternate cooling methods (remote coolers, water cooled, closed loop cooling, etc.), ambient conditions exceeding 45 °C, ambient conditions below 5 °C, energy or heat recovery options, environmental protections (NEMA 4, IEC 65, etc.), and dimensional changes or enclosure modifications. (Sullair, No. 0006 at p. 8)

In its comments, Sullivan-Palatek strongly urged the DOE to limit testing and sampling to the basic package as defined by CAGI. It also recommended that DOE permit add-ons and alterations to basic packages so that specialty products offered to the end-user customer base in the past can continue in the future. (Sullivan-Palatek, No. 0007 at p. 4)

As discussed in sections III.A.3.b and III.E.3, DOE is incorporating CAGI's recommended list of equipment (with certain modifications) to define the minimum testing configuration for a compressor basic model. DOE believes that the incorporation of this recommendation effectively excludes, from the scope of the test procedure, customized or specialty-purpose equipment that is created by adding additional equipment to what the industry refers to as a standard or basic package compressor.

Based on DOE's interpretation of the comments described above, two additional concerns remain: (1) Specialty-purpose equipment that is created by modifying or replacing equipment on a standard package compressor, and (2) specialty-purpose equipment that is not a derivative of other standard equipment. However, DOE notes that the commenters provided no specific examples of specialty-purpose compressors that have been distributed in commerce, nor did they provide any direct or quantitative evidence that such compressors consume more energy and are more burdensome to test than their ''general-purpose'' counterparts (beyond noting that more models may need to be certified). Regardless, given the commenters' concerns, DOE performed research (using interested party comments as a starting point) to determine if any additional scope exclusions are warranted. Specifically, DOE was able to identify 10 applications and feature categories that could possibly be used to characterize specialty-purpose compressors in the compressor industry:

(1) Corrosive Environments
(2) Hazardous Environments (combustion and/or explosion risk)
(3) Extreme Temperatures
(4) Marine Environments
(5) Weather-protected
(6) Mining Environments
(7) Military Applications
(8) Food Service Applications
(9) Medical Air Applications
(10) Petroleum, Gas, and Chemical Applications

Given the concerns raised by commenters, DOE established three specific criteria to help determine if test procedure exclusions are warranted for each of the aforementioned applications and feature categories. A compressor category must meet all criteria to be considered for exclusion.

The first criterion, distinguishability, is that compressors under consideration must be able to be distinguished from general-purpose compressors. In this case, to be distinguishable extends beyond being able to identify any difference whatsoever. Specifically, distinguishability is determined in the context of the test procedure. DOE's test procedure final rule contains instructions regarding compressor configuration during testing. During a test, only specific components are required to be connected; manufacturers may remove non-required components at their option. If the specialized nature of a compressor arises from a non-required component, manufacturers have the option to remove its influence on compressor performance. In that scenario, the specialty compressor, from the perspective of the test procedure, has collapsed to a general-purpose unit with no remaining distinction. In considering whether a compressor meets the distinguishability criterion, DOE will assess whether the specialized nature of the compressor arises from components or configurations that are removable or reconfigurable under the specific provisions of DOE's test.

As stated previously, DOE is incorporating CAGI's recommended list of equipment (with certain modifications), so the only specialty-

[13] ATEX is the common industry phrasing for European Parliament and Council Directive 2014/34/EU of 26 February 2014, which governs equipment and protective systems intended for use in potentially explosive atmospheres. The term ''ATEX'' is a portmanteau of ''atmosphères explosibles'', French for ''explosive atmospheres.''

purpose compressors that could warrant exclusion are those that are created by modifying or replacing equipment on a standard package compressor, and specialty-purpose equipment that is not derivative of other standard equipment.

Under the second criterion, manufacturers must currently make public representations for the specific category of compressors using test procedure metrics. This criterion establishes the need to use the test procedure for the specific category. Absent an energy conservation standard, the test procedure is needed only to measure metrics used in representations of compressor performance. If manufacturers make no representations for a specific category of compressors, the existence of a test procedure has no impact on them. Sullivan-Palatek commented that manufacturers typically do not publish CAGI datasheets for models that are variations of a basic package. (Sullivan-Palatek, No. 0007 at p.4) This suggests that it is rare for manufacturers to make public representations of the performance for specialty-purpose compressors.

The third criterion is that it must be impractical to apply the test procedure to compressors in the specific category, because an attribute of the compressor renders testing technically impossible or possible only with major modification, or because the test procedure produces non-representative results for the specific category of compressor. This criterion establishes that there is a technical impediment to using the test procedure with the specific category of compressors.

DOE performed research, using publicly available data, on each of the categories to determine if exclusions are warranted. In the following paragraphs, DOE discusses findings for each of the aforementioned ten specialty applications.

Corrosive Environments

Corrosive environments can be damaging to both the external components of a compressor and the internal components, if corrosive agents are ingested with the air. DOE's research indicated that corrosive agents are found in a wide range of varieties and severities. Certain corrosive agents may harm some materials but not others.

Compressors may be adapted to corrosive environments by using special materials, having special coatings, using additional intake air filtration, or using special or remote enclosures to isolate the compressor from the corrosive environment. However, most requirements for corrosive environments are customer-specific, making it difficult to create a generalized scope exclusion. Some end users also use general-purpose compressors in a corrosive environment, opting to replace the compressor at an earlier interval instead of purchasing a more expensive compressor that can last longer in the corrosive environment.

Based on this information, DOE does not believe that all corrosive environment compressors meet the first criterion of distinguishability; however certain corrosive environment compressors utilizing special materials and/or coatings may be distinguishable.

DOE did not find any public representations of the performance for compressors designed for corrosive environments, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for corrosive environments, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because manufacturers do not appear to make representations of performance for these compressors and there is no technical impediment to testing these compressors with the test procedure, DOE finds no cause to exclude compressors adapted to corrosive environments from the scope of this final rule.

Hazardous Environments

Hazardous environments include those in which there is the possibility of combustion or explosion. Compressors may be adapted to hazardous environments through modified electrical components and enclosures that protect against sparks and high temperatures. At least some of these components need to be included as part of the basic package during testing. Several standards specify the type and level of precautions required for these environments, so certification with one or more of these could be a method for defining the scope of exclusion.

For these reasons, DOE finds that hazardous environment compressors meet the first criterion of distinguishability. Hazardous environment compressors are designated as such by independent agencies such as UL, and given a rating that corresponds to the specific attributes of the hazardous environment for which the unit is being certified.

DOE did not find any public representations of the performance for compressors designed for hazardous environments, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for hazardous environments, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because manufacturers do not appear to make representations of performance for these compressors and there is no technical impediment to testing these compressors with the test procedure, DOE finds no cause to exclude compressors adapted to operate in hazardous environments from the scope of this final rule.

Extreme Temperatures

CAGI and Sullair identified the need to exclude compressors used in extreme temperatures. (CAGI, No. 0010, p. 4; Sullair, No. 0006 at p. 8) For high-temperature extremes, both commenters identified temperatures above 45 °C. For low-temperature extremes, Sullair indicated temperatures below 5 °C, while CAGI indicated temperatures below 0 °C. DOE notes that CAGI and Sullair did not present any standardized tests or inspections that might be used to uniformly classify a non-extreme temperature range for compressors.

In the absence of that information, DOE performed research and found neither industry-accepted, standardized test methods to determine allowable operating temperature, nor any industry-accepted certification programs to classify compressors for extreme temperatures. DOE also researched what types of modification and components might be employed to adapt compressors for extremely high- and low-temperature environments. For lower temperatures, a variety of heating devices may be used to heat the compressor package in various ways—such equipment is not required as a part of test procedure testing configuration and is, therefore, not a distinguishing feature.

In hotter environments, compressors may employ larger output air heat exchangers and associated fans. Unlike package heating and cooling, heat exchangers and fans are part of the test configuration. However, manufacturers may employ larger heat exchangers and fans for a variety of reasons, *e.g.* recovering waste heat for use in space heating. Furthermore, heat exchanger and fan size (as compared to compressor capacity) is not a standardized feature across the compressor industry, with different manufacturers choosing different-sized components to meet their specific design goals. Consequently, DOE is unable to establish a clear threshold to delineate larger heat exchangers and fans employed for high temperature applications. Furthermore, doing so opens a significant circumvention risk, as manufacturers could purposely substitute larger heat exchangers and fans in order to exclude compressors from regulation. For these reasons, DOE concludes that compressors designed for extreme temperature operation are not clearly distinguishable from general-purpose compressors.

DOE also did not find any public representations of the performance for compressors designed for extreme temperatures, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for extreme temperatures, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because (a) it is difficult to clearly identify compressors for extreme temperatures; (b) manufacturers do not appear to make representations of performance for these compressors; and (c) there is no technical impediment to testing these compressors with the test procedure, DOE does not find cause to exclude compressors adapted to extreme temperatures from the scope of this final rule.

Marine Environments

Marine air compressors are intended for use aboard ships, offshore platforms, and similar environments. In general, DOE found this to be a very broad category of compressors. There are a wide variety of standards for these applications, but many of the requirements are customer-specific, making it difficult to clearly identify the scope for exclusion. Marine compressors may be space constrained if installed on ships. However, this may not always be the case, and some marine environments may be able to utilize general-purpose compressors. Further, DOE found no way to clearly distinguish, from general-purpose compressors, those that are specifically developed for constrained spaces. DOE's research found that other items, such as saltwater coolers, may be employed on marine air compressors, however, this equipment does not need to be included for testing. For these reasons, DOE does not find marine environment compressors to meet the first criterion of distinguishability.

DOE did not find any public representations of the performance for compressors designed for marine environments, suggesting that representations are not commonly made.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for marine environments, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because (a) it is difficult to clearly identify compressors for marine environments; (b) manufacturers do not appear to make representations of performance for these compressors; and (c) there is no technical impediment to testing these compressors with the test procedure, DOE does not find cause to exclude compressors adapted to marine environments from the scope of this final rule.

Weather-Protected

Weather-protected compressors require features to prevent the ingress of water and debris, as well as accommodation for extreme temperatures in some cases. DOE found that third-party standards exist for ingress protection of the electrical components. However, DOE did not find an indication of a standard or certification for other aspects of weather protection, making it difficult to clearly identify a general scope for exclusion for all weather-protected equipment. However, DOE believes that certain weather-protected compressors (*i.e.,* those with electrical components rated for ingress protection) meet the first criterion of distinguishability.

DOE did not find any public representations of the performance for weather-protected compressors, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for weather-protected compressors, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because manufacturers do not appear to make representations of performance for these compressors and there is no technical impediment to testing these compressors with the test procedure, DOE finds no cause to exclude compressors adapted to corrosive environments from the scope of this final rule.

Mining Environments

Mining environments can include both surface and subsurface mine compressor applications. There are some standards for these applications, but many of the requirements are customer-specific, making it difficult to clearly identify the scope for exclusion. Some mining applications also use general-purpose compressors. For this reason, DOE does not find mining environment compressors to meet the first criterion of distinguishability.

DOE did not find any public representations of the performance for compressors designed for mining environments, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for mining environments, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because (a) it is difficult to clearly identify compressors designed for mining environments; (b) manufacturers do not appear to make representations of performance for these compressors; and (c) there is no technical impediment to testing these compressors with the test procedure, DOE does not find cause to exclude compressors designed for mining environments from the scope of this final rule.

Military Applications

Compressors used in military applications have a wide range of applications. Many military applications use common commercial or industrial compressors. Other military applications, however, must meet extensive customer-specific requirements. These requirements can vary greatly with the customer, and there are no commonly used standards for compressors in military applications. This makes it difficult to clearly identify the scope for exclusion. For this reason, DOE does not find military compressors to meet the first criterion of distinguishability.

DOE did not find any public representations of the performance for compressors designed for military applications, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for military applications, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because (a) it is difficult to clearly identify compressors designed for military applications; (b) manufacturers do not appear to make representations of performance for these compressors; and (c) there is no technical impediment to testing these compressors with the test procedure, DOE does not find cause to exclude compressors designed for military applications from the scope of this final rule.

Food Service Applications

Food service applications can have requirements for air purity and to use food-grade lubricants. Food grade lubricants need to be included for testing, so at least some compressors designed for food service applications meet the first criterion of distinguishability.

DOE did not find any public representations of the performance for compressors designed for food service applications, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for food service applications, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because manufacturers do not appear to make representations of performance for these compressors and there is no technical impediment to testing these compressors with the test procedure, DOE finds no cause to exclude compressors adapted to corrosive environments from the scope of this final rule.

Medical Air Applications

Medical air applications can have requirements for air purity, which is both rated according to ISO 8573–1 and included in the National Fire Protection Association Standard for Health Care Facilities (NFPA 99). DOE notes that most medical air compressors are lubricant-free and, as such, are already excluded from this final rule. In lubricated compressors, high air purity is attained using a combination of filters and dryers added to the system downstream of the compressor discharge. These items are outside the basic compressor package, so a medical air compressor collapses to a standard basic package for testing. For this reason, DOE does not find medical air application compressors to meet the first criterion of distinguishability.

DOE did not find any public representations of the performance for compressors designed for medical air applications, suggesting that representations are not commonly posted.

Finally, DOE found no evidence that testing with the test procedure is impractical for compressors designed for medical air applications, because these compressors operate in the same manner as general-purpose compressors.

Therefore, because (a) manufacturers do not appear to make representations of performance for compressors designed for medical air applications; (b) these compressors collapses to the basic package for testing; and (c) there is no technical impediment to testing these compressors with the test procedure, DOE does not find cause to exclude compressors designed for medical air applications from the scope of this final rule.

Petroleum, Gas, and Chemical Applications

The American Petroleum Institute standard 619, ''Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries,'' (API 619), specifies certain minimum requirements for compressors used in the petroleum, gas, and chemical industry. While API 619 contains many specific design requirements, it also indicates that customers must specify many design requirements themselves. As a result, compressors designed to meet API 619 requirements are not uniform; rather, they are, by definition, customized compressors. In addition to the design requirements, API 619 imposes rigorous testing, data reporting, and data retention requirements on manufacturers. For example, manufacturers are required to perform specific hydrostatic and operational mechanical vibration testing on each individual unit distributed in commerce. Furthermore, manufacturers must retain certain data for at least 20 years, such as certification of materials, test data and results, records of all heat treatment, results of quality control tests and inspections, and details of all repairs. Based on these testing, data reporting, and data retention requirements, DOE concludes that compressors designed and tested to the requirements of API 619 meet the first criterion of distinguishability.

Based on DOE's assessment of API 619, DOE believes that the minimum design and testing requirements specified in API 619 are created to achieve, among other goals, safety and reliability in the petroleum, gas, and chemical industry. These requirements ensure that the compressor can be operated and maintained safely, in the safety-critical petroleum, gas, and chemical industry. Thus, there is not a current industry test procedure that would apply and it is unclear if the methodology being adopted in this final rule would be representative of their actual use. Thus, DOE is declining to adopt a test procedure for compressors designed for petroleum, chemical and gas applications.

C. Metrics

1. Package Isentropic Efficiency

In the test procedure NOPR, DOE proposed ''package isentropic efficiency'' to be the energy metric for compressors, and defined package isentropic efficiency to mean the ratio of power required for an ideal isentropic compression process to the actual packaged compressor power input used at a given load point, as determined in accordance with the test procedures included in 10 CFR 431.344.[14] 81 FR 27220, 27232 (May 5, 2016). Because package isentropic efficiency is expressed relative to an ideal isentropic process between the same input and output pressures, it could therefore be used to compare units across a wide range of pressures. DOE presented this applicability across a wide range of pressures as an advantage of package isentropic efficiency over specific input power. *Ibid.*

Specifically, DOE proposed to establish two versions of package isentropic efficiency: Full-load package isentropic efficiency and part-load package isentropic efficiency. DOE proposed that full-load package isentropic efficiency would apply only to fixed-speed compressors, whereas part-load package isentropic efficiency would apply only to variable-speed compressors. Full-load package isentropic efficiency is evaluated at a single load point, while part-load package isentropic efficiency is a weighted composite of performance at multiple load points (or rating points). Equation 1 and Equation 2 describe the full- and part-load package isentropic efficiency, as proposed in the test procedure NOPR.

$$\eta_{\text{isen,FL}} = \frac{P_{\text{isen,100\%}}}{P_{\text{real,100\%}}} \qquad \textbf{Equation 1}$$

[14] Test methods are discussed specifically in section III.E.

Where:

$\eta_{isen,FL}$ = package isentropic efficiency at full-load operating pressure,

$P_{isen,100\neq}$ = isentropic power required for compression at full-load operating pressure, and

$P_{real,100\neq}$ = packaged compressor power input at full-load operating pressure.

$$\eta_{isen,PL} = \sum_i \omega_i \frac{P_{isen,i}}{P_{real,i}} \quad \textbf{Equation 2}$$

Where:

$\eta_{isen,PL}$ = part-load package isentropic efficiency,

ω_i = weighting factor for rating point i,

$P_{isen,i}$ = isentropic power required for compression at rating point i,

$P_{real,i}$ = packaged compressor power input at rating point i, and

i = load points at 100, 70, and 40 percent of full-load actual volume flow rate.

To clearly separate the two varieties of compressors, in the test procedure NOPR, DOE proposed the following definitions for fixed-speed and variable-speed compressors:

Fixed-speed compressor means an air compressor that is not capable of adjusting the speed of the driver continuously over the driver operating speed range in response to incremental changes in the required compressor flow rate.

Variable-speed compressor means an air compressor that is capable of adjusting the speed of the driver continuously over the driver operating speed range in response to incremental changes in the required compressor actual volume flow rate.

DOE received a significant volume of comments regarding these metrics, associated load points and weights, and the applicability of each version of package isentropic efficiency. The following subsections discuss these issues and relevant comments in detail.

a. Use of Full-Load and Part-Load Package Isentropic Efficiency as Regulatory Metrics

In response to DOE's proposal to use package isentropic efficiency as a metric, CASTAIR disagreed, stating that air compressors consume electricity (in kW, using electric motors that are already regulated) and produce flow (in cfm). CASTAIR further stated that power (in kW) and flow (in cfm) are very easy things to test and record, and suggested that DOE should then regulate, if it must, the efficiency between the two (*i.e.,* kW and cfm) for air ends. (CASTAIR, No. 0018 at p. 1) Based on this comment, DOE interprets that CASTAIR is suggesting that the efficiency of the compressor should be a simple calculation based on the regulated representation of efficiency for the electric motor and the airflow produced by the air compressor. In response to this suggestion, DOE clarifies that the efficiency and energy consumption of an air compressor is not solely a function of the motor. As DOE discussed in the energy conservation standards NOPR, opportunities exist to select or design higher efficiency motors, drives (if applicable), bare compressors (including multi-staging), mechanical equipment, and ancillary equipment. 81 FR 31680, 31701–2 (May 19, 2016). For this reason, DOE concludes that the efficiency of the motor alone, even when coupled with the output airflow of the compressor, is not an appropriate metric to represent to energy efficiency or consumption of an air compressor.

Alternatively, DOE recognizes that CASTAIR may have been recommending a metric of the form of power (in kW) per unit flow (in cfm). DOE acknowledges that this general metric could properly characterize the typical energy use of an air compressor, if coupled with an appropriate test method. However, this ratio has a significant shortcoming as a regulatory metric. Specifically, achievable kW/cfm is a function of both pressure and flow, which means an energy conservation standard would need to be a function of both pressure and flow—a more complex determination as compared to package isentropic efficiency.[15] Thus, in this final rule, DOE concludes that a metric of the form kW/cfm introduces unnecessary complexity into any energy conservation standards that would rely on such a metric (*i.e.,* adding pressure as a second dependent characteristic).

With respect to metric selection, Atlas Copco asserted that DOE's method of calculating compressor energy use is flawed because, as a steady-state metric, it lacks a means to compare in-operation energy savings of compressors with different operating profiles. Atlas Copco further asserted that DOE failed to use a methodology to calculate the performance of an air compressor at part-load, and failed to take into account energy losses due to the cyclic operations. Cyclic operations, commented Atlas Copco, are responsible for an additional vast amount of energy required without delivering any useful air and should be accounted for to understand cyclic demands required for certain applications. (Docket No. EERE–2013–BT–STD–0040, Atlas Copco, No. 0054 at p. 9; Atlas Copco, No. 0009 at pp. 13–14)

Atlas Copco suggested an alternative metric that considers energy consumption during loaded operation, unloaded operation, and the transient in-between. Specifically, Atlas Copco suggested a metric that calculates the energy consumption for one running hour and the accumulated useful volume of air which is delivered to the customer. Based on these values, the corresponding overall Specific Energy Requirement (SER) can be calculated, which can be converted to the isentropic efficiency. Atlas Copco went on to specifically define SER as the energy consumed during one hour of operation, divided by the useful volume of air produced during this time period, and provided an equation to convert SER to isentropic efficiency. Atlas Copco stated that these metrics reflect the true energy consumption and would allow customers to compare all compressor technologies on an apples-to-apples basis. It also stated that such metrics would provide a method to assess the part-load performance of variable-speed machines that cannot reach the 40-percent load point rather than allowing the compressor to test at the minimum achievable flow point, which unfairly penalizes large turndown variable-speed compressors. (Atlas Copco, No. 0009 at p. 12–13; Atlas Copco, No. 0009 at p. 15; Docket No. EERE–2013–BT–STD–0040, Atlas Copco, No. 0054 at pp. 9–11)

In its comments, Atlas Copco suggests that the energy consumption during one hour of operation can be calculated as the sum of the energy consumed during loaded and unloaded operation (which can be measured using ISO 1217:2009(E)), as well as the ''cycle energy requirement.'' Atlas Copco

[15] For example, higher flow machines can naturally achieve a better kW/cfm score as maximum achievable motor and bare compressor efficiency increase with size and flow. Alternatively, lower pressure machines can naturally achieve a better kW/cfm score as less power is required to compress the same volume of air to a lower pressure.

defines the cycle energy requirement as the total energy required for fully pressurizing the internals of the compressor package starting from idle regime until useful air delivery, summed with the full venting of the same internals starting from the end of useful air delivery until idle regime; *i.e.,* the energy consumed during transient operation between the loaded and unloaded state. Atlas Copco goes on to provide a suggested measurement procedure for the determination of cycle energy losses. (Atlas Copco, No. 0009 at pp. 13–14; Atlas Copco, Annex A, No. 0009 at pp. 3–13; Docket No. EERE–2013–BT–STD–0040, Atlas Copco, No. 0054 at p. 9–11) Further, Atlas Copco suggested that DOE establish separate regulations for the fixed flow profile and the variable flow profile, but to also have all machines list values for both. (Atlas Copco, No. 0009 at p. 11; Atlas Copco, No. 0009 at p. 15) Given Atlas Copco's suggestion to use a new metric, DOE is unclear what values Atlas Copco is referring to when it suggests that DOE list ''both.'' DOE is unclear whether Atlas Copco supports the use of its new metrics (SER and its associated isentropic efficiency) as the exclusive metrics for compressors, or if Atlas Copco is suggesting that the new metrics be used in addition to the DOE-proposed part-load and full-load package isentropic efficiency.

Sullair agreed that although measurements and efficiency standards for part-load operation of fixed-speed compressors may be useful, no standard has been established, tested, or proven to measure compressor performance across all fixed-speed control methods (modulation, load-unload, variable displacement, etc.) employed by various manufacturers. As a result, Sullair commented that it did not support a part-load test procedure for fixed-speed compressors at this time. Sullair noted that preliminary work is being done by CAGI to measure one of these control methods (variable displacement) and supported further development of a test procedure or metric across multiple manufacturers and control types prior to adoption by DOE. (Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at pp. 16–17)

Sullair cited that the variable-speed, part-load performance data used to develop both the EU Lot 31 draft standard and the proposed DOE standard came from CAGI's Performance Verification Program, which was gathered over the span of nearly 10 years. In contrast, Sullair argued that to rush development of a new test method and metric for part-load measurement of fixed-speed compressors, without support from the industry or verified supporting data from multiple manufacturers and units, would be rash and inappropriate. Sullair anticipated that such a development risks unintended consequences that may negatively impact the compressor industry, compressor consumers, and U.S. industry at-large. (Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at pp. 16–17)

Sullair concluded that, primarily because of a lack of verified data and an agreed upon industry test standard for all fixed-speed control types, DOE should proceed with its proposal to classify compressors as fixed-speed or variable-speed, and limit part-load testing to variable-speed compressors. (Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at pp. 16–17)

In agreement with Sullair, DOE acknowledges that a package isentropic efficiency metric that includes cycle losses (as recommended by Atlas Copco) could acceptably represent the typical energy use of compressors. However, as discussed in Sullair's comment, the use of cycle losses and the test and calculation methods recommended by Atlas Copco represent the opinions and findings of one industry participant, and do not represent an industry accepted metric or test method. Atlas Copco has not presented evidence that these methods and accompanying results have been validated or peer reviewed outside of Atlas Copco's organization. Further, DOE believes that the use of Atlas Copco's suggested metric and cycle loss test method is likely to increase the burden on manufacturers as it appears to require additional testing beyond what was proposed in the test procedure NOPR. Furthermore, the industry (outside of Atlas Copco) is unfamiliar with the additional testing that would be required. Finally, no historical performance data exists for the metric proposed by Atlas Copco, which makes it a poor choice for a regulatory metric at this time. Without historical performance data for the Atlas Copco metric, DOE would be unable to establish baseline and maximum technologically feasible efficiency levels, and would be unable to complete any of the analyses required to assess and establish energy conservation standards.

Alternatively, given the general support of CAGI, Sullivan-Palatek, Ingersoll Rand, and Sullair for items on which they did not directly comment on, DOE believes that full-load package isentropic efficiency represents an industry-accepted metric, which is backed by an industry-accepted test method (ISO 1217:2009(E), as amended), and has a large cache of reliable industry test data. (CAGI, No. 0010 at p. 3, Sullivan-Palatek, No. 0007 at p. 1; Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1) The use of full-load package isentropic efficiency in the EU Lot 31 draft standard further indicates that this metric is an appropriate and industry-accepted metric for the assessment of fixed-speed compressors. In summary, DOE again acknowledges that Atlas Copco's suggested metric, which incorporates part-load cycle losses, may acceptably represent the typical energy use of compressors, however for the reasons discussed in this section, DOE concludes that, at this time, it is not an appropriate metric to adopt. If this metric gains acceptance in the industry and the test method can be formalized and validated beyond a case study, DOE may consider incorporating such a method in future rulemakings.

With respect to Atlas Copco's suggestion that each compressor be labeled with scores from two metrics, DOE notes the core purpose of a Federal test procedure is to establish test methods to evaluate equipment against the applicable energy conservation standards. If DOE were to require the listing of two metrics on each compressor, DOE must require that each compressor test to two test methods. Requiring such testing and reporting would represent an incremental burden beyond what DOE proposed in the test procedure NOPR. In general, DOE strives to minimize the incremental burden of any test procedures rulemaking. Therefore, in this test procedure final rule, DOE does not adopt any mandatory testing or reporting beyond the metrics proposed in the test procedure NOPR.

Similarly to Atlas Copco, the CA IOUs suggested that, for fixed-speed compressors with either ''start/stop,'' or ''load/unload'' controls, the air flow and power consumption should be tested to capture energy consumption at full-load and fully unloaded. They also suggested that fixed-speed compressors with ''load/unload'' controls be tested to measure the duration of the purge cycle (time it takes to achieve fully unloaded power—also known as blowdown time), as this data can be mathematically combined with the airflow and power consumption data at full-load and fully unloaded to estimate the compressor's efficiency at various points between full-load and fully unloaded. (CA IOUs, No. 0012 at p. 1–2) Unlike Atlas Copco, the CA IOUs suggest that this data be measured and reported as supplemental information, rather than incorporated into a new metric.

While DOE agrees that information describing unloaded and transition states of operation could be useful to the end user, the CA IOUs' recommendation represents testing and reporting that is not essential to the output of the test procedures; requiring such testing and reporting would represent an incremental burden beyond what DOE proposed in the test procedure NOPR. In general, DOE strives to minimize the incremental burden of any test procedures rulemaking. Therefore, in this test procedure final rule, DOE is not adopting any mandatory testing or reporting of no-load power. Manufacturers may measure and advertise no-load power and blowdown time, and DOE may further explore no-load power measurement and reporting requirements in a future rulemaking.

CAGI also argued for the importance of considering operating conditions in determining efficiency. CAGI commented that, because field variables were a large determinant of system efficiency, any value assigned to package efficiency may be misleading to consumers. (Docket No. EERE–2012–BT–DET–0033, CAGI, No. 0003 at p. 8)

In response to CAGI's comment, DOE is not representing package isentropic efficiency as a substitute for consideration of site-specific operating factors. Rather, it is intended to serve as a common basis for comparison between compressors.

