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Whitepaper

Whitepaper

UL 61800-5-1

A new UL standard for adjustable speed drives and what you need to know

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UL 508C was obsolete and withdrawn by UL on February 1, 2020 and replaced with a new UL standard UL 61800-5-1, which was released in June 2012, for low-voltage adjustable speed drives (ASD) or variable frequency drives (VFD). The withdrawal of UL 508C has greatly impacted the industry. This whitepaper provides an author's perspective on what you need to know if you are a user, a panel builder, a manufacturer of motor control centers (MCC) or an OEM.

Background information and motivation behind the development of UL 61800-5-1

The main motivating factors behind the development of the new UL safety standard UL 61800-5-1 to replace UL 508C were:

- To create a single global set of requirements for the safety and design of low-voltage (LV) drive products.
- To reduce the design, testing and certification burden for drives, which otherwise required compliance with at least two different sets of requirements according to:
 - UL 508C for UL marking typically for drive applications in North America, and
 - EN/IEC 61800-5-1 for CE marking typically for drive applications in Europe and the rest of the world since both these UL and IEC standards were vastly different.
- And ultimately, to help create a single design of LV drive products that can be used globally without additionally requiring another certification based upon the geographical location where drive is installed and used.

The original intent was to develop a NEW global drive standard by harmonization of the requirements from UL and IEC for the low-voltage drives.

Therefore, originally for the first draft version, this new global standard was created taking requirements from UL 508C and IEC 61800-5-1. Eventually, because of the release of a new CSA standard for drives—CSA C22.2 No. 274, requirements from this CSA standard were also added in this new UL document. In the final version, additional new requirements were created and included to fill the gaps which were present in the original requirements of the above-mentioned parent UL, IEC and CSA documents.

The result is the publication of the most stringent new global standard for the safety of adjustable speed drives - UL 61800-5-1. Consequently, UL 61800-5-1 demonstrates more stringent construction and performance (testing) requirements for low-voltage drives as compared to obsolete and withdrawn UL 508C.

Continuous maintenance and further development of this new UL standard is an ongoing process like any other industry standard and will help bring both—the IEC and UL versions of 61800-5-1 together by eliminating national differences. This ultimately helps create global drive products using a single set of design, construction and testing requirements as originally envisioned.

The first edition of UL 61800-5-1 was published almost 8 years ago, in June 2012, and was introduced when the old UL standard for the drives—UL 508C, was active—which means both UL standards for drives—the old UL 508C and the new UL 61800-5-1 were co-existed for almost 8 years. However, finally, UL 508C was completely withdrawn by UL on February 1, 2020 and replaced with new UL 61800-5-1.

