

UL 840

ISBN 1-55989-391-5

Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840

Second Edition, Dated May 20, 1993

Revisions: This Standard contains revisions through and including September 7, 2000.

UL is in the process of converting its Standards for Safety to the Standard Generalized Markup Language (SGML), and implementing an SGML compliant document management and publishing system. SGML - an international standard (ISO 8879-1986) - is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Significant benefits that will result from UL's use of SGML and these new systems include increased productivity, reduced turnaround times, and data and information consistency, reusability, shareability, and portability. However, the fonts, pagination, and general formatting of UL's new electronic publishing system differ from that of UL's previous publishing system. Consequently, when revision pages are issued for a Standard with the new publishing system, these differences may result in the printing of pages on which no requirements have been changed - these additional pages result from relocation of text due to repagination and reformatting of the Standard with the new publishing system.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions dated September 7, 2000 include a reprinted title page (page1) for this Standard.

The revisions dated October 6, 1999 were issued for editorial corrections. These corrections include any combination of the following: Updated Foreword (item D); Updated Scope; title changes to UL 489 and/or UL 1950; Withdrawn standards, UL 519 and UL 547, being replaced by UL 2111; Removal of the "94" flammability classification. These revisions may also include other miscellaneous editorial corrections.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

UL's Standards for Safety are copyrighted by UL. Neither a printed copy of a Standard, nor the distribution diskette for a Standard-on-Diskette and the file for the Standard on the distribution diskette should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if

the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

Copyright © 2000 Underwriters Laboratories Inc.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-3	September 7, 2000
4	April 1, 1999
5	September 7, 2000
6-6B	October 6, 1999
7-8A	September 7, 2000
8B	October 6, 1999
9-15	May 20, 1993
16-22B	April 1, 1999
23	January 30, 1995
24	May 20, 1993
25	January 30, 1995
26-27	May 20, 1993
28-29	January 30, 1995
32	April 1, 1999

No Text on This Page

MAY 20, 1993
(Title Page Reprinted: September 7, 2000)



1

UL 840

Standard for Insulation Coordination Including Clearances and Creepage

Distances for Electrical Equipment

First Edition – December, 1984

Second Edition

May 20, 1993

The most recent designation of UL 840 as an American National Standard occurred on May 12, 2000.

This ANSI/UL Standard for Safety, which consists of the Second edition with revisions through September 7, 2000, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to the UL-RTP Standards Department, 12 Laboratory Dr., Research Triangle Park, NC 27709.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

ISBN 1-55989-391-5

COPYRIGHT © 1989, 2000 UNDERWRITERS LABORATORIES INC.

No Text on This Page

CONTENTS

FOREWORD	4
----------------	---

INTRODUCTION

1 Scope	5
2 General	6
2.1 Insulation coordination	6
2.2 Undated references	7
2.3 Units of measurement	8
2.4 Components	8
3 Glossary	8

CONSTRUCTION

4 Clearance A (Equivalency)	9
5 Clearance B (Controlled Overvoltage)	9
6 Creepage Distances	11
7 Measurement of Clearance and Creepage Distances	16
7A <i>Reserved</i>	22A
7B Use of Coatings to Achieve Insulation Coordination	22A

PERFORMANCE

8 Switching Test	22A
9 Recurring Peak Voltage Determination	22B
10 Dielectric Voltage-Withstand Tests	22B
10.1 Testing in lieu of measuring clearances	22B
10.2 Testing for controlled overvoltage	23
11 Printed Wiring Board Coating Performance Test	23
11.1 General	23
11.2 Dielectric voltage-withstand test	25
11.3 Environmental cycling test	26
11.4 Humidity conditioning test	26
11.5 Thermal conditioning test	26
11.6 Coating adhesion	28
11.7 Insulation resistance between conductors	28
11.8 Impulse withstand voltage	28
11.9 Resistance to soldering heat	29
11.10 Flammability	29
11.11 Comparative tracking index (CTI)	29

FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover an alternate approach to specifying through air and over surface spacings for electrical equipment through the use of the principles of insulation coordination.

1.2 The complete principles of insulation coordination involve the consideration of the combination of clearances, creepage distances, and the properties of solid insulation used to constitute the insulation system. The empirical data gathered thus far has been used to develop the requirements for clearances and creepage distances as presented in this standard. The data needed to develop the evaluation procedure for solid insulation is still being gathered. When available, this evaluation procedure will be added to this standard and is not expected to affect the requirements for clearances and creepage distances.

