

IEEE Guide to Classification for Software Anomalies

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Abstract: This guide provides supporting information to assist users applying the IEEE Std 1044-1993, IEEE Standard Classification for Software Anomalies, to decide whether to conform completely to or just extract ideas from IEEE Std 1044.1. This guide will enable users of IEEE Std 1044-1993 to implement and customize IEEE Std 1044-1993 for their organization in an effective and efficient manner.

Keywords: anomaly, category, classification, software, supporting data item

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Introduction

(This introduction is not a part of IEEE Std 1044.1-1995, IEEE Guide to Classification for Software Anomalies.)

On most projects, some formality in reporting anomalies allows you to record the facts and impressions about an anomaly when it is encountered so that it can be understood by someone at a later date. Typically, information about what happened, how it happened, and the environment in which it happened are put into the anomaly reports. IEEE Std 1044-1993 calls this information “supporting data items.” Armed with this information, the anomaly can be reproduced, a fix can be applied, and the new program can be verified not to have the same anomaly symptoms. Many anomaly tracking information systems of this type are well documented, have been used successfully for years, and are thought of as good anomaly tracking systems.

However, when an organization begins to mature, the universal software quality question is asked: “How best can we get rid of the bugs in our products or prevent them from happening?” To effectively answer this question, you need more information about the anomalies that have been found in the software. Knowing the date, submitter, software version, and module an anomaly was reported against usually does not point in the direction of problem areas. The information that will facilitate the discovery of “common errors made,” “most effective activity to find anomalies,” “the place where anomalies were first introduced,” and other telling facts about your development process comes from classification analysis of each anomaly reported. This is where application of the IEEE Std 1044-1993 classification scheme will prove invaluable.

Implementing IEEE Std 1044-1993 can lead to better project management decisions, increased depth of data analysis, and improved software development processes. The consistent historical data allows trend analysis through several releases of the same project, several projects, and/or organizations. This historical consistency of data makes it possible to measure the effects of any process changes you implement from release to release, project to project, or organization to organization. Additionally, using a database and change control procedure reduces the labor of tracking changes, analyzing data, and providing an audit trail. This guide provides the alternatives and methods for getting the most out of IEEE Std 1044-1993.

Many benefits of using IEEE Std 1044-1993 could be obtained by using any classification scheme. However, the big advantage of IEEE Std 1044-1993 is the effort saved by not re-inventing and debating yet another bug taxonomy. Also, wide-spread use of IEEE Std 1044-1993 means that eventually industry-wide information will be available to use for comparative purposes or to benchmark the process(es) used in software development.

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IEEE Guide to Classification for Software Anomalies

1. Overview

1.1 Purpose

The purpose of this guide is to provide supporting information to assist users who are applying the IEEE Std 1044-1993¹, IEEE Standard Classification for Software Anomalies, whether to conform completely to IEEE Std 1044-1993 or just to extract ideas from it. The guide will enable users of IEEE Std 1044-1993 to implement and customize IEEE Std 1044-1993 for their organization in an effective and efficient manner.

1.2 Scope

This guide accomplishes the following tasks:

- a) Describes how to apply IEEE Std 1044-1993
- b) Describes what is and is not compliant customization by
 - 1) Providing examples of use and customization
 - 2) Providing example definitions of classification terms and situations where different definitions might be applicable
- c) Provides some additional explanation of the “supporting data items” from IEEE Std 1044-1993
- d) Provides examples of measures that can be derived from the classification data
- e) Provides examples of where those metrics are useful
- f) Describes methods for analyzing the classification data

¹Information about references can be found in clause 2.

1.3 Goals

The goals of this guide are as follows:

- a) To facilitate the determination of the level of conformance and amount of detail in IEEE Std 1044-1993 that is appropriate to the organization
- b) To define the difference between conforming to IEEE Std 1044-1993 and using it as a reference in the organization's anomaly classification scheme

1.4 Audiences

This guide serves two audiences. The primary audience is those persons working on a project required to use IEEE Std 1044-1993 and looking for information to help implement IEEE Std 1044-1993 on their project. The second audience is comprised of the project managers or organization managers wishing to start or expand an anomaly tracking system and looking for proven methodologies to support that effort.

2. References

This guide shall be used in conjunction with the following publication:

IEEE Std 1044-1993, IEEE Standard Classification for Software Anomalies.²

3. Definitions

The IEEE Std 1044-1993 anomaly classification scheme consists of categories and classifications. The classification scheme is hierarchical in nature. Categories, the top level, represent attributes of an anomaly you might want to classify. Classifications within each category are hierarchical lists of choices to describe the attribute.