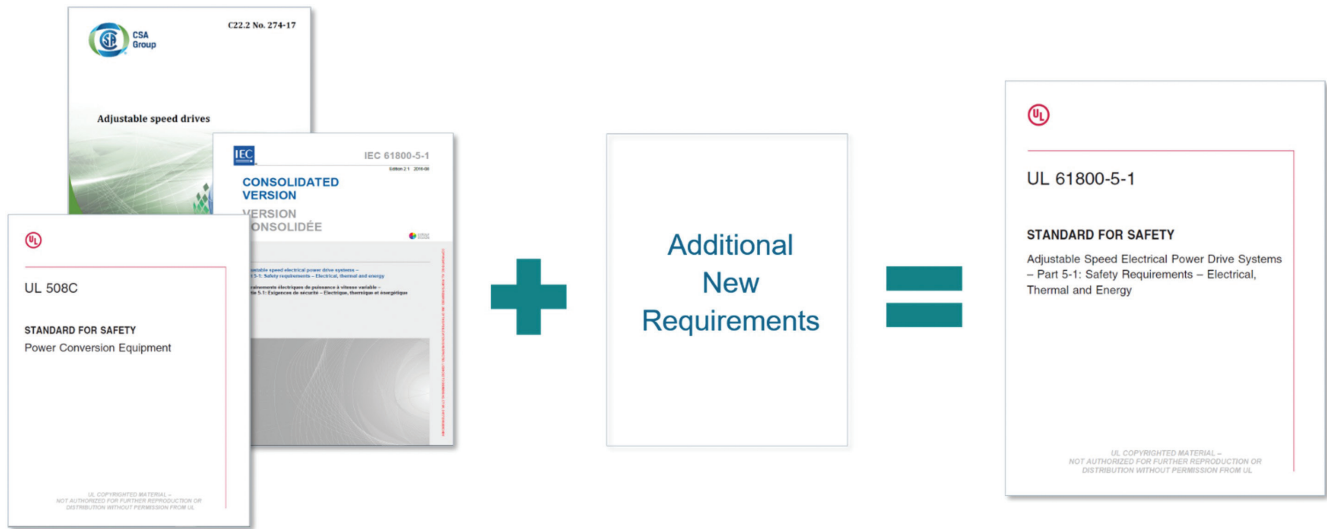


Figure 1
Formation of UL 61800-5-1: The most stringent safety standard for low-voltage drives

Major differences: UL 61800-5-1 (new) vs UL 508C (old and withdrawn)

There are plenty of differences in requirements between the UL 61800-5-1 (new) and UL 508C (old and withdrawn) standards. However, let us see the significant major differences which make the drive products safer using UL 61800-5-1 for design, testing and certification.

National Electrical Code (NEC/NFPA 70): As mentioned previously, UL 508C was the old UL standard for drives and withdrawn by UL on February 1, 2020, and currently, UL 61800-5-1 is the only available UL safety standard for low-voltage drives up to 1500V AC or DC. Since, UL 508C was scheduled to be withdrawn, unlike UL 61800-5-1, it was not maintained to meet the changing NEC code requirements and the latest technology safety requirements, which created additional significant gaps in its requirements compared to NEC as well as UL 61800-5-1.

New construction and performance requirements for drives: UL 61800-5-1 contains the most stringent construction and performance or testing requirements for the drive safety compliance.

According to new construction requirements of UL 61800-5-1, the drive needs to comply with new clearance and creepage distances (spacings) requirements. As a result, for an existing drive designed and certified according to UL 508C, a significant overhaul of the design may be required to comply with new construction requirements of UL 61800-5-1 to ensure required enhanced product safety.

Contrary to the old UL 508C, now the drive must comply with new rigorous performance or testing requirements of UL 61800-5-1. Here are just a few examples of the significant differences in drive performance requirements between the two UL documents.

Short-circuit tests: According to UL 61800-5-1, short-circuit tests are performed at the standard or low fault currents (5, 10, 18, 42 kA, etc.), as well as at the desired high fault currents (65 or 100kA or higher) on all output terminals including DC output of a drive, which are available for customer connections. There was no such requirement to test the DC output terminals of a drive previously when old UL 508C was used for the drive UL certification. So clearly, according to new UL 61800-5-1, more destructive testing and a greater number of test samples are now required.

Breakdown of component tests: The breakdown of component testing includes the drive circuit analysis for the identification of the components within the drive (e.g. diodes, DC bus capacitors, IGBT, power wiring board, components on the power wiring board, etc.), which pose a risk of electrical shock, fire or operator injury upon failure—which typically happens when the component shorts (or sometimes opens).

After such identification of components, contrary to UL 508C, the breakdown of component testing according to UL 61800-5-1 is performed on the drive by creating the abovementioned component failure at a standard fault currents (5, 10, 18, 42 kA, etc.) as well as at the desired high fault currents (65kA or 100kA or higher) when it is operating (typically) at a full load or partial load, whichever creates the worst case of failure according to circuit analysis.

In addition, the voltages of the drive control and communication circuits need to be monitored during this breakdown of component tests to ensure that their values do not exceed the limits specified in UL 61800-5-1 or the dielectric withstand test (hi-pot) test needs to be conducted after the breakdown of component test. This is done to ensure that the drive design is inherently safe and such kinds of component failures within the drive do not pose risk of electrical shock or fire.

These breakdown of component tests are repeated on all components one-by-one, which were identified through circuit analysis and which exhibit risks of electrical shock, fire or operator injury.

So as can be seen from the above, contrary to the requirements in withdrawn UL 508C, the internal components of a drive under tests truly experience the actual let-through current and associated electro-mechanical stresses under these simulated fault and component failure conditions according to UL 61800-5-1.

