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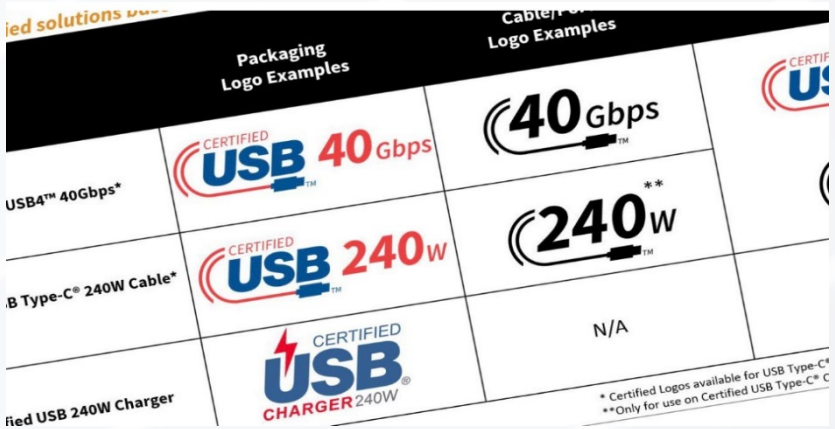
Demystifying USB Type-C® & PD: Compliance with EU RED and IEC 62368-1

Agenda

- Introduction of USB Type-C and Power Delivery
- USB-PD and Type-C compliance Testing
- Essential Regulatory standards and requirements
  - European Union - RED
  - IEC 62368-1
- Key considerations for designing and implementing USB Type-C & PD solutions
- Key test requirements and strategies for achieving compliance
- Q&A

USB Type-C® - One connector for all your charging needs

- European Union mandate set to begin in 2024 will require all new smartphones, tablets to use a common charger with USB- Type-C® connectors. Similarly for laptops from 2026
  - More countries expected to follow!
- The charging port and fast charging technology will be harmonized: first, USB Type-C® will be the common port.
- USB Power Delivery can transfer power up to 240W, well suited for
  - Laptop, Handheld battery operated power device, Monitors, TVs and many more
- Higher power levels elevates the safety and hazardous risk
  - Electric shock and Fire
  - Need to validate with IEC 62368-1 standard



USB Type-C® - De facto standard for wired charging

- ***Reversible:*** Type-C connectors are symmetrical, you can plug them in any direction.
- ***Higher power:*** Can transfer up to 240W of power with single connector. Charge laptops, tablets, and more - all from one port.
- ***Faster Data transfers:*** USB Type-C supports various USB specifications, including USB 3.1 Gen 2 and USB4
- ***Multi-tasking:*** Charge, transfer data, and even connect to displays - all with a single cable.
- ***Future-proof:*** Ready for the latest tech advancements.

New USB Power Delivery 3.1 specification

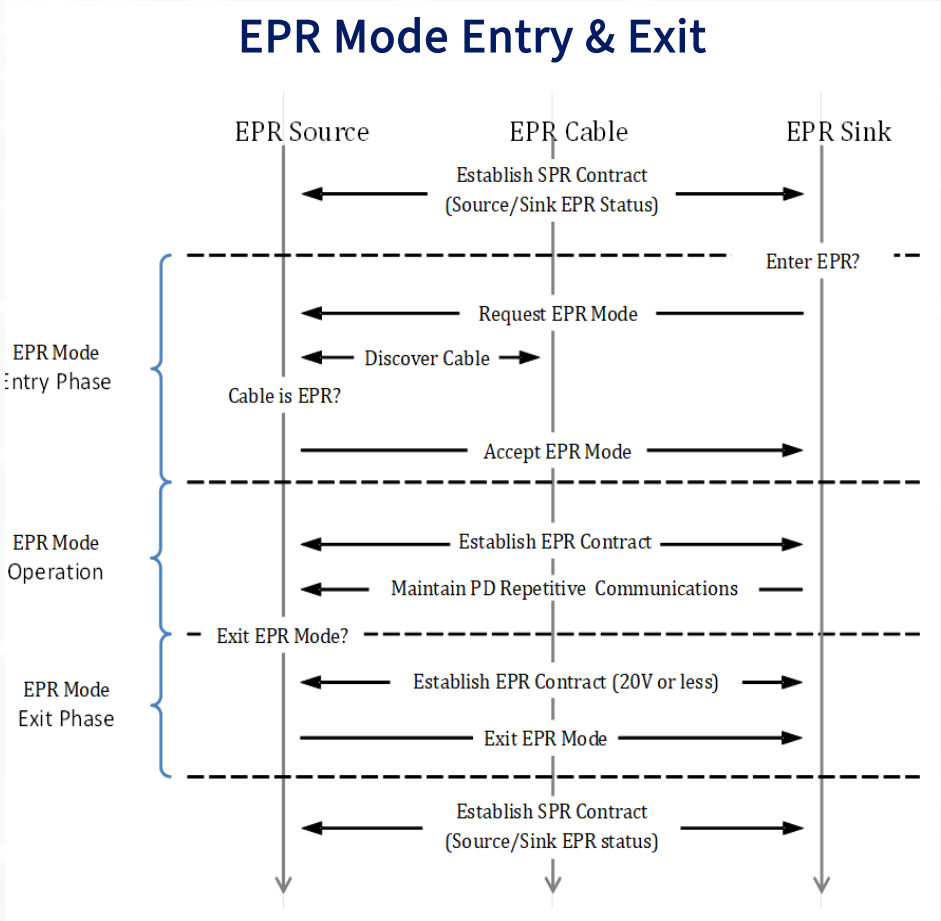
- USB Power Delivery 3.1 specification, extends the maximum supported power range over USB Type-C® Power Delivery port from 100W to 240W.
  - Extended Power Range (EPR): Extends the power range from a maximum of 100W (SPR) to a maximum of 240W.
  - Power direction is no longer fixed. This enables the product with the power (Host or Peripheral) to provide the power.
  - Optimize power management across multiple peripherals by allowing each device to take only the power it requires, and to get more power when required for a given application.
- Power transfer above 100W requires EPR capable Sources and EPR capable Sinks over EPR capable cables
- Adjustable Voltage Supply (AVS) is newly introduced in addition to Fixed Voltage and Programmable Power Supply (PPS) charging modes

