As originally published in the SMTA Proceedings

A STANDARDIZED RELIABILITY EVALUATION FRAMEWORK FOR CONNECTORS

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ABSTRACT
The iNEMI Connector Reliability Test Recommendations Project was organized to address the need for a standardized reliability qualification method for connectors. The project team reviewed current standards pertaining to connector reliability and also conducted an industry-wide connector reliability survey to determine common metrics for connector reliability guidelines across the industry.

This paper summarizes their findings and reviews a multi-level interconnect hierarchy and a matrix of application classes defined by the team. It also discusses possible connector reliability test strategies based on the interconnect hierarchy developed.

Key words: Connectors, reliability, test, industry standards, performance evaluation, connector classification

INTRODUCTION
Consistently testing the reliability of electrical connectors across types and use cases is a major challenge in the connector industry. Electrical connectors come in many shapes and sizes, and differ from use case to use case. In general, the purpose of an electrical connector is to allow an undisturbed electrical signal to travel between two points in a circuit. These are electromechanical in nature and also enable the circuit or circuits to be separated and re-connected with no unacceptable change to the signal

integrity. Several different standards exist within the connector industry to evaluate reliability.

The participants in the iNEMI Connector Reliability Test Recommendations Project reviewed these existing connector reliability testing standards. The following four standards were identified:

- EIA 364F: Electrical Connector/Socket Test Procedures Including Environmental Classifications (developed and maintained by EIA committee CE 2.0).
- EIA 364-1000: Environmental Test Methodology for Assessing the Performance of Electrical Connectors and Sockets Used in Controlled Environment Applications (developed and maintained by EIA committee CE 2.0).
- ISO/IEC TR 29106: Introduction to MICE Environmental Classification (developed and maintained by a joint ISO-IEC committee JTC1/SC25).
- IEC 61586-TS: Estimation of the Reliability of Electrical Connectors (developed and maintained by IEC subcommittee 48B).

The team conducted a review of these standards relative to their roles in assessing connector reliability, with contact resistance being the primary performance criterion. A stand-alone connector reliability standard would be expected to provide the following:

- Definition of application stresses, preferably in some type of categories.
- A test protocol stressing the potential degradation mechanisms in a manner that replicates what will occur in the actual application.
- Specific test conditions to use in the defined sequence.
- An evaluation procedure defining how data should be interpreted to provide a reliability assessment, either qualitatively indicating the part is fit for service in a specific class of application, or quantitatively by providing a numerical statement of the probability of the part operating throughout some stated lifetime.

This paper has two main contributions. First, it defines a multi-level interconnect hierarchy and a matrix of application classes and ranks severity of application stresses. The primary stresses of concern and the levels of these stresses used to define the application classes are derived from knowledge of the broad range of applications in which connectors are used. Second, it discusses possible connector reliability test strategies based on the multi-level interconnect hierarchy.

This paper is organized as follows. First it reviews current industry standards for connector reliability. Specifically, EIA-364-1000, EIA364-F, IEC 61586-TS, ISO/IEC TR 29106 and other related standards are compared. Second, it summarizes results from an industry-wide connector reliability survey conducted by the iNEMI team. The purpose of this survey was to determine common metrics for connector reliability guidelines across the industry. This paper focuses on the results related to connector reliability. This paper also proposes a new connector hierarchy based on the reliability data from the survey, and a connector reliability test strategy. Lastly, it discusses the project's conclusions as well as future work in connector reliability.

EIA 364F

The EIA 364F standard provides a set of application categories divided into two types. The first type defines application categories based on the types and levels of stress expected in the application. The second type defines application conditions based on a type of use (e.g., automotive, aircraft, etc.). These categories may be further differentiated based on some specific environmental conditions such as use temperature range, use in marine atmosphere, etc. Although EIA 364F provides recommended test sequences to assess the product against all the major degradation inducing stresses, it does not define a single sequence that includes all three of the primary stresses that can interact to cause connector failure (stress relaxation, corrosion, and motion driving stresses such as vibration and temperature cycling). Nor does it offer guidance on dealing with variability and impact of application conditions (environmental to localized/user-driven effects). A consistent use of the standard, along with maintaining data on actual field performance of test products, would allow it to provide a good qualitative assessment of connector reliability. Additionally, understanding the degree of interaction and dependencies in the test sequence would be invaluable as a means of inciting or eliminating manifestation of different failure mechanisms.

