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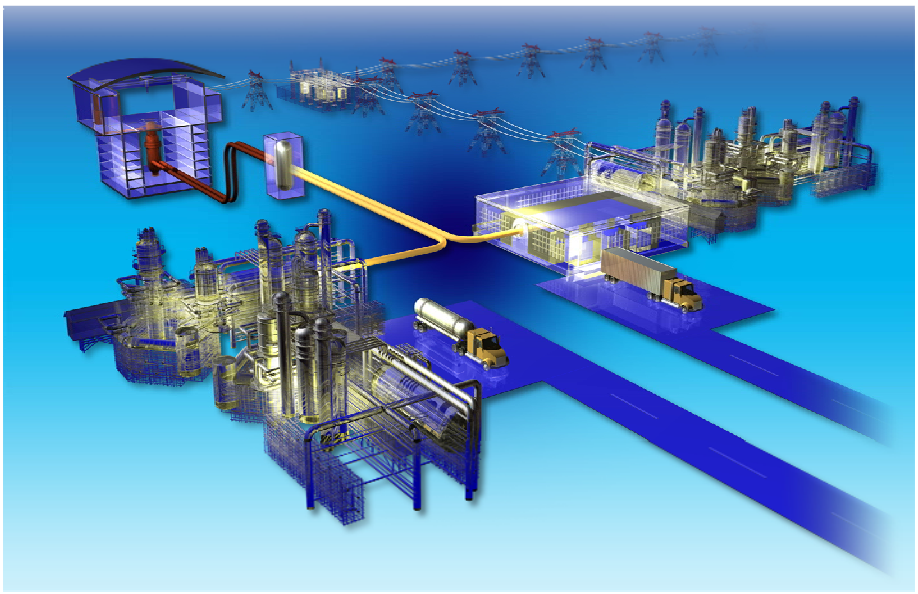
ORNL/TM-2010/285

AGC-1 Specimen Pre-irradiation Data Report

Tim Burchell, Joe Strizak, and Marie Williams
Oak Ridge National Laboratory

October 26, 2010



Prepared for
Office of Nuclear Energy Science and Technology

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
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U.S. DEPARTMENT OF ENERGY
Under DOE Contract No. DE-AC05-00OR22725

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ABREVIATIONS

AFCI	Advanced Fuel Cycle Initiative
AG	Against-Grain
AGC	ATR Graphite Creep
ASTM	American Society of Testing and Materials
ATR	Advanced Test Reactor
CTE	Coefficient of Thermal Expansion
DSC	Differential Scanning Calorimeter
GTMHR	Gas Turbine Modular Reactor
HOPG	Highly Oriented Pyrolytic Graphite
HTR	High Temperature Reactor
HTTR	High Temperature test Reactor
laser	Light amplified stimulated emission radiation
NIST	National Institute of Standards and Technology
NGNP	Next Generation Nuclear Plant
ORNL	Oak Ridge National Laboratory
PBMR	Pebble Bed Modular Reactor
SD	Standard Deviation
VHTR	Very High Temperature Reactor
WG	With-Grain
XRD	X-Ray Diffraction

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Summary

The AGC-1 irradiation capsule will provide irradiation creep design data and data for the effects of irradiation creep on key physical properties of several candidate graphites for the Next Generation Nuclear Plant (NGNP). A further objective of the AGC-1 creep capsule is to provide design data for the effects of neutron irradiation on the properties of a range of NGNP candidate graphites,

Pre-irradiation examination (characterization) of AGC-1 graphite creep specimens for the major grades, i.e., NBG-17, NBG-18, H-451, PCEA, IG-110, and IG-430 has been performed and is reported here. Moreover, pre-irradiation examination (characterization) of AGC-1 graphite "piggy-back" specimens for the minor grades, i.e., A3-Matrix, HLM, PGX, PPEA, NBG-25, S-2020, PCIB, BAN, NBG-10, has been performed and is also reported here. Pre-irradiation examination consisted of precise dimensional measurements (before and after heating to 800°C in the dilatometer) and non-destructive characterization of the physical properties. The properties measured were: bulk density by mensuration, electrical resistivity, elastic constants, including flexural dynamic Young's modulus (fundamental frequency method), and sonic elastic constants, including Young's modulus, shear modulus, and Poisson's ratio; ambient temperature thermal conductivity, and Thermal Expansion (RT-800°C). Significant differences were noted in the physical properties between the grades examined and are attributed to factors such as density, structure (filler particle size and pore size) and the forming method. A comparison of the specimen dimensions before and after heating (thermal expansion measurement) revealed significant residual dimensional change. It is strongly recommended that all AGC specimens be subjected to final measurements after thermal testing. The data reported here was previously delivered to INL as a data package in 2008 [1]. A number of transcription errors were identified and corrected during data evaluation. The future occurrence of such errors is unlikely since our testing and measurement equipment is in the process of upgrade to allow electronic data recording.

