

# C37.48™

## IEEE Guide for the Application, Operation, and Maintenance of High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

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**IEEE Power Engineering Society**

Sponsored by the  
Switchgear Committee



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# IEEE Guide for the Application, Operation, and Maintenance of High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

Sponsor

**Switchgear Committee  
of the  
IEEE Power Engineering Society**

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**Abstract:** Information on the application, operation and maintenance of high-voltage fuses (above 1000 V and through 169 kV), distribution enclosed single-pole air switches, fuse disconnecting switches, and accessories for use on ac distribution systems is provided. These include enclosed, open, and open-link types of distribution cutouts and fuses; distribution current-limiting fuses; distribution enclosed single-pole air switches; power fuses, including current-limiting types; outdoor and indoor fuse disconnecting switches; fuse supports, mountings, and links, all of the type used exclusively with the above; and removable switch blades for certain products among the above.

**Keywords:** current-limiting fuses, expulsion type fuses, distribution class fuses, power class fuses, fuse enclosure packages, high-voltage fuses, fuse, fuse applications, fuse disconnecting switches

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# Introduction

This introduction is not part of IEEE Std C37.48-2005, IEEE Guide for the Application, Operation, and Maintenance of High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

This guide is a revision of IEEE Std C37.48™-1997 to bring it up-to-date and in line with present day requirements for high-voltage fuses and switches. Significant changes include the clarification and expansion of application areas that have been reported as causing some confusion. Some additional information regarding the effect of ambient temperature on the current rating of a fuse has been added, as well as information regarding parallel fuses.

This guide was prepared by the Revision of Fuse Standards working group of the IEEE Subcommittee on High-Voltage Fuses. Liaison was maintained with the International Electrotechnical Commission (IEC) during the development of the revisions in order to incorporate the latest activities at the time of publication. It is one of a series of complementary standards covering various types of high-voltage fuses and switches, arranged so that certain standards apply to all devices while other standards provide additional specifications for a particular device. For any device, IEEE Std C37.40™-2003, IEEE Std C37.41™-2000, plus any additional standards covering that device, constitute a complete standard for the device. In addition, this document provides application, operation, and maintenance guidance for all the devices, and is supplemented by IEEE Std C37.48.1™-2002, which is an operation, classification, application, and coordination guide for current-limiting fuses.

The following standards make up this series:

ANSI C37.42-1996, American National Standard Specifications for High Voltage Expulsion Type Distribution Class Fuses, Cutouts, Fuse Disconnecting Switches and Fuse Links.

ANSI C37.45-1981 (R1992), American National Standard Specifications for Distribution Enclosed Single-Pole Air Switches.

ANSI C37.46-2000, American National Standard for High Voltage Expulsion and Current-limiting Type Power Class Fuses and Fuse Disconnecting Switches.

ANSI C37.47-2000, American National Standard for High-Voltage Current-limiting Type Distribution Class Fuses and Fuse Disconnecting Switches.

IEEE Std C37.40™-2003, IEEE Standard Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C37.41™-2000, IEEE Standard Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C37.48™ -2004, IEEE Guide for Application, Operation, and Maintenance of High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C37.48.1™-2002, IEEE Guide for the Operation, Classification, Application, and Coordination of Current-Limiting Fuses with Rated Voltages 1–38 kV.

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# IEEE Guide for the Application, Operation, and Maintenance of High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

## 1. Overview

### 1.1 Scope

This guide presents information on the application, operation, and maintenance of high-voltage fuses (above 1000 V), distribution enclosed single-pole air switches, fuse disconnecting switches, and accessories for use on ac distribution systems. Devices with rated maximum voltages to 169 kV are covered. These guidelines apply to the following specific types of equipment:

- a) Distribution and power class expulsion-type fuses.
- b) Distribution and power class current-limiting type fuses.
- c) Distribution and power class fuse disconnecting switches.
- d) Items a) through c) used in fuse-enclosure packages (see types listed in 1.3 and 1.4).
- e) Fuse supports, and fuse mountings, of the type intended for use with distribution and power class fuses, and fuse disconnecting switches.
- f) Removable switch blades of the type used exclusively with distribution class oil cutouts, power class fuses, and distribution class fuse disconnecting switches.
- g) Fuse links of the type used exclusively with distribution class oil cutouts, power class fuses, and distribution class fuse disconnecting switches.
- h) Distribution class oil cutouts.
- i) Distribution class enclosed single-pole air switches.
- j) Distribution and power classes of expulsion, current-limiting and combination external capacitor fuses used with a capacitor unit, groups of units, or capacitor banks.