Atlas Copco suggested that low-pressure air and lubricant-free compressors have their package isentropic efficiencies expressed as a function of discharge pressure in addition to flow rate, noting that full-load operating pressure is a significant variable that affects package isentropic efficiency for those compressor configurations. (Atlas Copco, No. 0009 at p. 15; Atlas Copco, Public Meeting Transcript, No. 0016 at pp. 41–42; EERE–2013–BT–STD–0040, Atlas Copco, No. 0054 at pp. 19–20) As discussed in sections III.B, DOE is narrowing the scope of this test procedure final rule to a smaller pressure range, which only includes lubricated compressors. This revised scope matches the range over which the dependency of isentropic efficiency on discharge pressure is described by CAGI as limited. Therefore, DOE concludes that the changes to the proposed metric, recommended by Atlas Copco, are not necessary. However, DOE may consider adding a pressure-dependent term, should it choose to pursue to test procedures or energy conservation standards for lubricant-free equipment or equipment outside of the 75–200 psig range in future rulemakings.

Scales Industrial Technologies agreed that the package isentropic efficiency metric is a good measurement, but commented that the metric is not common in industry. Scales Industrial Technologies suggested instead to use specific power, as it has been the industry-accepted expression of compressor efficiency. (Scales Industrial Technologies, No. 0013 at p. 4)

In response, DOE acknowledges that package isentropic efficiency is not as commonly used as specific power. However, based on the general support of other commenters for package isentropic efficiency, its use in the analogous EU Lot 31 draft standard, and its pressure independence over the scope being established in this final rule, DOE concludes that package isentropic efficiency is the most appropriate metric for describing the energy performance of compressors within the scope of this test procedure.

b. Load Points Selection and Applicability

As shown in Equation 1 and Equation 2 in the test procedure NOPR, DOE proposed that fixed-speed units be tested at a single load point, the full-load actual volume flow rate; and that variable-speed units be tested at three load points: 100, 70, and 40 percent of full-load actual volume flow rate. 81 FR 27220, 27232–4 (May 5, 2016).

In response, ASAP and NEEA generally supported DOE's proposed load points for full-load and part-load package isentropic efficiency. (ASAP and NEEA, No. 0015 at p. 2) Kaeser Compressors also supported the selection of load points that harmonized with the EU Lot 31 draft standard. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 63) Alternatively, the CA IOUs suggested that variable-speed compressors be tested at a minimum of six test points (excluding a no load power test point), in alignment with the CAGI Performance Verification Program test procedure, and also use a minimum volume flow rate no higher than 40 percent of the maximum volume flow rate to avoid possible loopholes. (CA IOUs, No. 0012 at p. 3)

With respect to the smallest flow rate load point for variable-speed compressors, CAGI noted that not all variable-speed compressors can reach a speed that achieves 40 percent of full-load actual volume flow rate, as minimum speeds can be limited by technical considerations such as bearing speeds, overheating, motor current, etc. (CAGI, Public Meeting Transcript, No. 0016 at p. 60) Kaeser Compressors and Sullair supported CAGI's remark, while Sullair continued to state that this is especially important for lubricant-free compressors due to technical limitations that keep them from running at speeds as low as 40 percent of [full] flow. (Sullair, Public Meeting Transcript, No. 0016 at p. 64) Kaeser Compressors added that, among other reasons, EU Lot 31 draft standard can set a 40-percent load point because it does not include lubricant-free compressors. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at pp. 64–5) In response to this concern, CAGI suggested that the lower load point should be at 40 percent flow or the manufacturer's minimum stated capacity, if greater. (CAGI, No. 0010 at p. 6) Sullair supported CAGI's comments. (Sullair, Public Meeting Transcript, No. 0016 at p. 64)

Atlas Copco commented that a provision that permits manufacturers to test at the manufacturer's stated minimum speed if a compressor cannot achieve the 40-percent load point would penalize compressor packages with large turndown ratios. (Atlas Copco, No. 0009 at p. 12–13) Atlas Copco further clarified that the disadvantage to larger turndown machines results from the higher average efficiency achieved by testing at a load point greater than 40 percent, which results in a higher average weighted isentropic efficiency. (Atlas Copco, Public Meeting Transcript, No. 0016 at p. 60) DOE notes in this statement that Atlas Copco has incorrectly quoted the test procedure NOPR, in which DOE made no mention of how to test a variable-speed compressor for which the 40-percent load point is unachievable due to technical limitations. Atlas Copco went on to suggest that compressors that cannot reach the 40-percent load point should instead be allowed to use the SER metric, which is discussed in section III.C.1.a. (Atlas Copco, No. 0009 at p. 11) Atlas Copco further commented that the draft EU compressor standard included no load power as a reported metric, allowing for a more complete picture of efficiency when a variable-speed compressor is used at flow rates below the manufacturer's minimum flow rate. (Atlas Copco, Public Meeting Transcript, No. 0016 at pp. 69–70)

Similar to Atlas Copco, Kaeser Compressors noted that there would be efficiency gains in testing at flow rates greater than 40 percent, but that there would also be market disadvantages because the unit would seem less flexible, and so there would be little incentive for manufacturers to declare relatively high flow rates. For that reason, Kaeser therefore suggested that main issue with the 40-percent load point was not the possibility of manufacturers artificially increasing efficiency ratings, but instead the fact that lubricant-free compressors may not be able to reach that flow rate. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at pp. 65–6) Sullair stated that manufacturers would lose marketability if they rated the unit at a greater minimum flow rate to gain efficiency, because the primary benefit of variable-speed compressors is to allow control over a wide range of flow rates. (Sullair, Public Meeting Transcript, No. 0016 at p. 66) Likewise, ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE did not support the CAGI proposal of using a lower load point of 40 percent or manufacturer minimum as it inflates efficiency ratings for compressors that cannot reach 40 percent and suggested that DOE work with CAGI to develop an alternative minimum test for compressors. (EERE–2013–BT–STD–0040, ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at p. 4)

In response to comments on the 40-percent load point, DOE reviewed all available CAGI Performance Verification Program data sheets for lubricant-free variable-speed compressors, and concurs with the concerns raised by industry that not all lubricant-free variable-speed compressors can achieve the 40-percent load point. Specifically, DOE found that 65 percent of CAGI data sheets for lubricant-free compressors were rated with a minimum flow greater than 40 percent of maximum flow.

DOE considers this data, in conjunction with the previously referenced comments, as clear evidence that the proposed test procedure load points do not apply to variable-speed lubricant-free compressors due to the technical limitations in the turndown ratio of such equipment. Further, DOE concludes that because of these technical limitations and other significant technological differences between lubricated and lubricant-free compressors, separate test methods and metrics may be required for each. In addition, the European Commission is exploring specific standards and test methods for lubricant-free compressors, but has not released a draft proposal of its standard. Based on the comments discussed in this section, DOE concludes that significant work is required to establish an acceptable test method specific to lubricant-free compressors, and that the most efficient path to establishing an acceptable test method for lubricant-free compressors is to monitor and, possibly, collaborate with the European Commission as its own work progresses. DOE may pursue a test procedure for lubricant-free equipment in a separate rulemaking, but is not including lubricant-free compressors in the scope of this test procedure final rule.

For lubricated compressors, DOE found that 16 percent of CAGI data sheets were rated with a minimum flow greater than 40 percent of maximum flow. These results indicate that 84 percent of lubricated variable-speed compressors are able to achieve the 40-percent load point.

DOE agrees with Atlas Copco that allowing those few lubricated variable-speed compressors that cannot achieve 40 percent flow to test using the minimum achievable flow as an alternative to the 40-percent load point would penalize high-turndown machines. Such penalization would occur because the package isentropic efficiency of a variable-speed compressor typically decreases as flow (*i.e.,* load) decreases. To confirm this, DOE reviewed available CAGI Performance Verification Program data sheets and found that for 82 percent of the rotary lubricated variable-speed models, the package isentropic efficiency at 40 percent of full-load actual volume flow rate was lower than the package isentropic efficiency at 70 percent of full-load actual volume flow rate.[16] Given this relationship between package isentropic efficiency and flow rate, a compressor's package isentropic efficiency (as proposed in the test procedure NOPR) would typically increase by replacing the 40-percent load point with a load point at a higher flow.

Given this information, DOE has two major concerns with CAGI's recommendation. First, CAGI's recommended method would not result in a fair and equitable efficiency metric. For example, given two compressors with the same full-load actual volume flow rate and full-load package isentropic efficiency, one with a manufacturer-specified minimum flow rate of 40 percent of full-load actual volume flow rate and one with a manufacturer-specified minimum flow rate of 70 percent of full-load actual volume flow rate, the latter would usually test at a better part-load package isentropic efficiency, even though the former provides more utility to the end user and has the potential to use less energy.

Second, CAGI's recommended method relies on a ''manufacturer's minimum stated capacity,'' and creates a significant opportunity for loopholes. For example, if a given variable-speed compressor does not meet the established energy conservation standard, a manufacturer may be able to restate its minimum capacity at a larger value and retest the model. Because package isentropic efficiency is typically greater at the rerated higher capacity, the manufacturer may be able to pass the standard with the rerated value. The result of this example directly conflicts with the intent of an energy conservation standard, because the resulting compressor offers reduced utility to the end user and may even consume more energy than it would with a lower stated minimum capacity.

Consequently, in this final rule, DOE rejects CAGI's recommendation to use the manufacturer's minimum stated capacity for variable-speed compressors if the compressor cannot achieve the 40-percent load point.

DOE concludes that the amount to which a variable-speed lubricated compressor can turn down is a distinct end user utility. Both Sullair and Kaeser Compressors clearly noted similar assertions that the speed and flow to which a variable-speed compressor can turn down is a distinct utility to the end user. (Sullair, Public Meeting Transcript, No. 0016 at p. 66; Kaeser Compressors, Public Meeting Transcript, No. 0016 at pp. 65–6)

DOE also concludes, based on previously mentioned data analysis as well as comments from Kaeser Compressors and Sullair (Sullair, Public Meeting Transcript, No. 0016 at p. 67; Kaeser Compressors, Public Meeting Transcript, No. 0016 at pp. 67–8), that for lubricated variable-speed compressors within the scope of this final rule, the majority of lubricated compressors are able to reach the 40-percent load point; *i.e.,* turning down to 40 percent of flow is technologically feasible for all pressures, flows, and horsepower of compressors within the scope of this final rule.

Consequently, DOE concludes that it is appropriate that the test method for variable-speed lubricated compressors require that a tested compressor reach each flow point because the part-load package isentropic efficiency metric is designed to align with the utility of the variable-speed compressors and must accurately represent their operation. For these reasons, DOE is adopting the methodology as proposed in the NOPR, which requires testing at the 40-percent load point. If a manufacturer has a basic model which is incapable of operating at the 40-percent load point, the manufacturer must seek a waiver from

[16] Not all units reported performance at 40 percent and 70 percent of full-load actual volume flow rate. In those cases, DOE generated estimates for those points using interpolation from surrounding data points.

the test procedure to obtain an alternative method of test from the Department pursuant to 10 CFR 431.401. As part of the test procedure waiver application, DOE would examine the details of the variable-speed compressor's performance curve (*e.g.,* the package isentropic efficiency over the range of available driver speeds for which the compressor is capable of operating) in order to determine the correct testing points and weightings for regulatory purposes. Since these could be different for each basic model, DOE believes it is best to determine the details on a basic model basis, rather than adopting a blanket approach of the manufacturer's specified minimum as suggested by CAGI. This would allow DOE to ensure fair and equitable ratings and not disadvantage those compressors that operate at lower speeds. This approach ensures that all compressors rated with the part-load package isentropic efficiency metric provide comparable utility to the end user, and that any compressors requiring a waiver would use a modified metric that reflects the reduction in utility resulting from their restricted range of flow rates.

DOE's regulations set forth at 10 CFR 431.401 contain provisions that permit a person to seek a waiver from the test procedure requirements for covered equipment if at least one of the following conditions is met: (1) The basic model contains one or more design characteristics that prevent testing according to the prescribed test procedures; or (2) the prescribed test procedures may evaluate the basic model in a manner so unrepresentative of its true energy consumption as to provide materially inaccurate comparative data. 10 CFR 431.401(a)(1) A petitioner must include in its petition any alternate test procedures known to the petitioner to evaluate the basic model in a manner representative of its energy consumption. 10 CFR 431.401(b)(1)(iii) DOE may grant a waiver subject to conditions, including adherence to alternate test procedures. 10 CFR 431.401(f)(2)

For the case of variable-speed compressors that cannot reduce flow to the 40-percent load point, DOE may grant a waiver using a modified test procedure that reflects the reduction in utility resulting from the compressor's restricted range of flow rates. The modified test procedure may calculate part-load package isentropic efficiency using a weighted average of the performance at full-load, the performance at the 70-percent load point (if the compressor can reach this load point), and the performance at the compressor's lowest load point. The weighted average may include modifications to reflect the reduction in utility resulting from the compressor's restricted range of flow rates. For example, the weighting may consider the typical change of efficiency with flow rate and may account for the increased energy required for the compressor to achieve the 70-percent and 40-percent load points by loading and unloading. DOE may determine the modified test procedure on a case-by-case basis, depending on the specific nature of the waiver request and the equipment construction.

Based on the preceding discussion, DOE concludes that no changes are needed in DOE's proposed definitions of fixed-speed compressor and variable-speed compressor. As a result, DOE is adopting the definitions of fixed-speed compressor and variable-speed compressor that it proposed in the test procedure NOPR.

With respect to the remaining load points (*i.e.,* 100 and 70 percent for variable-speed and 100 percent for fixed-speed), DOE reiterates that Kaeser Compressors, ASAP, and NEEA supported DOE's test procedure NOPR. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 63; ASAP and NEEA, No. 0015 at p. 2) However, the CA IOUs disagreed and suggested that variable-speed compressors be tested at a minimum of six test points while utilizing a minimum volume flow rate no higher than 40 percent of the maximum volume flow rate to avoid possible loopholes. In response, DOE recognizes that the CA IOUs' recommendation aligns with the current CAGI Performance Verification Program testing method; however, DOE has two major concerns with CA IOUs' recommendation. First, the CA IOUs' recommended method would not result in a repeatable, fair, and equitable efficiency metric. For example, given two compressors with the same full-load actual volume flow rate and full-load package isentropic efficiency, one could be tested at six points (40, 50, 60, 70, 80, and 100 percent of full-load actual volume flow rate) and one could be tested at 10 points (40, 50, 60, 70, 80, 90, 92.5, 95, 97.5, and 100 percent of full-load actual volume flow rate). As previously discussed, due to the fact that package isentropic efficiency varies as a function of actual volume flow rate, the latter compressor, tested at 10 load points would likely achieve a different part-load package isentropic efficiency score (as in the test procedure NOPR) than the former compressor.

Similarly, the lack of firmly specified load points creates a significant opportunity for loopholes. For example, if a given variable-speed compressor does not meet the established energy conservation standard, a manufacturer may be able to retest with additional load points that are biased to the compressor's most efficient flow range and ultimately pass the standard with this rerated value. This directly conflicts with the intent of an energy conservation standard, as the resulting compressor still consumes the same amount of energy as it did before the retesting and rerating.

Due to these concerns with the CA IOUs' suggestion, the general support provided by CAGI, ASAP, and NEEA, and the reasons established in the test procedure NOPR, DOE is adopting the load points of 100, 70, and 40 percent of full-load actual volume flow rate for the part-load package isentropic efficiency metric, and 100 percent of full-load actual volume flow rate for the full-load package isentropic efficiency metric.

c. Metric Applicability

In response to the test procedure NOPR, the CA IOUs suggested that fixed-speed ''inlet modulating'' [17] and ''variable displacement'' [18] compressors (herein referred to as ''fixed-speed variable-flow compressors'') should be tested at full-load and multiple part-loads in alignment with the CAGI Performance Verification Program test procedures for variable-speed compressors. According to the CA IOUs, this would provide valuable efficiency information for part-load conditions, which are common for fixed-speed compressors. (CA IOUs, No. 0012 at pp. 2) Similarly, ASAP and NEEA suggested that DOE require that fixed-speed compressors with controls that allow for variable airflows be tested in the same way as variable-speed compressors. ASAP and NEEA stated that this would facilitate the comparison between fixed-speed and variable-speed compressors

[17] Inlet modulating compressors adjust the capacity of the compressor to the demand required by the system with a regulating valve on the inlet. The control system closes the inlet valve in response to a reduction in system demand, effectively throttling the compressor by reducing the inlet pressure and, consequently, the mass flow of air entering the compressor. (*http://www.cagi.org/requestinator_dl.aspx?txdata=L3BkZnMvQ0FHSV9FbGVjdEhCX2NoMi5wZGY=,* page 88).

[18] Variable displacement compressors use a valve to divert a fraction of the inlet mass flow from the start of the rotor to an intermediate position of the compression system, reducing the effective length of the rotor but maintaining the inlet pressure and compression ratio. The valve is adjustable and responds to changes in discharge pressure. (*http://www.cagi.org/requestinator_dl.aspx?txdata=L3BkZnMvQ0FHSV9FbGVjdEhCX2NoMi5wZGY=,* page 88).

under part-load conditions. (ASAP and NEEA, No. 0015 at p. 2)

NEEA further commented that the efficiency metrics are appropriate for comparing variable-speed compressors amongst themselves, but made it hard to compare variable-speed compressors to fixed-speed compressors. (NEEA, Public Meeting Transcript, No. 0016 at p. 60–62) Conversely, Sullivan-Palatek commented that fixed-speed and variable-speed compressors are different products with different applications, which shouldn't be compared with each other. (Sullivan-Palatek, Public Meeting Transcript, No. 0016 at pp. 61–62)

Kaeser Compressors commented that the efficiency and utility of a variable-speed compressor relative to a fixed-speed compressor is promoted by utilities to consumers and stressed that the primary goal of the metric should be consistent assessment of variable-speed compressor efficiency. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at pp. 71–72) Sullair echoed this sentiment, stating that the industrial customers that purchase the equipment understand the energy efficiency associated with variable-speed compressors and purchase variable-speed compressors based on the best overall fit for the application. (Sullair, Public Meeting Transcript, No. 0016 at p. 72)

Sullair agreed that although measurements and efficiency standards for part-load operation of fixed-speed compressors may be useful, no standard has been established, tested or proven to measure compressor performance across all fixed-speed control methods (modulation, load-unload, variable displacement, etc.) employed by various manufacturers. As a result, Sullair commented that it did not support a part-load test procedure for fixed-speed compressors at this time. Sullair noted that preliminary work is being done by CAGI to measure one of these control methods (variable displacement) and supported further development of a test procedure or metric across multiple manufacturers and control types prior to adoption by DOE. (Docket No. EERE–2013–BT–STD–0040, Sullair, No. 0056 at pp. 16–17)

In agreement with the CA IOUs, ASAP, NEEA, and Sullair, DOE acknowledges that a part-load package isentropic efficiency metric for fixed-speed variable airflow compressors could acceptably represent the typical energy use of these compressors. DOE reviewed the scope and applicability of relevant, comparable testing and rating programs, namely, the CAGI Performance Verification Program and the EU Lot 31 draft standard for compressors. The CAGI Performance Verification Program separates rotary compressors into only two groupings: (1) ''rotary compressors,'' and (2) ''rotary variable frequency drive compressors.''[19] The former rates compressors at only full-load operating pressure, while the latter allows for multiple ratings at reduced flows. However, as indicated by the name of the latter grouping, it encompasses only compressors driven by variable-frequency drives. Consequently, fixed-speed variable airflow compressors are considered ''rotary compressors'' by the CAGI Performance Verification Program, and rated at only full-load operating pressure.

In addition, the EU Lot 31 draft standard defines a ''fixed-speed rotary standard air compressor'' to mean a rotary standard air compressor that is not equipped with a variable-speed drive when placed on the market; and defines a ''variable-speed rotary standard air compressor'' to mean a rotary standard air compressor that is equipped with a variable-speed drive when placed on the market. Consequently, similar to the CAGI program, the EU Lot 31 draft standard considers a fixed-speed variable airflow compressor to be a fixed-speed rotary standard air compressor, which is rated at only full-load operating pressure.

As a result of the research into relevant, comparable testing and rating programs for compressors, DOE agrees with Sullair that test methods for variable airflow fixed-speed compressors are still in the development stage and the limited available data is not yet fully verified. In other words, test methods are still a work in progress for this variety of fixed-speed compressors. Additionally, with no historical part-load performance data available for variable-flow fixed-speed compressors, DOE would be unable to establish baseline and maximum technologically feasible efficiency levels, and would be unable to complete any of the analyses required to assess and establish energy conservation standards. Alternatively, historical full-load isentropic efficiency currently exists for this equipment and was considered in the energy conservation standards NOPR.

In light of the precedent established by CAGI and the EU, the lack of a verified test method, and the lack of verified historical performance data, DOE concludes that it is not appropriate to establish part-load package isentropic efficiency as the rating metric for non-speed-varying varieties of variable airflow compressors at this time. Consequently, in this final rule, DOE reaffirms and establishes its NOPR test procedure that when rating a compressor for compliance purposes, full-load package isentropic efficiency applies to fixed-speed compressors, and part-load package isentropic efficiency applies to variable-speed compressors.

Although part-load package isentropic efficiency is not currently suitable as a regulatory metric for fixed-speed variable flow compressors, part-load performance information for these varieties of compressors can provide valuable information for the end user. Consequently, in this final rule DOE clarifies that manufacturers of fixed- and variable-speed compressors may continue making graphical or numerical representations of package isentropic efficiency and package specific power as functions of flow rate or rotational speed. In the test procedure NOPR, DOE proposed a similar allowance, applicable only to variable-speed compressors. 81 FR 27220, 27244 (May 5, 2016). DOE is opening this allowance to fixed-speed compressors to account for non-speed-varying varieties of variable airflow compressors and fixed-speed compressors that can vary speed continuously to adjust output flow, but cannot reach 40 percent of full-load actual volume flow rate.

DOE notes that graphical or numerical representations of package isentropic efficiency or package specific power at 40, 70, and 100 percent of the full-load actual volume flow rate must represent values measured in accordance with the DOE test procedure. DOE also notes that graphical or numerical representations of these metrics at any other load points must be generated using methods consistent with the DOE test procedure.

d. Metric Weights

In the test procedure NOPR, DOE proposed a part-load package isentropic efficiency metric that was a weighted composite of performance at multiple load points, following the structure of the EU Lot 31 draft standard. 81 FR 27220, 27233 (May 5, 2016). DOE further proposed weighting factors of 25, 50, and 25 percent for load points of 40, 70, and 100 percent of maximum flow, respectively. DOE cited alignment with the EU Lot 31 draft standard and a lack of industry weighting factors or real-world load profile data as rationale for the proposed weights. 81 FR 27220, 27234–5 (May 5, 2016).

In response to the proposed weights, P.R. China commented that there was no selection criteria provided to justify the weighting coefficients for the 40

[19] For more information see: *http://www.cagi.org/performance-verification/data-sheets.aspx.*

percent, 70 percent, and 100 percent package isentropic efficiency values. (P.R. China, No. 0049 at p. 3) CAGI did not provide any direct comments, but CAGI commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1)

In response to comments made by P.R. China regarding the justification of selected load weights, the part-load package isentropic efficiency metric is a benchmark for all variable-speed compressors. The benchmark's intent is not to mirror energy consumption for all consumers (which is calculated in the energy conversation standard), but to provide a consistent and repeatable measure of efficiency for variable-speed compressors. In this case, half of the weighting represents operating extremes (40 percent and 100 percent) for variable-speed compressors, and half characterizes the midpoint of those values (*i.e.,* 70 percent). Furthermore, DOE did not receive any data providing real-world representative load profile data. However, even in the presence of such data any given weighting would only reflect energy consumption for units that happened to be operated at that particular load profile. Additionally, the selected weights are in alignment with the EU Lot 31 draft standard, which carries the benefits of familiarity for consumers and reduced compliance burden for manufacturers who do business in both the US and EU markets. For these reasons, as well as those discussed in the test procedure NOPR, DOE is adopting the metric weights, as proposed.

2. Package Specific Power

In the May 5, 2016 test procedure NOPR, DOE defined ''package specific power'' to mean the compressor power input at a given load point, divided by the actual volume flow rate at the same load point, as determined in accordance with the test procedures proposed for 10 CFR 431.344. 81 FR 27220, 27256 (May 5, 2016). DOE noted that package specific power provides users with a direct way to calculate the power required to deliver a particular flow rate of air. The CAGI Performance Verification Program currently uses this metric to characterize compressor performance.[20] Given the prevalence of this metric in the industry, DOE deems it appropriate to provide a clear and uniform method to test and calculate this value. However, given the reasons noted in the test procedure NOPR, DOE selected package isentropic efficiency, rather than package specific power, as the rating metric for the compressors within the scope of this rulemaking.

For the reasons established in the test procedure NOPR, DOE is adopting the definition for package specific power, as proposed in the test procedure NOPR.

The specific methods and calculations used to find package specific power for a given compressor are discussed in section III.E.7.

3. Power Factor

In the test procedure NOPR, DOE did not explicitly propose measurement and reporting of power factor. In response, the CA IOUs commented that the test procedure NOPR proposed measurement of real power (*e.g.,* kW), cannot accurately reflect power generation needs. The CA IOUs added that measurement and reporting of power factor should be mandatory at all tested points so that power generation needs can be accurately estimated. (CA IOUs, No. 0012 at p. 3)

DOE agrees with the CA IOUs that power factor is a useful metric for estimating power generation needs. ISO 1217:2009(E), as amended,[21] allows two methods to determine packaged compressor power input, as discussed in section III.E.1.a. One of the allowable methods requires measurement of power factor as an intermediary to calculate packaged compressor power input. Because only one of the two allowable methods requires measurement of power factor, a mandatory reporting requirement for power factor would represent an incremental testing burden, beyond what DOE proposed in the test procedure NOPR, for some manufacturers. As such, there is not enough benefit to the end user to justify adopting mandatory measurement and reporting of power factor in this final rule. DOE may further explore power factor measurement and reporting requirements in future rulemakings.

D. Incorporation by Reference of Industry Standard(s)

In the test procedure NOPR, DOE stated that ISO 1217:2009(E) is an appropriate industry testing standard for evaluating the performance of applicable compressors, but noted that some sections of that standard were not applicable to the DOE test procedures. DOE further noted that additions and modifications to the test method described in ISO 1217:2009(E) would be necessary in order to determine the package isentropic efficiency of applicable compressors and improve repeatability and reproducibility of the ratings. Consequently, in the test procedure NOPR DOE proposed to incorporate by reference ISO 1217:2009(E) with a number of modifications. 81 FR 27220, 27236–27243 (May 5, 2016).

Specifically, DOE proposed to incorporate by reference the following sections and subsections of ISO 1217:2009(E):

- Sections 2, 3, and 4;
- Subsections 5.2, 5.3, 5.4, 5.6, 5.9, 6.2(g), 6.2(h); and
- Subsections C.1.1, C.2.2, C.2.3, C.2.4, C.4.1, C.4.2.1, C.4.2.3, C.4.3.2, C.4.4 of Annex C. 81 FR 27220, 27238 (May 5, 2016).

Conversely, in the test procedure NOPR, DOE proposed not to incorporate by reference the following sections, subsections and annexes of ISO 1217:2009(E) because they are not applicable to DOE's regulatory framework:

- Sections 1, 7, 8 and 9, in their entirety;
- Section 6, (except subsections 6.2(g), and 6.2(h), which would be incorporated by reference);
- Subsections 5.1, 5.5, 5.7, and 5.8;
- Annexes A, B, D, E, F, and G in their entirety; and
- Sections C.1.2, C.2.1, C.3, C.4.2.2, C.4.3.1 and C.4.5 of Annex C. 81 FR 27220, 27237 (May 5, 2016).

1. ISO 1217:2009(E)/Amd.1:2016

On April 15, 2016, ISO published an amendment to ISO 1217:2009(E) (ISO 1217:2009(E)/Amd.1:2016). In general, amendments to ISO standards play the role of materially altering and/or adding content to the source document; in this case, ISO 1217:2009(E). ISO 1217:2009(E)/Amd.1:2016 modifies the definitions of isentropic power and isentropic efficiency contained in sections 3.5.1 and 3.6.1 of ISO 1217:2009(E) to provide more detail, and provides equations to calculate those performance metrics in a new Annex H to ISO 1217:2009(E). ISO 1217:2009(E)/Amd.1:2016 makes no other changes to ISO 1217:2009(E). In this final rule, the combined result of the pre-amendment ISO 1217:2009(E) and ISO 1217:2009(E)/Amd.1:2016 is referred to as ''ISO 1217:2009(E), as amended.'' Where the pre-amendment

[20] *http://cagi.org/performance-verification/overview.aspx.*

[21] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic.

version is being referenced, it is referred to simply as ''ISO 1217:2009(E).''

Generally, DOE prefers to incorporate the most recent versions of industry standards, when such versions remain applicable to its test procedures. DOE reiterates that ISO 1217:2009(E)/Amd.1:2016 makes no other changes to ISO 1217:2009(E), beyond amending sections 3.5.1 and 3.6.1 and adding Annex H. Thus, for administrative consistency, in this final rule, any sections incorporated by reference in this final rule refer to the ISO 1217:2009(E) as amended, rather than the original ISO 1217:2009(E), as proposed in the test procedure NOPR. The following paragraphs discuss rationale for incorporating the amended sections 3.5.1 and 3.6.1, as well as certain sections of the new Annex H of ISO 1217:2009(E), as amended.

