1 Introduction

The major contribution of Sutter’s paper [P0515R2], “Consistent comparison,” is the design and specification of a new C++ operator. Spelled <=>, it is formally termed the three-way comparison operator and colloquially known as the spaceship operator.

Although it is a core language feature, this new operator’s behavior relies on new standard library components known as comparison category types. This paper provides standard library wording to specify those components and their (notional) underlying enums, 1 together with some related objects, functions, and algorithms.

Abstract

This paper proposes standard library wording to accompany the core language wording in Sutter’s proposal [P0515R2], “Consistent comparison.”

Isn’t it strange how a lamb can feel like a lion when comparing itself to a mouse, whereas a lion feels like a lamb when measuring itself against dragons?

— RICHÉLLE E. GOODRICH

What makes the Universe so hard to comprehend is that there’s nothing to compare it with.

— ASHLEIGH BRILLIANT

Contrast is what makes photography interesting.

— CONRAD HALL

1Ideally, enums alone would suffice. Alas, as Sutter’s paper notes at the top of §3, “enums don’t currently support a way to express value conversion relationships [that are desired].”
Application of this new language feature in the context of the standard library is beyond the scope of the present paper. Only those facilities proposed by Sutter’s paper are specified herein.

2 Comparison category types

In section 2.1, [P0515R2] proposes five comparison category types, each of which is a standard library type. Here are some of their salient features:

- **weak_equality** and **strong_equality** categorize/characterize the spaceship operator’s result when a type permits only equality (==, ! =) comparisons.
- **strong_ordering** and **weak_ordering** categorize/characterize the spaceship operator’s result when a type permits all six comparison operators, among which exactly one of \( x < y \), \( x = y \), and \( x > y \) will be true.\(^2\)
- **partial_ordering** categorizes/characterizes the spaceship operator’s result when a type permits all six comparison operators, but none of \( x < y \), \( x = y \), and \( x > y \) need be true.
- The **strong_** and **weak_** comparison category types are distinguished by the *substitutability* property, namely, whether \( a == b \) implies \( f(a) == f(b) \).\(^3\)
- “Each [comparison category type] has predefined values, three numeric values for each _ordering and two for each _equality.” Each call to a spaceship operator returns one of these values.
- Finally, there are selected implicit conversions among these comparison category types, as well as six named comparison functions taking an argument of comparison category type.\(^4\)

Please see §4 below for the proposed detailed specifications of these and related components. For further design details, tutorial information, proposed core language wording, and a bibliography of recent WG21 papers that explored other approaches, please consult Sutter’s paper.

3 Discussion

Following its review of Sutter’s paper, LEWG in Toronto approved all the library components specified below. However, Sutter’s paper does not recommend a name for the header in which the standard library will provide these components. During the Albuquerque LEWG meeting, the header name `<compare>` was selected.

4 Proposed wording\(^5\)

4.1 Insert, in alphabetical order, the following new entry into the C++ library headers table in subclause [headers]:

`<compare>`

---

\(^2\)In mathematics, this is known as the *trichotomy* property of an order relation. See, for example, the explanation at https://en.wikipedia.org/wiki/Trichotomy_(mathematics).

\(^3\)This assumes that “\( f \) reads only comparison-salient state that is accessible using the public const members.”

\(^4\)These functions are intended for users who prefer to avoid writing \( a<>b @ 0 \), where @ denotes any of the six traditional comparison operators.

\(^5\)Throughout this paper, all proposed additions are relative to [N4700], the pre-Albuquerque Working Draft. Editorial notes are displayed against a gray background.
4.2 Insert the following new row into the Language support library summary table in subclause [support.general]:

| 21.9 | Initializer lists | <initializer_list> |
| 21.x | Comparisons       | <compare>          |
| 21.10 | Other runtime support | <csignal> <csetjmp> <cstdarg> <cstdlib> <cstdlib> |

4.3 Insert the following new subclause below subclause [support.initlist] and above subclause [support.runtime]:

21.x Comparisons

21.x.1 Header <compare> synopsis

The header <compare> specifies types, objects, and functions for use primarily in connection with the three-way comparison operator ([expr.spaceship]).