EIA 364-1000

The EIA 364-1000 standard was developed for evaluating connectors used in one specific application — business office equipment. It provides several test sequence protocols that incorporate all the primary connector degradation stresses. It also includes one sequence that combines the three major degradation stresses that interact to cause resistance failures. This sequence includes a preconditioning stress of mating cycles to ensure any effects of plating damage are evaluated. The sequence differs depending on whether the plating is noble or non-noble. If a noble plating is used, then a mixed flowing gas test is included for the corrosion stress. If the plating is non-noble, the corrosion stress is provided by temperature humidity cycling. The standard differentiates the business office application based on categories of expected lifetime mating cycles, ambient operating temperature, and expected lifetime. Different levels of test conditions are prescribed for these different use factors. It does not provide a specific failure criterion, instead leaving this to the user to define; nor does it provide guidance on interpretation of the data for a reliability assessment. However, the data obtained is of a type that could be used to establish either a qualitative or quantitative reliability assessment relative to an established failure criterion.

ISO/IEC TR 29106

The ISO/IEC TR 29106 standard does not provide guidance on connector reliability testing. However, it does provide a system to define applications based on four categories of stress: mechanical, ingress, climatic/chemical, and electromagnetic. Each stress category is divided into three levels: mild, moderate, and severe. For each level, the range of stress severity is defined. For example, within the mechanical category applications with a moderate level of mechanical shock would be those where the expected shock level is between 70 m/s2 and 150 m/s2. The standard does not provide specific testing protocols; however, it does provide a good method of defining application classes based on application stress levels. It could thus be used in conjunction with other standards that provide general reliability testing protocols to define protocols specific to certain applications.

IEC 61586 TS

IEC 61586 TS provides a high-level overview of the issues that make it difficult to provide estimates of connector reliability. The primary issue it identifies is that a given connector can be used in a wide range of applications, thus any evaluation of the reliability of a connector must account for the specific application stress conditions, failure criteria, and expected lifetime. The standard describes the different degradation mechanisms that may occur for the various contact alloys and plating systems used by the connector industry. It also defines standard reliability test sequences for connectors using noble and non-noble plated contacts. Both sequences include the stresses needed to potentially excite the primary interacting degradation mechanisms that cause resistance changes. The actual level of test stresses to use in the sequence are not defined, though some guidance is provided on how to define the required conditions based on the use application stresses. The standard also provides guidance on statistical analysis of the test data in establishing a quantitative estimate of connector reliability.

COMPARISON OF STANDARDS

All of the standards reviewed provide valuable guidance for evaluating connector reliability, but EIA 364-1000 is the only one that provides a complete test protocol, including both test sequences and levels of stresses for the test conditions in the sequences to provide a connector reliability assessment. However, EIA 364-1000 is limited to one application category – business office equipment — although it provides varying levels of testing to accommodate a range of use conditions within the business office environment. The test sequences it defines could be used to assess reliability in other applications if the stress levels were appropriately modified.

EIA 364F provides both application classes and test protocols with specific test conditions. However, this standard does not have a sequence that includes all the stresses required to excite the primary degradation mechanisms that commonly interact to cause high resistance failures in contacts. Of the standards reviewed, ISO/IEC TR 29106 provides the most detailed method, using application stress levels to characterize application classes; but it does not provide any guidance on testing appropriate to each of the classes. IEC 61586 TS provides the most detailed description of a physics-of-failure approach to connector reliability testing along with standard reliability testing protocols and descriptions of statistical treatment of data to estimate connector reliability. But, in general, it lacks guidance to define the actual test conditions appropriate for different connector applications.

The review indicates none of the existing standards provides a comprehensive approach for assessing connector reliability in all cases. In reality, a single document to accomplish this would be quite cumbersome and might be effectively impractical when considering the range of connector application use conditions and contact materials used. It is likely that the optimal approach will be to use a combination of various standards focused on specific aspects of connector reliability. This approach would facilitate defining test programs customized for specific connector types and applications as needed. For example, the EIA 364F or ISO/IEC TR 29106 type standards could be used to define use application classes characterized by expected stress level. With the application class defined, a document with a defined reliability test sequence specific to the appropriate application class, (e.g., EIA 364-1000 for business office equipment) could be used. Alternatively, a standard such as IEC 61586 — which provides detailed guidance to use a physics-of-failure approach in order to define necessary test methods appropriate for the types of application stresses expected and the specific contact design characteristics — could be used to define the appropriate test methods and sequence. Though not specifically reviewed for this project (as its focus is on solid state components) JESD94, which defines a Knowledge Based Test Methodology (KBTM) for developing qualification test plans, is fundamentally consistent with the approach defined in IEC 61586. This similarity demonstrates a level of consensus in favor of a physics-of-failure approach for defining reliability test programs for electrical and electronic components.