In the test procedure NOPR, DOE provided equations to calculate isentropic power and package isentropic efficiency, as these equations were not present in ISO 1217:2009(E). The equations proposed in the test procedure NOPR are mathematically equivalent to those provided in the amended version of ISO 1217:2009(E) and could be used in the DOE test procedure with no impact on the calculated results. Thus, in this final rule, DOE is revising its proposed test procedure to incorporate by reference sections 3.5.1 and 3.6.1, as well as sections H.2 and H.3 of Annex H of ISO 1217:2009(E), as amended. These sections provide the symbols, subscripts, and equations needed to calculate isentropic power (and ultimately, package isentropic efficiency). Given that the equations found in ISO 1217:2009(E), as amended, are mathematically equivalent to those proposed by DOE in the test procedure NOPR, DOE concludes that this change is administrative in nature. An in-depth discussion of the calculations contained in these sections can be found in section III.E.5.

DOE is not incorporating the new sections H.1, H.4, and H.5 of Annex H to ISO 1214:2009, as amended, as these sections are not applicable to test method in the test procedure NOPR. Specifically, subsection H.1 provides a general introduction to Annex H, which is not necessary for the application of the symbols, subscripts, and equations in subsections H.2 and H.3 for the purposes of the calculation of isentropic power. Subsection H.4 provides a derivation of the relationship between isentropic efficiency and specific energy requirement. While the DOE test procedure adopted today requires the calculation of package isentropic efficiency and specific energy (also referred to as specific power), it does not require derivation of the relationship between these two metrics.[22] Subsection H.5 provides the relationship between customer acceptance tolerances for specific energy and isentropic efficiency. Customer acceptance tolerances are not directly applicable to, or necessary for DOE's test methods, as DOE is establishing its own sampling, representations, and enforcement provisions, as discussed in sections III.G and III.H.

2. Comments Related to the Incorporation of ISO 1217:2009(E)

In response to DOE's proposal to incorporate specific sections of ISO 1217:2009(E), commenters generally supported incorporating the test methods established in ISO 1217:2009(E). ASAP and NEEA commented that they support DOE's use of ISO 1217, with the modifications described in the test procedure NOPR, as the basis for the compressors test procedure. (ASAP and NEEA, No. 0015 at p. 2) Sullair strongly supported the use of ISO 1217:2009(E) as the basis for the DOE test procedure. (Sullair, No. 0006 at p. 1) Sullivan-Palatek advised against material deviations from the test procedure in ISO 1217:2009(E), so as to not invalidate previous performance data. (Sullivan-Palatek, No. 0007 at p. 3) CAGI urged DOE to formalize the incorporation of the ISO 1217:2009(E) test method so that the historical performance data obtained with that test method is compliant with the DOE test procedure. (CAGI, No. 0010 at p. 15)

Compressed Air Systems and Jenny Products dissented from the other commenters. Jenny Products objected to incorporating standards by reference and advocated for including the referenced sections directly in the text of the test procedure to avoid confusion. (Jenny Products, No. 0020 at p. 2) Compressed Air Systems suggested caution when adopting ISO standards, stating that standards adopted in the United States should favor U.S. manufacturing. (Compressed Air Systems, No. 0008 at p. 2) In response to Compressed Air Systems, DOE clarifies that any test procedures adopted by DOE must be fair and equitable to all industry participants, regardless of the location that equipment is manufactured.

In response to comments from Compressed Air Systems and Jenny Products about incorporating standards directly into the test procedure text, DOE is not allowed, due to copyright law, to print any material incorporated by reference into the **Federal Register** or Code of Federal Regulations. As a result, when DOE adopts portions of a test procedure from ISO, it must incorporate those sections by reference and refer to them appropriately in the test procedure. Once the regulation publishes, any standard incorporated by reference is incorporated based on the date of its publication and is not subject to change. In other words, if the external standard is revised in the future, DOE will continue to incorporate the prior version in this final rule.

In addition to general comments, DOE received comments pertinent to the specific sections of ISO 1217:2009(E) that DOE proposed to exclude or incorporate by reference in the test procedure NOPR. The following paragraphs summarize the sections of ISO 1217:2009(E) on which DOE received comment, summarize DOE's conclusions, and provide reference to the appropriate subsections of section III.E (test method), where these comments are addressed in detail.

DOE received specific comments regarding subsection 5.2 of ISO 1217:2009(E); these comments are presented and discussed in detail in section III.E.1.b. In response, DOE is adopting its proposal to incorporate all of subsection 5.2 of ISO 1217:2009(E), as amended, in this final rule.

DOE received comments suggesting that it reconsider subsections 6.2(i), 6.2(j) and 6.2(k) of ISO 1217:2009(E), with regard to the data acquisition requirements. DOE also received suggestions to incorporate requirements from Table 1 of ISO 1217:2009(E). (CAGI, No. 0010 at pp. 6–8, 10; CAGI, Public Meeting Transcript, No. 0016 at pp. 74, 83) (See also section III.E.4). In response, DOE decided to incorporate Table 1 by reference but not to incorporate sections 6.2(i), 6.2(j) and 6.2(k) by reference, as discussed in section III.E.4.

DOE received no specific comment on the other sections of ISO 1217:2009(E), other than the previously referenced comments expressing general support for the use of ISO 1217:2009(E). Thus, for the reasons discussed in this document and the test procedure NOPR, DOE incorporates the following sections of ISO 1217:2009(E), as amended, by reference, in this final rule:

- Sections 2, 3, and 4;
- Subsections 5.2, 5.3, 5.4, 5.6, 5.9, 6.2(g), 6.2(h); and

[22] For details on the calculation of package isentropic efficiency and specific power, see sections III.E.5 and III.E.7, respectively.

• Subsections C.1.1, C.2.2, C.2.3, C.2.4, C.4.1, C.4.2.1, C.4.2.3, C.4.3.2, C.4.4 of Annex C.
• Subsections H.2 and H.3 of Annex H.
• Table 1 of subsection 6.2.

Conversely, in this final rule DOE does not incorporate by reference the following sections of ISO 1217:2009(E), as amended:

• Sections 1, 7, 8 and 9, in their entirety;
• Section 6, (except subsections 6.2(g), and 6.2(h), which would be incorporated by reference);
• Subsections 5.1, 5.5, 5.7, and 5.8;
• Annexes A, B, D, E, F, and G in their entirety; and
• Sections C.1.2, C.2.1, C.3, C.4.2.2, C.4.3.1 and C.4.5 of Annex C.
• Subsections H.1, H.4 and H.5 of Annex H.

E. Test Method

In the test procedure NOPR, DOE proposed specific test methods to measure inlet pressure, discharge pressure, actual volume flow rate, and electrical input power. DOE also proposed specific methods to calculate package isentropic efficiency, package specific power, pressure ratio, full-load actual volume flow rate, full-load operating pressure, and maximum full-flow operating pressure. Many of the test methods and calculations proposed in the test procedure NOPR were incorporated by reference from ISO 1217:2009(E). However, DOE proposed several modifications and additions to the methods specified by ISO 1217:2009(E), as these are required to provide the necessary specificity and repeatability. Even with the proposed modifications and additions, DOE stated in the test procedure NOPR that its intent was to propose a test procedure that would remain closely aligned with existing and widely used industry procedures to limit testing burden on manufacturers.

DOE received many specific comments in response to the testing and calculation methods proposed in the test procedure NOPR, and one general comment from Jenny Products. The following sections walk through the methods in the test procedure NOPR, the interested party comments as they pertain to the section, and the methods DOE ultimately is adopting in this final rule.

Jenny Products made a general comment that the proposed test procedure had measurement equipment and test condition tolerances that were too tight for an initial DOE test procedure. Jenny Products suggested that relaxing the tolerances initially would reduce the burden of the test procedure from a compliance and financial standpoint, and that DOE could tighten the tolerances after manufacturers are comfortable with the test procedure. (Jenny Products, No. 0020 at p. 2)

DOE acknowledges the comment made by Jenny Products; however, DOE reiterates that the goal of the proposed test procedure was to align with ISO 1217:2009(E), as amended,[23] to reduce the burden and cost to manufacturers. Most manufacturers currently use ISO 1217:2009(E), and many of the testing- and calculation-related comments that DOE received suggested that DOE align its test procedure as closely as possible with ISO 1217:2009(E). As discussed in the following sections, in this final rule, DOE is modifying certain methods proposed in the test procedure NOPR, including the tolerances, in order to align as closely as possible to ISO 1217:2009(E), as amended.[24] With these modifications, the test methods established in this final rule are intended to produce results equivalent to those produced historically under ISO 1217:2009(E). Consequently, if historical test data meets the requirements of the test methods established in this final rule, then manufacturers may use this data for the purposes of representing any metrics subject to representations requirements. Therefore, because the industry-standard test method is ISO 1217:2009(E), DOE is using the tolerances specified in ISO 1217:2009(E), and DOE is not relaxing the tolerances as suggested by Jenny Products. DOE is also adopting additional tolerances that are not specified in ISO 1217:2009(E), and the reasoning for each of these tolerances is explained in the following sections.

1. Measurement Equipment

In the test procedure NOPR, DOE proposed that for the purposes of measuring air compressor performance, the equipment necessary to measure flow rate, inlet and discharge pressure, temperature, condensate, and energy must comply with the equipment and accuracy requirements specified in ISO 1217:2009(E) sections 5.2, 5.3, 5.4, 5.6, 5.9, C.2.3, and C.2.4 of Annex C. 81 FR 27220, 27237–8 (May 5, 2016). DOE also proposed the following specific additions:

• Electrical measurement equipment must be capable of measuring true root mean square (RMS) current, true RMS voltage, and real power up to the 40th harmonic of fundamental supply source frequency. 81 FR 27220, 27240 (May 5, 2016).
• Any instruments used to measure a particular parameter must have a combined accuracy of ±2.0 percent of the measured value at the fundamental supply source frequency, where combined accuracy is the sum of the individual accuracies in quadrature. 81 FR 27220, 27240 (May 5, 2016).
• Any instruments used to measure the density of air must have an accuracy of ±1.0 percent of the measured value. 81 FR 27220, 27241 (May 5, 2016).
• Any pressure measurement equipment used in a calculation of another variable (*e.g.,* actual volume flow rate) must also meet all accuracy and measurement requirements of section 5.2 of ISO 1217:2009(E). 81 FR 27220, 27241 (May 5, 2016).
• Any temperature measurement equipment used in a calculation of another variable (*e.g.,* actual volume flow rate) must also meet all accuracy and measurement requirements of section 5.3 of ISO 1217:2009(E). 81 FR 27220, 27241 (May 5, 2016).
• Where ISO 1217:2009(E) refers to ''corrected volume flow rate,'' the term is deemed synonymous with the term ''actual volume flow rate,'' as defined in section 3.4.1 of ISO 1217:2009(E). 81 FR 27220, 27238 (May 5, 2016).
• The piping connected to the discharge orifice of the compressor must be of a diameter at least equal to that of the compressor discharge orifice to which it is connected. The piping must be straight with a length of at least 15 times the diameter of the discharge piping. 81 FR 27220, 27241 (May 5, 2016).
• The pressure tap must be located on the discharge piping between 2 inches and 6 inches, inclusive, from the discharge orifice of the compressor at the higher point of the cross-section of the pipe. 81 FR 27220, 27241 (May 5, 2016).

DOE received specific comments related to the proposed requirements for equipment used to measure input power, air density, and pressure as well as requirements regarding their installation location. These comments are discussed in detail in the sections that follow.

[23] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic, so aligning with ISO 1217:2009(E), as amended, is equivalent to aligning with ISO 1217:2009(E) prior to Amendment 1:2016.

[24] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic, so aligning with ISO 1217:2009(E), as amended, is equivalent to aligning with ISO 1217:2009(E) prior to Amendment 1:2016.

Aside from the input power, pressure, and air density measurement equipment, DOE received no specific comments related to the remainder of this proposal. CAGI commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR, DOE is adopting the measurement equipment requirements (excluding input power, pressure, and air density measurement equipment) as proposed in the test procedure NOPR in this final rule.

a. Input Power Measurement

In the test procedure NOPR, DOE proposed that measurement equipment used for packaged compressor power input must comply with the equipment and accuracy requirements in section C.2.4 of Annex C of ISO 1217:2009(E). 81 FR 27220, 27257 (May 5, 2016). Section C.2.4 of Annex C of ISO 1217:2009(E) permits two methods to determine packaged compressor power input; (1) the double element wattmeter method, which gives a direct indication of the electrical kilowatt/input; and (2) a computation based on the separate measurements of voltage, current and power factor of the electrical supply.

DOE proposed requiring electrical measurement equipment to be capable of measuring true RMS current, true RMS voltage, and real power up to the 40th harmonic of fundamental supply source frequency. It also proposed requiring this equipment to have a combined accuracy of ±2.0 percent of the measured value at the fundamental supply source frequency, where combined accuracy is the square root of the sum of the squares of individual instrument accuracies. 81 FR 27220, 27240 (May 5, 2016).

In response to DOE's proposal, Scales Industrial Technologies recommended that power measurements should use the two- or three-wattmeter method, and not individual measurements of voltage, current, and power factor. (Scales Industrial Technologies, No. 0013 at p. 5) In response to Scales Industrial Technologies comment, DOE concludes that power measurements should not be restricted to the double element wattmeter method, because ISO 1217:2009(E), as amended,[25] allows power to be calculated from individual measurements, and these measurements would need to meet the additional accuracy and measurement requirements DOE proposed in the test procedure NOPR. So long as these requirements are met, DOE concludes that either method in section C.2.4 of Annex C of ISO 1217:2009(E), as amended, will produce valid and repeatable results. DOE notes that some manufacturers and customers may value measurement of power factor, and wishes to preserve their current ability to use it.

CAGI did not directly comment on this item, but CAGI commented that it was in agreement with DOE's proposal for items on which it did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) ASAP and NEEA also supported the proposed electrical measurement requirements. (ASAP and NEEA, No. 0015 at p. 3) However, Sullair also commented that for large air compressors above 200 hp, many units come with high-voltage equipment in the range of 2,300 or 4,160 volts, which makes the proposed limits for harmonics, THD, and voltage accuracy difficult to guarantee. (Sullair, No. 0006 at p. 4) DOE acknowledges Sullair's concern regarding compressors above 200 hp, however, in this final rule DOE is restricting to the scope of the test procedure to compressors with less than or equal to 200 compressors motor nominal horsepower. As such, the concerns raised by Sullair are no longer applicable.

Conversely, Jenny Products commented that power measuring devices are already regulated by the Air Conditioning, Heating, and Refrigeration Institute (AHRI) and the Canadian Standards Association (CSA). As a result, Jenny Products commented that any accuracy beyond that required by AHRI and CSA increases the cost of the equipment, increases the cost of certifying the equipment, reduces the reliability of the equipment, and imposes an additional financial burden to small manufacturers. (Jenny Products, No. 0020 at p. 4) DOE acknowledges comments made by Jenny Products and wishes to clarify that the CSA and AHRI do not certify or regulate the accuracy of power measurement equipment. The CSA product design and testing guidelines are intended to ensure the safe operation of products. AHRI provides standard test procedures for rating the performance of air conditioning, heating, and refrigeration equipment. As a result, DOE proposed requirements for the power measurement equipment in the absence of a standard accuracy requirement that ensures an equitable test for compressors regardless of testing location.

In summary, based on the general support provided by ASAP, NEEA, CAGI, Sullivan-Palatek, Ingersoll Rand, and Sullair, and for the reasons discussed in this section and the test procedure NOPR, DOE is adopting power measurement requirements, as proposed in the test procedure NOPR.

b. Pressure Measurement

In the test procedure NOPR, DOE proposed that equipment used for pressure measurement must comply with the requirements in section 5.2 of ISO 1217:2009(E). DOE also proposed additional requirements to remedy what it believed to be certain ambiguities in section 5.2 of ISO 1217:2009(E). Specifically, DOE proposed that discharge piping be at least equal in diameter to the discharge port and of at least 15 times that diameter in length. DOE also proposed that the pressure transducers be placed on the discharge piping between 2 inches and 6 inches from the discharge orifice of the compressor. Finally, DOE requested clarifications, but did not propose any itself, for a number of other ambiguities in section 5.2. 81 FR 27220, 27240–1 (May 5, 2016).

DOE received several comments on its proposals for discharge piping. CAGI agreed that the discharge pipe should be equal to, or greater than, the discharge orifice in diameter, and that the pressure tap should be located 2 to 6 inches from the compressor discharge. (CAGI, No. 0010 at p. 10; CAGI, Public Meeting Transcript, No. 0016 at pp. 89–90) Jenny Products made similar comments to CAGI's regarding the discharge pipe diameter, but suggested that the pressure tap be located on a receiver. (Jenny Products, No. 0020 at p. 4) However, CAGI did not see a need for a discharge pipe with a length of 15 times the diameter of the compressor discharge; instead, CAGI recommended a 6-inch minimum discharge pipe. (CAGI, No. 0010 at p. 10; CAGI, Public Meeting Transcript, No. 0016 at pp. 89–90) CAGI indicated that the use of an insertion-type mass flowmeter is the only possible reason to require a discharge pipe with the length proposed by DOE. CAGI indicated that ISO 1217 specifies that nozzles should be used for measuring flow and insertion-type

[25] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic.

flowmeters should not be used. (CAGI, No. 0010 at p. 10; CAGI, Public Meeting Transcript, No. 0016 at pp. 89–90) Sullair and Kaeser Compressors supported CAGI's opinions on the length of the discharge pipe. (Sullair, Public Meeting Transcript, No. 0016 at p. 91; Kaeser Compressors, Public Meeting Transcript, No. 0016 at pp. 92–93) Atlas Copco commented that it is possible for the test procedure to specify only the accuracy required, and not require a specific length of discharge pipe similar to the approach of ISO 1217:2009(E). (Atlas Copco, Public Meeting Transcript, No. 0016 at p. 94) Scales Industrial Technologies stated that the length of pipe varies with the type of meter, but that 15 times the diameter is acceptable in most cases. Scales Industrial Technologies also stated that, in many cases, it is also important to specify a required length of piping for the outlet of the flow measurement device. (Scales Industrial Technologies, No. 0013 at p. 6) Compressed Air Systems commented that the distance requirement had no merit and would add unnecessary cost to the test equipment required. (Compressed Air Systems, No. 0008 at p. 2)

In response to comments, DOE clarifies that it did not specify a discharge pipe length equal to 15 times the diameter of the outlet in order to accommodate insertion-type flowmeters. DOE specified this length to avoid oscillations in outlet pressure that can occur when an elbow or bend is placed a short distance from the compressor outlet. Kaeser Compressors acknowledged this need to ensure an adequate distance of discharge pipe before an elbow. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 93)

In response to commenters' concerns, DOE is adopting changes to its proposals for discharge piping in this final rule. Specifically, DOE is adopting the requirement that discharge pipe be a minimum of 6 inches long while also adopting tolerance for oscillations in outlet pressure as part of its stability criteria, as outlined in section III.E.4. This change aligns with recommendations of CAGI, Sullair, Kaeser Compressors, and Atlas Copco, and allows test labs to determine the length of discharge pipe that is required to ensure that outlet pressure oscillations remain within the stability criteria.

Further, based on the support received from CAGI, and for the reasons outlined in the test procedure NOPR, DOE is adopting its proposals that discharge piping be at least equal in diameter to the discharge port and that the pressure transducers be placed on the discharge piping between 2 inches and 6 inches from the discharge port.

DOE is also clarifying in this final rule that the pressure tap for the discharge pressure transducers is to be located at the highest point of the discharge pipe's cross section. In the test procedure NOPR, DOE stated that the discharge pressure transducers must be mounted on the discharge piping. As a result, DOE is revising the phrasing in this final rule to make clear the required location of the pressure tap for the discharge pressure transducers.

DOE also received comments on its request for clarifications of the ambiguities in section 5.2 of ISO 1217:2009(E). CAGI indicated that much of the content that DOE found ambiguous is intended as guidance for testers to eliminate leaks and ensure good data. (CAGI, No. 0010 at p. 10; CAGI, Public Meeting Transcript, No. 0016 at p. 89–90) Atlas Copco requested clarification of the ambiguities in section 5.2.1 of ISO 1217:2009(E), especially on the elimination of leaks. (Atlas Copco, No. 0009 at p. 17–18) Scales Industrial Technologies noted that some of the ambiguities appear to be applicable to larger reciprocating compressors and not for rotary screw models. (Scales Industrial Technologies, No. 0013 at p. 6) Jenny Products advised that leak detection can be conducted with soapy water and a paint brush, stated that pipes should be tight enough such that they don't leak, and suggested that a flexible hose be used to reduce vibration. (Jenny Products, No. 0020 at p. 4)

Upon review, DOE agrees with CAGI that most of the material in section 5.2 of ISO 1217:2009(E) is guidance for testers and is not required to perform a repeatable and accurate test. DOE believes that the accuracy requirements in section 5.2 are required, but that testers can consider the other materials as guidance. DOE also does not believe that the guidance materials prevent the performance of a repeatable and accurate test. Some of the guidance material might also help testers to avoid leaks in the system. As a result, in this final rule, DOE is adopting its proposal to incorporate by reference all of section 5.2 in ISO 1217:2009(E), as amended.[26]

c. Air Density Measurement

In the test procedure NOPR, DOE proposed that any measurement of air density have an accuracy of ± 1.0 percent of the measured value. 81 FR 27220, 27241 (May 5, 2016). In response to DOE's proposal, Kaeser Compressors commented at the public meeting that they agreed with the proposed accuracy requirement on the measurement of air density and clarified that manufacturers calculate density using other measured parameters in accordance with the test procedure. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 87–88) CAGI did not directly comment on this item, but CAGI commented that it was in agreement with DOE's proposals of items on which CAGI did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1)

In response to Kaeser Compressors, DOE clarifies that the intent of its test procedure NOPR proposal was that any *direct* measurement of density must have an accuracy of ± 1.0 percent of the measured value. Consequently, for the reasons established in the test procedure NOPR DOE is adopting the accuracy requirements for air density measure, as proposed in the test procedure NOPR, with the minor clarification that such requirements only apply to *directly* measured values.

2. Test Conditions

In the test procedure NOPR, DOE proposed that for both fixed-speed and variable-speed compressors, testing be conducted in accordance with the test conditions, unit configuration, and specifications of subsections 6.2(g), 6.2(h), of ISO 1217:2009(E) and C.1.1, C.2.2, C.2.3, C.2.4, C.4.1, C.4.2.1, C.4.2.3, C.4.3.2, and C.4.4 of Annex C to ISO 1217:2009(E), Annex C. 81 FR 27220, 27238 (May 5, 2016). In response to the test procedure NOPR, CAGI commented that it was in agreement with DOE's proposals of items on which CAGI did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR DOE is adopting the requirements as proposed in the test procedure NOPR.

In addition, DOE proposed specific requirements for the power supply and ambient conditions. These proposals and related comments are discussed in the following sections.

[26] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic.

a. Power Supply

In the test procedure NOPR, DOE noted that ISO 1217:2009(E) does not specify the power supply characteristics required for testing. As such, DOE proposed a set of requirements based on those adopted for similar equipment (*i.e.,* pumps); specifically these requirements were: (a) Input voltage at ±5 percent of the rated value of the motor; (b) input frequency at ±1 percent of the rated value of the motor; (c) input voltage unbalance at ±3 percent of the rated value of the motor; and d) total harmonic distortion at less than or equal to 12 percent. 81 FR 27220, 27238–9 (May 5, 2016).

Jenny Products commented that the power supplied to their facility, as well as other companies, do not meet the requirements proposed in the test procedure NOPR. (Jenny Products, No. 0020 at p. 3) Similarly, Compressed Air Systems argued that the electrical conditions should be recorded at the time of the test, but that creating a nearly static electrical condition is unnecessary because those conditions would rarely be seen in field applications. According to Compressed Air Systems, this approach would enable manufacturers to use existing equipment for the test. Compressed Air Systems further stated that the tolerances proposed in the test procedure NOPR would create undue compliance expense. (Compressed Air Systems, No. 0008 at p. 2) In response to Compressed Air Systems, DOE clarifies that it did not propose nearly static electrical conditions. Rather, DOE proposed tolerance ranges that define the acceptable condition of the power inputted to a compressor under test. The purpose of power supply and other testing tolerances is to ensure that all compressors are tested under similar conditions that result in fair and equitable ratings. Omitting or relaxing power supply tolerances, as implied by Compressed Air Systems and Jenny Products, respectively, and just requiring conditions to be recorded would not result in an equitable test, as large variations in power supply conditions can have a significant impact on the energy efficiency of a compressor under test and affect the repeatability of the test procedure.

Scales Industrial Technologies agreed with DOE's proposed voltage and frequency tolerance requirements, and stated that they should be less than 5 percent because many motors have efficiency reductions beyond 10 percent. Scales Industrial Technologies also stated that a voltage unbalance greater than 1 percent is not acceptable and can lead to significant increases in motor electric current. (Scales Industrial Technologies, No. 0013 at p. 5) Scales Industrial Technologies noted that the motor amps may increase by two times the square of the voltage unbalance and included a representation that shows the effect of voltage variation on ''T'' frame motor performance. (Scales Industrial Technologies, No. 0017.1 at p. 1; Scales Industrial Technologies, No. 0017.2 at p. 1)

CAGI suggested that the voltage tolerance range should be from 5 percent below to 10 percent above the nameplate voltage, and claimed that the range proposed by DOE would require significant and costly adaptations by the labs with negligible impact on test results. CAGI also suggested that the frequency tolerance should be ±5 percent and that the voltage imbalance should be ±3 percent. CAGI further suggested that DOE consider input provided by manufacturers regarding the total harmonic distortion tolerance, but had internal feedback that the range should be somewhere between ±12 and ±36 percent. (CAGI, No. 0010 at p. 8–9) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1)

CAGI's written comment, which were supported by other commenters, differs slightly from its original voltage tolerance proposal during the June 2016 public meeting. At the public meeting, CAGI suggested a ±10 percent voltage tolerance. (CAGI, Public Meeting Transcript, No. 0016 at pp. 96–7) This is slightly wider than its written proposal of 5 percent below to 10 percent above the nameplate voltage. (CAGI, No. 0010 at p. 8–9) Sullivan-Palatek, Kaeser Compressors, and Sullair supported CAGI's proposal at the public meeting. (Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 97; Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 98; Sullair, Public Meeting Transcript, No. 0016 at p. 98) Compressed Air Systems expressed a preference for testing at the nameplate voltage. (Compressed Air Systems, Public Meeting Transcript, No. 0016 at p. 99) Sullair reiterated that they believed 10 percent was a tolerance that manufacturers could work with. (Sullair, Public Meeting Transcript, No. 0016 at p. 100) Sullivan-Palatek stated that manufacturers often do not have controlled voltage at its facilities, but the test labs generally do. (Sullivan-Palatek, Public Meeting Transcript, No. 0016 at pp. 102–3)

DOE agrees with Scales Industrial Technologies that a narrow voltage, frequency, and voltage unbalance tolerance may improve accuracy and repeatability. However, DOE also agrees with CAGI, Ingersoll Rand, Kaeser Compressors, Sullair, and Sullivan-Palatek that there may be significant test burden associated with narrower voltage, frequency, and voltage unbalance tolerance ranges, and that this burden may not be justified by a minor increase in accuracy and repeatability. Therefore, in response to commenters concern of testing burden, in this final rule DOE adopts the broader voltage and frequency range proposed by CAGI in its written comment, *i.e.,* − 5 to +10 percent, and ±5 percent, respectively. DOE also adopts the voltage unbalance tolerance of ±3 percent, unchanged, as proposed in the test procedure NOPR.

With regard to total harmonic distortion, CAGI suggested that a range of ±12 to ±36 percent seemed appropriate, but commented that individual manufacturers would make recommendations as well. (CAGI, No. 0010 at pp. 8–9) DOE did not receive input from any of the other commenters with regard to total harmonic distortion. DOE adopts the test procedure NOPR proposal for total harmonic distortion tolerances without change. These changes pertain only to the power supply, fall within the range suggested by CAGI, and do not translate into a wider tolerance on the reported results.

b. Ambient Conditions

In the test procedure NOPR, DOE specifically proposed ambient test conditions. In addition to incorporating sections 6.2 g and 6.2 h of ISO 1217:2009(E), DOE proposed that testing should occur with an ambient air temperature of 80–90 °F, because this is the range that the CAGI Performance Verification Program uses. DOE proposed no requirements for inlet pressure or relative humidity. 81 FR 27220, 27238 (May 5, 2016).

