NMEA 2000 conformance testing and product certification

The NMEA 2000 product certification guarantees a certain level of quality and interoperability for NMEA 2000 networks by ensuring that a device supports a mandatory set of protocol services and hardware requirements. Developers can carry out the certification themselves or be supported by engineers experienced in the NMEA 2000 certification.

NMEA 2000 is a higher-layer protocol based on CAN CC (classic) for marine applications. It is the de-facto backbone for marine applications around the world, integrating navigation, propulsion, lighting, power, switching, and entertainment devices. It always uses a bit rate of 250 kbit/s and has a maximum of 50 physical devices on one network. Based on ISO 11783 (SAE J1939), it specifies a set of standardized messages called Parameter Group Number (PGN), each of them has a unique number. There are PGNs available for a wide variety of applications inside a vessel such as navigation, propulsion, lighting, etc. One additional feature that NMEA 2000 requires on top of the ISO 11783 basis is the Fast Packet Protocol. This is an additional transport protocol, which can transfer up to 223 bytes in up to 31 CAN CC frames. Larger vessels typically have one to three NMEA 2000 networks. The typical NMEA 2000 network has a backbone connected via T-pieces and drop cables down to the devices. At each end there is a 120-Ohm termination resistor which is an off-the-shelf component. Figure 1 shows a typical installation for a NMEA 2000 network. In a micro NMEA 2000 network, all cables use the 5-pin M12 type connector.

NMEA 2000 devices have a set of rules that must be followed to operate correctly. These include but are not limited to:
- The bit rate shall be 250 kbit/s.
- Provide a set of services to identify a device and its manufacturer as well as a list of transmit and receive PGNs.
- Provide the Load Equivalency Number (LEN), which describes how much current is drawn from the network.
- Provide configuration services to change features such as update rate, priority, and instance.
- Operate with a supply voltage between 9 V_{dc} and 16 V_{dc}.
- DC and AC isolation of I/Os from the NMEA 2000 connector.

Figure 1: A typical installation for a NMEA 2000 network (Source: Warwick Control Technologies)

These rules are defined in the NMEA 2000 specification package, which is available from the National Marine Electronics Association (NMEA) on its website (nmea.org). To be able to state that a product is a NMEA 2000 device, the NMEA requires that manufacturers put their products through the NMEA 2000 certification process. This is broken down into two main parts. The first is concerned with checking the requirements of the embedded software in the device to ensure that its communications conform to NMEA 2000, e.g. timing, requests, responses, and mandatory services. The second part is a self-certification checklist for hardware requirements mostly e.g. connectors, cables, PCB design, AC and DC isolation, and CAN signaling. These are described further in this article.
NMEA 2000 devices and implementations

There is a lot of devices available on the market that claim to be NMEA 2000 compatible devices in some way. However, in reality most of these devices do not actually meet all of the requirements of NMEA 2000. There is also a large number of open-source and private projects available online, which aim to integrate into NMEA 2000. Again, these projects do not support all of the requirements of NMEA 2000. When a device is a NMEA 2000 certified device, it means that it provides certain software services via the protocol and also the hardware meets certain requirements (e.g. DC and AC isolation).

Benefits of NMEA 2000 product certification

Product certification guarantees a certain level of quality and interoperability for NMEA 2000 networks by ensuring that a device supports a mandatory set of NMEA 2000 protocol services and hardware requirements. For device manufacturers, this means that they can state that their product is NMEA 2000 certified and use the NMEA 2000 logo in their marketing.

The NMEA 2000 product certification process partly consists of automated software tests and partly of a self-certification process to check on the hardware and other requirements. Both are specified in Appendix C of the NMEA 2000 specification package available from the NMEA.

Automated tests are specified in Appendix C3 and use the bench setup shown in Figure 2. It uses a CAN CC interface by Kvaser as the other device on the network, which connects to the Device Under Test (DUT) via a terminated bench-based CAN CC network. The NMEA 2000 certification tool is used on a Windows PC and provides instructions for initial conditions of each test. After setup, all of the NMEA 2000 message exchange is started by a press of a button.

![Figure 2: Setup for NMEA 2000 automated software testing (Source: Warwick Control Technologies)](Image)

Appendix C2 of the NMEA 2000 specification package is a self-certification process and takes the user through a set of hardware tests and checklist items to ensure that the product meets the requirements. These include such aspects as:

- Include measurements of DC or AC isolation between the NMEA 2000 connector and any other I/O that may be present on the device.
- Declaration of storage and operational temperatures.
- Details of CAN signal timing.

