

# IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations

Sponsor  
**Nuclear Power Engineering Committee  
of the  
IEEE Power Engineering Society**

Approved June 27, 1991  
**IEEE Standards Board**

**Abstract:** Establishes minimum functional design criteria for the power, instrumentation, and control portions of nuclear power generating station safety systems. The criteria are to be applied to those systems required to protect the public health and safety by functioning to mitigate the consequences of design basis events. The intent is to promote safe practices for design and evaluation of safety system performance and reliability. Although the standard is limited to safety systems, many of the principles may have applicability to equipment provided for safe shutdown, post-accident monitoring display instrumentation, preventive interlock features, or any other systems, structures, or equipment related to safety.

**Keywords:** Actuated equipment, associated circuits, Class 1E, design, failures, maintenance bypass, operating bypass, protection, safety function, sense and command features, sensor.

---

The Institute of Electrical and Electronics Engineers, Inc.  
345 East 47th Street, New York, NY 10017-2394, USA

Copyright © 1991 by the Institute of Electrical and Electronics Engineers, Inc.  
All rights reserved. Published 1991  
Printed in the United States of America

ISBN 1-55937-144-7

*No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.*

**IEEE Standards** documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

**Interpretations:** Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board  
445 Hoes Lane  
P.O. Box 1331  
Piscataway, NJ 08855-1331  
USA

IEEE Standards documents are adopted by the Institute of Electrical and Electronics Engineers without regard to whether their adoption may involve patents on articles, materials, or processes. Such adoption does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the standards documents.

## Foreword

(This Foreword is not a part of IEEE Std 603-1991, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.)

This standard establishes minimum functional design criteria for the power, instrumentation, and control portions of nuclear power generating station safety systems. These criteria are established to provide a means for promoting safe practices for design and evaluation of safety system performance and reliability. However, adhering to these criteria will not necessarily fully establish the adequacy of any safety system's functional performance and reliability; nonetheless, omission of any of these criteria will, in most instances, be an indication of safety system inadequacy.

## Application

The criteria established by this standard apply to those systems defined as safety systems and do not necessarily apply to all of the systems, structures, and equipment required for complete plant safety. Although the scope is limited to safety systems, many of the principles may have applicability to equipment provided for safe shutdown, accident monitoring display instrumentation, preventive interlock features, or any other systems, structures, or equipment related to safety, or all of the above.

To determine those systems subject to these criteria, an analysis of the overall plant response to postulated design basis events shall be performed. Good engineering judgment should be exercised in this analysis to assure that adequate margins exist in the design to protect the health and safety of the public without imposing unduly restrictive criteria on the design.

## Interdisciplinary Approach

The safety system criteria herein are established using a systems approach to the design of the power, instrumentation, and control portion of the safety system, as opposed to a specific engineering discipline approach (that is, electrical, mechanical, or civil). It shall be recognized that the safety functions cannot be accomplished without mechanical, as well as electrical equipment and circuitry. Therefore, the design by other than electrical engineering disciplines, primarily mechanical and nuclear engineering, should consider these criteria. In order for the safety system to meet the requirements of this standard and the supportive standards, the aggregate design of the safety system (without regard to discipline) may be constrained. Such constraints are themselves implicit interface requirements imposed upon the individual constituent parts to enable the entire safety system to meet these requirements. The areas where this standard interfaces with other standards are shown in Fig 1.

While this standard takes a systems approach to the design of the power, instrumentation, and control portion of the safety system, it does not attempt to establish new or different criteria for mechanical equipment or components. Such an attempt by a user is a misapplication of this standard. Nor does this standard attempt to establish the system level requirements that may be required by mechanical or civil equipment; for example, in-service inspection of piping is intentionally excluded. This standard is to provide criteria for the safety system without conflicting with existing standards. This standard is not intended to duplicate or conflict with component design requirements such as the ASME Boiler and Pressure Vessel Code. Rather, this standard is to complement and interface with such documents. This standard and others (for example, ANSI/ANS 51.1-1983 and ANSI/ANS 52.2-1983) establish systems criteria while other codes and standards establish detailed design requirements necessary to ensure the functional adequacy of the individual constituent parts of the safety system.

## Evolution

This standard was evolved from IEEE Std 603-1980, Standard Criteria for Safety Systems for Nuclear Power Generating Stations. It represents the fifth Subcommittee 6 (SC-6) publication of a systems criteria document. The series began with IEEE Std 279-1968, a trial-use protection system standard, followed by IEEE Std 279-1971, a full

protection system standard; IEEE Std 603-1977, a trial-use standard for safety systems; and IEEE Std 603-1980, a full safety system standard.