DOE received several comments on these proposals. CAGI agreed with the proposed ambient conditions in principle, but stated that the proposed range would be overly burdensome for manufacturers and that ambient temperature does not affect test results. (CAGI, No. 0010 at p. 8; CAGI, Public Meeting Transcript, No. 0016 at pp. 76–77) CAGI proposed, instead, an ambient air temperature range of 68–90 °F. (CAGI, No. 0010, p. 8; CAGI, Public Meeting Transcript, No. 0016 at pp. 76–77) Several manufacturers supported and echoed CAGI's statements. (Sullivan-Palatek, No. 0007 at p. 3; Sullivan-Palatek, Public Meeting Transcript, No. 0016 at pp. 77–78;

Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 79; Compressed Air Systems, No. 0008 at p. 2; Jenny Products, No. 0020 at p. 3) Scales Industrial Technologies stated that the temperature range should be resolved between the manufacturers and the testing companies, and that the proposed 80–90 °F temperature range may be hard to maintain for some compressors. (Scales Industrial Technologies, No. 0013 at p. 4) Sullivan-Palatek further stated that the measured efficiency of an air compressor is not affected when narrowing the temperature range from 68–90 °F to 80–90 °F according to testimony from industry engineers. (Sullivan-Palatek, No. 0007 at p. 3)

In response to ambient temperature concerns at the June 17, 2016, public meeting DOE stated that it was willing to consider CAGI's proposed temperature range. DOE also requested data to substantiate manufacturer claims that ambient temperature does not affect measured efficiency. (DOE, Public Meeting Transcript, No. 0016 at pp. 78–9). Kaeser Compressors responded by stating that Sullivan-Palatek compressors are tested at ambient temperatures below 80 °F, and their performance is verified at 80–90 °F, indicating that temperature does not affect compressor efficiency. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 79) Test data was not made available to DOE to support or refute the claims made by CAGI. Conversely, in written comments, Jenny Products stated that ambient temperature needs to be corrected for because it will affect test results. Further, Jenny suggested that the ''reference ranges and their subsequent correction factors'' be examined to avoid adding undue financial burden to small manufacturers, which DOE interpreted as comments being directed to the ambient conditions and applicable correction factors that have been defined as part of this test procedure. (Jenny Products, No. 0020 at p. 3) However, Jenny provided no quantitative or qualitative data or information to support the claim that the ambient temperature in the test location that a compressor is tested in impacts test results. Further, DOE notes that ISO 1217:2009, which is the industry accepted test method, does not specify a required ambient temperature range for testing.

Additionally, Sullivan-Palatek stated that many small businesses may not control the ambient temperature at which they test their compressors. (Sullivan-Palatek, No. 0007 at p. 3) Jenny Products commented that they do not have a climate-controlled room to test compressors, which would be problematic for winter testing as they are located in a cold climate. (Jenny Products, No. 0020 at p. 3) Compressed Air Systems also made comments that suggested that it does not control the ambient temperature of testing facilities. (Compressed Air Systems, No. 0008 at p. 2)

DOE acknowledges comments made by Compressed Air Systems and Jenny Products and agrees that the need to create a climate-controlled space for testing compressors could be a significant burden on these small businesses. Therefore, in this final rule, DOE is relaxing the proposal in the test procedure NOPR to limit ambient temperature to 68–90 °F, as suggested by CAGI. DOE concludes this temperature range provides representative measurements without imposing undue test burden on manufacturers.

DOE received no comments directly regarding the remaining test condition requirements proposed in the test procedure NOPR. Consequently, for the reasons established in the test procedure NOPR, DOE is adopting its proposal not to establish requirements for inlet pressure and relative humidity.

3. Equipment Configuration

In the test procedure NOPR, DOE proposed the following requirements related to equipment configuration for test:

- All ancillary equipment that is distributed in commerce with the compressor under test must be present and installed for all tests specified in this appendix. 81 FR 27220, 27239 (May 5, 2016).
- The inlet of the compressor under test must be open to the atmosphere and take in ambient air for all tests specified in this appendix. 81 FR 27220, 27239 (May 5, 2016).
- The compressor under test must be set up according to all manufacturer instructions for normal operation (*e.g.,* verify oil-level, connect all loose electrical connections, close-off bottom of unit to floor, cover forklift holes). 81 FR 27220, 27239 (May 5, 2016).

As discussed in section III.A.3.b, CAGI provided a list of equipment that it believed should be included for testing. CAGI also suggested that if a unit is offered for sale without a piece of equipment on its recommended list, the manufacturer must provide an appropriate component, and the selection and responsibility of providing and installing this component for testing shall be the responsibility of the manufacturer. (CAGI, No. 0010 at pp. 3–5)

As discussed in section III.A.3.b, DOE is adopting in this final rule a required minimum equipment configuration for compressor testing. This configuration is based on the list provided by CAGI, with some modifications. CAGI's list included many caveats and footnotes related to applicability of certain equipment to certain compressors, which DOE found to be ambiguous. In the interest of clarity, DOE is splitting CAGI's list into two separate lists, as shown in Table III.2 and Table III.3, and adopting these lists to describe the minimum equipment configuration for compressor testing. The first list contains equipment that must be included on a unit when testing, regardless of whether it is distributed in commerce with the basic model under test. This table aligns with many of the items that CAGI specified as ''yes.'' The second list contains equipment that is only required if it is distributed in commerce with the basic model under test. This represents much of the equipment that CAGI specified as ''if applicable.'' DOE believes that it is impossible to *require* the equipment on Table III.3 for testing, as many basic models do not require some of this equipment to achieve their basic functionality and adding such equipment is impossible or impractical.

Further, DOE agrees with CAGI and is adopting the provision that if a unit is offered for sale without a piece of equipment listed in Table III.2, the manufacturer must provide an appropriate component, and the selection and responsibility of providing and installing this component for testing shall be the responsibility of the manufacturer. The only alternative option under this testing structure would be for the testing laboratory to determine the needed specifications of the missing component and furnish that item. Based on discussion with industry testing experts, DOE concludes that this is not a reasonable alternative. A testing laboratory does not have the expertise to determine the needed specifications of the component, so the laboratory cannot reliably choose the component. In addition, due to the large number of ancillary components and the wide range of compressor sizes, it is impractical for DOE to specify the characteristics of these components as part of the test procedure. DOE is also adopting the requirement that DOE install any additional ancillary equipment provided by the manufacturer prior to performing enforcement testing of a compressor.

Additionally, DOE is specifying that additional ancillary equipment may be installed for testing, if distributed in commerce with a compressor, but this additional ancillary equipment is not required. This approach is consistent with the approach taken in the EU Lot 31 draft standard. DOE notes that it will not install any non-required ancillary equipment during any DOE-run assessment or enforcement testing. The list that CAGI provided is slightly modified from the list used by the EU Lot 31 draft standard, and the EU Lot 31 draft standard specifies the list as a minimum configuration.

TABLE III.2—LIST OF EQUIPMENT REQUIRED DURING TEST

Equipment	Fixed-speed rotary air compressors	Variable-speed rotary air compressors
Driver	Yes	Yes.
Bare compressors	Yes	Yes.
Inlet filter	Yes	Yes.
Inlet valve	Yes	Yes.
Minimum pressure check valve/backflow check valve	Yes	Yes.
Lubricant separator	Yes	Yes.
Air piping	Yes	Yes.
Lubricant piping	Yes	Yes.
Lubricant filter	Yes	Yes.
Lubricant cooler	Yes	Yes.
Thermostatic valve	Yes	Yes.
Electrical switchgear or frequency converter for the driver	Yes	Not applicable *.
Device to control the speed of the driver (e.g., variable speed drive)	Not applicable **	Yes.
Compressed air cooler(s)	Yes	Yes.
Pressure switch, pressure transducer, or similar pressure control device	Yes	Yes.
Moisture separator and drain	Yes	Yes.

* This category is not applicable to variable-speed rotary air compressors.
** This category is not applicable to fixed-speed rotary air compressors.

TABLE III.3—LIST OF EQUIPMENT REQUIRED DURING TEST, IF DISTRIBUTED IN COMMERCE WITH THE BASIC MODEL

Equipment	Fixed-speed rotary air compressors	Variable-speed rotary air compressors
Cooling fan(s) and motors	Yes	Yes.
Mechanical equipment	Yes	Yes.
Lubricant pump	Yes	Yes.
Interstage cooler	Yes	Yes.
Electronic or electrical controls and user interface	Yes	Yes.
All protective and safety devices	Yes	Yes.

DOE is also adopting some changes to the individual items included in the list from CAGI. DOE has changed any mention of ''oil'' in the list to ''lubricant,'' in order to be consistent with the terminology throughout the test procedure. DOE has added interstage cooler to the list of items that must be included if they are distributed in commerce with the compressor, to ensure that interstage coolers are not removed from a compressor for testing.

DOE is revising and clarifying the ''compressor control device'' item from CAGI's list. DOE is including ''pressure switch, pressure transducer, or similar pressure control device'' in the list of equipment that is required during a test, because all compressors must have the ability to load and unload in response to changes in outlet pressure. DOE is also including ''electronic or electrical controls and user interface'' in the list of equipment required during a test, if distributed in commerce with the basic model. Many compressors include controls that perform other tasks beyond controlling pressure, such as cycling the intercoolers or fans on and off depending upon temperature. In addition, many compressors include an interface panel through which a user can get information and control the compressor. This equipment, if present, impacts the energy consumption of the packaged compressor, and should be accounted for. As such, electronic or electrical controls and user interfaces must be included if they are distributed in commerce with the compressor.

DOE is adopting modifications to the electrical switchgear and frequency converters included in CAGI's list. DOE is specifying that that electrical switchgear or a frequency converter must be included for fixed-speed compressors, to ensure that there is a method to turn the driver on and off. For variable-speed compressors, DOE is adopting the requirement that they include a device to control the speed of the driver. CAGI had specified that a frequency converter be required for variable-speed compressors (CAGI, No. 0010 at pp. 4) A frequency converter is a common device for controlling the speed of an electric motor, but there may be other devices that can also control the driver speed. Therefore, DOE is only specifying that a piece of equipment capable of controlling driver speed is required. DOE is doing this to ensure that the requirement is only for the performance of the device, and is not a prescriptive requirement for a particular technology to control motor speed.

DOE is also aware that certain rotary compressors are distributed in commerce with storage tanks. CAGI commented that for reciprocating compressors, storage tanks should be included in the test when they are part of the package offered by manufacturers, because their inclusion will not affect performance. (CAGI, No. 0010 at p. 5) DOE reviewed this issue with an industry testing expert and concluded that CAGI's comment is also relevant to rotary compressors distributed in commerce with tanks; *i.e.,* tanks on rotary compressors will not affect rotary compressor performance either. Consequently, DOE concludes that tanks may be included during testing, if distributed in commerce with a compressor, but tanks are not required during testing.

Defining the list of equipment that must be installed as part of the test procedure addresses comments made by Jenny Products that identified a loophole, which would allow a manufacturer to remove ancillary equipment from the basic compressor package to improve the efficiency of the unit and sell the ancillary equipment as an optional package separate from the compressor. (Jenny Products, No. 0020 at p. 3)

DOE received no comments directly regarding the remaining equipment configuration requirements proposed in the test procedure NOPR. Consequently, for the reasons established in the test procedure NOPR, DOE is adopting its proposal that the compressor inlet be open to ambient conditions and intake ambient air during testing and the compressor under test must be set up according to all manufacturer instructions for normal operation.

4. Data Collection and Analysis

a. Stabilization and Data Sampling and Frequency

In the test procedure NOPR, DOE proposed several requirements for data collection and sampling. DOE proposed to require that measurements be taken at steady-state conditions, which are achieved when the difference between two consecutive, unique, power measurements, taken at least 10 seconds apart and no more than 60 seconds apart and measured per section C.2.4 of Annex C to ISO 1217:2009(E), is less than or equal to 300 watts. 81 FR 27220, 27239 (May 5, 2016).

DOE also proposed that at each load point, a minimum of 16 unique measurements must be recorded over a minimum time of 15 minutes. Each consecutive measurement must be no more than 60 seconds apart, no less than 10 seconds apart, and the difference in packaged compressor power input between the maximum and minimum measurement must be equal to or less than 300 watts, as measured per section C.2.4 of Annex C to ISO 1217:2009(E). Each measurement within the data recording must meet these requirements. If one or more measurements do not meet the requirements, the tester must take a new data recording of at least 16 new unique measurements collected over a minimum period of 15 minutes. 81 FR 27220, 27239 (May 5, 2016).

DOE received a number of comments in response to data collection and sampling requirements proposed in the test procedure NOPR. Jenny Products commented that the frequency of data sampling seems too high, noting that their process of manually recording readings takes more than 10 seconds to complete. (Jenny Products, No. 0020 at p. 4) DOE wishes to clarify that data samples must be taken between 10 and 60 seconds apart; DOE believes that 60 seconds provides enough time to manually record measurements. CAGI commented that it agrees with the proposed data sampling frequency requirements. (CAGI, No. 0010 at p. 10) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Based on the general support of commenters and the reasons established in the test procedure NOPR, DOE is adopting the requirements that at each load point, a minimum of 16 unique measurements must be recorded over a minimum time of 15 minutes and each consecutive measurement must be no more than 60 seconds apart, and not less than 10 seconds apart.

However, CAGI commented that it does not agree with the requirements of stability. CAGI recommended that DOE adopt Table 1 from Section 6.2 of ISO 1217:2009(E), to quantify the maximum permissible fluctuation from average during steady-state operation for discharge pressure, temperature at the nozzle or orifice plate, and differential pressure over the nozzle or orifice plate. CAGI also recommended that DOE incorporate by reference sections 6.2(i), 6.2(j), and 6.2(k) to help clarify stability. (CAGI, No. 0010 at pp. 6–8, 10; CAGI, Public Meeting Transcript, No. 0016 at pp. 74, 83) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Atlas Copco supports comments made by CAGI with regard to adopting the cited sections of ISO 1217:2009(E). (Atlas Copco, No. 0009 at pp. 17–18) CAGI and Kaeser Compressors commented that the power restriction of 300 W, likely taken from the CAGI Performance Verification Program, is inappropriate and not followed by some members as it is not a realistic stability requirement for larger horsepower compressors and that a more appropriate threshold is a percentage of full-load power. (CAGI, No. 0010 at p. 10; Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 82–83) CAGI and Kaeser Compressors further argue that the power is the measured result of the test, but the stability criteria should be strictly based on measured temperatures and pressures. (CAGI, No. 0010 at p. 10; Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 84)

In response to commenters' concerns over the 300 watt stability requirement, DOE agrees with the CAGI recommendation that stability should be determined using the maximum permissible fluctuation from average for discharge pressure, temperature at the nozzle or orifice plate, and differential pressure over nozzle or orifice plate from Table 1 in ISO 1217:2009(E). Therefore, in this final rule, DOE adopts revised requirements stating that steady-state is achieved when the difference between two consecutive, unique, measurements taken at least 10 seconds apart and no more than 60 seconds apart meet all of the following requirements from Table 1 of ISO 1217:2009(E), as amended: (1) Discharge pressure varies less than or equal to 1 percent from the average reading; (2) temperature at the nozzle or orifice plate, measured per section 5.3 of ISO 1217:2009(E), as amended, varies less than or equal to 2 K from the average reading; and (3) differential pressure over nozzle or orifice plate, measured per section 5.2 of ISO 1217:2009(E), as amended, varies less than or equal to 2 percent from the average reading.[27]

In response to CAGI's additional recommendation that DOE incorporate by reference sections 6.2(i), 6.2(j), and 6.2(k) of ISO 1217:2009(E), DOE reviewed these sections and concluded that these sections contain general qualitative guidance for testing, and that the same issues are already addressed in various other sections of the test procedure being established in this final rule. Therefore, DOE is not incorporating these sections in the test procedure.

Specifically, section 6.2(i) of ISO 1217:2009(E), as amended,[28] states that before readings are taken, the compressor shall be run long enough to ensure that steady-state conditions are reached so that no systematic changes

[27] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic.

[28] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic.

occur in the instrument readings during the test. In response, DOE clarifies that in this document DOE is adopting the specific requirement that steady-state is achieved when the difference between two consecutive, unique, measurements taken at least 10 seconds apart and no more than 60 seconds apart meet certain requirements from Table 1 of ISO 1217:2009(E), as amended. As such, DOE concludes that it is unnecessary to incorporate by reference the qualitative guidance provided section 6.2(i) of ISO 1217:2009(E), as amended.

Section 6.2(j) of ISO 1217:2009(E), as amended,[29] states that, should the test conditions be such that systematic changes cannot be avoided, or if individual readings are subject to great variations, then the number of readings shall be increased. In response, DOE clarifies that in this document DOE is adopting the requirement that if measurements do not meet stability requirements then a new data recording of at least 16 new unique measurements must be taken. As such, DOE does not incorporate by reference the qualitative guidance provided section 6.2(j) of ISO 1217:2009(E), as amended.

Section 6.2(k) of ISO 1217:2009(E), as amended,[30] states that for each load, a sufficient number of readings shall be taken to indicate that steady-state conditions have been reached. The number of readings and the intervals shall be chosen to obtain the required accuracy. In response, DOE clarifies that in this document DOE is adopting specific requirements that at each load point, a minimum of 16 unique measurements must be recorded over a minimum time of 15 minutes and each consecutive measurement must be no more than 60 seconds apart, and not less than 10 seconds apart. As such, DOE does not incorporate by reference the qualitative guidance provided in section 6.2(k) of ISO 1217:2009(E), as amended.

b. Calculations and Rounding

In the test procedure NOPR, DOE recognized that the order and manner in which values are rounded can affect the final represented values produced by the test procedure. DOE noted that ISO 1217:2009(E) does not specify rounding requirements. Consequently, DOE proposed its own rounding requirements for the calculations and representations required by the DOE test procedure. DOE proposed that package isentropic efficiency be rounded and represented to the nearest 0.001, specific power to the nearest 0.01 kW/100 cfm, pressure ratio to the nearest 0.1, actual volume flow rate to the nearest 0.1 cubic feet per minute (''cfm''), and full-load operating pressure to the nearest 1 psig. DOE further proposed to require that all calculations be performed with the raw measured data in order to ensure accuracy. 81 FR 27220, 27240 (May 5, 2016).

CAGI and Atlas Copco suggested that the full-load operating pressure should be expressed to the nearest 0.1 psig to ensure that the pressure ratio is not distorted. (CAGI, No. 0010 at p. 10; Atlas Copco, No. 0009 at p. 18) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1)

In response to CAGI and Atlas Copco's concerns that pressure ratio not be distorted, DOE first notes that, as discussed in sections III.A.8 and III.E.8, the term referred to as pressure ratio in the test procedure NOPR is now referred to as pressure ratio at full-load operating pressure in this final rule. Further, in this final rule, DOE specifies that all calculations for pressure ratio at full-load operating pressure be carried out with the raw measured data. As such, the rounding requirement for representations of full-load operating pressure does not affect the calculation of the pressure ratio at full-load operating pressure. Additionally, DOE is not specifying a method for calculating pressure ratio at any load point other than full-load operating pressure. Therefore, manufacturers are not restricted by any specific rounding or representations requirement for such information.

Based on this consideration, DOE does not believe that stricter rounding requirements are necessary in representations of the full-load operating pressure. Therefore, in this final rule DOE adopts the test procedure NOPR proposal for rounding and calculations requirements.

5. Determination of Full-Load and Part-Load Package Isentropic Efficiency

In the test procedure NOPR, DOE proposed to rate fixed-speed compressors with the full-load package isentropic efficiency metric. For variable-speed compressors, DOE proposed the use of the part-load package isentropic efficiency. 81 FR 27220, 27232–3 (May 5, 2016).

According to Equation 3 in the proposal, the full-load package isentropic efficiency is calculated at the full-load operating pressure. 81 FR 27220, 27234 (May 5, 2016).

$$\eta_{isen,FL} = \eta_{isen,100\%} = \frac{P_{isen,100\%}}{P_{real,100\%}} \qquad \textbf{Equation 3}$$

Where:

$\eta_{isen,FL} = \eta_{isen,100\%}$ = package isentropic efficiency at full-load operating pressure and 100 percent of full-load actual volume flow rate,

$P_{real,100\%}$ = packaged compressor power input at full-load operating pressure and 100 percent of full-load actual volume flow rate, as determined from Equation 4,[31] and

$P_{isen,100\%}$ = isentropic power required for compression at full-load operating pressure and 100 percent of full-load actual volume flow rate, as determined from Equation 5.

As referenced in Equation 3, the packaged compressor power input at full-load operating pressure and 100 percent of full-load actual volume flow rate was proposed to be determined in accordance with Equation 4. 81 FR 27220, 27234 (May 5, 2016).

$$P_{real,100\%} = K_5 \cdot P_{PR,100\%} \qquad \textbf{Equation 4}$$

[29] *Ibid.*

[30] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic.

[31] The correction factor for the shaft speed (K_4) in section C.4.3.1 of Annex C in ISO 1217:2009(E) is not applicable to this test procedure because the electric motor drive is included in the package, and it is therefore omitted from this equation.

Where:

K_5 = correction factor for inlet pressure, as determined in section C.4.3.2 of Annex C to ISO 1217:2009(E) at a contractual inlet pressure of 100 kPa,[32] and

$P_{PR,100\%}$ = packaged compressor power input reading at full-load operating pressure and 100 percent of full-load actual volume flow rate (W), as determined in section C.2.4 of Annex C to ISO 1217:2009(E).

The isentropic power required for compression at full-load operating pressure and 100 percent of full-load actual volume flow rate ($P_{isen,100\%}$), shown in equation 5, was proposed to be evaluated using measurements taken while the unit is operating at full-load operating pressure. 81 FR 27220, 27234–5 (May 5, 2016).

$$P_{isen,100\%} = \dot{V}_{1\_m3/s} \cdot p_1 \frac{\kappa}{(\kappa - 1)} \cdot \left[\left(\frac{p_2}{p_1} \right)^{\frac{\kappa-1}{\kappa}} - 1 \right] \qquad \textbf{Equation 5}$$

Where:

$\dot{V}_{1\_m3/s}$ = corrected volume flow rate at full-load operating pressure and 100 percent of full-load actual volume flow rate, as determined in section C.4.2.1 of Annex C of ISO 1217:2009(E) (cubic meters per second) with no corrections made for shaft speed,

p_1 = atmospheric pressure, as determined in section 5.2.2 of ISO 1217:2009(E) (Pa),

p_2 = discharge pressure at full-load operating pressure and 100 percent of full-load actual volume flow rate, determined in accordance with section 5.2 of ISO 1217:2009(E) (Pa), and

κ = isentropic exponent (ratio of specific heats) of air, which, for the purposes of this test procedure, is 1.400.[33]

Also according to the test procedure NOPR proposal, the part-load efficiency is calculated using Equation 6. 81 FR 27220, 27235–27236 (May 5, 2016).

$$\eta_{isen,PL} = \omega_{40\%} \times \eta_{isen,40\%} + \omega_{70\%} \times \eta_{isen,70\%} + \omega_{100\%} \times \eta_{isen,100\%} \qquad \textbf{Equation 6}$$

Where:

$\eta_{isen,PL}$ = part-load package isentropic efficiency for a variable-speed compressor,

$\eta_{isen,100\%}$ = package isentropic efficiency at full-load operating pressure, as determined in Equation 3,

$\eta_{isen,70\%}$ = package isentropic efficiency at 70 percent of full-load actual volume flow rate,

$\eta_{isen,40\%}$ = package isentropic efficiency at 40 percent of full-load actual volume flow rate,

$\omega_{40\%}$ = weighting at 40 percent of full-load actual volume flow rate (0.25),

$\omega_{70\%}$ = weighting at 70 percent of full-load actual volume flow rate (0.5), and

$\omega_{100\%}$ = weighting at 100 percent of full-load actual volume flow rate (0.25).

Package isentropic efficiencies at 70 percent and 40 percent of full-load actual volume flow rate were proposed to be calculated using equations of the same form as equations 3, 4 and 5, but with the necessary modification of the inputs. Thus, for the 70 percent case, the packaged compressor power input and the package isentropic efficiency are evaluated at 70 percent of the full-load actual volume flow rate, and those values are used to calculate the package isentropic efficiency at 70 percent. Analogously, for the 40 percent case the package compressor power input and the package isentropic efficiency are evaluated at 40 percent of the full-load actual volume flow rate, and those values are used to calculate the package isentropic efficiency at 40 percent.

In response to the test procedure NOPR, DOE did not receive any direct comments on this item. CAGI commented that it was in agreement with DOE's proposals of items on which CAGI did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR DOE is adopting the calculation methods for full-load and part-load package isentropic efficiency, as proposed in the test procedure NOPR.

However, as previously discussed in section III.D, ISO recently published an amendment to ISO 1217:2009(E), ISO 1217:2009(E)/Amd.1,[34] which includes formulas for isentropic efficiency and isentropic power. DOE reviewed the amendment and notes that the equations provided are equivalent to the equations DOE provided in the test procedure NOPR. Therefore, in this final rule DOE is amending its proposed test method to incorporate ISO 1217:2009(E), as amended, and referencing it for the calculation of package isentropic efficiency, rather than directly providing all the equations. DOE considers this to be an administrative change, as it has no impact on the ultimate result of the test procedure.

In this test procedure final rule, DOE is also establishing certain clarifying language that it concludes is required to clearly and unambiguously interpret the methods proposed in the test procedure NOPR. In the test procedure NOPR, DOE did not specify an operating pressure for the points at 70 and 40 percent of full-load actual volume flow rate. DOE is specifying in this final rule that these points be tested at full-load operating pressure. This is the same pressure used for the point at 100 percent of full-load actual volume flow rate.

DOE is also revising the pressure values used in the calculation of isentropic power. In the test procedure NOPR, DOE proposed to correct the measured real power to a standard atmospheric pressure of 100 kPa. For isentropic power, DOE proposed to use the atmospheric and discharge pressure values measured at each load point, without correction for atmospheric pressure. This creates an inconsistency, because real power is corrected to atmospheric pressure and isentropic power is not. Therefore, DOE is adopting a method that calculates the isentropic power at a standard atmospheric pressure of 100 kPa. The method specifies a discharge pressure that is equal to the sum of 100 kPa and

[32] The correction factor for inlet pressure uses contractual values for inlet pressure. Since a contractual value is not applicable to this test procedure, DOE proposed to use a value of 100 kPa from Annex F in ISO 1217:2009(E).

[33] The isentropic exponent of air has some limited variability with atmospheric conditions. DOE chose a fixed value of 1.400 to align with the EU Lot 31 draft standard's metric calculations.

[34] ISO 1217:2009(E) and ISO 1217:2009(E)/Amd.1 create one amended document, which is referred to in this final rule as ''ISO 1217:2009(E), as amended.''

the discharge gauge pressure measured during the test.

6. Allowable Deviation From Specified Load Points

In the test procedure NOPR, DOE proposed to explicitly limit the maximum allowable deviation from specified load points when testing to find part-load and full-load package isentropic efficiency and pressure ratio. Specifically, DOE proposed that maximum allowable deviations from the specified discharge pressure and volume flow rate in Tables C.1 and C.2 of Annex C of ISO 1217:2009(E) apply. 81 FR 27220, 27239–27240 (May 5, 2016). DOE also clarified that the term ''volume flow rate'' in Table C.2 of Annex C of ISO 1217:2009(E) refers to the actual volume flow rate of the compressor under test. 81 FR 27220, 27259 (May 5, 2016).

DOE received no comments directly regarding this proposed requirement, but notes that CAGI stated that it was in agreement with DOE's proposals of items on which CAGI did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Consequently, for the reasons established in the test procedure NOPR, DOE is adopting this proposal.

7. Determination of Package Specific Power

In the test procedure NOPR, DOE proposed that package specific power can be determined for both fixed and variable-speed air compressors at any load point using the equation for specific energy consumption in section C.4.4 of Annex C of ISO 1217:2009(E). 81 FR 27220, 27259 (May 5, 2016). DOE received no comments directly regarding this proposed requirement, but notes that CAGI stated that it was in agreement with DOE's proposals of items on which CAGI did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1)

In this final rule, DOE is adopting a clarification of the method for calculating corrected package power input for specific power. The clarification ensures that this value is calculated in the same way as it is calculated for isentropic efficiency. In the test procedure NOPR, DOE did not incorporate by reference the subsection in Annex C of ISO 1217:2009(E) in which the corrected package power input (P_{Pcorr}) is calculated. DOE has resolved this ambiguity by adopting an equation in this final rule for calculating P_{Pcorr}.

DOE is also adopting the clarification that correction for shaft speed shall not be performed when calculating package specific power. In the NOPR and this final rule, DOE does not allow for shaft speed correction when calculating package isentropic efficiency. Therefore, DOE believes it is most consistent and clear to require the same standards for determining package specific power.

8. Determination of Pressure Ratio at Full-Load Operating Pressure

In the test procedure NOPR, DOE proposed a method to determine pressure ratio. Specifically DOE proposed that pressure ratio be defined by the following equation:

$$PR = \frac{p_2}{p_1}$$

Where:

PR = pressure ratio

P_1 = atmosphere pressure as determined in section 5.2.2 of ISO 1217:2009(E) (Pa), and

P_2 = discharge pressure at full-load operating pressure, determined in accordance with section 5.2 of ISO 1217: 2009 (Pa). 81 FR 27220, 27260 (May 5, 2016).