namespace std {

// [cmp.categories], comparison category types
class weak_equality;
class strong_equality;
class partial_ordering;
class weak_ordering;
class strong_ordering;

// named comparison functions
constexpr bool is_eq (weak_equality cmp) noexcept { return cmp == 0; }
cconstexpr bool is_neq (weak_equality cmp) noexcept { return cmp != 0; }
cconstexpr bool is_lt (partial_ordering cmp) noexcept { return cmp < 0; }
cconstexpr bool is_lteq(partial_ordering cmp) noexcept { return cmp <= 0; }
cconstexpr bool is_gt (partial_ordering cmp) noexcept { return cmp > 0; }
cconstexpr bool is_gteq(partial_ordering cmp) noexcept { return cmp >= 0; }

// [cmp.common], common comparison category type
template<class... Ts>
  struct common_comparison_category
  { using type = see below; };
template<class... Ts>
  using common_comparison_category_t
    = typename common_comparison_category<Ts...>::type;

// [cmp.alg], comparison algorithms
template<class T>
  constexpr strong_ordering strong_order (const T& a, const T& b);
template<class T>
  constexpr weak_ordering weak_order (const T& a, const T& b);
template<class T>
  constexpr partial_ordering partial_order(const T& a, const T& b);
template<class T>
  constexpr strong_equality strong_equal (const T& a, const T& b);
21.x.2 Comparison category types

1 The ..._equality and ..._ordering types are collectively termed the comparison category types. Each is specified in terms of an exposition-only data member named value whose value typically corresponds to that of an enumerator from one of the following exposition-only enumerations:

```cpp
enum class eq { equal = 0, equivalent = equal, nonequal = 1, nonequivalent = nonequal }; // exposition only
enum class ord { less = -1, greater = 1 }; // exposition only
enum class ncmp { unordered = -127 }; // exposition only
```

2 [Note: The types strong_ordering and weak_equality correspond, respectively, to the terms total ordering and equivalence in mathematics. — end note]

3 The relational and equality operators for the comparison category types are specified with an anonymous parameter of unspecified type. This type shall be selected by the implementation such that these parameters can accept literal 0 as a corresponding argument. [Example: nullptr_t satisfies this requirement. — end example] In this context, the behavior of a program that supplies an argument other than a literal 0 is undefined.

4 For the purposes of this subclause, substitutability is the property that \( f(a) == f(b) \) is true whenever \( a == b \) is true, where \( f \) denotes a function that reads only comparison-salient state that is accessible via the argument’s public const members.

21.x.2.1 Class weak_equality

1 The weak_equality type is typically used as the result type of a three-way comparison operator that (a) admits only equality and inequality comparisons, and (b) does not imply substitutability.

```cpp
namespace std {
    class weak_equality {
        int value; // exposition only

        // exposition-only constructor
        explicit constexpr weak_equality(eq v) noexcept : value(int(v)) {}

    public:
        // valid values
        static const weak_equality equivalent;
        static const weak_equality nonequivalent;

        // comparisons
        friend constexpr bool operator==(weak_equality v, unspecified) noexcept;
        friend constexpr bool operator!=(weak_equality v, unspecified) noexcept;
        friend constexpr bool operator==(unspecified, weak_equality v) noexcept;
        friend constexpr bool operator!=(unspecified, weak_equality v) noexcept;
    }
}
```

// valid values’ definitions
inline constexpr
    weak_equality weak_equality::equivalent (eq::equivalent);
inline constexpr
    weak_equality weak_equality::nonequivalent(eq::nonequivalent);
}

constexpr bool operator==(weak_equality v, unspecified) noexcept;
constexpr bool operator==(unspecified, weak_equality v) noexcept;
2 Returns: \( v.value == 0 \).

constexpr bool operator!=(weak_equality v, unspecified) noexcept;
constexpr bool operator!=(unspecified, weak_equality v) noexcept;
3 Returns: \( v.value != 0 \).