Once the basic test methods are defined, the actual test conditions must then be established using standards that define test conditions appropriate to specific use application stress levels. This process is consistent with a KBTM approach. Though not reviewed for this project, an example of such a document is ISO/IEC TR 60721-4-3, "Classification of environmental conditions: Guidance for the correlation and transformation of environmental conditions classes of IEC 60721-3 to the environmental tests of IEC 60068 – Stationary use at weather-protected locations."

iNEMI RELIABILITY SURVEY RESULTS

The iNEMI connector reliability team conducted a 32-question industry survey to determine common metrics for connector reliability guidelines across the industry.

The survey covered the following topics:

- Participants' organizational demographics
- Connector standards usage
- Connector performance
- Connector types
- Connector design and selection parameters
- Metallization
- Lubrication

This paper focuses on the results of the reliability questions.

Organizations Participating in Survey

A broad range of industry sectors was represented in this survey. More than half of the individuals who responded to the survey were OEMs or in the connector business. The other half of the participants were in other areas of the technology industry ranging from market research to semiconductor manufacturing. Almost all of the companies surveyed had significant market presence with over $100 million annual revenue. The majority of the individuals who responded were in a product development or quality/reliability position within their companies, while the rest of the respondents ranged in roles from component engineering to failure analysis.

Standards Usage

We presented a list of seven common standards and an eighth option that allowed respondents to name their own standards (see Figure 1). Most of the participants reported that they used EIA 364-1000 or relied on their own internal standards. The GR-1217-CORE, EIA364-E and IEC 60512 series were the next most used. The least commonly used standards were MIL-STD series (1344, 883, 1580, 981, 750 and 202) and the IEEE standard 1156.1-1993. All of the participants who answered the question said that their company used its own internal standards when gaps were identified with industry standards, or when these standards did not corroborate their practices. Most of the participants expect the lifetime of connectors to be 5-10 years. The military-aerospace industries expect upwards of a 25-year lifespan.

Types of Failure

The last series of questions focused on three types of failures: operational, mechanical and application. The most common types of operational failures are shown in Figure 2. Open circuit types of failures fell heavily into the 'very common' category while electrical shorts fell mostly in the 'common' category. Some of the occasional failures lean toward signal integrity and overheating. The second type of failure mechanism we asked about was mechanical failure. Housing failures and unintended disconnects were the most cited reasons for a mechanical failure while a contact being bent or a connector that was unable to connect were the most common issues (see Figure 3). Lastly, the survey asked about application failures. Respondents indicated that the most common application failure was solderability, but all of the failure modes given were reportedly seen in application failures equally (Figure 4).

Performance Levels

Next, the survey looked at how connector designers consider the performance levels given in IEEE Std. 1156.1-1993 when designing their connectors. The majority of the designers said they design and expect their designs to perform to level 5: Environment primarily intended for sheltered applications subject to minimal vibration, shock, or temperature variations (controlled indoor). Almost all of the survey participants designed custom solutions (e.g. board-to-board connectors for PCB mounting and I/O connectors). Other categories such as intersystem cabling, special application connectors and chip-to-package connectors were not used as frequently by survey respondents. These results are discussed in detail in the next section.

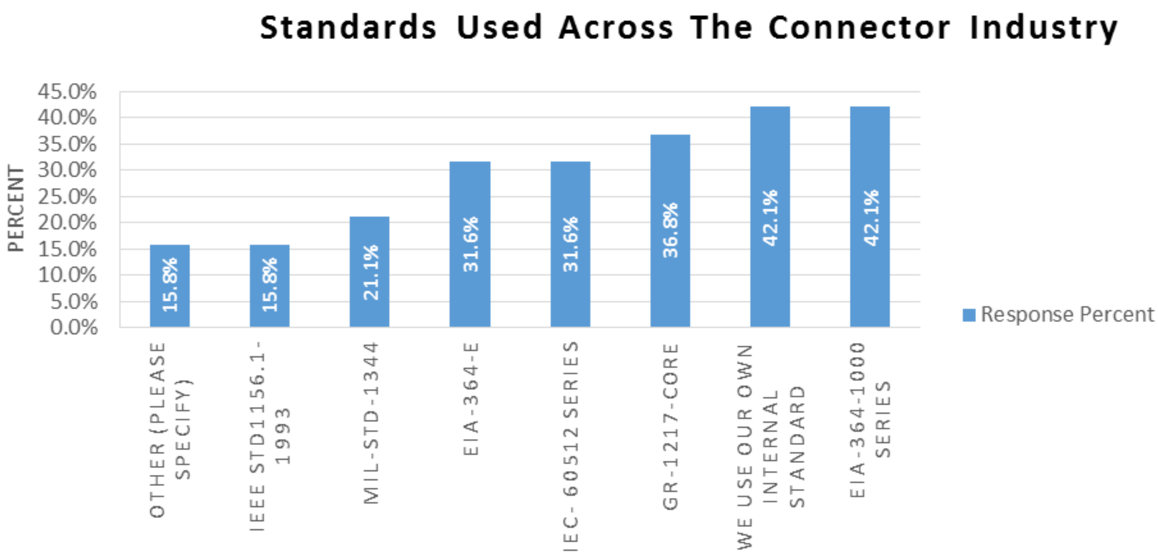

Figure 1: Results from the iNEMI Connector Reliability Test Recommendations Project survey: "What are the typical standards your organization uses for design/qualification of connectors?"