A sufficient body of experimental data has been acquired from the AGC-1 creep specimens and their "sister" specimens to fully characterize the properties of interest (for

the major grades) for the purpose of the AGC-1 experiment. These data, evaluated and reported here, provide a sound and sufficient pre-irradiation data set for determination of the effects of irradiation induced dimensional change and creep strain on the physical properties of the nuclear graphite grades in the AGC-1 capsule.

1. Background

The AGC-1 irradiation capsule [2, 3] will provide irradiation creep design data, and data for the effects of irradiation creep on key physical properties, of several candidate graphites for the Next Generation Nuclear Plant (NGNP) program. A further objective is to provide design data for the effects of neutron irradiation on the properties of a range of NGNP relevant graphites, such data to include: dimensional changes, strength, elastic modulus, thermal conductivity and coefficient of thermal expansion (CTE).

The experimental plan for the evaluation of AGC-1 specimens [4] defined the work scope of an experimental program to characterize the structure and determine the tensile and compressive strengths of the graphites included in the AGC-1 irradiation creep capsule [2, 3]. Because these tests are of a destructive nature they were performed on duplicate or "sister" specimens with the same geometry as the AGC-1 creep specimens. These data are needed to support the design of graphite components for the NGNP.

The data to be obtained from the AGC-1 irradiation creep capsule includes:

- Irradiation creep design data and data on the effects of irradiation creep on key physical properties [strength, elastic modulus, CTE]
- The effects of neutron irradiation on the properties of a wide range of NGNP relevant graphites, including, dimensional changes, strength, elastic modulus, thermal conductivity, and CTE.
- Data on the single-crystal irradiation behavior of graphites to be derived from highly oriented pyrolytic graphite (HOPG).

The graphites grades to be included in the AGC-1 capsule can be categorized as follows.

a. Major Grades
   These graphites are reactor vendor's candidates for the core structures of NGNP, and include four new grades (NBG-17, NBG-18, PCEA, and IG-430) as well as

two historical (reference) grades (H-451 and IG-110). These grades are most likely to receive reasonably large neutron doses in their lifetime and will be subjected to significant stresses in operation. Consequently, these grades occupy the stressed and companion unstressed positions in the AGC-1 capsule and hence yield irradiation creep data.

b. Minor Grades

These grades are NGNP relevant grades that are most likely to be used in low neutron dose regions of the core; e.g., the permanent structure of the prismatic block very high temperature reactor (VHTR) design and includes grades PGX and HLM.

c. Alternate Grades

Grades that NGNP vendors have identified as being of interest as alternate graphites for certain components within the reactor, and includes grades PPEA and PCIB.

d. Experimental Grades

Two experimental graphites are included in AGC-1 (BAN and A3 matrix). BAN graphite is an experimental grade whose manufacturing process and raw materials are such that it should offer superior irradiation stability. A3 matrix is the blend of graphites and carbonized phenolic resin used as the matrix in the NGNP fuel compact or fuel pebble. Samples of A3 matrix were obtained from the NGNP program and were produced at Oak Ridge National Laboratory (ORNL).

e. Single Crystal Graphite

The dimensional change behavior of graphite is particularly significant to the behavior of polycrystalline (polygranular) graphites. Therefore, samples of HOPG are included in AGC-1.

A more complete description of all of the graphite samples included in capsule AGC-1 is given in the AGC-1 Experimental Plan [2].

This report contains the following information as required by the experimental plan [2]:

- Graphite grades and billet sizes
- Sample cutting plans and drawings
- Specimen numbering scheme
- Test/experimental methods
- Revised AGC-1 layout and loading plans with specimen identity numbers [3]
- Pre-irradiation examination data for creep, control, and piggy-back samples
- Evaluation and analysis of the data.