21.x.2.2 strong_equality

1 The `strong_equality` type is typically used as the result type of a three-way comparison operator that (a) admits only equality and inequality comparisons, and (b) does imply substitutability.

namespace std {
    class strong_equality {
        int value; // exposition only

        // exposition-only constructor
        explicit constexpr strong_equality(eq v) noexcept : value(int(v)) {} 

    public:
        // valid values
        static const strong_equality equal;
        static const strong_equality nonequal;
        static const strong_equality equivalent;
        static const strong_equality nonequivalent;

        // conversion
        constexpr operator weak_equality() const noexcept;

        // comparisons
        friend constexpr bool operator==(strong_equality v, unspecified) noexcept;
        friend constexpr bool operator!=(strong_equality v, unspecified) noexcept;
        friend constexpr bool operator==(unspecified, strong_equality v) noexcept;
        friend constexpr bool operator!=(unspecified, strong_equality v) noexcept;
    }

    // valid values' definitions
    inline constexpr
        strong_equality strong_equality::equal (eq::equal);
inline constexpr
        strong_equality strong_equality::nonequal (eq::nonequal);
inline constexpr
        strong_equality strong_equality::equivalent (eq::equivalent);
inline constexpr
        strong_equality strong_equality::nonequivalent (eq::nonequivalent);
constexpr operator weak_equality() const noexcept;

Returns: value == 0 ? weak_equality::equivalent : weak_equality::nonequivalent.

constexpr bool operator==(strong_equality v, unspecified) noexcept;
constexpr bool operator==(unspecified, strong_equality v) noexcept;

Returns: v.value == 0.

constexpr bool operator!=(strong_equality v, unspecified) noexcept;
constexpr bool operator!=(unspecified, strong_equality v) noexcept;

Returns: v.value != 0.

21.2.3 Class partial_ordering

The partial_ordering type is typically used as the result type of a three-way comparison operator that (a) admits all of the six comparison operators, (b) does not imply substitutability, and (c) permits two values to be incomparable (i.e., a < b, a == b, and a > b might all be false).

namespace std {
    class partial_ordering {
        int value;  // exposition only
        bool is_ordered;  // exposition only

        // exposition-only constructors
        explicit constexpr partial_ordering(eq v) noexcept : value(int(v)), is_ordered(true) {}
        explicit constexpr partial_ordering(ord v) noexcept : value(int(v)), is_ordered(true) {}
        explicit constexpr partial_ordering(ncmp v) noexcept : value(int(v)), is_ordered(false) {}

    public:
        // valid values
        static const partial_ordering less;
        static const partial_ordering equivalent;
        static const partial_ordering greater;
        static const partial_ordering unordered;

        // conversion
        constexpr operator weak_equality() const noexcept;

        // comparisons
        friend constexpr bool operator==(partial_ordering v, unspecified) noexcept;
        friend constexpr bool operator!=(partial_ordering v, unspecified) noexcept;
        friend constexpr bool operator<(partial_ordering v, unspecified) noexcept;
        friend constexpr bool operator<=(partial_ordering v, unspecified) noexcept;
        friend constexpr bool operator>(partial_ordering v, unspecified) noexcept;
        friend constexpr bool operator>=(partial_ordering v, unspecified) noexcept;
    }
friend constexpr bool operator==(unspecified, partial_ordering v) noexcept;
friend constexpr bool operator!=(unspecified, partial_ordering v) noexcept;
friend constexpr bool operator<(  unspecified, partial_ordering v) noexcept;
friend constexpr bool operator<=(unspecified, partial_ordering v) noexcept;
friend constexpr bool operator>(  unspecified, partial_ordering v) noexcept;
friend constexpr bool operator>=(unspecified, partial_ordering v) noexcept;

};

// valid values' definitions
inline constexpr
  partial_ordering partial_ordering::less   (ord::less);
inline constexpr
  partial_ordering partial_ordering::equivalent(eq::equivalent);
inline constexpr
  partial_ordering partial_ordering::greater (ord::greater);
inline constexpr
  partial_ordering partial_ordering::unordered (ncmp::unordered);

constexpr operator weak_equality() const noexcept;