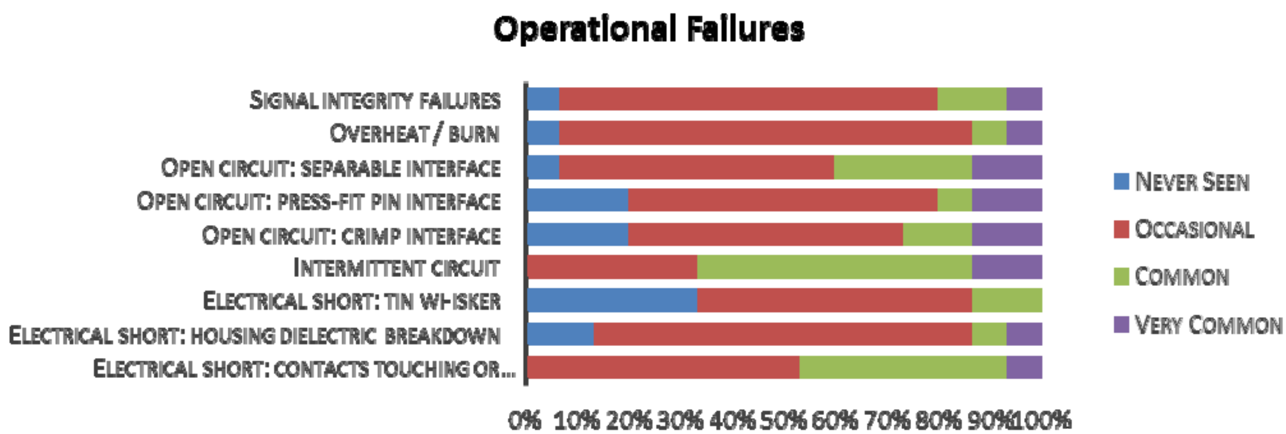

Figure 2: Results from the iNEMI Connector Reliability Test Recommendations Project survey question: "Based on your experience, how common are the following operational failures (failures that prevent a properly applied connector from performing its function)?"