As can be recognized from the above explanation once again that according to the new requirements of UL 61800-5-1, for the breakdown of component tests also, additional destructive tests are required on a greater number of drive test samples, and this means the drive is heavily beaten up to ensure the higher level of product safety in the end use.

This kind of rigorous testing ultimately exhibits that the drive, which inherently has robust and reliable design can only pass such rigorous tests using the requirements according to new UL 61800-5-1. Such a demanding evaluation of a drive also ensures that, in normal, abnormal and fault conditions of drive operation, as well as during all possible failure modes, the drive maintains a high level of safety and does not pose risks due to electrical, thermal and energy to operators or property, and confirms complete peace of mind to equipment owners.

New plenum rating requirements: New plenum rating requirements have been introduced in UL 61800-5-1 to align with NEC requirements. According to these new requirements, an enclosed drive having polymeric (non-metallic) enclosure with surface area exceeding 25 square inches needing plenum rating marking are now required to be tested according to UL 2043. This test is a fire test method for determining the fire performance response of a drive, which is subjected to an open-flame ignition source and evaluated using a product calorimeter. The purpose of this test is to determine the rate of heat and smoke release of the burning product samples as they relate to the requirements for fire-resistant and low-smoke-producing characteristics in accordance with the provisions of the National Electric Code, NFPA 70; Standard for the Installation of Air Conditioning and Ventilating Systems, NFPA 90A.

Keeping up with new technologies: Moreover, after the introduction of UL 61800-5-1, the old UL 508C was not maintained to cover the requirement changes needed because of new emerging technologies in product safety and new applications. From the product safety perspective this means that the products which have undergone design, testing and certification according to the old UL 508C after publication of new UL 61800-5-1, will not technically meet the same level of safety in design, construction and performance as the products certified according to new UL 61800-5-1 do. Therefore, UL 61800-5-1 certified products are safer and more robust than those certified according to UL 508C.

In addition to these requirements, many other new requirements have been created and are in the process of being published in upcoming edition of UL 61800-5-1 — for example, multi-motor control, revision to the motor overload protection, output phase to ground fault, revision to the requirements for across-the-line capacitors and others, which are all missing in UL 508C since it was not maintained and is in the process of being withdrawn.

Readers are encouraged to refer to the documents available on the UL and NEMA websites included in the reference section of this article to find more technical detail and information about the major differences in the requirements of the new UL 61800-5-1 and old UL 508C.

Figure 2

Comparison of UL Certification types

	UL 61800-5-1	UL 508C
Construction Requirements		
Clearances and Creepage Distances NEW	✓ YES	✗ NO
Multiple Motor Control Application NEW	✓ YES	✗ NO
Across-the-Line Capacitors per UL 60384-14 NEW	✓ YES	✗ NO
Plenum Rating NEW	✓ YES	✗ NO
Motor Overload and Overtemperature Protection*	✓ YES	✗ NO
Performance Requirements		
Short-Circuit Tests on DC Output Terminals NEW At standard fault currents (5, 10, 18kA etc.) At high fault currents (65 or 100kA)	✓ YES	✗ NO
	✓ YES	✗ NO
	✓ YES	✗ NO
Breakdown of Component Tests NEW At standard fault currents (5, 10, 18kA etc.) At high fault currents (65 or 100kA)	✓ YES	✗ NO
	✓ YES	✗ NO
	✓ YES	✗ NO
Protective Bonding Tests NEW	✓ YES	✗ NO
Multiple Motor Control Application NEW	✓ YES	✗ NO
Fire Test for Plenum Rating per UL 2043 NEW	✓ YES	✗ NO
Tests for Motor Overload and Overtemperature Protection*	✓ YES	✗ NO
Line to Ground Short-Circuit Tests* At standard fault currents (5, 10, 18kA etc.) At high fault currents (65 or 100kA)	✓ YES	✗ NO
	✓ YES	✗ NO
	✓ YES	✗ NO

*Coming soon

UL process of withdrawing UL 508C standard and the implementation of UL 61800-5-1

The UL and Standards Technical Panel (STP) of UL 508C and UL 61800-5-1 agreed to the timeline and process, as shown in Figure 2, of transitioning from the old UL 508C standard to the new UL 61800-5-1 standard. The transition plan clearly shows adequate time (over 8 years) allowed for drive manufacturers to convert the design and certification of their products to comply with UL 61800-5-1, as well as to system builders to modify their equipment design to use drives certified according to new UL 61800-5-1.