## Relationship to Other Standards

This standard establishes functional and design criteria that are general in nature. It requires supportive standards containing both general and detailed criteria to comprise a minimal set of requirements for the safety system.

Other IEEE standards prepared in support of the criteria of this standard are referenced throughout this standard. The American National Standards, in particular ANSI/ANS 51.1-1983 and ANSI/ANS 52.1-1983, also contain functional and design criteria for safety systems.

## Purpose of Revision

During the development of IEEE Std 603-1980, six future tasks were identified. Those tasks have been completed. The result is that changes to the Standard were found to be important regarding some definitions and criteria for shared systems. In addition, position papers were prepared and presented at Power Engineering Society meetings on safe shutdown (IEEE-PES-WM 1983) and automatic termination of protective action (IEEE-PES-SM 1985). A position paper on diversity has been prepared and is planned for presentation in the near future.

The American National Standards Institute endorsed IEEE Std 603-1980 in 1987. Their endorsement took the form of a published correction sheet designated ANSI/IEEE Std 603-1980. It included mostly editorial changes, some changes in references and a few text clarifications. The corrections by ANSI have been addressed in this revision.

The U.S. Nuclear Regulatory Commission endorsed IEEE Std 603-1980 with Regulatory Guide 1.153 in December 1985. R.G. 1.153 stated five modifications/supplements to IEEE Std 603-1980. Three of the USNRC items resulted in changes included in this revision. They deal with clarification of Fig 6 of this standard, clarification of the criteria for interaction between sense and command features and other systems, and a change in the language used in the definition of safety system. The definition of the term “safety system” now agrees with that used in Section 50.49 of 10 CFR 50. The two other USNRC items deal with how the NRC will use standards referenced in IEEE Std 603 and did not result in changes in the document.

The Instrument Society of America asked that the determination of setpoints be consistent with how they specify them in standard ISA S67.04. The standard has been revised to refer to the ISA document for direction.

Other changes included cover consideration of human factors, clarification of the design basis event requirements for critical points in time or the plant conditions, and update of the references.

## Future Work

Definitions have been changing in the industry. It will be a future work task for the work group to review the definitions, together with ASME, ANS and the ISA, to standardize terms and maximize clarity.

This document was prepared by the Safety-Related Systems Working Group SC 6.3 of the IEEE Nuclear Power Engineering Committee. The members of the working group were:

**Britton P. Grim, Chair**

W. W. Bowers  
R. L. Copyak  
P. M. Holzman

R. Kendall  
R. L. Olson  
G. Peterson

D. Sokolsky  
D. J. Zaprazny

The following persons were on the balloting committee that approved this standard for submission to the IEEE Standards Board:

S. K. Aggarwal  
R. E. Allen  
J. T. Bauer  
F. D. Baxter  
W. W. Bowers  
D. F. Brosnan  
N. M. Burstein  
S. P. Carfagno  
R. Carruth  
G. L. Doman  
E. F. Dowling  
R. E. Dulski  
N. C. Farr  
R. Fleming  
J. R. Fragola  
J. M. Gallagher

W. C. Gangloff  
L. W. Gaussa, Sr.  
L. C. Gonzalez  
L. Gradin  
B. P. Grim  
A. R. Hall  
R. E. Hall  
G. K. Henry  
S. Kasturi  
J. T. Keiper  
D. C. Lampken  
J. D. LaMont  
A. Marion  
R. D. Miller  
B. Nemroff  
M. Pai

J. R. Penland  
W. K. Peterson  
C. A. Petrizzo  
N. S. Porter  
W. S. Raughley  
E. W. Rhoads  
A. R. Roby  
W. G. Schwartz  
A. F. Sleva  
P. B. Stevens  
P. Szabados  
L. D. Test  
J. E. Thomas  
J. T. Ullo  
F. J. Volpe

When the IEEE Standards Board approved this standard on June 27, 1991, it had the following membership:

**Marco W. Migliaro**, *Chair*  
**Donald C. Loughry**, *Vice Chair*  
**Andrew G. Salem**, *Secretary*

Dennis Bodson  
Paul L. Borrill  
Clyde Camp  
James M. Daly  
Donald C. Fleckenstein  
Jay Forster\*  
David F. Franklin  
Ingrid Fromm  
Thomas L. Hannan

Donald N. Heirman  
Kenneth D. Hendrix  
John W. Horch  
Ben C. Johnson  
Ivor N. Knight  
Joseph L. Koepfinger\*  
Irving Kolodny  
Michael A. Lawler  
John E. May, Jr.