3.1 anomaly: Any condition that deviates from the expected based on requirements specifications, design documents, user documents, standards, etc. or from someone's perceptions or experiences. Anomalies may be found during, but not limited to, the review, test, analysis, compilation, or use of software products or applicable documentation.

3.2 category: An attribute of an anomaly to which a group of classifications belongs. A specifically defined division in a system of classification; class.

3.3 classification: A choice within a category to describe the category (attribute) of an anomaly.

3.4 supporting data item: Data used to describe an anomaly and the environment where it was encountered.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

4. Getting started

So, how do you use IEEE Std 1044-1993 most effectively? To start, consider whether you want to review it for ideas on enhancing your existing anomaly classification scheme, or whether you intend to implement IEEE Std 1044-1993 in your organization.

The following process can help you determine what makes the most sense for the project, software development method, life cycle, and organization. These steps assume that you have read IEEE Std 1044-1993 and recognize the terminology used in that standard. Use the following steps and questions as a guide to determine the extent to which you want to use IEEE Std 1044-1993 within your organization:

- a) What categories are you currently recording? Refer to clause 5 of this guide for a discussion of what “categories” are, the usefulness of each, and which are mandatory for compliance to IEEE Std 1044-1993.
 - 1) None — go to next step
 - 2) Some — list them and map them to IEEE Std 1044-1993 (the terms you currently used may be different)
- b) Is conformance to IEEE Std 1044-1993 required?
 - 1) Yes — select mandatory categories, consider each of the optional categories
 - 2) No — consider each of the categories
- c) List the categories to be considered. For each category, ask the following questions:
 - 1) Can it be classified easily within your organization?
 - i) Yes — select it
 - ii) No — continue with (2) below
 - 3) Could you use the data now or at any time in the future? (Take a quick look at clause 10 to get some ideas for how you might want to use the data)
 - i) Yes — select it
 - ii) No — continue with (3) below
 - 3) Would you consider hiring a consultant to collect, analyze, and/or produce this information?
 - i) Yes — select it
 - ii) No — do not select this category
- d) For each category selected, decide which ones are essential for your business today and flag them as mandatory. Naturally, if conformance to IEEE Std 1044-1993 is required, then all of IEEE Std 1044-1993’s mandatory categories will be mandatory for your organization.

When you start using the new anomaly tracking system, it is suggested you minimize the mandatory categories for which you require users to enter data. After the organization becomes comfortable with the anomaly database and realizes a need for complete data, then mandate additional categories as appropriate. If you meet resistance to the data collection, asking people after the fact to “fill in the blanks” encourages them to think about anomaly classification. Knowing how the data will be analyzed and applied also encourages filling in the information—simply knowing that the data will be analyzed (that the effort of providing the information is not futile) can provide sufficient encouragement.

- e) For each category selected, list the classifications to be used by your organization. Consider the following, and refer to clause 6 of this guide for a complete discussion of classifications, how to use them, how to define them, how to select them, and how to augment them.
 - 1) Start with the highest-level classifications
 - 2) Classify a set of anomalies using the selected categories and the high-level classifications
 - 3) Does this high-level scheme make sense to you?

- 4) Add detail (lower hierarchy of classifications) to the categories that are not sufficiently differentiated
- 5) Create/invent new classifications within the categories for special cases found in your organization and projects
- f) Document the categories. Define what the organization means by each category, using the organization's terminology and references. Use clause 5 and annex A of this guide to get started on the definitions.
- g) Document the classifications. Write sentences or paragraphs to describe exactly what the classifications mean to your organization, using your organization's terminology. Use 6.1 and annex A of this guide to get started on the definitions.
- h) If conformance or reference to IEEE Std 1044-1993 is important to you, document your implementation with respect to IEEE Std 1044-1993. Produce a traceability matrix (similar to that shown in table 12) and provide a conformance rationale.
- i) The supporting data items complete the anomaly tracking system. Table 13 represents those pieces of information that may be used to isolate, fix, and track the anomaly. Read through the supporting data items included in IEEE Std 1044-1993 to determine if there are any that sound like good ideas. Remember, there is no requirement in IEEE Std 1044-1993 to use any of the supporting data items. They are listed merely as seeds to get you thinking. Clause 7 of this guide discusses the supporting data items with a slightly different perspective from IEEE Std 1044-1993 in order to help you define which supporting data items to collect.
- j) Document all new supporting data items you are adding to your anomaly tracking system. Again, use your organization's terminology and pertinent examples.
- k) For each category, identify when during your anomaly tracking process the data is available. Clause 8 of this guide describes examples of anomaly processing, and suggests when during that process (from a variety of perspectives) to collect classification data.
- l) Determine how you are going to incorporate the classification of data into your anomaly tracking process. Clause 9 of this guide describes several different methodologies you may be using or may want to consider.
- m) Plan how you are going to use the data and how you are going to inform others of analysis performed on the data. This will help you to answer the question in step c.2) above, and you plan for getting the most out of using the classification scheme. Clause 10 of this guide describes valid statistical analysis and a variety of ways in which you can use the classification data to improve your project management, process improvement, and product assessment. Collect the classification data to answer the questions that are most important.
- n) Provide training on the classification scheme to your users and to management. Train your users so they are starting with the same understanding. Make sure they know where to find definitions, and make sure they know how you are planning to use the data. This is important to gain their buy-in, to motivate them to take more interest, and to be more regular, accurate and complete in their data entry. Train your management on how you plan to analyze and use the data collected. This will give them a greater interest in the data so that they will encourage their staff to be accurate and complete in their data entry.