Destructive measurement data from “sister” specimens are reported elsewhere [6].

2. Experimental

2.1 Materials

The graphites to be included in AGC-1 are given in Table1 along with information on their potential application in an NGNP. Creep data will be obtained for six major graphite grades; i.e., both stressed and unstressed samples of these grades are included in the capsule. The major grades are H-451 and IG-110, both of which are included as reference graphites, and four new grades, PCEA, NBG-17, NBG-18, and IG-430. These four graphites are all contenders for use in potential NGNP designs such as the Pebble Bed Modular Reactor (PBMR) or prismatic block reactors such as the General Atomics' design Gas Turbine Modular Helium Reactor (GTMHR) or Framatome/AREVA's prismatic reactor design. In addition, AGC-1 contains ten minor grades of graphite. These minor grades are not located in the stressed section of the capsule, and thus no creep data will be generated for them. However, as discussed subsequently, they will yield significant amounts of design data. The minor grades include candidates for lower dose locations in the prismatic reactor designs, such as permanent reflectors and core supports components, and include grades HLM, PGX, PCIB, NBG-25, and 2020. Three additional grades of graphite are included in AGC-1 because of their interest to the NGNP program, grades NBG-10, PPEA, and BAN. Grade NBG-10 is an extruded grade and its behavior is of interest in comparison with the vibrationally molded grades NBG-17 and -18. Grade PPEA provides a comparison of the performance of identical pitch-coke and petroleum-coke graphites. BAN graphite is an experimental grade that is expected to exhibit superior irradiation behavior. A3 fuel matrix (a graphite filler carbonized resin binder material) is included to yield dimensional change and physical property data for the NGNP fuels research program. Finally, samples of HOPG are included to provide vital data on the crystal dimensional change rates.

Table 1. Experiment AGC-1 graphite materials test matrix

Graphite	Reactor Vendor	Proposed Use	Capsule Location	Remarks
H-451	General Atomics	Prismatic fuel element and replaceable reflector	Creep	Historical Reference Only a few samples
IG-110	JAERI, INET	Prismatic fuel element, replaceable reflector, and core support pedestals Pebble bed reflector	Creep	Historical Reference Only a few samples Currently being used in the HTTR and HTR-10
PCEA	AREVA	Prismatic fuel and replaceable block	Creep	AREVA wants to construct the entire graphite core out of the same graphite
NBG-18	PBMR AREVA	Pebble bed reflector structure and insulation blocks Prismatic Fuel element and replaceable reflector;	Creep	Candidate for PBMR replaceable reflector
NBG-17	AREVA PBMR	Prismatic Fuel element and replaceable reflector Pebble bed reflector structure and insulation blocks	Creep	AREVA wants to construct the entire graphite core out of the same graphite. NBG-17 is finer grain than NBG-18
IG-430	JAERI	Prismatic fuel element, replaceable reflector, and core support pedestals	Creep	JAERI wants to use this graphite in the GTHTR 300
HLM		Prismatic large permanent reflector	Piggy-back	Fort St. Vrain permanent reflector. Similar to PGX
PGX	AREVA JAERI	Prismatic large permanent reflector	Piggy-back	AREVA may use this material; preference is to use PCEA or NBG-17 for Permanent reflector. HTTR permanent structure.
NBG-25		Core support candidate	Piggy-back	Isostatic fine grain
2020		Prismatic core support pedestals and blocks	Piggy-back	Fine grain isotropic NPR candidate material
PCIB		Core support candidate	Piggy-back	Fine grain isotropic
BAN			Piggy-back	Experimental graphite with potentially superior irradiation life
NBG-10	PBMR	Prismatic Fuel element and replaceable reflector Pebble bed reflector structure and insulation blocks	Piggy-back	PBMR's original choice for replaceable reflector Price/performance will be the basis between NBG-18 and NBG-10

Graphite	Reactor Vendor	Proposed Use	Capsule Location	Remarks
PPEA		Needed to provide comparison with PCEA	Piggy-back	Provides direct comparison of pitch coke and petroleum coke graphite performance
HOPG		Needed to determine change in crystalline structure	Piggy-back	Provides insight to single crystal changes during neutron irradiation
A3 Matrix		Needed to determine fuel compact irradiated material behavior	Piggy-back	Provides dimensional change and thermal conductivity data for matrix materials

Capsule AGC-1 graphite grades, vendors, and available processing information are given in Table 2.

