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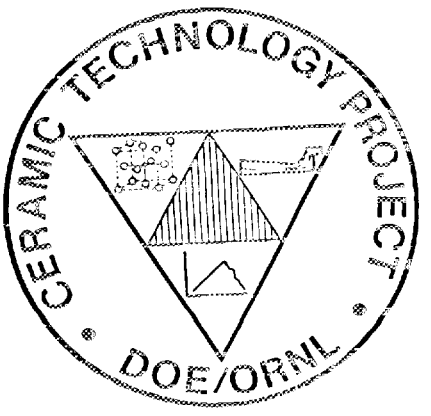
Ceramic Technology Project Database: March 1990 Summary Report

B. L. P. Keyes

CERAMIC TECHNOLOGY PROJECT



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1. page 103

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David R. Hamrin

David R. Hamrin
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ORNL/M-1860

Metals and Ceramics Division

CERAMIC TECHNOLOGY PROJECT DATABASE: MARCH 1990 SUMMARY REPORT

B. L. P. Keyes

July 1992

NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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Office of Transportation Technologies
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CERAMIC TECHNOLOGY PROJECT DATABASE: MARCH 1990 SUMMARY REPORT*

B. L. P. Keyes

ABSTRACT

This report is the fifth in a series of semiannual data summary reports on information being stored in the Ceramic Technology Project (CTP) database. The overall system status as of March 31, 1990, is summarized, and the latest additions of ceramic mechanical properties data are given for zirconia, silicon carbide, and silicon nitride ceramic mechanical properties data, including some properties on brazed specimens.

1. INTRODUCTION

Unlike the previous reports,[1-4] which concentrated on one class of ceramics per report, this summary contains new test results on several classes of ceramic materials, including zirconias, silicon carbides, and silicon nitrides. Primary sources for information in this report are the semiannual and bimonthly CTP progress reports, ORNL/TM-6513, ORNL/5612, a data disk from M. K. Ferber of Oak Ridge National Laboratory (ORNL), and a package of test results from N. L. Hecht of the University of Dayton Research Institute.

The addition of several new files during this period has further enhanced the usefulness of the overall system. Brazed-specimen bend [modulus of rupture (MOR) four-point], fracture toughness, and shear strength tests, which require more

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characterization than tests on non-joined specimens, are now included in the database. A hardness measurement file and an extended comments file for individual test results were also appended to the system.

A hard-copy guide to using the database has also been completed through the first draft. This guide will serve as instructions on using the database until the computerized interface is completed in 1991.

2. SYSTEM STATUS UPDATE

The database presently contains about 5,497 test results on over 320 different batches of ceramic materials. Approximately 46% of these are on zirconia-based ceramics, 9% are on silicon carbides, 21% are on silicon nitrides, 5.7% are on whisker-reinforced silicon nitrides, 16.3% are on alumina-based ceramics (including whisker-reinforced aluminas and mullites), and 2% are on other ceramics. Table 1 provides a more detailed overview of the data presently stored in the system.

Several new files, including three which store brazed-specimen test data, were added to the database during this summary period. Although the testing procedures for unjoined and joined specimens may be the same, additional information is needed to characterize the joint and all the materials used to create it. Often, dissimilar materials are brazed together, as in the case of the MS-PSZ and nodular, cast-iron joints made at ORNL and Battelle Columbus Laboratories. To characterize such a joint would require two material fields and two batch code fields, along with the information on the filler material, the brazing method used, heat treatments, etc. The database now contains files on MOR four-point bend strength tests, shear strength tests, and fracture toughness tests performed on brazed specimens.

TABLE 1. CTP DATABASE SUMMARY AS OF MARCH 31, 1990

Material Class	------ Brazed Specimens ------- MOR 4	Shear Str.	Toughness	Creep	Cyclic Fatigue	Density	Dynamic Fatigue	Elasticity	Fracture Toughness	Hardness	Interrupted Fatigue	Material Characteristics
Alumina				1	15		9	24	20			19
Alumina + reinforcing fibers						7			39			91
Alumina + Zirconia												
Mullite								2				2
Mullite + reinforcing fibers								11	16			48
Silicon Carbide						10	13	15	24	27		7
Silicon Nitride		3		27	19	28	16	24	85	112		29
Silicon Nitride + reinforcing fibers					15	2		16	31			44
Zirconia	123	58	2		51	158		92	54		239	37
Zirconia + reinforcing fibers												5
Other									3	27		
Total records	123	61	2	28	100	205	38	184	272	166	239	282

Material Class	MOR 3 Pt Bend	MOR 4 Pt Bend	Oxidation Rate	Poisson's Ratio	Shear Modulus	Tensile	Thermal Conductivity	Thermal Contraction	Thermal Diffusivity	Thermal Expansion	Thermal Shock	X-Ray Diffraction
Alumina		371				28	3			1	2	
Alumina + reinforcing fibers		144				11	34		18	4	6	
Alumina + Zirconia		7						23		21		
Mullite	1	4										
Mullite + reinforcing fibers	9	22										
Silicon Carbide		235								23		17
Silicon Nitride	10	573	1	2	1	73	9		10	44		49
Silicon Nitride + reinforcing fibers		106	3	17	16	86	9		17	14		
Zirconia		1554				50						72
Zirconia + reinforcing fibers		2				36						
Other		59										
Total records	20	3077	4	19	17	284	55	23	45	107	8	138

Grand total test result records on file: 5497

Another new file contains the results of various hardness tests. Averaged hardness values are found in the material characteristics file, but the new file provides the user with a better idea of the actual measurements.

Comments on some of the test results exceed the short field space allotted in the test results records. For example, occasionally, a specimen breaks in the grips or the electrical power is interrupted during the test, thus causing abnormal results, or some other out-of-the-ordinary occurrence takes place that affects the outcome of the results. Such details are important and need to be taken into consideration before analyzing the data. These additional comments are stored in DATATXT, an extended comments file whose records contain details pertaining to one test, rather than to a whole set of tests from a single reference. Only those tests containing a "Y" or "T" in the SEETEXT field in the test results record will have entries in this file.

Although the database is physically located in a microcomputer, direct access to users is very limited to protect the integrity of the database. Changes, additions, and deletions are made by one person to avoid jeopardizing the entire system through misuse or abuse by those not familiar with the files. User access is limited to downloaded files on floppy disks in the user's choice of formats. The database itself is a collection of related files created in dBASE IV structure, which can be linked by a set of parameters. However, no formal computerized interface currently exists to provide automatic linking of these files, although plans for one are in progress. To aid the user with downloaded files, a hard-copy version of a database guide has been prepared so the user will have adequate information on file contents, general terminology, and interfile linkage until a computerized interface becomes available. The guide includes file maps, field definitions and characteristics, linkage maps, and a recent database contents overview and will be sent to each person requesting data.

3. DATA SUMMARY

This report covers eight different batches of four zirconia ceramics, two batches of two silicon carbides, and nine batches of six silicon nitrides. This report also contains the first data to be stored in the database on the mechanical properties of brazed ceramics. M. L. Santella of ORNL initially succeeded in brazing a partially stabilized zirconia to nodular cast iron by coating the zirconia with titanium and the cast iron with copper. Work at Battelle Columbus Laboratories on this same topic yielded a brazing procedure where no copper coating was needed to produce a stable, strong joint. Additional data from Battelle has been requested but has not yet been received.

Much of the bend strength data on zirconias in this report were produced by a study of diesel engine environmental effects on the strength of partially stabilized zirconias. In that study, Nilcra MS-PSZ and TS-PSZ specimens were: (1) exposed to one of the two diesel engine combustion chamber environments for 100 h, (2) aged for 100 h at temperatures ranging from 700 to 800°C, or (3) remained in the as-fabricated condition prior to testing to failure. All specimens were broken in a four-point bend fixture in air at room temperature. Strength comparisons and Weibull plots accompany the data tables for this study, found in Appendix B.

Tracking down background information for a specific batch of a material is a time-consuming, often frustrating, experience that is often necessary to confirm the validity of the data. Keeping assigned batch numbers with the material as it goes through testing frequently appears to be a neglected task. Some of the data in this report include the original batch codes assigned to the materials by the fabricators. When no batch identifier is mentioned, a code is assigned by database personnel based upon the source (report code) and the company, laboratory, or individual who reported the data. It is possible for material with a known batch code to be the same as a material with a locally assigned (by database personnel) batch code if, for example, data for the material were reported

without the original fabricator's code. Unless the unknown-batch-code data are exact duplicates of known-batch-code data, the unknown-batch-code data are assigned a unique identifier to distinguish them from other batches of the same material.

All Weibull analyses shown in this report were performed using the rank regression method, in which a least-squares fit to the data is used to estimate the modulus. Specifically, the data were sorted and the X-Y coordinates, ln (MOR strength) and lnln [1/(1-F)] , were calculated using Microsoft EXCEL™ (version 2.0) on an Apple Macintosh computer. The data were then transferred to Cricket Graph™ (version 1.3.1), where they were plotted with the best-fit line, using Cricket Graph's built-in, curve-fitting routines.

Data tables for this report are organized according to type of data: Appendix A contains available background information on the ceramics presented in this report; Appendix B contains the experimental text data arranged in sections by property type. Some of the test data listed in Appendix B may not be represented by materials in Appendix A but will be included in a later report (if and when such information becomes available). It is the policy for this database to store the available information for future use, whether or not a complete set of information is available on a material. However, complete sets are preferred and sought as time permits.

4. SYSTEM ACCESS

Direct access to the master database is very limited to protect the integrity of the master files. Past experience has shown that major disasters often occur when too many people have direct access to unprotected files at the microcomputer level. Since most users would prefer to have the data in a familiar format, to subset, analyze, and rearrange to suit their needs, this method satisfies both situations; the master files are protected, and the user gets the data in a readily consumable form. While direct access is faster, the

process of downloading across phone lines can be time consuming and hazardous to the integrity of the data being transmitted. This database was designed as a repository, not a full-function analytical tool.

Access to the data is attained by calling the database administrator and requesting all files or just those pertaining to certain materials or test types. The CTP database is a microcomputer-based system of files organized in the dBASE IV structure. Access to the data can be provided by calling the database personnel during working hours (7 a.m. to 3:20 p.m., Eastern time) at 615-574-5113. The information requested by the user (in the user-designated format, including software and disk type) will then be downloaded from the master files, reformatted (if necessary), and sent out to the user as soon as possible. No plans are being considered for direct access from outside systems at this time. Direct transfer is also available by special arrangement but may be time consuming due to the sizes and numbers of files. No guarantee is given for the validity of data transmitted directly because of possible phone line problems. Until a computerized interface becomes available, the *CTP Database User's Guide* will also be sent to all first-time users when the document becomes available.

Several file formats, other than dBASE IV, are available for files downloaded for users. These formats have been categorized as either Apple Macintosh-compatible files (on 3.5-in. floppy disks) or IBM PC-compatible files (on 3.5-in. floppy disks up to 1.44 MB or 5.25-in. floppy disks from 360 KB to 1.44 MB). When requesting information from the database, users should indicate disk size and density as well as file type.

Macintosh file types available are Microsoft EXCEL; SYL; and plain, printable ASCII. IBM file types are Lotus 1-2-3, Microsoft EXCEL, DIF, SDF, SYLK, plain ASCII, delimited ASCII, and dBASE III+. Other formats may be available by special arrangement with database personnel.

With computer diseases becoming so rampant, users should be aware that precautions are taken to ensure that the disks they receive from the database are disease

free. Only new disks are used for transmittals to avoid spreading any computer diseases that might be hiding. No recycled, reformatted disks are sent to users. Both the master system (IBM PC/AT) and the Macintosh IIcx are checked regularly for such illnesses, and none have been found so far. Use of both computers is limited to one person who screens incoming software carefully to avoid contamination of either system. No information is downloaded from public bulletin boards to either system. Both systems have virus detection software installed, and all efforts are made to ensure both systems stay disease free. If users have problems with disks received from the database, they should inform database personnel immediately so that steps can be taken to correct the problems.

5. FUTURE PLANS

The sixth database summary report is scheduled for completion in September 1990 and will feature the latest additions of data to the database. Plans are currently being made to write a computerized user interface using the dBASE IV programming language. The interface will link the database's many files together, providing better access to information in the system. This interface will be available to all users of the database who request it.

6. ACKNOWLEDGMENTS

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7. REFERENCES

1. M. K. Booker, "Ceramics Technology for Advanced Heat Engines Project Data Base: A Summary Report," ORNL/M-462, Martin Marietta Energy Systems Inc., Oak Ridge Natl. Lab.

2. B. L. P. Booker, "Ceramics Technology for Advanced Heat Engines Project Data Base: September 1988 Summary Report," ORNL/M-755, Martin Marietta Energy Systems Inc., Oak Ridge Natl. Lab., March 1989.

3. B. L. P. Keyes, "Ceramics Technology for Advanced Heat Engines Project Data Base: March 1989 Summary Report," ORNL/M-1098, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., April 1990.

4. B. L. P. Keyes, "Ceramics Technology for Advanced Heat Engines Project Database: September 1989 Summary Report," ORNL-M/1286, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., October 1990.

APPENDIX A. MATERIAL CHARACTERISTICS AND BACKGROUND INFORMATION

SECTION 1. MATERIAL CHARACTERISTICS INFORMATION

MATERIAL	BATCH CODE	MATERIAL CLASS	FABRICATOR	PRIMARY MATRIX	ADDITIVES	SOURCE
CVD-SiC*	CVD/UDRI/SA9	SIC	CVD Inc.	SiC		ORNL/TM-10705,p.309
HEXOLOY SA*	UDRI-SA9	ALPHA SIC	SOHIO Engineered Materials	alpha SiC	B, Al	ORNL/TM-10705,p285+
HEXOLOY SA	SOHIO/UDRI/1	ALPHA SIC	SOHIO Engineered Materials	alpha SiC	B, Al	BM11/87, p.70
CERALLOY 147-3	CERADYNE/UDRI/2	SIN, ISOPR	Ceradyne	Si3N4	Y2O3,Al2O3	
EC-152	NGK/UDRI/1	SIN, SINT	NGK Spark Plug	Si3N4		BM10/88, p.91
NT-154	NORTON/UDRI/2	SIN, SINT&HP	Norton/TRW	Si3N4		BM10/88, p.90
NT-154	NORTON/ORNL/1	SIN, SINT&HP	Norton/TRW	Si3N4		BM12/88, p.19
SN-252	KYOCERA/UDRI/2	SIN, ISOPR	Kyocera	Si3N4	Yb2O3,Y2O3,Al2O3	BM11/87, p.21
SN-4	HOWMET/UDRI/1	SIN, ISOPR	Howmet	Si3N4	10% Y2O3, Al2O3	BM10/88, p.90
GTE PY6	GTEL/UDRI/1	SIN, HP	GTE Laboratories	beta Si3N4	6w%Y2O3	BM11/87, p.70
GTE PY6*	UDRI-SA9	SIN, HP	GTE Laboratories	beta Si3N4	6w%Y2O3	ORNL/TM-10705,p285+
TS-PSZ*	NILCRA/UDRI/1	ZRO PSZ	Nilcra Ceramics	ZrO2	3w%MgO	ORNL/TM-10308,p256
MS-PSZ*	NILCRA/UDRI/1	ZRO PSZ	Nilcra Ceramics	ZrO2	3w%MgO	ORNL/TM-10308,p256
Z-201*	KYO1985/MTL	ZRO PSZ	Kyocera	ZrO2	Y2O3	ORNL/TM-10308,p217

MATERIAL	BATCH CODE	DENSITY g/cm^3	MOE GPa	MOR4 MPa	HARDNESS TEST	HARDNESS VALUE	THERMAL EXPANSION COEFFICIENT 1.E-06/°C	POISSONS RATIO	KIC MPa√m
CVD-SiC*	CVD/UDRI/SA9		470.0	554.0	VICKERS	2600 kg/mm2		0.230	2.600
HEXOLOY SA*	UDRI-SA9	3.17	300.0	325.0	VICKERS	2740 kg/mm2	4.500		4.000
HEXOLOY SA	SOHIO/UDRI/2	3.17	427.0	331.0	VICKERS	2539 kg/mm2	5.400		2.000
CERALLOY 147-3	CERADYNE/UDRI/2								
EC-152	NGK/UDRI/2								
NT-154	NORTON/UDRI/2	3.23		310.5					
NT-154	NORTON/ORNL/1								
SN-252	KYOCERA/UDRI/2								
SN-4	HOWMET/UDRI/2	3.23	204.0						
GTE PY6	GTEL/UDRI/2	3.24	293.0	641.0	VICKERS	1458kg/mm2	3.400		3.000
GTE PY6*	UDRI-SA9	3.24	267.0	800.0			3.500		4.250
TS-PSZ*	NILCRA/UDRI/1	5.78			VICKERS	1025 kg/mm2	9.500		6.000
MS-PSZ*	NILCRA/UDRI/1	5.69			VICKERS	1099 kg/mm2	10.300		7.600
Z-201*	KYO1985/MTL	5.85	201.0	745.0	KNOOP.3kg	10.5 kg/mm2			8.800

* These data included, although from a different batch, for guidance purposes only.

SECTION 2. GENERAL TEXT INFORMATION ON MATERIALS IN THIS REPORT

MATERIAL	BATCH CODE	REFERENCE CODE	CATEGORY	SEQ	TEXT
SILICON CARBIDES					
CVD SiC	CVD/UDRI/2	UDRIPKGNOV89	PROCESS	A	SiC prepared by chemical vapor deposition techniques.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	PROCESS	A B	Cold formed (injection molded or isostatic pressed) and pressurelessly sintered alpha-silicon carbide with additions of B and Al.
SILICON NITRIDES					
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	PROCESS	A B	Cold formed (isopressing/slip casting/injection molding) sintered Si3N4 with additions of Y2O3 and Al2O3.
EC-152	NGK/UDRI/2	UDRIPKGNOV89	PROCESS	A	Gas pressure sintered Si3N4 with additions of Al2O3 and Y2O3.
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	PROCESS	A	Injection molded and HIP'ed beta silison nitride with additions of Y2O3.
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	PROCESS	A	Sintered and HIP'ed Si3N4.
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	PROCESS	A B	Cold formed (die pressing/isostatic pressing) sintered and HIP'ed Si3N4 with 10% oxide sintering aids (Al2O3 and Y2O3).
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	PROCESS	A B C	Cold formed (isopressed/slip cast/etc.) and sintered Si3N4 with additions of Yb2O3, Y2O3, and Al2O3 (Note: the sintering process is controlled to promote the growth of a beta Si3N4 whisker phase in the Si3N4 matrix).

SECTION 3. DENSITIES

MATERIAL	BATCH CODE	REFERENCE CODE	PROCESS	SPECIMEN NUMBER	TEMP °C	DENSITY g/cm^3
SILICON CARBIDES						
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	16	21	3.1600
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	17	21	3.1500
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	18	21	3.1400
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	19	21	3.1600
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	20	21	3.1500
SILICON NITRIDES						
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	6	21	3.2600
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	7	21	3.2700
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	8	21	3.2700
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	9	21	3.2700
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	10	21	3.2700
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	96	21	3.2300
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	97	21	3.2300
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	98	21	3.2300
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	99	21	3.2300
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	100	21	3.2400
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	8	21	3.2300
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	17	21	3.2300
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	IMMERSION METHOD	20	21	3.2300

SECTION 4. HARDNESS MEASUREMENTS

MATERIAL	BATCH CODE	REFERENCE CODE	HARDNESS TEST	SPECIMEN NUMBER	LOAD g	INDENT DEPTH µm	UNITS	HARDNESS VALUE
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	21	500.0	22.3	kg/mm	1865.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	21	500.0	18.9	kg/mm	2596.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	21	500.0	19.0	kg/mm	2568.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	21	500.0	18.4	kg/mm	2739.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	21	500.0	18.0	kg/mm	2862.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	22	500.0	17.9	kg/mm	2894.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	22	500.0	18.5	kg/mm	2709.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	22	500.0	17.6	kg/mm	2993.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	22	500.0	18.3	kg/mm	2769.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	22	500.0	20.0	kg/mm	2318.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	23	500.0	17.6	kg/mm	2993.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	23	500.0	19.3	kg/mm	2489.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	23	500.0	17.9	kg/mm	2894.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	23	500.0	19.7	kg/mm	2389.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	23	500.0	19.3	kg/mm	2489.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	24	500.0	17.8	kg/mm	2926.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	24	500.0	17.5	kg/mm	3028.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	24	500.0	17.9	kg/mm	2894.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	24	500.0	19.0	kg/mm	2568.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	24	500.0	18.5	kg/mm	2709.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	25	500.0	17.2	kg/mm	3134.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	25	500.0	18.1	kg/mm	2830.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	25	500.0	18.6	kg/mm	2680.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	25	500.0	17.5	kg/mm	3028.0
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	VICKERS	25	500.0	18.2	kg/mm	2799.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	61	300.0	19.7	kg/mm	1433.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	61	300.0	20.0	kg/mm	1391.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	61	300.0	19.4	kg/mm	1478.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	61	300.0	19.1	kg/mm	1525.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	61	300.0	19.7	kg/mm	1433.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	62	300.0	18.3	kg/mm	1661.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	62	300.0	19.2	kg/mm	1509.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	62	300.0	18.9	kg/mm	1557.0

SECTION 4. HARDNESS MEASUREMENTS, CONTINUED

MATERIAL	BATCH CODE	REFERENCE CODE	HARDNESS TEST	SPECIMEN NUMBER	LOAD g	INDENT DEPTH μm	UNITS	HARDNESS VALUE
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	62	300.0	18.9	kg/mm	1557.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	62	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.5	kg/mm	1625.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	19.0	kg/mm	1541.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	18.8	kg/mm	1574.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	19.0	kg/mm	1541.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	63	300.0	19.9	kg/mm	1405.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	64	300.0	18.5	kg/mm	1625.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	64	300.0	20.5	kg/mm	1324.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	64	300.0	19.3	kg/mm	1494.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	64	300.0	19.6	kg/mm	1448.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	64	300.0	18.9	kg/mm	1557.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	66	300.0	18.6	kg/mm	1608.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	66	300.0	18.9	kg/mm	1557.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	66	300.0	19.5	kg/mm	1463.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	66	300.0	19.6	kg/mm	1448.0
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	VICKERS	66	300.0	19.3	kg/mm	1494.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	31	500.0	23.9	kg/mm	1623.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	31	500.0	23.7	kg/mm	1651.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	31	500.0	24.0	kg/mm	1610.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	31	500.0	24.0	kg/mm	1610.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	31	500.0	24.8	kg/mm	1508.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	32	500.0	23.5	kg/mm	1679.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	32	500.0	24.0	kg/mm	1610.0

SECTION 4. HARDNESS MEASUREMENTS, CONTINUED

MATERIAL	BATCH CODE	REFERENCE CODE	HARDNESS TEST	SPECIMEN NUMBER	LOAD g	INDENT DEPTH µm	UNITS	HARDNESS VALUE
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	32	500.0	23.4	kg/mm	1693.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	32	500.0	23.6	kg/mm	1665.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	32	500.0	24.3	kg/mm	1570.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	33	500.0	23.4	kg/mm	1693.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	33	500.0	24.5	kg/mm	1545.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	33	500.0	24.3	kg/mm	1570.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	33	500.0	24.1	kg/mm	1596.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	33	500.0	23.3	kg/mm	1708.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	34	500.0	23.5	kg/mm	1679.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	34	500.0	24.0	kg/mm	1610.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	34	500.0	24.5	kg/mm	1579.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	34	500.0	23.5	kg/mm	1679.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	34	500.0	24.2	kg/mm	1583.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	35	500.0	24.2	kg/mm	1583.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	35	500.0	24.0	kg/mm	1610.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	35	500.0	23.5	kg/mm	1679.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	35	500.0	23.5	kg/mm	1679.0
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	VICKERS	35	500.0	24.7	kg/mm	1520.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	12	300.0	20.8	kg/mm	1286.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	12	300.0	17.5	kg/mm	1817.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	12	300.0	19.9	kg/mm	1405.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	12	300.0	19.0	kg/mm	1541.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	16	300.0	19.6	kg/mm	1448.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	16	300.0	19.2	kg/mm	1509.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	16	300.0	18.7	kg/mm	1591.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	16	300.0	19.8	kg/mm	1419.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	16	300.0	19.5	kg/mm	1463.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	18	300.0	19.5	kg/mm	1463.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	18	300.0	19.0	kg/mm	1541.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	18	300.0	18.7	kg/mm	1591.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	18	300.0	19.3	kg/mm	1494.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	18	300.0	20.0	kg/mm	1391.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	19	300.0	18.5	kg/mm	1625.0

SECTION 4. HARDNESS MEASUREMENTS, CONTINUED

MATERIAL	BATCH CODE	REFERENCE CODE	HARDNESS TEST	SPECIMEN NUMBER	LOAD g	INDENT DEPTH µm	UNITS	HARDNESS VALUE
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	19	300.0	18.5	kg/mm	1625.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	19	300.0	19.5	kg/mm	1463.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	19	300.0	18.5	kg/mm	1625.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	19	300.0	19.0	kg/mm	1541.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	20	300.0	19.0	kg/mm	1541.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	20	300.0	19.0	kg/mm	1541.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	20	300.0	19.0	kg/mm	1541.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	20	300.0	17.5	kg/mm	1817.0
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	VICKERS	20	300.0	18.6	kg/mm	1608.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	1	200.0	14.5	kg/mm	1764.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	1	200.0	15.2	kg/mm	1605.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	1	200.0	14.2	kg/mm	1839.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	1	200.0	16.5	kg/mm	1362.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	1	200.0	14.0	kg/mm	1892.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	2	200.0	15.1	kg/mm	1627.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	2	200.0	14.9	kg/mm	1671.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	2	200.0	16.1	kg/mm	1431.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	2	200.0	15.3	kg/mm	1584.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	2	200.0	15.8	kg/mm	1486.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	3	200.0	15.5	kg/mm	1544.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	3	200.0	14.4	kg/mm	1789.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	3	200.0	15.3	kg/mm	1584.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	3	200.0	15.9	kg/mm	1467.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	3	200.0	15.0	kg/mm	1648.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	4	200.0	15.7	kg/mm	1505.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	4	200.0	16.5	kg/mm	1362.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	4	200.0	15.0	kg/mm	1648.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	4	200.0	15.7	kg/mm	1505.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	4	200.0	15.0	kg/mm	1648.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	5	200.0	15.1	kg/mm	1627.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	5	200.0	14.8	kg/mm	1693.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	5	200.0	15.8	kg/mm	1486.0
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	VICKERS	5	200.0	15.0	kg/mm	1648.0

APPENDIX B. TEST RESULTS

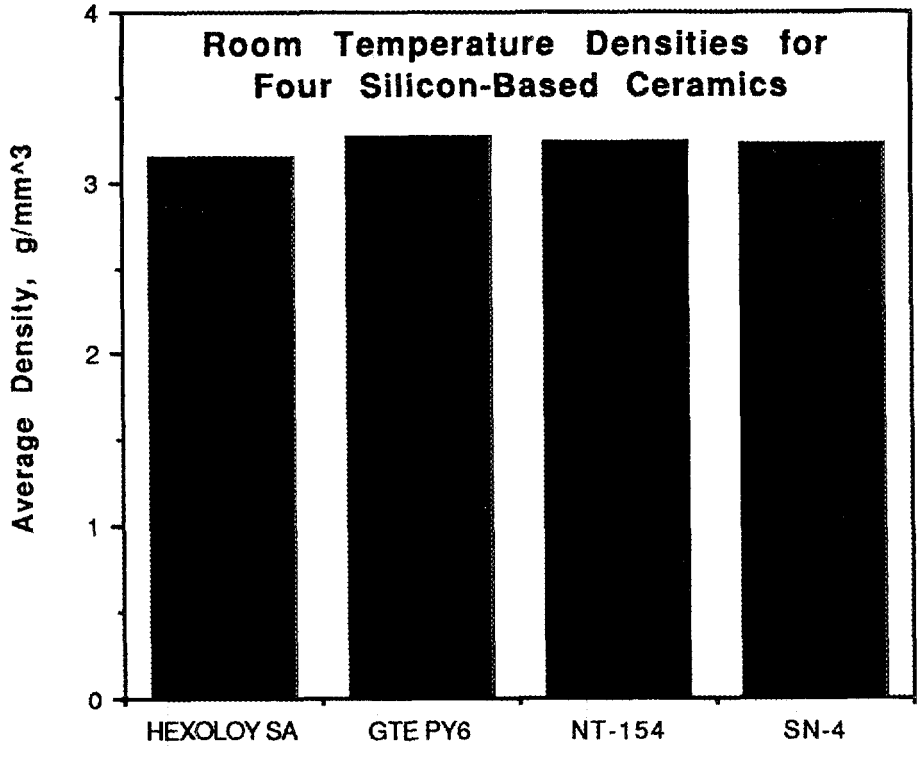

Figure 1.1 Average density at room temperature comparison among three silicon nitrides and one silicon carbide, all tested at UDRI.

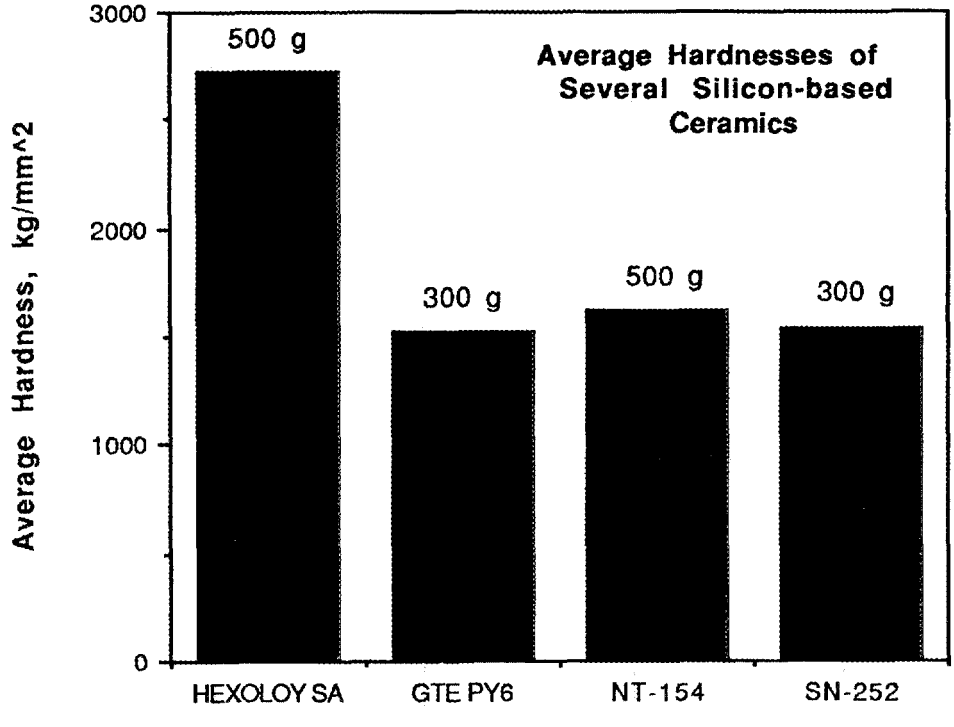

Figure 1.2 Average hardnesses for three silicon nitrides and one silicon carbide tested at UDRI. Vickers test was used with the loads indicated in grams over the bars.