CAGI did not directly comment on pressure ratio, but CAGI stated that it was in agreement with DOE's proposals of items on which CAGI did not directly comment. (CAGI, No. 0010, p. 3) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1)

As discussed in section III.A.1, Scales Industrial Technologies indicated that DOE's proposed definition of pressure ratio was not sufficiently clear, and could be interpreted in multiple ways. (Scales Industrial Technologies, No. 0013, at p. 1) Jenny Products commented that ambient temperature, barometric pressure, humidity, and altitude must be corrected for because they will all affect test results. (Jenny Products, No. 0020 at p. 3)

As discussed in section III.A.1, in an effort to add clarity, the term referred to as pressure ratio in the test procedure NOPR is now referred to as pressure ratio at full-load operating pressure in this final rule. Additionally, in this final rule, DOE is incorporating clarifying changes to the test method and calculations for pressure ratio at full-load isentropic efficiency. Specifically, DOE reviewed the test method proposed in the test procedure NOPR and agrees with Scales Industrial Technologies that the method was ambiguous and would create results that vary with atmospheric pressure. Further, DOE agrees with Jenny Products that it is important to account for ambient barometric pressure.

Specifically, compressors within the scope of this rulemaking all use control devices. As a result, the full-load operating pressure is a characteristic of each model and remains constant under varying atmospheric pressure. This means that the method proposed by DOE would result in a pressure ratio that is dependent on the atmospheric pressure at which the test is performed. This dependence on atmospheric pressure reduces the repeatability of the method.

To remove the dependence on atmospheric pressure, DOE is adopting a revised method for measuring pressure ratio at full-load operating pressure in this final rule. This method uses a standard atmospheric pressure, 100 kPa, and uses the full-load operating pressure declared for the compressor. As a result, this method creates results that are independent of the atmospheric pressure at which testing is performed.

9. Maximum Full-Flow Operating Pressure, Full-Load Operating Pressure, and Full-Load Actual Volume Flow Rate

In the test procedure NOPR, DOE proposed a detailed method to determine maximum full-flow operating pressure, full-load operating pressure, and full-load actual volume flow rate. Specifically, DOE proposed that the full-load operating pressure would be a manufacturer-declared value based on the measured maximum full-flow operating pressure. In its proposal, DOE allowed manufacturers to declare a full-load operating pressure of between 90 percent and 100 percent of the maximum full-flow operating pressure. The full-load operating pressure would then be used for subsequent testing in order to determine the full-load actual volume flow rate, specific power and package isentropic efficiency. 81 FR 27220, 27241–27243 (May 5, 2016).

DOE received many comments related to its proposal that full-load operating pressure would be a manufacturer-declared value based on the measured maximum full-flow operating pressure, as well as comments related to the procedure to determine maximum full-flow operating pressure. These comments are discussed in the paragraphs that follow. However, DOE received no comments regarding the proposed method to determine full-load actual volume flow rate. Consequently, for the reasons established in the test procedure NOPR, DOE is adopting this method as proposed in the test procedure NOPR.

Jenny Products commented that the procedure to determine maximum full-flow operating pressure was confusing, but did not offer specific guidance as to how it could be simplified. (Jenny Products, No. 0020 at p. 4) Further, Jenny Products stated that ISO allowed for a tolerance of ±2 psig for pressure variation vs. the ±1 psig variation proposed by DOE when determining the maximum full-flow operating pressure. DOE would like to clarify that the discharge pressure variation tolerance in ISO 1217:2009(E) is ±1 percent from average as specified in 6.2 Table 1. With respect to Jenny Products comments regarding the detail of the procedure to determine maximum full-flow operating pressure, DOE recognizes that the procedure is nuanced, but believes that the detail is necessary to ensure a repeatable and reproducible test across all compressors included in the scope of this final rule. DOE also notes that the accuracy requirement of ±1 psig is necessary due to the discrete increments of pressure required as discussed in the test procedure NOPR. 81 FR 27220, 27242 (May 5, 2016). Consequently, DOE adopts the method to determine maximum full-flow operating pressure as proposed in the test procedure NOPR in this final rule.

Compressed Air Systems commented that the operating pressure is a range, not a static number, and can vary between load and unload pressure. (Compressed Air Systems, No. 0008 at p. 2) In response to Compressed Air Systems' concern, DOE agrees that compressors may output air at a range of pressures. However, DOE must select a specific pressure value for manufacturers to use, in order to fairly and equitably measure compressor performance.

In response to DOE's proposal, Atlas Copco objected to manufacturers self-declaring full-load operating pressure of between 90 and 100 percent of maximum full-flow operating pressure, claiming that this creates a loophole where fixed-speed machines can select the optimal pressure for maximum efficiency (between 90–100 percent), but variable-speed units are penalized because all points have to achieve efficiencies greater than required by the standard. (Atlas Copco, No. 0009 at p. 15) In response to Atlas Copco's concern, DOE clarifies that manufacturers currently self-declare full-load operating pressure and the provision proposed by DOE in the test procedure NOPR allows manufacturers to continue this practice. Further, any potential benefit to fixed-speed compressors from this self-declaration could be realized equally by all fixed-speed compressors and thus not be considered a loophole. Additionally, in the energy conservation standards NOPR, DOE proposed fixed-speed and variable-speed compressors to be considered in separate equipment classes with separate proposed standards. As such, any benefits provided to fixed-speed compressors would have no bearing on the performance or relative ranking of variable compressors, which would be assessed using a completely separate metric and proposed standard.

Atlas Copco also claimed there could be a loophole whereby a manufacturer represents the full-load operating pressure at which the compressor achieves its optimum efficiency (*e.g.,* 125 psig), but markets the product at a different pressure (*e.g.,* 90 psig). To remedy these concerns, Atlas Copco suggested any declared full-load operating pressure must have an associated efficiency that is above the standard. (Atlas Copco, No. 0009 at pp. 15–16) DOE agrees with Atlas Copco that rating a compressor at one pressure and marketing a compressor at a different pressure is undesirable and believes the provisions of the test procedure NOPR are in agreement with Atlas Copco's suggestion. Specifically, in the test procedure NOPR, DOE clearly proposed that any representation of full-load actual volume flow rate, full-load operating pressure, full-load package isentropic efficiency, and part-load package isentropic efficiency must be made according to the DOE test procedure. Given this provision, manufacturers can only self-declare one full-load operating pressure, and the package isentropic efficiency associated with this operating pressure must be represented in accordance with the DOE test procedure.

Scales Industrial Technologies indicated a preference for the manufacturer's maximum design pressure at full capacity in response to a request for comment regarding the full-load operating pressure. (Scales Industrial Technologies, No. 0013 at pp. 7) DOE is unclear as to the exact meaning of maximum design pressure at full capacity. However, requiring use of an objective maximum pressure (*i.e.,* maximum full-flow operating pressure) would force a manufacturer to rate a compressor in a manner unfamiliar to customers and, possibly, in a way that does not characterize the way the compressor is likely to be operated in practice. The 10-percent psig limit proposed in the test procedure NOPR balances DOE's need to create a fair and equitable rating point while maintaining the flexibility needed for compressor manufacturers to continue to meet the needs of their end users.

CAGI agreed that manufacturers should be allowed to self-declare a full-load operating pressure, but suggested a tolerance of either 10 percent or 10 psi,[35] whichever is greater. CAGI added that a 10-percent range would not be practical for lower-pressure equipment. (CAGI, No. 0010 at p. 11) DOE interpreted this comment to translate to the following requirement:

If measured maximum full-flow operating pressure is greater than 100 psig, manufacturers would be allowed to declare a full-load operating pressure of between 90 percent and 100 percent of the measured maximum full-flow operating pressure. If measured maximum full-flow operating pressure is less than or equal to 100 psig, manufacturers would be allowed to declare a full-load operating pressure as a value that is up to 10 psi[36] less than the measured maximum full-flow operating pressure.

CAGI suggested that this is a better approach because the 10 percent range proposed by DOE would not be practical for low-pressure equipment. (CAGI, No. 0010 at p. 11) Sullair and CAGI had previously suggested this approach in the June 2016 public meeting. (Sullair, Public Meeting Transcript, No. 0016 at p. 105; CAGI, Public Meeting Transcript, No. 0016 at p. 105–6)

The CAGI suggestion would only affect units whose maximum full-flow operating pressures are less than 100 psig. For those units, 10 percent of the full-operating pressure would be 10 psi[37] or less. DOE concludes that CAGI's recommendation is reasonable, and aligns with DOE's intent to create a fair and equitable rating point while maintaining the flexibility needed for compressor manufacturers to continue to meet the needs of their end users.

Thus, in this final rule DOE adopts CAGI's suggestion that if measured maximum full-flow operating pressure is greater than 100 psig, manufacturers are allowed to declare a full-load operating pressure of between 90 percent and 100 percent of the measured maximum full-flow operating pressure; and if measured maximum full-flow operating pressure is less than or equal to 100 psig, manufacturers are

[35] Here, there is no difference between absolute and gauge pressure.

[36] Here, there is no difference between absolute and gauge pressure.

[37] Here, there is no difference between absolute and gauge pressure.

allowed to declare a full-load operating pressure as a value that is up to 10 psi [38] less than the measured maximum full-flow operating pressure.

In this test procedure final rule, DOE is adopting a minor modification to the starting pressure used in the maximum full-flow operating pressure test method. In the test procedure NOPR, DOE proposed to start the test by adjusting the backpressure of the system so the measured discharge pressure is 90 percent of the expected maximum full-flow operating pressure, rounded to the nearest integer, in psig. If the expected maximum full-flow operating pressure is not known, DOE proposed to adjust the backpressure of the system so that the measured discharge pressure is 75 psig. The intent of this provision is to ensure that all compressors within the scope of this rulemaking can be tested to find maximum full-flow operating pressure, even when no expected value is known. As discussed in section III.B, the scope of this test procedure is now restricted to compressors with full-load operating pressure greater than or equal to 75 psig. To achieve the original intent of this provision, the starting discharge pressure for this test must be slightly lower than that 90 percent of the lowest possible maximum full-flow operating pressure (*i.e.,* 75 psig). Consequently, it is appropriate to revise the default starting discharge pressure to 65 psig.

F. Definition of Basic Model

In the course of regulating products and equipment, DOE has developed the concept of using a ''basic model'' for testing to allow manufacturers to group similar equipment to minimize testing burden, provided all representations regarding the energy use of compressors within that basic model are identical and based on the most consumptive, least efficient unit. 76 FR 12422, 12423 (Mar. 7, 2011).[39] In that rulemaking, DOE established that manufacturers may elect to group similar individual models within the same equipment class into the same basic model to reduce testing burden, provided all representations regarding the energy use of individual models within that basic model are identical and based on the most consumptive unit. 76 FR 12422, 12423 (Mar. 7, 2011). However, manufacturers group models with the understanding that there is increased risk associated with such model consolidation, due to the potential for an expanded impact from a finding of noncompliance. Consolidation of models within a single basic model results in such increased risk because DOE determines compliance on a basic model basis. *Ibid.*

In keeping with this practice, in the test procedure NOPR, DOE proposed a definition of basic model for compressors that defines the compressor models on which manufacturers must conduct testing to demonstrate compliance with any energy conservation standard for compressors, while still enabling manufacturers to group individual models to reduce the burden of testing. DOE proposed to establish a definition of basic model that is similar to other commercial and industrial equipment. Specifically, DOE proposed to define a compressor basic model to include all units of a class of compressors manufactured by one manufacturer, having the same primary energy source, and having essentially identical electrical, physical, and functional (or pneumatic) characteristics that affect energy consumption and energy efficiency. The requirement of ''essentially identical electrical . . . characteristics'' means that models with different compressor motor nominal horsepower ratings must be classified as separate basic models. 81 FR 27220, 27243 (May 5, 2016).

In response to the test procedure NOPR, DOE received comments expressing concern that under the definition of the basic model, small changes to certified compressors may require manufacturers to retest or perform an AEDM in order to recertify the equipment. Specifically, Sullivan-Palatek commented that the substitution of non-standard electric motors, controls, or coolers would be a significant burden due to the testing that would be required for that compressor. Sullivan-Palatek further commented that DOE should consider the definition of basic model that CAGI currently uses, which permits add-ons and alterations to basic packages. Sullivan-Palatek indicated that this definition of basic model would allow manufacturers to offer specialty products without the burden of certifying each customized compressor as a new basic model. (Sullivan-Palatek, No. 0007 at pp. 1, 4; Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 44) Kaeser Compressors and Sullair also commented that customers often request small changes, particularly at higher compressor capacities, and used motor substitutions as the primary example of what may constitute additional basic models. (Kaeser Compressors, Public Meeting Transcript, No. 0016 at p. 46; Sullair, Public Meeting Transcript, No. 0016 at p. 131) CAGI stated that the DOE definition of a basic model differed from the industry definition of a standard model, which the industry uses to represent efficiency. CAGI implied that the difference in the interpretation of what constitutes a basic model would cause many more compressor models to be tested in order to represent their efficiency, which is burdensome to manufacturers. (CAGI, Public Meeting Transcript, No. 0016 at p. 125–8) Sullair commented that many non-standard compressor models exist which include modifications that increase the energy consumed by the compressor compared to its basic model. (Sullair, Public Meeting Transcript, No. 0016 at p. 113)

DOE clarifies that changes, such as the use of alternate brand components (*e.g.,* motors, filters, drives) trigger the need for a new basic model only if the variant no longer has essentially identical electrical, physical, and functional (or pneumatic) characteristics that affect energy consumption and energy efficiency. In response to CAGI's concerns that a greater number of basic models may need to represent efficiency in comparison to the industry practice of a standard model, DOE believes that changes made to the test configuration (see section III.E.3) that are adopted in this final rule result in a DOE basic model that more closely aligns with the industry's concept of a standard model. However, based on Sullair's comment, DOE concludes that some additional basic models (as compared to the industry's ''standard models'') are justified, as some models exhibit unique efficiency characteristics, and accurate representation of equipment efficiency is critical to setting an equitable test procedure. Finally, DOE notes that in this final rule it is also adopting a provision to allow for the use of an AEDM to alleviate the burden of representing the efficiency of basic models that are similar in design to a standard compressor, but with modifications to suit an application or customer request.

[38] Here, there is no difference between absolute and gauge pressure.

[39] These provisions allow manufacturers to group individual models with essentially identical, but not exactly the same, electrical, physical, and functional characteristics that affect energy performance characteristics into a basic model to reduce testing burden. Under DOE's certification requirements, all the individual models within a basic model identified in a certification report as being the same basic model must have the same certified efficiency rating and use the same test data underlying the certified rating. The Compliance Certification and Enforcement final rule also establishes that the efficiency rating of a basic model must be based on the least efficient or most energy consuming individual model (*i.e.,* put another way, all individual models within a basic model must be at least as energy efficient as the certified rating). 76 FR 12422, 12428–12429 (March 7, 2011).

Consequently, DOE is adopting in this final rule the definition for basic model as proposed in the test procedure NOPR.

G. Sampling Plan for Testing and Alternative Efficiency Determination Methods

DOE must provide test procedures that produce results that reflect energy efficiency, energy use, and estimated operating cost of industrial equipment during a representative average use cycle. (42 U.S.C. 6314(a)(2)) These representative values are used when making public representations and when determining compliance with prescribed energy conservation standards. In the test procedure NOPR, DOE proposed two uniform methods for manufacturers to determine representative values of energy and cost-related metrics: A statistical sampling plan or an alternative efficiency determination method. 81 FR 27220, 27244 (May 5, 2016). The following sections discuss comments received in response to DOE's test procedure NOPR regarding statistical sampling and AEDMs.

1. Sampling Plan and Representations

a. Minimum Sample Size

In the test procedure NOPR, DOE proposed a statistical sampling plan that requires a minimum of two units be tested to ensure a basic model's compliance. 81 FR 27220, 27244–5 (May 5, 2016). In response to the proposed sampling plan, CAGI, Compressed Air Systems, Sullair, and Sullivan-Palatek commented that, due to low production volume of some compressors models, a minimum of two samples would be impractical to test as there is not adequate inventory to meet the sampling requirements. (CAGI, No. 0010 at p. 11, Compressed Air Systems, No. 0008 at p. 2, Sullair, No. 0006 at p. 9; Sullair, Public Meeting Transcript, No. 0016 at p. 124; Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 56) Ingersoll Rand, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0011 at p. 1; Sullair, No. 0006 at p. 1; Sullivan-Palatek, No. 0007 at p. 1) Sullair and Sullivan-Palatek further commented that, for customized low volume units, they use a mixture of customer acceptance test data and estimation rather than testing per the CAGI Performance Verification Program. (Sullair, Public Meeting Transcript, No. 0016 at pp. 43; Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 44) Ingersoll Rand commented that testing is performed on every compressor package that it produces, but some units are unique and driven by customer-specific application requirements. (Ingersoll Rand, Public Meeting Transcript, No. 0016 at pp. 44–45)

In response to the concerns regarding low-volume units, DOE understands that within the scope in the test procedure NOPR, certain basic models may be produced in low volume and a minimum of two samples are impractical to test for these low volume basic models due to inadequate inventory availability. However, DOE believes that the majority of these low volume units are larger capacity models (*i.e.,* models with compressor motor nominal horsepower greater than 200 hp and full-load operating pressures greater than 200 psig). As noted in section III.B, DOE is limiting the applicability of the test procedure established in this final rule to only lubricated compressors with compressor nominal motor horsepower of 10 to 200 hp (inclusive) and full-load operating pressures of 75 to 200 psig (inclusive). This revised scope aligns with the scope recommended by CAGI and other manufacturers. Further, the 10 to 200 hp scope established in this final rule aligns directly with the scope of the CAGI Performance Verification Program for rotary compressors. Manufacturers who participate in this program [40] are required to test multiple basic models per year as a part of the program's compliances and certification requirements. Basic models are selected at the discretion of the CAGI program manager, with the intent of testing through the range of eligible products over a period of several years. For each basic model selected, manufacturers must make available two individual units that are randomly selected from available manufacturer and/or distributor stock. Consequently, DOE concludes that the majority of the basic models within the scope of the test procedure established by this final rule are commonly available (*i.e.,* not low production volume) and are typically produced in quantities of at least two units per year.

However, even with the reduced scope established in this test procedure final rule, a small number of basic models may still be produced in very limited quantities. This limited subset of models may be produced in low quantities for a variety of reasons; for example, specific customer requirements may lead manufacturers to customize existing basic models or produce new, custom compressors, with unique performance characteristics. To address the industry's concern regarding the testing of low-volume production compressors, DOE specifically proposed, in the test procedure NOPR, to allow manufacturers to certify the energy efficiency of basic models through the use of an AEDM in lieu of physical testing. In such cases, no physical testing is required and, therefore, the sample size provisions are not applicable. Complete discussion of AEDM is provided in section III.G.2, where DOE discusses its rationale for adopting certain AEDM provisions in this final rule.

In summary, DOE concludes that the reduced scope has significantly reduced the number of low-production-volume basic models that are subject to this test procedure. Further, DOE concludes that the allowance of an AEDM in the place of testing sufficiently addresses the industry's concern regarding testing the limited number of low-shipments-volume compressor basic models that remain in scope. DOE also notes that relying on a sample size of at least two units is important to account for manufacturing variability and test uncertainty. Using a sample size of at least two units and the associated statistics provides consumers and DOE with reasonable assurance that any representative value of package isentropic efficiency or other values associated with a given basic model is, in fact, representative of the population of units to which that basic model rating applies. For these reasons, in this final rule, DOE is adopting a minimum sample size of two units, as proposed in the test procedure NOPR.

b. Sampling Statistics

In the test procedure NOPR, DOE proposed that package isentropic efficiency be represented as the lower of (1) the mean of the test sample, and (2) the lower 95 percent confidence limit (LCL) divided by 0.95. 81 FR 27220, 27244–27245 (May 5, 2016). DOE also proposed that package specific power, full-load actual volume flow rate, full-load operating pressure, and pressure ratio be represented as the mean of the test sample. 81 FR 27220, 27244 (May 5, 2016).

In response to DOE's proposal, CAGI, Ingersoll Rand, and Sullivan-Palatek commented that the 95 percent lower confidence limit as part of the sampling plan results in a more conservative rating than the current industry standard. (CAGI, No. 0010 at p. 14; Ingersoll Rand, Public Meeting

[40] The following manufacturers participate in the CAGI Rotary Compressor Performance Verification Program according to the participant directory: Atlas Copco, Boge, Chicago Pneumatic, CompAir, FS Curtis, Gardner Denver, Ingersoll Rand, Kaeser Compressors, Mattei, Quincy, Sullair and Sullivan-Palatek. The participant directory is available at *http://www.cagi.org/performance-verification/.*

Transcript, No. 0016 at pp. 121–2; Sullivan-Palatek, No. 0007 at pp. 2, 4) CAGI's comments regarding sampling were supported by Sullair. (Sullair, No. 0006 at p. 1) CAGI, Ingersoll Rand, and Sullivan-Palatek further stated that data published under the CAGI Performance Verification Program was not collected using the sampling method proposed in the test procedure NOPR (*i.e.,* the lower of the sample mean or the 95 percent confidence limit divided by 0.95). They further argued that adjustments may be needed to the minimum standard levels proposed in the compressors energy conservation standard NOPR, which was made with unaltered CAGI Performance Verification Program data, to account for the proposed sampling plan. (CAGI, No. 0010 at pp. 15–16; Ingersoll Rand, No. 0011 at pp. 1–2; Sullivan-Palatek, No. 0007 at p. 4) Sullivan-Palatek further commented that the proposed standards, if left without adjustment, represented an extra level of performance above and beyond the TSL2 standard. (Sullivan-Palatek, No. 0007 at p. 4)

In response to commenters' concerns, DOE acknowledges that the proposed sampling plan may result in a more conservative rating than the current industry standard, as the proposed sampling statistics for package isentropic efficiency are designed to account for variability in testing and manufacture (as is done with most other covered products and equipment). Requiring the use of sampling statistics, rather than the sample mean, provides end-users and DOE with reasonable assurance that any individual unit distributed in commerce is as efficient, or better, than its basic model rating. DOE believes that this assurance is beneficial to the end user, and as such rejects the use of the sample mean for representations of package isentropic efficiency.

In the absence of a specific alternative recommendation for package isentropic efficiency sampling statistics, DOE adopts the sampling statistics plan, as proposed in the test procedure NOPR, in this final rule. Specifically, package isentropic efficiency shall be represented as the lower of (1) the mean of the test sample, and (2) the lower 95 percent confidence limit (LCL) divided by 0.95.

DOE received no comments disagreeing with the test procedure NOPR proposal that package specific power, full-load actual volume flow rate, full-load operating pressure, and pressure ratio shall be represented as the mean of the test sample. Consequently, in this final rule, DOE adopts this requirement, as proposed in the test procedure NOPR. However, DOE acknowledges that the sampling plan proposed in the test procedure NOPR may result in package isentropic efficiency ratings that differ from those used in the energy conservation standards NOPR analysis. This is because the energy conservation standards analysis assumed mean package isentropic efficiency values for each basic model, while in practice some basic models may be rated using the lower 95 percent LCL divided by 0.95. Consequently, in the concurrent energy conservation standards final rule, DOE will account for the effect of rating using the lower 95 percent LCL divided by 0.95, and adjust the analysis and efficiency levels, where applicable.

c. 180-Day Representations Requirement

EPCA prescribes that all representation of the metrics discussed in section III.G.1.b must be made in accordance with DOE test procedures and representations requirements, beginning 180 days after publication of such a test procedure final rule in the **Federal Register**. (42 U.S.C. 6314(d)(1))

In response to DOE's test procedure NOPR, CAGI commented that the adoption of the 180-day effective date is a significant burden that DOE did not consider. (CAGI, No. 0010 at pp. 11, 14) These comments were echoed by Ingersoll Rand. (Ingersoll Rand, No. 0011 at p. 2; Ingersoll Rand, Public Meeting Transcript, No. 0016 at p. 14) Atlas Copco raised similar concerns in its comments. (Atlas Copco, No. 0009 at p. 7–10) Likewise, Jenny Products commented that it will not be able to comply within 180 days and noted that it would need to order test equipment, construct an environmental testing room, train employees to conduct testing, build compressors, and test compressors. Jenny Products indicated that they have over 110,880 different basic models that would need to be certified. (Jenny Products, No. 0020 at pp. 4–5) CAGI noted that while the proposed full- and part-load package isentropic efficiency metric isn't used by the industry nor represented in literature, four other metrics (package specific power, full-load actual volume flow rate, full-load operating pressure, and pressure ratio) are. CAGI further stated that the requirement to review literature and verify compliance with the test procedure within 180 days of publication for these four metrics is unreasonable. (CAGI, No 0010 at p. 14) Ingersoll Rand, Sullair, and Sullivan-Palatek made similar comments as CAGI, with Ingersoll Rand stating that its existing compressor data would likely be rendered invalid due to changes in the test procedure, and the proposed test procedure would impose significant burden to re-evaluate its existing portfolio of products. (Ingersoll Rand, No. 0011 at p. 2; Ingersoll Rand, Public Meeting Transcript, No. 0016 at pp. 131, 133; Sullair, No. 0006 at pp. 1, 9; Sullivan-Palatek, No. 0007 at p. 5) CAGI requested that DOE delay the compliance date of the test procedures to coincide with the compliance date of any energy conservation standards. CAGI further stated that there is ample precedent to support such a delay.[41] (CAGI, No 0010 at p. 15; CAGI, No 0010 at p. 11) Ingersoll Rand and Sullair made similar comments with respect to delaying the compliance date of the test procedure; Ingersoll Rand specifically commented that the compliance date should be delayed to coincide with the energy conservation standard. (Ingersoll Rand, No. 0011 at p. 2; Sullair, No. 0006 at p. 9)

CAGI also commented that aligning the test methods and tolerances with current practice would significantly minimize the 180-day burden of the sampling plan. (CAGI, No. 0010 at p. 11) Ingersoll Rand and Sullair had similar comments to CAGI. Specifically, Sullair stated that if the scope of the test procedure was limited to commonly commercial units with test procedures that had better alignment with ISO 1217:2009(E), the burden [of representing efficiency per the proposed test procedure within 180 days] would be reduced. (Ingersoll Rand, Public Meeting Transcript, No. 0016 at pp. 131, 133; Sullair, Public Meeting Transcript, No. 0016 at p. 134)

Similarly, Atlas Copco stated that the DOE's proposed test procedure omits or changes key elements from ISO 1217:2009(E), ultimately requiring every manufacturer to retest (or perform an AEDM) and rerate every compressor within 180 days, if manufacturers were to continue making representations. Atlas Copco also stated that this scenario would be unduly burdensome, and recommended that DOE adopt a three-year transition rule allowing manufacturers to meet testing and modeling requirements with valid data generated under ISO 1217:2009(E). Atlas Copco cited case law supporting its recommendation of adoption of a three-year transition period, specifically, *Center for Biological Diversity* v. *National Highway Traffic Safety Administration,*[42] 538 F.3d 1172, 1206

[41] DOE notes that under EPCA, it does not have the authority to implement such a delay.

[42] DOE notes that this case is not pertinent to the regulation of industrial equipment under EPCA.

(9th Cir. 2008). (Atlas Copco, No. 0009 at pp. 7–10)

DOE acknowledges Atlas Copco's concerns that its test method, as proposed in the test procedure NOPR differed from ISO 1217:2009(E). However, as discussed in sections III.B and III.E, in this final rule DOE is modifying its NOPR proposal to reduce scope and better align with ISO 1217:2009(E). As stated by CAGI, Ingersoll Rand, and Sullair, DOE believes that increased alignment with ISO 1217:2009(E) will reduce the burden of making representation per the test procedure within 180 days.

Regarding comments requesting that DOE extend the 180-day representations requirement, DOE reiterates that EPCA prescribes the effective date for test procedure representations in 42 U.S.C. 6314(d)(1) and does not provide DOE with discretion to delay the effective date for covered equipment. However, EPCA does provide an allowance for individual manufacturers to petition DOE for an extension of the 180-day effective date if the manufacturer may experience undue hardship as a result of 180-day timeframe provided under 42 U.S.C. 6314(d)(1). To receive such an extension, petitions must be filed with DOE not later than 60 days before the representations are required to reflect the DOE test procedure and must detail how the manufacturer will experience undue hardship. (42 U.S.C. 6314 (d)(2)) Beyond this extension, as noted above, DOE lacks authority to extend the date for adjust representations to reflect the DOE test procedure.

In response to these concerns, DOE notes that EPCA prescribes the effective date for test procedure representations in 42 U.S.C. 6314(d)(1) and does not provide DOE with discretion as to the effective date for different equipment. However, to reduce, to the extent possible, the potential burden cited by manufacturers, in this final rule, DOE is establishing test procedures that are intended to produce results equivalent to those produced under ISO 1217:2009(E), as amended.[43] As discussed in section III.E, in this final rule DOE is making many modifications to the methods proposed in the test procedure NOPR proposal to align as closely as possible to ISO 1217:2009(E), as amended. In addition, as discussed in section III.B, DOE is limiting the scope of the adopted test procedures to be consistent with compressors that currently participate in the CAGI program. As noted by CAGI and Sullair, these modifications to align the scope and test methods of the test procedures adopted in this final rule with ISO 1217:2009(E), as amended, mitigate the majority of the commenters' concerns. DOE understands that manufacturers of compressors may have historical test data that were developed based on ISO 1217:2009(E). If historical test data is based on the same methodology being adopted in this final rule, then manufacturers may use this data for the purposes of representing any metrics subject to the representations requirements. Additionally, DOE concludes that Atlas Copco's request for a three-year transition rule is no longer pertinent, as the request is predicated on the assumption that historical data tested to ISO 1217:2009(E) does not meet the requirements of the DOE test procedure.