Companies wishing to develop NMEA 2000 devices can carry out the certification of the product to NMEA 2000 themselves by purchasing the NMEA 2000 certification tool from the NMEA. An alternative route is to benefit from the experience and guidance from the team at Warwick Control Technologies with their NMEA 2000 conformance and product certification services.

Whichever route is chosen, a Manufacturer Code (unique to company) and Product Code (unique to product) must be obtained from the NMEA.

Certification service

The main reason why companies use the conformance and product certification services from Warwick, is to benefit from the company’s expertise and experience. In general, there are two levels of service available:

- **Pre-conformance test:** This is recommended for customers who need to check the main software conformance to the NMEA 2000 communication requirements and the CAN signalling of a prototype device. This can also be extended to look at NMEA 2000 hardware requirements if a customer is not confident in its hardware design.

- **Full product certification:** This is recommended for customers who think that their device is ready to go for full product certification with the NMEA. This includes a check of both software and hardware of the device.

The benefit of engaging Warwick earlier in the project and using the pre-conformance test service is that the developer will get early advice on issues that could delay development, increase project costs, and delay the product release date. The general benefits of the engagement include:

- Engaged engineers are experienced with the NMEA 2000.
- Know how to analyse the test failures.
- Tests provided in addition to those required by the NMEA, therefore helping to provide a high level of product for customers.

Common issues

A common misunderstanding is that NMEA 2000 is simply the SAE J1939 with parameters for marine applications instead of those for trucks. From the experience of Warwick Control Technologies, some companies simply do this and somehow obtain the details of the PGNs that they need from the Internet. When these are put through the software tests that are executed by the official NMEA 2000 certification tool, this often results in many failures.

There are also many commonly seen issues that lead to a failure and the need for re-testing. These are not always obvious initially and include such aspects as:

- **Sample point:** The requirement is that it should be set between 85 % and 90 %. However, often values of 75 % or less are used. This is often due to the default setting in the example source code that companies new to CAN have obtained for implementation of their low-level CAN drivers.
**Automatic retransmission:** In early implementations of CAN, the automatic retransmission of a CAN frame upon corruption was mandatory. This became an option when Time Triggered CAN was introduced. To pass the software tests for NMEA 2000, automatic retransmissions should be enabled. This option is often disabled by default in the CAN drivers.

**AC/DC isolation of NMEA 2000 connector:** The pins in the NMEA 2000 connector need to be isolated from other I/Os. If a device is repurposed from another application, often the isolation does not meet the NMEA 2000 requirements.

**Use of proprietary PGNs:** The approach should be where possible to use an already available PGN from the standard, even if not all fields are needed. The unneeded fields can be set to “unavailable”. Proprietary PGNs should only be needed when there is not a standardized PGN available for the device’s purpose. The NMEA does strongly encourage companies in this situation to get involved in the standardisation of new PGNs.

**Termination:** Often a device is being repurposed from another CAN application to NMEA 2000 and may have a termination inside the device. The original application is sometimes one that uses a PCB populated termination resistor in the device. For NMEA 2000 applications, a device may not have a termination resistor. The termination resistor can only be a harness-fitted component at each end of the backbone network providing two terminations in total.

**Final word**

Whilst conformance testing and NMEA 2000 product certification ensure that a device meets the protocol requirements, they do not ensure interoperability with other devices. It is part of the testing regime required for a NMEA 2000 product. The simpler devices usually are quite straightforward. However, vessels tend to have a multi-function display (MFD) for access to the information from NMEA 2000 devices and to control aspects of the vessel. This is one of the more complex devices on the vessel. Entertainment head units and remote controllers are other examples of complex devices needing to integrate with the vessel MFD devices and can often be challenging. Interoperability of new devices with the more complex devices is not guaranteed by the NMEA 2000 product certification process and therefore additional testing is recommended.

**Author**

Dr. Chris Quigley
Warwick Control Technologies
enquiries@warwickcontrol.com
www.warwickcontrol.com

---

BY ENGINEERS, FOR ENGINEERS

We were founded by engineers for engineers, and take pride in making CAN interfaces that work ‘out of the box’.

As connectivity in the world expands, so do we. We are expanding our offerings beyond CAN to other types of connectivity, creating a world of possibilities.