

Telcordia qualification: reducing the pressure

SINCE THE EARLY days of fibre-optic communications, Telcordia Technologies (formerly Bellcore Labs) has engaged in setting standards that ensure the reliability of devices going into optical networks. Telcordia is now the predominant standards body for optical components used in telecoms equipment, with its generic requirement (GR) documents employed worldwide by all the major optical component and equipment vendors.

It therefore stands to reason that compliance with Telcordia qualification is a must for manufacturers looking to launch products into the competitive telecoms market. Things are never quite that straightforward, though – the problem being that performing the qualification can be extremely costly and time-consuming.

The foremost goal for today's optical-device makers is to balance confidence in their products' reliability with the cost of verification. Put another way, vendors need to develop a qualification programme that meets their testing needs while minimizing the operational impact in terms of time, resource and expenditure.

Grand guidelines

The key Telcordia standard for optical-comms applications is GR-468-CORE, which sets out the reliability requirements for most of the optoelectronic devices used in telecoms equipment. The document covers, for example, the lasers, LEDs, photodiodes and optical modulators used to create equipment such as digital cross-connects, optical amplifiers, and terminal and add-drop multiplexers.

The basic aim of GR-468 is to ensure sound reliability practices throughout a product's life cycle. The qualification programme – a table of test procedures – forms the heart of the Telcordia standard. But the document also describes the whole range of high-level reliability practices, including: lot-to-lot control; corrective actions for failures; environmental, health and safety considerations; and documentation processes.

GR-468 was updated in September 2004 to reflect advances in optical technology and incorporate new product developments such as tunable lasers. The scope of the standard

Telcordia qualification can offer big benefits for manufacturers of optical components and devices. But such advantages don't come cheap. Reinhard Pusch, general manager for German test laboratory microtec, explains what's involved and how vendors can minimize the costs of running rigorous testing procedures.



Outsourcing options: independent test labs provide manufacturers with access to a wide range of high-end test and measurement equipment, as well as expertise in performing GR-468 qualification.

was extended to include higher-level devices like optical transmitters, receivers and transponders below the circuit-package level. The new version doesn't change the number of tests listed, the test conditions or other basic requirements for qualification, but in some cases alters the test durations. The cost and time needed to perform a complete qualification programme are now often marginally reduced. Crucially, components qualified to the previous version are considered compliant with the new issue, although some systems vendors refer back to the old GR-468 to meet its more stringent conditions.

The majority of the GR-468 document comprises a detailed description of the test procedures that optical-component makers must employ to assess device reliability. The programme requires vendors to characterize the basic performance parameters of their devices, as well as examine environmental effects and accelerated aging. The programme can be split into three stages:

Stage one enables full characterization of product performance under nominal operating conditions. Manufacturers need to examine a representative selection of devices to investigate optical and electrical parameters (optical power, spectral characteristics and laser-drive voltage, for example), perform operational shock and vibration analysis, and examine physical parameters such as electrostatic discharge and hermeticity. The exact parameter set employed depends largely on the product's application, which may vary between customers.

The second stage lets vendors demonstrate that their products survive under normal mechanical and environmental stresses, such as those experienced during transportation, storage, installation or over an operating lifetime of around 20 years. Mechanical tests included at this stage include shock, vibration and thermal shock, plus fibre and connector integrity tests. Environmental tests include powered and nonpowered storage at high temperatures and humidity, plus temperature cycling. The standard calls for test durations of up to 2000 hours, or even 5000 hours for some specific cases.

The final stage of the programme comprises the accelerated-aging tests, which focus on the physics of failure mechanisms. Such tests are conducted at different stress levels until failures occur. The proposed programme is a continuation of the above environmental-stress tests, but extended to up to 10 000 hours and applied to a smaller number of samples.