Charging Modes/ Power Profiles Summary

Charging Modes	Available Voltage & Current	Power Range	Comment
Fixed Voltage Charging: Standard Power Range (SPR)	3A: 5V, 9V, 15V, 20V 5A[1]: 20V	15 – 60W 60 – 100W	No change from previous version
Programmable Power Supply (PPS): Standard Power Range (SPR)	3A: 5V Prog (3.3-5.9V), 9V Prog (3.3-11V), 15V Prog (3.3–16V), 20V Prog (3.3 – 21V) 5A[1]: 20V Prog (3.3 – 21V)	15 – 60W 60 – 100 W	No change from previous version
Fixed Voltage Charging: Extended Power Range (EPR)	3A: 5V, 9V, 15V, 20V 5A[2]: 20V **5A[2]:** 28V, 36V, 48V	15 – 60W 60 – 100W 100 – 240W	**Newly introduced.** Available only after EPR Mode Entry.
Adjustable Voltage Supply (AVS): Standard Power Range (SPR) Extended Power Range (EPR) [1] Requires 5A E-marker cable. [2] Requires EPR Capable cable.	**5A[2]:** 28V Prog (18V - 28V), 36V Prog (18V - 36V), 48V Prog (18V - 48V) 5A:[1] 20V Prog (9V – 20V) 3A: 15V Prog (9V -15V) 20V Prog (9V – 20V)	90 – 140W 90 – 180W 90 – 240W >60 – 100W >27 – 45W >60 – 100W	**Newly introduced.** Available only after EPR Mode Entry.

Extended Power Range- Mode of Operation

- **Standard Power Range (SPR)**: The classic mode of power delivery operation where power contracts are negotiated using SPR PDOs (Power Data Objects).
- **Extended Power Range (EPR) :** Dedicated mode of operation to negotiate the EPR power profiles
- **Power levels above 100W**, are only transferred between known EPR capable Sources and EPR capable Sinks over EPR capable cables
- **EPR Sources** are capable of both Fixed and an Adjustable Voltage Supply (AVS) operation.
- **Loss of communications** between the Source and Sink will cause a hard reset to be initiated resulting in a return to SPR operation.



USB Compliance Testing – *USB-IF* requirement

- USB-IF compliance testing is highly recommended.
  - Ensures Interoperability
  - Guarantees Performance
  - Protects Consumers
  - Maintains Market Credibility
  - Simplifies Design and Development
- USB Compliance ensure your product functions correctly, avoids compatibility issues, and protects against potential safety risks.

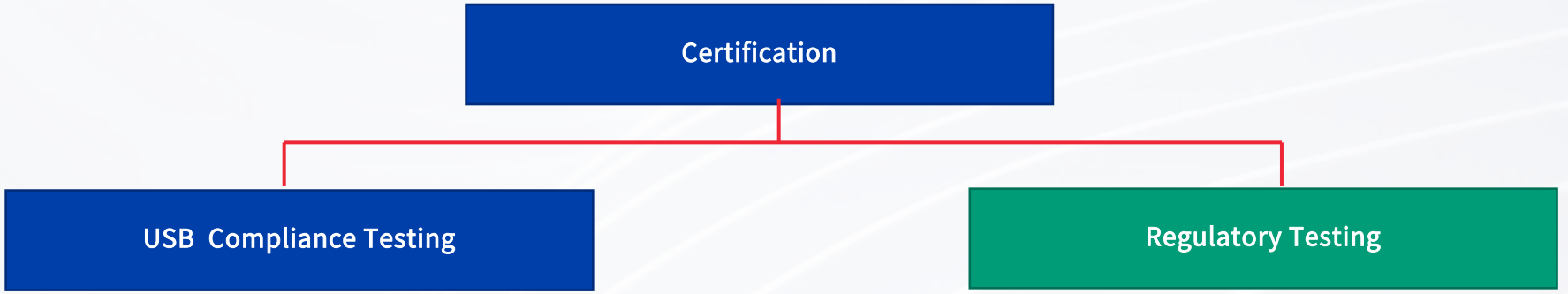
Test Matrix

Product Type	Testing Required						
	USB-C CabCon	USB-C EPC	USB PD	USB-C Functional	USB-C IOP	USB-C Source Power	USB 3.2 and 2.0[1]
Cable	X	X[2]	X[3]	X[3]			
Charger			X	X	X	X	X[4]
PSD				X	X		X[7]
PD PSD			X	X	X	X[6]	X[7]
Host & Hub				X	X	X	X
PD Host & PD Hub			X	X	X	X	X
Alt Mode Only Host			X	X	X		
Device				X	X		X
PD Device			X	X	X	X[5]	X
OTG	Not compatible with USB Type-C						

Note 1: See USB 3.2 Product Matrix and USB 2.0 Product Matrix to determine required USB 3.2 and 2.0 Compliance tests.
Note 2: USB-C EPC tests are required for USB Type-C plug to Type-C plug cables and not applicable for legacy cables.
Note 3: USB PD tests are required if the cable has an Emarker and for Emarker silicon.
Note 4: Requires USB 3.2 Product Matrix and USB 2.0 Product Matrix because USB Battery Charging Test is required on the port.
Note 5: USB Source Power Tests are required for a PD Device on each DRP port.
Note 6: If the port is a DRP (e.g. a Battery Pack) then USB Source Power Tests are required.
Note 7: If the port supports USB BC 1.2, then USB 3.2 Product Matrix and USB 2.0 Product Matrix apply for USB Battery Charging Test.

Source: https://www.usb.org/sites/default/files/USB-C%20Product%20Matrix%202022%2008%2003.pdf
Note: Refer USB.org for most updated test matrix

USB Type-C certification



	USB Interface Standard Testing	Regulatory Standard
Requirement	Logo testing requirement of USB-IF	Regulatory Requirement
Authorities	USB-IF -> Approved Labs	National authorities -> Approved Labs
What is tested?	Compliance to standard	Safety and Performance
Outcome	Inter-operable product	Safe to operate and its compatibility
Typical Standards	USB, DisplayPort, Thunderbolt etc	IEC 62368-1/ IEC 62680-1-2 /IEC 62680-1-3
Product certificate	Interface logo	CE / CB Scheme / NRTL/ GS Many others..