## 1.2 Background

The distribution class and power class expulsion-type fuses listed in 1.1 are similar to those now covered in IEC 60282-2. The distribution class expulsion-type fuses are similar to the class “A” fuses covered in the IEC document and the power class fuses are similar to their class “B” fuses. At present, IEEE and ANSI standards do not cover the class “C” fuses listed in the IEC standard. Some of the current-limiting type fuses listed in 1.1 are similar to those now covered in IEC 60282-1. However, significant differences exist in the testing requirements of IEC and IEEE/ANSI. IEEE fuse standards reflect, primarily, applications common in North America, and in countries that use electrical systems designed using similar principles. IEC standards tend to rely heavily on practices common in Europe. Since IEC testing differences include testing at different voltages for the same fuse rated voltage, and different or no testing for fuses intended for use in a surrounding temperature above 40 °C, the user is advised to exercise extreme caution if devices specified and tested per IEC standards are compared to those specified and tested per IEEE/ANSI standards. The differences in test requirements may result in devices tested to IEC not being suitable for applications where devices tested to IEEE and ANSI standards are required, or vice versa.

In the headings and the text of this document there will be some areas where information is included in brackets [ ]. The information in the brackets is a term used in IEC standards that may be similar to the term used in this document, a term that is common in some parts of the world, or a term that has been used previously in IEEE or ANSI standards. Caution is again advised when making comparisons.

## 1.3 Description of fuse-enclosure packages (FEPs) using expulsion-type indoor power class fuses

- *Type 1E*: A fuse mounted in an enclosure with relatively free air circulation within the enclosure (for example, an expulsion fuse mounted in an enclosure or in a vault)
- *Type 2E*: A fuse mounted in a container with restricted air flow surrounding the fuse, but relatively free air circulation within the enclosure on the outside of the container (for example, an expulsion fuse in an enclosure with insulating barriers that form a container that restricts the airflow)
- *Type 3E*: A fuse mounted in an enclosure, directly immersed in liquid, with relatively free liquid circulating around the fuse (for example, an expulsion fuse in a switchgear enclosure)

## 1.4 Description of FEPs using current-limiting type indoor distribution and power class fuses

- *Type 1C*: A fuse mounted in an enclosure with relatively free air circulation within the enclosure (for example, a fuse mounted in a live front pad mounted transformer or in a vault)
- *Type 2C*: A fuse mounted in a container with restricted air flow surrounding the fuse, but with relatively free air circulation within the enclosure on the outside surfaces of the container (for example, a fuse inside a canister in a vault)
- *Type 3C*: A fuse mounted in a container with restricted air flow surrounding the fuse, but relatively free liquid circulating within the enclosure on the outside surfaces of the container (for example, a fuse inside a canister immersed in transformer oil)
- *Type 4C*: A combination of types 2C and 3C, where the container is partially in air and partially in liquid (for example, a fuse inside a transformer bushing)
- *Type 5C*: A fuse mounted in an enclosure, directly immersed in liquid, with relatively free liquid circulation around the fuse (for example, an oil immersed fuse in a transformer or switchgear enclosure)

## 2. References

It is intended that this standard be used in conjunction with the following referenced standards. When the standard referenced below is superseded by an approved revision, the revised document may or may not apply. At the time of publication of this document, the editions listed below were valid. Since all standards are subject to revision at varying times, a revised document may or may not apply. In the interim period prior to revision of this standard, all parties making agreements based on these documents are encouraged to investigate the possibility of using the most recent editions of the relevant standards.

ANSI C37.46-2000, American National Standard for High Voltage Expulsion and Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches.<sup>1</sup>

ANSI C37.47-2000, American National Standard for High Voltage Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches.

IEC 60282-1 (2002-01-29), High-voltage fuses—Part 1: Current-limiting fuses.<sup>2</sup>

IEC 60282-2 (1997-12-17), High Voltage Fuses—Part 2: Expulsion fuses.

IEEE Std 18™-2002, IEEE Standard for Shunt Power Capacitors.<sup>3, 4</sup>

IEEE Std C37.40™ -2003, IEEE Standard Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C37.41™-2000, IEEE Standard Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C37.48.1™-2002, IEEE Guide for the Operation, Classification, Application, and Coordination of Current-limiting Fuses with Rated Voltages 1–38 kV.

IEEE Std C37.99™ -2000, IEEE Guide for the Protection of Shunt Capacitor Banks.

IEEE Std C62.92.2™, IEEE Guide for the Application of Neutral Grounding in Electrical Utility System Part II—Introduction.

IEEE Std C62.92.4™, IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems Part IV –Distribution.