Table 2. Capsule AGC-1 graphite grades, vendors, and available processing information

Graphite Grade	Source	Country of Origin	Process Details
NBG-17	SGL Carbon	Germany/France	Pitch coke, vibrationally molded, medium grain
NBG-18	SGL Carbon	Germany/France	Pitch coke, vibrationally molded, medium grain
H-451 (Reference Grade)	SGL Carbon	USA	Petroleum coke, extruded, medium grain
PCEA	GrafTech International	USA	Petroleum coke, extruded, medium grain
IG-110 (Reference Grade)	Toyo Tanso	Japan	Petroleum coke, isostatically molded, fine grain
IG-430	Toyo Tanso	Japan	Pitch coke, isostatically molded, fine grain
Highly Oriented Pyrolytic Graphite (HOPG)	Advanced Ceramics	USA	Gas phase deposition, high temperature annealed
A3 Matrix Graphite/Carbon	ORNL	USA	Blend of natural flake & manufactured graphite powders, phenolic resin bonded, hot pressed & carbonized
HLM	SGL Carbon	USA	Petroleum coke, extruded, medium grain
PGX	GrafTech International	USA	Petroleum coke, molded, medium grain
PPEA	GrafTech International	USA	Pitch coke, extruded, medium grain
NBG-25	SGL Carbon	Germany/France	Isostatically molded, fine grained
2020	Carbone of America	USA	Isostatically molded, fine grained
PCIB	GrafTech International	USA	Petroleum coke, Isostatically molded, fine grained
BAN	GrafTech International	USA	Petroleum (needle) coke, secondary/green coke process, extruded, medium grain
NBG-10	SGL Carbon	France	Pitch coke, extruded, medium grain

Table 3 identifies the codes that were used to designate the graphite grades included in capsule AGC-1.

Table 3. Graphite grade marking codes to be used for the AGC series of experiments

Graphite Code Letter	Graphite Grade
A	NBG-17
B	NBG-18
C	H-451
D	PCEA
E	IG-110
F	IG-430
G	HOPG
H	A3-MATRIX
J	HLM
K	PGX
L	PPEA
M	NBG-25
N	2020
P	PCIB
R	BAN
S	NBG-10

Each specimen was individually packaged and the container marked with a unique number (ORNL Specimen Tracking Number). The number was comprised of several (alpha-numeric) digits, such as:

EW2-01

The first digit defines the graphite grade (see Table 3). The next digit defines the specimen orientation, **W** for with-grain and **A** for against grain. The final combination of numbers precisely defines the specimen location with the graphite billet/block which can be determined from the billet cutting and specimen extraction plans in Figs 2 through 26.

Additionally the specimens were laser engraved with their capsule position code, such as "2S15" (Fig. 1). The first digit defined the AGC-1 capsule channel (there are six peripheral channels in AGC-1), the second digit indicated the stress state (S for stressed and U for unstressed) and the last digits indicate the specimen position in the channel (the position number increases as you move away from the reactor flux mid-line). Originally the specimen channel location numbering system, as defined in the Experimental Plan [2] assumed the capsule would have three channels each at two stress levels (2 ksi and 3 ksi). However, during the final stages of the capsule design the possibility of an excessive bending moment on the capsule resulting from the

unsymmetrical channel loading pattern forced a redesign in which opposing channels carried identical load negating and bending moments. Consequently the AGC-1 capsule actually has three stress levels (2, 2.5, and 3 ksi) and with two channels at each stress.

Fig. 1. Typical AGC-1 creep specimen showing laser engraved unique number

The AGC-1 capsule redesign forced a revision in the experimental layout within the capsule. Consequently a revised capsule layout was planned [3]. Unfortunately, by the time the need for this revision was apparent the graphite specimens had been prepared, engraved, and pre-irradiation examination had been completed. Consequently, the specimen laser engraved numbers, whilst still unique, no longer indicate the specimen's location in the AGC-1 capsule.