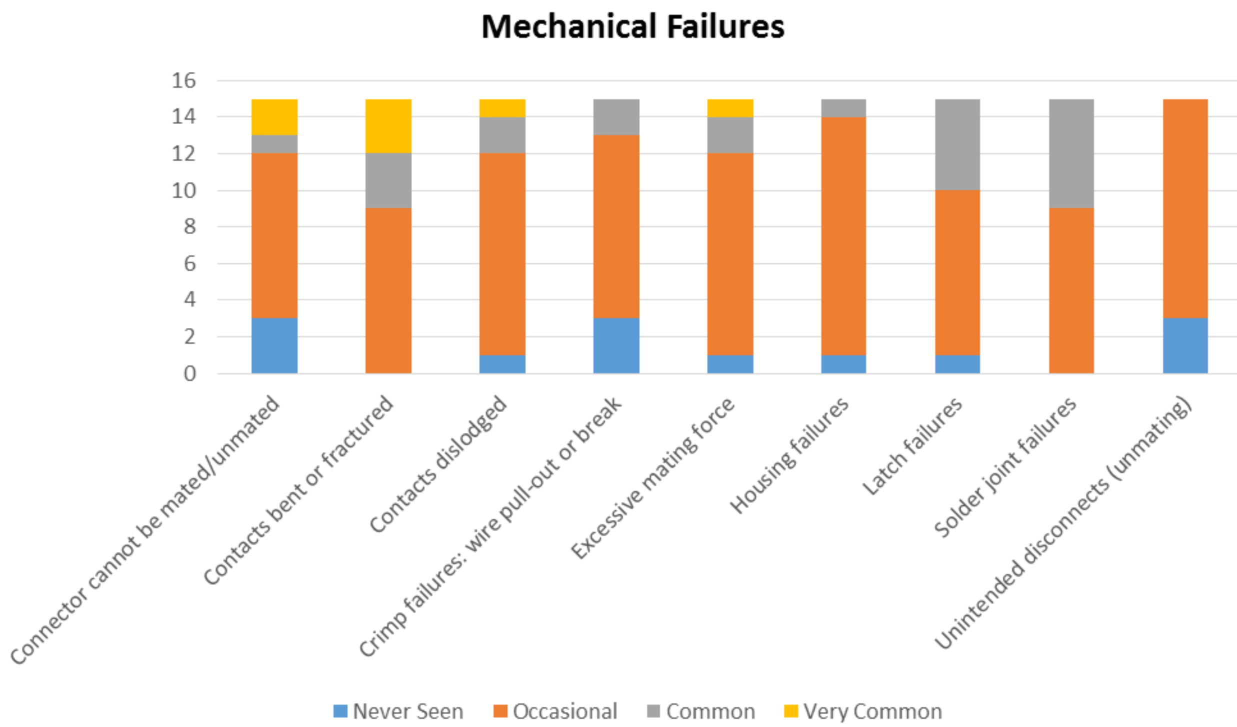

Figure 3: Results from the iNEMI Connector Reliability Test Recommendations Project survey question: "Based on your experience, how common are the following mechanical failures (generally includes failures due to distortion or breakage of parts)?"

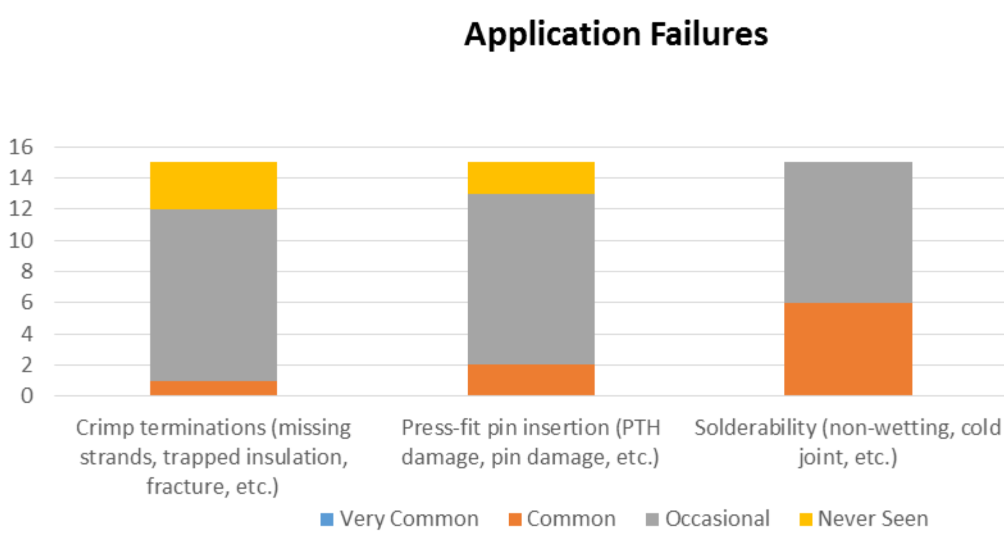

Figure 4: Results from the iNEMI Connector Reliability Test Recommendations Project survey question: "Based on your experience, how common are the following application failures (failures that occur while part is being terminated to wires, soldered to boards, etc.)?"

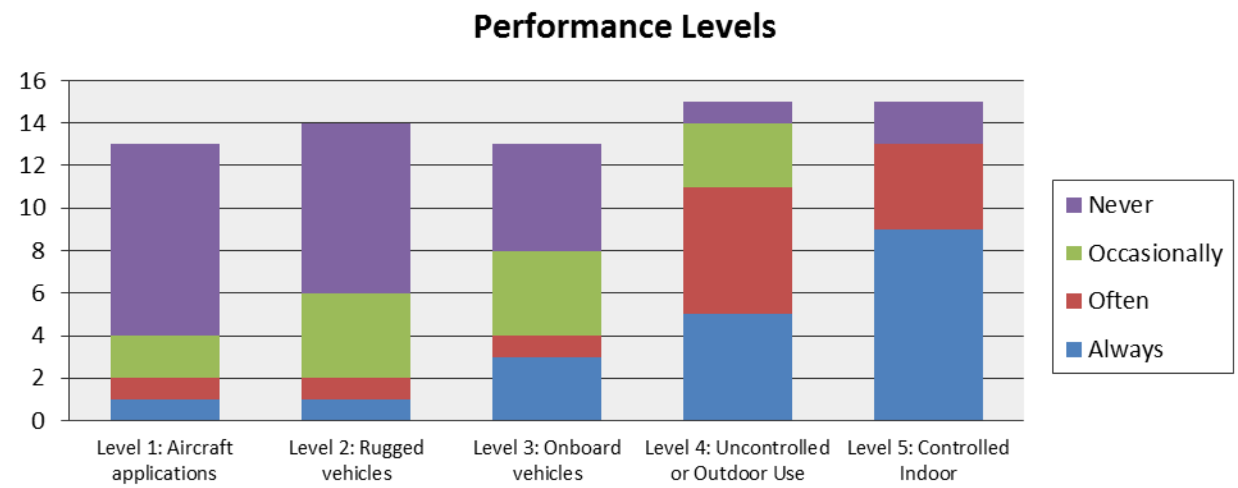

Figure 5: Results from the iNEMI Connector Reliability Test Recommendations Project survey question: "How often do you design/select connectors to these performance levels?"