SECTION 1. TEST BACKGROUND INFORMATION FOR NON-BRAZED SPECIMEN TESTS

REFERENCE CODE	TEST TYPE	SEQ	TEST BACKGROUND INFORMATION
ORNL-5612	MOR4PTB	A B C D E F G H I J K L M N O P Q R S T	This report continues the work reported under REF_CODE ORNL-6513. The same 2 diesel engines were used to expose the specimens to the combustion environment, with access through the unused glow plug port, adjacent to the fuel injector. The 2-cylinder engine was new prior to these exposures, running at a nominal constant speed of 1800-1900 rpm and a load of 41-43Nm torque. Fuel consumption was about 213 g/kWh. The 1-cylinder engine was run at similar conditions at half the load and fuel consumption. Exposure times for both engines was 100 hrs, which was accumulated over several weeks of running several hours each day. The single cylinder engine had been used for other purposes prior to these experiments and had aged to the point that the fuel injector was wetting the surfaces of the specimens, resulting in high thermal stresses, often leading to failure within the engine. Two specimens were gripped side-by-side separated by a shim and inserted through the glow plug port. Only 40-41mm of each specimen was exposed. Two fuel mixtures were used: d-2 is Philips D-2 diesel, the reference fuel; d-2b was a mixture of 50% Philips D-2 and 50%aromatic blend (53.5wt% Phillips Light Cycle Oil and 46.5wt% Exxon heavy aromatic naptha targeted for lower cetane number/lower hydrogen content. After exposure, the specimens were broken in air at room temperature using a conventional 4 point bend fixture. The MOR bars were 50 x 4.5 x 3.5mm with chamfered edges, polished longitudinally to .25 micrometers.
SA12ORNL469	MOR4PTB	A B C D E F G H I J K	About 40mm of one end of the specimens were exposed for 100h to discontinuous combustion conditions of a Deutz F1L511W diesel engine burning 50% D-2 diesel fuel and 50% aromatic blend (53.5% Philips light Cycle Oil (LCO), 46.5% Exxon heavy aromatic Naptha (HAN)). The engine was 2 cylinder indirect injection and air-cooled. Specimen geometry for MOR bars was 50mm x 4.5mm x 3.5mm. All specimens were broken in air at room temperature. The test rig outer span was 40mm, inner span was 20mm. Specimens were polished longitudinal to .25 micrometers, with average grain size of 30 to 50 um. Original product forms were rectangular plates, 101.6mm x 101.6mm x 6.35 mm. These conditions apply for both TS-PSZ and MS-PSZ materials for the diesel study. Work performed at ORNL by C.R. Brinkman and K. C. Liu.

SECTION 1. TEST BACKGROUND INFORMATION FOR NON-BRAZED SPECIMEN TESTS

REFERENCE CODE	TEST TYPE	SEQ	TEST BACKGROUND INFORMATION
UDRIPKGNOV89	MOR4PTB	A B C D E F G H	Bend tests were made using 2 Instron Universal Testing Machines (Model 1123) following MIL-STD-1942(MR). High temperature measurements were conducted in 2 ATS #3320 high-temperature furnaces. Test specimens were 3mmx4mmx50mm with the tensile surface ground and polished to 16 microinch finish (MIL-STD-1942(MR), size B). Long edges were rounded and polished to minimize edge failures. The 4-point bend tests had outer spans of 40mm, inner spans of 20mm. Bend fixtures for room temperature tests were made from steel. For higher temps, the fixtures were made of SiC. Data submitted by Norman Hecht, UDRI, November, 1989.
UDRIPKGNOV89	FRACTUFF	A B C	Fracture toughness was measured using both controlled flaw and microindent methods. An indent load of 2000 grams was used in both methods. Data submitted by Norman Hecht, UDRI, November, 1989.
UDRIPKGNOV89	HARDNESS	A B C	Hardness measured by Vicker's microindent hardness tester. Fracture origins were determined by optical microscopy and SEM (JEOL/SM-80 with EG&G Ortec System 5000 Microanalysis System). Data submitted by Norman Hecht, UDRI, November, 1989.
UDRIPKGNOV89	MOE	A B	The elastic modulus was measured by a Grindo-Sonic (Model MR35T) Transient Impulse/Elastic Modulus Apparatus. Data from Norman Hecht, UDRI, November, 1989.
UDRIPKGNOV89	TENSILE	A B C D E	Tensile strength measurements were made using an Instron Electro-Mechanical Test System (Model 1361) equipped with Instron "sure-grip" universal coupling and water-cooled holders for high-temp tensile testing. An Instron high-temperature short furnace was used for high temperature measurements. Data submitted by Norman L. Hecht, The University of Dayton Research Institute in November, 1989.
UDRIPKGNOV89	THERMEXP	A B	Thermal expansion was measured from 25°-1400°C using a Theta Industries Dilatronic II-Model 6024. Data submitted by Norman Hecht, UDRI, November, 1989.

SECTION 2. CYCLIC FATIGUE TEST RESULTS

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRN.	SPECIMEN NUMBER	TEMP °C	STRESS MPa	CYCLES AT STRESS	CYCLES TO FAILURE	COMMENTS
SILICON NITRIDE									
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-21	1300	338	1024490		STEP 1
						358	233240		STEP 2
						372	191000		STEP 3
						388	44383	1493113	STEP 4, FAIL
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-24	1370	207	467600		STEP 1
						220	216200		STEP 2
						243	131766	815566	STEP 3, FAIL
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-19	1200	475	270	270	
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-20	1200	449	8605	8605	
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-22	1300	388	278	278	
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-23	1300	361	762	762	
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-26	1300	234	2349	2349	
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-27	1370	212	51	51	
NT-154	NORTON/ORNL/CIP	BM689ORNL27	AIR	CP-29	1370	212	238	238	
ZIRCONIA									
MS-PSZ	NILCRA/ORNL-KCL	SA11ORNL306	AIR	40	400	238	1103	1103	
MS-PSZ	NILCRA/ORNL-KCL	SA11ORNL306	AIR	34	1000	140	45100		STEP 1
						154	44850		STEP 2
						168	43938		STEP 3
						183	96657	230545	STEP 4, FAIL
MS-PSZ	NILCRA/ORNL-KCL	SA11ORNL306	AIR	35	1000	161	46600		STEP 1
						175	42400		STEP 2
						188	89735	178735	STEP 3, FAIL

SECTION 3. FRACTURE TOUGHNESS TEST RESULTS

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPECIMEN NUMBER	TEST TYPE	TEMP °C	LOAD N	KIC MPa√m	CRACK LENGTH µm	X-HEAD SPEED mm/sec	SPECIMEN GEOMETRY
SILICON CARBIDES											
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	21	CONTROLLED FLAW	21	97.90	1.500	57.900	0.0200	4.0030x2.9794mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	22	CONTROLLED FLAW	21	93.40	1.400	63.300	0.0200	3.9853x2.9972mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	23	CONTROLLED FLAW	21	97.00	1.400	53.000	0.0200	3.9980x2.9616mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	24	CONTROLLED FLAW	21	93.90	1.500	64.900	0.0200	3.9929x2.9921mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	25	CONTROLLED FLAW	21	95.20	1.400	59.900	0.0200	3.9903x2.9896mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	26	CONTROLLED FLAW	21	96.10	1.500	63.600	0.0200	4.0030x2.9896mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	27	CONTROLLED FLAW	21	103.20	1.500	53.500	0.0200	3.9954x2.9769mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	28	CONTROLLED FLAW	21	95.60	1.400	55.600	0.0200	4.0005x2.9642mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	29	CONTROLLED FLAW	21	95.60	1.400	59.300	0.0200	3.9980x2.9870mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	30	CONTROLLED FLAW	21	105.40	1.600	62.300	0.0200	4.0056x2.9845mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	151	CONTROLLED FLAW	1400	200.60	3.300	68.800	0.0200	4.0005x2.9439mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	152	CONTROLLED FLAW	1400	215.70	3.100	52.500	0.0200	4.0056x2.9820mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	154	CONTROLLED FLAW	1400	159.70	2.600	67.500	0.0200	4.0030x2.9870mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	155	CONTROLLED FLAW	1400	204.60	3.500	76.300	0.0200	3.9954x2.9693mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	156	CONTROLLED FLAW	1400	177.90	3.000	75.000	0.0200	3.9954x2.9743mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	157	CONTROLLED FLAW	1400	166.40	2.900	78.100	0.0200	4.0005x2.9921mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	158	CONTROLLED FLAW	1400	185.00	3.000	68.800	0.0200	4.0056x2.9693mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	159	CONTROLLED FLAW	1400	169.90	2.800	69.400	0.0200	4.0030x2.9667mm
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	160	CONTROLLED FLAW	1400	215.30	3.600	72.500	0.0200	3.9853x2.9769mm
SILICON NITRIDES											
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	61	CONTROLLED FLAW	21	250.90	3.600	52.500	0.0200	3.9954x2.9566mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	62	CONTROLLED FLAW	21	209.50	2.900	46.300	0.0200	3.9980x2.9489mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	63	CONTROLLED FLAW	21	254.00	3.700	51.300	0.0200	3.9853x2.9388mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	64	CONTROLLED FLAW	21	240.20	3.300	48.800	0.0200	3.9903x2.9616mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	65	CONTROLLED FLAW	21	235.70	3.100	42.500	0.0200	3.9903x2.9591mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	66	CONTROLLED FLAW	21	250.00	3.400	43.800	0.0200	4.0005x2.9312mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	67	CONTROLLED FLAW	21	248.20	3.200	43.800	0.0200	4.0030x2.9693mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	68	CONTROLLED FLAW	21	253.50	3.200	38.800	0.0200	4.0030x2.9439mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	69	CONTROLLED FLAW	21	258.00	2.900	32.500	0.0200	4.0056x2.9489mm
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	70	CONTROLLED FLAW	21	259.80	3.100	35.000	0.0200	3.9980x2.9464mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	31	CONTROLLED FLAW	21	201.50	2.700	45.000	0.0200	3.9827x2.9388mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	32	CONTROLLED FLAW	21	217.50	3.200	51.300	0.0200	3.9954x2.9210mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	33	CONTROLLED FLAW	21	227.30	3.100	46.300	0.0200	3.9903x2.9439mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	34	CONTROLLED FLAW	21	208.60	3.200	56.300	0.0200	3.9853x2.9413mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	35	CONTROLLED FLAW	21	223.70	3.100	48.800	0.0200	3.9903x2.9489mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	36	CONTROLLED FLAW	21	216.20	3.200	52.500	0.0200	3.9878x2.9464mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	37	CONTROLLED FLAW	21	229.50	3.400	53.800	0.0200	4.0005x2.9515mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	38	CONTROLLED FLAW	21	224.60	3.100	46.300	0.0200	3.9980x2.9489mm

SECTION 3. FRACTURE TOUGHNESS TEST RESULTS, CONTINUED

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPECIMEN NUMBER	TEST TYPE	TEMP °C	LOAD N	KIC MPa√m	CRACK LENGTH µm	X-HEAD SPEED mm/sec	SPECIMEN GEOMETRY
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	39	CONTROLLED FLAW	21	227.70	3.400	53.800	0.0200	4.0030x2.9464mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	40	CONTROLLED FLAW	21	225.50	3.200	51.300	0.0200	3.9980x2.9489mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	51	CONTROLLED FLAW	1400	287.80	3.500	37.500	0.0200	4.0030x2.9794mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	52	CONTROLLED FLAW	1400	297.10	3.900	41.300	0.0200	4.0056x2.9159mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	53	CONTROLLED FLAW	1400	271.80	3.100	32.500	0.0200	4.0056x2.9464mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	54	CONTROLLED FLAW	1400	298.00	4.200	48.800	0.0200	4.0005x2.9464mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	56	CONTROLLED FLAW	1400	259.80	3.500	45.000	0.0200	4.0056x2.9489mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	57	CONTROLLED FLAW	1400	278.00	3.500	37.500	0.0200	4.0081x2.9286mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	58	CONTROLLED FLAW	1400	279.30	4.000	47.500	0.0200	4.0005x2.9134mm
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	60	CONTROLLED FLAW	1400	263.80	3.400	40.000	0.0200	4.0234x2.9261mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	1A	CONTROLLED FLAW	21	951.90	3.600	33.100	0.0200	6.1646x3.0810mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	2A	CONTROLLED FLAW	21	911.80	3.800	38.900	0.0200	6.1544x3.0734mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	2B	CONTROLLED FLAW	21	898.50	3.600	37.000	0.0200	6.1570x3.0709mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	3A	CONTROLLED FLAW	21	911.80	3.700	37.400	0.0200	6.1570x3.0607mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	3B	CONTROLLED FLAW	21	947.40	3.700	33.900	0.0200	6.1595x3.0658mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	4A	CONTROLLED FLAW	21	938.50	3.700	35.500	0.0200	6.1570x3.0683mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	4B	CONTROLLED FLAW	21	929.60	3.800	36.800	0.0200	6.1646x3.0709mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	5A	CONTROLLED FLAW	21	880.70	3.900	45.000	0.0200	6.1570x3.0709mm
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	5B	CONTROLLED FLAW	21	867.40	3.400	35.000	0.0200	6.1595x3.0734mm

SECTION 4. INTERRUPTED FATIGUE TEST RESULTS ON A YITTRIA-PARTIALLY STABILIZED ZIRCONIA

MATERIAL	BATCH CODE	REFERENCE CODE	SPECIMEN NUMBER	WIDTH mm	THICK mm	RIG NO.	TEMP. °C	HOLD TIME hours	APPLIED STRESS MPa	REQUIRED LOADING N	LOADING RATE N/s	FRACTURE LOAD N	FRACTURE STRENGTH MPa
Z-201	KYOCERA/1985	ORNL/FERBER-289	13	2.7915	2.5502	4	800	0.5	0	0	222.4	282.89	296.9
Z-201	KYOCERA/1985	ORNL/FERBER-289	14	2.7915	2.5451	5	800	0.5	0	0	222.4	292.68	308.4
Z-201	KYOCERA/1985	ORNL/FERBER-289	15	2.7889	2.5451	6	800	0.5	0	0	222.4	289.12	304.9
Z-201	KYOCERA/1985	ORNL/FERBER-289	19	2.7889	2.5527	1	800	24	0	0	222.4	305.13	319.9
Z-201	KYOCERA/1985	ORNL/FERBER-289	20	2.7915	2.5527	2	800	24	0	0	222.4	286.45	300
Z-201	KYOCERA/1985	ORNL/FERBER-289	21	2.7864	2.5451	3	800	24	0	0	222.4	286.45	302.4
Z-201	KYOCERA/1985	ORNL/FERBER-289	22	2.7915	2.5527	6	800	168	0	0	222.4	284.67	298.1
Z-201	KYOCERA/1985	ORNL/FERBER-289	23	2.7915	2.5476	5	800	168	0	0	222.4	256.2	269.4
Z-201	KYOCERA/1985	ORNL/FERBER-289	25	2.7915	2.5527	4	800	168	0	0	222.4	258.87	271.1
Z-201	KYOCERA/1985	ORNL/FERBER-289	26	2.7915	2.5425	1	800	336	0	0	222.4	319.37	337.2
Z-201	KYOCERA/1985	ORNL/FERBER-289	27	2.7915	2.5425	2	800	336	0	0	222.4	326.48	344.7
Z-201	KYOCERA/1985	ORNL/FERBER-289	28	2.7915	2.5425	3	800	336	0	0	222.4	339.38	358.3
Z-201	KYOCERA/1985	ORNL/FERBER-289	29	2.7915	2.5425	4	800	24	181.656	172.062	222.4	323.81	341.9
Z-201	KYOCERA/1985	ORNL/FERBER-289	30	2.7915	2.54	5	800	24	181.656	171.718	222.4	284.67	301.1
Z-201	KYOCERA/1985	ORNL/FERBER-289	31	2.7864	2.5425	6	800	24	181.656	171.749	222.4	316.7	335
Z-201	KYOCERA/1985	ORNL/FERBER-289	32	2.7889	2.5451	4	800	168	181.656	172.249	222.4	298.02	314.3
Z-201	KYOCERA/1985	ORNL/FERBER-289	33	2.7991	2.5451	5	800	168	181.656	172.876	222.4	350.95	368.8
Z-201	KYOCERA/1985	ORNL/FERBER-289	34	2.7915	2.5425	6	800	168	181.656	172.062	222.4	277.11	292.5
Z-201	KYOCERA/1985	ORNL/FERBER-289	35	2.7864	2.5425	1	800	214	181.656	171.749	222.4	308.69	326.5
Z-201	KYOCERA/1985	ORNL/FERBER-289	36	2.7889	2.5451	2	800	214	181.656	172.249	222.4	343.83	362.6
Z-201	KYOCERA/1985	ORNL/FERBER-289	37	2.7915	2.5425	3	800	214	181.656	172.062	222.4	326.04	344.2
Z-201	KYOCERA/1985	ORNL/FERBER-289	38	2.7915	2.5425	4	1000	144	0	0	222.4	208.17	219.8
Z-201	KYOCERA/1985	ORNL/FERBER-289	39	2.7889	2.5476	5	1000	144	0	0	222.4	267.77	281.8
Z-201	KYOCERA/1985	ORNL/FERBER-289	40	2.7915	2.5476	6	1000	144	0	0	222.4	279.78	294.2

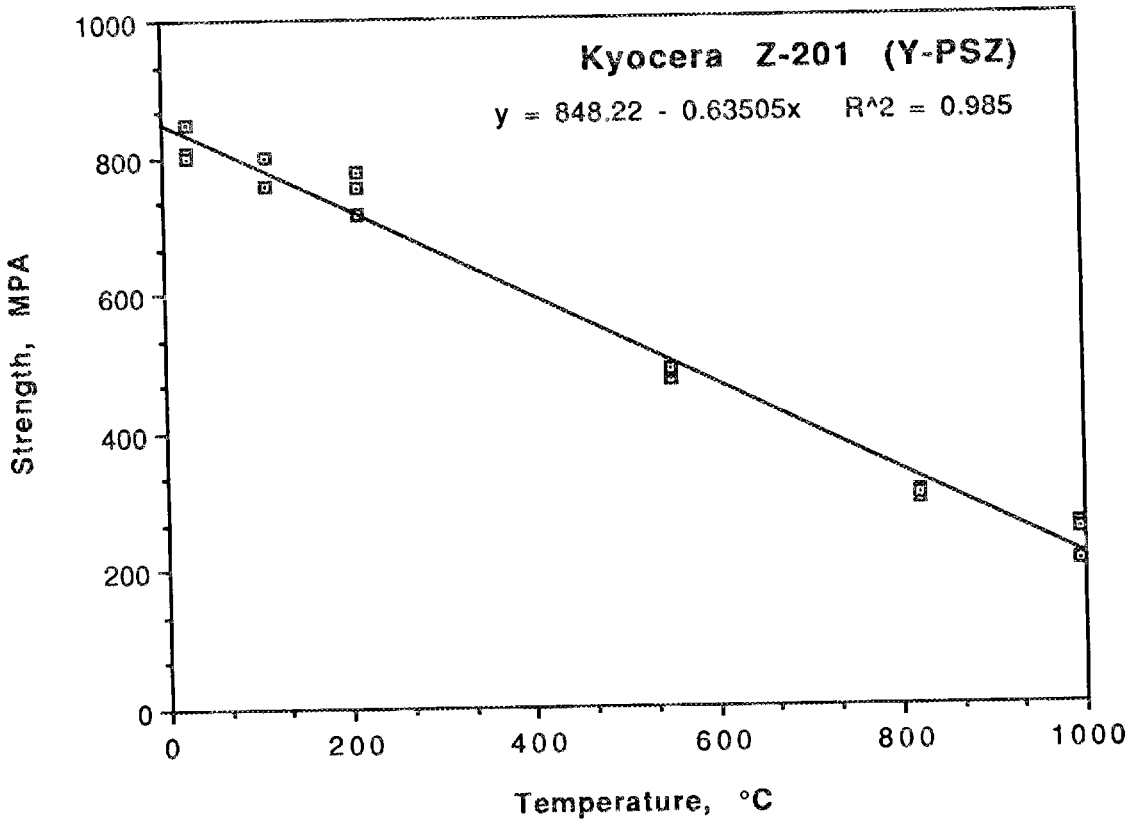

Figure 2.1. Strength vs. temperature plot for Kyocera Z-201 (1985), a yittria-partially stabilized zirconia.

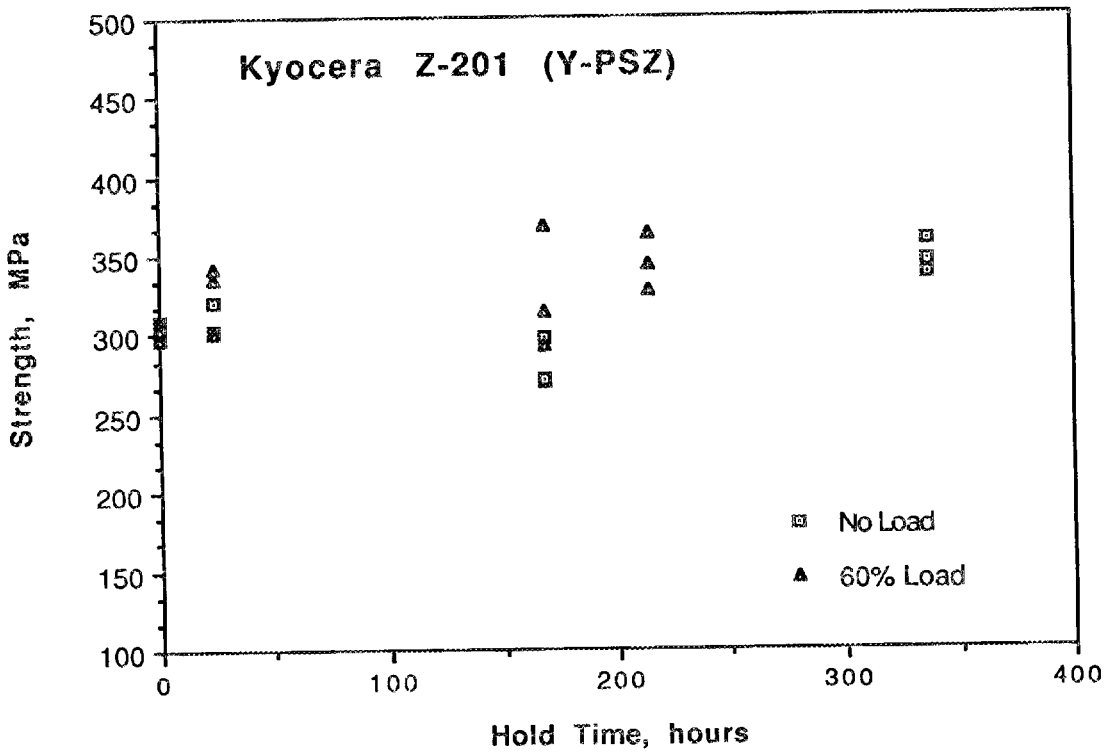

Figure 2.2. Strength vs. hold time for Kyocera Z-201 (1985) with no load and with 60% load.

SECTION 5. MOR 4-POINT BEND TEST RESULTS

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPECIMEN NUMBER	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/sec	COMMENTS
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	1	21	645.0	3.9954	3.0175	532.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	2	21	395.9	3.9903	2.9972	331.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	4	21	511.5	3.9929	2.9769	434.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	5	21	702.8	4.0005	2.9566	535.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	6	21	502.6	3.9700	2.9794	428.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	7	21	627.2	3.9954	3.0099	520.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	9	21	484.8	3.9726	2.9794	412.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	10	21	520.4	4.0005	2.9870	437.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	62	1000	814.0	4.0234	2.9845	681.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	63	1000	885.2	4.0310	2.9820	741.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	64	1000	467.0	3.9726	2.9870	395.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	65	1000	538.2	3.9599	2.9820	459.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	66	1000	960.8	4.0284	2.9896	801.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	67	1000	1112.0	4.0259	2.9870	929.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	68	1000	814.0	4.0234	2.9870	680.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	69	1000	765.1	4.0208	2.9870	640.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	70	1000	716.1	4.0259	2.9870	598.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	51	1000	693.9	3.9878	2.9134	615.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	53	1000	218.0	3.9878	2.9642	187.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	54	1000	2086.1	3.9700	2.9515	652.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	55	1000	653.9	3.9980	2.9413	567.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	56	1000	916.3	3.9827	3.0023	766.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	57	1000	751.7	3.9751	2.9362	658.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	58	1000	636.1	3.9827	3.0048	531.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	59	1000	498.2	3.9700	2.9464	434.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	60	1000	484.8	3.9421	2.9439	426.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	21	1200	578.2	3.9878	2.9743	492.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	22	1200	493.7	3.9624	2.9515	429.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	23	1200	627.2	3.9700	2.9972	528.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	24	1200	609.4	3.9878	2.9794	516.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	25	1200	520.4	3.9802	2.9769	443.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	26	1200	569.3	3.9929	2.9718	484.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	27	1200	649.4	3.9751	2.9870	549.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	28	1200	551.6	3.9700	2.9743	471.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	29	1200	569.3	3.9776	2.9718	486.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	30	1200	645.0	3.9675	2.9794	549.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	41	1200	636.1	3.9675	2.9540	551.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	42	1200	707.2	3.9700	2.9769	603.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	43	1200	653.9	3.9903	2.9616	560.0	0.000423	