5. Categories

The mandatory categories established in IEEE Std 1044-1993 are the minimum set of categories needed to establish a common definition and provide common terminology and concepts to communicate among projects, business environments, and personnel. There is probably some overlap with data you currently collect. Implementation of IEEE Std 1044-1993 for compliance shall include documenting the traceability matrix between the IEEE Std 1044-1993 codes and your classification schema. Think of this traceability matrix as a way to audit conformance to IEEE Std 1044-1993.

Compare your current method with IEEE Std 1044-1993, looking for similarities and adding additional classifications to your chosen categories where necessary. Include all of the categories you might use. If others start using some of the categories and get feedback from the analysis of that data, they will want to use more categories or greater levels of classification detail in order to learn more about what is happening. For that reason, start by requiring the use of only your essential categories. The use of additional categories will follow naturally. Using the codes in IEEE Std 1044-1993 (RR100, IV200, AC100, IM300, DP123, etc.), even if strictly internal to the database, will facilitate comparison of data with others in the industry.

5.1 Category meanings

The following lists show each category, its associated process step, and the question that category should answer. According to IEEE Std 1044-1993, impact identification may occur at any time during the four process steps; however, in practice, the impact categories generally fit best into the Recognition and Investigation anomaly processing steps.

The Recognition categories and their meanings are as follows:

Recognition categories	Definition
Product Status	What is the usability of the product with no changes?
Project Activity	What were you doing when the anomaly occurred?
Project Phase	In which life cycle phase is the product?
Repeatability	Could you make the anomaly happen more than once?
Suspected Cause	What do you think might be the cause?
Symptom	How did the anomaly manifest itself?

The Impact categories that might be classified during the Recognition step are the following:

Recognition Impact categories	Definition
Customer Value	How important a fix is to customers?
Mission/Safety	How bad was the anomaly with respect to project objectives or human well-being?
Severity	How bad was the anomaly in more objective engineering terms?

The Investigation categories and their meanings are as follows:

Investigation categories	Definition
Actual cause	What caused the anomaly to occur?
Source	Where was the origin of the anomaly?
Type	What type of anomaly/enhancement at the code level?

The Impact categories that might be classified during the Investigation step are the following:

Investigation impact categories	Definition
Priority	Rank the importance of resolving the anomaly (subjective)
Project cost	Relative effect on the project budget to fix
Project quality/reliability	Impact to the product quality or reliability to make the fix
Project risk	Risk associated with implementing a fix
Project schedule	Relative effect on the product schedule to fix
Societal	Impact to society of implementing the fix

The Action categories and their meanings are as follows:

Action categories	Definition
Corrective action	What to do to prevent the anomaly from happening again
Resolution	What action to take to resolve the anomaly

The Disposition category and its meaning are as follows:

Disposition category	Definition
Disposition	What actually happened to close the anomaly

You may update the impact classifications during any of the steps of the anomaly process, or you might restrict modification of certain Impact categories to certain steps. The partitioning described in the above lists have been found to be practical for assigning classifications in the Impact categories.

5.2 Standard compliance at the category level

To comply with IEEE Std 1044-1993, an implementation shall include all 11 mandatory categories from IEEE Std 1044-1993. Table 1 lists the mandatory categories according to IEEE Std 1044-1993. Table 2 lists the optional categories.