Lawrence V. McCall  
Donald T. Michael\*  
Stig L. Nilsson  
John L. Rankine  
Ronald H. Reimer  
Gary S. Robinson  
Terrance R. Whittemore

Deborah A. Czyz  
*IEEE Standards Project Editor*

\*Member Emeritus

| CLAUSE                                                                         | PAGE |
|--------------------------------------------------------------------------------|------|
| 1. Scope .....                                                                 | 1    |
| 1.1 Illustration .....                                                         | 1    |
| 1.2 Application .....                                                          | 3    |
| 2. Definitions.....                                                            | 5    |
| 3. References .....                                                            | 7    |
| 4. Safety System Designation .....                                             | 8    |
| 4.1 .....                                                                      | 8    |
| 4.2 .....                                                                      | 8    |
| 4.3 .....                                                                      | 9    |
| 4.4 .....                                                                      | 9    |
| 4.5 .....                                                                      | 9    |
| 4.6 .....                                                                      | 9    |
| 4.7 .....                                                                      | 9    |
| 4.8 .....                                                                      | 9    |
| 4.9 .....                                                                      | 10   |
| 4.10 .....                                                                     | 10   |
| 4.11 .....                                                                     | 10   |
| 4.12 .....                                                                     | 10   |
| 5. Safety System Criteria .....                                                | 10   |
| 5.1 Single-Failure Criterion .....                                             | 10   |
| 5.2 Completion of Protective Action .....                                      | 11   |
| 5.3 Quality .....                                                              | 11   |
| 5.4 Equipment Qualification .....                                              | 11   |
| 5.5 System Integrity .....                                                     | 11   |
| 5.6 Independence .....                                                         | 12   |
| 5.7 Capability for Test and Calibration.....                                   | 13   |
| 5.8 Information Displays.....                                                  | 13   |
| 5.9 Control of Access.....                                                     | 14   |
| 5.10 Repair .....                                                              | 14   |
| 5.11 Identification .....                                                      | 14   |
| 5.12 Auxiliary Features .....                                                  | 14   |
| 5.13 Multi-Unit Stations .....                                                 | 14   |
| 5.14 Human Factors Considerations .....                                        | 15   |
| 5.15 Reliability .....                                                         | 15   |
| 6. Sense and Command Features—Functional and Design Requirements.....          | 15   |
| 6.1 Automatic Control.....                                                     | 15   |
| 6.2 Manual Control .....                                                       | 15   |
| 6.3 Interaction Between the Sense and Command Features and Other Systems ..... | 16   |
| 6.4 Derivation of System Inputs .....                                          | 16   |
| 6.5 Capability for Testing and Calibration.....                                | 16   |
| 6.6 Operating Bypasses.....                                                    | 17   |
| 6.7 Maintenance Bypass .....                                                   | 18   |
| 6.8 Setpoints.....                                                             | 18   |

| CLAUSE                                                                                                                              | PAGE |
|-------------------------------------------------------------------------------------------------------------------------------------|------|
| 7. Executive Features—Functional and Design Requirements.....                                                                       | 18   |
| 7.1 Automatic Control.....                                                                                                          | 18   |
| 7.2 Manual Control .....                                                                                                            | 18   |
| 7.3 Completion of Protective Action .....                                                                                           | 18   |
| 7.4 Operating Bypass .....                                                                                                          | 19   |
| 7.5 Maintenance Bypass .....                                                                                                        | 19   |
| 8. Power Source Requirements .....                                                                                                  | 19   |
| 8.1 Electrical Power Sources .....                                                                                                  | 19   |
| 8.2 Non-electrical Power Sources .....                                                                                              | 19   |
| 8.3 Maintenance Bypass .....                                                                                                        | 19   |
| Annex A (Informative) Illustration of Some Basic Concepts for Developing the Scope of a Safety System.....                          | 20   |
| Annex B (Informative) Other Standards That Provide Additional Information That May Be Useful<br>in Applying IEEE Std 603-1991 ..... | 29   |

# IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations

## 1. Scope

The criteria contained in this standard establish minimum functional and design requirements for the power, instrumentation, and control portions of safety systems for nuclear power generating stations. To satisfy the criteria in this standard, interface requirements may be imposed on the other portions of the safety system as shown in Fig 1. Safety system functional and design criteria are also contained in other standards.<sup>1</sup>