STANDARD CLASS/PACKAGING HIERARCHY

Having a defined set of interconnect levels is beneficial in guiding development of reliability testing protocols. The level of interconnect is often closely correlated with the level of reliability required and with the number and range of detrimental stresses to which interconnects will be subjected. Given this, being able to categorize parts based on the level of interconnect they employ helps identify key factors that are required to define a reliability evaluation program. Among these factors are:

- What level of reliability is appropriate?
- What lifetime is expected?
- What are the expected types and levels of stresses the part will see?
- What defines product failure?
- What is the effect of a product failure?
- What repairs and/or replacements may be possible?

Looking at the extremes of possible levels of interconnect helps us to understand why this classification can be useful. When viewed from the aspect of required reliability, the lowest level of interconnects, e.g. on-chip and chip-to-package, typically have the highest requirements. Two factors drive this. First, if lacking redundancy, any interconnect failure will cause a system failure. Second, due to the quantity of these interconnects in most systems they represent by far the greatest proportion of interconnects. Thus even very low ppm failure rates will not be sufficient to ensure adequate system reliability. Fortunately, when viewed from the aspect of external stresses, these interconnects are typically well-protected. Further, the components with these interconnects usually have well-defined applications, thus designers know the stress levels that will be applied. As a result, appropriate test methods are defined for most types of components and applications.

At the other extreme of levels of interconnect are indoor connections between systems and outdoor transmission and communications cabling. A greater number of ranges and stresses may exist in the application for these types of interconnects. Besides the well-controlled stresses due, primarily, to operating conditions such as applied voltages and current, these interconnects will see larger excursions of temperature and humidity, vibration, mechanical shock, particulates and other contaminants, etc. Clearly, the sources of degradation are greater than for the lower levels of interconnect. However, the reliability requirement is typically lower as there are generally fewer of these interconnects and they can often be accessed for repair.

These two extremes illustrate that, in general, moving from a low to high level of interconnect decreases the required level of reliability. But achieving the required reliability may become more difficult since the drivers of degradation are typically more numerous and severe at the higher levels of interconnect. This defines a strong correlation between level of interconnect and two primary factors (required level of reliability and types and range of stress) which must be defined in order to develop a reliability test program. Given this, it is clear that a common defined list of levels of interconnect would be useful in developing connector reliability test programs.

Various sources currently exist to classify level of interconnect. Differences in these usually result from the starting level. Since it was agreed that it would be beneficial to organize any series of reliability testing documents around the concept of levels of interconnect, the group wanted to get input from the industry to develop a common classification that could be used for future work. The survey, therefore, included a question on this topic. A list of eleven possible levels of interconnect was provided. These were:

- On-chip interconnects
- Chip-to-package
- Package-to-board
- PCB mount
- Board-to-board

- Chassis-to-chassis
- Input/output (I/O)
- Intersystem cabling
- Campus/metropolitan area
- Long-haul telecom/datacom
- Special application connectors

Respondents were asked to rate these from level 1 up to level 11. It was not necessary for the respondent to rate every level proposed. For example, if they felt only 6 levels existed they could rate that number only. Responses are shown in Table 1.

It should be noted that survey respondents were from some of the key market leaders in the connector manufacturing industry and the electrical/electronics manufacturing industry (i.e., OEM connector users). Electrical/electronics manufacturing respondents were from companies in the data and communications, integrated circuits and defense industries. Each of these groups included at least one respondent from a company ranked among the top five in its industry. Table 2 summarizes the responses provided.

In Table 1, the top row of numbers, 1 to 11, represent the possible levels to which the respondents could assign the types of interconnects. The integer numbers in the matrix show the number of respondents who assigned each type of interconnect to the indicated level. For example, for on-chip interconnects:

- Thirteen respondents total
- 54% (seven of thirteen) chose to assign a level for the type of interconnect
- Of these seven:
  - Five (71%) assigned on-chip interconnects as Level 1
  - One (14%) assigned on-chip interconnects as Level 2
  - One (14%) assigned on-chip interconnects as Level 4

To initially assess the responses, the count for each level was considered by identifying the highest percentage of "votes" which is indicated in red. For some types of interconnects there was no clear highest level. In those cases, where there where "ties" in between levels chosen, more than one level is indicated in blue. The responses resulted in dropping the Campus/Metropolitan Area as no respondent selected it as a useful designation. The team also decided to drop the Special Application Connectors as a type as respondents had a wide spread (from level 2 to 8) in responses with no clear preferred level. Based on this evaluation, the review group used the input from the respondents to create the categories shown in Table 2.