NEMA CP 1-2000, Shunt Capacitors.<sup>5</sup>

NFPA 70-2002: National Electrical Code® (NEC®).<sup>6</sup>

<sup>1</sup>ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

<sup>2</sup>IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

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<sup>6</sup>The NEC is published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, USA (<http://www.nfpa.org>). Copies are also available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

NFPA 70E, 2004 Edition: Electrical Safety in the Workplace.

NOTE—Fuse standards listed as “ANSI C37.xx”, were formerly developed by NEMA. The responsibility for maintaining them has passed to the IEEE and, at their next revision, they will carry the designation “IEEE C37.xx”.<sup>7</sup>

### 3. Abbreviations

FEP fuse enclosure package

F/C fuse container

RMAT rated maximum application temperature

TCC time-current characteristic

## 4. General application guidelines for all fuse types

### 4.1 Introduction

The application, operation, and maintenance of equipment covered by this guide is the responsibility of the user, who is expected to take into account system-specific requirements. As an aid in obtaining satisfactory performance of equipment, this guide provides information on some of the more important features of the above functions for normal conditions of service; unusual conditions may require special measures.

Although fuses are single-phase devices, they can be applied with single- or three-phase equipment or lines, or a combination of these. However, characteristics of the power system should be considered when selecting all fuses.

A fuse, when applied in an electric circuit within the limits of its ratings, protects the circuit. Its primary function is to isolate faulted equipment from the system. When applied with other equipment in a coordinated overcurrent protection scheme, it may also limit service interruptions to only a predetermined section of a power system. In many applications, it is possible that the equipment connected to the system can be protected from excessive damage. In this latter application, the primary function is to remove the faulted equipment from the system, and the secondary function is to minimize, or in some cases prevent, damage to the connected equipment as much as possible, considering the varying fault or overload circumstances that can occur.

Fuse performance depends upon the integrity, including quality assurance and quality control processes, with which the fuse was manufactured, the correctness of its application, and the attention it receives after it is installed. If not properly applied and maintained, it might not perform properly when required, which might result in considerable damage to costly equipment or extensive interruptions in service.

*It cannot be stressed too strongly that prescribed safety rules and manufacturers' recommendations and instructions should be adhered to at all times when operating or maintaining these devices near energized equipment or conductors. This is especially true for devices where air-insulated blades, insulating barriers or liners, or fuses are removed or replaced while mating contacts are energized. (In some cases, NFPA 70E, 2004 Edition may be applicable.)*

<sup>7</sup>Notes in text, tables, and figures are given for information only, and do not contain requirements needed to implement the standard.

## 4.2 Service conditions

### 4.2.1 Usual

Usual service conditions conforming to this guide are defined in IEEE Std C37.40-2003. These conditions specify limits in altitude and ambient temperature.

### 4.2.2 Unusual

Unusual service conditions are defined in IEEE Std C37.40-2003, which gives examples of such conditions. Equipment covered by IEEE Std C37.40 that depends on air at atmospheric pressure for its insulating and cooling medium will have a higher temperature rise and a lower dielectric withstand when operated at altitudes higher than 1000 m. Historically, equipment covered by IEEE Std C37.40 has used correction factors for dielectric strength and rated continuous current when applied at altitudes above 1000 m. In addition, equipment designed for standard temperature use could be used at its normal rated continuous current without exceeding ultimate standard temperature limits if the ambient temperature did not exceed the maximum ambient temperature assigned to the device in accordance with IEEE Std C37.40-2003, multiplied by an appropriate factor. Altitude correction factors are being studied by the Switchgear Committee, and will be added to IEEE Std C37.40-2003 directly or by reference when they are approved. In the meantime, users should consult the manufacturer for appropriate derating when the equipment is applied above 1000 m.

If, during service, the fuse will be subjected to mechanical vibratory stress that may damage the fuse element, the manufacturer should be consulted to verify that it can withstand these conditions.

## 4.3 Selection of class and type of fuse

No generalizations can be made about selecting the class and type of fuse that should be used at a particular location. In selection of the class of fuse, factors such as power being supplied, dielectric properties of the equipment being protected, X/R ratios, fault currents available, and transient recovery voltage (TRV) severity require consideration. The major classes of fuses are power class and distribution class.