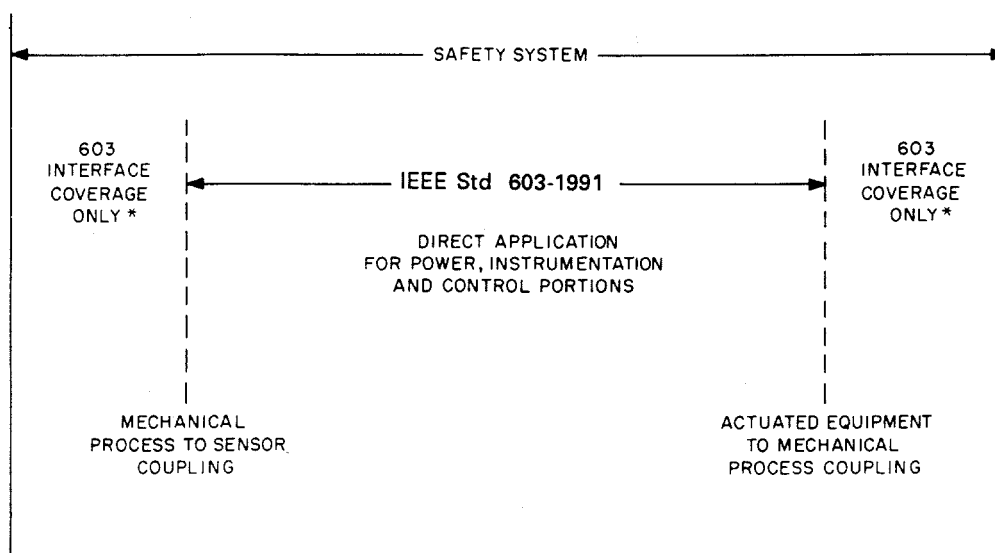
### 1.1 Illustration

Figure 2 illustrates the scope of this standard in the form of a 3×3 matrix. The labeling across the top of the matrix illustrates that the safety systems can be subdivided into the three general elements of sense and command features, execute features, and power sources. These general elements represent a grouping of devices that provides similar performance characteristics for many discrete safety functions. The labeling on the left side of the matrix illustrates that the safety systems can also be subdivided into the three operational elements of reactor trip system and engineering safety features, auxiliary supporting features, and other auxiliary features. When viewing an entire row of the matrix, it can be seen that an operational element may form a system.

Illustrating the scope of this standard in matrix form shows that each operational element contains one or more general elements. This matrix should not be interpreted to mean that every operational element shall contain all of the general elements or that a particular general element is limited to application in only one operational element.

---

<sup>1</sup>See Section 3 and Appendix B for applicable standards.



\*The criteria herein are directed to the power, instrumentation, and control portions of the safety system. To satisfy these criteria, interface requirements may be imposed on the other portions of the safety system.

**Figure 1—Nonelectrical Interface Scope Diagram**

|                                            |                                                                | GENERAL ELEMENTS<br>OF A SAFETY SYSTEM |                     |                  |
|--------------------------------------------|----------------------------------------------------------------|----------------------------------------|---------------------|------------------|
|                                            |                                                                | SENSE AND<br>COMMAND<br>FEATURES       | EXECUTE<br>FEATURES | POWER<br>SOURCES |
| OPERATIONAL ELEMENTS<br>OF A SAFETY SYSTEM | REACTOR TRIP<br>SYSTEM AND<br>ENGINEERED<br>SAFETY<br>FEATURES |                                        |                     | N/A              |
|                                            | AUXILIARY<br>SUPPORTING<br>FEATURES                            |                                        |                     |                  |
|                                            | OTHER<br>AUXILIARY<br>FEATURES                                 |                                        |                     |                  |

## NOTES:

- 1 — The protection system of IEEE Std 279-1971 (withdrawn) and of this standard is the sense and command features for the reactor trip system and the engineered safety features.
- 2 — Power sources, by definition, are considered auxiliary supporting features or other auxiliary features and, therefore, are not shown as part of the reactor trip system and engineered safety features.
- 3 — When viewing an entire single row of the matrix, it can be seen that an operational element may form a system; for example, a service water system. However, when viewing an entire column, general elements represent a grouping of devices that provide similar performance characteristics (for example, sensors) for many discrete safety functions.
- 4 — Each operational element contains one or more general elements. Every operational element does not necessarily contain all of the general elements.
- 5 — A device that serves as a general element is not necessarily limited to application in only one operational element.