2. Alternative Efficiency Determination Method

An AEDM is a mathematical model that a manufacturer may validate and use to predict the energy efficiency or energy consumption characteristics of a basic model. In the test procedure NOPR, DOE proposed the use of a validated AEDM as an alternative to testing to reduce testing burden. DOE laid out the basic criteria an AEDM must satisfy, as well as validation, records retention, enforcement, and representations requirements related to AEDMs. 81 FR 27220, 27245–6 (May 5, 2016).

Specifically, the test procedure NOPR contained four AEDM validation classes, applicable to four varieties of compressor: (1) Rotary, fixed-speed; (2) rotary, variable-speed; (3) reciprocating, fixed-speed; and (4) reciprocating, variable-speed. DOE also proposed that two basic models be tested to validate the AEDM for each validation class for which it is intended to be applied. Validation is achieved by demonstrating that the results from the mathematical model are in agreement with the results obtained from actual testing of the requisite number of basic models in accordance with the applicable DOE test procedures. In the test procedure NOPR, DOE proposed that the AEDM-predicted results for a basic model must be (for energy consumption metrics) equal to or greater than 95-percent or (for energy efficiency metrics) less than or equal to 105-percent of the tested results for that same model for the AEDM results to be valid. 81 FR 27220, 27245–27246 (May 5, 2016).

In response to the test procedure NOPR, CAGI commented that the representative values for a number of basic models can be predicted using computer modeling and prediction techniques based on a single common basic package compressor model. As such, CAGI suggested that DOE relax the AEDM definition so that testing does not need to be carried out on every basic model. (CAGI, No. 0010 at p. 15) Compressed Air Systems commented that the use of AEDMs could translate to large expenses for small air compressor packagers, as they often do not have the necessary staff and software. Compressed Air Systems also stated that the specialized nature of small packagers means that most products are low-volume and customized, and that the cost to develop an AEDM for those products would make it impossible to maintain a competitive price. (Compressed Air Systems, No. 0008 at p. 2) CASTAIR commented that AEDM modeling would be too large an expense for small air compressor assemblers due to the cost in staffing, equipment, and facilities. (CASTAIR, No. 0018 at p. 1)

In response to CAGI's comment, DOE clarifies that the proposed AEDM requirements are that a minimum of two basic models be tested for each validation class; there is no requirement that all basic models for which the AEDM is applicable be tested. That is, while an AEDM may be validated for a large number of basic models within a given validation class, only two of those basic models need to be tested in accordance with the test procedure and related sampling plans to validate the AEDM for all basic models in that validation class. DOE believes, therefore, that the AEDM requirements, as proposed in the test procedure NOPR, already align with CAGI's suggestions and no modification is necessary. DOE believes that at least two unique models for each validation class must be tested to ensure the broad applicability and accuracy of the validated AEDM across the range of basic models to which it may be applied.

With respect to Compressed Air Systems and CASTAIR's comments, DOE also notes that AEDMs were proposed as an optional strategy to evaluate equipment at a lower cost than physical testing. Under the test procedure NOPR proposal, manufacturers may continue to conduct physical testing according to the proposed test procedure and sampling plan instead of choosing to rate equipment using an AEDM, or both. Thus, given the optional nature of the AEDM, DOE does not expect the

[43] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic, so aligning with ISO 1217:2009(E), as amended, is equivalent to aligning with ISO 1217:2009(E) prior to Amendment 1:2016.

inclusion of AEDMs to result in additional burden to manufacturers. In fact, in many cases, use of an AEDM dramatically reduces the cost of rating compressor models, as once the AEDM is developed and validated, it can be used on any basic model for which it is validated.

The use of an AEDM may be particularly helpful for customized and/or low-volume basic models that are rarely manufactured and sold. As noted in section III.G.1.a, commenters expressed concern that some units are not produced in enough quantity to meet the minimum sample size of two units, which makes the application of the test procedures impractical. In those cases, use of an AEDM may be a less burdensome way to determine the performance data required for representation and compliance with any energy conservation standard. With AEDMs, several similar models can be accurately evaluated based on test data for only a few models, which can greatly reduce the costs associated with determining the performance of customized models. Furthermore, AEDMs can be validated using test data from commonly available basic models and then used to estimate the performance of low-volume units, which reduces the cost of testing per unit for low-volume basic models. Thus, AEDMs are a convenient option to reduce the testing burden on customized equipment and/or equipment with low sales volume.

Additionally, in response to Compressed Air Systems and CASTAIR's specific comments on the burden of test procedures or an AEDM, any test procedures or energy conservation standards DOE promulgates must be equitable to all industry participants, meaning that all participants, regardless of size, must be held to the same testing and energy conservation standard criteria. As discussed further in section IV.B, DOE analyzed the costs of conducting testing and rating of compressors in accordance with the test procedures adopted in this final rule and accounted for the costs of such testing on manufacturers, including small manufacturers, in its energy conservation standards NOPR analysis. 81 FR 31680, 31761 (May 19, 2016). However, as noted in the energy conservation standards NOPR, additional compliance flexibilities may be available through other means. For example, individual manufacturers may petition DOE for a waiver of the applicable test procedures. In addition, EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8,000,000 may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. *Ibid.*

DOE did not receive any specific comments regarding the applicability of the AEDM validation tolerances or other AEDM requirements proposed in the test procedure NOPR. Accordingly, DOE is adopting the AEDM validation requirements proposed in the test procedure NOPR. However, due the revised scope of the test procedures adopted in this final rule (discussed in section III.B), DOE is reducing the number of validation classes from four to two. Specifically, DOE is adopting AEDM provisions for rotary fixed-speed and rotary variable-speed compressors and removing the validation classes of reciprocating fixed-speed and reciprocating variable-speed compressors, as the latter are no longer within the scope of applicability of this final rule.

H. Enforcement Provisions

Enforcement provisions govern the process DOE follows when performing its own assessment of basic model compliance with standards, as described under 10 CFR 429.110. In the test procedure NOPR, DOE proposed requirements related to the variability of the enforcement sample, as well as the methods it would use to determine full-load operating pressure and full-load actual volume flow rate when determining compliance for enforcement purposes. 81 FR 27220, 27246–27247 (May 5, 2016). The following sections discuss interested party comments related to the enforcement sampling plan for package isentropic efficiency and enforcement testing procedures for full-load operating pressure and full-load actual volume flow rate, respectively.

1. Sample Variability for Package Isentropic Efficiency

In the test procedure NOPR, DOE proposed an enforcement procedure in which DOE would evaluate compliance based on the arithmetic mean of a sample not to exceed four units. 81 FR 27220, 27246 (May 5, 2016). This proposal mirrors the enforcement provisions adopted in the test procedure final rule for commercial and industrial pumps. 81 FR 4086 (Jan. 25, 2016).

In response to DOE's proposal, CAGI commented that using the sample mean for enforcement without considering the standard deviation of the sample increases the risk of a finding of noncompliance. (CAGI, No. 0010 at pp. 12–13) CAGI and Ingersoll Rand also noted that the sampling plans in appendices A, B, and C to subpart C of 10 CFR part 429 do account for product variability when evaluating compliance for other covered products and equipment. (CAGI, No. 0010 at pp. 12–13; Ingersoll Rand, Public Meeting Transcript, No. 0016 at p. 140) CAGI recommended that DOE not use the arithmetic mean when evaluating compliance during an enforcement test, and instead account for product variability in a manner similar to appendices A, B, and C to subpart C of 10 CFR part 429 and in alignment with ISO 1217:2009(E). (CAGI, No. 0010 at p. 13) Ingersoll Rand commented that the enforcement procedure should allow for a 5-percent tolerance and not use the sample mean, and noted that certain other covered products and equipment allow for a tolerance on top of the sample mean. (Ingersoll Rand, Public Meeting Transcript, No. 0016 at pp. 140–141) Sullair and Sullivan-Palatek stated that they support CAGI's position relative to sampling and enforcement. (Sullair, No. 0006 at p. 9; Sullivan-Palatek, No. 0007 at pp. 1)

CAGI and Sullair commented that, for low-volume compressors, manufacturers may not be able to produce 4 units for the DOE to conduct enforcement testing on, because manufacturers may not manufacture four units of a given model within a year. (CAGI, No. 0010 at p. 13; Sullair, Public Meeting Transcript, No. 0016 at p. 141)

In response to these comments, DOE is not finalizing an enforcement sampling plan in this rule. Because compliance with any standards will not be required for 5 years, DOE will engage in a separate rulemaking to allow for further comments and input on how DOE should evaluate compliance.

2. Full-Load Operating Pressure and Actual Volume Flow Rate

In the test procedure NOPR, DOE proposed to adopt provisions that specify how DOE would determine the full-load operating pressure for the purposes of measuring the full-load actual volume flow rate, package isentropic efficiency, specific power, and pressure ratio for any equipment tested for enforcement purposes. In addition, DOE proposed a method for determining the appropriate standard level for any tested equipment based on the tested full-load actual volume flow rate. Specifically, to verify the full-load operating pressure certified by the manufacturer, DOE proposed to perform the same procedure proposed for determining the maximum full-flow operating pressure of each unit tested, except that DOE would begin searching for maximum full-flow operating pressure at the manufacturer's certified value of full-load operating pressure prior to increasing discharge pressure. As DOE has proposed to allow manufacturers to self-declare a full-load operating pressure value of between 90 and 100 percent (inclusive) of the measured maximum full-flow operating pressure, DOE proposed to compare the measured value(s) of maximum full-flow operating pressure from a sample of one or more units to the certified value of full-load operating pressure. If a sample of more than one units is used, DOE proposed to calculate the mean of the measurements. If the certified value of full-load operating pressure is greater than or equal to 90 and less than or equal to 100 percent of the maximum full-flow operating pressure determined through DOE's testing (*i.e.,* within the tolerance allowed by DOE in the test procedures), then DOE proposed it would use the certified value of full-load operating pressure certified by the manufacturer as the basis for determining full-load actual volume flow rate, package isentropic efficiency, and other applicable values. Otherwise, DOE proposed it would use the maximum full-flow operating pressure as the basis for determining the full-load actual volume flow rate, package isentropic efficiency, and other applicable values. That is, if the certified value of full-load operating pressure is found to be valid, DOE proposed it would set the compressor under test to that operating pressure to determine the full-load actual volume flow rate, package isentropic efficiency, specific power, and pressure ratio in accordance with the DOE test procedures. If the certified full-load operating pressure is found to be invalid, DOE proposed it would use the measured maximum full-flow operating pressure resulting from DOE's testing as the basis for determining the full-load actual volume flow rate, package isentropic efficiency, specific power, and pressure ratio for any tested equipment.

Similarly, DOE proposed a procedure to verify the full-load actual volume flow rate of any certified equipment and determine the applicable full-load actual volume flow rate DOE would use when determining the standard level for any tested equipment. Specifically, DOE proposed to use the full-load actual volume flow rate determined based on verification of full-load operating pressure and compare such value to the certified value of full-load actual volume flow rate certified by the manufacturer. If DOE found the full-load operating pressure to be valid, DOE proposed it would use the full-load actual volume flow rate determined at the full-load operating pressure certified by the manufacturer. If the full-load operating pressure was found to be invalid, DOE proposed it would use the actual volume flow rate measured at the maximum full-flow operating pressure as the full-load actual volume flow rate. DOE proposed it would compare the measured full-load actual volume flow rate (determined at the applicable operating pressure) from an appropriately sized sample to the certified value of full-load actual volume flow rate. If the full-load actual volume flow rate measured by DOE is within the allowances of the certified full-load actual volume flow rate specified in Table III.4, then DOE proposed it would use the manufacturer-certified value of full-load actual volume flow rate as the basis for determining the standard level for tested equipment. Otherwise, DOE proposed it would use the measured actual volume flow rate resulting from DOE's testing when determining the standard level for tested equipment. 81 FR 27220, 27247 (May 5, 2016).

TABLE III.4—ENFORCEMENT ALLOWANCES FOR FULL-LOAD ACTUAL VOLUME FLOW RATE

Manufacturer certified full-load actual volume flow rate (m^3/s) × 10^{-3}	Allowable percent of the certified full-load actual volume flow rate (%)
0 < and ≤ 8.3	±7
8.3 < and ≤ 25	±6
25 < and ≤ 250	±5
> 250	±4

In response, CAGI commented that it agreed with the tolerances DOE proposed in Table III.4. However, CAGI disagreed with DOE's proposal to continue an enforcement test when a compressor under test is determined not to deliver the full-load actual volume flow rate certified by the manufacturer (accounting for allowable enforcement deviations). CAGI stated that the proposed methodology could, in some cases, allow DOE to evaluate compliance of a compressor based on a lower than certified full-load actual volume flow rate, and, therefore, a correspondingly lower package isentropic efficiency standard level. CAGI stated that this is because compressors that do not provide the full-load actual volume flow rate certified by the manufacturer may still be deemed compliant provided the compressor was compliant with the standard determined based on the tested (*i.e.,* lower that the manufacturer-rated) full-load actual volume flow rate. CAGI suggested this scenario is not fair to the users of industry products and recommend that a manufacturer that fails to provide the flow that is claimed and certified by the manufacturer after taking allowable deviations into account be deemed to have failed. (CAGI, No. 0010 at p. 11; CAGI, Public Meeting Transcript, No. 0016 at p. 106) Atlas Copco made similar comments with respect to testing at a lower volume flow rate and the equity of doing so. (Atlas Copco, No. 0009 at p. 18) CAGI's position regarding the tolerances and enforcement of full-load actual volume flow rate is supported by Sullair, Sullivan-Palatek, and Ingersoll Rand. (Sullair, No. 0006 at p. 9; Sullivan-Palatek, No. 0007 at p. 1; Ingersoll Rand, No. 0011 at p. 1) DOE received no comments disagreeing with the proposed method for determining maximum and full-load operating pressure.

DOE acknowledges the concerns of commenters that allowing compressor equipment to be deemed compliant with any applicable standards for compressors when the full-load actual volume flow rate is below the certified and represented value is unfair to compressor end users. DOE typically designs the enforcement provisions to minimize risk for manufacturers such that equipment with capacities (*i.e.,* full-load actual volume flow rates) that differ from the certified values may still be deemed compliant based on the tested energy performance and a unit is not be deemed non-compliant on the grounds of the tested capacity alone. However, given the broad manufacturer support for modified enforcement provisions in this case, in this final rule, DOE is adopting CAGI and Atlas Copco's recommendation to declare compressors with tested full-load actual volume flow rates below the certified value non-compliant. Specifically, the certified full-load actual volume flow rate will be considered valid only if all measurement(s) (either the measured full-load actual volume flow rate for a single unit sample or the measured values for each unit in a multiple unit sample) are within the percentage of the certified full-load actual volume flow rate specified in Table III.4. If the representative value of full-load actual volume flow rate as tested is outside of the allowable tolerances specified in Table III.4, DOE will make a determination that the basic model is not in compliance with the applicable regulations for that model. Specifically, DOE will fail such models on the basis of making representations that are not in accordance with the test procedure, which is consistent with DOE's authority under 42 U.S.C. 6316(a) and 6314(d).

DOE is also adopting a small modification in the starting pressure used when determining maximum full-flow operating pressure during enforcement testing. In the test procedure NOPR, DOE stated that testing would start at the certified value for full-load operating pressure. This starting value, however, creates the possibility that units could unload on the first test point, requiring testers to start the test again. There are many compressors that have a full-load operating pressure equal to their maximum full-flow operating pressure. DOE has also been told by an industry testing expert that the cut-out controls on compressors can vary by 1 or more psig between units. Therefore, starting the test at the certified full-load operating pressure creates the potential that the unit under test could unload at the starting discharge pressure. To prevent this possibility, DOE is adopting a starting point for this method equal to 90 percent of the certified full-load operating pressure. This allows the unit to be tested at several discharge pressures prior to reaching the range of pressures at which it is likely to unload.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Order 12866

The Office of Management and Budget (OMB) has determined that test procedure rulemakings do not constitute ''significant regulatory actions'' under section 3(f) of Executive Order 12866, Regulatory Planning and Review, 58 FR 51735 (Oct. 4, 1993). Accordingly, this action was not subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget (OMB).

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.,* as amended by the Small Business Regulatory Enforcement Fairness Act of 1996) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment and a final regulatory flexibility analysis (FRFA) for any such rule that an agency adopts as a final rule, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities.

A regulatory flexibility analysis examines the impact of the rule on small entities and considers alternative ways of reducing negative effects. Also, as required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemakings,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of General Counsel's Web site at: *http://energy.gov/gc/office-general-counsel.* As part of the test procedure NOPR published on May 5, 2016 (81 FR 27220), DOE concluded that the cost effects accruing from the final rule would not have a ''significant economic impact on a substantial number of small entities,'' and that the preparation of a FRFA is not warranted. DOE has submitted a certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the Small Business Administration for review under 5 U.S.C. 605(b).

DOE reviewed this rule, which establishes a new test procedure for compressors, under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003.

DOE certifies that the adopted rule does not have a significant impact on a substantial number of small entities. DOE notes that certification of compressor models is not currently required because energy conservation standards do not currently exist for compressors. That is, any burden associated with testing compressors in accordance with the requirements for this test procedure will not be required until the promulgation of any energy conservation standards for compressors. On this basis, DOE maintains that the test procedure final rule has no incremental burden associated with it and a FRFA is not required.

1. Description and Estimate of the Number of Small Entities Affected

For the compressors manufacturing industry, the Small Business Administration (SBA) has set a size threshold, which defines those entities classified as small businesses for the purpose of the statute. DOE used the SBA's size standards to determine whether any small entities are be required to comply with the rule. The size standards are codified at 13 CFR part 121. The standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at: *http://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf.* Compressor manufacturers are classified under NAICS 333912, ''Air and Gas Compressor Manufacturing.'' The SBA sets a threshold of 1,000 employees or less for an entity to be considered as a small business for this category.

To estimate the number of small business manufacturers of equipment applicable to this rulemaking, DOE conducted a market survey using available public information. DOE's research involved industry trade association membership directories (including CAGI), individual company and online retailer Web sites, and market research tools (*e.g.,* Hoovers reports) to create a list of companies that manufacture products applicable to this rulemaking. DOE presented its list to manufacturers in MIA interviews and asked industry representatives if they were aware of any other small manufacturers during manufacturer interviews and at DOE public meetings. DOE reviewed publicly available data and contacted select companies on its list, as necessary, to determine whether they met the SBA's definition of a small business manufacturer. DOE screened out companies that do not offer products applicable to this rulemaking, do not meet the definition of a small business, or are foreign-owned and operated.

DOE identified a total of 40 manufacturers of applicable air compressor products sold in the United States. Nineteen of these manufacturers met the 1,000-employee threshold defined by the SBA to qualify as a small business, but only 15 were domestic companies. Seven domestic small businesses manufacture rotary air compressors.

Within the air compressor industry, manufacturers can be classified into two categories; original equipment manufacturers (OEMs) and compressor packagers. OEMs manufacture their own air-ends and assemble them with other components to create complete package air compressors. Packagers assemble motors and other accessories with air-ends purchased from other companies, resulting in a complete air compressor.

Within the rotary air compressor industry, DOE identified 22 manufacturers; 16 are OEMs and seven are packagers of compressors. Of the 22 total manufacturers, seven large OEMs supply approximately 80 percent of shipments and revenues. Of the seven domestic small rotary air compressor businesses identified, DOE's research indicates that two are OEMs and five are packagers.

2. Discussion of Testing Burden and Comments

a. Burden Related to Test Method and Retesting Equipment for Representations

In the test procedure NOPR, DOE stated that ISO 1217:2009(E) is an appropriate industry testing standard for evaluating compressor performance, with the caveat that ISO 1217:2009(E) is written as a customer acceptance test, and as such it required several modifications and additions in order to provide the specificity and repeatability required by DOE. Consequently, DOE proposed several modifications and additions to ISO 1217:2009(E) and proposed to incorporate by reference only the sections of ISO 1217:2009(E) that are relevant to the equipment within the scope of applicability of DOE's proposed test procedures. DOE stated that by proposing to incorporate by reference much of ISO 1217:2009(E) into the proposed DOE test procedures, DOE believed that the resulting DOE test procedures would remain closely aligned with existing and widely used industry procedures and limit the testing burden on manufacturers. 81 FR 27220, 27236–27237 (May 5, 2016).

DOE received many comments regarding the burden imposed by DOE's proposed test procedures. Many of these comments argued that DOE's proposed modifications and additions to ISO 1217:2009(E) were materially significant, such that historical test data obtained under ISO 1217:2009(E) could no longer be used for representation purposes. As a result, the comments stated that manufacturers would be required to retest all equipment if they wanted to continue making public representations of package specific power, full-load actual volume flow rate, full-load operating pressure and pressure ratio.

Specifically, CAGI, Atlas Copco, Ingersoll Rand, Sullair, and Sullivan-Palatek commented that the proposed rule includes modifications to the CAGI Performance Verification Program which, coupled with the 180-day effective compliance date of the proposed test procedures, presents a significant burden for manufacturers to verify compliance in their efficiency and non-efficiency representations. (CAGI, No 0010 at pp. 11, 14; Ingersoll Rand, No. 0011 at p. 2; Atlas Copco, No. 0009 at pp. 7–10; Sullair, No. 0006 at pp. 1, 9; Sullivan-Palatek, No. 0007 at pp. 5)

In response to the 2012 NOPD, CAGI commented that ''test procedures for measuring the energy efficiency, energy use, or estimated annual operating cost of compressors during a representative average use cycle or period of use would be unduly burdensome or impossible to conduct,'' and that ''there would also be a cost impact to the users for this, which would place heavier financial burdens, especially on small business users.'' (Docket No. EERE–2012–BT–DET–0033, CAGI, No. 0003 at p. 6)

However, in response to the more recent 2016 test procedure NOPR, CAGI commented that if the test methods and tolerances are aligned with current practice, the burden of the sampling plan will be significantly minimized. (CAGI, No. 0010 at p. 11)

CASTAIR and Compressed Air Systems commented that the proposed regulations will force CASTAIR and other small businesses out of the rotary screw market. (CASTAIR, No. 0018 at p. 1; Compressed Air Systems, No. 0008 at p. 2) Compressed Air Systems stated that the test method would require large investments, which would be in excess of their annual sales volume, represent a higher per-unit cost due to their low volume of shipments compared to large manufacturers, and take a longer time to recover the cost of investing test equipment, placing small businesses at a competitive disadvantage relative to large manufacturers. (Compressed Air Systems, No. 0008 at pp. 2, 4–5; Compressed Air Systems, Public Meeting Transcript, No. 0016 at p. 143) Similarly, Jenny Products commented that the cost of compliance, including test facilities or the cost of independent lab testing, would bankrupt their small business and is unduly burdensome. (Jenny Products, No. 0020 at pp. 1, 3) Further, Jenny Products asserted that the test procedure is complicated and primarily developed by CAGI members, which unfairly burdens non-CAGI members and small businesses that can't afford to test their equipment. (Jenny Products, No. 0020 at pp. 2, 4–5)

DOE acknowledges the commenters' general concerns that the test procedures, as proposed in the test procedure NOPR, differed enough from ISO 1217:2009(E) that, if adopted, manufacturers may need to retest all units in order to continue making representations. However, DOE reiterates that, as stated in the test procedure NOPR, DOE's intent is to propose test procedures that remain closely aligned with existing and widely used industry procedures and limit testing burden on manufacturers.

In response to the commenters' concerns, in this final rule, DOE is making many modifications to the methods proposed in the test procedure NOPR, in order to align as closely as possible to ISO 1217:2009(E), as amended.[44] A complete discussion of these modifications is found in section III.E of this final rule. With these modifications, the test methods established in the final rule are intended to produce results equivalent to those produced historically under ISO 1217:2009(E). Consequently, if historical test data are consistent with values that are generated when testing with the test methods established in this final rule, then manufacturers may use this data for the purposes of representing any metrics subject to representations requirements. (DOE, Public Meeting Transcript, No. 0016 at p. 136)

However, DOE acknowledges that current representations for some models may not be based on test data or may be based on test data that is not in alignment with the test methods established in this final rule. DOE agrees that for those models, further testing or the application of an AEDM may be needed to continue making representations. However, DOE also notes that such representations are voluntary and if manufacturers require longer than 180 days to determine accurate represented values consistent with the adopted test procedure, the manufacturer may elect to not make public representations of standardized metrics until such testing is completed.

At this time, DOE does not have direct data regarding how many models require further testing or application of an AEDM, however, DOE estimates that this is a small percentage of total models. Specifically, DOE estimates that 90 percent of models within the scope of this test procedure final rule participate in the CAGI Performance Verification Program. All members of the CAGI Performance Verification Program must represent the performance of all of their models (within the scope of the program) based on ISO 1217:2009(E) testing. Thus, DOE believes it is fair to assume that the vast majority of models participating in the CAGI Performance Verification Program have historical ISO 1217:2009(E) test data available, which DOE believes is consistent with any values that generated by the test procedure adopted in this final rule. DOE acknowledges that the remainder of the models (*i.e.,*

[44] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic, so aligning with ISO 1217:2009(E), as amended, is equivalent to aligning with ISO 1217:2009(E) prior to Amendment 1:2016.

those not participating in the CAGI Performance Verification Program), approximately 15 percent, may not have historical test data available. However, DOE reviewed publically available marketing data from all known manufacturers that do not participate in the CAGI Performance Verification Program and found none of these manufacturers currently represent package isentropic efficiency, package specific power, full-load actual volume flow rate, full-load operating pressure, or pressure ratio at full-load operating pressure for compressors within the scope of this test procedure final rule. As such, these manufacturers incur no burden as a direct result of this test procedure final rule, as they are not required to make any representations until the effective date of any relevant future energy conservation standards.[45]

In summary, DOE concludes that the test procedures and associated representations requirements established in this test procedure final rule are not unduly burdensome, as (1) the test method follows accepted industry practice, and (2) only a limited number of models (if any) may, at the manufacturer's discretion, need to be retested in order to continue to make representations. Further DOE notes that impact to each manufacturer will be different, and manufactures may petition DOE for an extension of the 180-day representations requirement, for up to an additional 180 days, if manufacturers feel it represents an undue hardship. (42 U.S.C. 6314 (d)(2)) However, as any representations are voluntary prior to the compliance date of any energy conservations standards for compressors that may be set, there is no direct burden associated with any of the testing requirements established in this final rule. As such, specific quantification of the burden associated with testing and rating equipment to comply with any energy conservation standards is addressed in the associated compressors energy conservation standard rulemaking manufacturer impact analysis (Docket No. EERE–2013–BT–STD–0040).

b. Burdens Related to Low Shipment-Volume Equipment

In the test procedure NOPR, DOE proposed a scope of applicability of compressors that meet the following criteria:

- Are air compressors;
- are rotary or reciprocating compressors;
- are driven by a brushless electric motor;
- are distributed in commerce with a compressor motor nominal horsepower greater than or equal to 1 and less than or equal to 500 hp; and
- operate at a full-load operating pressure of greater than or equal to 31 and less than or equal to 225 pounds per square inch gauge; 81 FR 27220, 27224–27225 (May 5, 2016).

In response to the test procedure NOPR, many interested parties commented that DOE's proposed scope would capture many low-shipment volume or ''custom'' compressor models, and the requirement to test such models would cause undue burden.

Specifically, Atlas Copco stated that the test procedures would result in duplicative testing for custom units, because custom units already undergo customer acceptance tests based on ISO 1217:2009(E). Atlas Copco also commented that an AEDM would not alleviate the burden because it requires validation through testing. Atlas Copco further recommended that DOE establish a de minimis rule exempting small volume (fewer than 20 units per year), customized orders from the test requirements in order to avoid unduly burdensome testing requirements. (Atlas Copco, No. 0009 at pp. 6–7) Compressed Air Systems stated that the requirement to test two units of custom models that are only sold once 2 or 3 years will add undue cost, causing many manufacturers to stop production of low-shipment-volume models. (Compressed Air Systems, No. 0008 at p. 2) CAGI stated that manufacturers cannot build four units of all basic models for the purposes of DOE enforcement. Considering the definition of a basic model, CAGI expects that many basic models will rarely be sold, and it would be impractical to build those units only for testing purposes. (CAGI, No. 0010 at p. 13)

Sullair commented that it would be a burden to test or model all of its basic units as the company has more than 500 basic models in the range proposed by DOE for the test procedures, most of which are not high-volume products. (Sullair, No. 0006 at p. 9) Sullair elaborates that a number of those low-volume basic models are above 200 hp, which would be a significant burden to test per proposed test procedures and would likely result in Sullair ceasing to represent efficiency metrics for those units. Sullairs comment is supported by comments made by Sullivan-Palatek. (Sullair, No. 0006 at pp. 3–4; Sullivan-Palatek, No. 0007 at p. 3)

In response to these comments, DOE acknowledges the commenter's concerns that the scope of the test procedure, as defined in the test procedure NOPR includes many low-shipment volume or custom compressor models, and the requirement to test such models could cause significant burden. Therefore in this final rule, DOE is taking two key steps to address commenters' concerns and reduce the burden of testing, especially for low-volume equipment: (1) DOE is significantly limiting the scope of this final rule, as compared to the scope proposed in the test procedure NOPR, and (2) DOE is allowing the use of an AEDM, in lieu of testing. As discussed in section III.B, the scope of this test procedure final rule is limited to compressors that meet the following criteria:

- Are air compressors;
- are rotary compressors;
- are not liquid ring compressors;
- are driven by a brushless electric motor;
- are lubricated compressors;
- have a full-load operating pressure of 75–200 psig;
- are not designed and tested to the requirements of The American Petroleum Institute standard 619, ''Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries;'' and
- have a capacity that is either:
  - 10–200 compressor motor nominal horsepower (hp), or
  - 35–1,250 full-load actual volume flow rate (cfm).

