



AEROSPACE INFORMATION REPORT

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SAE AE-7 High Temperature Components Survey, 2005

RATIONALE

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1. SCOPE

To present the results of a survey taken concerning future applications for high-temperature electronics and sensors.

1.1 Purpose

A survey was conducted to start collecting information needed to better identify how a common set of high-temperature components and component standards might meet the most market needs crossing industry boundaries.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 Sandia National Laboratories Publications

SAND2006-0091 has a complete list of survey responses.

SAND2006-0091, Printed April 2006
Available to the public from
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

3. STATEMENT OF PROBLEM

3.1 Existing Programs

Programs within the U.S. DOE, U.S. DOD, and NASA are developing new high-temperature electronic components and sensors. These new components have commercial applications for:

- a. Deep drilling for fossil energy
- b. Geothermal power production
- c. Combustion engine controls for both automotive and aircraft
- d. High-efficiency motor controls for hybrid/electric vehicles
- e. Improved controls for the U.S. electric power grid

3.2 Survey Targets

The survey targeted application designers in the aerospace, drilling and automotive industries via email and direct polling at the October 2005 meeting of the SAE AE-7 (SAE International - Aerospace Electronics Chapter 7). Application engineers are concerned with design level issues. The majority of responses came from engineers within the aerospace industry.

4. SURVEY PROCESS

4.1 Getting the Information

On April 4-5, 2005, the first joint meeting between the aerospace and drilling industry was held in Dayton, OH, hosted by the Air Force Research Laboratory at Wright-Patterson. NASA-Glenn, JPL, and the Army Research Laboratory also participated in the meeting. All of these organizations share a common interest in the development of commercially available high-temperature electronic components and sensors. One of the outcomes of the meeting was an agreement to conduct an industry survey of high-temperature applications. This report covers the basic results of this survey.

The survey targeted application designers in the aerospace, drilling and automotive industries via email and direct polling at the October 2005 meeting of the SAE AE-7 (SAE International - Aerospace Electronics Chapter 7). Responses were given anonymously.

This was the first survey of its type. Many of the questions offered individuals the opportunity to write-in a response. A copy of the survey is attached as an appendix to this report. A follow on survey with more targeted questions is recommended.

4.2 Who Responded

The first question of the survey asked: Please indicate what industry you work in. Please circle one or more. Below is a list of options and the numbers of circled responses.

- Aircraft Power - 15
- Aircraft Engines - 9
- Automotive - 2
- Electric Power Grid - 2

- Interstate Trucking - 0
- Radiation Hard Systems - 5
- Well Drilling and Exploration - 3
- Well Logging - 3
- Well Monitoring - 2

The survey attempted to reach application designers and not component producers. These responses came from ~20% of those polled. The majority of those polled are engineers having attended HiTEC (High-Temperature Electronics Conference) and the October 2005 meeting of the SAE AE-7 (SAE International - Aerospace Electronics Chapter 7).

Individuals were also asked about temperature of interest:

Please circle the temperature range needed by the application you listed as the most HT application benefiting your industry.

There were four temperature ranges:

- 150 to 250 °C - 10 responses
- 251 to 300 °C - 8 responses
- 301 to 350 °C - 2 responses
- 351 °C and higher - 3 responses

5. COMMENTS TO SURVEY QUESTION RESPONSE

There were a number of questions where the individual was given a chance to write-in a response. These comments are not easily tabulated in the form of a table. Each of the questions is listed below, along with the reasons for the question. General results of the question are suggested along with examples of actual given answers.

For a complete list of responses, see Section 7 of this document.

5.1 Survey Question 1: Component Wish List

Respondents were given a chance fill in a table of most desired high-temperature components. The table had three columns: Most Desired HT Components, Estimated. Development Time [near-term (1 to 2 years), mid-term (3 to 5 years), far-term (>5 years)], Estimated Volume for Your Application.

Some noteworthy results.