Challenges in Validating Higher Power USB-Type-C Designs

- **Compliance to USB standard:** Protocol, timing and power needs to be validated as per the latest specification.
- **Higher Risk of Safety (Fire hazard):** Design needs to be tested with fail safe.
- **Interoperability:** Any errors in protocol & timing may call for hard reset and falls back to 100W (SPR) range, which impact the user experience
- **Reliability:** Designs needs to be validated for reliability and robustness to accommodate the temperature and component drifts
- **Regulatory Testing:** Based on the various country regulations, you might need to validate your device.
  - Functional Safety testing - IEC 62368-1

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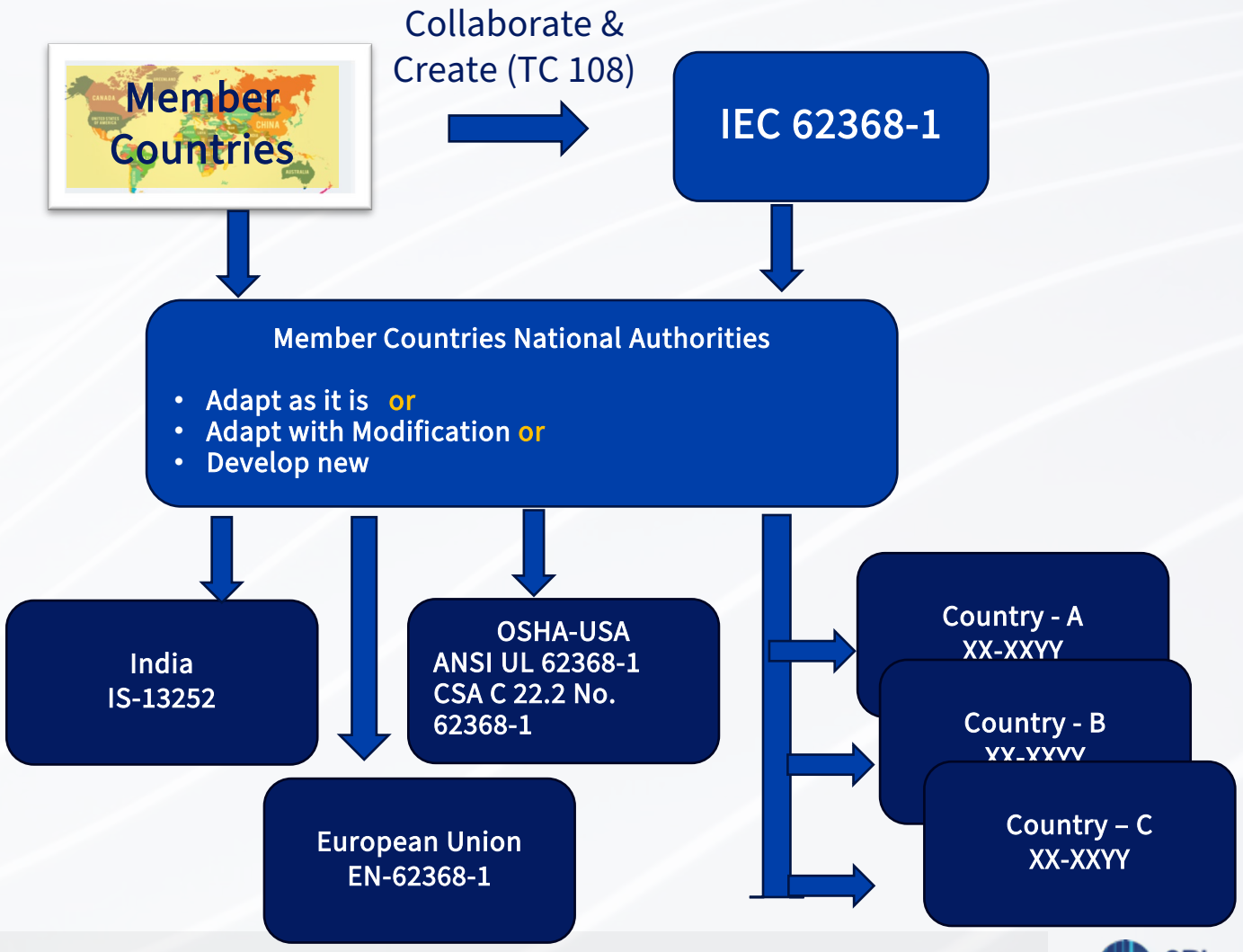
USB Type-C® - Regulatory Testing Requirements

USB Type-C Regulatory Requirements

- ***Requirement 1:*** Electrical Safety compliance to IEC 62368-1 with USB Type C EPR (>100W)
- ***Requirement 2:*** USB Type C implementation as per European Union Radio Equipment Directive (RED)

What is IEC 62368-1 and why it is important

- Electrical safety standard for Audio/Video and ICT equipment
- Followed globally
- Harmonized as a national standard in many geographies
- Hazard based approach
- Safety requirements in normal and abnormal conditions (single fault)
- Compliance is mandatory in many countries

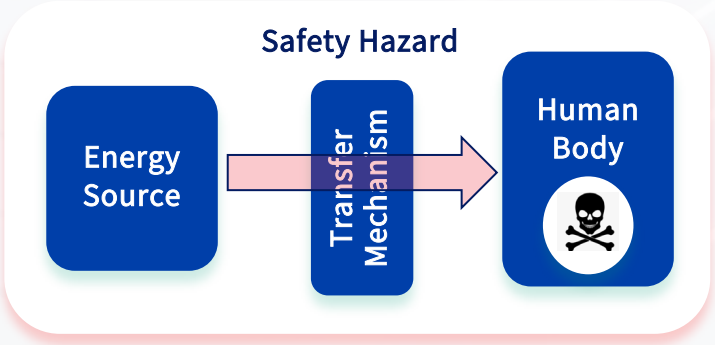


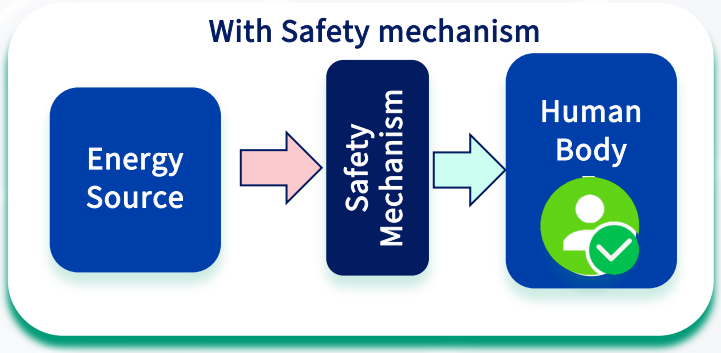
Hazards covered by IEC 62368-1 Standard

- Typical causes of hazard
  - **Electric Shock**
  - **Fire**
  - Hazardous substances
  - Mechanical
  - Thermal injury
  - Radiation

Point of discussion related to USB Power Delivery/Type-C Design

Other international standards specific to DC power on communication lines such as IEC 62368-3/ IEC 63315 can be considered in future