This revised scope generally aligns with the scope recommended by CAGI and supported by many manufacturers. Further, the 10 to 200 hp scope established in this final rule falls within the scope of the CAGI Performance Verification Program for rotary compressors. Manufacturers who participate in this program are required to test multiple basic models per year as a part of the program's compliances and certification requirements. Basic models are selected at the discretion of the CAGI program manager, with the intent of testing the range of eligible products over a period of several years. For each basic model selected, manufacturers must make available two individual units that are randomly selected from available manufacturer and/or distributor stock. Consequently, DOE concludes that the majority of the basic models within the scope of the test procedure established by this final rule are commonly available (*i.e.,* not low production volume) and are typically

[45] DOE accounts for mandatory testing burden for compressors in the energy conservation standards analyses.

produced in quantities of at least two units per year.

However, even with the reduce scope established in this test procedure final rule, a small number of basic models may still be produced in very limited quantities. To address the industry's concern regarding the testing of low-volume production compressors, DOE specifically proposed, in the test procedure NOPR, to allow manufacturers to certify the energy efficiency of basic models through the use of an AEDM in lieu of physical testing. In such cases, no physical testing is required and, therefore, the sample size provisions are not applicable. Complete discussion of AEDM is provided in section III.G.2, where DOE discusses its rationale for adopting certain AEDM provisions in this final rule.

In summary, DOE concludes that the reduced scope has significantly reduced the number of low-production-volume basic models that are subject to this test procedure. Further DOE concludes that the allowance of an AEDM in the place of testing sufficiently addresses the industry's concern regarding testing the limited number of low-shipments-volume compressor basic models that remain in scope. For these reasons, DOE concludes that the test procedures and associated representations requirements established in this final rule are not unduly burdensome.

Further, the concerns raised by Atlas Copco, which lead them to request a de minimis rule exempting small volume custom orders, have been mitigated by the scope limitations and allowance for AEDMs discussed earlier in this section. However, DOE further clarifies that any test procedures it promulgates must be equitable to all industry participants, meaning that all participant and regulated equipment must be held to the same testing criteria, regardless of manufacturer size or physical location. However, DOE reiterates that no direct burden is associated with this test procedure final rule until the compliance date of any energy conservation standard for compressors that may be set and any direct quantification of testing burdens are calculated as part of that rulemaking. (Docket No. EERE–2013–BT–STD–0040)

Finally, regarding CAGI's comment regarding a sample size of up to four units for enforcement testing, DOE is not finalizing an enforcement sampling plan in this rule. Because compliance with any standards will not be required for 5 years, DOE will engage in a separate rulemaking to allow for further comments and input on how DOE should evaluate compliance.

c. Comments on the NOPR Regulatory Flexibility Analysis

In the test procedure NOPR, DOE preliminarily concluded that the proposed test procedures do not represent a significant incremental burden for any of the identified small entities.

In response to DOE's request for comment, Compressed Air Systems provided an additional 16 names of domestic small manufacturers producing equipment within the scope of this rulemaking. (Docket No. EERE–2013–BT–STD–0040, Compressed Air Systems, No. 0061, pp. 3–4) Upon further research, DOE concluded that one of the sixteen entities produces equipment within the scope of this rulemaking and added that entity to its list of domestic small manufacturers producing equipment within the scope of this rulemaking.

In response to DOE's conclusions, Compressed Air Systems stated that small businesses will be uniquely burdened by the test procedures because they will now have to test their products, leading to costs associated with large in-house test areas, additional employees, and electricity costs. (Compressed Air Systems, No. 0008 at p. 2; Compressed Air Systems, No. 0008, p. 3) Furthermore, it stated that the testing cost per unit would be significantly higher for smaller suppliers. CASTAIR commented that the proposed regulations will force it to abandon the market and requested that DOE exempt American air compressor assemblers from regulation. (CASTAIR, No. 0018, pp. 1–2) Both CASTAIR and Compressed Air Systems stressed that testing costs would not be alleviated through use of AEDM as such practices are not currently used. (CASTAIR, No. 0018, p. 1; Compressed Air Systems, No. 0008, p. 2)

DOE acknowledges the concerns raised by CASTAIR and Compressed Air Systems. Fundamentally, DOE reiterates, as noted in the test procedure NOPR, that the promulgation of test procedures alone, in the absence of existing energy conservation standards, does not require a manufacturer to perform any certification testing. As such, the burden associated with compliance testing will be assessed in the weighing of costs and benefits of the associated energy conservation standards rulemaking for compressors. However, DOE recognizes that an energy conservation standard rulemaking from compressors is ongoing and may result in standards and associated certification requirements for certain compressors in the near future. Therefore, DOE has considered the burden associated with the testing and rating requirements adopted in this final rule and, to the extent possible, has sought to minimize burden on manufacturers while ensuring that the test procedures adopted herein result in consistent, reliable, and repeatable values. Financial burden stemming from these DOE test procedures can be discussed in two general categories: (1) Aggregates costs of testing in order to continue representing standardized metrics that are now specified in the DOE test procedures, and (2) the per-unit cost of testing to the specified DOE test method.

Regarding the first cost category, DOE researched public literature of the identified small manufacturers and found that seven of the eight currently do not make representations of package specific power, full-load actual volume flow rate, full-load operating pressure, and pressure ratio at full-load operating pressure. None make representations of package isentropic efficiency. Those that do not make representations of these metrics are not expected to incur burden, as they can continue to not make representations of these metrics after promulgation of this test procedure final rule. As noted above, the certification burden is associated with the energy conservation standard and will be assessed as part of that rulemaking (Docket No. EERE–2013–BT–STD–0040).

Further, the one small manufacturer making representations of package specific power, full-load actual volume flow rate, full-load operating pressure, and pressure ratio at full-load operating pressure does so as a part of the CAGI Performance Verification Program, which relies on ISO 1217:2009(E) test data. As discussed previously, the test methods established in this final rule are intended to produce results equivalent to those produced historically under ISO 1217:2009(E), as amended. Consequently, if historical test data meet the requirements of the test methods established in this final rule, then manufacturers may use these data for the purposes of representing any metrics subject to representations requirements. (DOE, Public Meeting Transcript, No. 0016 at p. 136) Thus, DOE expects that this manufacturer will incur burdens no different from other manufacturers participating in the CAGI Performance Verification Program.

Regarding the second cost category, the per-unit cost of testing to the specified DOE test method, DOE reiterates that the test methods established in this final rule are based on the industry accepted test method, ISO 1217:2009(E), as amended, and intended to produce results equivalent to those produced historically under ISO 1217:2009(E).[46] As such, DOE concludes that the method itself is not overly burdensome as it is currently employed by the many manufacturers who participate in the CAGI program.[47] However, DOE acknowledges the commenters' concerns that testing may be more costly and burdensome for small manufacturers, as they may not have in-house test facilities. In the energy conservation standards NOPR, DOE assessed the per-unit cost to test compressors for compliance, and concluded that the industry average cost was $2,400 for a fixed-speed rotary compressor, and $3,025 for a variable-speed compressor. (see chapter 12 of TSD[48]) These costs represent industry-average values (*i.e.,* a mix of in-house and third-party testing costs) and were based on data gathered during confidential manufacturer interviews. Based on these data, DOE estimates that third party testing costs approximately 50 percent more than the stated industry-average values (*i.e.,* $3,600 for fixed-speed and $4,538 for variable-speed compressors).[49] Although most small manufacturers incur testing costs in this higher range, some larger manufacturers may also incur similar third party testing costs. Given these costs, DOE again, acknowledges that that testing may be more costly small manufacturers.

Finally, in response to CASTAIR's recommendation that DOE exempt American air compressor assemblers from regulation, DOE clarifies that any test procedure it promulgates must be equitable to all industry participants, meaning that all participant and regulated equipment with in an equipment class must be held to the same testing criteria, regardless of shipments volume or the nature of a shipment order.

Based on its research and discussions presented in this section, DOE concludes that the cost burdens accruing from the compressors test procedure final rule do not constitute ''significant economic impact on a substantial number of small entities.''

C. Review Under the Paperwork Reduction Act of 1995

While there are currently no energy conservation standards for compressors, DOE recently published a final determination establishing compressors as a type of covered equipment. 81 FR 79991 (Nov. 15, 2016). DOE is also considering establishing energy conservation standards for such equipment as part of a parallel rulemaking (Docket No. EERE–2013–BT–STD–0040). Manufacturers of compressors will be required to certify to DOE that their equipment complies with any applicable energy conservation standards, once established. To certify compliance, manufacturers must first obtain test data for their products according to the DOE test procedures for compressors and maintain records of that testing for a period of two years after discontinuing the product, consistent with the requirements of 10 CFR 429.71. As part of this test procedure final rule, DOE is establishing regulations for recordkeeping requirements for compressors. The collection-of-information requirement for the certification (to be finalized in a separate rulemaking) and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910–1400. Public reporting burden for the certification and recordkeeping requirement is estimated to average 30 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

CAGI stated that, based on its members' experience with its Performance Verification Program, the recordkeeping burden estimate (30 hours/year) is too low. CAGI also stated that complying with the recordkeeping requirements would entail significant development of procedures, recordkeeping, quality control measures, etc. (CAGI, No. 0010 at p. 13) Sullair fully supported CAGI's comments on recordkeeping. (Sullair, No. 0006 at p. 9) Ingersoll Rand stated that it would need two or three employees for a period of 12 months in order to sample, re-test and evaluate their units according to the requirements of the proposed test procedure. Ingersoll Rand also stated that additional staff would be needed indefinitely to comply with the recordkeeping requirements of the proposed rule. (Ingersoll Rand, No. 0011 at p. 2) Jenny Products commented that the recordkeeping requirements are burdensome. (Jenny Products, No. 0020 at p. 5)

DOE understands that the recordkeeping requirements may vary between manufacturers, and that in some cases the recordkeeping burden may be greater than estimated. However, DOE has not received any data to support the claim that the average recordkeeping burden is greater than it estimated. Without data to support an update to its estimate, DOE cannot review that estimate. The burden discussed in this section relates only to the development and retention of test records and development and submission of certification paperwork; it does not address the burden of conducting the test procedure, itself, which is addressed elsewhere in this rule. Therefore, in this final rule DOE does not adjust the recordkeeping burden estimate in the test procedure NOPR.

D. Review Under the National Environmental Policy Act of 1969

In this final rule, DOE establishes a new test procedure that it expects will be used to develop and implement future energy conservation standards for compressors. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq.*) and DOE's implementing regulations at 10 CFR part 1021. Specifically, this final rule creates a new test procedure without affecting the amount, quality or distribution of energy usage, and, therefore, does not result in any environmental impacts. Thus, this rulemaking is covered by Categorical Exclusion A6 under 10 CFR part 1021, subpart D, which applies to any rulemaking that creates a new rule without changing the environmental effect of that rule. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

[46] In this final rule, DOE is incorporating by reference parts of ISO 1217:2009(E) as amended by Amendment 1:2016. Amendment 1:2016 did not introduce any changes in regards to this particular topic, so aligning with ISO 1217:2009(E), as amended, is equivalent to aligning with ISO 1217:2009(E) prior to Amendment 1:2016.

[47] The following manufacturers participate in the CAGI Rotary Compressor Performance Verification Program according to the participant directory: Atlas Copco, Boge, Chicago Pneumatic, CompAir, FS Curtis, Gardner Denver, Ingersoll Rand, Kaeser Compressors, Mattei, Quincy, Sullair and Sullivan-Palatek. The participant directory is available at *http://www.cagi.org/performance-verification/.*

[48] Available at: *https://www.regulations.gov/document?D=EERE-2013-BT-STD-0040-0037.*

[49] Third party testing is readily available in North America and one site is currently used by the CAGI Performance Verification Program.

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism,'' 64 FR 43255 (August 4, 1999), imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE examined this final rule and determined that it will not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this final rule. States can petition DOE for a waiver of Federal preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d) 6316(a)) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard; and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation (1) clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this final rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a regulatory action resulting in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820; also available at *http://energy.gov/gc/office-general-counsel.* DOE examined this final rule according to UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of $100 million or more in any year, so these requirements do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This final rule will not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights'' 53 FR 8859 (March 18, 1988), that this regulation will not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for agencies to review most disseminations of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed this final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use,'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgated or is expected to lead to promulgation of a final rule, and that (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use if the regulation is implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

This regulatory action is not a significant regulatory action under Executive Order 12866. Moreover, it does not have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects.

L. Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the NOPR must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission (FTC) concerning the impact of the commercial or industry standards on competition.

The test procedures for compressors adopted in this final rule incorporate testing methods contained in certain sections of the following commercial standards: ISO 1217:2009(E), as amended through ISO 1217:2009(E)/Amd.1:2016.

While this test procedure is not exclusively based on this industry testing standard, some components of the DOE test procedure adopt definitions, test parameters, measurement techniques, and additional calculations from them without amendment. DOE has evaluated these standards and is unable to conclude whether it fully complies with the requirements of section 32(b) of the FEAA (*i.e.,* whether it was developed in a manner that fully provides for public participation, comment, and review.) DOE has consulted with both the Attorney General and the Chairman of the FTC about the impact on competition of using the methods contained in these standards and has received no comments objecting to their use.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule before its effective date. The report will state that it has been determined that the rule is not a ''major rule'' as defined by 5 U.S.C. 804(2).

N. Description of Materials Incorporated by Reference

In this final rule, DOE incorporates by reference specific sections from a method of test published by the International Organization for Standardization (ISO), titled ''Displacement compressors—Acceptance tests,'' ISO 1217:2009(E). Specifically, the test procedure codified by this final rule references the following parts of ISO 1217:2009(E): Sections 2, 3, and 4; sections 5.2, 5.3, 5.4, 5.6, 5.9; paragraphs 6.2(g), and 6.2(h) including Table 1; sections C.1.1, C.2.2, C.2.3, C.2.4, C.4.1, C.4.2.1, C.4.2.3, C.4.3.2, C.4.4 of Annex C. The test procedure also references Amendment 1 to ISO 1217:2009(E) (ISO 1217:2009(E)/Amd.1:2016), titled ''Calculation of isentropic efficiency and relationship with specific energy.'' Specifically, the test procedure codified by this final rule references the following parts of Amendment 1 to ISO 1217:2009(E): Sections 3.5.1 and 3.6.1; sections H.2 and H.3 of Annex H.

Members of the compressors industry developed ISO 1217:2009(E), which contains methods for determining inlet and discharge pressures, actual volume flow rate, packaged compressor power input, and package isentropic efficiency for electrically driven packaged displacement compressors.

Copies of ISO 1217:2009(E) and of ISO 1217:2009(E)/Amd.1:2016 may be purchased from ISO at Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland +41 22 749 01 11, or by going to *www.iso.org.*

V. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

List of Subjects

10 CFR part 429

Administrative practice and procedure, Confidential business information, Energy conservation, Imports, Intergovernmental relations, Small businesses.

10 CFR part 431

Administrative practice and procedure, Confidential business information, Energy conservation, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Issued in Washington, DC, on December 1, 2016.

Kathleen B. Hogan,

Deputy Assistant Secretary for Energy Efficiency, Energy Efficiency and Renewable Energy.

For the reasons stated in the preamble, DOE proposes to amend parts 429 and 431 of chapter II, subchapter D of title 10, Code of Federal Regulations as set forth below:

PART 429—CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317; 28 U.S.C. 2461 note.

■ 2. In § 429.2, revise paragraph (a) to read as follows:

§ 429.2 Definitions.

(a) The definitions found in §§ 430.2, 431.2, 431.62, 431.72, 431.82, 431.92, 431.102, 431.132, 431.152, 431.192, 431.202, 431.222, 431.242, 431.262, 431.282, 431.292, 431.302, 431.322, 431.342, 431.442, and 431.462 of this chapter apply for purposes of this part.

* * * * *

■ 3. Add § 429.63 to read as follows:

§ 429.63 Compressors.

(a) *Determination of represented value.* Manufacturers must determine the represented value, which includes the certified rating, for each basic model of compressor either by testing in conjunction with the applicable sampling provisions or by applying an AEDM.

(1) *Units to be tested.* (i) If the represented value is determined through testing, the general requirements of § 429.11 apply; and

(ii) For each basic model selected for testing, a sample of sufficient size must be randomly selected and tested to ensure that—

(A) *Measures of energy efficiency.* Any represented value of the full- or part-load package isentropic efficiency or other measure of energy efficiency of a basic model for which customers would favor higher values is less than or equal to the lower of:

(*1*) The mean of the sample, where:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

And $\bar{x}$ is the sample mean; n is the number of samples; and x_i is the measured value for the i^{th} sample; or, (*2*) The lower 95 percent confidence limit (LCL) of the true mean divided by 0.95, where:

$$LCL = \bar{x} - t_{0.95}\left(\frac{s}{\sqrt{n}}\right)$$

And $\bar{x}$ is the sample mean; s is the sample standard deviation; n is the number of samples; and $t_{0.95}$ is the t statistic for a 95 percent one-tailed confidence interval with n − 1 degrees of freedom (from appendix A of this subpart); and

(B) *Package specific power.* The representative value(s) of package specific power of a basic model must be the mean of the package specific power measurement(s) for each tested unit of the basic model.

(2) *Alternative efficiency determination methods.* In lieu of testing, any represented value of efficiency, consumption, or other non-energy metrics listed in paragraph (a)(3) of this section for a basic model may be determined through the application of an AEDM pursuant to the requirements of § 429.70 and the provisions of this section, where:

(i) Any represented values of package isentropic efficiency or other measure of energy consumption of a basic model for which customers would favor higher values must be less than or equal to the output of the AEDM; and

(ii) Any represented values of package specific power, pressure ratio at full-load operating pressure, full-load actual volume flow rate, or full-load operating pressure must be the output of the AEDM corresponding to the represented value of package isentropic efficiency determined in paragraph (a)(2)(i) of this section.

(3) *Representations of non-energy metrics*—(i) *Full-load actual volume flow rate.* The representative value of full-load actual volume flow rate of a basic model must be either—

(A) The mean of the full-load actual volume flow rate for the units in the sample; or

(B) As determined through the application of an AEDM pursuant to the requirements of § 429.70.

(ii) *Full-load operating pressure.* The representative value of full-load operating pressure of a basic model must be less than or equal to the maximum full-flow operating pressure and greater than or equal to the lesser of—

(A) 90 percent of the maximum full-flow operating pressure; or

(B) 10 psig less than the maximum full-flow operating pressure, where the maximum full-flow operating pressure must either be determined as the mean of the maximum full-flow operating pressure values for the units in the sample or through the application of an AEDM pursuant to the requirements of § 429.70.

(iii) *Pressure ratio at full-load operating pressure.* The representative value of pressure ratio at full-load operating pressure of a basic model must be either be determined as the mean of the pressure ratio at full-load operating pressure for the units in the sample or through the application of an AEDM pursuant to the requirements of § 429.70.

(b) [Reserved]

■ 4. Section 429.70 is amended by adding paragraph (h) to read as follows:

§ 429.70 Alternative methods for determining energy efficiency and energy use.

* * * * *

(h) *Alternative efficiency determination method (AEDM) for compressors*—(1) *Criteria an AEDM must satisfy.* A manufacturer may not apply an AEDM to a basic model to determine its efficiency pursuant to this section, unless:

(i) The AEDM is derived from a mathematical model that estimates the energy efficiency or energy consumption characteristics of the basic model as measured by the applicable DOE test procedure;

(ii) The AEDM is based on engineering or statistical analysis, computer simulation or modeling, or other analytic evaluation of performance data; and

(iii) The manufacturer has validated the AEDM, in accordance with paragraph (h)(2) of this section.

(2) *Validation of an AEDM.* Before using an AEDM, the manufacturer must validate the AEDM's accuracy and reliability as follows:

(i) *AEDM overview.* The manufacturer must select at least the minimum number of basic models for each validation class specified in paragraph (h)(2)(iv) of this section to which the particular AEDM applies. Using the AEDM, calculate the energy use or energy efficiency for each of the selected basic models. Test each basic model and determine the represented value(s) in accordance with § 429.63(a). Compare the results from the testing and the AEDM output according to paragraph (h)(2)(ii) of this section. The manufacturer is responsible for ensuring the accuracy and repeatability of the AEDM.

(ii) *AEDM basic model tolerances.* (A) The predicted representative values for each basic model calculated by applying the AEDM may not be more than five percent greater (for measures of efficiency) or less (for measures of consumption) than the represented values determined from the corresponding test of the model.

(B) The predicted package isentropic efficiency for each basic model calculated by applying the AEDM must meet or exceed the applicable federal energy conservation standard.

(iii) *Additional test unit requirements.* (A) Each AEDM must be supported by test data obtained from physical tests of current models; and

(B) Test results used to validate the AEDM must meet or exceed current, applicable Federal standards as specified in part 431 of this chapter; and

(C) Each test must have been performed in accordance with the applicable DOE test procedure with which compliance is required at the time the basic models used for validation are distributed in commerce.

(iv) *Compressor validation classes.*

Validation class	Minimum number of distinct basic models that must be tested
Rotary, Fixed-speed	2 Basic Models.
Rotary, Variable-speed	2 Basic Models.

(3) *AEDM Records Retention Requirements.* If a manufacturer has used an AEDM to determine representative values pursuant to this section, the manufacturer must have available upon request for inspection by the Department records showing:

(i) The AEDM, including the mathematical model, the engineering or statistical analysis, and/or computer simulation or modeling that is the basis of the AEDM;

(ii) Equipment information, complete test data, AEDM calculations, and the statistical comparisons from the units tested that were used to validate the AEDM pursuant to paragraph (h)(2) of this section; and

(iii) Equipment information and AEDM calculations for each basic model to which the AEDM was applied.

(4) *Additional AEDM requirements.* If requested by the Department, the manufacturer must:

(i) Conduct simulations before representatives of the Department to predict the performance of particular basic models of the equipment to which the AEDM was applied;

(ii) Provide analyses of previous simulations conducted by the manufacturer; and/or

(iii) Conduct certification testing of basic models selected by the Department.

■ 5. Section 429.134 is amended by adding paragraph (p) to read as follows:

§ 429.134 Product-specific enforcement provisions.

* * * * *

(p) *Compressors*—(1) *Verification of full-load operating pressure.* (i) The maximum full-flow operating pressure of each tested unit of the basic model will be measured pursuant to the test requirements of appendix A to subpart T of part 431 of this chapter, where 90 percent of the value of full-load operating pressure certified by the manufacturer will be the starting point of the test method prior to increasing discharge pressure. The measured maximum full-flow operating pressure (either the single measured value for a single unit sample or the mean of the measured maximum full-flow operating pressures for a multiple unit sample) will be compared to the certified rating for full-load operating pressure to determine if the certified rating is valid or not. The certified rating for full-load operating pressure will be considered valid only if the certified rating for full-load operating pressure is less than or equal to the measured maximum full-flow operating pressure and greater than or equal to the lesser of—

(A) 90 percent of the measured maximum full-flow operating pressure; or

(B) 10 psig less than the measured maximum full-flow operating pressure.

(ii) If the certified full-load operating pressure is found to be valid, then the certified value will be used as the full-load operating pressure and will be the basis for determination of full-load actual volume flow rate, pressure ratio at full-load operating pressure, specific power, and package isentropic efficiency.

(iii) If the certified full-load operating pressure is found to be invalid, then the measured maximum full-flow operating pressure will be used as the full-load operating pressure and will be the basis for determination of full-load actual volume flow rate, pressure ratio at full-load operating pressure, specific power, and package isentropic efficiency.

(2) *Verification of full-load actual volume flow rate.* The measured full-load actual volume flow rate will be measured, pursuant to the test requirements of appendix A to subpart T of part 431 of this chapter, at the full-load operating pressure determined in paragraph (p)(1) of this section. The certified full-load actual volume flow rate will be considered valid only if the measurement(s) (either the measured full-load actual volume flow rate for a single unit sample or the mean of the measured values for a multiple unit sample) are within the percentage of the certified full-load actual volume flow rate specified in Table 1 of this section:

TABLE 1 OF § 429.134—ALLOWABLE PERCENTAGE DEVIATION FROM THE CERTIFIED FULL-LOAD ACTUAL VOLUME FLOW RATE

Manufacturer certified full-load actual volume flow rate (m^3/s) $\times 10^{-3}$	Allowable percent of the certified full-load actual volume flow rate (%)
0 < and ≤ 8.3	±7
8.3 < and ≤ 25	±6
25 < and ≤ 250	±5
> 250	±4

(i) If the certified value of full-load actual volume flow rate is found to be valid, the full-load actual volume flow rate certified by the manufacturer will be used as the basis for determination of the applicable standard.

(ii) If the certified value of full-load actual volume flow rate is found to be invalid, the entire sample (one or multiple units) will be considered as failing the enforcement test.

(3) *Ancillary equipment.* Prior to testing each compressor, DOE will install any required ancillary equipment specified by the manufacturer in the certification report submitted pursuant to § 429.63(b).

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 6. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317; 28 U.S.C. 2461 note.

■ 7. Section 431.342 is revised to read as follows:

§ 431.342 Definitions concerning compressors.

The following definitions are applicable to this subpart, including appendix A. In cases where there is a conflict, the language of the definitions adopted in this section take precedence over any descriptions or definitions found in any other source, including in ISO Standard 1217:2009(E), ‘‘Displacement compressors—Acceptance tests,’’ as amended through Amendment 1:2016(E), ‘‘Calculation of isentropic efficiency and relationship with specific energy’’ (incorporated by reference, see § 431.343). In cases where definitions reference design intent, DOE will consider all relevant information, including marketing materials, labels and certifications, and equipment design, to determine design intent.

Actual volume flow rate means the volume flow rate of air, compressed and delivered at the standard discharge point, referred to conditions of total temperature, total pressure and composition prevailing at the standard inlet point, and as determined in accordance with the test procedures prescribed in § 431.344.

Air compressor means a compressor designed to compress air that has an inlet open to the atmosphere or other source of air, and is made up of a compression element (bare compressor), driver(s), mechanical equipment to drive the compressor element, and any ancillary equipment.

Ancillary equipment means any equipment distributed in commerce with an air compressor but that is not a bare compressor, driver, or mechanical equipment. Ancillary equipment is considered to be part of a given air compressor, regardless of whether the ancillary equipment is physically attached to the bare compressor, driver, or mechanical equipment at the time when the air compressor is distributed in commerce.

Auxiliary substance means any substance deliberately introduced into a compression process to aid in compression of a gas by any of the following: Lubricating, sealing mechanical clearances, or absorbing heat.

Bare compressor means the compression element and auxiliary devices (*e.g.,* inlet and outlet valves, seals, lubrication system, and gas flow paths) required for performing the gas compression process, but does not include any of the following:

(1) The driver;

(2) Speed-adjusting gear(s);

(3) Gas processing apparatuses and piping; and

(4) Compressor equipment packaging and mounting facilities and enclosures.

Basic model means all units of a class of compressors manufactured by one manufacturer, having the same primary energy source, the same compressor motor nominal horsepower, and essentially identical electrical, physical, and functional (or pneumatic) characteristics that affect energy consumption and energy efficiency.

Brushless electric motor means a machine that converts electrical power into rotational mechanical power without use of sliding electrical contacts.

Compressor means a machine or apparatus that converts different types of energy into the potential energy of gas pressure for displacement and compression of gaseous media to any higher pressure values above atmospheric pressure and has a pressure ratio at full-load operating pressure greater than 1.3.

Compressor motor nominal horsepower means the motor horsepower of the electric motor, as determined in accordance with the applicable procedures in subparts B and X of this part, with which the rated air compressor is distributed in commerce.

Driver means the machine providing mechanical input to drive a bare compressor directly or through the use of mechanical equipment.

Fixed-speed compressor means an air compressor that is not capable of adjusting the speed of the driver continuously over the driver operating speed range in response to incremental changes in the required compressor flow rate.

Full-load actual volume flow rate means the actual volume flow rate of the compressor at the full-load operating pressure.

Lubricant-free compressor means a compressor that does not introduce any auxiliary substance into the compression chamber at any time during operation.

Lubricated compressor means a compressor that introduces an auxiliary substance into the compression chamber during compression.