A complete listing of the specimens examined and reported here is in Tables 4-24. The INL drawing item for each specimen is given along with the ORNL sample identities.

2.2 Specimen Extraction Plans

Figures 2 - 26 provide cutting plans for the various graphite billets/block acquired for this work. Each graphite grade was acquired with appropriate paper work attesting to its grade authenticity and was subjected to independent chemical analysis [1] to assure the graphite did not contain any undesirable chemical elements.

Table 4. Grade NBG-17 AGC-1 creep specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
NBG-17	A	1S3	34	.500 x 1.000	Creep	AW1-01
NBG-17	A	1S11	34	.500 x 1.000	Creep	AW1-02
NBG-17	A	1S12	34	.500 x 1.000	Creep	AW1-03
NBG-17	A	1S13	34	.500 x 1.000	Creep	AL6-01
NBG-17	A	1U3	50	.500 x 1.000	Creep	AW2-01
NBG-17	A	1U11	50	.500 x 1.000	Creep	AW2-02
NBG-17	A	1U12	50	.500 x 1.000	Creep	AW2-03
NBG-17	A	2S4	34	.500 x 1.000	Creep	AL6-02
NBG-17	A	2S6	34	.500 x 1.000	Creep	AW4-01
NBG-17	A	2S10	34	.500 x 1.000	Creep	AL6-03
NBG-17	A	2U4	50	.500 x 1.000	Creep	AW4-02
NBG-17	A	2U6	50	.500 x 1.000	Creep	AW4-03
NBG-17	A	2U10	50	.500 x 1.000	Creep	AW5-01
NBG-17	A	3S8	34	.500 x 1.000	Creep	AL8-01
NBG-17	A	3S13	34	.500 x 1.000	Creep	AW5-02
NBG-17	A	3U8	50	.500 x 1.000	Creep	AW5-03
NBG-17	A	3U12	50	.500 x 1.000	Creep	AW6-01
NBG-17	A	4S8	34	.500 x 1.000	Creep	AW6-02
NBG-17	A	4S11	34	.500 x 1.000	Creep	AL8-02
NBG-17	A	4S12	34	.500 x 1.000	Creep	AW6-03
NBG-17	A	4U8	50	.500 x 1.000	Creep	AW7-01
NBG-17	A	4U11	50	.500 x 1.000	Creep	AW7-02
NBG-17	A	5S3	34	.500 x 1.000	Creep	AL8-03
NBG-17	A	5S6	34	.500 x 1.000	Creep	AW7-03
NBG-17	A	5S14	34	.500 x 1.000	Creep	AW9-01
NBG-17	A	5U3	50	.500 x 1.000	Creep	AW9-02
NBG-17	A	5U6	50	.500 x 1.000	Creep	AW9-03
NBG-17	A	5U13	50	.500 x 1.000	Creep	AW10-01
NBG-17	A	6S1	34	.500 x 1.000	Creep	AW10-02
NBG-17	A	6S8	34	.500 x 1.000	Creep	AW10-03
NBG-17	A	6S15	34	.500 x 1.000	Creep	AW12-01
NBG-17	A	6U1	50	.500 x 1.000	Creep	AW12-02
NBG-17	A	6U8	50	.500 x 1.000	Creep	AW12-03
NBG-17	A	6U14	50	.500 x 1.000	Creep	AW13-01
NBG-17	A	Spare 1A	50	.500 x 1.000	Creep	AL7-01
NBG-17	A	Spare 2A	50	.500 x 1.000	Creep	AL7-07
NBG-17	A	Spare 1W	50	.500 x 1.000	Creep	AW13-02
NBG-17	A	Spare 2W	50	.500 x 1.000	Creep	AW13-03