While Telcordia qualification represents a vital stage in product development, it can be a costly business, with a range of factors contributing towards the large upfront expendi-



All options: GR-468 covers optoelectronic modules and components, while more complex set-ups can employ GR-1312 for optical amplifiers and DWDM systems, or use GR-1221 for passive subsystems.

ture that's required. Firstly, there's the large number of components that need to be assessed to qualify a device – around 100 for a laser diode or photodiode and about 80 for a highly integrated module.

The test and measurement apparatus itself can be pricey, and with a wide variety of procedures needed, the equipment budget soon adds up. Required systems could include high- and low-temperature ovens, temperature-cycling chambers, steady-state and cyclic humidity chambers, lifetime test racks, and equipment for shock and vibration analysis. What's more, this array of kit calls for skilled and experienced staff to perform all these tests

in the correct way.

Finally, the time taken to run the Telcordia tests is not insignificant. The normal duration for a module qualification is around 2000 hours – equivalent to running the equipment for around three months. And correctly calculating failure rates over a 20 year lifetime requires a test time of between 5000 and 10 000 hours. Complete GR-468 qualification of a pump laser module, for example, could result in a total cost of €100 000–180 000. With figures like this to deal with, what the component vendors really need to know is how they can best minimize their expenditure.

Cut the costs

An important step towards reducing qualification costs is the adoption of a “building-block” approach for product development and manufacturing. This enables component makers that produce more than one product type to qualify an individual block of devices once, and then use these results for subsequent qualification of similar devices. Vendors taking this approach must follow the rule of similarity assessment as given in GR-468, but if performed correctly, this method could cut their costs dramatically.

Manufacturers must also ensure that components entering the testing procedure are actually ready to be qualified. In other words, they should perform a risk analysis beforehand to identify any critical or weak points of the design or manufacturing process. Vendors can also run a prequalification programme, which includes critical tests that will detect any potential weaknesses. Early corrective action can then avoid failures during the main qualification stage.

The latest version of GR-468 is arranged in sections that describe various aspects of the qualification process (as opposed to qualification of the different product groups). This new structure helps to expand the standard's relevance – as specific sections don't have to be added for each new product type – and also offers more flexibility for specifying the details of a qualification programme.

Component makers now have to select a set of tests based on customer requirements for a specific product, which calls for more effort on a user's part. Getting this selection right, however, can seriously cut down the qualification cost and time.

One important change in the updated standard is that while the original explicitly stated a maximum power variation of 0.5 dB as the pass/fail criteria, a specific value is no longer given. Instead, it's left to the manufacturer and its customer to agree upon the appropriate value for each application on a

OUTSOURCING OPTIONS

Telcordia qualification calls for an extensive set of test and measurement equipment, as well as a bank of technical expertise. While large component manufacturers often have their own test gear, as well as a dedicated team in charge of device qualification, smaller vendors may not have access to such a facility.

The alternative is to outsource qualification to an independent test house. One such company is microtec, an independent and certified test lab based in Germany. Following its takeover of the former Alcatel Technology Centre in Stuttgart last year, microtec offers characterization, qualification and reliability analysis, life tests, failure analysis and risk assessment for both optoelectronic and microelectronic devices.

Microtec's general manager Reinhard Pusch explained what's involved in performing Telcordia GR-468 qualification for a device such as a pump-laser module. "Firstly, microtec recommends that a risk analysis is performed," he explained. "This step involves analysing factors such as the material combinations, packaging hermeticity and fibre-coupling stability to ascertain any potential flaws in the device."

case-by-case basis. GR-468 also offers the option of performing tests in sequence, which can reduce the number of components needed for qualification by increasing the duration of the process.