SECTION 5. MOR 4-POINT BEND TEST RESULTS

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	1	21	645.0	3.9954	3.0175	532.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	2	21	395.9	3.9903	2.9972	331.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	4	21	511.5	3.9929	2.9769	434.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	5	21	702.8	4.0005	2.9566	535.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	6	21	502.6	3.9700	2.9794	428.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	7	21	627.2	3.9954	3.0099	520.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	9	21	484.8	3.9726	2.9794	412.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	10	21	520.4	4.0005	2.9870	437.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	62	1000	814.0	4.0234	2.9845	681.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	63	1000	885.2	4.0310	2.9820	741.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	64	1000	467.0	3.9726	2.9870	395.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	65	1000	538.2	3.9599	2.9820	459.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	66	1000	960.8	4.0284	2.9896	801.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	67	1000	1112.0	4.0259	2.9870	929.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	68	1000	814.0	4.0234	2.9870	680.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	69	1000	765.1	4.0208	2.9870	640.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	70	1000	716.1	4.0259	2.9870	598.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	51	1000	693.9	3.9878	2.9134	615.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	53	1000	218.0	3.9878	2.9642	187.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	54	1000	2086.1	3.9700	2.9515	652.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	55	1000	653.9	3.9980	2.9413	567.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	56	1000	916.3	3.9827	3.0023	766.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	57	1000	751.7	3.9751	2.9362	658.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	58	1000	636.1	3.9827	3.0048	531.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	59	1000	498.2	3.9700	2.9464	434.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	60	1000	484.8	3.9421	2.9439	426.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	21	1200	578.2	3.9878	2.9743	492.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	22	1200	493.7	3.9624	2.9515	429.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	23	1200	627.2	3.9700	2.9972	528.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	24	1200	609.4	3.9878	2.9794	516.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	25	1200	520.4	3.9802	2.9769	443.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	26	1200	569.3	3.9929	2.9718	484.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	27	1200	649.4	3.9751	2.9870	549.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	28	1200	551.6	3.9700	2.9743	471.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	29	1200	569.3	3.9776	2.9718	486.0	0.042330	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	30	1200	645.0	3.9675	2.9794	549.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	41	1200	636.1	3.9675	2.9540	551.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	42	1200	707.2	3.9700	2.9769	603.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	43	1200	653.9	3.9903	2.9616	560.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	44	1200	756.2	3.9878	2.9337	661.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	45	1200	218.0	3.9903	2.9235	192.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	46	1200	778.4	3.9827	2.9921	655.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	47	1200	582.7	3.9954	2.9108	516.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	48	1200	782.9	3.9878	2.9845	661.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	49	1200	516.0	3.9751	2.9921	435.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	50*	1200	387.0	3.9649	2.9566	335.0	0.000423	SPECIMEN DELAMINATED
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	11	1400	467.0	3.9624	2.9489	407.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	12	1400	440.4	4.0640	2.9845	365.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	13	1400	604.9	3.9827	2.9743	515.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	14	1400	596.0	3.9903	3.0201	491.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	15	1400	676.1	3.9649	2.9718	576.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	17	1400	751.7	3.9929	2.9464	651.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	18	1400	640.5	3.9878	3.0023	535.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	19	1400	693.9	3.9726	2.9921	585.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	20	1400	569.3	3.9700	3.0124	474.0	0.042330	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	31	1400	658.3	3.9675	2.9769	562.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	32	1400	564.9	3.9700	2.9794	481.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	33	1400	729.5	3.9878	2.9769	619.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	34	1400	774.0	3.9624	3.0201	643.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	35	1400	707.2	3.9954	2.9743	600.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	36	1400	747.3	3.9776	2.9769	636.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	37	1400	489.3	3.9776	2.9870	414.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	38	1400	765.1	3.9751	2.9972	643.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	39	1400	707.2	3.9802	2.9667	606.0	0.000423	
CVD SIC	CVD/UDRI/2	UDRIPKGNOV89	AIR	40	1400	716.1	3.9548	2.9566	622.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	41	21	480.4	4.0005	2.9947	402.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	42	21	587.1	3.9954	2.9820	496.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	43	21	418.1	3.9903	3.0074	348.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	44	21	475.9	3.9878	3.0074	396.0	0.042330	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	45	21	493.7	4.0005	2.9921	414.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	46	21	462.6	3.9929	3.0048	385.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	47	21	547.1	3.9903	3.0124	453.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	48	21	480.4	4.0005	3.0023	400.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	49	21	369.2	3.9980	3.0150	305.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	50	21	507.1	4.0081	2.9997	422.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	123	21	449.3	4.0107	3.0099	371.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	124	21	475.9	3.9903	2.9972	398.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	125	21	444.8	3.9929	2.9693	379.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	126	21	502.6	4.0081	3.0175	413.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	127	21	502.6	4.0234	3.0124	413.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	6	1000	524.9	3.9878	3.0099	436.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	7	1000	444.8	4.0030	2.9820	375.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	8	1000	516.0	4.0005	2.9845	434.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	9	1000	542.7	3.9878	3.0023	453.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	10	1000	538.2	4.0005	2.9997	449.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	11	1000	493.7	4.0030	3.0124	408.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	12	1000	440.4	4.0005	3.0023	366.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	13	1000	511.5	3.9903	3.0023	427.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	14	1000	498.2	3.9903	2.9794	422.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	15	1000	467.0	3.9878	3.0099	388.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	103	1000	507.1	3.9954	2.9769	430.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	104	1000	484.8	4.0030	3.0074	402.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	105	1000	533.8	4.0005	3.0201	439.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	106	1000	449.3	4.0056	3.0124	471.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	107	1000	547.1	4.0005	2.9820	461.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	108	1000	431.5	4.0030	2.9870	362.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	109	1000	573.8	3.9903	2.9997	479.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	110	1000	395.9	3.9853	3.0048	330.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	111	1000	556.0	3.9980	3.0023	463.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	112	1000	502.6	4.0030	3.0023	418.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	83	1000	516.0	3.9903	2.9972	432.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	84	1000	489.3	3.9954	2.9820	413.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	85	1000	489.3	3.9954	2.9794	414.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	86	1000	422.6	3.9802	2.9870	357.0	0.000423	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	87	1000	569.3	4.0056	2.9820	480.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	88	1000	520.4	4.0081	2.9870	437.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	89	1000	444.8	4.0056	2.9997	370.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	90	1000	444.8	4.0030	2.9845	374.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	91	1000	502.6	4.0030	3.0175	414.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	92	1000	511.5	4.0030	2.9845	430.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	51	1200	467.0	3.9954	3.0048	388.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	52	1200	649.4	4.0056	2.9896	544.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	53	1200	404.8	4.0005	3.0074	336.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	54	1200	551.6	3.9903	2.9972	462.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	55	1200	533.8	4.0030	2.9997	445.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	56	1200	529.3	4.0030	3.0099	438.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	57	1200	520.4	4.0030	2.9997	433.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	58	1200	511.5	4.0005	3.0048	425.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	59	1200	529.3	4.0056	3.0124	437.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	60	1200	533.8	4.0056	3.0099	441.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	113	1200	529.3	3.9954	2.9870	445.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	114	1200	542.7	4.0132	3.0099	448.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	115	1200	578.2	4.0081	2.9794	488.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	116	1200	329.2	4.0056	2.9947	275.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	117	1200	467.0	3.9903	3.0099	388.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	118	1200	418.1	4.0056	2.9769	353.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	119	1200	440.4	4.0056	2.9972	367.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	120	1200	498.2	4.0056	2.9972	415.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	121	1200	471.5	3.9980	2.9972	394.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	122	1200	516.0	3.9929	2.9972	432.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	72	1200	493.7	4.0030	2.9947	413.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	73	1200	427.0	3.9929	3.0048	355.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	74	1200	582.7	3.9980	2.9997	486.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	75	1200	556.0	3.9929	2.9997	464.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	76	1200	462.6	4.0030	2.9997	385.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	77	1200	458.1	4.0030	3.0201	376.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	78	1200	596.0	4.0030	2.9870	501.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	79	1200	551.6	3.9878	2.9921	464.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	80	1200	538.2	3.9878	3.0099	447.0	0.000423	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
SILICON NITRIDES											
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	26	21	885.2	3.9980	2.9870	744.7	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	28	21	1005.3	3.9954	3.0124	831.5	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	29	21	885.2	3.9980	2.9870	744.7	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	30	21	880.7	3.9929	2.9845	742.6	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	51	1000	858.5	3.9929	3.0175	708.1	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	52	1000	636.1	3.9954	2.9997	530.9	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	53	1000	596.0	3.9929	3.0074	495.1	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	54	1000	569.3	3.9980	3.0150	470.2	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	55	1000	578.2	3.9929	2.9896	486.1	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	56	1000	524.9	3.9980	2.9870	441.3	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	57	1000	751.7	3.9929	3.0124	622.6	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	58	1000	604.9	3.9929	3.0150	499.9	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	59	1000	782.9	3.9903	2.9921	664.7	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	60	1000	782.9	3.9954	3.0048	650.9	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	41	1000	600.5	3.9980	3.0175	495.1	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	42	1000	564.9	3.9980	2.9820	476.4	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	43	1000	671.7	3.9980	2.9870	564.7	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	44	1000	707.2	3.9954	2.9896	594.3	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	45	1000	542.7	3.8608	3.0124	464.7	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	46	1000	564.9	3.9980	3.0175	465.4	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	47	1000	511.5	3.9954	3.0201	421.3	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	48	1000	502.6	3.9980	2.9870	422.7	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	49	1000	524.9	3.9929	3.0124	434.4	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	50	1000	649.4	3.9980	3.0124	537.1	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	11	1200	618.3	3.9929	3.0124	511.6	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	12	1200	658.3	3.9980	3.0124	544.7	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	13	1200	640.5	3.9980	2.9845	539.9	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	14	1200	662.8	3.9954	2.9896	557.1	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	15	1200	573.8	3.9980	3.0226	471.6	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	16	1200	613.8	4.0005	2.9947	513.0	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	17	1200	649.4	3.9980	3.0150	536.4	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	18	1200	636.1	3.9903	2.9845	537.1	0.042330	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	82	1200	613.8	3.9980	2.9769	520.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	31	1400	458.1	3.9929	3.0074	381.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	32	1400	609.4	4.0056	3.0074	505.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	33	1400	498.2	3.9980	3.0175	411.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	34	1400	573.8	4.0030	3.0124	474.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	35	1400	587.1	4.0132	2.9997	491.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	36	1400	458.1	3.9827	3.0150	380.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	37	1400	538.2	3.9980	2.9997	449.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	38	1400	5804.6	4.0005	2.9997	389.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	39	1400	564.9	3.9827	3.0074	471.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	40	1400	489.3	4.0030	2.9972	408.0	0.042330	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	93	1400	576.2	4.0056	3.0099	478.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	94	1400	502.6	3.9980	2.9997	419.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	95	1400	422.6	4.0005	3.0124	349.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	96	1400	484.8	4.0056	3.0150	399.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	97	1400	556.0	3.9929	3.0023	463.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	98	1400	431.5	4.0030	2.9896	362.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	99	1400	520.4	4.0081	2.9896	436.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	100	1400	511.5	3.9980	2.9921	429.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	101	1400	489.3	4.0107	3.0201	401.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	102	1400	498.2	4.0030	3.0201	410.0	0.004233	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	61	1400	382.5	3.9954	2.9769	324.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	62	1400	467.0	3.9929	2.9997	390.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	64	1400	493.7	3.9954	3.0023	411.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	65	1400	467.0	3.9954	2.9947	391.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	66	1400	498.2	4.0056	2.9845	419.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	67	1400	516.0	4.0030	2.9820	435.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	68	1400	498.2	3.9802	2.9972	418.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	69	1400	458.1	3.9751	3.0023	384.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	70	1400	400.3	4.0005	2.9997	334.0	0.000423	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	71	1400	471.5	3.9954	2.9921	395.0	0.000423	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	19	1200	618.3	3.9980	3.0201	508.9	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	20	1200	689.4	3.9980	3.0099	570.9	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	31	1200	496.2	3.9929	2.9997	415.8	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	32	1200	404.8	3.9954	3.0150	334.4	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	33	1200	453.7	3.9980	2.9896	380.6	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	34	1200	564.9	3.9929	3.0150	466.8	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	35	1200	378.1	3.9980	2.9947	316.5	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	36	1200	538.2	3.9954	3.0175	444.0	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	37	1200	507.1	3.9954	3.0175	417.8	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	38	1200	538.2	3.9954	3.0023	448.2	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	39	1200	444.8	3.9929	3.0201	366.1	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	40	1200	516.0	3.9954	2.9870	434.4	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	1	1400	275.8	3.9980	2.9870	231.7	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	2	1400	222.4	3.9980	3.0150	183.4	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	3	1400	224.6	3.9980	2.9921	188.2	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	4	1400	238.9	4.0005	2.9896	200.6	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	5	1400	286.9	3.9929	3.0124	237.9	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	6	1400	241.5	4.0005	2.9947	202.0	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	7	1400	193.5	3.9954	2.9896	162.7	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	8	1400	206.8	3.9980	2.9921	173.1	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	9	1400	271.8	4.0030	2.9896	228.2	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	10	1400	227.3	3.9980	2.9845	191.7	0.042330	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	21	1400	177.0	3.9954	2.9896	148.9	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	22	1400	151.2	4.0005	2.9820	127.6	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	23	1400	185.0	3.9980	2.9870	155.8	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	24	1400	183.3	4.0005	2.9870	153.8	0.000423	
CERALLOY 147-3	CERADYNE/UDRI/2	UDRIPKGNOV89	AIR	25	1400	171.7	3.9980	2.9845	144.8	0.000423	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	1	1000	987.5	4.0200	3.0300	803.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	2	1000	1178.7	4.0100	3.0200	968.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	3	1000	956.3	4.0200	3.0300	777.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	4	1000	969.7	4.0200	3.0300	787.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	5	1000	831.8	4.0200	3.0300	678.0	0.04	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	6	1000	1169.8	4.0200	3.0200	958.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	7	1000	1018.6	4.0200	3.0100	836.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	8	1000	1187.6	4.0200	3.0300	970.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	9	1000	1120.9	4.0100	3.0300	911.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	10	1000	898.5	4.0100	3.0200	738.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	40	1000	987.5	4.0100	3.0100	813.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	41	1000	911.8	4.0200	3.0200	747.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	42	1000	987.5	4.0200	3.0400	798.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	43	1000	1023.0	4.0300	3.0300	829.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	44	1000	943.0	4.0200	3.0400	762.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	45	1000	947.4	4.0300	3.0200	774.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	46	1000	929.6	4.0100	3.0400	751.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	47	1000	1054.2	4.0100	3.0300	861.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	48	1000	733.9	4.0100	3.0200	603.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	49	1000	898.5	4.0200	3.0200	737.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	19	1200	1014.1	4.0100	3.0300	828.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	20	1200	1005.3	4.0100	3.0200	826.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	21	1200	1031.9	4.0100	3.0200	847.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	22	1200	1009.7	4.0200	3.0200	825.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	23	1200	947.4	4.0100	3.0300	771.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	24	1200	1089.8	4.0200	3.0200	894.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	25	1200	1031.9	4.0200	3.0200	845.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	26	1200	1014.1	4.0100	3.0200	833.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	27	1200	943.0	4.0100	3.0100	778.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	28	1200	978.6	4.0100	3.0100	807.0	0.04	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	29	1200	827.3	4.0100	3.0100	680.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	30	1200	693.9	4.0000	3.0100	572.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	31	1200	800.6	4.0100	3.0200	655.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	32	1200	716.1	4.0100	3.0100	589.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	33	1200	733.9	4.0100	3.0300	600.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	34	1200	725.0	4.0100	3.0500	584.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	35	1200	765.1	4.0100	3.0300	626.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	36	1200	716.1	4.0100	3.0300	586.0	0.0004233	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	37	1200	751.7	4.0200	3.0200	615.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	38	1200	720.6	4.0100	3.0100	594.0	0.0004233	
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	11	1400	431.5	4.0200	3.0200	353.0	0.04	Width and thickness used for
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	12	1400	475.9	4.0200	3.0200	389.0	0.04	the MOR calc. are averages
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	13	1400	422.6	4.0200	3.0200	346.0	0.04	of 10 unoxid. specimens.
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	14	1400	449.3	4.0200	3.0200	367.0	0.04	See note above.
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	15	1400	600.5	4.0200	3.0200	491.0	0.04	See note above.
EC-152	NGK/UDRI/2	UDRIPKGNOV89	AIR	18	1400	400.3	4.0200	3.0200	211.0	0.0004233	See note above.
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	71	21	956.3	4.0056	3.0074	792.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	72	21	1054.2	3.9980	2.9997	879.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	73	21	978.6	4.0056	3.0099	809.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	74	21	1129.8	3.9980	2.9997	942.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	75	21	898.5	3.9929	3.0048	748.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	76	21	1174.3	3.9929	2.9921	986.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	77	21	1134.2	3.9827	2.9896	956.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	78	21	1049.7	3.9929	3.0023	875.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	79	21	1080.9	4.0056	3.0023	898.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	80	21	898.5	4.0030	3.0074	745.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	111	1000	858.5	3.9980	2.9997	716.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	112	1000	849.6	4.0030	2.9972	709.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	113	1000	876.3	3.9954	2.9921	735.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	114	1000	782.9	3.9980	2.9947	655.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	115	1000	894.1	3.9929	2.9870	753.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	116	1000	951.9	3.9980	2.9972	795.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	117	1000	956.3	3.9827	2.9845	809.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	118	1000	876.3	3.9827	3.0023	732.0	0.042330	1 lower pt failed during test.
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	119	1000	862.9	3.9980	2.9921	723.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	120	1000	876.3	3.9954	2.9972	732.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	91	1000	769.5	3.9954	2.9972	643.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	92	1000	676.1	3.9929	3.0023	564.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	93	1000	756.2	3.9929	2.9972	632.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	94	1000	1005.3	4.0030	3.0099	832.0	0.004233	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	95	1000	916.3	3.9954	2.9972	766.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	96	1000	831.8	3.9954	2.9997	694.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	97	1000	796.2	3.9929	2.9997	665.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	98	1000	876.3	3.9929	2.9972	733.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	99	1000	818.4	3.9954	3.0124	677.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	100	1000	925.2	4.0030	2.9997	771.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	101	1000	800.6	3.9878	2.9870	675.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	102	1000	831.8	3.9954	2.9896	699.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	103	1000	782.9	3.9954	2.9972	654.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	104	1000	800.6	4.0005	2.9921	671.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	105	1000	849.6	3.9903	2.9997	710.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	106	1000	836.2	3.9929	2.9947	701.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	107	1000	818.4	3.9878	2.9921	688.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	108	1000	858.5	3.9980	3.0074	712.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	109	1000	849.6	3.9929	2.9972	711.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	110	1000	827.3	3.9980	3.0124	684.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	41	1200	831.8	3.9929	2.9972	696.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	42	1200	840.7	3.9980	3.0023	700.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	43	1200	751.7	3.9853	2.9972	630.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	44	1200	845.1	3.9929	3.0124	700.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	45	1200	840.7	4.0005	3.0048	698.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	46	1200	849.6	4.0107	3.0099	702.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	47	1200	791.7	3.9980	3.0124	655.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	48	1200	840.7	4.0081	3.0201	690.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	49	1200	751.7	4.0055	3.0150	619.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	50	1200	689.4	4.0107	3.0175	566.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	81	1200	791.7	3.9853	2.9921	666.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	82	1200	774.0	3.9903	3.0074	643.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	83	1200	725.0	3.9878	3.0048	604.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	84	1200	733.9	3.9878	3.0074	611.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	85	1200	689.4	3.9903	2.9972	577.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	86	1200	707.2	3.9903	3.0074	588.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	87	1200	738.4	3.9878	2.9921	620.0	0.004233	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	88	1200	707.2	4.0056	3.0074	586.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	89	1200	800.6	3.9878	3.0150	663.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	90	1200	765.1	3.9929	3.0150	632.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	51	1200	676.1	4.0081	3.0124	558.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	52	1200	707.2	4.0030	2.9997	589.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	53	1200	751.7	4.0132	2.9972	626.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	54	1200	667.2	4.0081	3.0074	552.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	55	1200	698.3	4.0081	3.0124	576.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	56	1200	582.7	4.0030	3.0353	474.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	57	1200	711.7	3.9954	3.0023	593.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	58	1200	671.7	3.9980	3.0023	559.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	59	1200	711.7	4.0056	3.0251	582.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	60	1200	756.2	4.0005	3.0074	627.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	11	1400	609.4	3.9980	3.0251	500.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	12	1400	609.4	3.9980	3.0302	498.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	13	1400	582.7	3.9954	3.0277	477.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	14	1400	538.2	3.9980	3.0251	441.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	15	1400	645.0	4.0030	3.0455	521.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	16	1400	573.8	3.9980	3.0150	474.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	17	1400	596.0	4.0056	3.0099	493.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	18	1400	645.0	3.9980	3.0201	531.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	19	1400	680.5	4.0081	3.0328	554.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	20	1400	533.8	3.9954	3.0048	444.0	0.042330	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	31	1400	342.5	4.0132	3.0251	280.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	32	1400	462.6	4.0208	3.0048	382.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	33	1400	458.1	4.0005	3.0201	377.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	34	1400	355.8	4.0030	3.0150	293.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	35	1400	409.2	3.9903	2.9921	344.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	36	1400	404.8	3.9980	3.0099	335.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	37	1400	404.8	3.9954	3.0150	334.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	38	1400	467.0	4.0081	3.0099	386.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	39	1400	458.1	3.9980	2.9997	382.0	0.004233	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	40	1400	475.9	4.0081	3.0099	393.0	0.004233	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	21	1400	324.7	3.9980	3.0023	270.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	22	1400	407.0	3.9980	3.0023	339.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	23	1400	396.3	4.0081	3.0175	326.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	24	1400	399.9	3.9954	3.0074	332.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	25	1400	329.2	4.0005	2.9972	275.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	26	1400	355.8	4.0030	3.0048	295.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	27	1400	386.1	4.0030	3.0099	319.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	28	1400	397.7	4.0030	3.0048	330.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	29	1400	335.4	4.0411	3.0074	275.0	0.000423	
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	30	1400	383.9	3.9980	2.9896	322.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	1	21	898.5	3.9878	2.9870	758.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	2	21	1160.9	3.9853	2.9845	981.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	3	21	1147.6	3.9853	2.9870	968.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	4	21	1009.7	3.9853	2.9870	852.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	5	21	1120.9	3.9853	2.9870	946.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	6	21	1201.0	3.9878	2.9921	1009.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	7	21	1000.8	3.9878	2.9870	844.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	8	21	1103.1	3.9853	2.9845	932.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	9	21	1103.1	3.9853	2.9870	931.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	10	21	1005.3	3.9878	2.9921	845.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	91	21	943.0	4.0005	2.9921	790.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	92	21	907.4	3.9980	2.9947	759.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	93	21	831.8	4.0005	2.9896	698.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	94	21	827.3	4.0035	2.9896	694.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	95	21	965.2	4.0081	2.9947	806.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	61	1000	1000.8	3.9980	2.9870	842.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	62	1000	876.3	4.0005	2.9896	735.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	63	1000	938.5	4.0030	2.9921	786.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	64	1000	911.8	4.0005	2.9896	765.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	65	1000	898.5	4.0030	3.0023	747.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	66	1000	965.2	4.0081	2.9947	806.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	67	1000	636.1	4.0030	2.9997	530.0	0.042330	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	68	1000	876.3	4.0005	2.9921	734.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	69	1000	809.5	4.0005	2.9921	678.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	70	1000	938.5	4.0030	2.9947	784.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	41	1000	947.4	3.9878	2.9896	798.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	42	1000	969.7	3.9853	2.9845	820.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	43	1000	858.5	3.9853	2.9870	724.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	44	1000	907.4	3.9929	2.9947	760.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	45	1000	978.6	3.9878	2.9921	822.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	46	1000	947.4	3.9827	2.9845	801.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	47	1000	960.8	4.0030	2.9896	806.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	48	1000	956.3	3.9827	2.9845	809.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	49	1000	974.1	3.9827	2.9947	818.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	50	1000	889.6	4.0005	2.9997	741.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	81	1200	858.5	4.0030	2.9947	717.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	82	1200	858.5	4.0005	2.9921	719.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	83	1200	898.5	4.0107	2.9947	749.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	84	1200	867.4	4.0030	2.9921	726.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	85	1200	791.7	4.0030	2.9997	659.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	86	1200	782.9	4.0005	2.9972	654.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	87	1200	747.3	4.0107	2.9921	624.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	88	1200	858.5	3.9980	2.9870	722.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	89	1200	716.1	4.0005	2.9870	602.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	90	1200	822.9	4.0005	2.9896	690.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	71	1200	720.6	4.0030	2.9820	607.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	72	1200	756.2	4.0005	2.9870	636.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	73	1200	765.1	4.0005	2.9972	639.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	74	1200	720.6	4.0056	2.9947	602.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	75	1200	747.3	4.0081	2.9997	622.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	76	1200	725.0	4.0081	2.9947	605.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	77	1200	685.0	4.0056	2.9997	570.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	78	1200	689.4	4.0081	2.9947	575.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	79	1200	822.9	4.0030	2.9972	687.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	80	1200	814.0	4.0030	2.9947	680.0	0.000423	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	11	1400	698.3	3.9929	2.9972	584.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	12	1400	756.2	3.9980	2.9997	631.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	13	1400	796.2	3.9954	3.0074	661.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	14	1400	685.0	3.9954	3.0175	565.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	15	1400	769.5	4.0030	3.0074	638.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	16	1400	707.2	3.9980	3.0175	583.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	17	1400	738.4	3.9929	3.0099	612.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	18	1400	716.1	4.0005	3.0023	596.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	19	1400	716.1	3.9853	2.9896	603.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	20	1400	756.2	3.9929	3.0023	630.0	0.042330	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	21	1400	422.6	3.9903	2.9896	355.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	22	1400	418.1	3.9929	2.9947	350.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	23	1400	502.6	4.0005	3.0124	415.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	24	1400	502.6	3.9954	2.9997	419.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	25	1400	484.8	3.9954	3.0048	403.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	26	1400	538.2	3.9954	2.9972	450.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	27	1400	507.1	3.9929	2.9947	425.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	28	1400	333.6	4.0030	3.0074	276.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	29	1400	324.7	4.0005	2.9997	271.0	0.000423	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	30	1400	329.2	4.0005	3.0023	274.0	0.000423	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	11	1000	667.2	4.0000	3.0000	555.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	12	1000	622.7	4.0100	3.0100	514.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	13	1000	609.4	4.0000	3.0200	501.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	14	1000	609.4	4.0100	3.0100	504.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	15	1000	622.7	3.9900	3.0100	515.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	16	1000	667.2	4.0000	3.0100	553.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	17	1000	693.9	3.9800	3.0100	576.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	18	1000	671.7	4.0100	3.0100	555.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	19	1000	573.8	4.0000	3.0000	479.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	20	1000	618.3	4.0100	3.0200	509.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	1	1000	587.1	4.0000	3.0100	486.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	2	1000	551.6	4.0100	3.0100	455.0	0.0004233	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	3	1000	569.3	3.9900	2.9800	484.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	4	1000	609.0	4.0000	2.9900	510.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	5	1000	564.9	4.0000	3.0100	467.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	6	1000	556.0	3.9900	3.0100	461.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	7	1000	516.0	4.0100	3.0100	426.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	8	1000	533.8	4.0100	3.0200	438.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	9	1000	542.7	4.0100	3.0100	448.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	10	1000	587.1	4.0000	3.0000	489.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	41	1200	560.5	4.0100	3.0200	460.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	42	1200	662.8	3.9800	3.0100	549.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	43	1200	529.3	4.0000	3.0100	439.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	44	1200	604.9	3.9900	3.0100	501.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	45	1200	631.6	3.9900	3.0100	523.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	46	1200	524.9	3.9900	3.0000	438.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	47	1200	609.4	4.0000	3.0200	503.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	48	1200	560.5	4.0100	3.0100	464.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	49	1200	511.5	4.0000	3.0000	425.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	50	1200	489.3	4.0000	3.0300	401.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	51	1200	596.0	4.0000	3.0100	494.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	52	1200	627.2	4.0000	3.0100	518.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	53	1200	604.9	4.0000	3.0000	504.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	54	1200	591.6	3.9900	3.0100	491.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	55	1200	600.5	4.0000	3.0200	495.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	56	1200	564.9	4.0100	3.0000	470.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	57	1200	578.2	3.9900	3.0200	476.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	58	1200	573.8	3.9900	3.0200	473.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	59	1200	636.1	3.9900	3.0100	529.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	21	1400	564.9	4.0100	3.0100	467.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	22	1400	542.7	3.9900	3.0000	452.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	23	1400	520.4	3.9900	3.0100	431.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	24	1400	551.6	4.0000	3.0100	457.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	25	1400	604.9	3.9900	3.0000	506.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	26	1400	493.7	4.0200	3.0200	404.0	0.04	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	27	1400	578.2	4.0000	3.0000	481.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	28	1400	556.0	4.0200	3.0200	456.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	29	1400	591.6	4.0100	3.0100	489.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	30	1400	542.7	4.0100	3.0100	449.0	0.04	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	0	1400	520.4	3.9900	2.9900	438.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	0	1400	649.4	4.0100	2.9900	543.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	33	1400	613.8	4.0100	3.0100	508.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	34	1400	587.1	3.9900	3.0300	482.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	35	1400	640.5	4.0200	3.0200	525.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	36	1400	578.2	4.0000	3.0000	482.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	37	1400	591.6	4.0000	3.0000	492.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	38	1400	582.7	4.0200	3.0100	481.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	39	1400	618.3	4.0000	3.0200	507.0	0.0004233	
SN-252	KYOCERA/UDRI/2	UDRIPKGNOV89	AIR	40	1400	627.2	3.9800	3.0100	520.0	0.0004233	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	6	20	2077.2	6.1595	3.0734	1020.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	7	20	2010.5	6.1595	3.0759	986.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	8	20	2072.8	6.1620	3.0912	1006.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	9	20	2224.0	6.1620	3.0785	1088.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	10	20	2090.6	6.1620	3.0759	1025.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	11	20	2299.6	6.1595	3.0785	1126.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	12	20	2224.0	6.1671	3.0759	1089.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	13	20	1716.9	6.1620	3.0785	840.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	14	20	1748.1	6.1620	3.0759	857.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	15	20	1668.0	6.1595	3.0836	814.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	16	20	1779.2	6.1620	3.0785	871.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	17	20	2023.8	6.1646	3.0937	980.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	18	20	2001.6	6.1620	3.0785	979.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	19	20	2184.0	6.1620	3.0785	1069.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	20	20	2246.2	6.1595	3.0759	1101.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	64	20	2055.0	6.1595	3.0861	1001.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	65	20	2072.8	6.1620	3.0937	1004.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	66	20	2179.5	6.1620	3.0861	1061.0	0.042330	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	68	20	1196.5	6.1620	3.0836	584.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	69	20	2135.0	6.1595	3.0861	1040.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	39	20	1450.1	4.1072	3.0937	1054.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	40	20	1192.1	4.0945	3.0937	869.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	41	20	1503.4	4.1072	3.0912	1095.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	42	20	1063.1	4.1021	3.0912	775.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	43	20	1289.9	4.1021	3.0861	944.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	44	20	1370.0	4.1097	3.0912	997.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	45	20	1494.5	4.0894	3.0886	1095.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	46	20	1165.4	4.1046	3.0912	849.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	47	20	1192.1	4.0894	3.0861	875.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	48	20	1156.5	4.1097	3.0709	853.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	49	20	1378.9	4.1046	3.0886	1006.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	50	20	1298.8	4.1072	3.0886	947.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	51	20	1272.1	4.0996	3.0836	933.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	52	20	1152.0	4.1046	3.0886	841.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	53	20	1352.2	4.1072	3.0912	985.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	54	20	1276.6	4.1046	3.0886	932.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	55	20	1098.7	4.0665	3.0861	811.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	56	20	1214.3	4.1072	3.0836	889.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	57	20	1383.3	4.0970	3.0836	1015.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	58	20	1276.6	4.1046	3.0810	936.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	34	1000	1574.6	6.1646	3.0937	763.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	35	1000	1401.1	6.1646	3.0861	682.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	36	1000	1463.4	6.1671	3.1013	705.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	37	1000	1401.1	6.1646	3.0963	678.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	38	1000	1841.5	6.1646	3.0886	895.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	59	1000	1165.4	6.1671	3.0963	563.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	60	1000	996.4	6.1620	3.0886	484.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	61	1000	1112.0	6.1646	3.0912	539.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	62	1000	934.1	6.1620	3.1064	449.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	63	1000	1103.1	6.1646	3.0886	536.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	23	1200	902.9	6.1646	3.0861	440.0	0.042330	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPEC. No.	TEMP °C	LOAD N	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	24	1200	867.4	6.1722	3.0886	421.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	25	1200	800.6	6.1646	3.0937	388.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	26	1200	862.9	6.1646	3.0963	417.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	27	1200	680.5	6.1646	3.0886	331.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	28	1200	894.1	6.1646	3.0937	433.0	0.042330	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	29	1200	591.6	6.1570	2.8575	336.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	30	1200	622.7	6.1646	3.0963	301.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	31	1200	618.3	6.1595	3.0912	330.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	32	1200	636.1	6.1620	3.0937	308.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	33	1200	640.5	6.1595	3.0734	315.0	0.000423	
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	21*	1400	395.9	6.1722	3.0988	191.0	0.042330	SEE DATATXT
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	22*	1400	391.4	6.1722	3.0988	189.0	0.042330	SEE DATATXT

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. NO.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	COMMENTS
SILICON CARBIDE WHISKER-REINFORCED SILICON NITRIDE										
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	26	25	4.50	3.50	465.0	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	27	25	4.50	3.50	512.3	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	28	25	4.50	3.50	493.7	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	29	25	4.50	3.50	470.5	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	30	25	4.50	3.50	468.5	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	36	25	4.50	3.50	522.1	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	37	25	4.50	3.50	522.1	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	38	25	4.50	3.50	523.0	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	39	25	4.50	3.50	540.3	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	40	25	4.50	3.50	525.3	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	41	25	4.50	3.50	575.0	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	42	25	4.50	3.50	495.2	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	43	25	4.50	3.50	508.9	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	44	25	4.50	3.50	531.8	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	45	25	4.50	3.50	576.9	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	46	25	4.50	3.50	584.2	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	47	25	4.50	3.50	416.7	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	48	25	4.50	3.50	403.3	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	49	25	4.50	3.50	440.6	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	50	25	4.50	3.50	595.7	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	51	25	4.50	3.50	369.5	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	52	25	4.50	3.50	459.9	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	53	25	4.50	3.50	568.1	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	54	25	4.50	3.50	424.5	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	55	25	4.50	3.50	570.9	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	56	25	4.50	3.50	533.3	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	57	25	4.50	3.50	482.3	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	58	25	4.50	3.50	542.2	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. NO.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	COMMENTS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	59	25	4.50	3.50	411.2	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	60	25	4.50	3.50	547.1	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	62	25	4.50	3.50	462.0	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	63	25	4.50	3.50	489.7	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	64	25	4.50	3.50	546.9	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	65	25	4.50	3.50	567.3	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	66	25	4.50	3.50	535.1	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	67	25	4.50	3.50	555.7	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	68	25	4.50	3.50	491.9	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	69	25	4.50	3.50	563.5	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	70	25	4.50	3.50	443.6	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	AS FABRICATED	AIR	71	25	4.50	3.50	495.6	
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	1	25	4.50	3.50	533.9	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	2	25	4.50	3.50	515.4	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	3	25	4.50	3.50	508.5	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	4	25	4.50	3.50	566.3	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	5	25	4.50	3.50	517.7	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	6	25	4.50	3.50	527.8	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	7	25	4.50	3.50	535.4	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	8	25	4.50	3.50	577.7	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	9	25	4.50	3.50	561.1	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	10	25	4.50	3.50	542.0	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	11	25	4.50	3.50	557.3	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	12	25	4.50	3.50	576.6	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	13	25	4.50	3.50	531.1	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	14	25	4.50	3.50	528.7	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	15	25	4.50	3.50	529.8	**SEE TESTBKGD FOR DETAILS

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. NO.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	COMMENTS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	16	25	4.50	3.50	533.2	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	17	25	4.50	3.50	515.6	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	18	25	4.50	3.50	520.2	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	19	25	4.50	3.50	487.5	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	20	25	4.50	3.50	408.2	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	21	25	4.50	3.50	518.7	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	22	25	4.50	3.50	505.4	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	23	25	4.50	3.50	321.2	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	24	25	4.50	3.50	505.6	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	25	25	4.50	3.50	488.4	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	33	25	4.50	3.50	546.7	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	32	25	4.50	3.50	419.0	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	31	25	4.50	3.50	420.6	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	34	25	4.50	3.50	512.6	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	35	25	4.50	3.50	572.1	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	71	25	4.50	3.50	474.7	**SEE TESTBKGD FOR DETAILS
SNW-1000	GTE/174-MA-1607	ORNL-CRB1289	1000H/D-2/E2**	AIR	72	25	4.50	3.50	545.6	**SEE TESTBKGD FOR DETAILS

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
Zirconias											
MS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	113	25	4.50	3.50	611.6		**SEE TESTBKGD FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	111	25	4.50	3.50	632.1		**SEE TESTBKGD FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	112	25	4.50	3.50	619.6		**SEE TESTBKGD FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	114	25	4.50	3.50	620.7		**SEE TESTBKGD FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	1	25	4.50	3.50	679.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	2	25	4.50	3.50	703.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	3	25	4.50	3.50	668.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	4	25	4.50	3.50	674.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	5	25	4.50	3.50	692.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	6	25	4.50	3.50	695.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	7	25	4.50	3.50	726.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	8	25	4.50	3.50	706.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	9	25	4.50	3.50	697.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	10	25	4.50	3.50	682.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	11	25	4.50	3.50	611.1	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	12	25	4.50	3.50	708.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	13	25	4.50	3.50	733.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	14	25	4.50	3.50	684.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	15	25	4.50	3.50	698.3	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	16	25	4.50	3.50	680.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	17	25	4.50	3.50	603.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	18	25	4.50	3.50	681.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	19	25	4.50	3.50	698.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	20	25	4.50	3.50	680.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	21	25	4.50	3.50	674.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	22	25	4.50	3.50	642.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	23	25	4.50	3.50	695.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	24	25	4.50	3.50	708.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	25	25	4.50	3.50	691.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	26	25	4.50	3.50	725.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	27	25	4.50	3.50	685.2	0.00847	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	28	25	4.50	3.50	636.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	29	25	4.50	3.50	694.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	30	25	4.50	3.50	690.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	31	25	4.50	3.50	662.3	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	32	25	4.50	3.50	685.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	33	25	4.50	3.50	718.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	34	25	4.50	3.50	702.1	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	35	25	4.50	3.50	666.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	36	25	4.50	3.50	691.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	37	25	4.50	3.50	653.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	38	25	4.50	3.50	632.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	39	25	4.50	3.50	666.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	40	25	4.50	3.50	685.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	51	25	4.50	3.50	603.2	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	52	25	4.50	3.50	561.8	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	53	25	4.50	3.50	648.1	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	54	25	4.50	3.50	622.1	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	55	25	4.50	3.50	644.4	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	56	25	4.50	3.50	536.1	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	57	25	4.50	3.50	673.8	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	58	25	4.50	3.50	640.9	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	41	25	4.50	3.50	659.8	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	42	25	4.50	3.50	642.0	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	43	25	4.50	3.50	610.4	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	44	25	4.50	3.50	567.8	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	59	25	4.50	3.50	674.5	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	60	25	4.50	3.50	639.9	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	45	25	4.50	3.50	635.1	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	46	25	4.50	3.50	583.4	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	47	25	4.50	3.50	659.3	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	48	25	4.50	3.50	601.1	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	49	25	4.50	3.50	637.9	0.00847	**SEE TEXT FOR DETAILS