Table 1—Category use required for compliance with IEEE Std 1044-1993

IEEE Std 1044-1993—Mandatory categories	
Code	Category
IV100	Actual cause
DP100	Disposition
RR100	Project activity
IM600	Project cost
RR200	Project phase
IM500	Project schedule
AC100	Resolution
IM100	Severity
IV200	Source
RR500	Symptom
IV300	Type

Table 2— Category use optional for compliance with IEEE Std 1044-1993

IEEE Std 1044-1993—Optional categories	
Code	Category
AC200	Corrective action
IM300	Customer value
IM400	Mission/safety
IM200	Priority
RR600	Product status
IM800	Project quality/reliability
IM700	Project risk
RR400	Repeatability
IM900	Societal
RR300	Suspected cause

Exactly which categories you determine to be essential within your organization may vary. For example, table 3 shows the categories used by each of four organizations (A–D) who have experimented with IEEE Std 1044-1993. The final column in table 3 compares these organizations' category choices to the categories labeled *mandatory* in IEEE Std 1044-1993.

Table 3—Mandatory categories used by four organizations compared to IEEE Std 1044-1993

IEEE Std 1044-1993 Category	Organization				Mandatory in IEEE Std 1044-1993
	A	B	C	D	
Actual cause	✓	✓	✓	✓	✓
Corrective action					
Customer value			✓	✓	
Disposition	✓	✓		✓	✓
Mission/safety					
Priority			✓	✓	
Product status					
Project activity	✓	✓	✓	✓	✓
Project cost	✓			✓	✓
Project phase	✓	✓	✓	✓	✓
Project quality/reliability					
Project risk					
Project schedule	✓	✓	✓	✓	✓
Repeatability					
Resolution	✓	✓	✓	✓	✓
Severity	✓	✓	✓	✓	✓
Societal					
Source	✓	✓	✓	✓	✓
Suspected cause					
Symptom	✓	✓	✓	✓	✓
Type	✓		✓	✓	✓

In this example, organizations A and D can claim full compliance with IEEE Std 1044-1993 because only they use all categories defined as *mandatory* in IEEE Std 1044-1993.

6. Classifications

There are several ways to customize the IEEE Std 1044-1993 classifications, as follows:

- a) Define the classifications
- b) Add classifications
- c) Ignore classifications
- d) Rename classifications

6.1 Establishing classification definitions

IEEE Std 1044-1993 assumes you will provide definitions for the classifications you use. This way you can create definitions to best fit your organization's products. Example definitions are included in annex A to either use as is or to help you get started developing definitions customized to your organization.

The Customer Value field provides a useful illustration of how different definitions apply to different organizations. Table 4 shows the classifications for Customer Value from IEEE Std 1044-1993.

Table 4—Customer Value classifications from IEEE Std 1044-1993

IEEE Std 1044-1993—Customer Value	
Code	Classification
IM310	Priceless
IM320	High
IM330	Medium
IM340	Low
IM350	None
IM360	Detrimental

Tables 5 and 6 show two different examples of classification definitions for the same category (Customer Value). An organization selling commercial, off-the-shelf software to many customers might use the definitions for Customer Value shown in table 5, whereas an organization satisfying a single customer might instead use the definitions shown in table 6. Note that in table 6 the number of classifications was reduced from 6 to 4, so technically this example does not comply with IEEE Std 1044-1993 because it does not use all the first level classifications for Customer Value.

Table 5— Example Customer Value classifications for commercial model

Commercial products—Customer Value	
Classification	Description
Priceless	The customer cannot continue using the software, or the customer will not buy the software until this anomaly is addressed. (CUSTOMER VALUE = 1)
High	The customer can still use the software, but cannot perform a critical task, or the customer is seriously considering not purchasing the product until this anomaly is addressed. (CUSTOMER VALUE = 2)
Medium	The customer can use the software (a workaround exists) but the defect is very annoying or the customer will purchase on the assurance that the anomaly will be addressed in a future release. (CUSTOMER VALUE = 3)
Low	The customer is mildly interested in the anomaly though the work around is an acceptable alternative, or the customer will purchase without anomaly resolution. (CUSTOMER VALUE = 4)
None	Several customers have indicated conflicting opinions about the anomaly. (CUSTOMER VALUE = 5)
Detrimental	Addressing the anomaly would have a negative effect on existing customers or could limit sales. (CUSTOMER VALUE = 6)

Table 6—Example Customer Value classifications for contract developers

Custom software development—Customer Value	
Classification	Description
Critical	An immediate loss of revenue results from a non-conformance to a contract requirement. (CUSTOMER VALUE = 1)
High	A failure to comply with contract requirements or the requirements definition. (CUSTOMER VALUE = 2)
Medium	A failure to comply with organization or project defined specification, procedure or standard. (CUSTOMER VALUE = 3)
Low	All other anomalies or action items. (CUSTOMER VALUE = 4)