1.3 These requirements may be used as an alternate to required spacing levels specified in end-product standards. The end product standard spacing requirements may be based on use and systems where overvoltages are not controlled, or if controlled, the level of control is unknown.

1.4 These alternate requirements are intended to be applied to a particular product category if the standard covering the product category specifically references UL 840 or any of the requirements therein.

1.5 Users of these requirements may need to specify the overvoltage levels and the methods of control which will be utilized, and establish the pollution degree to which the product insulation system will be expected to be subjected.

1.6 It is not intended that the test values in this standard be employed for production line testing. However, users of these requirements will need to establish a means to ensure that production controls applied to permit the spacing reduction remain in effect during the manufacture of the product. This could include sample testing or physical measurements or another equivalent means.

1.7 Users of these requirements will additionally need to ensure that influencing factors not addressed in this standard, such as mechanical movement, field placement of conductive material, and product damage, will not affect the system for insulation coordination. Examples are the deformation of the enclosure, movement of the fittings for conduit or armored cable, or the improper installation of field wiring. Clearances and creepage distances at those locations must be verified for compliance by physical measurement in accordance with Section 7, Measurement of Clearance and Creepage Distances.

1.8 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.8 revised September 7, 2000

2 General

2.1 Insulation coordination

2.1.1 This standard uses the principles of insulation coordination to provide requirements for clearances and creepage distances for electrical equipment. A design consideration is to prevent undesirable breakdowns in some areas due to their disruptive nature and potential for risk of fire and electric shock. Insulation coordination also requires the awareness of the insulating material properties so that design of the product can utilize the reduced spacing concept.

2.1.2 Insulation coordination, as evaluated and implemented through the use of this standard, can be achieved in a multiconcept process.

- a) The first concept detailed in Section 4, Clearance A (Equivalency), of this standard is an alternative approach to measuring spacings currently defined in various product standards. This approach uses a dielectric voltage-withstand test impulse to evaluate equivalence of designed spacings to the predefined dimension. An actual reduction in spacings can be permitted through a refinement in manufacturing techniques while maintaining equivalent breakdown levels.
- b) The second concept detailed in Section 5, Clearance B (Controlled Overvoltage), of this standard, a step in the insulation coordination process, is the selection of clearances based on the level of overvoltage protection and pollution degree.
- c) The third concept detailed in Section 6, Creepage Distances, of this standard is the selection of an appropriate set of creepage distances based on operating voltage, pollution degree and material tracking characteristics.
- d) The last concept, currently anticipated though not described in detail in this standard, is the choice of solid insulation to coordinate with the clearances and creepage distances chosen. The solid insulation must have suitable tracking properties for creepage considerations and it must have a breakdown level exceeding that of the controlled overvoltage level provided.

2.1.3 The database upon which these requirements are based is contained in the International Electrotechnical Commission (IEC) Publications for Insulation Coordination Within Low Voltage Systems Including Clearances and Creepage Distances for Equipment, 664, and the Supplement, IEC Publication 664A.

2.1.4 The data contained in these IEC documents relate the ability of clearances to withstand overvoltages based on the characteristics of the electrical field. For a specified overvoltage, an inhomogeneous field condition of two electrodes, which is represented by a point and a plane, requires the largest clearance. As the condition of the electric field is improved by control of electrode shape, the clearance required to withstand the overvoltage decreases. The limit for this decrease in clearance is that of the homogenous field which is represented by two parallel planes. Using this data it is possible to evaluate clearances by their ability to withstand overvoltages. It should be recognized that the use of this technique requires the regular rechecking of the ability of the clearance to withstand the prescribed overvoltage because of possible variations in the production process, the wearing of tools, or other factors that might influence the clearance or electrical field condition. The database may also be used to specify, for a given overvoltage, the inhomogeneous field clearance, and the continued provision of this clearance may be made by measurements of the clearance.

2.1.5 The data contained in these documents relating to the selection of creepage distances is based on an evaluation of empirical data coming from experience, and the results of extensive testing of certain combinations of materials in differing pollution degrees. The major variables for the selection of creepage distances are the arc tracking characteristics of the material used and the conditions of pollution. The four pollution degrees are based on the levels of moisture and contaminants at the creepage distance and therefore, the pollution degree which may exist.

2.1.6 The values for creepage distances presented in this standard are for equipment being subjected to long term stress. Many products, and circuits within those products, are only subjected to short term or intermittent stress. End-product standards can permit a reduction in minimum creepage distance based on this use factor. A single row reduction (in Table 6.1) while maintaining the same pollution degree and material group, would be typical.