2 Returns: value == 0 \ ? weak_equality::equivalent : weak_equality::nonequivalent.
[Note: The result is independent of the is_ordered member. — end note]

constexpr bool operator==(partial_ordering v, unspecified) noexcept;
constexpr bool operator< (partial_ordering v, unspecified) noexcept;
constexpr bool operator<=(partial_ordering v, unspecified) noexcept;
constexpr bool operator> (partial_ordering v, unspecified) noexcept;
constexpr bool operator>=(partial_ordering v, unspecified) noexcept;

3 Returns: for operator@, v.is_ordered && v.value @ 0.

constexpr bool operator==(unspecified, partial_ordering v) noexcept;
constexpr bool operator<(  unspecified, partial_ordering v) noexcept;
constexpr bool operator<=(unspecified, partial_ordering v) noexcept;
constexpr bool operator>(  unspecified, partial_ordering v) noexcept;
constexpr bool operator>=(unspecified, partial_ordering v) noexcept;

4 Returns: for operator@, v.is_ordered && 0 @ v.value.

constexpr bool operator!=(partial_ordering v, unspecified) noexcept;
constexpr bool operator!= (unspecified, partial_ordering v) noexcept;

5 Returns: for operator@, !v.is_ordered || v.value != 0.

21.x.2.4 Class weak_ordering

1 The weak_ordering type is typically used as the result type of a three-way comparison operator that (a) admits all of the six comparison operators, and (b) does not imply substitutability.

namespace std {
  class weak_ordering {
    int value;   // exposition only

    // exposition-only constructors

explicit constexpr weak_ordering(eq v) noexcept : value(int(v)) {}
explicit constexpr weak_ordering(ord v) noexcept : value(int(v)) {}

public:
    // valid values
    static const weak_ordering less;
    static const weak_ordering equivalent;
    static const weak_ordering greater;

    // conversions
    constexpr operator weak_equality() const noexcept;
    constexpr operator partial_ordering() const noexcept;

    // comparisons
    friend constexpr bool operator==(weak_ordering v, unspecified) noexcept;
    friend constexpr bool operator!=(weak_ordering v, unspecified) noexcept;
    friend constexpr bool operator< (weak_ordering v, unspecified) noexcept;
    friend constexpr bool operator<=(weak_ordering v, unspecified) noexcept;
    friend constexpr bool operator> (weak_ordering v, unspecified) noexcept;
    friend constexpr bool operator>=(weak_ordering v, unspecified) noexcept;

    // valid values' definitions
    inline constexpr
        weak_ordering weak_ordering::less (ord::less);
    inline constexpr
        weak_ordering weak_ordering::equivalent(eq::equivalent);
    inline constexpr
        weak_ordering weak_ordering::greater (ord::greater);

constexpr operator weak_equality() const noexcept;
2 Returns: value == 0 ? weak_equality::equivalent
            : weak_equality::nonequivalent.

constexpr operator partial_ordering() const noexcept;
3 Returns: value == 0 ? partial_ordering::equivalent
            : value < 0 ? partial_ordering::less : partial_ordering::greater.
4 Returns: \(v.value \neq 0\) for \(\text{operator@}\).

\begin{verbatim}
constexpr bool operator==(unspecified, weak_ordering v) noexcept;
constexpr bool operator!=(unspecified, weak_ordering v) noexcept;
constexpr bool operator< (unspecified, weak_ordering v) noexcept;
constexpr bool operator<=(unspecified, weak_ordering v) noexcept;
constexpr bool operator> (unspecified, weak_ordering v) noexcept;
constexpr bool operator>=(unspecified, weak_ordering v) noexcept;
\end{verbatim}

5 Returns: \(0 \neq v.value\) for \(\text{operator@}\).

21.x.2.5 Class \texttt{strong_ordering} \[cmp.
\texttt{strongord}\]

1 The \texttt{strong_ordering} type is typically used as the result type of a three-way comparison operator that (a) admits all of the six comparison operators, and (b) does imply substitutability.

namespace std {
    class strong_ordering {
        int value; // exposition only