### 4.3.1 Fuse class

#### 4.3.1.1 Power class fuses

Power class fuses are as follows:

- a) Generally used in three-phase applications.
- b) Generally used in substations, cabinets, or vaults where a large amount of electrical power is being supplied to a distribution system or in a facility that requires large quantities of energy.
- c) Generally used in that part of a system where high dielectric properties are required for all equipment.
- d) Normally placed in a position on the system where fault currents are high, X/R ratios are high, and TRV characteristics are more severe than those found in the applications where distribution fuses are used.
- e) Used in single-phase applications where severe faults, high X/R, or severe TRV is anticipated in an area where distribution fuses would normally be used.

#### 4.3.1.2 Distribution class fuses

Distribution class fuses are as follows:

- a) Generally used in single-phase applications.

- b) Generally used in the distribution line on single-phase taps for sectionalizing purposes or for protecting single-phase transformers supplying residential or small business energy requirements.
- c) Generally used in that part of a system where the requirements of the system can be accommodated by the distribution fuse's rated interrupting capabilities, and dielectric properties.
- d) Suitable for use in three-phase applications where the high capabilities of the power fuse are not required and other application requirements are met.

### 4.3.2 Fuse types

#### 4.3.2.1 Expulsion-type fuses

An expulsion fuse is a vented device in which the expulsion effect of the gases produced by the interaction of the arc with other parts of the fuse results in the current interruption in the circuit. A consideration in their application is the criteria that the gases expelled are properly directed, and that the noise and pressure created is acceptable. Some power class expulsion fuses can be provided with an exhaust-control device to virtually eliminate the effect of these gases. Manufacturers' recommendations for the use of expulsion-type fuses should be followed. In most cases, expulsion fuses do not appreciably limit the circuit's prospective fault current.

#### 4.3.2.2 Non-expulsion-type fuses

Non-expulsion-type fuses may be current-limiting or non-current-limiting. When a current-limiting fuse is exposed to a current high enough to produce melting before the first peak of current, it abruptly introduces sufficient resistance into the circuit to prevent that peak being reached. The lowest current at which a particular fuse exhibits this current-limiting action is called its threshold current. Typically, this current may be from about 25 to 50 times the fuse's current rating, depending on fuse design and circuit X/R. This guide will refer to such currents as "high" currents. Current-limiting fuses can also interrupt lower currents, ones that do not produce a current-limiting action. However, differences in the ability of certain types of design to interrupt these "low" currents leads to three different classes of current-limiting fuses—backup, general-purpose, and full-range. IEEE Std C37.48.1 discusses the design and application of current-limiting fuses in more detail. The major uses for non-expulsion-type fuses are in applications where the clearances to grounded parts are limited or the current-limiting properties of current-limiting fuses are required.

##### 4.3.2.2.1 Backup current-limiting fuse

This is a current-limiting fuse that provides only fault current interrupting duty from its rated maximum interrupting current down to its rated minimum interrupting current (see 5.1.3.1). Some auxiliary device is used to interrupt any lower faults or overcurrents. The low current interrupting ability of different types of backup fuses varies significantly. The minimum interrupting current of a particular type or rating may produce a melting time as short as a few cycles to as long as 1000 s or more.

##### 4.3.2.2.2 General-purpose current-limiting fuse

This is a current-limiting fuse that can satisfactorily interrupt high and low fault currents and overcurrents. It is required that a fuse must demonstrate an interrupting capability with currents as low as will cause the melting time of the fuse to be at least 1 h (see 5.1.3.2).

##### 4.3.2.2.3 Full-range current-limiting fuse

This is a current-limiting fuse that can satisfactorily interrupt high and low fault currents, as well as any overcurrent that causes the fuse to melt, with the fuse applied at its rated maximum application temperature specified (see 4.12.1 and 5.1.3.3).

#### 4.3.2.2.4 Non-current-limiting fuses

There are other types of non-expulsion-type fuses such as liquid fuses, vacuum fuses, or SF<sub>6</sub> fuses. However, their application is very special. In all cases the manufacturer's recommendations should be followed. These types of non-expulsion fuses do not appreciably limit the circuit's prospective fault current.

### 4.4 Clearances and spacing

Minimum electrical spacings and clearances for power fuse and disconnecting switch installations shall be in accordance with tables 7, 8, and 9 of ANSI C37.46-2000. The application should recognize the conditions prevalent during design testing (per IEEE Std C37.41-2000) and generally conform to the test clearances and conditions as a minimum, unless the manufacturer recommends the minimum clearances to be observed.

Expulsion fuses should be applied with adequate clearance in the direction or directions in which they are vented, and facilities should be provided to ensure that operators are not exposed to fuse discharges either during replacement or when working in the area. When this is not possible, the circuit should be de-energized.

### 4.5 Fuse position

The positioning of the fuses should be such that their operation is facilitated. When devices are used by a utility, the operating practices of that utility should be adhered to.