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	50	25	4.50	3.50	659.0	0.00847	**SEE TEXT FOR DETAILS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	61	25	4.50	3.50	689.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	62	25	4.50	3.50	671.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	63	25	4.50	3.50	669.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	64	25	4.50	3.50	664.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	65	25	4.50	3.50	659.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	66	25	4.50	3.50	658.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	67	25	4.50	3.50	657.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	68	25	4.50	3.50	656.3	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	69	25	4.50	3.50	655.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	70	25	4.50	3.50	655.3	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	71	25	4.50	3.50	653.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	72	25	4.50	3.50	647.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	73	25	4.50	3.50	644.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	74	25	4.50	3.50	641.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	75	25	4.50	3.50	639.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	76	25	4.50	3.50	638.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	77	25	4.50	3.50	636.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	78	25	4.50	3.50	627.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	79	25	4.50	3.50	536.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	80	25	4.50	3.50	527.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	81	25	4.50	3.50	676.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	82	25	4.50	3.50	672.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	83	25	4.50	3.50	667.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	84	25	4.50	3.50	663.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	85	25	4.50	3.50	646.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	86	25	4.50	3.50	644.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	87	25	4.50	3.50	641.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	88	25	4.50	3.50	641.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	90	25	4.50	3.50	639.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	91	25	4.50	3.50	635.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	92	25	4.50	3.50	630.9	0.00847	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	93	25	4.50	3.50	629.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	94	25	4.50	3.50	622.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	95	25	4.50	3.50	619.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	96	25	4.50	3.50	614.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	97	25	4.50	3.50	609.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	98	25	4.50	3.50	597.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	99	25	4.50	3.50	596.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	100	25	4.50	3.50	512.7	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	131	25	4.50	3.50	641.3	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	132	25	4.50	3.50	642.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	133	25	4.50	3.50	645.3	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	134	25	4.50	3.50	593.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	135	25	4.50	3.50	620.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	136	25	4.50	3.50	662.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	137	25	4.50	3.50	593.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	138	25	4.50	3.50	656.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	139	25	4.50	3.50	644.0	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	140	25	4.50	3.50	634.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	141	25	4.50	3.50	651.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	142	25	4.50	3.50	653.4	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	143	25	4.50	3.50	589.1	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	144	25	4.50	3.50	658.8	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	145	25	4.50	3.50	591.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	146	25	4.50	3.50	649.5	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	147	25	4.50	3.50	651.6	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	148	25	4.50	3.50	627.2	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	149	25	4.50	3.50	649.9	0.00847	
MS-PSZ	NILCRA/ORNL-CRB	ORNL-6153	AGE/100H@800	AIR	159	25	4.50	3.50	646.8	0.00847	
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	221	25	4.50	3.50	664.1		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	222	25	4.50	3.50	623.7		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	223	25	4.50	3.50	591.4		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	224	25	4.50	3.50	597.7		

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	225	25	4.50	3.50	651.5		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	226	25	4.50	3.50	671.4		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	227	25	4.50	3.50	639.7		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	228	25	4.50	3.50	636.7		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	229	25	4.50	3.50	648.7		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	230	25	4.50	3.50	626.8		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	231	25	4.50	3.50	656.5		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	232	25	4.50	3.50	664.9		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	233	25	4.50	3.50	568.2		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	234	25	4.50	3.50	638.4		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	235	25	4.50	3.50	609.0		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	236	25	4.50	3.50	603.7		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	237	25	4.50	3.50	670.8		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	238	25	4.50	3.50	574.4		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	239	25	4.50	3.50	630.6		
TS-PSZ	NILCRA/85-218	ORNL-5612	AS FABRICATE	AIR	240	25	4.50	3.50	624.7		
TS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	70	25	4.50	3.50	550.0		**SEE TESTBKGD FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	145	25	4.50	3.50	546.5		**SEE TESTBKGD FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	142	25	4.50	3.50	499.1		**SEE TESTBKGD FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	143	25	4.50	3.50	427.7		**SEE TESTBKGD FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-5612	100H/D2+B/E2**	AIR	148	25	4.50	3.50	525.9		**SEE TESTBKGD FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	72	25	4.50	3.50	598.6	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	73	25	4.50	3.50	604.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	74	25	4.50	3.50	613.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	75	25	4.50	3.50	590.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	76	25	4.50	3.50	595.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	77	25	4.50	3.50	612.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	78	25	4.50	3.50	559.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	79	25	4.50	3.50	593.8	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	80	25	4.50	3.50	609.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	82	25	4.50	3.50	556.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	83	25	4.50	3.50	588.2	0.00847	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	84	25	4.50	3.50	591.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	85	25	4.50	3.50	590.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	86	25	4.50	3.50	584.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	87	25	4.50	3.50	595.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	88	25	4.50	3.50	586.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	90	25	4.50	3.50	576.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	91	25	4.50	3.50	591.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	92	25	4.50	3.50	599.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	93	25	4.50	3.50	600.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	94	25	4.50	3.50	587.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	96	25	4.50	3.50	572.6	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	97	25	4.50	3.50	590.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	98	25	4.50	3.50	601.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	99	25	4.50	3.50	585.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	100	25	4.50	3.50	596.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	101	25	4.50	3.50	579.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	102	25	4.50	3.50	562.6	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	103	25	4.50	3.50	589.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	104	25	4.50	3.50	602.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	105	25	4.50	3.50	589.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	106	25	4.50	3.50	581.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	107	25	4.50	3.50	602.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	109	25	4.50	3.50	595.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	110	25	4.50	3.50	607.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	111	25	4.50	3.50	591.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	112	25	4.50	3.50	588.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	113	25	4.50	3.50	594.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	114	25	4.50	3.50	600.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	115	25	4.50	3.50	588.8	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	117	25	4.50	3.50	522.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	118	25	4.50	3.50	587.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	119	25	4.50	3.50	598.9	0.00847	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	120	25	4.50	3.50	599.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	121	25	4.50	3.50	578.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	122	25	4.50	3.50	590.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	124	25	4.50	3.50	577.8	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	125	25	4.50	3.50	593.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	126	25	4.50	3.50	605.8	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	127	25	4.50	3.50	600.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	128	25	4.50	3.50	587.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	129	25	4.50	3.50	490.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AS FABRICATE	AIR	130	25	4.50	3.50	586.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	71	25	4.50	3.50	204.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	65	25	4.50	3.50	228.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	133	25	4.50	3.50	285.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	66	25	4.50	3.50	307.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	81	25	4.50	3.50	309.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	95	25	4.50	3.50	334.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	123	25	4.50	3.50	453.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	144	25	4.50	3.50	453.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	63	25	4.50	3.50	474.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	58	25	4.50	3.50	475.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	89	25	4.50	3.50	501.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	150	25	4.50	3.50	515.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	151	25	4.50	3.50	546.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	EXPOSED/100H	AIR	152	25	4.50	3.50	540.0	0.00847	**SEE TEXT FOR DETAILS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	11	25	4.50	3.50	541.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	12	25	4.50	3.50	532.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	13	25	4.50	3.50	551.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	14	25	4.50	3.50	536.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	15	25	4.50	3.50	525.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	46	25	4.50	3.50	555.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	47	25	4.50	3.50	553.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	48	25	4.50	3.50	553.1	0.00847	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	49	25	4.50	3.50	576.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	50	25	4.50	3.50	556.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	51	25	4.50	3.50	537.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	52	25	4.50	3.50	569.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	53	25	4.50	3.50	544.6	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	54	25	4.50	3.50	549.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	55	25	4.50	3.50	559.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	56	25	4.50	3.50	566.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	57	25	4.50	3.50	562.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	59	25	4.50	3.50	550.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	60	25	4.50	3.50	506.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	136	25	4.50	3.50	553.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	137	25	4.50	3.50	560.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	138	25	4.50	3.50	553.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@700	AIR	140	25	4.50	3.50	505.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	1	25	4.50	3.50	569.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	2	25	4.50	3.50	568.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	3	25	4.50	3.50	624.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	4	25	4.50	3.50	583.6	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	5	25	4.50	3.50	597.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	6	25	4.50	3.50	529.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	7	25	4.50	3.50	558.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	8	25	4.50	3.50	543.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	9	25	4.50	3.50	519.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	10	25	4.50	3.50	558.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	11	25	4.50	3.50	536.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	12	25	4.50	3.50	539.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	13	25	4.50	3.50	535.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	14	25	4.50	3.50	527.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	15	25	4.50	3.50	555.6	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	16	25	4.50	3.50	525.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	17	25	4.50	3.50	481.3	0.00847	

SECTION 5. MOR 4-POINT BEND TEST RESULTS, continued

MATERIAL	BATCH CODE	REFERENCE CODE	HEAT TREATMENT	TEST ENVIRON.	SPEC. No.	TEMP °C	WIDTH mm	THICK mm	BEND STRENGTH MPa	X-HEAD SPEED mm/s	COMMENTS
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	18	25	4.50	3.50	427.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	19	25	4.50	3.50	501.6	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@750	AIR	20	25	4.50	3.50	520.2	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	6	25	4.50	3.50	548.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	7	25	4.50	3.50	528.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	8	25	4.50	3.50	505.8	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	9	25	4.50	3.50	514.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	10	25	4.50	3.50	517.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	31	25	4.50	3.50	533.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	32	25	4.50	3.50	512.4	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	33	25	4.50	3.50	540.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	34	25	4.50	3.50	525.9	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	35	25	4.50	3.50	520.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	36	25	4.50	3.50	522.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	37	25	4.50	3.50	529.5	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	38	25	4.50	3.50	537.8	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	39	25	4.50	3.50	520.1	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	40	25	4.50	3.50	536.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	41	25	4.50	3.50	536.0	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	42	25	4.50	3.50	538.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	43	25	4.50	3.50	529.7	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	44	25	4.50	3.50	526.3	0.00847	
TS-PSZ	NILCRA/ORNL-CRB	ORNL-6513	AGE/100H@800	AIR	45	25	4.50	3.50	544.1	0.00847	

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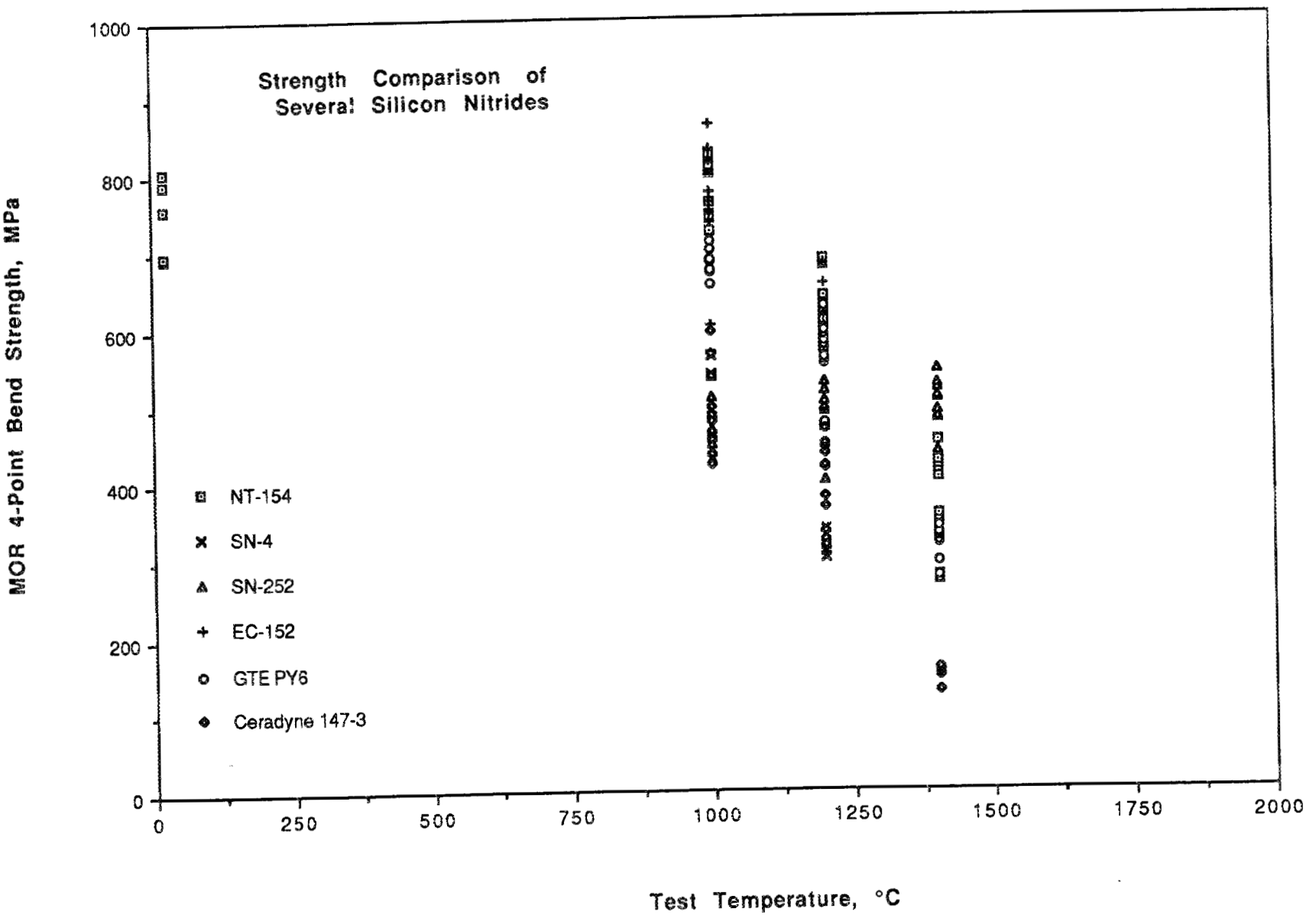

Figure 2.3. A comparison of bend strengths of the UDRIsilicon nitrides tested at .000423 mm/sec.

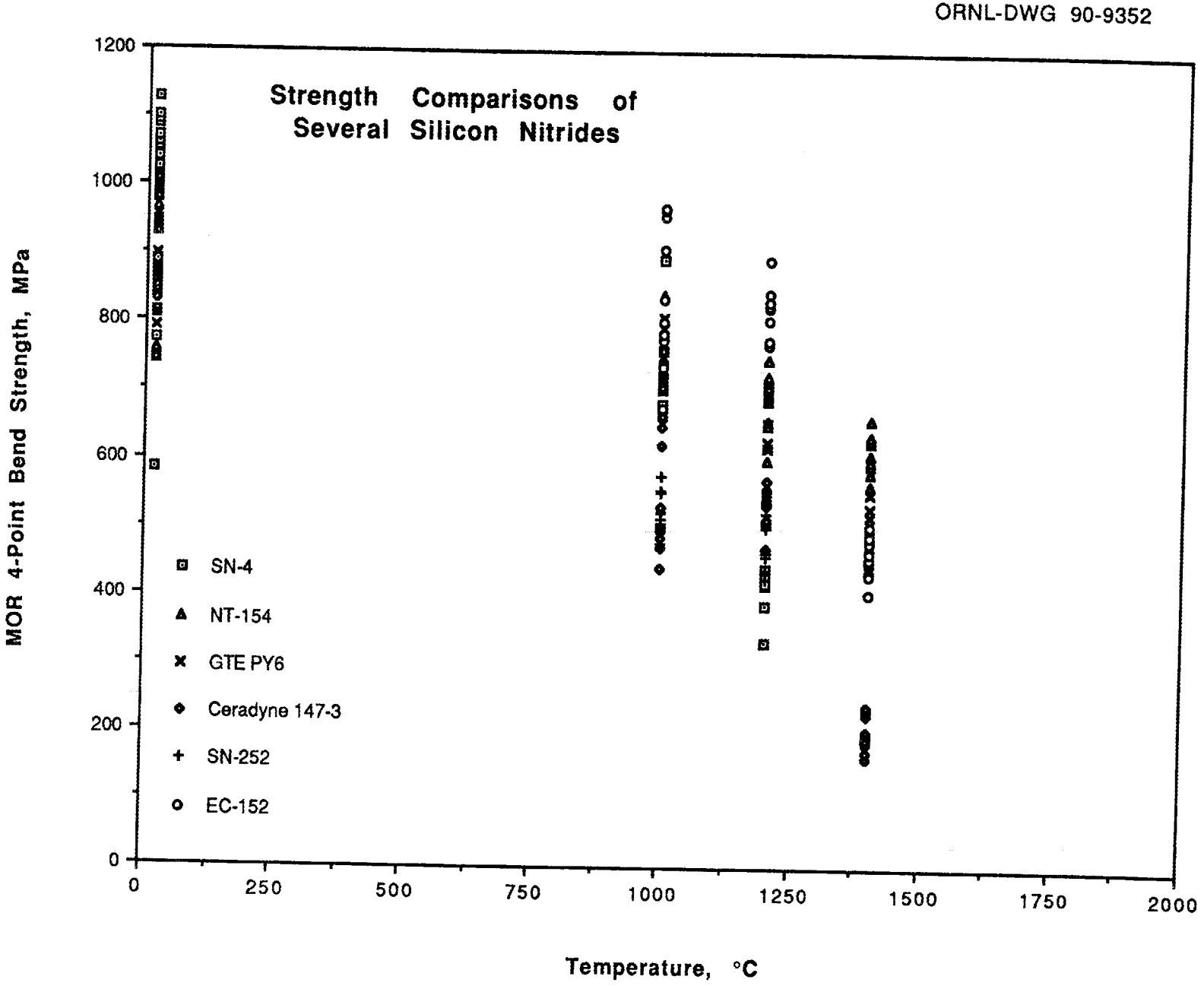

Figure 2.4. A comparison of the bend strengths of the UDRI silicon nitrides tested at 0.0423 mm/sec.

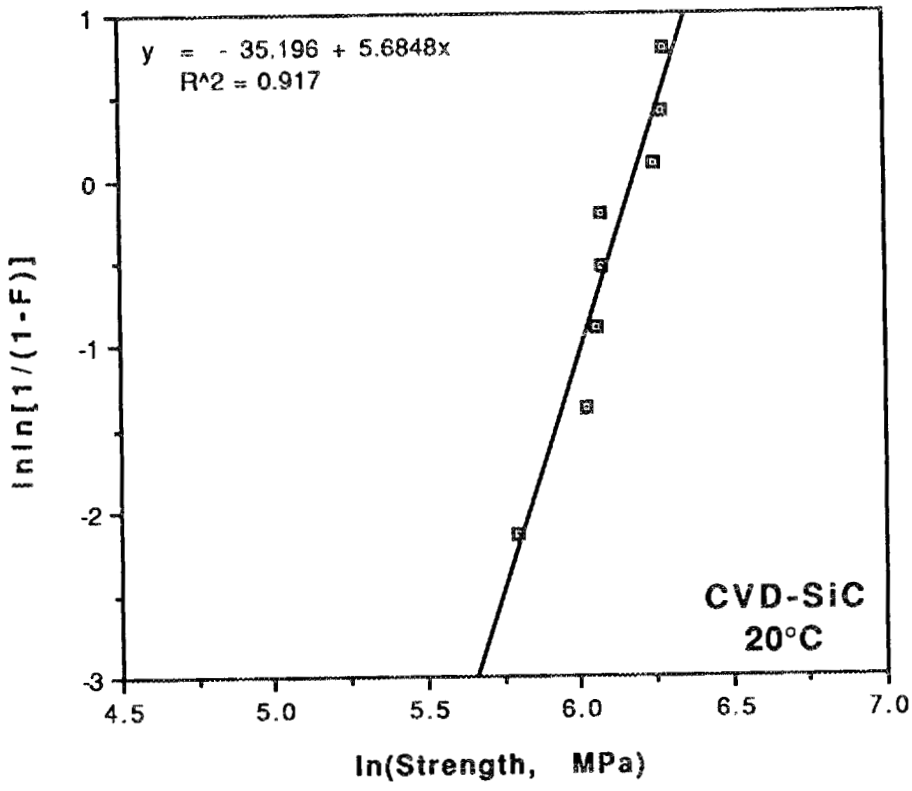

Figure 2.5. Weibull plot of CVD SiC at room temperature. Crosshead speed was 0.04 millimeters per second.

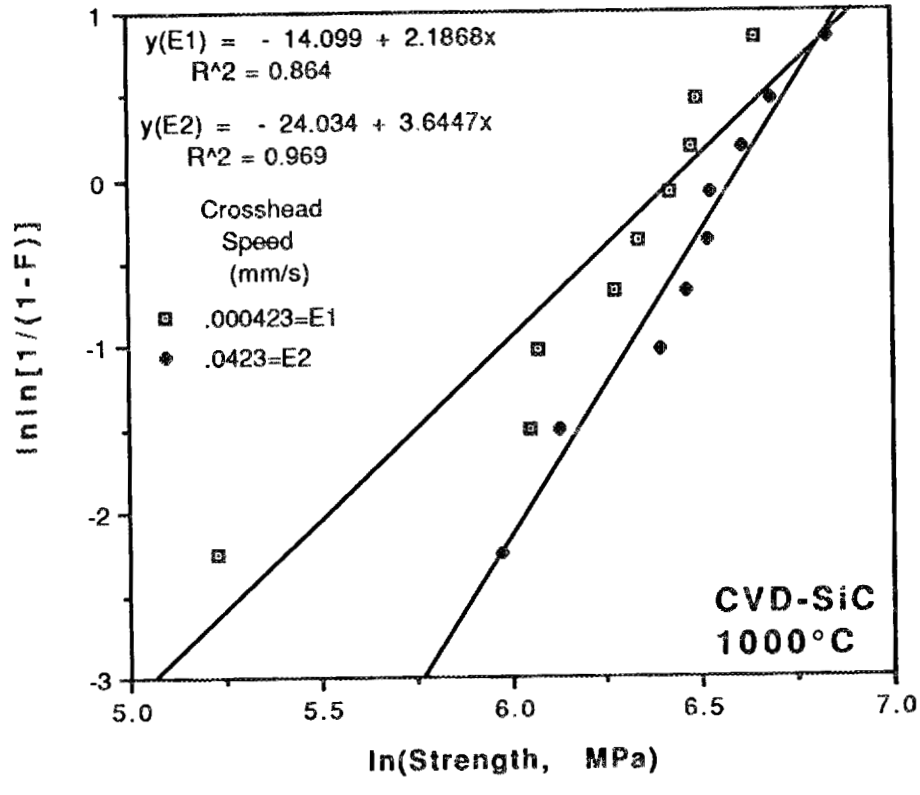

Figure 2.6. Weibull plot of CVD-SiC tests run at 1000°C using 2 different crosshead speeds.

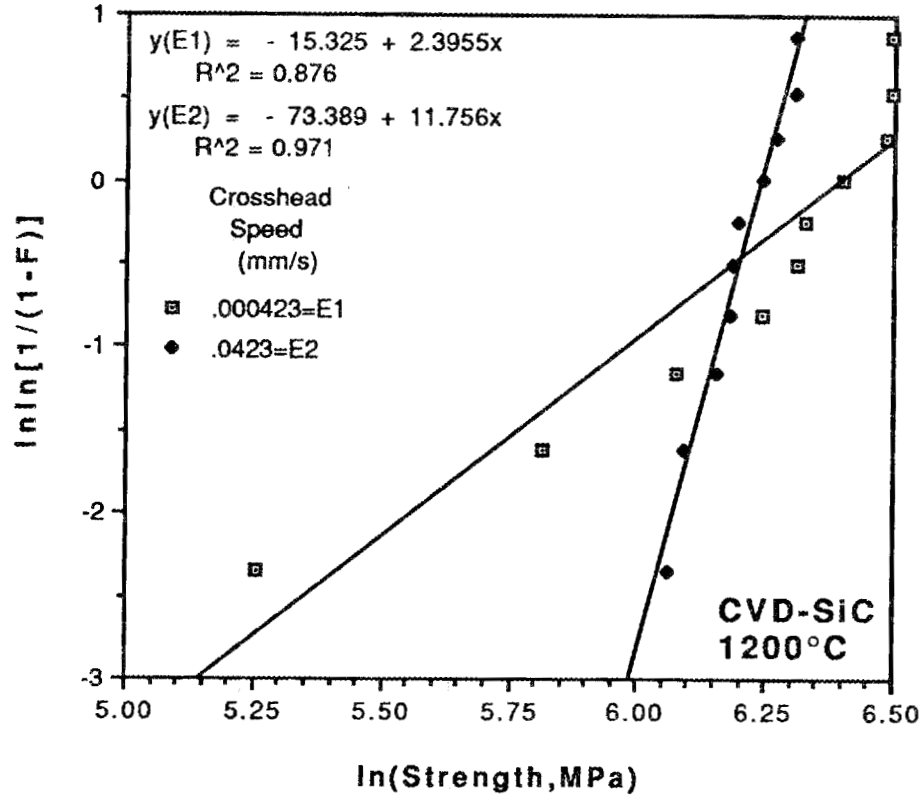

Figure 2.7. Weibull plot of CVD-SiC tests run at 1200°C at 2 crosshead speeds.

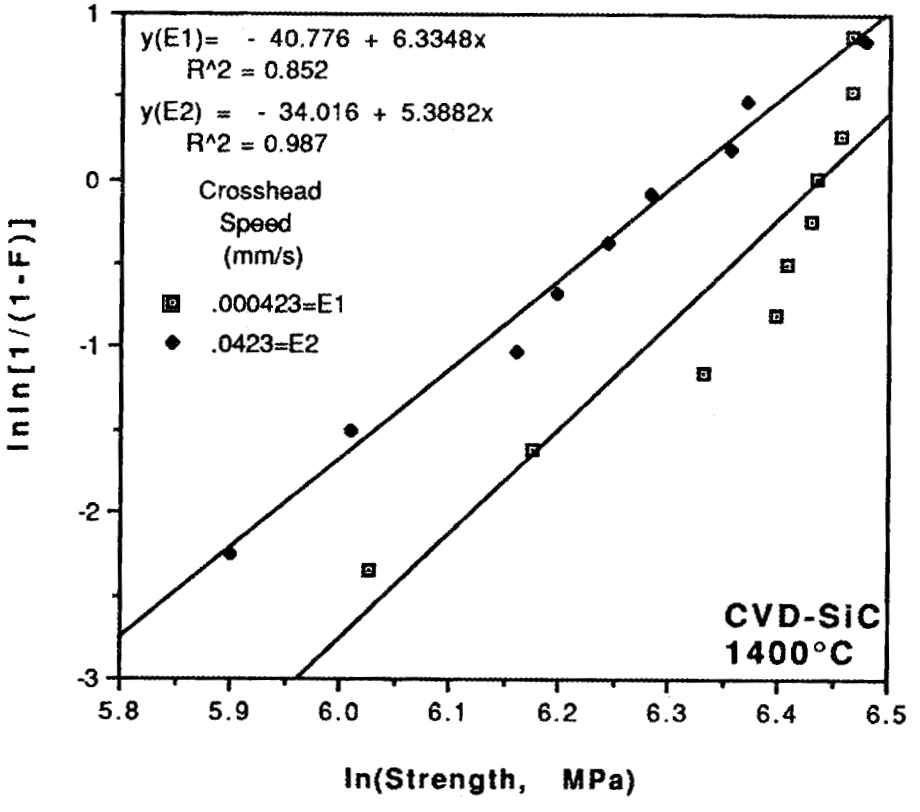

Figure 2.8. Weibull plot of CVD-SiC tests run at 1400°C using 2 crosshead speeds.

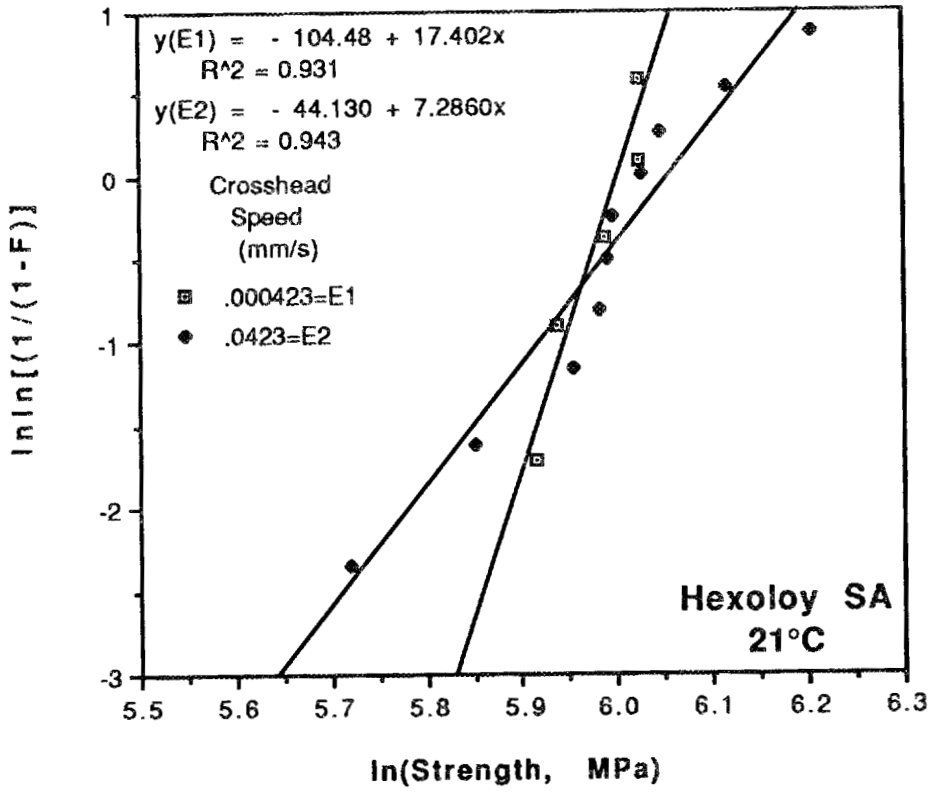

Figure 2.9. Weibull plot of Hexoloy SA MOR 4-point bend tests run at 21°C at 2 crosshead speeds.

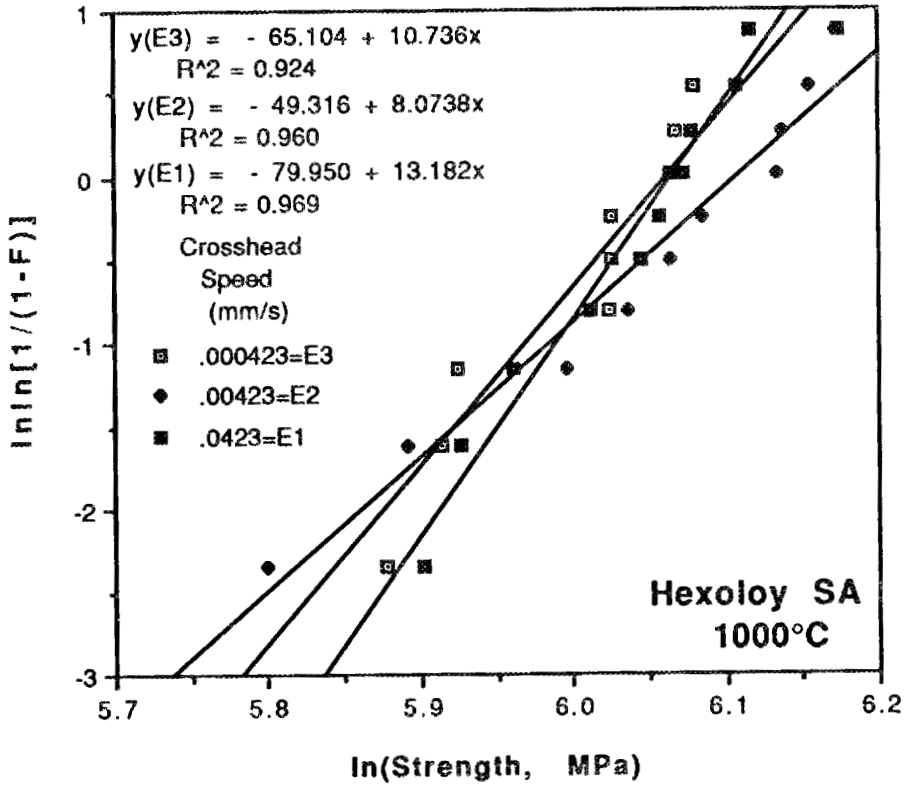

Figure 2.10. Weibull plot of Hexoloy SA MOR 4-point bend tests run at 1000°C at 3 crosshead speeds.