- Number One Near-term Component needing development
 - Drilling industry - >200 °C high-density non-volatile Memory - 1000/year
 - Aerospace - 65 to 300 °C SiC Diode - 3000/year

- b. Mid-to Far-Term Development - 16 or 32 bit microprocessor
 - Automotive - 100 to 300K/year
 - Aerospace - 50 per aircraft (50 to 100K/year)
 - Drilling - 1000s
- c. Most Requested Components for Aerospace Industry
 - Power Semiconductor Devices 200 to 300 °C, Diodes, FETs, MOSFETS, IGBTs - in the 1000s/year
 - Capacitors - 100 to 800 V, 10 µF, low loss
- d. Packaging (200 to 300 °C) - Drilling and Aerospace
 - Printed wiring boards, interconnects, insulation, potting materials, connectors, electrical feed-through, connectors

Differences in the three industries also became apparent within component selections.

- a. Automotive industry generally high volume needed (100 000s/year)
 - 1. Automotive industry felt development of all products were far-term
- b. Aerospace industry indicated a greater need for Power Semiconductor Devices and Power Management Devices
 - 1. Aerospace industry needs range from 1000s to 10 000s/year to 50 to 100/aircraft (50 to 100K/year) commercial
 - 2. Aerospace industry perceived more mid- to far-term development times
- c. Drilling industry indicated greater need for Memory related devices and Sensors
 - 1. Well industries perceived more near- to mid-term development times of key components
 - 2. Well industries needs ranged from 100s to 1000s/year

The drilling industry has the closest (only) near-term applications, and is also the smallest in volume. The aerospace industry is next with near- to far-term applications with approximately 10 to 100 times the potential market. The automotive responses were far-term and relatively low volume by conventional automotive market standards. These results may be due to only two responses from this industry.

The overall conclusion of this survey identified the application with the most cross cutting industry support for high-temperature components was the need for power control electronics with a potential market >100K devices per year. Data acquisition was second with a need for non-volatile memory (Flash, EEPROM) listed as components needing development.

5.2 Survey Question 2

Please identify what one HT application would benefit your industry the most. If reasonable, please provide some of the necessary attributes needed for commercial success.

Reasoning: This question was asked to help identify common applications and basic requirements. Responses can be grouped into two categories, power and data acquisition. There were 14 power applications given to 5 data acquisition. Most of the responses were power applications targeting power converters for both DC/DC and AC/DC. Among the power applications were two for high-temperature motor controls. Examples of responses are listed below.

Power Applications Response Examples:

- Power Converters (220 VAC and 440 VAC to 28 VDC) and Inverters (27 VDC to 115 VAC)
- Power Converters 4 to 350 kW
- Aircraft power electronics: voltages to 600 V, -55 to 300 °C and capacitors with high efficiency and a 20 year life
- Aircraft Power Conversion: 10 to 100 A / 1000 V rectifiers and SCRs with 0.1 to 20 µF / 600 V capacitors
- High efficiency power converters (250 to 300 °C): Medium temp (150 to 200 °C) highly reliable power converters

Data Acquisition Response Examples:

- Sensor support electronics for HT well monitoring (250 °C), data acquisition, data reduction, memory, telemetry systems, batteries, DC/DC converters
- Sensors MTBF 20 000 h with high shock
- HT miniaturized combustion control system

In general, the drilling industry people favored data acquisition applications. The aerospace industry favored power applications with needs for engine data acquisition control systems.

5.3 Survey Question 3

Please identify what one HT application “outside” of your industry would benefit your industry the most.

Reasoning: This question was asked to encourage and gain insight for cross industry applications using the same high-temperature components. A few individuals responded by saying that they didn’t know about high-temperature applications in other industries. Several answers indicated that some individuals didn’t understand the question.

Examples:

- Aircraft engine distributed control most closely matches the component selection we need down hole. The promise of larger (future) volumes of this industry could encourage vendors to supply the smaller quantities we need for down hole right now. Similarly, the testing and qualification that we do now helps provide reliability validation for the more critical upcoming aircraft applications.
- Manufacture of HT analog and digital signal conditioning integrated circuits
- HT power devices (high-voltage caps and power transistors)
- Solid State Power Controller used to replace circuit breakers and relays

Clearly, there is room to improve the general cross industry understanding of high-temperature applications. There is a need to better identify industry requirements so that engineers within the aerospace, drilling and automotive industry can maximize the production volumes of high-temperature electronic components and sensors.