Why it is critical with USB Type-C EPR

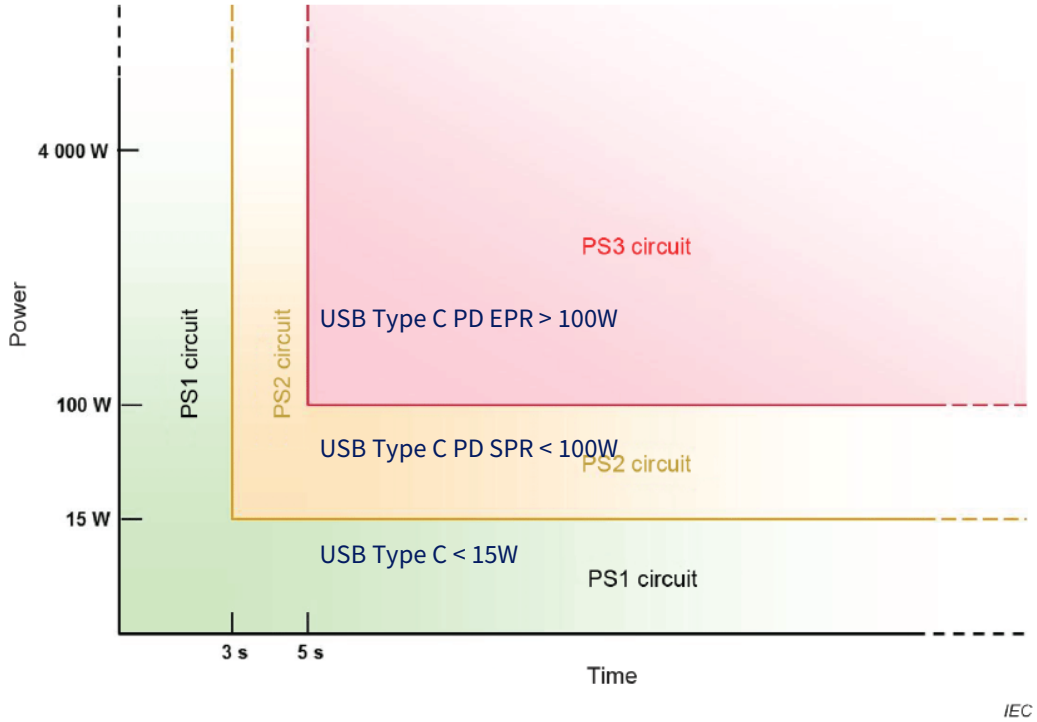


Figure 36 – Illustration of power source classification

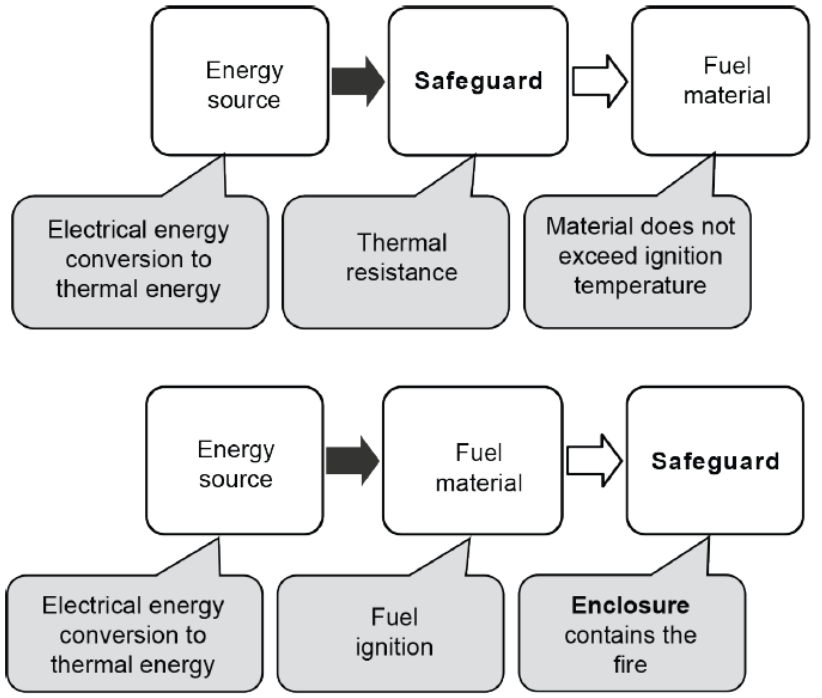


Figure 6 – Models for protection against fire

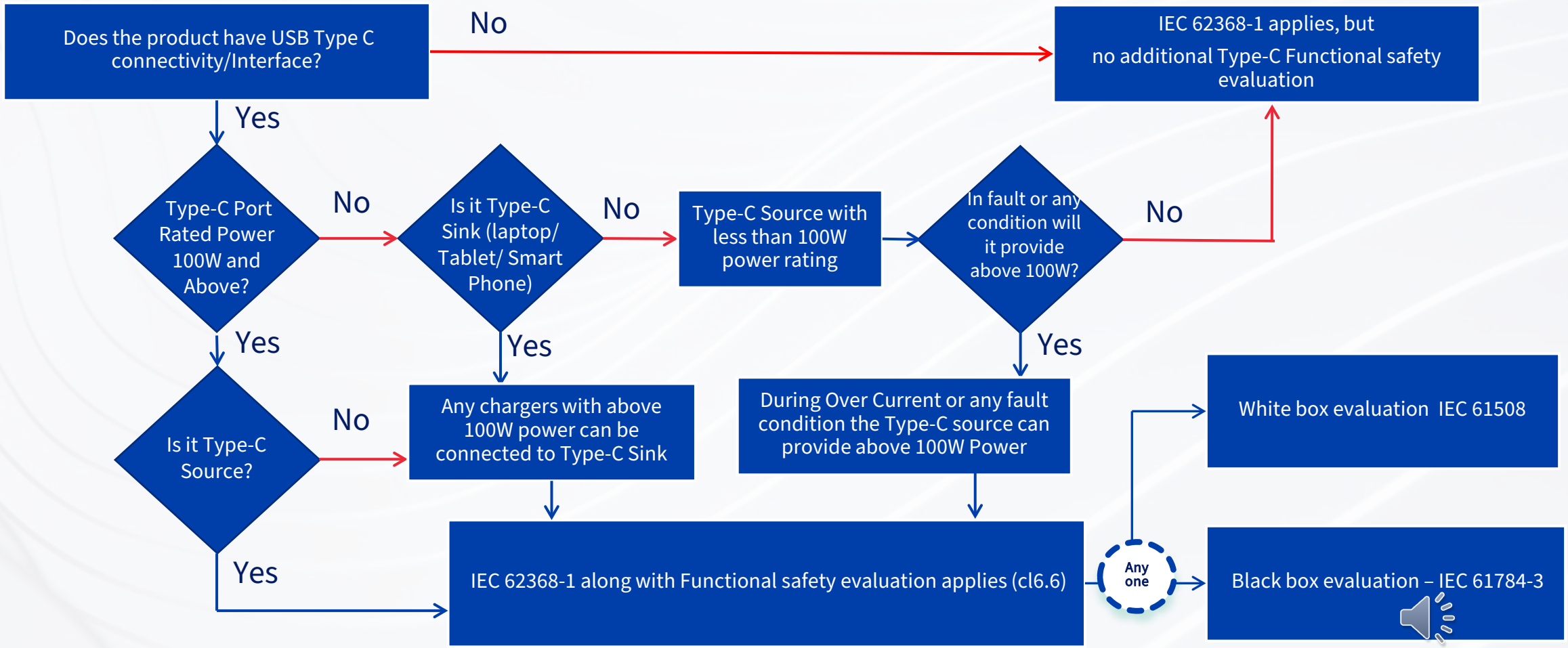
USB Type C PD Extended Power Delivery (> 100W) is considered is Power Source (PS3) which is a potential source of ignition (fire hazard) unless it is connected to a suitable device which is designed to accept > 100W power.