In summary, the UL 61800-5-1 implementation plan as shown in Figure 2 shows that after February 1, 2020:

- All **new products** are required to be investigated under UL 61800-5-1
- Products certified under UL 508C **may** retain the UL mark if an alternate construction is not made to the product (for example, due to component obsolescence requiring replacement). Such alternate construction requires product re-design, testing and certification according to UL 61800-5-1

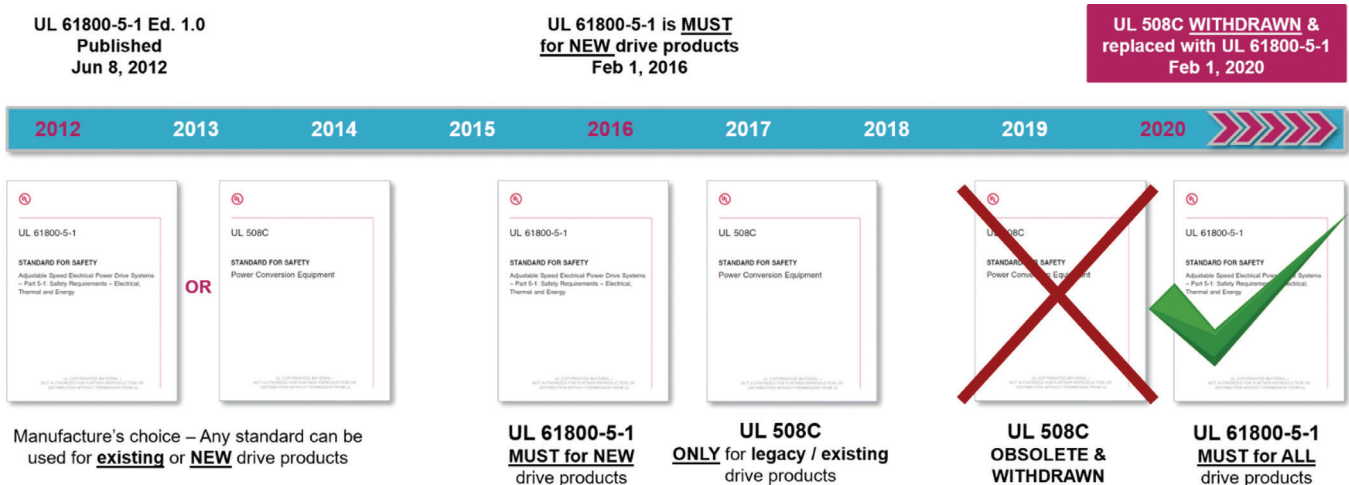


Figure 3

UL 508C to UL 61800-5-1 transition plan

Industry impact

What does this UL change mean to drive end-customers/end-users?

After publication of UL 61800-5-1, many end-customers/equipment owners/drive users (e.g. in automobile, water/waste-water, infrastructure, construction, oil-and-gas, power plants, buildings, metals, pulp-and-paper industries, etc.) have already been specifying the new and latest technology adjustable speed drives certified according to UL 61800-5-1 in their requirement and bid specifications. Especially after February 2016, they no longer allow the use of obsolete and old technology drive products certified according to UL 508C.

Now after withdrawal of UL 508C on February 1, 2020, these customer specifications have now started mandating the use of UL 61800-5-1-certified drives to the OEMs, system builders and subsequently, to the drive manufacturers.

Moreover, since UL 508C has been withdrawn and UL 61800-5-1 is the only UL safety standard for low-voltage drives, UL announced the removal of references to UL 508C and their replacement with UL 61800-5-1 in ALL UL product and system standards where drives are used—for example, UL 508A, UL 845, UL 1995 and others.

Therefore, it is prudent to use the latest drive technology products in equipment (i.e. industrial control panel, MCC, pump skid, chiller, HVAC equipment, etc.) which are designed and certified according to the latest, most rigorous and enhanced safety requirements of UL 61800-5-1 to ensure process continuity and the safety of personnel and property. Certainly, equipment owners, do not want to use obsolete and outdated drive products that are designed with safety requirements that have not been up to date with NEC/NFPA 70.