        // exposition-only constructors
        explicit constexpr strong_ordering(eq v) noexcept : value(int(v)) {}  
        explicit constexpr strong_ordering(ord v) noexcept : value(int(v)) {}  

        public:
        // valid values
        static const strong_ordering less;
        static const strong_ordering equal;
        static const strong_ordering equivalent;
        static const strong_ordering greater;

        // conversions
        constexpr operator weak_equality() const noexcept;
        constexpr operator strong_equality() const noexcept;
        constexpr operator partial_ordering() const noexcept;
        constexpr operator weak_ordering() const noexcept;

        // comparisons
        friend constexpr bool operator==(strong_ordering v, unspecified) noexcept;
        friend constexpr bool operator!=(strong_ordering v, unspecified) noexcept;
        friend constexpr bool operator< (strong_ordering v, unspecified) noexcept;
        friend constexpr bool operator<=(strong_ordering v, unspecified) noexcept;
        friend constexpr bool operator> (strong_ordering v, unspecified) noexcept;
        friend constexpr bool operator>=(strong_ordering v, unspecified) noexcept;
        
        // valid values’ definitions
        inline constexpr
```cpp
inline constexpr
strong_ordering strong_ordering::equal (eq::equal);
inline constexpr
strong_ordering strong_ordering::equivalent(eq::equivalent);
inline constexpr
strong_ordering strong_ordering::greater (ord::greater);
}

constexpr operator weak_equality() const noexcept;
2 Returns: value == 0 ? weak_equality::equivalent
       : weak_equality::nonequivalent.

constexpr operator strong_equality() const noexcept;
3 Returns: value == 0 ? strong_equality::equal : strong_equality::nonequal.

constexpr operator partial_ordering() const noexcept;
4 Returns: value == 0 ? partial_ordering::equivalent
       : value < 0 ? partial_ordering::less : partial_ordering::greater.

constexpr operator weak_ordering() const noexcept;
5 Returns: value == 0 ? weak_ordering::equivalent
       : value < 0 ? weak_ordering::less : weak_ordering::greater.

constexpr bool operator==(strong_ordering v, unspecified) noexcept;
constexpr bool operator!=(strong_ordering v, unspecified) noexcept;
constexpr bool operator< (strong_ordering v, unspecified) noexcept;
constexpr bool operator<=(strong_ordering v, unspecified) noexcept;
constexpr bool operator> (strong_ordering v, unspecified) noexcept;
constexpr bool operator>=(strong_ordering v, unspecified) noexcept;
6 Returns: v.value @ 0 for operator@.

constexpr bool operator==(unspecified, strong_ordering v) noexcept;
constexpr bool operator!=(unspecified, strong_ordering v) noexcept;
constexpr bool operator< (unspecified, strong_ordering v) noexcept;
constexpr bool operator<= (unspecified, strong_ordering v) noexcept;
constexpr bool operator> (unspecified, strong_ordering v) noexcept;
constexpr bool operator>=(unspecified, strong_ordering v) noexcept;
7 Returns: 0 @ v.value for operator@.

21.x.3 Class template common_comparison_category
 template<class... Ts>

1 The type common_comparison_category provides an alias for the strongest comparison category to which all of the template arguments can be converted. [Note: A comparison category type is stronger than another if they are distinct types and an instance of the former can be converted to an instance of the latter. — end note]
struct common_comparison_category { using type = see below; };

2 Remarks: The member *typedef-name type* shall denote the common comparison type ([class.spaceship]) of Ts..., the expanded parameter pack. [Note: This is well-defined even if the expansion is empty or includes a type that is not a comparison category type. — end note]

21.x.4 Comparison algorithms [cmp.alg]

```cpp
template<class T>
constexpr strong_ordering strong_order(const T& a, const T& b);
```

1 Effects: Compares two values and produces a result of type *strong_ordering*:

(1.1) — If `numeric_limits<T>::is_iec559` is *true*, returns a result of type *strong_ordering* that is consistent with the *totalOrder* operation as specified in ISO/IEC/IEEE 60559.

(1.2) — Otherwise, returns `a <=> b` if that expression is well-formed and convertible to *strong_ordering*.

(1.3) — Otherwise, if the expression `a <=> b` is well-formed, then the function shall be defined as deleted.

(1.4) — Otherwise, if the expressions `a == b` and `a < b` are each well-formed and convertible to `bool`, returns *strong_ordering::equal* when `a == b` is *true*, otherwise returns *strong_ordering::less* when `a < b` is *true*, and otherwise returns *strong_ordering::greater*.

(1.5) — Otherwise, the function shall be defined as deleted.