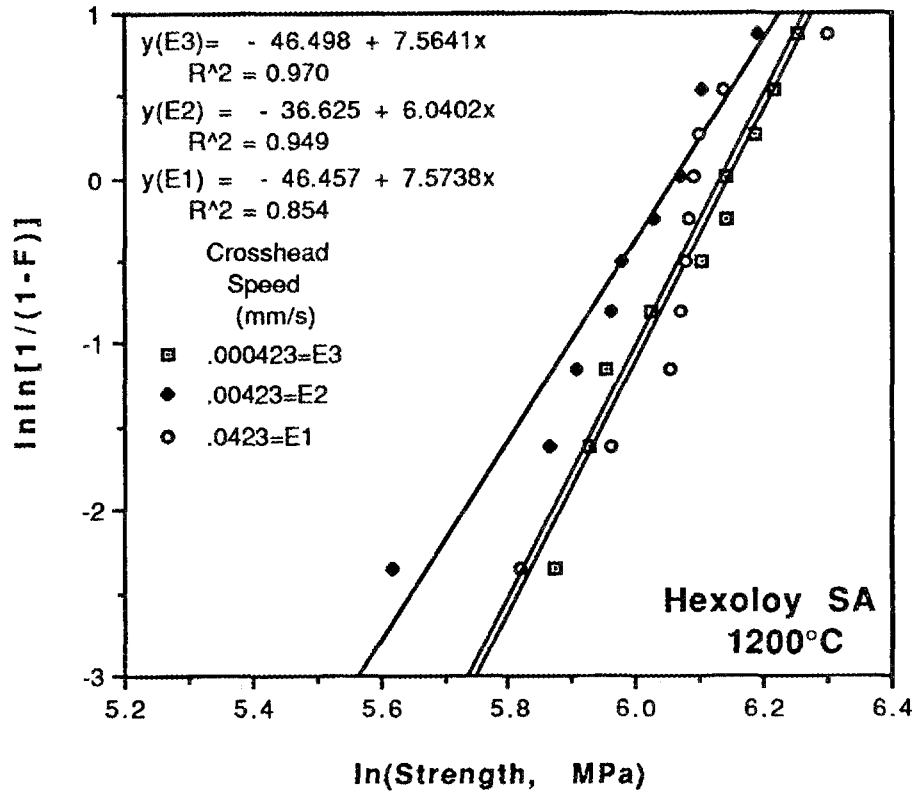

Figure 2.11. Weibull plot of Hexoloy SA MOR 4-point bend tests run at 1200°C at 3 crosshead speeds.

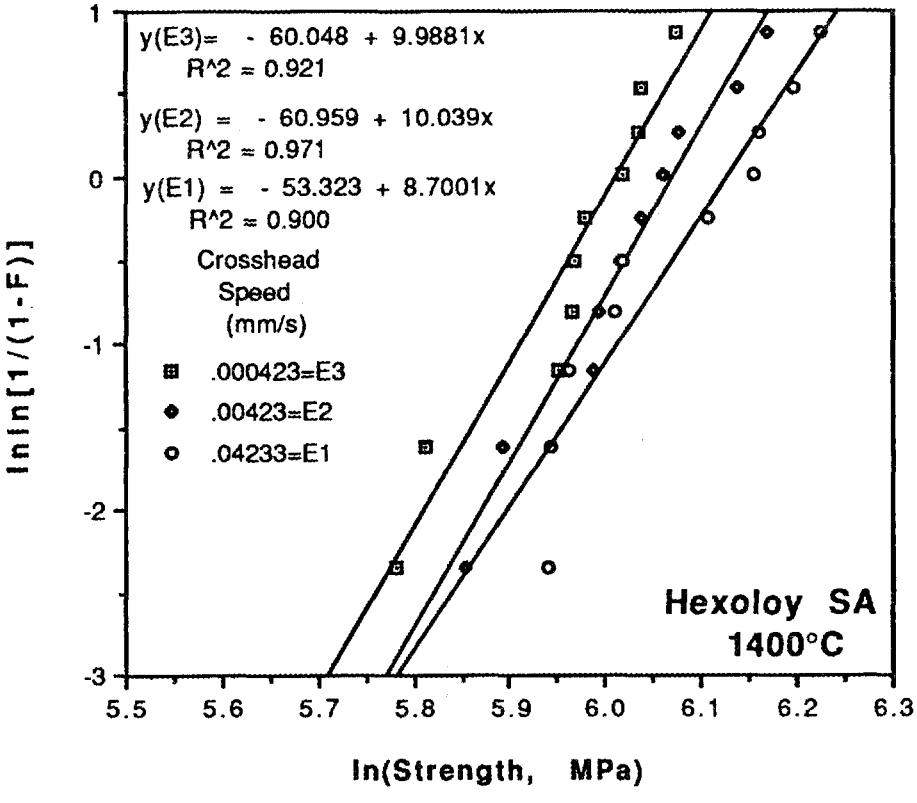

Figure 2.12. Weibull plot of Hexaloy SA MOR 4-point bend tests run at 1400°C at 3 crosshead speeds.

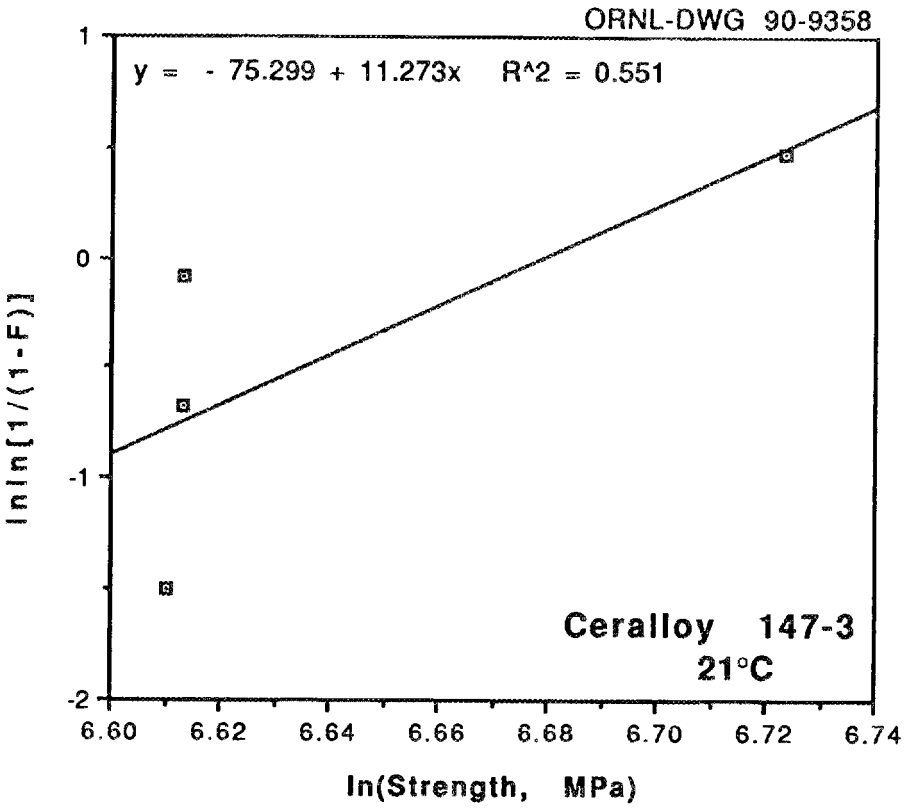

Figure 2.13. Weibull plot of Ceralloy 147-3 MOR 4-point bend tests run at 21°C at a crosshead speed of .04233 millimeters per second.

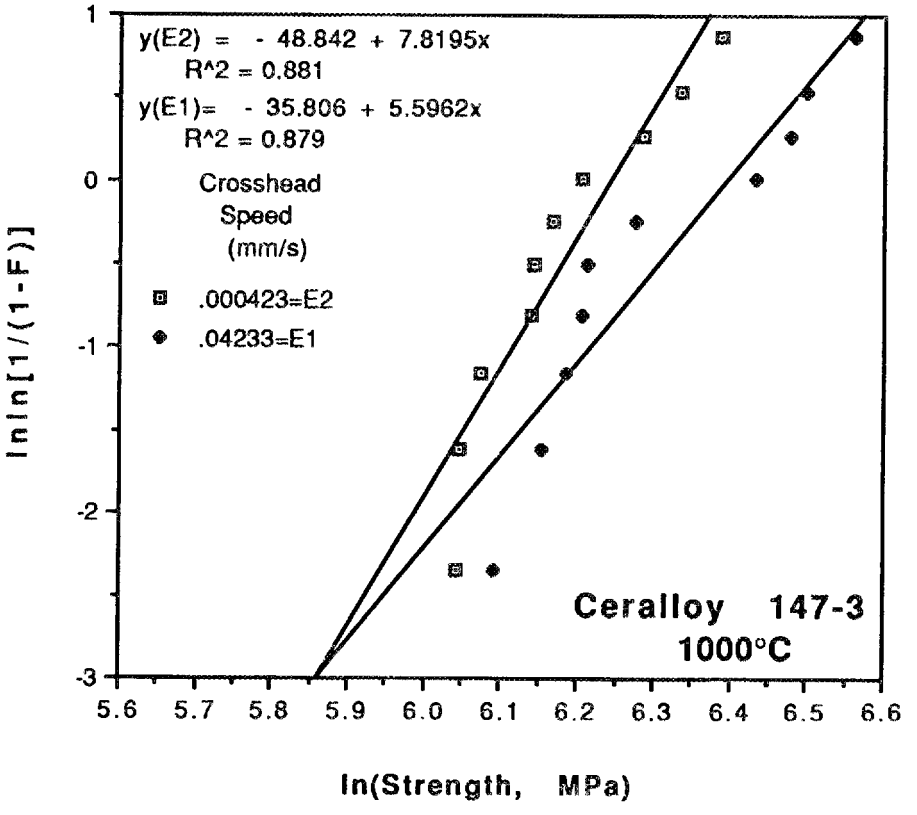

Figure 2.14. Weibull plot of Ceralloy 147-3 MOR 4-point bend tests run at 1000°C at 2 crosshead speeds.

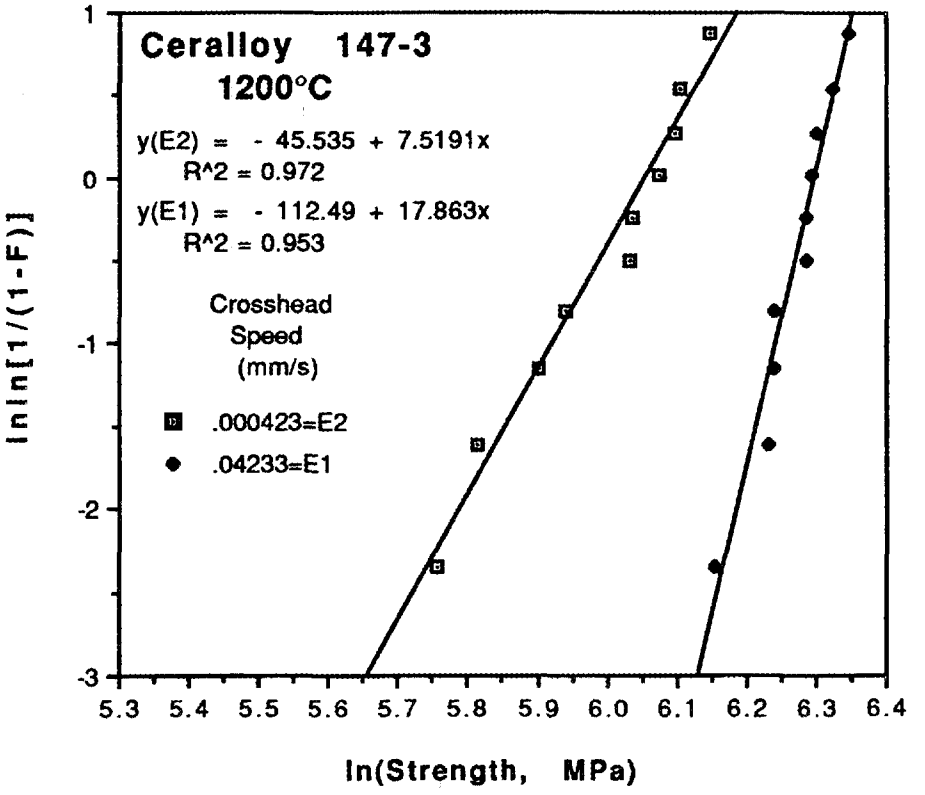

Figure 2.15. Weibull plot of Ceralloy 147-3 MOR 4-point bend tests run at 1200°C at 2 crosshead speeds.

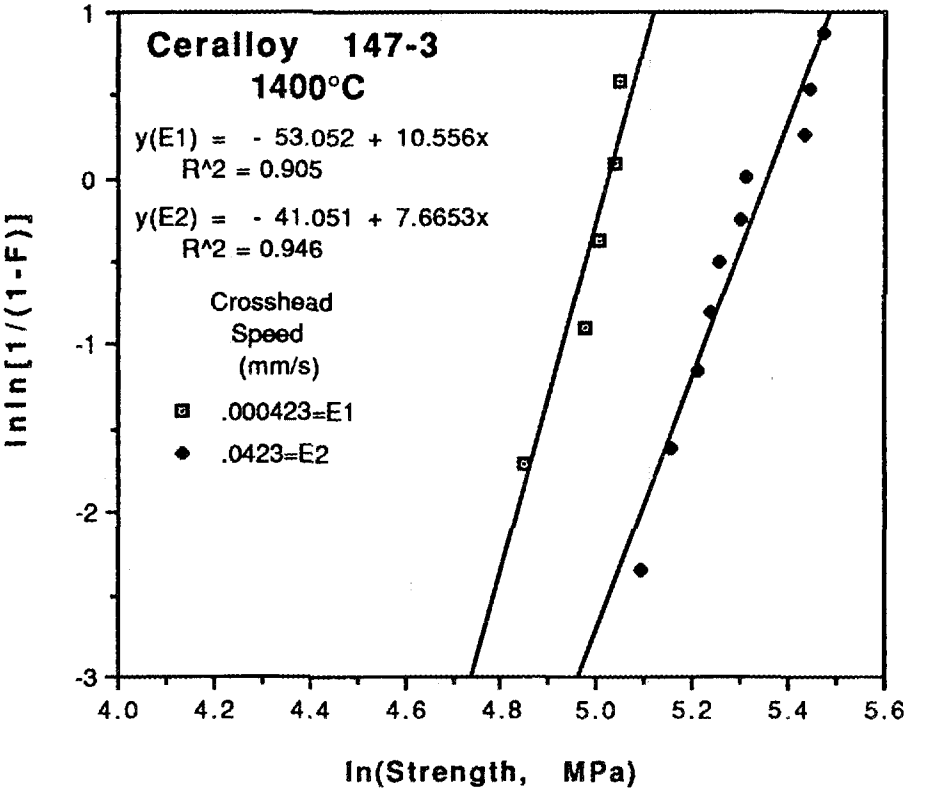

Figure 2.16. Weibull plot of Ceralloy 147-3 MOR 4-point bend tests run at 1400°C at 2 crosshead speeds.

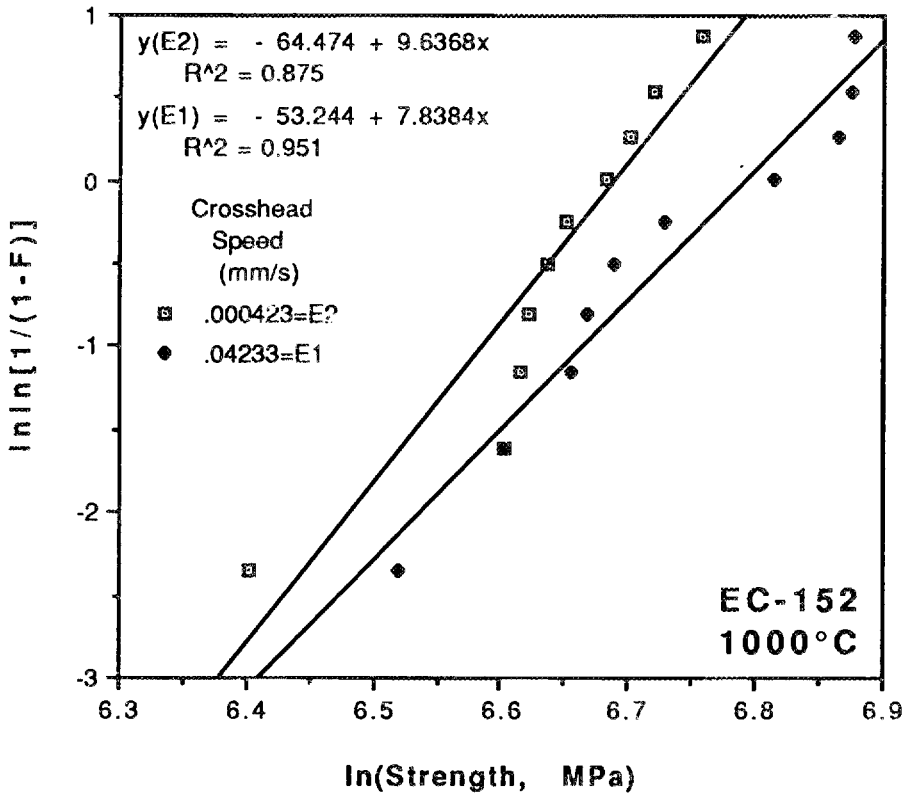

Figure 2.17. Weibull plot of EC-152 MOR 4-point bend tests run at 1000°C at 2 crosshead speeds.

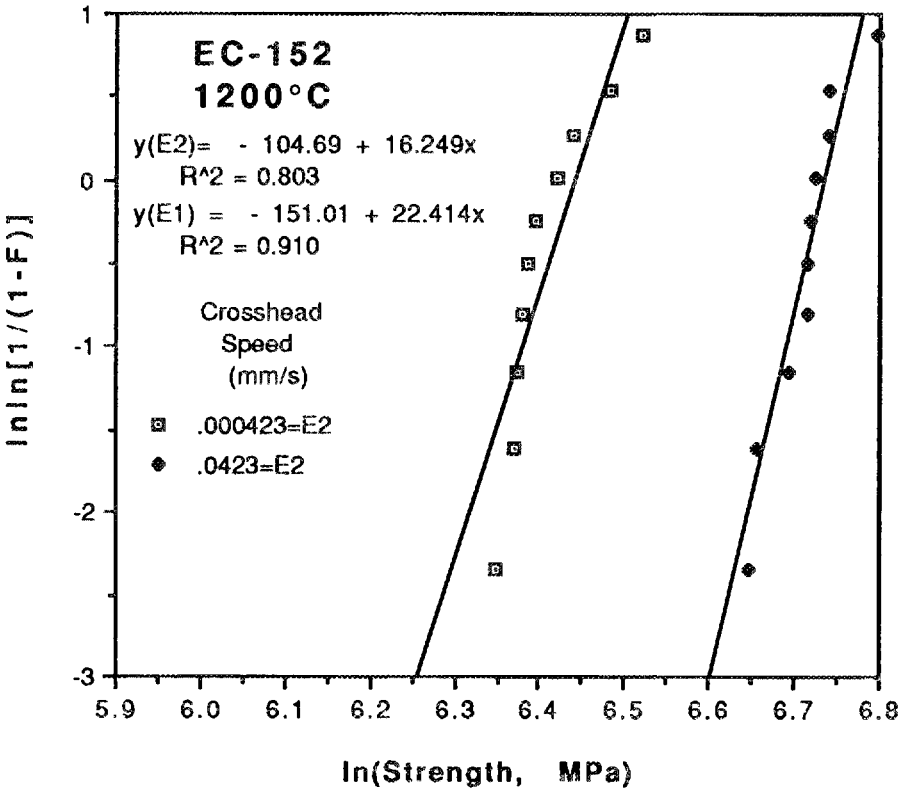

Figure 2.18. Weibull plot of EC-152 MOR 4-point bend tests run at 1200°C at 2 crosshead speeds.

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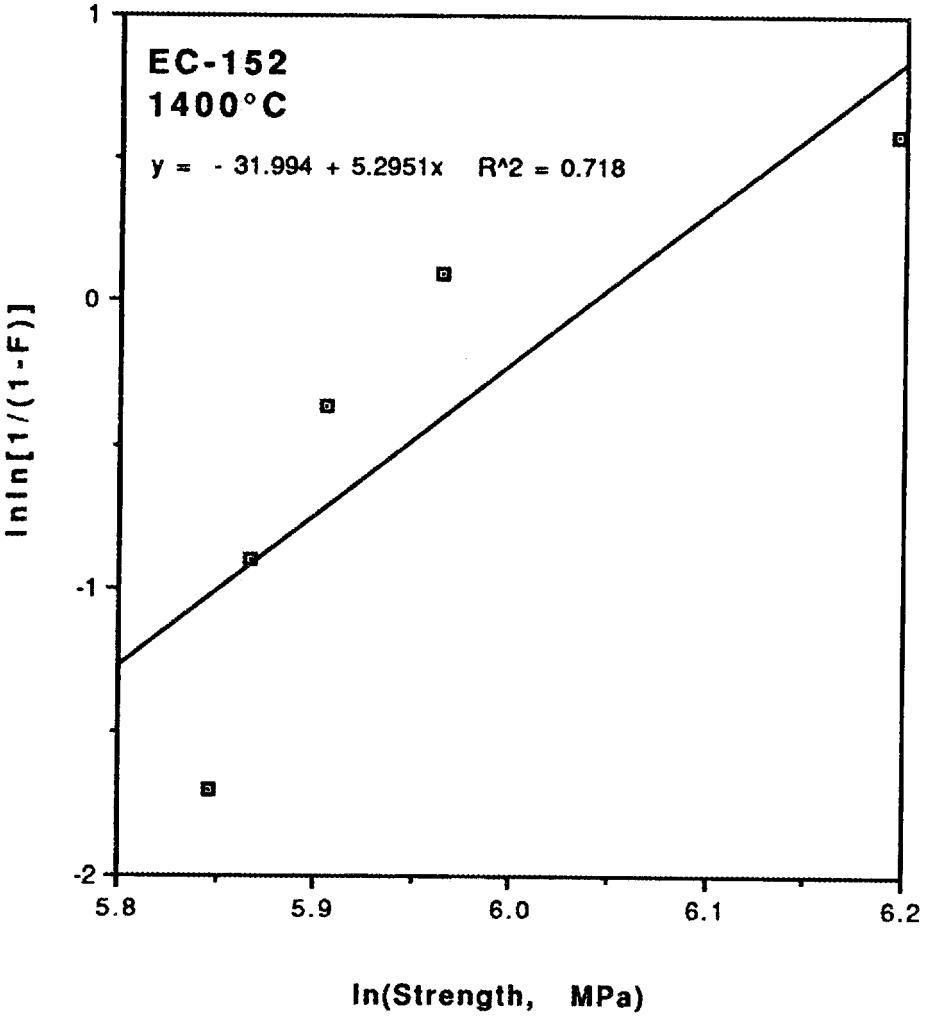

Figure 2.19. Weibull plot of EC-152 MOR 4-point bend tests run at 1400°C at 0.0423 millimeters per second.

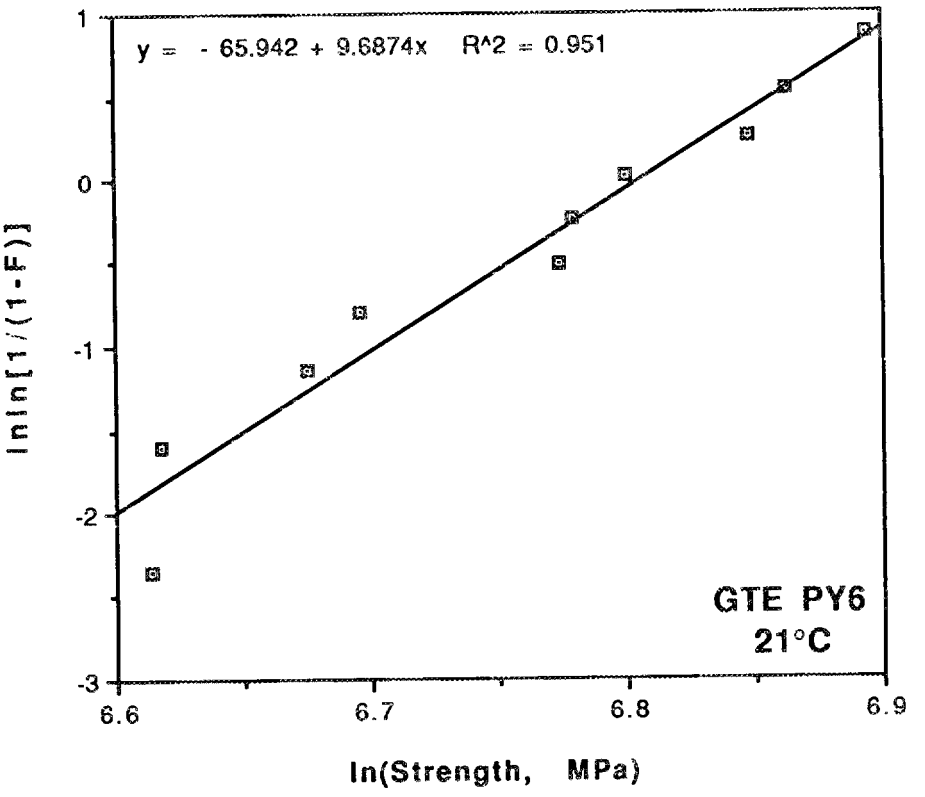

Figure 2.20. Weibull plot of GTE PY6 MOR 4-point bend tests run at 21°C at 0.04233 millimeters per second.

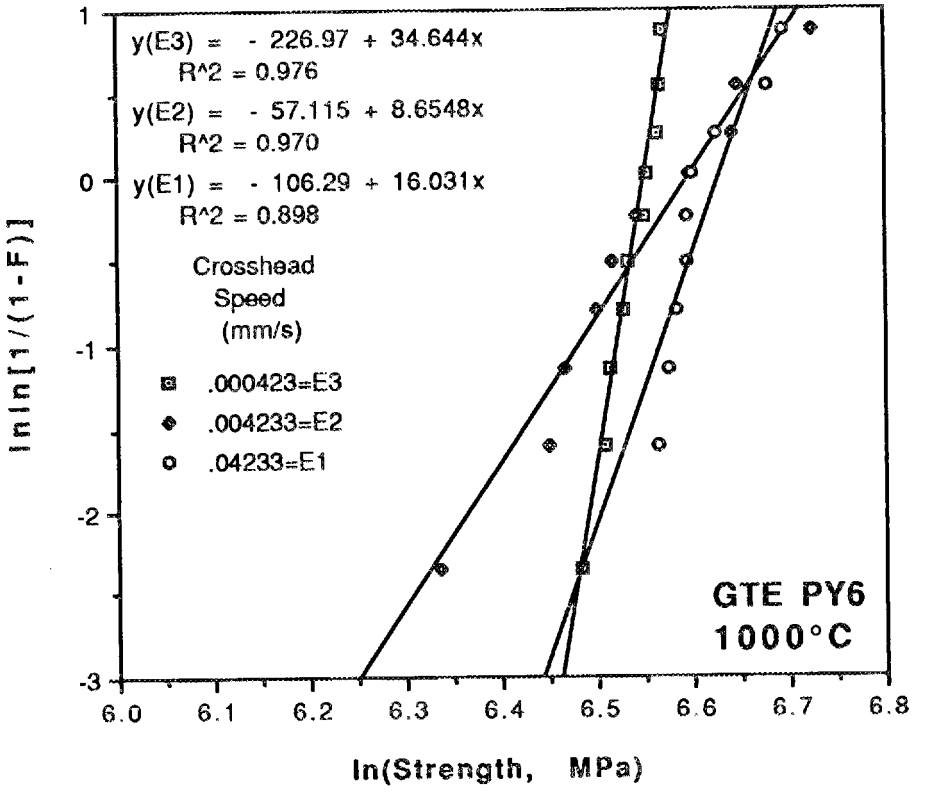

Figure 2.21. Weibull plot of GTE PY6 MOR 4-point bend tests run at 1000°C at 3 crosshead speeds.

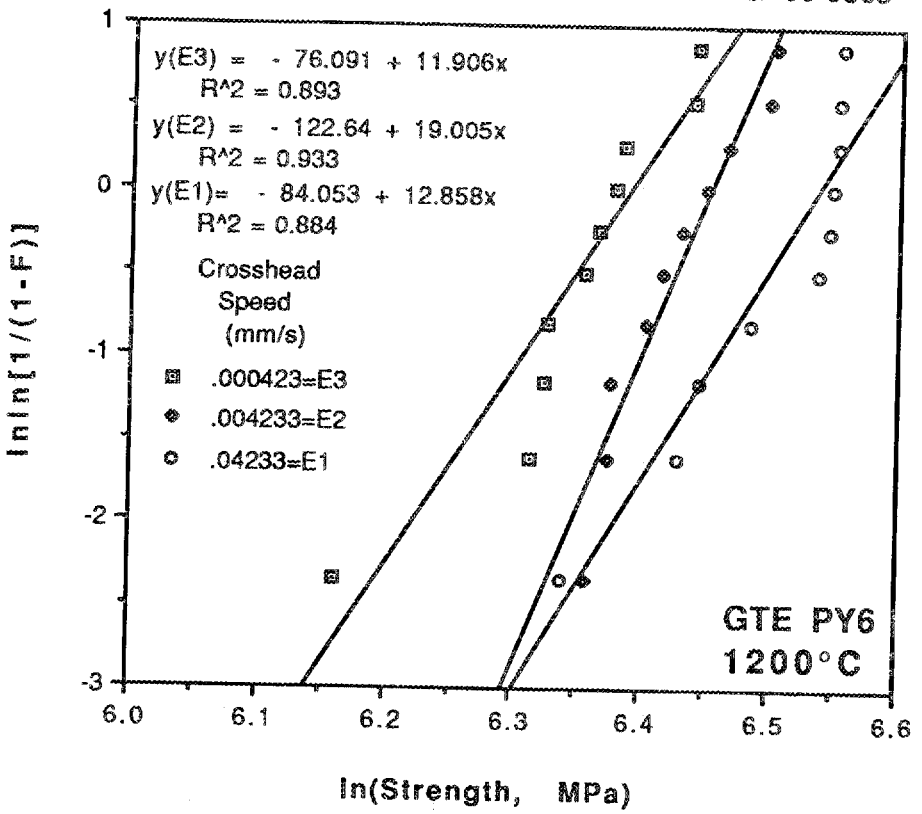

Figure 2.22. Weibull plot of GTE PY6 MOR 4-point bend tests run at 1200°C at 3 crosshead speeds.

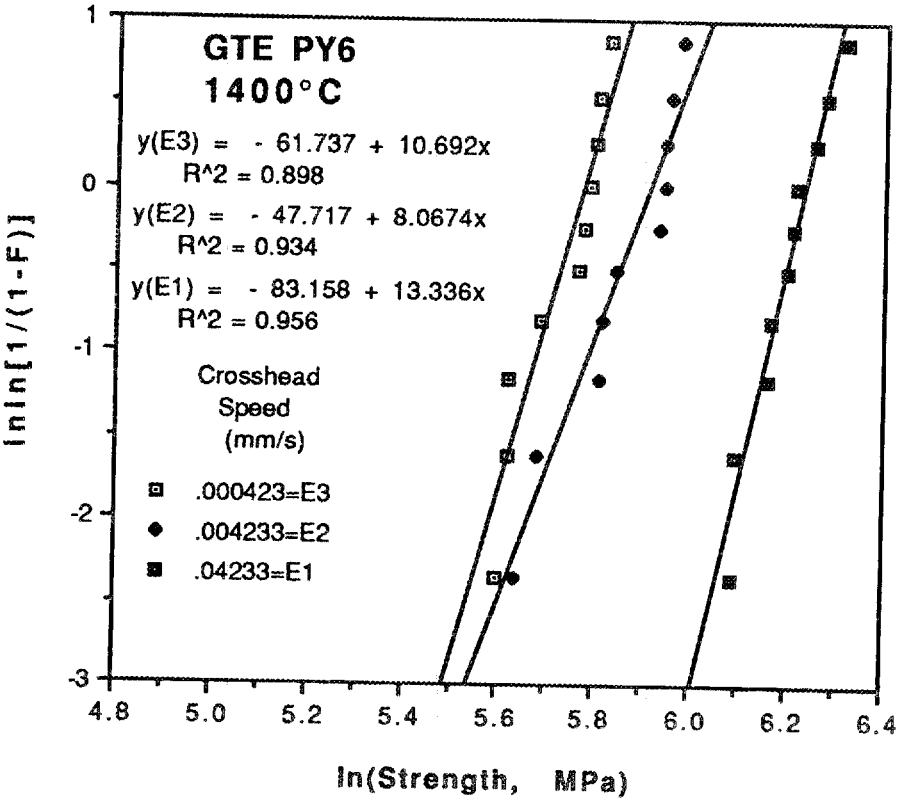

Figure 2.23. Weibull plot of GTE PY6 MOR 4-point bend tests run at 1400°C at 3 crosshead speeds.