Authority Having Jurisdiction (AHJ)* and electrical inspectors have increasingly started requesting UL 61800-5-1-certified drives in the equipment or panels used at the end-customers'/end-users' installation locations.

What does this UL change mean to OEMs and equipment manufacturers comprised of drives—e.g. Panels, MCCs, HVAC, chillers, etc.?

After the withdrawal of UL 508C on February 1, 2020, OEMs and system or panel builders who use low-voltage drives in their equipment (e.g. industrial control panels, MCCs, HVAC equipment, chillers, etc.) will have some time to change their equipment design and switch to UL 61800-5-1-certified drives in their product.

However, due to the specifications from industrial users/customers mandating the latest or new UL 61800-5-1-certified drives, OEMs and system or panel builders will have to adapt to this change sooner than later, and quickly modify their equipment design to use UL 61800-5-1-certified drives to get ahead of the curve as well as their competition to support their customers.

As a result, these OEMs/system and panel builders will stipulate the drive manufacturers to supply the replacement drives with the latest and new technology with UL 61800-5-1 certification for their equipment.

* Authority Having Jurisdiction (AHJ) means the organization, office, or individual responsible for approving layout drawings, equipment, an installation or a procedure. Usually the AHJ is the building and/or fire official of the city or county in which the job site is located.

What does this UL change mean for drive manufacturers?

According to the UL certification group within UL LLC, any drive products that are listed according to UL 508C will remain UL-listed until they will be modified (i.e. typically requiring changes to the construction or design of a drive). This means, if a drive manufacturer has to undergo the replacement of components due to supply chain issues such as the shortage or discontinuation or obsolescence of a drive component (e.g. capacitors, diodes, IGBTs, etc.), then they do not have a choice but to re-design the complete drive.

Such situations can cause the disruption in the supply chain of the drives to the end-customers, machine builders or system / panel builders who use such drives certified according to the old UL 508C in their equipment, and therefore, they now also have to undergo a complete design change, plus testing and recertification. This kind of reactive situation causes severe negative business impact to all involved in the supply chain, as well, as it will typically take significant time to complete the re-design, testing and necessary certification, plus get the approvals to release product. This means very high risk of business discontinuity for everyone involved.

Moreover, following the UL withdrawal of the old UL 508C, drive manufacturers are now expected to supply UL 61800-5-1-certified drives, and those who were not proactively following the UL process of transitioning their drive designs from the old UL 508C to the new UL 61800-5-1 standard in a timely manner, within the last 8 years approximately, would face extreme challenges in convincing end-customers, machine builders and system / panel builders, to use drives certified according to outdated, obsolete technology and the withdrawn UL 508C in their equipment. They might not be able to respond to market requirements and demands in a timely manner.

Retrofit or repair of equipment comprised of old UL 508C-certified drives

UL compliance of a system / equipment after retrofit or repair at the end-customer's or equipment owner's site typically does not fall under UL's responsibility unless such requirement of on-site UL certification of retrofitted or repaired equipment is specified in the equipment retrofit or repair specifications by an equipment owner or customer.

In such cases, UL Field Evaluation or Field Inspection Service group (or any other NRTL) needs to be engaged to carry out the field evaluation and certification approval of the finished equipment after retrofit or repair. Moreover, in such cases, whether to use the same old UL 508C-certified drive or to use its UL 61800-5-1 certified successor is solely at discretion of the end-customer or equipment owner.

However, following the UL announcement of withdrawal of UL 508C, the AHJ and electrical inspectors, and therefore, generally, the customers and equipment owners have been specifying the UL 61800-5-1-certified drives for a retrofit or repair of equipment (e.g. panels, MCC, HVAC equipment, chillers, etc.). As a result, use of UL 61800-5-1-certified drives is a highly anticipated reality for such kind of jobs, as well.

In these kinds of situations, machine builders and system or panel builders, who have proactively adapted UL 61800-5-1-certified drives in their equipment designs already, are in a better position to offer proper replacement options in the field per customer specifications, and certainly, will also have greater opportunities of winning similar retrofit or repair opportunities, in future compared to their competitors.

*References to the old and withdrawn UL 508C are being replaced with NEW UL 61800-5-1 in ALL UL standards including UL 508A (Industrial Control Panels), UL 845 (Motor Control Centers (MCC)), UL 1995 (Heating and Cooling Equipment—HVAC / R) and others.