Applicability

Source (Power Source Equipment) – Power Adaptor	IEC 62368-1 Power source classification	Cable	Sink (peripheral/device) Laptop
15W type C	PS 1	No additional requirements	Functional Safety Testing Required
< 100W type C (USB PD - SPR)	PS 2	No additional requirements	Functional Safety Testing Required
> 100W (USB PD EPR)	PS 3	Cable must be capable to handle >100W power. Must be e marked	Must be designed to accept power above 100W Enclosure must be fire resistant with V1 or better material Or reject to accept power greater than 100W

No Electrical hazard has been foreseen because the voltage is always less than 60V DC which is classified as ES1 in normal condition and single fault condition

Flow chart for IEC 62368-1 for Type-C Designs



Applicability of IEC 62368-1 for Type-C Source

- Few sample Type-C Source

Power Level: 7.5W to 85W

Additional functional safety evaluation is not required

Power Level: 86W to 100W

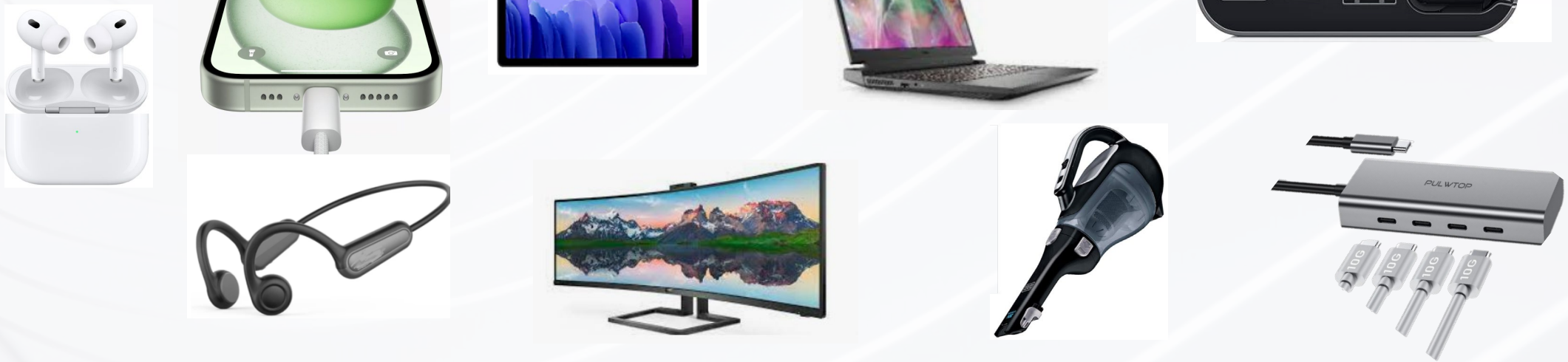
Under Over Current Condition power may go beyond 100W, so Additional functional safety evaluation is required

Power Level: 100W to 240W

Power Level is above 100W, so Additional functional safety evaluation is required

Applicability of IEC 62368-1 for Type-C Sink

- **All Type-C Sink / DRP** devices can be connected to any power source which may supply above 100W, so all sink / DRP device with Type-C port should be ***validated for Functional safety as part of IEC 62368-1***



Requirement 2: EU RED

USB Type C implementation as per European Union Radio Equipment Directive (RED) Directive 2014/53/EU Annex Ia, part 1

In so far as they are capable of being recharged by means of wired charging, the categories or classes of radio equipment referred to in point 1 of this Part shall:

2.1.be equipped with the USB Type-C receptacle, as described in the standard EN IEC 62680-1-3:2021 “Universal serial bus interfaces for data and power – Part 1-3: Common components – USB Type-C® Cable and Connector Specification”, and that receptacle shall remain accessible and operational at all times;

2.2.be capable of being charged with cables which comply with the standard EN IEC 62680-1-3:2021 “Universal serial bus interfaces for data and power – Part 1-3: Common components – USB Type-C® Cable and Connector Specification”.

3. In so far as they are capable of being recharged by means of wired charging at voltages higher than 5 Volts, currents higher than 3 Amperes or powers higher than 15 Watts, the categories or classes of radio equipment referred to in point 1 of this Part shall:

3.1. incorporate the USB Power Delivery, as described in the standard EN IEC 62680-1-2:2021 “Universal serial bus interfaces for data and power – Part 1-2: Common components – USB Power Delivery specification”;

3.2. ensure that any additional charging protocol allows for the full functionality of the USB Power Delivery referred to in point 3.1, irrespective of the charging device used.