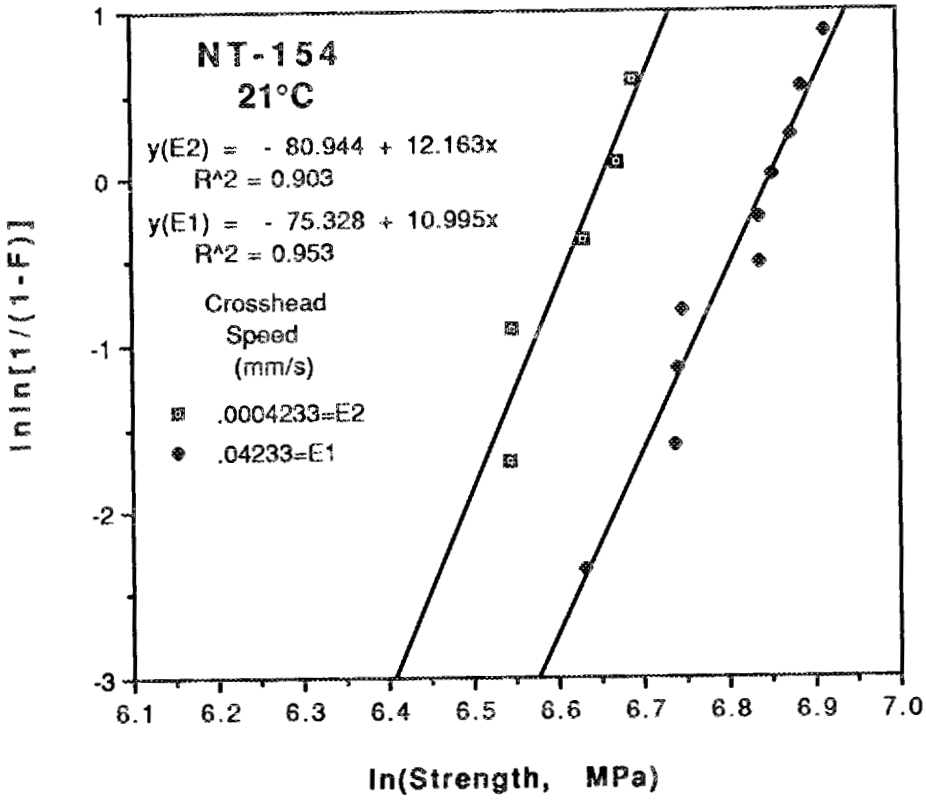

Figure 2.24. Weibull plot of NT-154 MOR 4-point bend tests run at 21°C at 2 crosshead speeds.

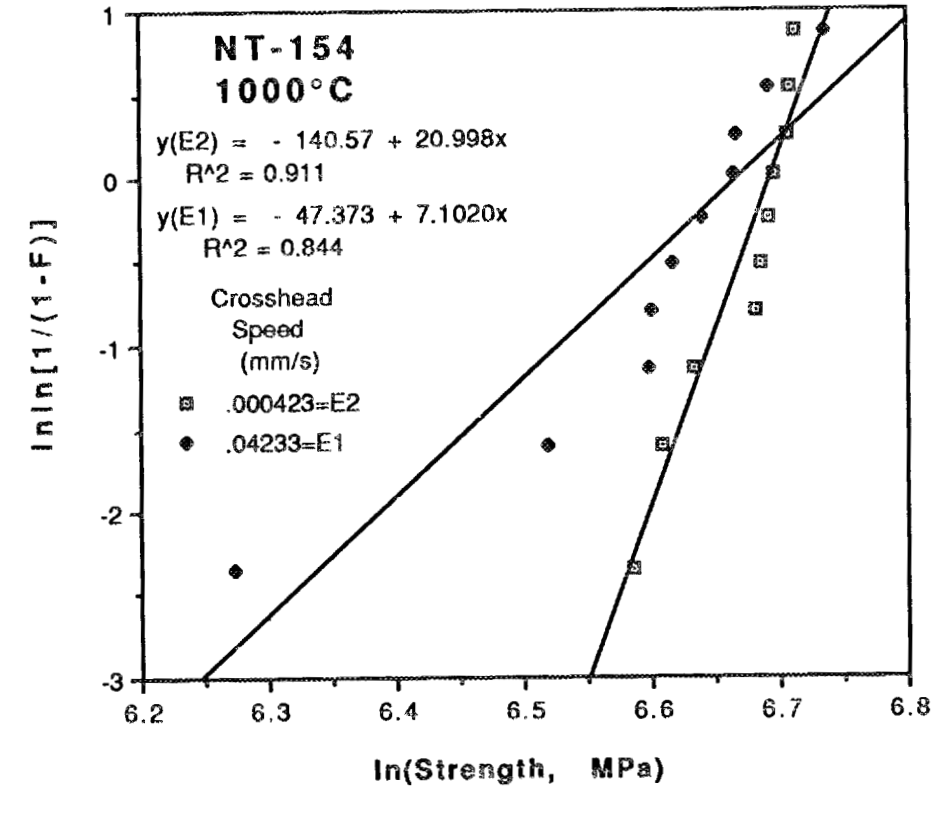

Figure 2.25. Weibull plot of NT-154 MOR 4-point bend tests run at 1000°C at 2 crosshead speeds.

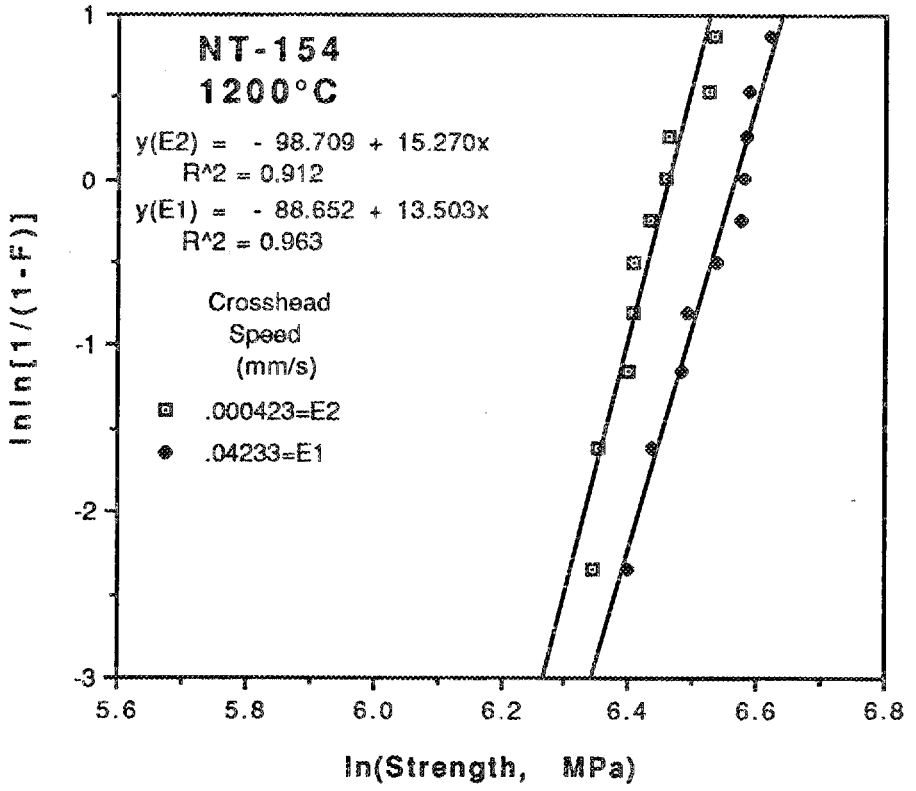

Figure 2.26. Weibull plot of NT-154 MOR 4-point bend tests run at 1200°C at 2 crosshead speeds.

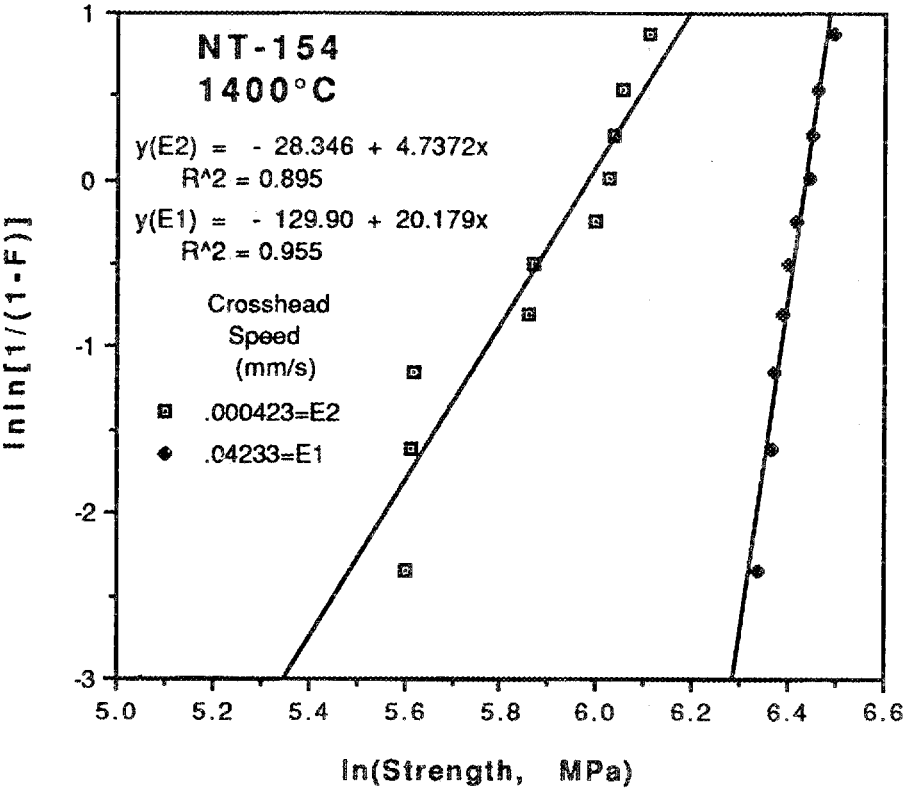

Figure 2.27. Weibull plot of NT-154 MOR 4-point bend tests run at 1400°C at 2 crosshead speeds.

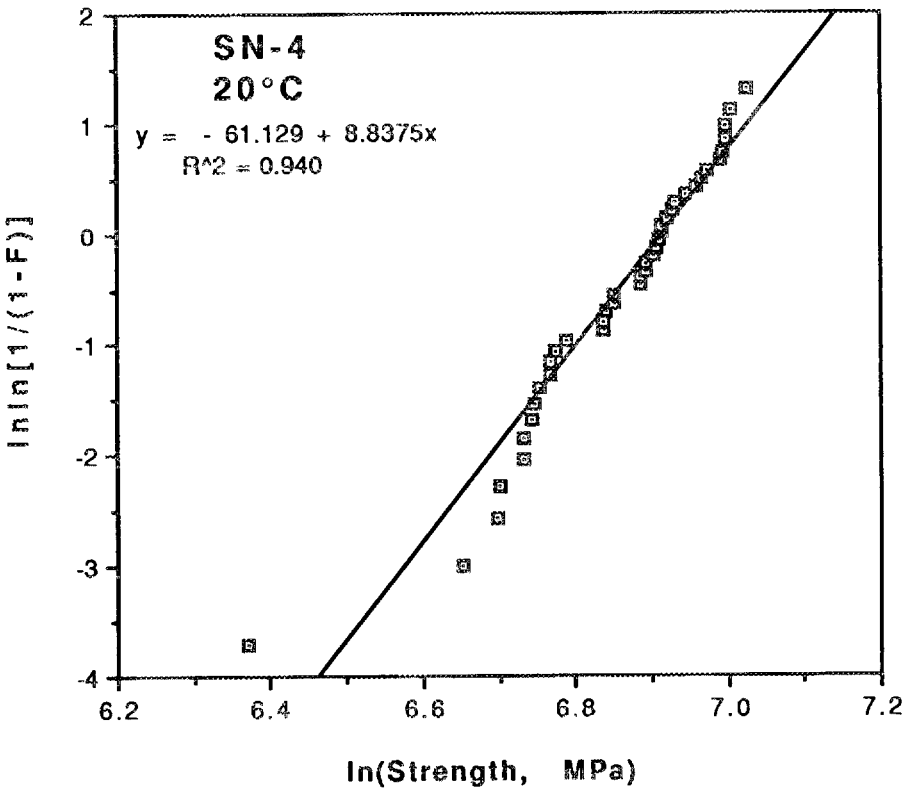

Figure 2.28. Weibull plot for SN-4 MOR 4-point bend tests run at 20°C at .0423 millimeters per second.

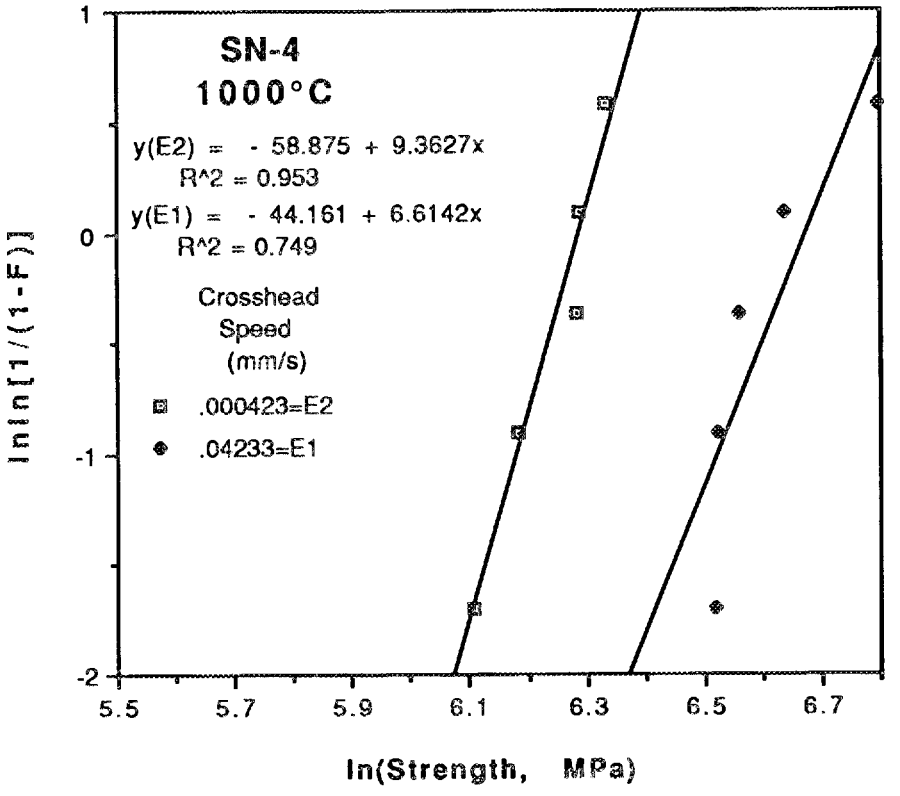

Figure 2.29. Weibull plot OF SN-4 MOR 4-point bend tests run at 1000°C at 2 crosshead speeds.

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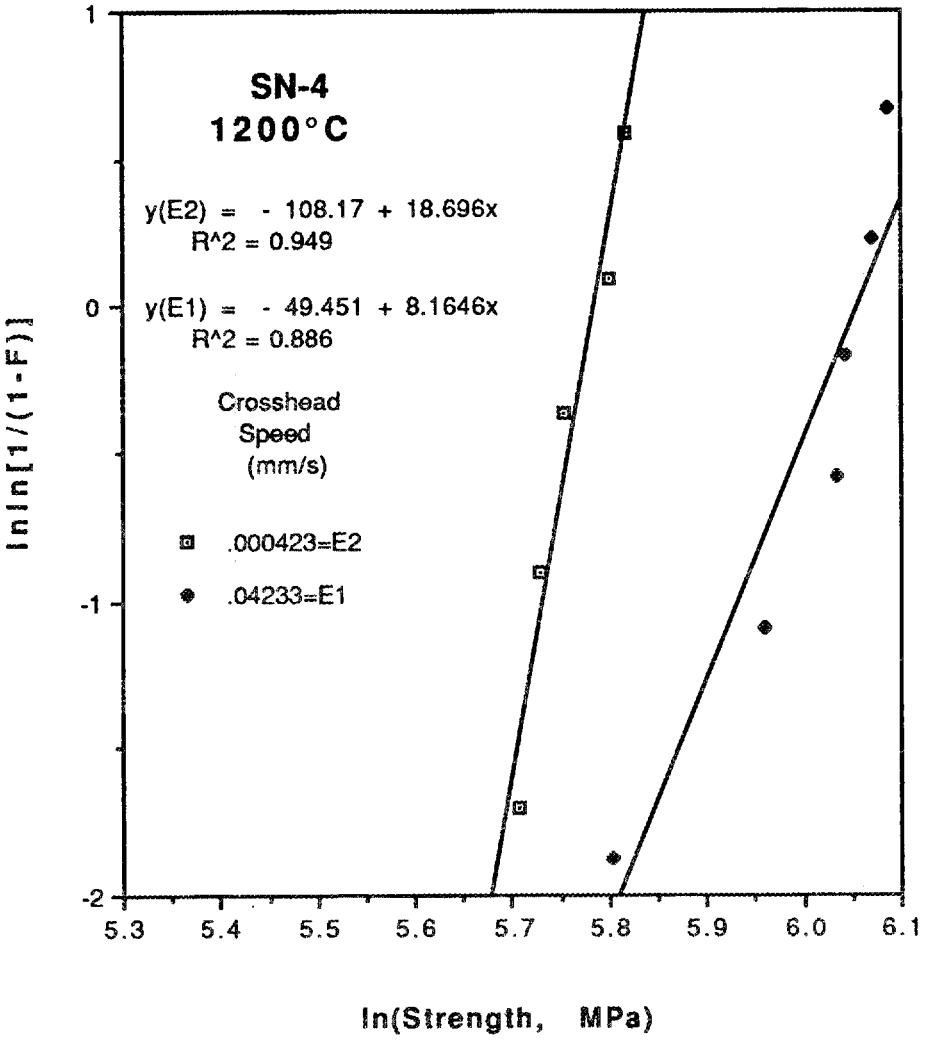

Figure 2.30. Weibull plot of SN-4 MOR 4-point bend tests run at 1200°C at 2 crosshead speeds.

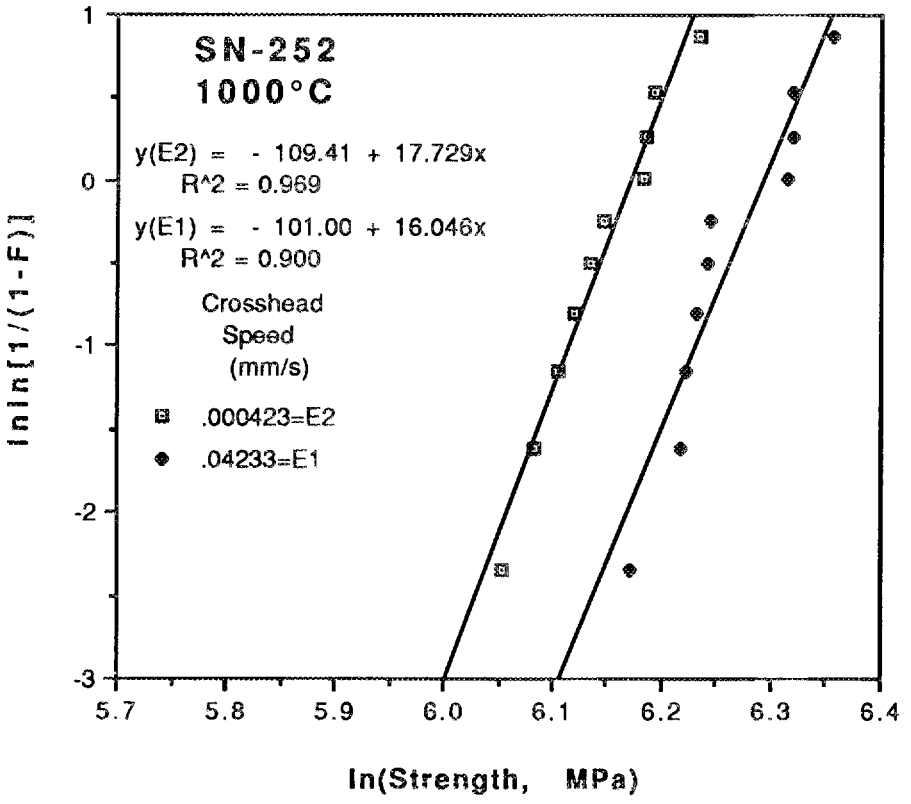

Figure 2.31. Weibull plot of SN-252 MOR 4-point bend tests run at 1000°C at 2 crosshead speeds.

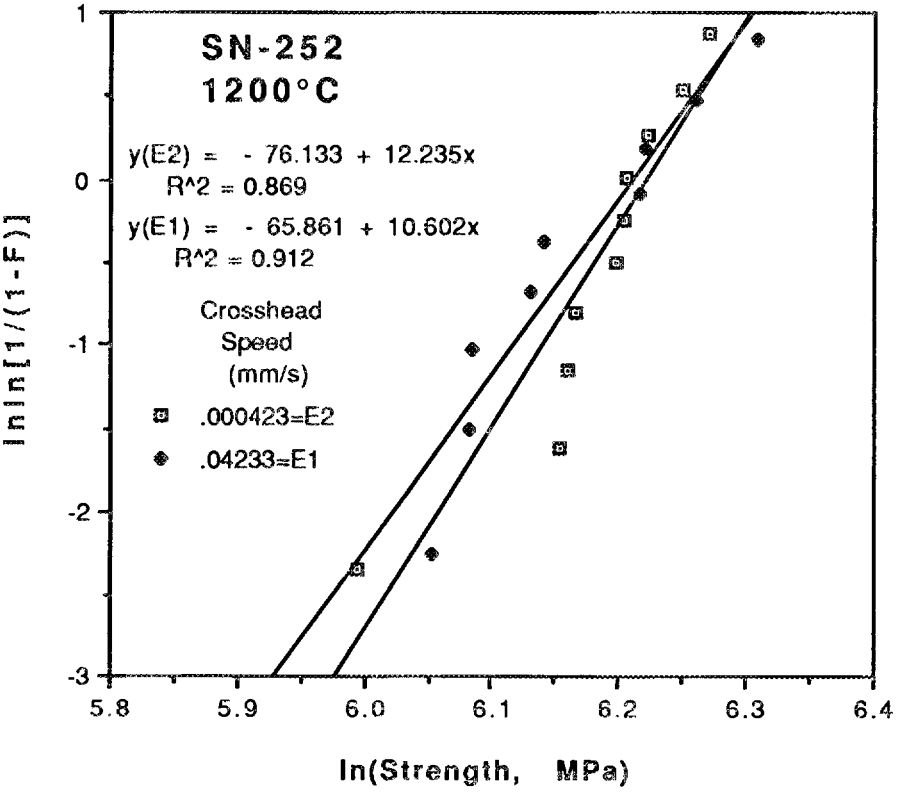

Figure 2.32. Weibull plot of SN-252 MOR 4-point bend tests run at 1200°C at 2 crosshead speeds.

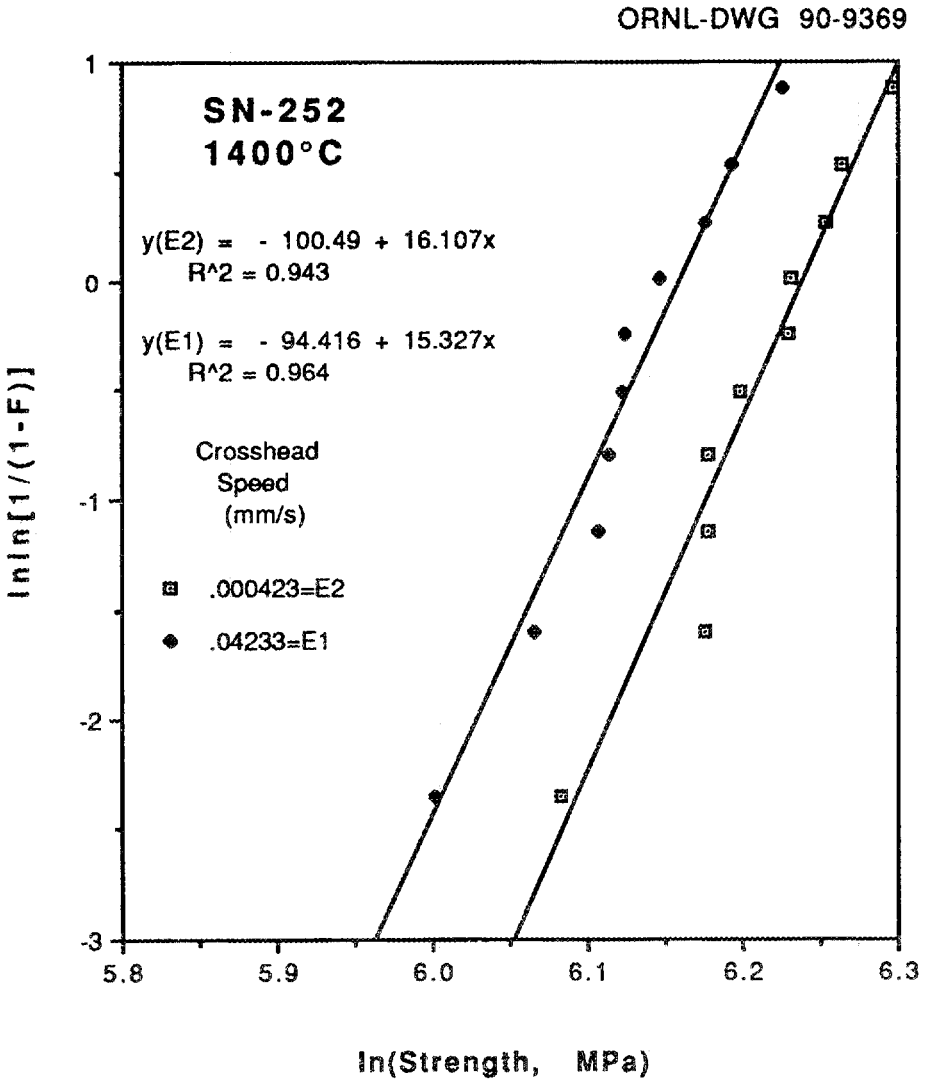

Figure 2.33. Weibull plot of SN-252 MOR 4-point bend tests run at 1400°C at 2 crosshead speeds.

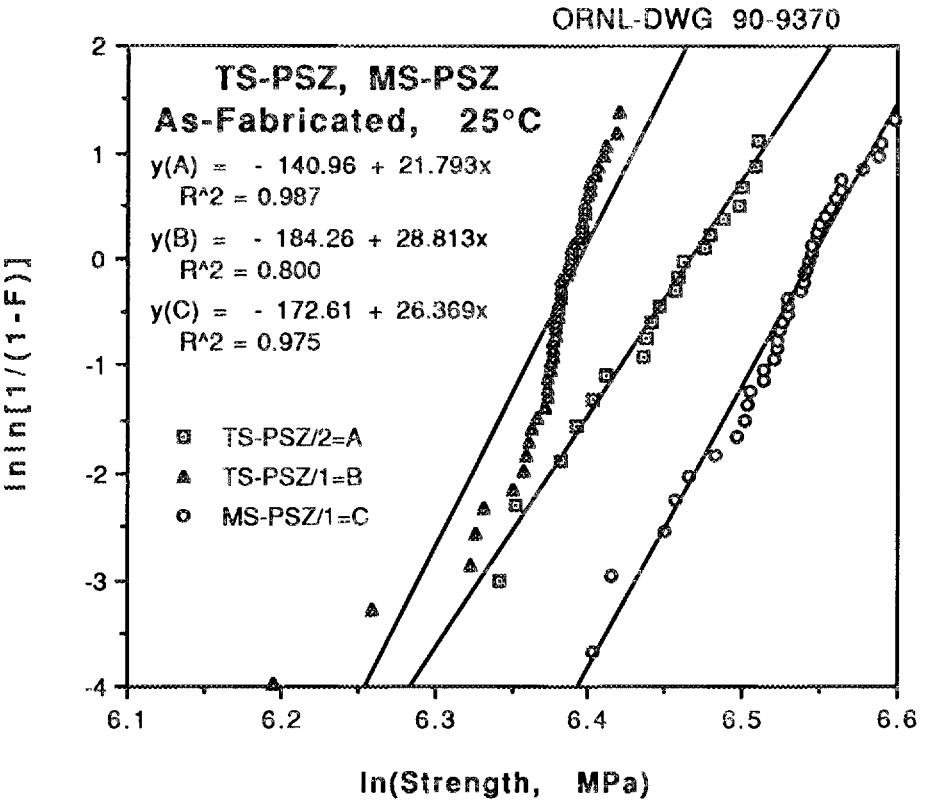

Figure 2.34. Weibull plot comparing 2 batches of Nilcra TS-PSZ with 1 batch of Nilcra MS-PSZ in the as-fabricated condition at 25°C.

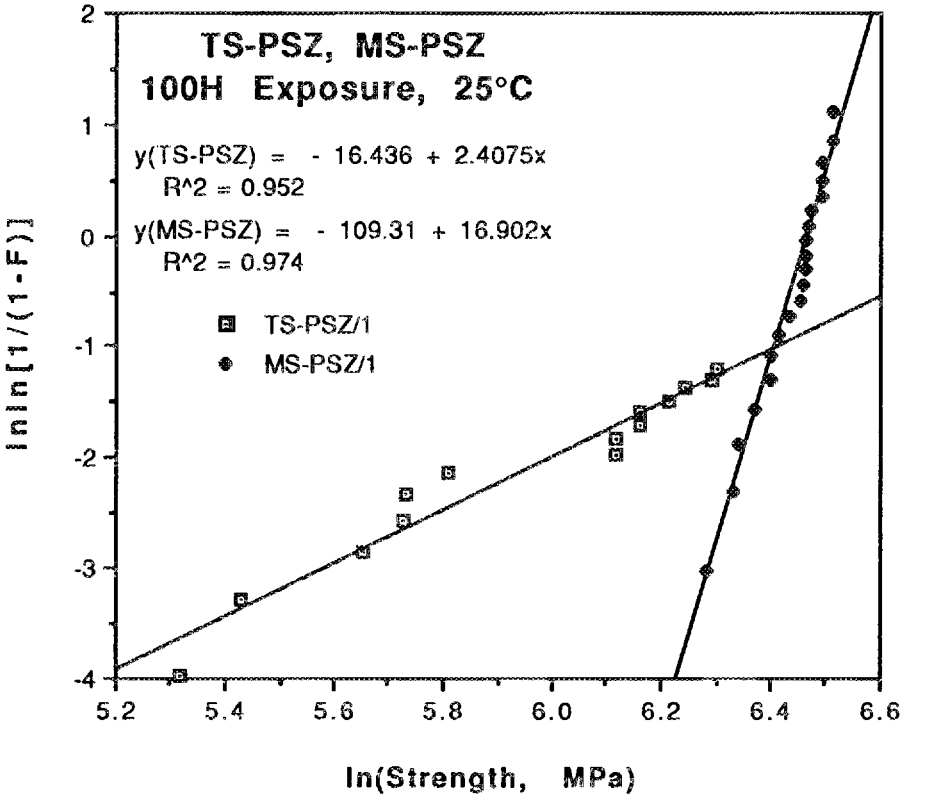

Figure 2.35. Weibull plot comparing MS-PSZ and TS-PSZ tested at 25°C after 100 hours diesel engine exposure.