Table 5. Grade NBG-17 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
NBG-17	A	1PB16	64	.500 x .250 x .126	C	AW14C01
NBG-17	A	2PB16	64	.500 x .250 x .126	C	AW14C02
NBG-17	A	3PB16	64	.500 x .250 x .126	C	AW14C04
NBG-17	A	4PB16	64	.500 x .250 x .126	C	AW15C02
NBG-17	A	Spare 1	64	.500 x .250 x .126	C	AW15C03
NBG-17	A	Spare 2	64	.500 x .250 x .126	C	AW15C06
NBG-17	A	1PB1	16	.250 x .250	D	AW16D01
NBG-17	A	1PB7	16	.250 x .250	D	AW16D02
NBG-17	A	1PB12	16	.250 x .250	D	AW16D03
NBG-17	A	2PB6	16	.250 x .250	D	AW16D04
NBG-17	A	2PB15	16	.250 x .250	D	AW16D05
NBG-17	A	3PB4	16	.250 x .250	D	AW16D06
NBG-17	A	3PB8	16	.250 x .250	D	AW17D01
NBG-17	A	3PB12	16	.250 x .250	D	AW17D02
NBG-17	A	3PB13	16	.250 x .250	D	AW17D03
NBG-17	A	3PB15	16	.250 x .250	D	AW17D04
NBG-17	A	4PB4	16	.250 x .250	D	AW17D05
NBG-17	A	4PB6	16	.250 x .250	D	AW17D06
NBG-17	A	4PB10	16	.250 x .250	D	AW18D01
NBG-17	A	4PB12	16	.250 x .250	D	AW18D02
NBG-17	A	4PB14	16	.250 x .250	D	AW18D03
NBG-17	A	4PB15	16	.250 x .250	D	AW18D04
NBG-17	A	Spare 1	16	.250 x .250	D	AW18D05
NBG-17	A	Spare 2	16	.250 x .250	D	AW18D06

Table 6. Grade NBG-18 AGC-1 creep specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
NBG-18	B	1S1	35	.500 x 1.000	Creep	BL6-01
NBG-18	B	1S4	35	.500 x 1.000	Creep	BW1-01
NBG-18	B	1U1	48	.500 x 1.000	Creep	BW1-02
NBG-18	B	1U4	48	.500 x 1.000	Creep	BW1-03
NBG-18	B	2S2	35	.500 x 1.000	Creep	BW2-01
NBG-18	B	2S11	35	.500 x 1.000	Creep	BW2-02
NBG-18	B	2S12	35	.500 x 1.000	Creep	BL6-02
NBG-18	B	2U2	48	.500 x 1.000	Creep	BW2-03
NBG-18	B	2U11	48	.500 x 1.000	Creep	BW3-01
NBG-18	B	3S2	35	.500 x 1.000	Creep	BW3-02
NBG-18	B	3S11	35	.500 x 1.000	Creep	BW3-03
NBG-18	B	3S12	35	.500 x 1.000	Creep	BL6-03
NBG-18	B	3S14	35	.500 x 1.000	Creep	BW5-01
NBG-18	B	3U2	48	.500 x 1.000	Creep	BW5-02
NBG-18	B	3U11	48	.500 x 1.000	Creep	BW5-03
NBG-18	B	3U13	48	.500 x 1.000	Creep	BW7-01
NBG-18	B	4S5	35	.500 x 1.000	Creep	BW7-02
NBG-18	B	4S7	35	.500 x 1.000	Creep	BL7-01
NBG-18	B	4S14	35	.500 x 1.000	Creep	BW7-03
NBG-18	B	4U5	48	.500 x 1.000	Creep	BW8-01
NBG-18	B	4U7	48	.500 x 1.000	Creep	BW8-02
NBG-18	B	4U13	48	.500 x 1.000	Creep	BW8-03
NBG-18	B	5S5	35	.500 x 1.000	Creep	BL7-02
NBG-18	B	5S8	35	.500 x 1.000	Creep	BW9-01
NBG-18	B	5S15	35	.500 x 1.000	Creep	BW9-02
NBG-18	B	5U5	48	.500 x 1.000	Creep	BW9-03
NBG-18	B	5U8	48	.500 x 1.000	Creep	BW10-01
NBG-18	B	5U14	48	.500 x 1.000	Creep	BW10-02
NBG-18	B	6S3	35	.500 x 1.000	Creep	BL7-03
NBG-18	B	6S6	35	.500 x 1.000	Creep	BW10-03
NBG-18	B	6S13	35	.500 x 1.000	Creep	BW11-01
NBG-18	B	6U3	48	.500 x 1.000	Creep	BW11-02
NBG-18	B	6U6	48	.500 x 1.000	Creep	BW11-03
NBG-18	B	6U12	48	.500 x 1.000	Creep	BW12-01
NBG-18	B	Spare 1A	48	.500 x 1.000	Creep	BL8-01
NBG-18	B	Spare 2A	48	.500 x 1.000	Creep	BL8-02
NBG-18	B	Spare 1W	48	.500 x 1.000	Creep	BW12-02
NBG-18	B	Spare 2W	48	.500 x 1.000	Creep	BW12-03