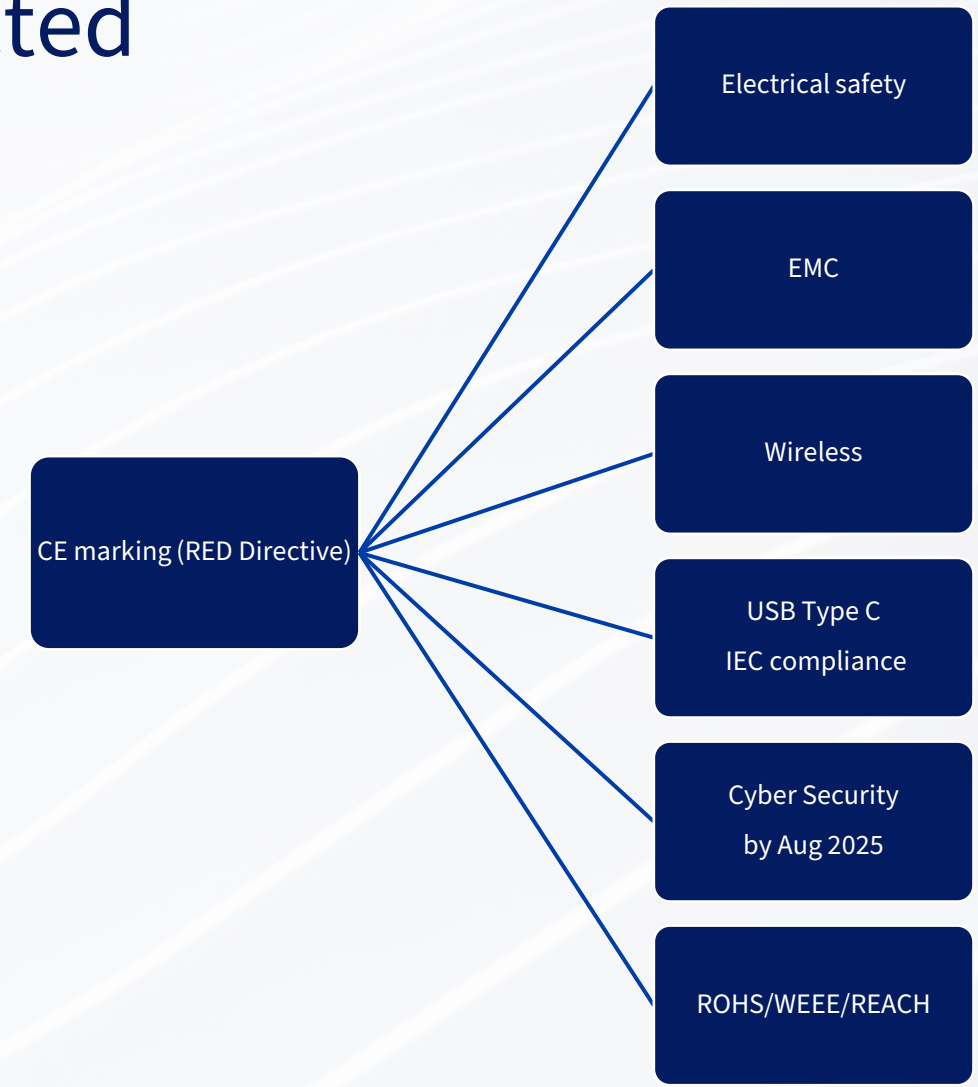
Products to be validated/ Impacted

Effective from 28 Dec 2024

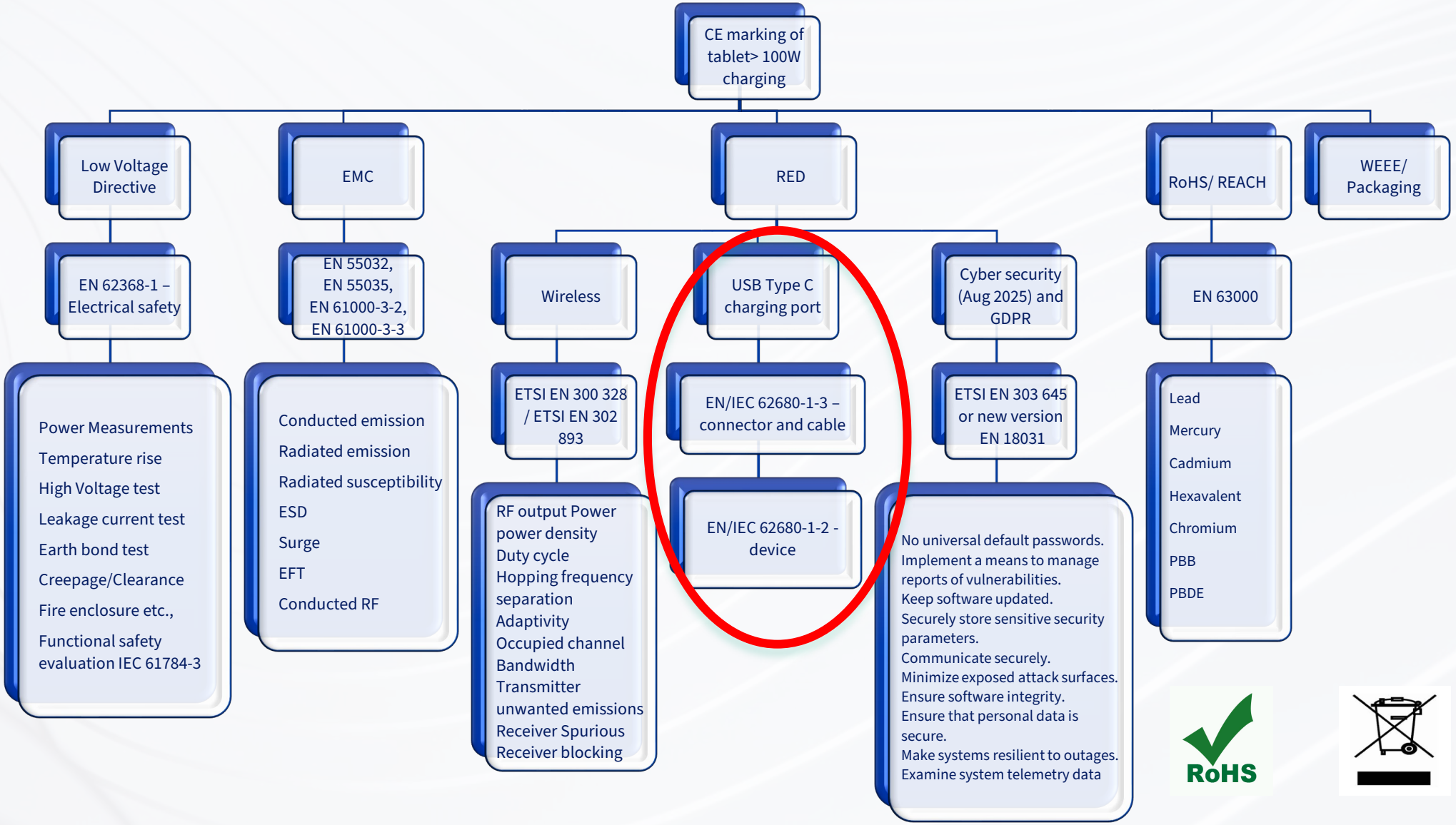
- Mobile phones
- Tablets
- Digital cameras
- Head phones
- Headsets
- Portable speakers
- E-readers
- Keyboards
- Mouse
- Portable navigation systems
- Earbuds
- Handheld videogame consoles

Effective from 28 Apr 2026

- Laptops



Example of CE marking of a Tablet after Dec 2024



CE marking is mandatory to enter European Union

How to meet the requirements

- Option -1 : Device, connectors and cables certified by USB IF

- Option -2 : Obtain a test report as per IEC 62680 series along with interoperability test reports from independent test lab like GRL