### 4.6 Noise level

Expulsion fuses may produce intense short-term noise levels during fault interruption. The height, location, and exhaust control of expulsion fuses should be such as to minimize the noise level at any location normally occupied by personnel. Some power-class expulsion fuses can be provided with an exhaust-control device to virtually eliminate the noise produced during an interruption.

### 4.7 Selection of fuse voltage rating

(See 5.4.2.2 and 5.4.3.2 for specific guidelines for voltage rating selection for capacitor fuses.)

The selection of the proper voltage rating for fuses is based on consideration of the following system parameters:

- a) Maximum system line-to-line or line-to-ground power-frequency recovery voltage.
- b) System neutral grounding.
- c) Single- or three-phase circuits

The rated voltage of expulsion fuses may exceed the system voltage by any desired amount. Care should be taken in applying current-limiting fuses with higher voltage ratings than the system voltage. Current-limiting fuses can produce peak arc voltages higher than the fuse voltage rating. These overvoltages should not exceed system and equipment insulation levels. The sparkover voltage of source side connected surge arresters should be considered. The fuse manufacturer's recommendations should be followed in this regard.

#### 4.7.1 Power class fuses

The fuse should have a maximum voltage rating equal to or exceeding the maximum system line-to-line voltage.

Most power fuses are used on three-phase applications. When used on a single-phase circuit of an effectively grounded system (see IEEE Std C62.92 for a description of system grounding), the fuse should have a maximum voltage rating of at least 1.15 times maximum line-to-ground voltage of the system. However, if the fuse has been tested for rated interrupting current at rated maximum voltage, or if the fault current where the fuse is to be applied does not exceed 87% of the fuse rated interrupting current, then the fuse need only have a maximum voltage rating equal to or greater than the maximum line-to-ground voltage of the system, when applied on a single-phase circuit of an effectively grounded system.

#### **4.7.2 Distribution class fuses**

##### **4.7.2.1 Fuses for ungrounded-neutral systems or systems having higher resistance grounding than effectively grounded neutral (multigrounded) systems**

A single-voltage rated distribution fuse should have a maximum voltage rating equal to or exceeding the maximum system line-to-line voltage. A slant-voltage-rated (multiple-voltage-rated) cutout (e.g., 15/27 kV) should have a maximum voltage rating to the left of the slant equal to or exceeding the maximum system line-to-line voltage.

##### **4.7.2.2 Fuses for effectively grounded-neutral (multigrounded) systems**

###### **4.7.2.2.1 Single-voltage-rated distribution fuses**

- a) In single-phase, line-to-neutral circuits, the fuse should have a maximum voltage rating equal to or exceeding the maximum system line-to-ground voltage, and a basic insulation level (BIL) coordinated with the line-to-ground insulation of other connected apparatus.
- b) In three-phase circuits where multiphase faults not involving ground can occur, the fuse should have a maximum voltage rating equal to or exceeding the maximum system line-to-line voltage.
- c) In three-phase circuits where multiphase faults not involving ground cannot occur or are unlikely (for example, where phase isolation is employed as in underground or cubicle construction), and the fuse is not required to protect transformers against secondary faults of the types that would impose greater than line-to-ground recovery voltage, the fuse may have a maximum voltage rating equal to or exceeding the maximum system line-to-ground voltage. It should have a BIL coordinated with the line-to-ground insulation of other connected apparatus. Another device may be required to clear transformer secondary faults, should they occur.

###### **4.7.2.2.2 Slant-voltage-rated (multiple-voltage-rated) distribution cutouts**

- a) In single-phase, line-to-neutral circuits, the cutout should have a maximum voltage rating to the left of the slant equal to or exceeding the maximum system line-to-ground voltage.
- b) In three-phase circuits, the cutout should have a maximum voltage rating to the right of the slant equal to or exceeding the maximum system line-to-line voltage. Some of the criteria for using slant-voltage-rated cutouts in three-phase circuits as herein set forth are:
  - 1) Three-phase faults not involving ground, which impose 87% of line-to-line voltage across the first cutout to clear, seldom occur. Operation of another device may be required to clear such faults, but experience indicates such cases are rare.
  - 2) Phase-to-phase faults not involving ground generally cause two cutouts to operate in series to clear the fault. Even with differences in fuse-link melting time, both cutouts work together to clear high-current faults. On medium-current faults, the possibility exists of load current continuing to flow through one of the cutouts, after fault clearing by series operation of the two cutouts. Operation of another device may be required if the cutout does not clear the continuing load current, but experience indicates that such cases are rare.