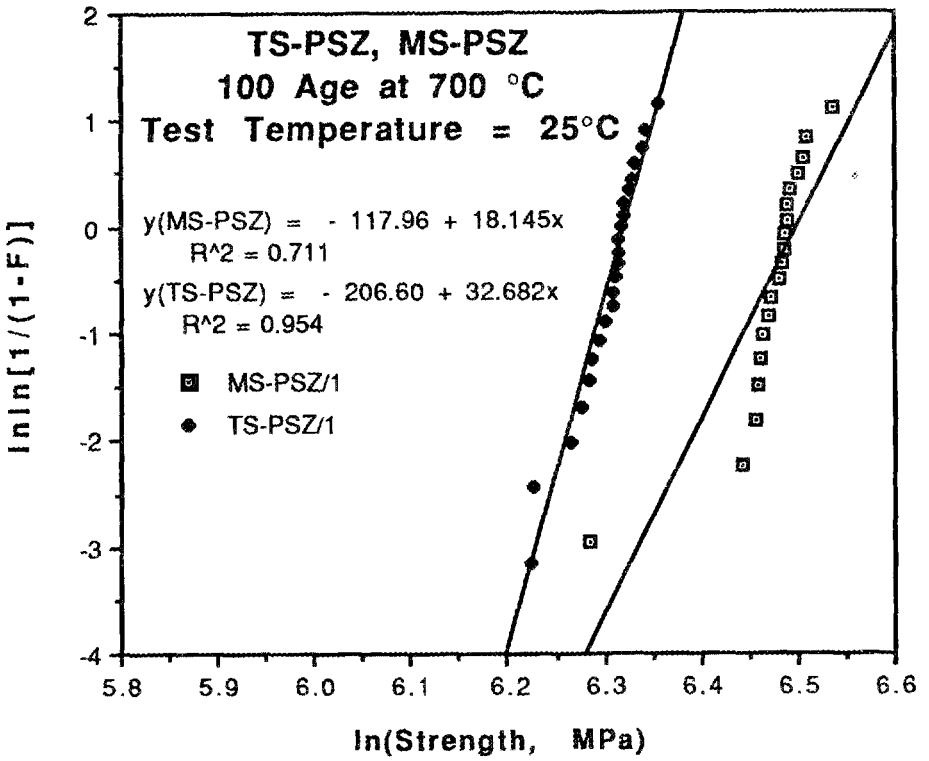

Figure 2.36. Weibull plot comparing TS-PSZ to MS-PSZ after aging 100 hours at 700°C. Test temperature was 25°C.

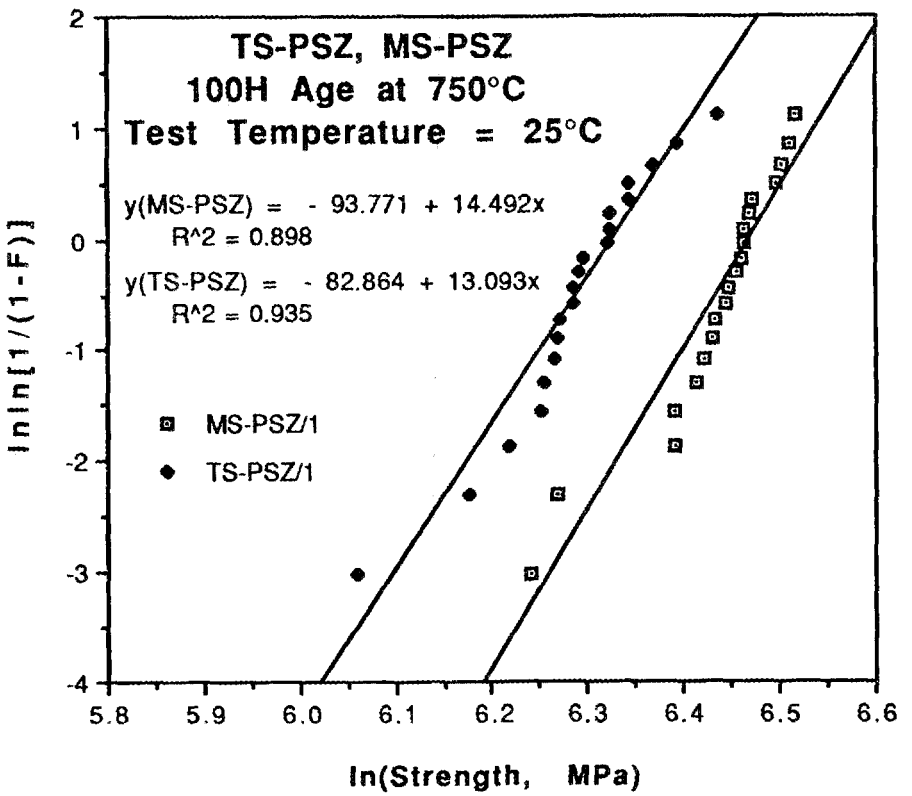

Figure 2.37. Weibull plot comparing MS-PSZ to TS-PSZ after aging 100 hours at 750°C. Test temperature was 25°C.

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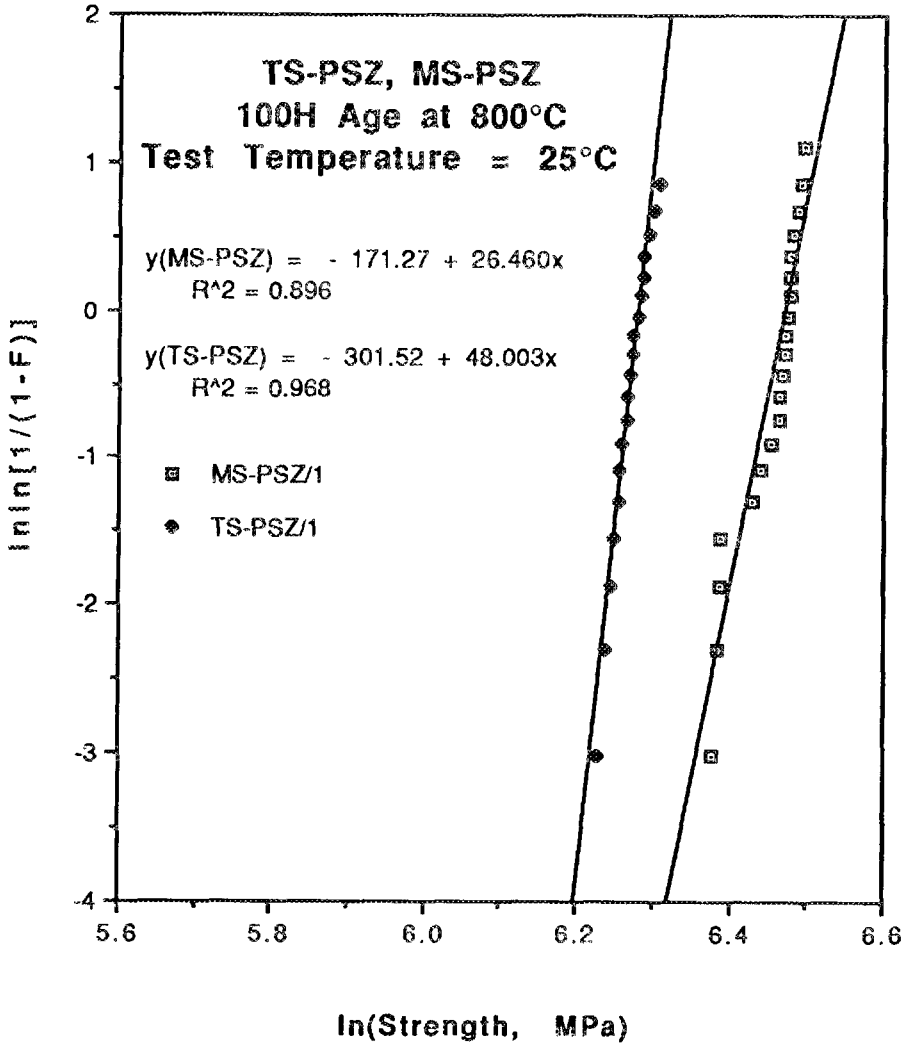

Figure 2.38. Weibull plot comparing MS-PSZ and TS-PSZ after aging 100 hours at 800°C. Test temperature was 25°C.

SECTION 6. MODULUS OF ELASTICITY

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON	SPECIMEN NUMBER	TEST TYPE	TEST TEMP °C	MODULUS ELASTICITY GPa
SILICON CARBIDE							
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	16	SONIC	20	420.60
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	17	SONIC	20	411.63
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	18	SONIC	20	411.63
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	19	SONIC	20	417.84
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	20	SONIC	20	436.45
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	20	SONIC	1000	417.84
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	19	SONIC	1000	399.22
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	18	SONIC	1000	397.84
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	17	SONIC	1000	396.46
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	16	SONIC	1000	395.08
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	16	SONIC	1400	393.02
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	17	SONIC	1400	385.43
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	18	SONIC	1400	388.88
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	19	SONIC	1400	395.08
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	20	SONIC	1400	408.18
SILICON NITRIDES							
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	6	SONIC	21	301.31
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	7	SONIC	21	301.31
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	8	SONIC	21	301.31
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	9	SONIC	21	304.07
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	AIR	10	SONIC	21	299.93
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	96	SONIC	20	310.96
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	97	SONIC	20	309.58
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	98	SONIC	20	309.58
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	99	SONIC	20	310.28
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	100	SONIC	20	310.28
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	100	SONIC	1000	302.69
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	99	SONIC	1000	297.86
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	98	SONIC	1000	296.49
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	97	SONIC	1000	296.49
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	96	SONIC	1000	299.93

SECTION 6. MODULUS OF ELASTICITY

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON	SPECIMEN NUMBER	TEST TYPE	TEST TEMP °C	MODULUS ELASTICITY GPa
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	96	SONIC	1400	297.17
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	97	SONIC	1400	293.73
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	98	SONIC	1400	290.97
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	99	SONIC	1400	294.42
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	99	SONIC	1400	294.42
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	100	SONIC	1400	294.42
SN-4	HOWMET/UDRI/2	UDRIPKGNOV89	AIR	8	SONIC	21	174.00

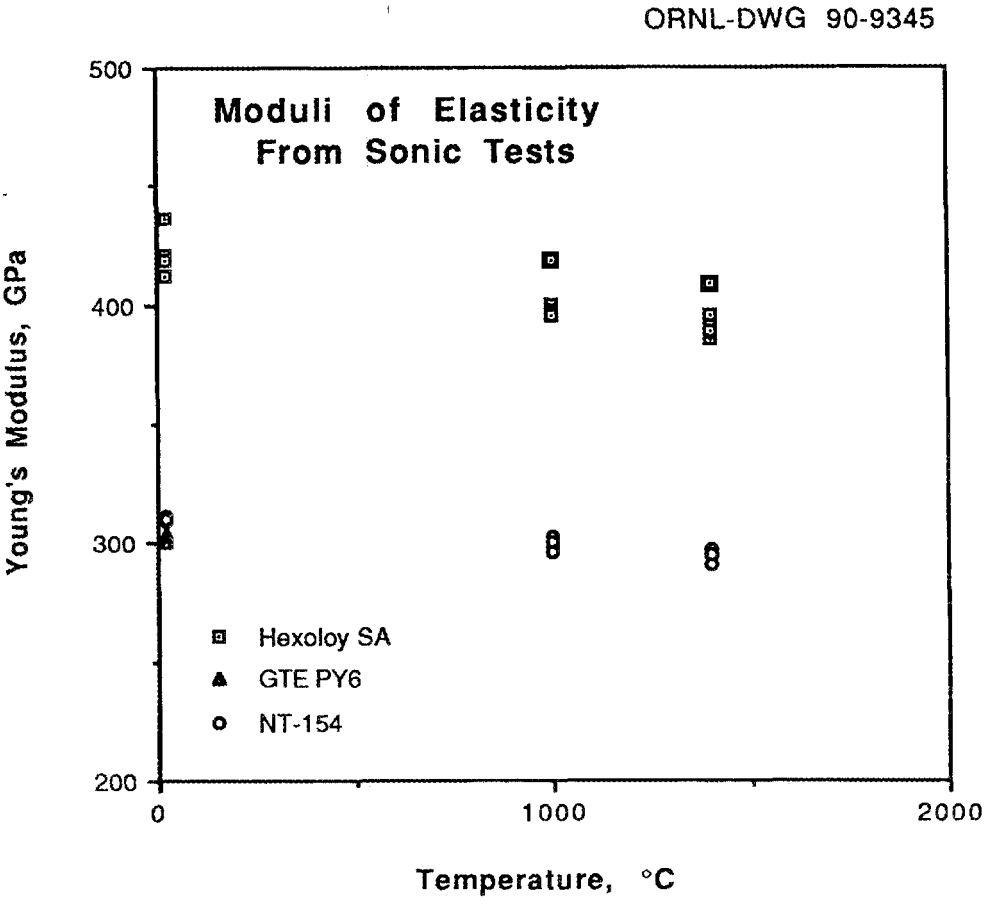

Figure 2.39. A comparison of moduli of elasticity for two silicon nitrides and one silicon carbide.

SECTION 7. TENSILE TEST RESULTS

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPECIMEN NUMBER	TEMP °C	TENSILE STRENGTH MPa	SPECIMEN DIAMETER mm	LOAD N	COMMENTS
SILICON CARBIDES									
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	3	21	251.0	6.36	7962.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	4	21	247.0	6.36	7828.5	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	5	21	294.0	6.51	9785.6	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	6	21	307.0	6.33	9652.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	7*	21	161.0	6.62	5560.0	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	8	21	253.0	6.42	8184.3	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	10	21	277.0	6.36	8807.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	12	21	219.0	6.37	6983.4	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	14	21	286.0	6.36	9073.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	15	21	220.0	6.39	7072.3	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	16	21	250.0	6.37	7961.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	17	21	352.0	6.34	11120.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	18	21	290.0	6.36	9207.4	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	19*	21	246.0	6.37	7828.5	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	20*	21	225.0	6.37	7161.3	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	22*	21	128.0	6.35	4047.7	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	23*	21	194.0	6.35	6138.2	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	25*	21	208.0	6.35	6583.0	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	26	21	228.0	6.36	7250.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	27*	21	170.0	6.32	5337.6	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	28*	21	157.0	6.35	4981.8	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	30	21	257.0	6.36	8139.8	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	38*	21	224.0	6.36	7116.8	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	122*	21	220.0	6.36	6983.4	Specimen failed at grind mark on the surface.
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	123	21	191.0	6.35	6049.3	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	36	1000	258.0	6.35	8184.3	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	42	1000	237.0	6.35	7517.1	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	46	1000	261.0	6.33	8228.8	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	51	1000	204.0	6.32	6405.1	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	52	1000	238.0	6.34	7517.1	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	53	1000	245.0	6.36	7784.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	54	1000	261.0	6.35	8273.3	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	55	1000	195.0	6.35	6182.7	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	56	1000	241.0	6.35	7650.6	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	57	1000	219.0	6.36	6938.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	60	1000	247.0	6.36	7828.5	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	61	1000	219.0	6.36	6938.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	62	1000	232.0	6.35	7339.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	63	1000	269.0	6.34	8495.7	

SECTION 7. TENSILE TEST RESULTS, CONTINUED

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPECIMEN NUMBER	TEMP °C	TENSILE STRENGTH MPa	SPECIMEN DIAMETER mm	LOAD N	COMMENTS
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	64	1000	271.0	6.35	8584.6	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	107	1200	182.0	6.34	5737.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	111	1200	208.0	6.31	6494.1	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	113	1200	214.0	6.35	6761.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	100	1200	267.0	6.33	8406.7	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	116	1200	268.0	6.34	8451.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	103	1200	268.0	6.37	8540.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	93	1200	269.0	6.34	8495.7	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	102	1200	274.0	6.33	8629.1	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	104	1200	278.0	6.33	8762.6	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	89	1200	279.0	6.34	8807.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	92	1200	289.0	6.35	9162.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	105	1200	292.0	6.35	9251.8	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	118	1200	295.0	6.34	9340.8	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	119	1200	301.0	6.37	9607.7	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	109	1200	314.0	6.34	9919.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	66	1400	258.0	6.35	8184.3	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	67	1400	222.0	6.36	7027.8	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	68	1400	237.0	6.35	7517.1	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	69	1400	233.0	6.33	7339.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	70	1400	182.0	6.36	5782.4	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	71	1400	258.0	6.36	8184.3	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	73	1400	270.0	6.34	8540.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	74	1400	270.0	6.35	8540.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	75	1400	286.0	6.35	9073.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	77	1400	281.0	6.35	8896.0	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	78	1400	237.0	6.34	7472.6	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	79	1400	229.0	6.34	7250.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	80	1400	251.0	6.35	7961.9	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	82	1400	223.0	6.34	7027.8	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	83	1400	233.0	6.37	7428.2	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	84	1400	288.0	6.35	9118.4	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	85	1400	269.0	6.34	8495.7	
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	AIR	86	1400	264.0	6.35	8362.2	

SECTION 7. TENSILE TEST RESULTS, CONTINUED

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPECIMEN NUMBER	TEMP °C	TENSILE STRENGTH MPa	SPECIMEN DIAMETER mm	LOAD N	STRAIN %	LOADING RATE N/sec	YOUNGS MODULUS GPa	COMMENTS
SILICON NITRIDES												
NT-154	NORTON/ORNL/CIP	BM889ORNL27	AIR	CP-3	1100	534.0			0.2240	0.125	236.9	LOADRATE=MPA/SEC
NT-154	NORTON/ORNL/CIP	BM889ORNL27	AIR	CP-11	1100	443.0			0.1820	0.125	242.3	LOADRATE=MPA/SEC
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-5	1100	721.0			0.2470	35.000	290.4	LOADRATE=MPA/SEC
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-6	1100	560.0			0.2260	0.125	247.4	LOADRATE=MPA/SEC
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-10	1200	638.0				35.000		LOADRATE=MPA/SEC
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-9	1200	524.0			0.2310	0.125	224.5	LOADRATE=MPA/SEC
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-1*	1200	419.0				35.000		*FAILED IN BUTTONHEAD
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-4*	1200	525.0				35.000	254.9	*FAILED IN BUTTONHEAD
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-2	1300	382.0				35.000		LOADRATE=MPA/SEC
NT-154	NORTON/ORNL/CAS	BM889ORNL28	AIR	PC-3	1300	295.0			0.2420	0.125	211.9	LOADRATE=MPA/SEC
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	89	21	490.0	6.36	15568.0				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	80	21	614.0	6.35	19437.8				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	36	21	637.0	6.37	20282.9				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	48	21	638.0	6.36	20238.4				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	9	21	654.0	6.35	20727.7				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	16	21	684.0	6.34	21617.3				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	39	21	684.0	6.35	21661.8				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	21	21	702.0	6.35	22240.0				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	75	21	718.0	6.36	22773.8				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	56	21	767.0	6.34	24197.1				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	7	21	782.0	6.35	24775.4				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	43	21	855.0	6.35	27088.3				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	35	21	857.0	6.35	27132.8				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	54	21	895.0	6.35	28378.2				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	34	21	906.0	6.35	28689.6				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	59	1000	424.0	6.34	13388.5				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	111	1000	434.0	6.34	13699.8				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	107	1000	449.0	6.35	14233.6				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	58	1000	525.0	6.36	16680.0				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	108	1000	531.0	6.35	16813.4				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	104	1000	546.0	6.49	18058.9				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	78	1000	550.0	6.34	17391.7				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	106	1000	550.0	6.38	17569.6				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	88	1000	565.0	6.41	18236.8				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	91	1000	576.0	6.36	18281.3				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	87	1000	591.0	6.34	18681.6				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	79	1000	598.0	6.38	19081.9				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	109	1000	626.0	6.35	19838.1				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	110	1000	654.0	6.35	20683.2				
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	72	1000	661.0	6.35	20905.6				

SECTION 7. TENSILE TEST RESULTS, CONTINUED

MATERIAL	BATCH CODE	REFERENCE CODE	TEST ENVIRON.	SPECIMEN NUMBER	TEMP °C	TENSILE STRENGTH MPa	SPECIMEN DIAMETER mm	LOAD N	COMMENTS
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	60	1200	342.0	6.56	11564.8	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	8	1200	438.0	6.35	13877.8	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	92	1200	444.0	6.35	14055.7	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	53	1200	485.0	6.35	15345.6	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	6	1200	496.0	6.35	15701.4	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	4	1200	508.0	6.35	16101.8	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	5	1200	512.0	6.34	16190.7	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	18	1200	523.0	6.35	16546.6	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	90	1200	533.0	6.35	16902.4	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	69	1200	537.0	6.33	16902.4	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	17	1200	542.0	6.35	17169.3	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	83	1200	581.0	6.35	18414.7	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	15	1200	610.0	6.35	19304.3	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	66	1200	623.0	6.35	19749.1	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	73	1200	624.0	6.36	19793.6	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	55	1400	225.0	6.35	7116.8	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	47	1400	264.0	6.35	8362.2	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	46	1400	287.0	6.36	9118.4	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	41	1400	236.0	6.35	10319.4	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	44	1400	339.0	6.34	10719.7	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	38	1400	345.0	6.35	10942.1	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	50	1400	349.0	6.35	11075.5	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	10	1400	353.0	6.34	11164.5	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	19	1400	357.0	6.35	11297.9	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	14	1400	365.0	6.35	11564.8	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	45	1400	366.0	6.34	11564.8	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	40	1400	377.0	6.36	11965.1	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	51	1400	388.0	6.36	12321.0	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	52	1400	399.0	6.35	12632.3	
NT-154	NORTON/UDRI/2	UDRIPKGNOV89	AIR	49	1400	406.0	6.36	12899.2	
ZIRCONIAS									
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	26	25	468.0			
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	28	400	341.0			
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	29	400	440.0			
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	30	800	265.0			
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	31	800	258.0			
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	38	800	190.0			
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	32	1000	222.0			
MS-PSZ	NILCRA/ORNL/1	SA11ORNL306	AIR	33	1000	194.0			

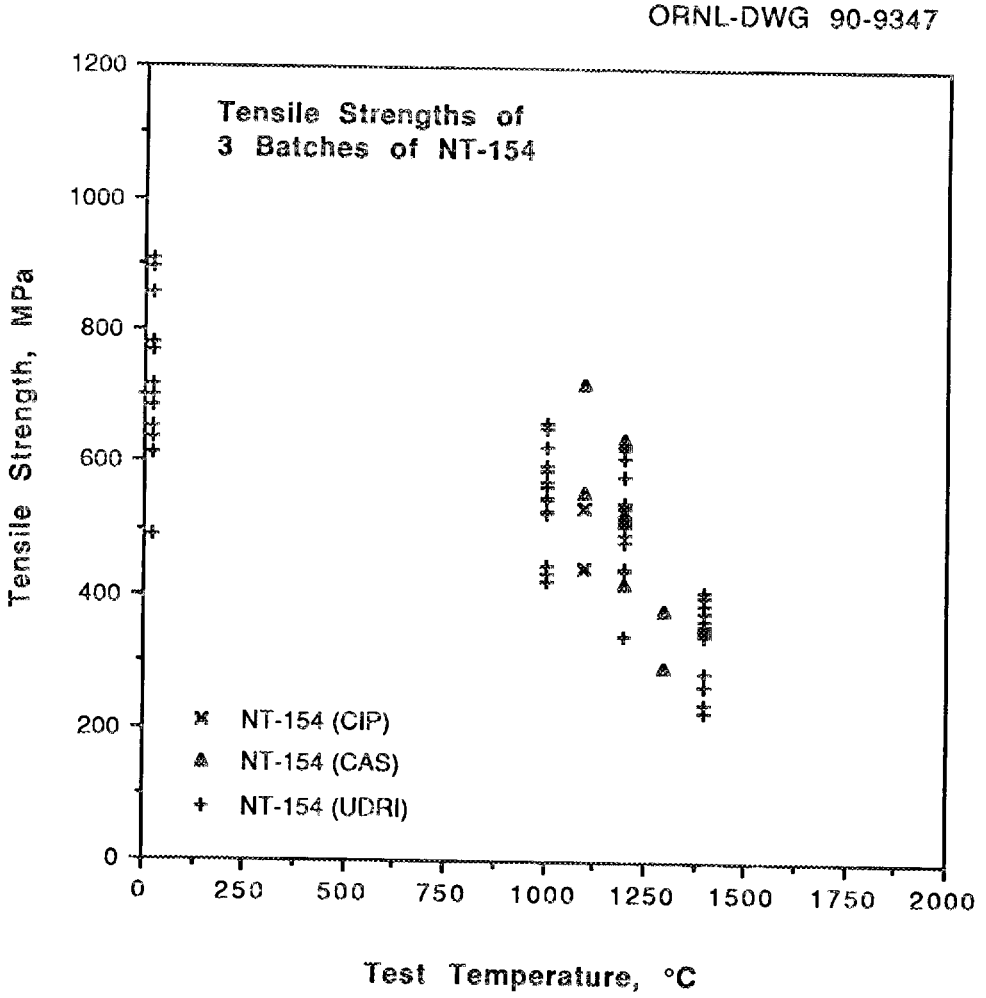

Figure 2.40. A comparison of tensile strengths for three batches of NT-154.

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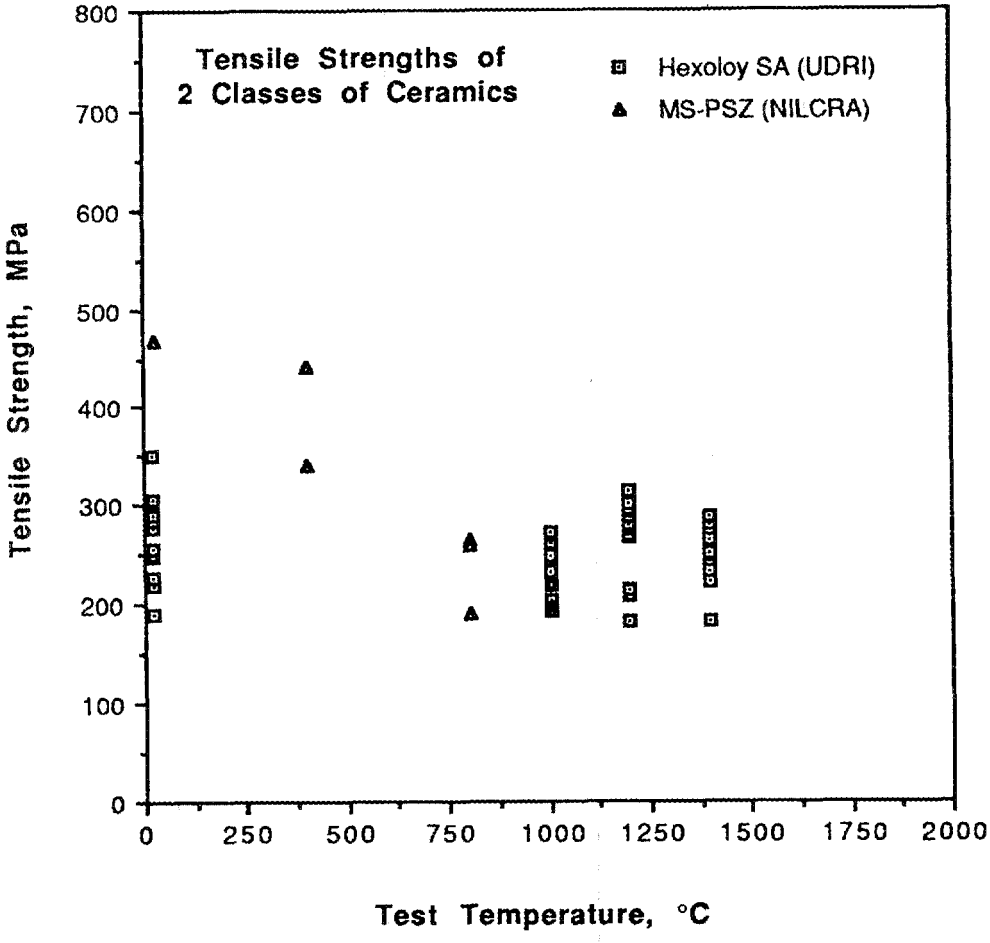


Figure 2.41 A comparison of tensile strengths for two classes of ceramic materials.

SECTION 8. THERMAL EXPANSION TEST RESULTS

MATERIAL	BATCH CODE	REFERENCE CODE	SPECIMEN NUMBER	TEMP °C	TEMPERATURE RANGE °C	COEFFICIENT OF THERMAL EXPANSION 1.E-06/°C
SILICON CARBIDE						
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	1	1400	25-1400	4.80
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	2	1400	25-1400	5.00
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	3	1400	25-1400	4.80
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	4	1400	25-1400	4.90
HEXOLOY SA	SOHIO/UDRI/2	UDRIPKGNOV89	5	1400	25-1400	4.90
SILICON NITRIDE						
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	1	850	25-850	3.10
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	2	850	25-850	3.20
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	3	850	25-850	3.10
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	4	850	25-850	3.20
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	5	850	25-850	3.20
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	1	1400	25-1400	3.40
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	2	1400	25-1400	3.50
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	3	1400	25-1400	3.50
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	4	1400	25-1400	3.40
GTE PY6	GTEL/UDRI/2	UDRIPKGNOV89	5	1400	25-1400	3.40

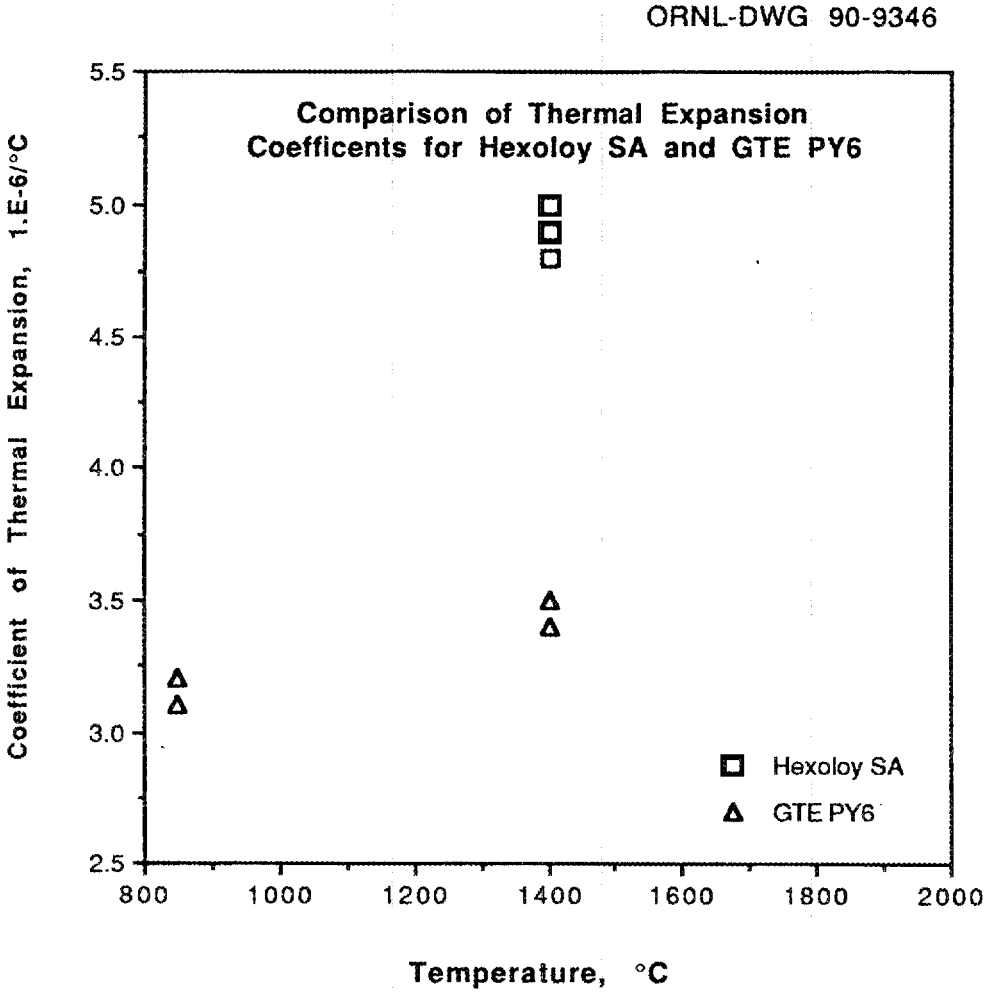


Figure 2.42. A comparison of thermal expansion coefficients between a silicon carbide and a silicon nitride.