USB technology	With Power Delivery (>15W)	Without Power Delivery (up to 15W)
Connectors and cable used with listed devices in RED	Connectors and cables must be tested as per IEC 62680-1-3	Connectors and cables must be tested as per IEC 62680-1-3
Listed devices in RED	Device must be tested • per IEC 62680-1-2 • Cable and connectors used with device must be tested as per IEC 62680-1-3 • Device must fulfil Type C functional and IoP	Device must be tested • Cable and connectors used with device must be tested as IEC 62680-1-3 • Device must fulfil Type C functional and IoP

Few IEC References

- **IEC 62680-1-2** - Universal Serial Bus Interfaces (USB) For Data And Power - Part 1-2: Common Components - USB Power Delivery Specification
- **IEC 62680-1-3 -** Universal serial bus interfaces for data and power –Part 1-3: Common components – USB Type-C® Cable and Connector Specification
- **IEC 60950-1** Information technology equipment – Safety
- **IEC 60065** - Audio, video and similar electronic apparatus – Safety requirements
- ***IEC 62368-1 = IEC 60950-1 + IEC 60065***
- **IEC 62368-3 -** Safety aspects for DC power transfer through communication cables and ports
- **IEC 63315 (draft PT 63315) -** SAFETY – DC power transfer between ICT equipment ports using ICT cabling at ≤ 60 Vd.c.
- ***IEC 61784-3:2017*** -Industrial Communication Networks - Profiles - Part 3: Functional Safety Fieldbuses - General Rules And Profile Definitions
- **IEC 61508 Ed. 2.0 : 2010** CMV -Functional Safety Of Electrical/ Electronic/ Programmable Electronic Safety-Related Systems - Parts 1 To 7 Together With A Commented Version (See Functional Safety And IEC 61508)
- **IEC 60730-1 Ed. 5.2 b:2020** - Automatic Electrical Controls - Part 1: General Requirements

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Validating USB Type-C Designs IEC62368-1

Certifying with IEC 62368-1 Functional Safety

- To validate/ Certify the PS3 class device (Above 100W) the design needs to be validated
  - **Option 1: Functional Safety - *White Box Testing***
    - Manufacture's process to develop software safeguards subjected to functional safety requirements
    - Evaluation to
      - UL 1998, classes 3-15
      - UL 60730, Annex H.11.12.3
  - **Option 2: Validation Tests – *Blackbox testing***
    - Manufacture's of USB-PD EPR implementation subjected to the USB-PD compliance Test specification
    - Each unique version of software including subsequent revisions shall be subjected to the entirety of these test cases

IEC 62368-1 Blackbox Testing (Option 2)

- Only Peripherals designed for over 100W should be able to receive power over 100W
- In case of any unknown failures, the design should fall back to “risk addressed” state
- Robust communication mechanism to prevent communication failures
- Function safety compliance in accordance to IEC 61784-3
  - Message corruption
  - Unintended repetition of a message
  - Incorrect message sequence
  - Message loss
  - Unacceptable delay of message
  - Message insertion
  - Message masquerade
  - Incorrect address

Black Box Testing Using GRL-C2-EPR

- Black box testing allows you to test the design with following error conditions as defined in IEC 61784-1
  - Message corruption
  - Unintended repetition of a message
  - Incorrect message sequence
  - Message loss
  - Unacceptable delay of message
  - Message insertion
  - Message masquerade
  - Incorrect address
- Ensures the design will provide power only when EPR capable cable and device is connected
- If any errors, the system will default to the safe zone of less than 100W

USB Type-C® Power Delivery Tester & Analyzer - EPR

The only instrument you need for validating compliance, inter-operability, and reliability of your designs

Overview

- Fully Integrated and Automated Compliance Testing Solution for the latest Power Delivery 3.1 V1.2 Specification
- Backwards compatible with Power Delivery 3.0 and 2.0 Specifications.
- Two independent ports (Source/Sink up to 240W each) for testing multiport devices
- All-in-one tester, integrated protocol exerciser, analyzer, e-load, power supply, Oscilloscope, and multimeters makes it less complex test setup
- Designed for reliability, robustness testing and beyond compliance testing
- Extensive API support to write custom test programs (C# and Python) to meet your unique testing requirements

IEC 62368-1 Functional Safety Testing using C2-EPR

- Supports all tests required by IEC 62368-1 Functional safety
- Validates PSE, Cable and PD
- Emulate source or a sink device for the entire EPR range
- Traceable calibration
- Inbuilt self test kit / Calibration verification kit for re-assurance of the quality
- Detailed Test Reports for the validation and analysis

Option	Description
GRL-USB-PD-C2-SAFETY	C2-EPR tester with IEC 62368-1 Functional Safety Tests License
GRL-C2-EPR-CALKIT	C2-EPR System Calibration Verification Kit

IEC 62368-1 – Functional Safety Tests

C2-EPR tester with IEC 62368-1 Functional Safety Tests License

- C2-EPR offers a ready to use IEC 62368-1 Conformance tests and report
- Report can be used directly for IEC 62368-1 functional safety testing evidence of conformance (PDF and HTML Versions are available)

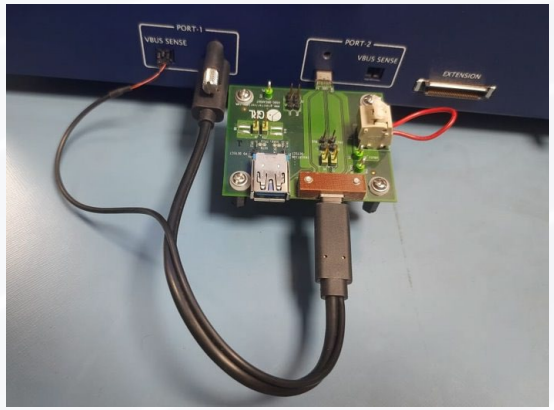
IEC Functional Safety Tests(IEC 62368-1/IEC 61784-3)

Sl No	Test Name	Test Result
1	1.Message corruption	PASS
2	2.Unintended repetition of a message	PASS
3	3.Incorrect message sequence	PASS
4	4.Message loss	PASS
5	5.Unacceptable delay of message	PASS
6	6.Message insertion	PASS
7	7.Message masquerade	PASS
8	8.Incorrect address	PASS