BL8-01 was subsequently rejected upon receipt inspection at INL

Table 7. Grade NBG-18 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
NBG-18	B	1PB18	66	.500 x .250 x .126	C	BW14C01
NBG-18	B	1PB25	66	.500 x .250 x .126	C	BW14C02
NBG-18	B	2PB18	66	.500 x .250 x .126	C	BW14C03
NBG-18	B	2PB24	66	.500 x .250 x .126	C	BW14C04
NBG-18	B	3PB18	66	.500 x .250 x .126	C	BW14C05
NBG-18	B	4PB18	66	.500 x .250 x .126	C	BW15C02
NBG-18	B	4PB23	66	.500 x .250 x .126	C	BW15C03
NBG-18	B	4PB25	66	.500 x .250 x .126	C	BW15C04
NBG-18	B	Spare 1	66	.500 x .250 x .126	C	BW15C05
NBG-18	B	Spare 2	66	.500 x .250 x .126	C	BW15C08
NBG-18	B	1PB3	18	.250 x .250	D	BW16D01
NBG-18	B	1PB4	18	.250 x .250	D	BW16D02
NBG-18	B	1PB9	18	.250 x .250	D	BW16D03
NBG-18	B	1PB14	18	.250 x .250	D	BW16D04
NBG-18	B	2PB9	18	.250 x .250	D	BW16D05
NBG-18	B	2PB11	18	.250 x .250	D	BW17D01
NBG-18	B	2PB13	18	.250 x .250	D	BW17D02
NBG-18	B	3PB1	18	.250 x .250	D	BW17D03
NBG-18	B	3PB5	18	.250 x .250	D	BW17D04
NBG-18	B	3PB9	18	.250 x .250	D	BW17D06
NBG-18	B	4PB2	18	.250 x .250	D	BW18D03
NBG-18	B	4PB8	18	.250 x .250	D	BW18D04
NBG-18	B	Spare 1	18	.250 x .250	D	BW18D05
NBG-18	B	Spare 2	18	.250 x .250	D	BW18D08

Table 8. Grade H-451 AGC-1 creep specimens examined and reported here

Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
H-451	C	1S8	32	.500 x 1.000	Creep	CW7-01
H-451	C	1S15	32	.500 x 1.000	Creep	CW7-03
H-451	C	1U8	52	.500 x 1.000	Creep	CW8-02
H-451	C	1U14	52	.500 x 1.000	Creep	CW8-03
H-451	C	2S13	32	.500 x 1.000	Creep	CW9-01
H-451	C	2U12	52	.500 x 1.000	Creep	CW9-02
H-451	C	3S1	32	.500 x 1.000	Creep	CW9-03
H-451	C	3S10	32	.500 x 1.000	Creep	CW10-01
H-451	C	3U1	52	.500 x 1.000	Creep	CW10-02
H-451	C	3U10	52	.500 x 1.000	Creep	CW10-03
H-451	C	4S2	32	.500 x 1.000	Creep	CW11-01
H-451	C	4S13	32	.500 x 1.000	Creep	CW11-02
H-451	C	4U2	52	.500 x 1.000	Creep	CW11-03
H-451	C	4U12	52	.500 x 1.000	Creep	CW12-01
H-451	C	5S7	32	.500 x 1.000	Creep	CW12-02
H-451	C	5U7	52	.500 x 1.000	Creep	CW13-01
H-451	C	6S5	32	.500 x 1.000	Creep	CW13-02
H-451	C	6S9	32	.500 x 1.000	Creep	CW13-03
H-451	C	6U5	52	.500 x 1.000	Creep	CW14-01
H-451	C	6U9	52	.500 x 1.000	Creep	CW14-02
H-451	C	Spare 1	52	.500 x 1.000	Creep	CW15-01
H-451	C	Spare 2	52	.500 x 1.000	Creep	CW15-02