```cpp
template<class T>
constexpr weak_ordering weak_order(const T& a, const T& b);
```

2 Effects: Compares two values and produces a result of type *weak_ordering*:

(2.1) — Returns `a <=> b` if that expression is well-formed and convertible to *weak_ordering*.

(2.2) — Otherwise, if the expression `a <=> b` is well-formed, then the function shall be defined as deleted.

(2.3) — Otherwise, if the expressions `a == b` and `a < b` are each well-formed and convertible to `bool`, returns *weak_ordering::equivalent* when `a == b` is *true*, otherwise returns *weak_ordering::less* when `a < b` is *true*, and otherwise returns *weak_ordering::greater*.

(2.4) — Otherwise, the function shall be defined as deleted.

```cpp
template<class T>
constexpr partial_ordering partial_order(const T& a, const T& b);
```

3 Effects: Compares two values and produces a result of type *partial_ordering*:

(3.1) — Returns `a <=> b` if that expression is well-formed and convertible to *partial_ordering*.

(3.2) — Otherwise, if the expression `a <=> b` is well-formed, then the function shall be defined as deleted.

(3.3) — Otherwise, if the expressions `a == b` and `a < b` are each well-formed and convertible to `bool`, returns *partial_ordering::equivalent* when `a == b` is *true*, otherwise returns *partial_ordering::less* when `a < b` is *true*, and otherwise returns *partial_ordering::greater*.

(3.4) — Otherwise, the function shall be defined as deleted.
template<class T>
    constexpr strong_equality strong_equal(const T& a, const T& b);

4 Effects: Compares two values and produces a result of type \texttt{strong\_equality}:

(4.1) — Returns \(a \leftrightarrow b\) if that expression is well-formed and convertible to \texttt{strong\_equality}.

(4.2) — Otherwise, if the expression \(a \leftrightarrow b\) is well-formed, then the function shall be defined as deleted.

(4.3) — Otherwise, if the expression \(a == b\) is well-formed and convertible to \texttt{bool}, returns
\texttt{strong\_equality::equal} when \(a == b\) is \texttt{true}, and otherwise returns \texttt{strong\_equality::nonequal}.

(4.4) — Otherwise, the function shall be defined as deleted.

template<class T>
    constexpr weak_equality weak_equal(const T& a, const T& b);

5 Effects: Compares two values and produces a result of type \texttt{weak\_equality}:

(5.1) — Returns \(a \leftrightarrow b\) if that expression is well-formed and convertible to \texttt{weak\_equality}.

(5.2) — Otherwise, if the expression \(a \leftrightarrow b\) is well-formed, then the function shall be defined as deleted.

(5.3) — Otherwise, if the expression \(a == b\) is well-formed and convertible to \texttt{bool}, returns
\texttt{weak\_equality::equivalent} when \(a == b\) is \texttt{true}, and otherwise returns \texttt{weak\_equality::nonequivalent}.

(5.4) — Otherwise, the function shall be defined as deleted.

4.4 Deprecate \texttt{rel\_ops} as follows:

- Create a new subclause \[depr.rel_ops\] in Annex D.
- Populate that new subclause with the following text as its initial paragraph, followed by the namespace \texttt{std::rel\_ops} synopsis from \[utility.syn\], followed in turn by (suitably renumbered) paragraphs 1 through 9 from subclause \[operators\].
- Remove subclause \[operators\] and also remove the namespace \texttt{rel\_ops} synopsis from \[utility.syn\].

1 The header \texttt{<utility>} has the following additions:

4.5 Preserve the normative intent of the original \[operators\]/10 as follows:

- Create a new subclause within \[requirements\].
- Populate that new subclause with the following text as its heading and initial paragraph, followed by paragraphs 2 through 9 from the original subclause \[operators\]:

\textbf{20.5.x Operators} \[requirements.operators\]

1 In this library, whenever a declaration is provided for an \texttt{operator!=, operator>, operator>=}, or \texttt{operator<=}, its requirements and semantics are as follows, unless explicitly specified otherwise.
4.6 Insert the following new text, suitably indented, into [algorithm.syn] immediately above //28.6, modifying sequence operations:

```cpp
// [alg.3way], three-way comparison algorithms
template<class T, class U>
    constexpr auto compare_3way(const T& a, const U& b);

template<class InputIterator1, class InputIterator2, class Cmp>
    constexpr auto
    lexicographical_compare_3way(InputIterator1 b1, InputIterator1 e1,
        InputIterator2 b2, InputIterator2 e2, Cmp comp)
    -> common_comparison_category_t<decltype(comp(*b1,*b2)), strong_ordering>;
```

4.7 Insert the following new subclause immediately above subclause [alg.modifying.operations]:

**28.5.14 Three-way comparison algorithms**

```cpp
// [alg.3way]
template<class T, class U> constexpr auto compare_3way(const T& a, const U& b);
```

1 **Effects:** Compares two values and produces a result of the strongest applicable comparison category type:

   (1.1) — Returns \(a \Leftrightarrow b\) if that expression is well-formed.

   (1.2) — Otherwise, if the expressions \(a == b\) and \(a < b\) are each well-formed and convertible to \(\text{bool}\), returns \(\text{strong\_ordering::equal}\) when \(a == b\) is \(\text{true}\), otherwise returns \(\text{strong\_ordering::less}\) when \(a < b\) is \(\text{true}\), and otherwise returns \(\text{strong\_ordering::greater}\).

   (1.3) — Otherwise, if the expression \(a == b\) is well-formed and convertible to \(\text{bool}\), returns \(\text{strong\_equality::equal}\) when \(a == b\) is \(\text{true}\), and otherwise returns \(\text{strong\_equality::nonequal}\).

   (1.4) — Otherwise, the function shall be defined as deleted.

```cpp
template<class InputIterator1, class InputIterator2, class Cmp>
    constexpr auto
    lexicographical_compare_3way(InputIterator1 b1, InputIterator1 e1,
        InputIterator2 b2, InputIterator2 e2, Cmp comp)
    -> common_comparison_category_t<decltype(comp(*b1,*b2)), strong_ordering>;
```

2 **Requires:** \(\text{Cmp}\) shall be a function object type whose return type is a comparison category type.

3 **Effects:** Lexicographically compares two ranges and produces a result of the strongest applicable comparison category type. Equivalent to:

```cpp
for ( ; b1 != e1 && b2 != e2; ++b1, void(++b2) )
    if (auto cmp = comp(*b1,*b2); cmp != 0)
return cmp;
return b1 != e1 ? strong_ordering::greater
    : b2 != e2 ? strong_ordering::less : strong_ordering::equal;

template<class InputIterator1, class InputIterator2>
constexpr auto
lexicographical_compare_3way(InputIterator1 b1, InputIterator1 e1,
    InputIterator2 b2, InputIterator2 e2);

4 Effects: Equivalent to return
lexicographical_compare_3way(b1, e1, b2, e2,
    [](const auto& t, const auto& u)
    { return compare_3way(t, u); } );

5 Acknowledgments

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6 Bibliography


7 Document history

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<th>Date</th>
<th>Changes</th>
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<td>1</td>
<td>2017-11-10</td>
<td>• Updated wording relative to latest (pre-Albuquerque) Working Draft. • Fixed minor typos. • Applied Albuquerque LEWG guidance re name of proposed header. • Applied Albuquerque LWG guidance improving §4 (Proposed Wording). • Applied Albuquerque CWG guidance deleting all §4 bullets involving memberwise behavior. • Published as P0768R1, post-Albuquerque.</td>
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