Key takeaways

UL 61800-5-1

- Requires the most stringent construction and performance (testing) evaluation of low-voltage drives
- Requires a greater number of destructive tests representing real-life drive operation and application conditions
- Requires the significant and rigorous testing of a greater number of drive test samples as compared to the old and withdrawn UL508C
- Ultimately ensures enhanced product safety
- The ONLY valid and current UL safety standard for low-voltage drives as UL 508C was obsolete and withdrawn on February 1, 2020*
- End-users and machine builder customers have already started specifying the use of UL 61800-5-1-certified drives for their applications

Machine builders/system or panel builders

- Need to adapt this UL change (UL 61800-5-1-certified drives) sooner than later
- Should be proactive by modifying the design of their equipment quickly to replace old UL 508C-certified drives with the equivalent UL 61800-5-1-certified drives
- Faster implementation of such design changes will help address new market and customer requirements even more effectively to obtain better market exposure and coverage
- Ultimately end-customers/end-users will get the latest technology, and safer, more robust products

SINAMICS low-voltage drive portfolio

Siemens was one of the first to recognize the benefits and enhanced level of safety that this new drive safety standard UL 61800-5-1 inherently offers and provides a significant added value to its customers, users, machine builders, panel builders, solution providers and system integrators, and therefore, Siemens was one of the first drive manufacturers to adopt UL 61800-5-1 as soon as it was published. Since it was valuable to its customers, yet not at all easy, Siemens modified, re-tested and re-certified all existing UL 508C-listed drive products to the new UL 61800-5-1 standard, and decided to release all upcoming new low-voltage drive products with UL 61800-5-1 certification only.

In addition to compliance with the most stringent new low-voltage adjustable speed drive safety standard UL 61800-5-1, SINAMICS drive products also meet the requirements of the latest and upcoming EN/IEC standards, EU regulations and NEMA standards requirements ensuring improved EMC performance as well as enhanced product safety and energy efficiency.

Please visit the [Siemens website](#) to learn more about the SINAMICS low-voltage drives portfolio, how these products can be beneficial to new applications or integrate into existing applications, and how they can be easily configured for cost-optimization and resource-saving operation, to help reduce total cost-of-ownership.

Additional resources

- **UL webinar recording on the impact of withdrawal of UL 508C**

This UL webinar recording is available on-demand to provide major differences between UL 508C and UL 61800-5-1, and how the VFD certification according to UL 61800-5-1 helps reduce costs and time for product release in global markets.

[Click here.](#)

- **UL notice of withdrawal of UL 508C**

This UL notice was sent out to all UL subscribers (manufacturers) to inform them on the withdrawal of UL 508C references from ALL UL standards and their replacement with UL 61800-5-1.

[Click here.](#)

- **UL bulletin on implementation of UL 61800-5-1**

This UL bulletin provides details of UL STP (Standards Technical Panel) approved withdrawal plan of UL 508C and its replacement with new UL 61800-5-1 for continuing certification of adjustable speed drives.

[Click here.](#)

- **UL FAQ on implementation of UL 61800-5-1**

UL document showing frequently asked questions related to UL STP (Standards Technical Panel) approved withdrawal plan of UL 508C and its replacement with a new UL 61800-5-1 for continuing certification of adjustable speed drives.

[Click here.](#)

- **NEMA Paper on “New UL Variable-Frequency Drive Standard and Its Effects on Unit Short-Circuit Rating”**

This NEMA paper focuses on the impact of the new UL Standard UL 61800-5-1 on safety requirements for adjustable speed drives with respect to certification of these devices. Specifically, it addresses changes in the evaluation of short circuit ratings assigned by the drive manufacturer.

[Click here.](#)

- **Standard for Adjustable Speed Electrical Power Drive Systems**

Part 5-1: Safety Requirements—Electrical, Thermal and Energy, UL 61800-5-1

- **Standard for Standard for Power Conversion Equipment, UL 508C (Withdrawn)**

- **IEC 61800-5-1, Adjustable speed electrical power drive systems**

Part 5-1: Safety requirements—Electrical, Thermal and Energy

- **CSA C22.2 No. 274-17, Adjustable speed drives**

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