**Figure 2—3 × 3 Matrix Representation of Safety System**

Figure 3 illustrates typical equipment examples for each portion of the matrix diagram. As shown, some components can be fitted into more than one category depending on the component's use.

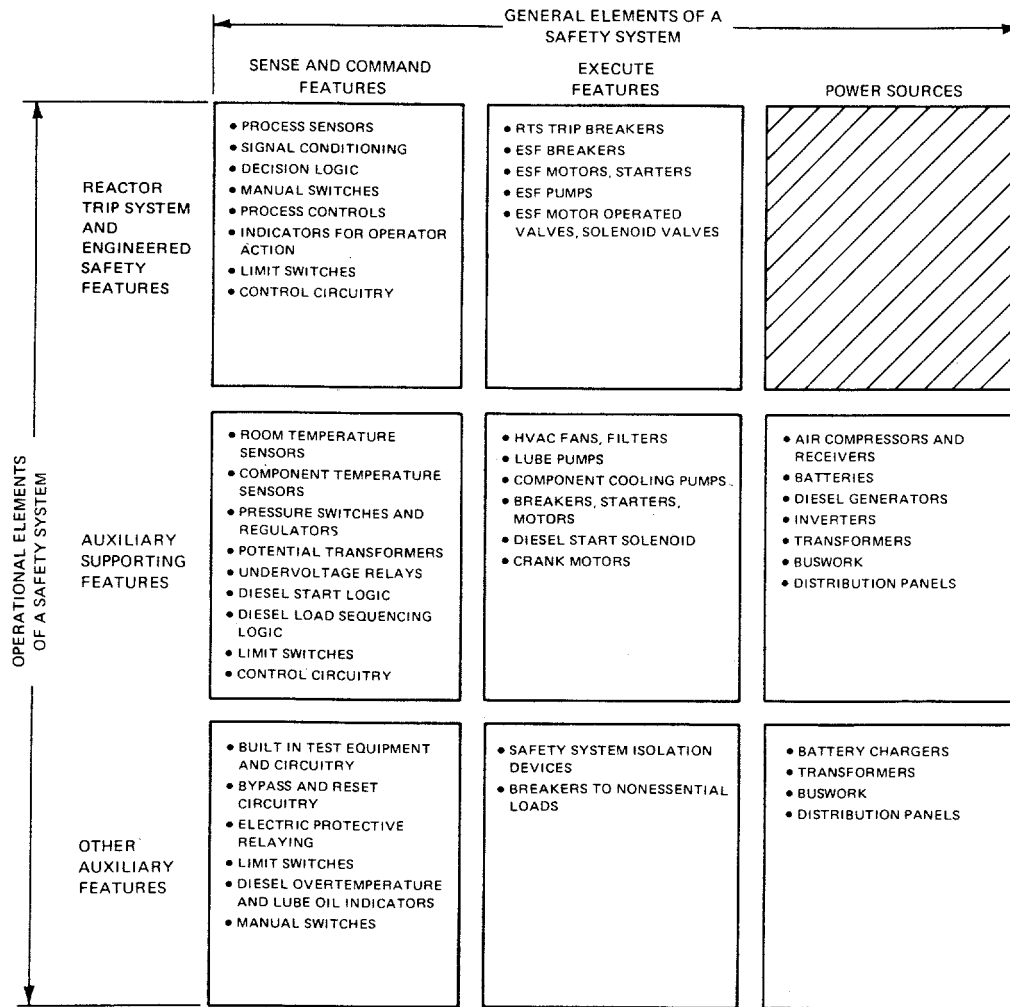
Figure 4 illustrates where criteria for each portion of the matrix can be found in this standard.

## 1.2 Application

The safety system criteria established herein are to be applied to those systems required to protect the public health and safety by functioning to prevent or mitigate the consequences of design basis events. However, this standard does not apply to all of the systems, structures, and equipment required for complete plant safety, for example, fire protection systems.

Guidance on the application of these criteria for safety systems using digital programmable computers is provided in IEEE/ANS 7.4.3.2-1982 [13]<sup>2</sup>.

<sup>2</sup>The numbers in brackets correspond to those of the references listed in Section 3.



## NOTES:

1 — The items listed are only representative examples as to inclusion or location in the matrix.

2 — See Fig 2 for additional notes.

**Figure 3—Examples of Equipment Fitted to Safety System Scope Diagram**