



Technical Specification

ISO/IEC TS 18661-5

Programming languages, their environments, and system software interfaces — Floating-point extensions for C —

Part 5: Supplementary attributes

*Langages de programmation, leurs environnements et interfaces
du logiciel système — Extensions à virgule flottante pour C —*

Partie 5: Attributs supplémentaires

**Second edition
2025-03**



COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2025

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Conformance	1
5 C standard conformance	2
5.1 Freestanding implementations	2
5.2 Predefined macros	2
5.3 Standard headers	2
6 Standard pragmas	2
7 Evaluation formats	3
7.1 General	3
7.2 Evaluation method pragma	3
7.3 Evaluation method pragma for decimal floating types	4
7.4 Effective evaluation method macros	4
7.5 Evaluation type macros	4
7.6 Evaluation formats for <code><tgmath.h></code>	5
8 Optimization controls	5
8.1 General	5
8.2 The <code>FP_ALLOW_VALUE_CHANGING_OPTIMIZATION</code> pragma	6
8.3 The <code>FP_ALLOW_ASSOCIATIVE_LAW</code> pragma	6
8.4 The <code>FP_ALLOW_DISTRIBUTIVE_LAW</code> pragma	7
8.5 The <code>FP_ALLOW_MULTIPLY_BY_RECIPROCAL</code> pragma	7
8.6 The <code>FP_ALLOW_ZERO_SUBNORMAL</code> pragma	8
8.7 The <code>FP_ALLOW_CONTRACT_FMA</code> pragma	8
8.8 The <code>FP_ALLOW_CONTRACT_OPERATION_CONVERSION</code> pragma	9
8.9 The <code>FP_ALLOW_CONTRACT</code> pragma	9
9 Reproducibility	10
9.1 General	10
9.2 The <code>FP_REPRODUCIBLE</code> pragma	10
9.3 Reproducible code	11
10 Alternate exception handling	12
10.1 General	12
10.2 The <code>FENV_EXCEPT</code> pragma	13
Bibliography	20

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

ISO and IEC draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO and IEC take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO and IEC had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents and <https://patents.iec.ch>. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 22, *Programming languages, their environments and system software interfaces*.

This second edition cancels and replaces the first edition (ISO/IEC TS 18661-5:2016), which has been technically revised.

The main changes are as follows:

- The specification has been updated to extend ISO/IEC 9899:2024.
- Conformance macros have been added to allow conformance to each of the four feature sets (evaluation formats, optimization controls, reproducibility, and alternate exception handling) independently.

A list of all parts in the ISO/IEC 18661 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

The IEEE 754-1985 standard for binary floating-point arithmetic was motivated by an expanding diversity in floating-point data representation and arithmetic, which made writing reliable programs, debugging and moving programs between systems exceedingly difficult. Now the great majority of systems provide data formats and arithmetic operations according to IEEE 754. Corresponding versions of IEEE 754 and ISO/IEC 60559 have equivalent content.

Support for IEEE 754-1985 was added in ISO/IEC 9899:1999 (also referred to as C99), and ISO/IEC 9899:2018 is still based on IEEE 754-1985. However, IEEE 754 underwent a major revision in 2008 and a minor revision in 2019, which added several new features.

The purpose of the ISO/IEC 18661 series (first published 2014 through 2016) has been to specify C language support for the new features introduced into IEEE 754 since 1985. Most of the ISO/IEC 18661 series has been incorporated into ISO/IEC 9899:2024 (also referred to as C23 because major work on this revision was completed in 2023), which supports all required and most recommended features in IEEE 754-2019.

IEEE 754 defines alternatives for certain attributes of floating-point semantics, and aims to provide, through programming languages, a means by which a program can specify which of the alternative semantics apply to a given block of code. The program specification of attributes is constant (fixed at translation time), not dynamic (changeable at execution time).

The `FENV_ROUND` and `FENV_DEC_ROUND` pragmas in C23 provide the rounding direction attributes required by IEEE 754.

IEEE 754 also recommends other attributes that are not supported in C23, including:

- `preferredWidth`: evaluation formats for floating-point operations;
- `value-changing optimizations`: allow/disallow program transformations that can affect floating-point result values;
- `reproducibility`: support for getting floating-point result values and exceptions that are exactly reproducible on other systems;
- `alternate exception handling`: methods of handling floating-point exceptions.

To supplement the IEEE 754 support in C23, this document provides these recommended attributes by means of standard pragmas. The pragma parameters represent the alternative semantics. The pragmas are similar in form to the floating-point pragmas (`FENV_ACCESS`, `FP_CONTRACT`, `CX_LIMITED_RANGE`) that have been in C since 1999.

Programming languages, their environments, and system software interfaces — Floating-point extensions for C —

Part 5: Supplementary attributes

1 Scope

This document specifies extensions to programming language C to include pragmas corresponding to attributes specified and recommended in ISO/IEC 60559 but not supported in ISO/IEC 9899:2024 (also referred to as C23).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 9899:2024, *Information technology — Programming languages — C*

ISO/IEC 60559:2020, *Information technology — Microprocessor Systems — Floating-Point arithmetic*