SECTION 9. MOR 4-POINT BEND STRENGTH TEST RESULTS FOR BRAZED SPECIMENS

BASE MATERIAL = MG-PSZ
BATCH CODE FOR BASE MATERIAL = CORNING ZYCRON L
REFERENCE CODE =BM1298BCL65
OTHER MATERIAL = MG-PSZ
BATCH CODE FOR OTHER MATERIAL = CORNING ZYCRON L

FILLER MATERIAL = CaO-TiO2-SiO2+30w% ZrO2
JOINT METHOD = HOT PRESSED
JOINT PROCESS = HP/1420C/13.79MPa
NO ADDITIONAL HEAT TREATMENT AFTER BRAZE
TESTS WERE PERFORMED IN AIR

2 MG-PSZ (Corning Zycron L) billets (D-shaped) were joined together by hotpressing the MG-PSZ+CTS(CaO-TiO2-SiO2)+MG-PSZ sandwich in a creep testing unit at 1420C and 13.79MPa. Bend bars, 2.54x5.08x63.5mm, were machined from the 50.8mm diameter x 38.1mm long cylinder and tested in a 4-point fixture with outer span of 31.75mm and 19.05mm inner span. A thermal expansion mismatch between the materials caused a poor quality joint.
These specimens were joined in the same manner as mentioned before except that 30wt% ZrO2 was added to the CTS layer to overcome thermal expansion problems which caused extensive cracking. Like before, 2 D-shaped Mg-PSZ billets were pressed together with the CTS-ZrO layer in between. Specimens were cut so that the joint was in the middle. Work was performed by R.A.Schmidt, A.T.Hopper, J. Ahmad and R.A.Rosenfield at Battelle Columbus Laboratories.

TEMP °C	SPECIMEN NUMBER	BEND STRENGTH MPa	WIDTH mm	THICK mm
25	HP5-ZZB3	81.9	5.08	2.54
25	HP5-ZZB4	63.7	5.08	2.54
25	HP5-ZZB5	71.5	5.08	2.54
25	HP5-ZZB6	79.5	5.08	2.54
25	HP5-ZZB8	60.9	5.08	2.54
25	HP5-ZZB9	53.6	5.08	2.54
25	HP5ZZB10	54.4	5.08	2.54
25	HP5ZZB11	49.3	5.08	2.54
25	HP5ZZB12	72.9	5.08	2.54
25	HP5ZZB13	68.9	5.08	2.54

BASE MATERIAL = MG-PSZ/TI COATING
BASE MATERIAL BATCH CODE = CORNING-ZYCRONL
REFERENCE CODE = SA12BCL279
OTHER MATERIAL = CAST IRON
OTHER MATERIAL BATCH CODE = 60% PEARLITE

FILLER MATERIAL = L&M 604
JOINT METHOD = HOT PRESSING
NO ADDITIONAL HEAT TREATMENT AFTER BRAZE
TESTS WERE PERFORMED IN AIR

A 50.8mm square x 19.05mm thick piece of nodular cast iron (ground with 240-grit SiC paper) was brazed to a 50.8mm diameter x 19.05mm thick disk of MG-PSZ (Corning Zycron L) which had been coated with .3um thick layer of Ti at NASA-Lewis using RF-sputter. The cast iron was NOT coated with copper! Each specimen was ultrasonnically cleaned w/acetone, then alcohol. The iron was placed on top the MG-PSZ to provide a load during brazing. Details of the braze: temperature increased 30C/minute to 650C, then 7C/minute to 720C. Power was then shut off and the joint allowed to cool to room temperature. All work was performed in a vacuum at about 1.E-05 torr.

TEMP °C	SPECIMEN NUMBER	BEND STRENGTH MPa	WIDTH mm	THICK mm
25	MCB-4	164.0	5.08	2.54
25	MCB-5	76.0	5.08	2.54
25	MCB-6	161.0	5.08	2.54

SECTION 9. MOR 4-POINT BEND STRENGTH TEST RESULTS FOR BRAZED SPECIMENS, CONTINUED

BASE MATERIAL = MG-PSZ
BATCH CODE FOR BASE MATERIAL = CORNING ZYCRON L
REFERENCE CODE = SA11BCL209
OTHER MATERIAL = MG-PSZ
BATCH CODE FOR OTHER MATERIAL = CORNING ZYCRON L

FILLER MATERIAL = CaO-TiO2-SiO2
JOINT METHOD = HOT PRESSED
JOINT PROCESS = HP/1420C/13.79MPa
NO ADDITIONAL HEAT TREATMENT AFTER BRAZE
TESTS WERE PERFORMED IN AIR

2 MG-PSZ (Corning Zycron L) billets were joined together by hotpressing the MG-PSZ+CTS(CaO-TiO2-SiO2)+MG-PSZ sandwich in a creep testing unit at 1420C and 13.79MPa. Bend bars, 2.54x5.08x63.5mm, were machined from the 50.8mm diameter x 38.1mm long cylinder and tested in a 4-point fixture with outer span of 31.75mm and 19.05mm inner span. A thermal expansion mismatch between the materials caused a poor quality joint. Work was performed by R.A.Schmidt, A.T.Hopper, J. Ahmad and R.A.Rosenfield at Battelle Columbus Laboratories.

TEMP °C	SPECIMEN NUMBER	LOAD N	BEND STRENGTH MPa	WIDTH mm	THICK mm	COMMENTS
25	ZZB-3	135.7	81.9	5.08	2.54	CTS-BONDED ZrO2
25	ZZB-4	105.0	63.7	5.08	2.54	CTS-BONDED ZrO2
25	ZZB-5	117.9	71.5	5.08	2.54	CTS-BONDED ZrO2
25	ZZB-6	130.8	79.5	5.08	2.54	CTS-BONDED ZrO2

BASE MATERIAL = MG-PSZ/TI
BASE MATERIAL BATCH CODE = CORNING-ZYCRONL
REFERENCE CODE = SA11BCL212
OTHER MATERIAL = CAST IRON/CU
OTHER MATERIAL BATCH CODE = 60% PEARLITE

FILLER MATERIAL = L&M 604
JOINT METHOD = ACTIVE SUBSTRATE
JOINT PROCESS = HP/750C/10min./vac.
NO ADDITIONAL HEAT TREATMENT AFTER BRAZE
TESTS WERE PERFORMED IN AIR

Specimens (2.5x5.08x63.5mm) were cut from MG-PSZ with Ti coating (plasma ion etched for 1 minute, then RF-sputtered 15 minutes at 6.67e-12MPa, 1.4um thick), joined by active substrate brazing (Lucas-Milhaupt No. 604, Ag-30Cu-10Sn) to nodular cast iron (60% pearlite)that had been vapor-deposit plated with copper. Both materials had been ground to 0.3um finish. The bend strength was calculated using the monolithic materials equation. Work performed at Battelle Columbus Laboratories by A.T.Hopper, J.Ahmad and A. Rosenfield.

TEMP °C	SPECIMEN NUMBER	LOAD N	BEND STRENGTH MPa	WIDTH mm	THICK mm
25	MCB-1	151.0	88.9	5.08	2.54
25	MCB-2	138.0	81.4	5.08	2.54
25	MCB-3	138.0	80.9	5.08	2.54

SECTION 9. MOR 4-POINT BEND STRENGTH TEST RESULTS FOR BRAZED SPECIMENS, CONTINUED

BASE MATERIAL = MS-PSZ/TI COATING
BASE MATERIAL BATCH CODE = NILSEN/ORNL/J1
REFERENCE CODE = SA10ORNL175
OTHER MATERIAL = TITANIUM
OTHER MATERIAL BATCH CODE = ASTM/B265 GR1
FILLER MATERIAL = BR604
JOINT METHOD = ACTIVE SUBSTRATE
JOINT PROCESS = BRAZED IN VAC@735C
NO ADDITIONAL HEAT TREATMENT AFTER BRAZE
TESTS WERE PERFORMED IN AIR

See SA10ORNL174 for main details. These specimens were Nilsen MS-PSZ brazed to nodular cast iron, grade 8003, using active substrate process(AS), where the zirconia plate was vapor coated with commercially pure titanium and the iron was plated with copper to improve wetting. Brazing was done in a vacuum with Handy & Harmon Braze 604 (BVAg-18). Load rate was 22.7 kg/sec. Outer span was 19.05mm, inner span was 6.35mm. Work performed at ORNL by Mike Santella.

TEMP °C	SPECIMEN NUMBER	BEND STRENGTH MPa	WIDTH mm	THICK mm
25	MCB-343A	435.0	2.50	2.00
25	MCB-344A	309.0	2.50	2.00
25	MCB-345A	351.0	2.50	2.00
25	MCB-364A	345.0	2.50	2.00
25	MCB-365A	307.0	2.50	2.00
25	MCB-366A	399.0	2.50	2.00
200	MCB-298D	353.0	2.50	2.00
200	MCB-344B	287.0	2.50	2.00
200	MCB-345B	319.0	2.50	2.00
200	MCB-364B	280.0	2.50	2.00
200	MCB-365B	106.0	2.50	2.00
200	MCB-365C	142.0	2.50	2.00
200	MCB-366B	332.0	2.50	2.00
200	MCB-366C	309.0	2.50	2.00
400	MCB-298E	182.0	2.50	2.00
400	MCB-344C	180.0	2.50	2.00
400	MCB-344D	168.0	2.50	2.00
400	MCB-345C	212.0	2.50	2.00
400	MCB-364C	173.0	2.50	2.00
400	MCB-364D	166.0	2.50	2.00
400	MCB-365D	197.0	2.50	2.00
400	MCB-366C	189.0	2.50	2.00
400	MCB-366D	137.0	2.50	2.00
575	MCB-298F	118.0	2.50	2.00
575	MCB-344E	100.0	2.50	2.00
575	MCB-345D	128.0	2.50	2.00
575	MCB-345E	107.0	2.50	2.00
575	MCB-364E	109.0	2.50	2.00
575	MCB-364F	103.0	2.50	2.00
575	MCB-365E	49.0	2.50	2.00

SECTION 9. MOR 4-POINT BEND STRENGTH TEST RESULTS FOR BRAZED SPECIMENS, CONTINUED

BASE MATERIAL = MS-PSZ/TI COATING
BASE MATERIAL BATCH CODE = NILSEN/ORNL/J1
REFERENCE CODE = SA10ORNL175
OTHER MATERIAL = CAST IRON/COPPER COATING
OTHER MATERIAL BATCH CODE = CUMMINS/GR.8003

FILLER MATERIAL = BR604
JOINT METHOD = ACTIVE SUBSTRATE
JOINT PROCESS = BRAZED IN VAC@735C
NO ADDITIONAL HEAT TREATMENT AFTER BRAZE
TESTS WERE PERFORMED IN AIR

See SA10ORNL174 for main details. These specimens were Nilsen MS-PSZ brazed to nodular cast iron, grade 8003, using active substrate process(AS), where the zirconia plate was vapor coated with commercially pure titanium and the iron was plated with copper to improve wetting. Brazing was done in a vacuum with Handy & Harmon Braze 604 (BVAg-18). Load rate was 22.7 kg/sec. Outer span was 19.05mm, inner span was 6.35mm. Work performed at ORNL by Mike Santella.

TEMP °C	SPECIMEN NUMBER	BEND STRENGTH MPa	WIDTH mm	THICK mm
25	MCB-351A	25.0	2.50	2.00
25	MCB-367A	36.0	2.50	2.00
25	MCB-369A	102.0	2.50	2.00
200	MCB-300F	363.0	2.50	2.00
200	MCB-349A	58.0	2.50	2.00
200	MCB-350B	237.0	2.50	2.00
200	MCB-367B	326.0	2.50	2.00
400	MCB-300G	364.0	2.50	2.00
400	MCB-349B	80.0	2.50	2.00
400	MCB-350C	249.0	2.50	2.00
400	MCB-367C	358.0	2.50	2.00
400	MCB-369B	111.0	2.50	2.00
400	MCB-369C	53.0	2.50	2.00
575	MCB-300H	39.0	2.50	2.00
575	MCB-349C	28.0	2.50	2.00
575	MCB-350D	101.0	2.50	2.00
575	MCB-367D	70.0	2.50	2.00
575	MCB-367E	28.0	2.50	2.00
575	MCB-369C	27.0	2.50	2.00
575	MCB-369D	16.0	2.50	2.00

SECTION 9. MOR 4-POINT BEND STRENGTH TEST RESULTS FOR BRAZED SPECIMENS, CONTINUED

BASE MATERIAL = MS-PSZ/TI COATING
BASE MATERIAL BATCH CODE = NILSEN/ORNL/J1
REFERENCE CODE = SA10ORNL175
OTHER MATERIAL = MS-PSZ/TI COATING
OTHER MATERIAL BATCH CODE = NILSEN/ORNL/J1

FILLER MATERIAL = BR604
JOINT METHOD = ACTIVE SUBSTRATE
JOINT PROCESS = BRAZED IN VAC@735C
NO ADDITIONAL HEAT TREATMENT AFTER BRAZE
TESTS WERE PERFORMED IN AIR

Individual plates (25x14x3mm) were joined alone the 25x3mm edge, surface ground on both faces, polished to 1 micrometer diamond finish on the tensile face, then cut into MOR bars 28x2.5x2mm with the brazed joint in the middle of each bar. Outer span 19.05mm, inner span 6.35mm. Work done by Mike Santella at ORNL.

These specimens were Nilsen MS-PSZ brazed to nodular cast iron grade 8003 (from Cummins Engine Co.), using active substrate process(AS), where the zirconia plate was vapor coated with commercially pure titanium and the iron was plated with copper to improve wetting. Brazing was done in a vacuum with Handy & Harmon Braze 604 (BVAg-18). Load rate was 22.7 kg/sec. Outer span was 19.05mm, inner span was 6.35mm. Work performed at ORNL by Mike Santella.

TEMP °C	SPECIMEN NUMBER	BEND STRENGTH MPa	WIDTH mm	THICK mm
25	MCB-299A	571.0	2.50	2.00
25	MCB-299B	532.0	2.50	2.00
25	MCB-299C	493.0	2.50	2.00
25	MCB-346A	327.0	2.50	2.00
25	MCB-347A	269.0	2.50	2.00
25	MCB-348A	314.0	2.50	2.00
25	MCB-361A	332.0	2.50	2.00
25	MCB-362A	432.0	2.50	2.00
25	MCB-363A	312.0	2.50	2.00
200	MCB-299D	459.0	2.50	2.00
200	MCB-346B	444.0	2.50	2.00
200	MCB-347B	323.0	2.50	2.00
200	MCB-347C	293.0	2.50	2.00
200	MCB-348B	383.0	2.50	2.00
200	MCB-362B	239.0	2.50	2.00
200	MCB-363B	342.0	2.50	2.00
400	MCB-299E	356.0	2.50	2.00
400	MCB-346C	370.0	2.50	2.00
400	MCB-347D	228.0	2.50	2.00
400	MCB-348C	325.0	2.50	2.00
400	MCB-361B	242.0	2.50	2.00
400	MCB-362C	319.0	2.50	2.00
400	MCB-362D	299.0	2.50	2.00
400	MCB-363C	199.0	2.50	2.00
400	MCB-363D	296.0	2.50	2.00
575	MCB-299F	61.0	2.50	2.00
575	MCB-346D	149.0	2.50	2.00
575	MCB-347E	124.0	2.50	2.00
575	MCB-348D	127.0	2.50	2.00
575	MCB-348E	94.0	2.50	2.00
575	MCB-362D	125.0	2.50	2.00
575	MCB-362E	71.0	2.50	2.00
575	MCB-363D	109.0	2.50	2.00
575	MCB-363E	48.0	2.50	2.00

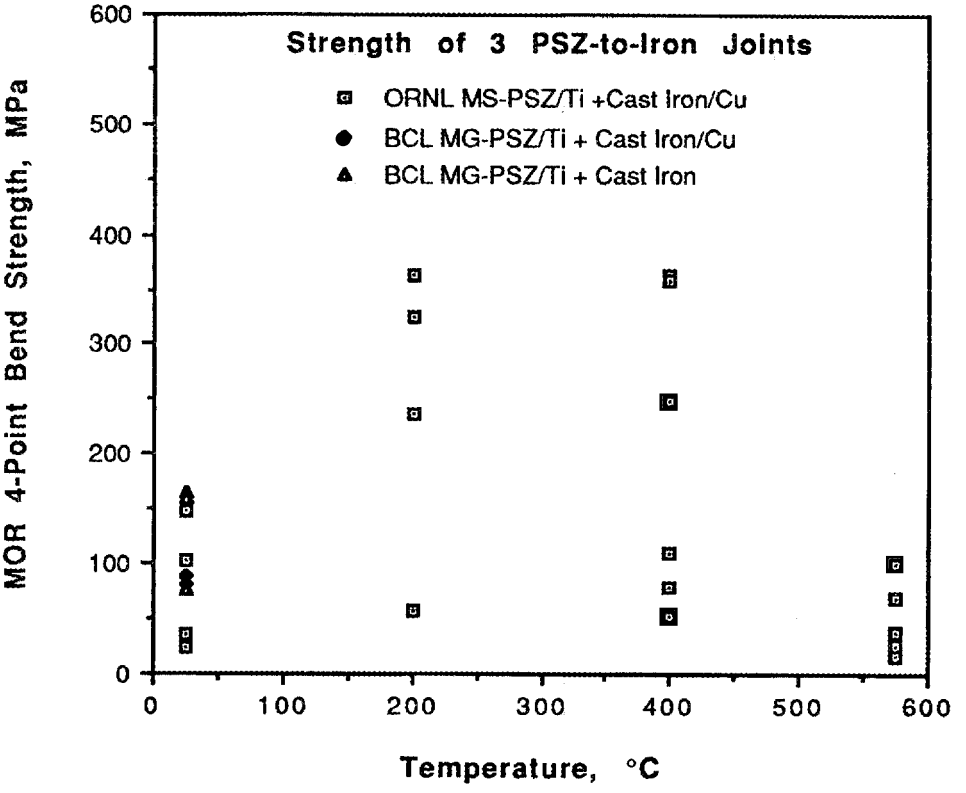
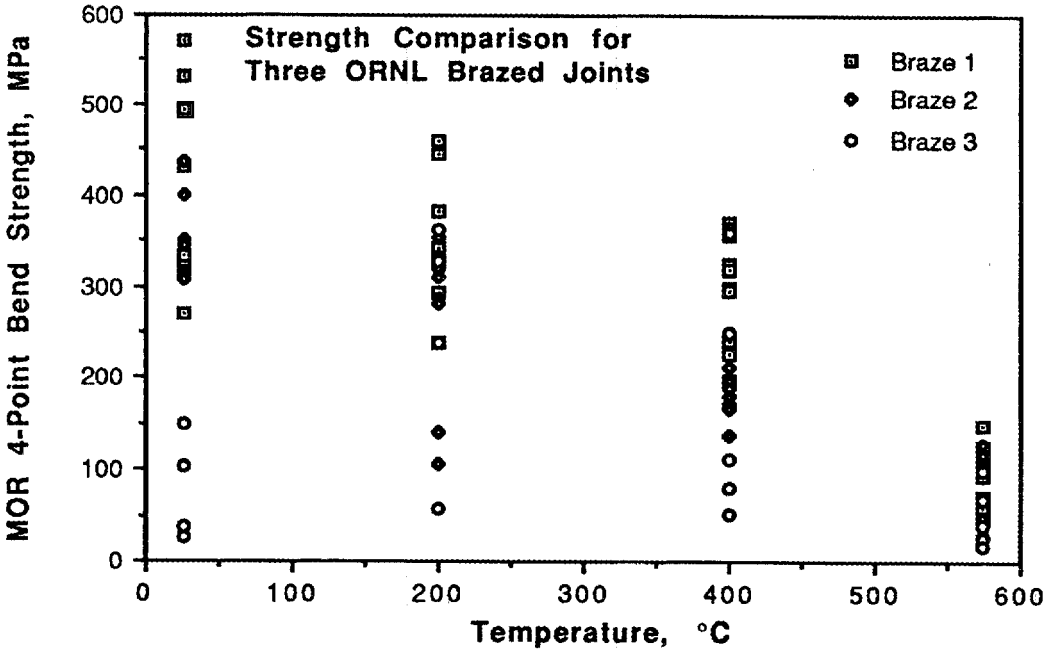


Figure 2.43. A comparison of strengths of three different PSZ-to-cast iron brazed joints.



Braze 1 = MS-PSZ/Ti + BR604 + MS-PSZ/Ti
Braze 2 = MS-PSZ/Ti + BR604 + Titanium
Braze 3 = MS-PSZ/Ti + BR604 + Cast Iron

Figure 2.44. MOR 4-point bend strength test results for three brazed Ti-coated MS-PSZ joints.

SECTION 10. SHEAR STRENGTH OF BRAZED SPECIMENS

BASE MATERIAL = MS-PSZ
BASE MATERIAL BATCH CODE = NILSEN/ORNL/J1
REFERENCE CODE = SA10ORNL171
OTHER MATERIAL = CAST IRON/COPPER COATING
OTHER MATERIAL BATCH CODE = CUMMINS/GR.8003

FILLER MATERIAL = INCUSIL-15ABA
JOINT METHOD = ACTIVE FILLER METAL
JOINT PROCESS = BRAZED IN VAC@770C
NO POST BRAZE HEAT TREATMENT
TESTS WERE PERFORMED IN AIR

A pad/bar type specimen was used, with the pad 12.7x12.7x5.1mm and the bar 12.7x 5.1x3.4mm.The pad is OTHER MATERIAL, the bar is BASE MATERIAL.
The AFM (active filler metal) method used Incusil-15 ABA, composed of Ag-23.5Cu-14.5In-1.3Ti (wt%). Testing was done in a pad/bar tester on a 44.5kN Instron tensile machnine equipped with a clam-shell furnace and a quartz line for elevated temperature testing. Work was performed at Oak Ridge National Laboratory by Mike Santella.

SPECIMEN CODE	TEMP °C	SHEAR STRENGTH MPa	COMMENTS
MCB-60	25	127.0	UNPOLISHD ZrO2, UNCOAT Fe
MCB-61	25	165.0	UNPOLISHD ZrO2,Cu-COAT Fe
MCB-62	25	77.0	POLISHD ZrO2, UNCOAT Fe
MCB-63	25	11.0	POLISHD ZrO2,Cu-COAT Fe
MCB-79	400	140.0	UNPOLISHD ZrO2,Cu-COAT Fe
MCB-96	400	28.0	UNPOLISHD ZrO2,Cu-COAT Fe

BASE MATERIAL = MS-PSZ
BASE MATERIAL BATCH CODE = NILSEN/ORNL/J1
REFERENCE CODE = SA10ORNL172
OTHER MATERIAL = TITANIUM
OTHER MATERIAL BATCH CODE = ASTM/B265 GR1

FILLER MATERIAL = INCUSIL-15ABA
JOINT METHOD = ACTIVE FILLER METAL
JOINT PROCESS = BRAZED IN VAC@770C
TESTS WERE PERFORMED IN AIR

A pad/bar type specimen was used, with the pad 12.7x12.7x5.1mm and the bar 12.7x 5.1x3.4mm.The pad is OTHER MATERIAL, the bar is BASE MATERIAL.
The AFM (active filler metal) method used Incusil-15 ABA, composed of Ag-23.5Cu-14.5In-1.3Ti (wt%). Testing was done in a pad/bar tester on a 44.5kN Instron tensile machnine equipped with a clam-shell furnace and a quartz line for elevated temperature testing. Work was performed at Oak Ridge National Laboratory by Mike Santella.

SPECIMEN CODE	TEMP °C	POST-BRAZE HEAT TREATMENT	SHEAR STRENGTH MPa	COMMENTS
MCB-111	400	400C/100h	67.0	UNPOLISHD ZrO2
MCB-187	25	400C/500h	39.0	UNPOLISHD ZrO2
MCB-188	25	400C/500h	111.0	UNPOLISHD ZrO2
MCB-108	25	AS BRAZED	289.0	UNPOLISHD ZrO2
MCB-109	400	AS BRAZED	123.0	UNPOLISHD ZrO2

SECTION 10. SHEAR STRENGTH OF BRAZED SPECIMENS, CONTINUED

BASE MATERIAL = MS-PSZ/ TITANIUM COATING
BASE MATERIAL BATCH CODE = NILSEN/ORNL/J1
REFERENCE CODE = SA10ORNL170
OTHER MATERIAL = CAST IRON/COPPER COATING
OTHER MATERIAL BATCH CODE = CUMMINS/GR.8003

FILLER MATERIAL = BR 604
JOINT METHOD = ACTIVE SUBSTRATE
JOINT PROCESS = BRAZED IN VAC@735C
TESTS WERE PERFORMED IN AIR

A pad/bar type specimen was used, with the pad 12.7x12.7x5.1mm and the bar 12.7x 5.1x3.4mm.The pad is OTHER MATERIAL, the bar is BASE MATERIAL. The joint was produced by active substrate: the zirconia specimens were vapor coated with pure titanium to .6 micrometers thick. Specimens were not preheated before coating. The nodular cast iron specimens were cleaned, then electroplated with pure copper to improve wetting and bonding capabilities. All brazing was done in a vacuum. Handy & Harmon Braze 604 (BVAg-18) composed of Ag-30Cu-10Sn (wt%) was the filler material.

SPECIMEN CODE	TEMP °C	POST-BRAZE HEAT TREATMENT	SHEAR STRENGTH MPa	COMMENTS
MCB-65	25	AS BRAZED	194.0	
MCB-66	25	AS BRAZED	191.0	
MCB-70	400	AS BRAZED	85.0	
MCB-71	400	AS BRAZED	96.0	
MCB-73	400	400C/100h	30.0	

BASE MATERIAL = MS-PSZ/ TITANIUM COATING
BASE MATERIAL BATCH CODE = NILSEN/ORNL/J1
REFERENCE CODE = SA10ORNL170
OTHER MATERIAL = TITANIUM
OTHER MATERIAL BATCH CODE = ASTM/B265 GR1

FILLER MATERIAL = BR 604
JOINT METHOD = ACTIVE SUBSTRATE
JOINT PROCESS = BRAZED IN VAC@735C
TESTS WERE PERFORMED IN AIR

A pad/bar type specimen was used, with the pad 12.7x12.7x5.1mm and the bar 12.7x 5.1x3.4mm.The pad is OTHER MATERIAL, the bar is BASE MATERIAL. The joint was produced by active substrate: the zirconia specimens were vapor coated with pure titanium to .6 micrometers thick. Specimens were not preheated before coating. All brazing was done in a vacuum. Handy & Harmon Braze 604 (BVAg-18), composed of Ag-30Cu-10Sn (wt%), was the filler material.

SPECIMEN CODE	TEMP °C	POST-BRAZE HEAT TREATMENT	SHEAR STRENGTH MPa	COMMENTS
MCB-97	25	AS BRAZED	262.0	
MCB-98	400	AS BRAZED	133.0	
MCB-171	25	400C/500h	291.0	
MCB-172	25	400C/500h	259.0	
MCB-100	400	400C/100h	123.0	

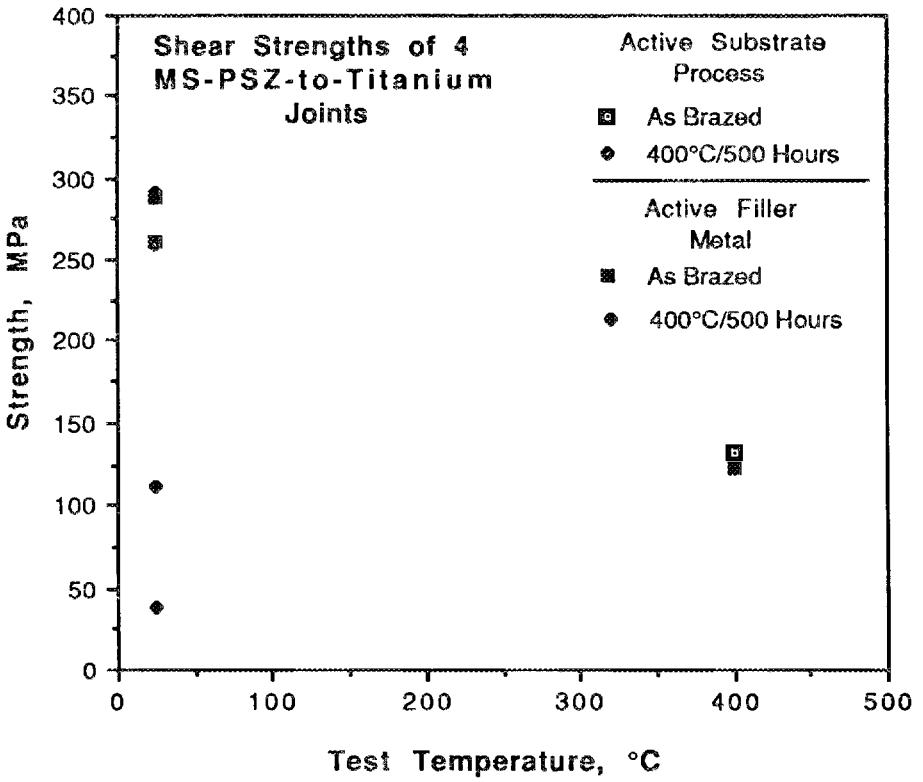


Figure 2.45. Shear strengths of four MS-PSZ-titanium joints made with different processes and heat treatments.

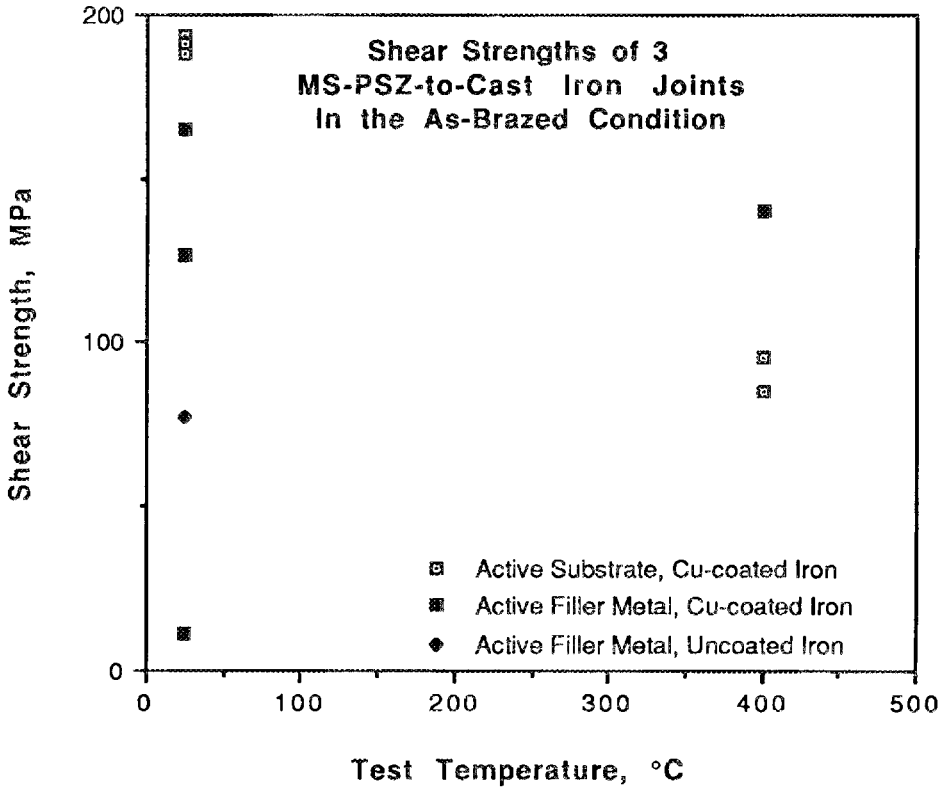


Figure 2.46. Shear strengths of three MS-PSZ-to-Cast Iron joints, all in the as-brazed condition.

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