C2-EPR System Calibration Verification Kit

Built-In Self Test Kit for ISO Requirement

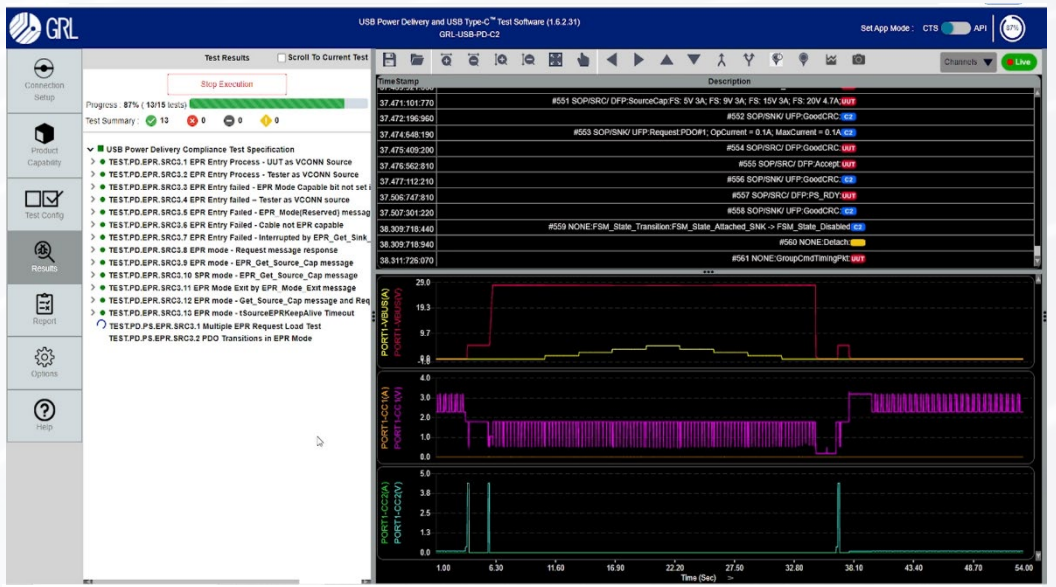
- External Built-In self test kit provided for calibration & verification
  - Port Voltage Check
    - Validate the voltage measurement accuracy
    - Internal and External verification
    - V_VBUS Range: 5V and 48V
    - V_CONN Range: 3V and 5.5V
- Port Current Check
  - Measure the current in Port1 and DMM and compare it and verify the accuracy.
    - V_BUS Current: 1A and 5A
    - V_CONN Current: 0.1A and 1.5A
- Easy to do accredited calibration for the Voltage and Current parameters using the C2-EPR



C2-EPR for USB-PD Compliance Testing

Easy to use for beginners

- Power Packed USB-IF Compliance
  - Latest PD 3.1 version 1.2
  - Legacy: PD 3.0, Deterministic and Communication engine MOIs.
  - Type-C Functional & Fast Role swap
- Powerful, one button compliance testing solution
- Generate, Verify and compare VIF files using Get Capability
- Quick Charge Compliance Testing
- VESA DisplayPort Alt mode tests
- Thunderbolt 4 Power Tests

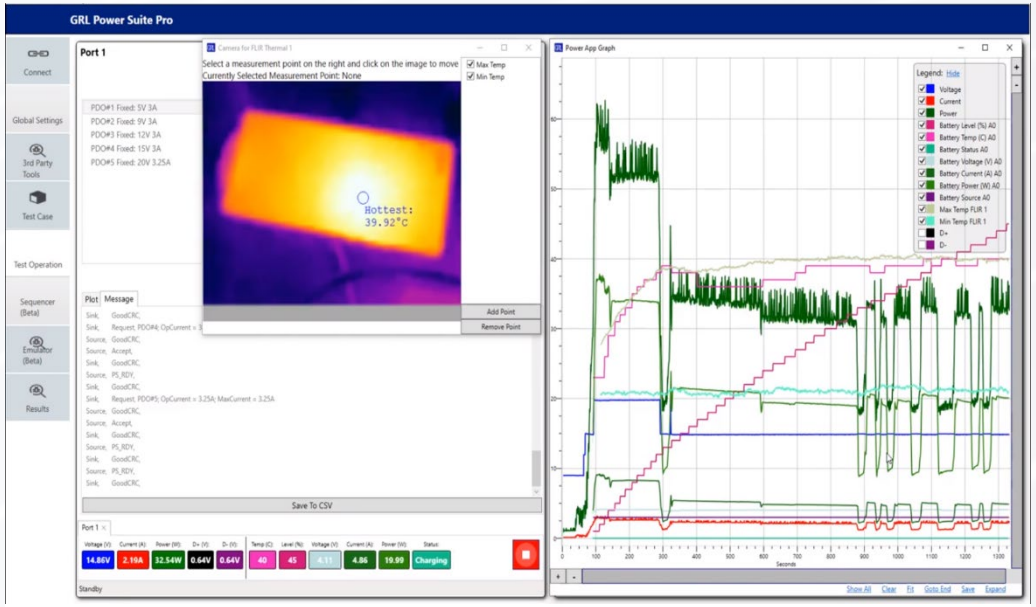


Detailed step by step pass/fail analysis and link to compliance specification for debugging

Powerful Power Suite Pro

Advance features for expert users

- Emulate Chargers, Phones, Laptops and many more devices
- Create your own test configurations and validate unexpected behaviors
- Thermal profiling and Hot Spot Identification with Automated Max temperature & Hot Spot Temperature tracking
- Over Current Protection Checking
- Attach/Detach Cycle Stability Validation
- For Android and iOS device battery charging % and voltage/current plotting



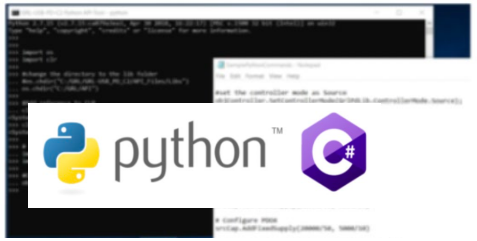
USB PD Protocol & VBUS/CC/D+/D- Visibility During Interoperability Testing Using Sniffer Analyzer Features

One solution for all your needs

- Easy to use, complete automated solution
  - Compliance testing
  - Inter-op testing
  - Reliability & Robustness testing
  - Multi port, complex shared power validation
  - Beyond compliance testing
  - IEC62368-1 Validation

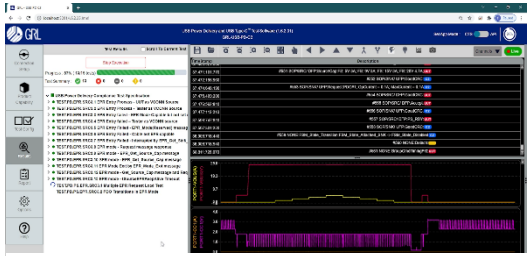
GRL-USB-PD-C2-EPR

Multi port switch for efficiently testing multiple DUTs with one tester



Write your own test cases beyond compliance using C# and Python

Powerful protocol & Trace viewer, bugs never get un-noticed.



Detailed test execution steps to correlate with CTS and test execution

Thank You!

https://graniteriverlabs.com/