This connector hierarchy will be used in future work to develop reliability testing guidelines. In two cases there were two interconnect classes with similar weighted average levels and that perform similar functions. In those cases the two interconnect classes were combined into a single level.

A Proposed Connector Reliability Test Strategy

The reliability of a connector is a function of the application in which it will be used. Considering the variety of applications in which connectors are used, ranging from small, embedded and portable devices to massive multi-purpose systems, it is not possible to define a testing protocol specific to all possible applications. In fact, identical contact types within the same connector may have very different performance requirements and be subjected to very different levels of stress. For example, consider the case where one contact is transferring signals at micro-amp current levels and its twin in the next position is carrying several amps of current in a power circuit. These two identical contacts will likely have very different reliabilities. Ultimately, the end-use reliability testing of connectors must be done within the system-level reliability test of the systems in which they are used. Such end use testing for a specific application can be defined understanding a specific application's environment and contact performance requirements, assessing likely degradation mechanisms, and determining proper test conditions to excite these mechanisms and assess their effects. The IEC 61586 TS standard reviewed and the JEDS94 KBTM approach mentioned both utilize this approach.

However, initial qualification of electrical connectors cannot be customized for every possible use. Thus, in addition to the use of customized testing for a specific application it would be beneficial to have standard testing protocols to provide an indication of reliability of connectors in an application class. The fact that the industry reliability standards reviewed define application classes indicates an industry recognition of the utility of this approach. These documents show it is possible and of practical use to define a manageable number of connector application categories. And the typical conditions in these classes can serve as a guide for developing common connector reliability evaluation plans. Defining reliability testing based on the stress levels of these categories can verify connectors as generally suitable for a specific application category or categories. This knowledge will be beneficial to system designers, helping them select connectors that will have a high probability of meeting the reliability requirements of the system in which they are being considered for use. For example, EIA TP 364-1000 provides this type of evaluation for connectors to be used in business office equipment applications and has been in regular use for more than ten years. Such standards can serve as a common basis determining if a connector will provide the general level of reliability for the class of application. Then if there are some differences between the standard stresses defined in the application class and the stresses in a specific application, additional customized testing could be performed; but it could be focused on just those areas of difference.

Table 1. Survey Responses: Summary of Level of Interconnect

	Responses		Percent of Respondents Selecting Indicated Level**											Wt. Avg. Level
Level of Interconnect	*Tot.*	*% Use**	1	2	3	4	5	6	7	8	9	10	11	
On Chip Interconnects	*13*	*54%*	**71%**	14%		14%								1.57
Chip to Package	*14*	*50%*	29%	**71%**										1.71
Package to Board	*15*	*87%*	8%	31%	**46%**	8%		8%						2.85
PCB Mount	*14*	*93%*	15%	**23%**	**23%**	**23%**	8%	8%						3.08
Board to Board	*14*	*100%*	7%	7%	**43%**	**29%**	7%			7%				3.57
Input/output (IO)	*14*	*93%*		**31%**	8%	8%	**31%**	**23%**						4.08
Chassis to Chassis	*13*	*62%*	13%		25%		**50%**	13%						4.13
Intersystem Cabling	*13*	*69%*		11%	11%	**33%**	22%	11%	11%					4.44
Long Haul Telecom / Datacom	*14*	*21%*			33%				67%					5.67
Special Application Connectors	*12*	*58%*		29%		14%	29%			29%				4.86
Campus / Metropolitan Area	***13***	***0%***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***No Score***

Table 2. Suggested Hierarchy

Level 1	On-chip
Level 2	Chip-to-package
Level 3	Package-to-board/PCB mount
Level 4	Board-to-board
Level 5	Chassis-to-chassis & input/output (I/O)
Level 6	Intersystem cabling
Level 7	Long-haul telecom/datacom

Table 3. Environment Class

	General Environmental Characteristics	Degradation Mechanisms	Typical Application
A	Equipment is used in locations with good temperature and humidity control Infrequent to daily temperature cycling due to on/off cycles	Dry Air Oxidation	Non-industrial business office, living areas of homes, etc.
B	Some external temperature and humidity variation affecting system internal operating conditions Condensation possible Low level exposure to pollutant gasses	Pore Corrosion Moderate Loss of Normal Force Fretting Motion	Light industrial operations with good environmental controls, Otherwise mild applications with poor environmental controls, automotive passenger cabins
C	External temperature and humidity are poorly controlled or uncontrolled Condensation is likely Moderate to high levels of particulate and pollutant gas concentrations	Corrosion Creep Major Loss of Normal Force Fretting Motion	Indoor heavy industrial environments, automotive under-hood, outdoor uses