Finally, if a manufacturer is not experienced in performing these tests, it can turn to one of several independent test and measurement houses (see "Outsourcing Options"). It's not a straightforward task to define a qualification programme compliant with Telcordia GR-468 and inexperienced users run the risk of claiming compliance without having included all the tests needed to verify reliability for a specific application. Outsourcing the qualification gives vendors access to expert assistance in selecting the right test programmes to identify any design weaknesses, as well as offering the flexibil-

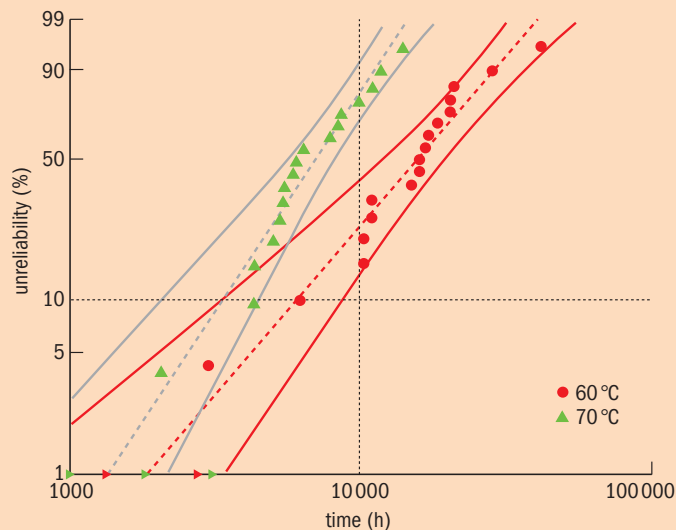


Fig. 1: The Weibull curve presents the time-to-failure distribution for a laser module, based on the results of microtec's accelerated-aging tests.

Based on this risk analysis, microtec then establishes a short test programme to identify any weak points and prepare the laser for qualification. This phase could include, for example, a temperature-cycle test followed by a hermeticity and internal-moisture analysis. Pusch also recommends that the electrical operation is pre-tested at a high temperature, with online measurements of the front and back facet.

After the prequalification process, microtec then generates

a detailed test programme. "The latest version of GR-468 is more than ever just a guideline," Pusch explained. "So microtec has to establish a cost-effective programme that covers all of the GR-468 requirements, based on information from the manufacturer." The firm needs to establish which parameters should be characterized and the pass/fail criteria, as well as defining the frequency of intermediate measurements, the test operating conditions, and whether to use sequential or

parallel testing.

"Microtec can optimize the logistics for the test programme in order to complete qualification in the minimum time and reach preliminary release as soon as possible," said Pusch. "To better understand what is going on during the test, we also recommend online monitoring." He added that all of microtec's equipment is regularly calibrated and the climate ovens are permanently monitored during a test to ensure stable conditions.

It's important that manufacturers get the test results in their hands as soon as possible. Microtec usually passes on results following each intermediate test, or during online monitoring if anything unexpected occurs. A complete qualification report will include reliability calculations according to GR-468, presented as diagrams that show component behaviour over time or as a statistical model such as a Weibull curve (see figure 1), which presents the distribution of time-to-failure and enables estimates of failure rates.

"GR-468 also requires failure analysis and corrective action on all failed devices," said Pusch. "And microtec is well equipped to perform such analysis on any devices that fail."

ity to access a wide range of expensive analysis equipment.

Systems requirements

Over the last 20 years, the responsibility for Telcordia qualification has shifted from the systems vendor to the component maker. With increasing cost pressure on systems houses, and the fact that component makers tend to perform qualification for several customers at once, it makes economic sense for the responsibility for GR-468 testing to lie with the component manufacturer.

Nevertheless, a systems vendor still has responsibility to its customers to verify the reliability of any optoelectronic components within the optical equipment. This is usually done by carefully checking the results of the component supplier's GR-468

test report. The systems vendor should also take care of issues like ambient-temperature analysis, as well as examining the effects of any soldering processes on the reliability of devices on the board.

When dealing with a new technology or supplier, it's prudent for a systems manufacturer to perform at least a short-track verification. This could involve running two or three of the most critical tests, such as temperature cycling, humidity and electrical endurance. Surprisingly, it's not that unusual for Telcordia-tested devices to fail such a test, giving the systems manufacturer a good basis for fruitful discussions with the component vendor. ●

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