Maximum full-flow operating pressure means the maximum discharge pressure at which the compressor is capable of operating, as determined in accordance with the test procedure prescribed in § 431.344.

Mechanical equipment means any component of an air compressor that transfers energy from the driver to the bare compressor.

Package isentropic efficiency means the ratio of power required for an ideal isentropic compression process to the actual packaged compressor power input used at a given load point, as determined in accordance with the test procedures prescribed in § 431.344.

Package specific power means the compressor power input at a given load point, divided by the actual volume flow rate at the same load point, as determined in accordance with the test procedures prescribed in § 431.344.

Positive displacement compressor means a compressor in which the admission and diminution of successive volumes of the gaseous medium are performed periodically by forced expansion and diminution of a closed space(s) in a working chamber(s) by means of displacement of a moving member(s) or by displacement and forced discharge of the gaseous medium into the high-pressure area.

Pressure ratio at full-load operating pressure means the ratio of discharge pressure to inlet pressure, determined at full-load operating pressure in accordance with the test procedures prescribed in § 431.344.

Reciprocating compressor means a positive displacement compressor in which gas admission and diminution of its successive volumes are performed cyclically by straight-line alternating movements of a moving member(s) in a compression chamber(s).

Rotary compressor means a positive displacement compressor in which gas admission and diminution of its successive volumes or its forced discharge are performed cyclically by rotation of one or several rotors in a compressor casing.

Rotor means a compression element that rotates continually in a single direction about a single shaft or axis.

Variable-speed compressor means an air compressor that is capable of adjusting the speed of the driver continuously over the driver operating speed range in response to incremental changes in the required compressor actual volume flow rate.

■ 8. Add §§ 431.343 through 431.346 and appendix A to subpart T to read as follows:

Appendix A to Subpart T of Part 431—Uniform Test Method for Certain Air Compressors

§ 431.343 Materials incorporated by reference.

(a) *General.* DOE incorporates by reference the following standards into part 431. The material listed has been approved for incorporation by reference by the Director of the Federal Register in accordance with 6 U.S.C. 522(a) and 1 CFR part 51. Any subsequent amendment to a standard by the standard-setting organization will not affect the DOE test procedures unless and until amended by DOE. Material is incorporated as it exists on the date of the approval and a notice of any change in the material will be published in the **Federal Register**. All approved material is available from the sources below. It is available for inspection at U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, Sixth Floor, 950 L'Enfant Plaza SW., Washington, DC 20024, (202) 586–6636, or go to *http://www1.eere.energy.gov/buildings/appliance_standards/.* Also, this material is available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.*

(b) *ISO.* International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland +41 22 749 01 11, *www.iso.org.*

(1) ISO Standard 1217:2009(E), (''ISO 1217:2009(E)''), ''Displacement compressors—Acceptance tests,'' July 1, 2009, IBR approved for appendix A to this subpart:

(i) Section 2. Normative references;

(ii) Section 3. Terms and definitions;

(iii) Section 4. Symbols;

(iv) Section 5. Measuring equipment, methods and accuracy (excluding 5.1, 5.5, 5.7, and 5.8);

(v) Section 6. Test procedures, introductory text to Section 6.2, Test arrangements, and paragraphs 6.2(g) and 6.2(h) including Table 1—Maximum deviations from specified values and fluctuations from average readings;

(vi) Annex C (normative), Simplified acceptance test for electrically driven packaged displacement compressors (excluding C.1.2, C.2.1, C.3, C.4.2.2, C.4.3.1, and C.4.5).

(2) ISO 1217:2009/Amd.1:2016(E), Displacement compressors—Acceptance tests (Fourth edition); Amendment 1: ''Calculation of isentropic efficiency and relationship with specific energy,'' April 15, 2016, IBR approved for appendix A to this subpart:

(i) Section 3.5.1: isentropic power;

(ii) Section 3.6.1: isentropic efficiency;

(iii) Annex H (informative), Isentropic efficiency and its relation to specific energy requirement, sections H.2, Symbols and subscripts, and H.3, Derivation of isentropic power.

§ 431.344 Test procedure for measuring and determining energy efficiency of compressors.

(a) *Scope.* This section is a test procedure that is applicable to a compressor that meets the following criteria:

(1) Is an air compressor;

(2) Is a rotary compressor;

(3) Is not a liquid ring compressor;

(4) Is driven by a brushless electric motor;

(5) Is a lubricated compressor;

(6) Has a full-load operating pressure greater than or equal to 75 pounds per square inch gauge (psig) and less than or equal to 200 psig;

(7) Is not designed and tested to the requirements of the American Petroleum Institute Standard 619, ''Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries;''

(8) Has full-load actual volume flow rate greater than or equal to 35 cubic feet per minute (cfm), or is distributed in commerce with a compressor motor nominal horsepower greater than or equal to 10 horsepower (hp); and

(9) Has a full-load actual volume flow rate less than or equal to 1,250 cfm, or is distributed in commerce with a compressor motor nominal horsepower less than or equal to 200 hp.

(b) *Testing and calculations.* Determine the applicable full-load package isentropic efficiency ($\eta_{isen,FL}$), part-load package isentropic efficiency ($\eta_{isen,PL}$), package specific power, maximum full-flow operating pressure, full-load operating pressure, full-load actual volume flow rate, and pressure ratio at full-load operating pressure using the test procedure set forth in appendix A of this subpart.

§ 431.345 [Reserved]

§ 431.346 [Reserved]

Appendix A to Subpart T of Part 431—Uniform Test Method for Certain Air Compressors

Note: Starting on July 3, 2017, any representations made with respect to the energy use or efficiency of compressors subject to testing pursuant to 10 CFR 431.344 must be made in accordance with the results of testing pursuant to this appendix.

I. Measurements, Test Conditions, and Equipment Configuration

A. Measurement Equipment

A.1. For the purposes of measuring air compressor performance, the equipment necessary to measure volume flow rate, inlet and discharge pressure, temperature, condensate, and packaged compressor power input must comply with the equipment and accuracy requirements specified in ISO 1217:2009(E) sections 5.2, 5.3, 5.4, 5.6, 5.9, and Annex C, sections C.2.3 and C.2.4 (incorporated by reference, see § 431.343).

A.2. Electrical measurement equipment must be capable of measuring true root mean square (RMS) current, true RMS voltage, and real power up to the 40th harmonic of fundamental supply source frequency.

A.3. Any instruments used to measure a particular parameter specified in paragraph (A.1.) must have a combined accuracy of ±2.0 percent of the measured value at the fundamental supply source frequency, where combined accuracy is the square root of the sum of the squares of individual instrument accuracies.

A.4. Any instruments used to directly measure the density of air must have an accuracy of ±1.0 percent of the measured value.

A.5. Any pressure measurement equipment used in a calculation of another variable (*e.g.,* actual volume flow rate) must also meet all accuracy and measurement requirements of section 5.2 of ISO 1217:2009(E) (incorporated by reference, see § 431.343).

A.6. Any temperature measurement equipment used in a calculation of another variable (*e.g.,* actual volume flow rate) must also meet all accuracy and measurement requirements of section 5.3 of ISO 1217:2009(E) (incorporated by reference, see § 431.343).

A.7. Where ISO 1217:2009(E) refers to ''corrected volume flow rate,'' the term is deemed synonymous with the term ''actual volume flow rate,'' as defined in section 3.4.1 of ISO 1217:2009(E) (incorporated by reference, see § 431.343).

B. Test Conditions and Configuration of Unit Under Test

B.1. For both fixed-speed and variable-speed compressors, conduct testing in accordance with the test conditions, unit configuration, and specifications of ISO 1217:2009(E), Section 6.2 paragraphs (g) and (h) and Annex C, sections C.1.1, C.2.2, C.2.3, C.2.4, C.4.1, C.4.2.1, C.4.2.3, and C.4.3.2 (incorporated by reference, see § 431.343).

B.2. The power supply must:

(1) Maintain the voltage greater than or equal to 95 percent and less than or equal to 110 percent of the rated value of the motor,

(2) Maintain the frequency within ±5 percent of the rated value of the motor,

(3) Maintain the voltage unbalance of the power supply within ±3 percent of the rated values of the motor, and

(4) Maintain total harmonic distortion below 12 percent throughout the test.

B.3. Ambient Conditions. The ambient air temperature must be greater than or equal to 68 °F and less than or equal to 90 °F for the duration of testing. There are no ambient condition requirements for inlet pressure or relative humidity.

B.4. All equipment indicated in Table 1 of this appendix must be present and installed for all tests specified in this appendix. If the compressor is distributed in commerce without an item from Table 1 of this appendix, the manufacturer must provide an appropriate item to be installed for the test. Additional ancillary equipment may be installed for the test, if distributed in commerce with the compressor, but this additional ancillary equipment is not required. If any of the equipment listed in Table 2 of this appendix is distributed in commerce with units of the compressor basic model, it must be present and installed for all tests specified in this appendix.

TABLE 1—EQUIPMENT REQUIRED DURING TEST

Equipment	Fixed-speed rotary air compressors	Variable-speed rotary air compressors
Driver	Yes	Yes.
Bare compressors	Yes	Yes.
Inlet filter	Yes	Yes.
Inlet valve	Yes	Yes.
Minimum pressure check valve/backflow check valve	Yes	Yes.
Lubricant separator	Yes	Yes.
Air piping	Yes	Yes.
Lubricant piping	Yes	Yes.
Lubricant filter	Yes	Yes.
Lubricant cooler	Yes	Yes.
Thermostatic valve	Yes	Yes.
Electrical switchgear or frequency converter for the driver	Yes	Not applicable.[1]
Device to control the speed of the driver (e.g., variable speed drive)	Not applicable[2]	Yes.
Compressed air cooler(s)	Yes	Yes.
Pressure switch, pressure transducer, or similar pressure control device	Yes	Yes.
Moisture separator and drain	Yes	Yes.

[1] This category is not applicable to variable-speed rotary air compressors.

[2] This category is not applicable to fixed-speed rotary air compressors.

TABLE 2—EQUIPMENT REQUIRED DURING TEST, IF DISTRIBUTED IN COMMERCE WITH THE BASIC MODEL

Equipment	Fixed-speed rotary air compressors	Variable-speed rotary air compressors
Cooling fan(s) and motors	Yes	Yes.
Mechanical equipment	Yes	Yes.
Lubricant pump	Yes	Yes.
Interstage cooler	Yes	Yes.
Electronic or electrical controls and user interface	Yes	Yes.
All protective and safety devices	Yes	Yes.

B.5. The inlet of the compressor under test must be open to the atmosphere and take in ambient air for all tests specified in this appendix.

B.6. The compressor under test must be set up according to all manufacturer instructions for normal operation (*e.g.,* verify lubricant level, connect all loose electrical connections, close off bottom of unit to floor, cover forklift holes).

B.7. The piping connected to the discharge orifice of the compressor must be of a diameter at least equal to that of the compressor discharge orifice to which it is connected. The piping must be straight with a length of at least 6 inches.

B.8. Transducers used to record compressor discharge pressure must be located on the discharge piping between 2 inches and 6 inches, inclusive, from the discharge orifice of the compressor. The pressure tap for transducers must be located at the highest point of the pipe's cross section.

II. Determination of Package Isentropic Efficiency, Package Specific Power, and Pressure Ratio at Full-Load Operating Pressure

A. Data Collection and Analysis

A.1. Stabilization. Record data at each load point under steady-state conditions. Steady-state conditions are achieved when a set of two consecutive readings taken at least 10 seconds apart and no more than 60 seconds apart are within the maximum permissible fluctuation from the average (of the two consecutive readings), as specified in Table 1 of ISO 1217:2009(E) (incorporated by reference, see § 431.343) for—

(1) Discharge pressure;

(2) Temperature at the nozzle or orifice plate, measured per section 5.3 of ISO 1217:2009(E) (incorporated by reference, see § 431.343); and

(3) Differential pressure over the nozzle or orifice plate, measured per section 5.2 of ISO 1217:2009(E) (incorporated by reference, see § 431.343).

A.2. Data Sampling and Frequency. At each load point, record a minimum set of 16 unique readings, collected over a minimum time of 15 minutes. Each consecutive reading must be no more than 60 seconds apart, and not less than 10 seconds apart. All readings at each load point must be within the maximum permissible fluctuation from average specified in Table 1 of ISO 1217:2009(E) (incorporated by reference, see § 431.343) for—

(1) Discharge pressure;

(2) Temperature at the nozzle or orifice plate, measured per section 5.3 of ISO 1217:2009(E) (incorporated by reference, see § 431.343); and

(3) Differential pressure over the nozzle or orifice plate, measured per section 5.2 of ISO 1217:2009(E) (incorporated by reference, see § 431.343).

If one or more readings do not meet the requirements, then all previous readings must be disregarded and a new set of at least 16 new unique readings must be collected over a minimum time of 15 minutes. Average the readings to determine the value of each parameter to be used in subsequent calculations.

A.3. Calculations and Rounding. Perform all calculations using raw measured values. Round the final result for package isentropic efficiency to the thousandth (*i.e.,* 0.001), for package specific power in kilowatts per 100 cubic feet per minute to the nearest hundredth (*i.e.,* 0.01), for pressure ratio at full-load operating pressure to the nearest tenth (*i.e.,* 0.1), for full-load actual volume flow rate in cubic feet per minute to the nearest tenth (*i.e.,* 0.1), and for full-load operating pressure in pounds per square inch gauge (psig) to the nearest integer (*i.e.,* 1). All terms and quantities refer to values determined in accordance with the procedures set forth in this appendix for the tested unit.

B. Full-Load Operating Pressure and Full-Load Actual Volume Flow Rate

Determine the full-load operating pressure and full-load actual volume flow rate (referenced throughout this appendix) in accordance with the procedures prescribed in section III of this appendix.

C. Full-Load Package Isentropic Efficiency for Fixed- and Variable-Speed Air Compressors

Use this test method to test fixed-speed air compressors and variable-speed air compressors.

C.1. Test unit at full-load operating pressure and full-load volume flow rate according to the requirements established in sections I, II.A, and II.B of this appendix. Measure volume flow rate and calculate actual volume flow rate in accordance with section C.4.2.1 of Annex C of ISO 1217:2009(E) (incorporated by reference, see § 431.343) with no corrections made for shaft speed. Measure discharge gauge pressure and packaged compressor power input. Measured discharge gauge pressure and calculated actual volume flow rate must be within the deviation limits for discharge pressure and volume flow rate specified in Tables C.1 and C.2 of Annex C of ISO 1217:2009(E) (incorporated by reference, see § 431.343), where full-load operating pressure and full-load actual volume flow rate (as determined in section III of this appendix) are the targeted values.

C.2. Calculate the package isentropic efficiency at full-load operating pressure and full-load actual volume flow rate (full-load package isentropic efficiency, $\eta_{isen,FL}$) using the equation for isentropic efficiency in section 3.6.1 of ISO 1217:2009(E) as modified by ISO 1217:2009/Amd.1:2016(E) (incorporated by reference, see § 431.343). For P_{isen}, use the isentropic power required for compression at full-load operating pressure and full-load actual volume flow rate, as determined in section II.C.2.1 of this appendix. For P_{real}, use the real packaged compressor power input at full-load operating pressure and full-load actual volume flow rate, as determined in section II.C.2.2 of this appendix.

C.2.1. Calculate the isentropic power required for compression at full-load operating pressure and full-load actual volume flow rate using equation (H.6) of Annex H of ISO 1217:2009/Amd.1:2016(E) (incorporated by reference, see § 431.343). For q_{V1}, use the actual volume flow rate (cubic meters per second) calculated in section II.C.1 of this appendix. For p_1, use 100 kPa. For p_2, use the sum of (a) 100 kPa, and (b) the measured discharge gauge pressure (Pa) from section II.C.1 of this appendix. For *K,* use the isentropic exponent (ratio of specific heats) of air, which, for the purposes of this test procedure, is 1.400.

C.2.2. Calculate real packaged compressor power input at full-load operating pressure and full-load actual volume flow rate using the following equation:

$$P_{real,100\%} = K_5 \cdot P_{PR,100\%}$$

Where:

K_5 = correction factor for inlet pressure, as determined in section C.4.3.2 of Annex C to ISO 1217:2009(E) (incorporated by reference, see § 431.343). For calculations of this variable use a value of 100 kPa for contractual inlet pressure; and

$P_{PR,100\%}$ = packaged compressor power input reading at full-load operating pressure and full-load actual volume flow rate measured in section II.C.1 of this appendix (W).

D. Part-Load Package Isentropic Efficiency for Variable-Speed Air Compressors

Use this test method to test variable-speed air compressors.

D.1. Test unit at two load points: (1) Full-load operating pressure and 70 percent of full-load actual volume flow rate and (2) full-load operating pressure and 40 percent of full-load actual volume flow rate, according to the requirements established in sections I, II.A, and II.B of this appendix. To reach each specified load point, adjust the speed of the driver and the backpressure of the system. For each load point, measure volume flow rate and calculate actual volume flow rate in accordance with section C.4.2.1 of Annex C of ISO 1217:2009(E) (incorporated by reference, see § 431.343), with no corrections made for shaft speed. For each load point, measure discharge gauge pressure and packaged compressor power input. Measured discharge gauge pressure and calculated actual volume flow rate must be within the deviation limits for discharge pressure and volume flow rate specified in Tables C.1 and C.2 of Annex C of ISO 1217:2009(E), where the targeted values are as specified in the beginning of this section.

D.2. For variable-speed compressors, calculate the part-load package isentropic efficiency using the following equation:

$$\eta_{isen,PL} = \omega_{40\%} \times \eta_{isen,40\%} + \omega_{70\%} \times \eta_{isen,70\%} + \omega_{100\%} \times \eta_{isen,100\%}$$

Where:

$\eta_{isen,PL}$ = part-load package isentropic efficiency for a variable-speed compressor;

$\eta_{isen,100\%}$ = package isentropic efficiency at full-load operating pressure and 100 percent of full-load actual volume flow rate, as determined in section II.C.2 of this appendix;

$\eta_{isen,70\%}$ = package isentropic efficiency at full-load operating pressure and 70 percent of full-load actual volume flow rate, as determined in section II.D.3 of this appendix;

$\eta_{isen,40\%}$ = package isentropic efficiency at full-load operating pressure and 40 percent of full-load actual volume flow rate, as determined in section II.D.4 of this appendix;

$\omega_{40\%}$ = weighting at 40 percent of full-load actual volume flow rate and is 0.25;

$\omega_{70\%}$ = weighting at 70 percent of full-load actual volume flow rate and is 0.50; and

$\omega_{100\%}$ = weighting at 100 percent of full-load actual volume flow rate and is 0.25.

D.3. Calculate package isentropic efficiency at full-load operating pressure and 70 percent of full-load actual volume flow rate using the equation for isentropic efficiency in section 3.6.1 of ISO 1217:2009(E) as modified by ISO 1217:2009/Amd.1:2016(E) (incorporated by reference, see § 431.343). For P_{isen}, use the isentropic power required for compression at full-load operating pressure and 70 percent of full-load actual volume flow rate, as determined in section II.D.3.1 of this appendix. For P_{real}, use the real packaged compressor power input at full-load operating pressure and 70 percent of full-load actual volume flow rate, as determined in section II.D.3.2 of this appendix.

D.3.1. Calculate the isentropic power required for compression at full-load operating pressure and 70 percent of full-load actual volume flow rate using equation (H.6) of Annex H of ISO 1217:2009/Amd.1:2016(E) (incorporated by reference, see § 431.343). For q_{V1}, use actual volume flow rate (cubic meters per second) at full-load operating pressure and 70 percent of full-load actual volume flow rate, as calculated in section II.D.1 of this appendix. For p_1, use 100 kPa. For p_2, use the sum of (a) 100 kPa, and (b) discharge gauge pressure (Pa) at full-load operating pressure and 70 percent of full-load actual volume flow rate, as calculated in section II.D.1 of this appendix. For *K,* use the isentropic exponent (ratio of specific heats) of air, which, for the purposes of this test procedure, is 1.400.

D.3.2. Calculate real packaged compressor power input at full-load operating pressure and 70 percent of full-load actual volume flow rate using the following equation:

$$P_{real,70\%} = K_5 \cdot P_{PR,70\%}$$

Where:

K_5 = correction factor for inlet pressure, as determined in section C.4.3.2 of Annex C to ISO 1217:2009(E) (incorporated by reference, see § 431.343). For calculations of this variable use a value of 100 kPa for contractual inlet pressure; and

$P_{PR,70\%}$ = packaged compressor power input reading at full-load operating pressure and 70 percent of full-load actual volume flow rate, as measured in section II.D.1 of this appendix (W).

D.4. Calculate package isentropic efficiency at full-load operating pressure and 40 percent of full-load actual volume flow rate using the equation for isentropic efficiency in section 3.6.1 of ISO 1217:2009(E) as modified by ISO 1217:2009/Amd.1:2016(E) (incorporated by reference, see § 431.343). For $P_{isen,}$ use the isentropic power required for compression at full-load operating pressure and 40 percent of full-load actual volume flow rate, as determined in section II.D.4.1 of this appendix. For $P_{real,}$ use the real packaged compressor power input at full-load operating pressure and 40 percent of full-load actual volume flow rate, as determined in section II.D.4.2 of this appendix.

D.4.1. Calculate the isentropic power required for compression at full-load operating pressure and 40 percent of full-load actual volume flow rate using equation (H.6) of Annex H of ISO 1217:2009/Amd.1:2016(E) (incorporated by reference, see § 431.343). For q_{V1}, use actual volume flow rate (cubic meters per second) at full-load operating pressure and 40 percent of full-load actual volume flow rate, as calculated in section II.D.1 of this appendix. For p_1, use 100 kPa. For p_2, use the sum of (a) 100 kPa, and (b) discharge gauge pressure (Pa) at full-load operating pressure and 40 percent of full-load actual volume flow rate, as calculated in section II.D.1 of this appendix. For *K*, use the isentropic exponent (ratio of specific heats) of air, which, for the purposes of this test procedure, is 1.400.

D.4.2. Calculate real packaged compressor power input at full-load operating pressure and 40 percent of full-load actual volume flow rate using the following equation:

$$P_{real,40\%} = K_5 \cdot P_{PR,40\neq}$$

Where:

K_5 = correction factor for inlet pressure, as determined in section C.4.3.2 of Annex C to ISO 1217:2009(E) (incorporated by reference, see § 431.343). For calculations of this variable use a value of 100 kPa for contractual inlet pressure; and

$P_{PR,40\%}$ = packaged compressor power input reading at full-load operating pressure and 40 percent of full-load actual volume flow rate, as measured in section II.D.1 of this appendix (W).

E. Determination of Package Specific Power

For both fixed and variable-speed air compressors, determine the package specific power, at any load point, using the equation for specific energy consumption in section C.4.4 of Annex C of ISO 1217:2009(E) (incorporated by reference, see § 431.343) and other values measured pursuant to this appendix, with no correction for shaft speed. Calculate P_{Pcorr} in section C.4.4 of Annex C of ISO 1217:2009(E) (incorporated by reference, see § 431.343) using the following equation:

$$P_{Pcorr} = K_5 \cdot P_{PR}$$

Where:

K_5 = correction factor for inlet pressure, as determined in section C.4.3.2 of Annex C to ISO 1217:2009(E) (incorporated by reference, see § 431.343). For calculations of this variable use a value of 100 kPa for contractual inlet pressure; and

P_{PR} = packaged compressor power input reading (W), as determined in section C.2.4 of Annex C to ISO 1217:2009(E) (incorporated by reference, see § 431.343).

F. Determination of Pressure Ratio at Full-Load Operating Pressure

Pressure ratio at full-load operating pressure, as defined in § 431.342, is calculated using the following equation:

$$LCL = \bar{x} - t_{0.95}\left(\frac{s}{\sqrt{n}}\right)$$

Where:

PR = pressure ratio at full-load operating pressure;

p_1 = 100 kPa; and

p_{FL} = full-load operating pressure, determined in section III.C.4 of this appendix (Pa gauge).

III. Method to Determine Maximum Full-Flow Operating Pressure, Full-Load Operating Pressure, and Full-Load Actual Volume Flow Rate

A. Principal Strategy

The principal strategy of this method is to incrementally increase discharge pressure by 2 psig relative to a starting point, and identify the maximum full-flow operating pressure at which the compressor is capable of operating. The maximum discharge pressure achieved is the maximum full-flow operating pressure. The full-load operating pressure and full-load actual volume flow rate are determined based on the maximum full-flow operating pressure.

B. Pre-test Instructions

B.1. Safety

For the method presented in section III.C.1 of this appendix, only test discharge pressure within the safe operating range of the compressor, as specified by the manufacturer in the installation and operation manual shipped with the unit. Make no changes to safety limits or equipment. Do not violate any manufacturer-provided motor operational guidelines for normal use, including any restriction on instantaneous and continuous input power draw and output shaft power (*e.g.,* electrical rating and service factor limits).

B.2. Adjustment of Discharge Pressure

B.2.1. If the air compressor is not equipped, as distributed in commerce by the manufacturer, with any mechanism to adjust the maximum discharge pressure output limit, proceed to section III.B.3 of this appendix.

B.2.2. If the air compressor is equipped, as distributed in commerce by the manufacturer, with any mechanism to adjust the maximum discharge pressure output limit, then adjust this mechanism to the maximum pressure allowed, according to the manufacturer's operating instructions for these mechanisms. Mechanisms to adjust discharge pressure may include, but are not limited to, onboard digital or analog controls, and user-adjustable inlet valves.

B.3. Driver speed

If the unit under test is a variable-speed compressor, maintain maximum driver speed throughout the test. If the unit under test is a fixed-speed compressor with a multi-speed driver, maintain driver speed at the maximum speed throughout the test.

B.4. Measurements and Tolerances

B.4.1. Recording

Record data by electronic means such that the requirements of section B.4.5 of section III of this appendix are met.

B.4.2. Discharge Pressure

Measure discharge pressure in accordance with section 5.2 of ISO 1217:2009(E) (incorporated by reference, see § 431.343). Express compressor discharge pressure in psig in reference to ambient conditions, and record it to the nearest integer. Specify targeted discharge pressure points in integer values only. The maximum allowable measured deviation from the targeted discharge pressure at each tested point is ±1 psig.

B.4.3. Actual Volume Flow Rate

Measure actual volume flow rate in accordance with section C.4.2.1 of Annex C of ISO 1217:2009(E) (incorporated by reference, see § 431.343) (where it is called ''corrected volume flow rate'') with no corrections made for shaft speed. Express compressor actual volume flow rate in cubic feet per minute at inlet conditions (cfm).

B.4.4. Stabilization

Record data at each tested load point under steady-state conditions, as determined in section II.A.1 of this appendix.

B.4.5. Data Sampling and Frequency

At each load point, record a set of at least of two readings, collected at a minimum of 10 seconds apart. All readings at each load point must be within the maximum permissible fluctuation from the average (of the two consecutive readings), as specified in II.A.2 of this appendix. Average the measurements to determine the value of each parameter to be used in subsequent calculations.

B.5. Adjusting System Backpressure

Set up the unit under test so that backpressure on the unit can be adjusted (*e.g.,* by valves) incrementally, causing the measured discharge pressure to change, until the compressor is in an unloaded condition.

B.6. Unloaded Condition

A unit is considered to be in an unloaded condition if capacity controls on the unit automatically reduce the actual volume flow rate from the compressor (*e.g.,* shutting the motor off, or unloading by adjusting valves).

C. Test Instructions

C.1. Adjust the backpressure of the system so the measured discharge pressure is 90 percent of the expected maximum full-flow operating pressure, rounded to the nearest integer, in psig. If the expected maximum full-flow operating pressure is not known, then adjust the backpressure of the system so that the measured discharge pressure is 65 psig. Allow the unit to remain at this setting for 15 minutes to allow the unit to thermally stabilize. Then measure and record discharge pressure and actual volume flow rate at the starting pressure.

C.2. Adjust the backpressure of the system to increase the discharge pressure by 2 psig from the previous value, allow the unit to remain at this setting for a minimum of 2 minutes, and proceed to section III.C.3 of this appendix.

C.3. If the unit is now in an unloaded condition, end the test and proceed to section III.C.4 of this appendix. If the unit is not in an unloaded condition, measure discharge pressure and actual volume flow rate, and repeat section III.C.2 of this appendix.

C.4. Of the discharge pressures recorded under stabilized conditions in sections III.C.1 through III.C.3 of this appendix, identify the largest. This is the maximum full-flow operating pressure. Determine the full-load operating pressure as a self-declared value greater than or equal to the lesser of (A) 90 percent of the maximum full-flow operating pressure, or (B) 10 psig less than the maximum full-flow operating pressure.

C.5. The full-load actual volume flow rate is the actual volume flow rate measured at the full-load operating pressure. If the self-declared full-load operating pressure falls on a previously tested value of discharge pressure, then use the previously measured actual volume flow rate as the full-load actual volume flow rate. If the self-declared full-load operating pressure does not fall on a previously tested value of discharge pressure, then adjust the backpressure of the system to the self-declared full-load operating pressure and allow the unit to remain at this setting for a minimum of 2 minutes. The measured actual volume flow rate at this setting is the full-load actual volume flow rate.

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