Table 4. Mechanical Classes

		General Mechanical Characteristics	Degradation Mechanisms	Typical Application
Mechanical Class	1	Sources of vibration and shock are external to application	Fretting Motion	Non-mechanical devices used in fixed locations, e.g. home/office electronics, appliances such as microwave ovens which have no or minimal moving parts
Mechanical Class	2	Sources of vibration and shock are internal to the system but of low intensity	Fretting Motion Plating Wear	Electronics with sources of vibration such as copiers and audio speakers, appliances such as washers and dryers, automobiles passenger compartments
Mechanical Class	3	Sources of vibration and shock are internal and/or external to the system and of high intensity	Fretting Motion Plating Wear Mechanical Failure of Components and Terminations	Mechanical machinery with heavy and/or rapidly moving parts or electronics in mobile machinery which with poor vibration and shock damping, e.g. high speed assembly equipment, engine mounted applications, certain types of power tools

Development of application categories based on physics-of-failure to target an application's landscape from usage to environmental condition should be considered to determine a connector's overall expected performance level. A physics-of-failure view of the primary causes of connector electrical resistance failures finds two stress categories common to almost all applications, and these must typically interact to cause an electrical resistance failure at a contact interface. The first cause is environmental and the second is mechanical and these are, in fact, the primary stress types noted in the connector reliability standards reviewed. Groupings based on the levels of severity of the types of stresses in these two categories can form the basis of application stress classes to guide a reliability test program.

The primary environmental stresses of concern are steady state temperature, temperature cycling, humidity levels, and corrosive pollutant gasses. The primary mechanical stresses of concern are vibration and shock. Based on the review of the standards a useful approach to categorizing the structures is by defining conditions for mild, moderate, and severe levels. Tables 3 and 4 were developed based on this approach and with reference to some of the recommended test conditions included in those standards.

To define testing for a given connector, its environmental and mechanical stress class would be identified. In selecting the appropriate class, the worst case characteristic would be used. For example, if a connector was to be used in an application in which the temperature would not exceed 60C, but where high levels of particulates and pollutant gasses were expected, the appropriate environmental class from Table 3 would be "C."

After determining the appropriate environmental and mechanical classes, the corresponding reliability test guides would be used to determine appropriate test stress levels. The duration of testing would be adjusted as needed based on the expected lifetime of the product in the intended use. Also, specific failure criteria would be defined based on the intended use. With these factors defined, a reliability test plan would then be developed using the protocol described in the section above.

It should be noted that, in addition to stresses experienced while a connector is in service, use conditions are comprised of various elements, from the material to device fabrication to product level or system assembly and transportation (shipping/handling) until the end-user destination. Also, as mentioned previously, other factors such as particulate ingress, number of possible mating cycles, etc. may apply at mild to severe levels in any application class. Therefore, appropriate stresses other than application class-defined levels of climatic and mechanical stresses would likely be included in any reliability testing protocol. These additional stresses may be part of the test sequence for the reliability test group or may be applied to additional test groups. Knowledge of the ultimate planned use of the connector would be needed to properly determine the inclusion of these additional stresses. Such knowledge could be from a specific customer based on the planned use or from knowledge of the manner in which the connector is typically used by the target market for which it is designed.

CONCLUSIONS & FUTURE WORK

From the review of existing documents and the survey responses the project team concluded that there is agreement on the need for some common approach to assessing connector reliability. They also concluded that there is sufficient agreement on definition of levels of interconnect and on primary connector test methods to allow a structure of common application classes and related test conditions to support an effort to develop standard reliability testing protocols for connectors.

The iNEMI Connector Reliability Test Recommendations Project team recommends additional work to define specific test conditions to be used to evaluate the expected degradation of connectors used under the stress levels in the defined application classes. This could form the basis for standardized reliability test procedures for each application class. Such a system of standardized testing would allow designers to more easily compare connectors during their initial system design phase.

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ABOUT iNEMI

The International Electronics Manufacturing Initiative's mission is to forecast and accelerate improvements in the electronics manufacturing industry for a sustainable future. This industry-led consortium is made up of approximately 90 manufacturers, suppliers, industry associations and consortia, government agencies and universities. iNEMI roadmaps the needs of the electronics industry, identifies gaps in the technology infrastructure, establishes implementation projects to eliminate these gaps (both business and technical), and stimulates standards activities to speed the introduction of new technologies. The consortium also works with government agencies, universities and other funding agencies to set priorities for future industry needs and R&D initiatives. iNEMI is based in Herndon, Virginia (near Washington, D.C.), with regional offices in Shanghai, China; Limerick, Ireland; and Tokyo, Japan. For additional information about iNEMI, go to http://www.inemi.org