Table 9. Grade H-451 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID nunber
H-451	C	2PB20	65	.500 x .250 x .126	C	CW1C02
H-451	C	3PB20	65	.500 x .250 x .126	C	CW1C03
H-451	C	4PB20	65	.500 x .250 x .126	C	CW1C04
H-451	C	6PB21	65	.500 x .250 x .126	C	CW2C01
H-451	C	Spare 1	65	.500 x .250 x .126	C	CW2C03
H-451	C	Spare 2	65	.500 x .250 x .126	C	CW1C05
H-451	C	1PB2	17	.250 x .250	D	CW3D01
H-451	C	1PB5	17	.250 x .250	D	CW3D02
H-451	C	1PB11	17	.250 x .250	D	CW3D04
H-451	C	2PB2	17	.250 x .250	D	CW4D01
H-451	C	3PB11	17	.250 x .250	D	CW4D02
H-451	C	Spare 1	17	.250 x .250	D	CW5D01
H-451	C	Spare 2	17	.250 x .250	D	CW5D03

Table 10. Grade PCEA AGC-1 creep specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID nunber
PCEA	D	1S2	33	.500 x 1.00	Creep	DW1-01
PCEA	D	1S6	33	.500 x 1.00	Creep	DW1-02
PCEA	D	1S14	33	.500 x 1.00	Creep	DW1-03
PCEA	D	1U2	49	.500 x 1.00	Creep	DW2-01
PCEA	D	1U6	49	.500 x 1.00	Creep	DW2-02
PCEA	D	1U13	49	.500 x 1.00	Creep	DW2-03
PCEA	D	2S1	33	.500 x 1.00	Creep	DW3-01
PCEA	D	2S8	33	.500 x 1.00	Creep	DW3-02
PCEA	D	2S14	33	.500 x 1.00	Creep	DW3-03
PCEA	D	2U8	49	.500 x 1.00	Creep	DW-401
PCEA	D	2U1	49	.500 x 1.00	Creep	DW4-03
PCEA	D	2U13	49	.500 x 1.00	Creep	DW5-01
PCEA	D	3S6	33	.500 x 1.00	Creep	DA601
PCEA	D	3S15	33	.500 x 1.00	Creep	DW5-02
PCEA	D	3U6	49	.500 x 1.00	Creep	DW5-03
PCEA	D	3U14	49	.500 x 1.00	Creep	DW6-01
PCEA	D	4S1	33	.500 x 1.00	Creep	DA602
PCEA	D	4S6	33	.500 x 1.00	Creep	DA701
PCEA	D	4S15	33	.500 x 1.00	Creep	DW6-02
PCEA	D	4U1	49	.500 x 1.00	Creep	DW6-03
PCEA	D	4U6	49	.500 x 1.00	Creep	DW7-01
PCEA	D	4U14	49	.500 x 1.00	Creep	DW7-02
PCEA	D	5S4	33	.500 x 1.00	Creep	DW7-03
PCEA	D	5S9	33	.500 x 1.00	Creep	DW8-01
PCEA	D	5S11	33	.500 x 1.00	Creep	DA702
PCEA	D	5S12	33	.500 x 1.00	Creep	DW8-02
PCEA	D	5U4	49	.500 x 1.00	Creep	DW8-03
PCEA	D	5U9	49	.500 x 1.00	Creep	DW9-01
PCEA	D	5U11	49	.500 x 1.00	Creep	DW9-02
PCEA	D	6S4	33	.500 x 1.00	Creep	DW9-03
PCEA	D	6S11	33	.500 x 1.00	Creep	DW10-01
PCEA	D	6S12	33	.500 x 1.00	Creep	DA801
PCEA	D	6U11	49	.500 x 1.00	Creep	DW10-02
PCEA	D	6U4	49	.500 x 1.00	Creep	DW10-03
PCEA	D	Spare 1W	49	.500 x 1.00	Creep	DW11-01
PCEA	D	Spare 2W	49	.500 x 1.00	Creep	DW11-02
PCEA	D	Spare1A	49	.500 x 1.00	Creep	DA802
PCEA	D	Spare2A	49	.500 x 1.00	Creep	DA901

Table 11. Grade PCEA AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
PCEA	D	1PB17	68	.500 x .250 x .126	C	DW14C01
PCEA	D	1PB24	68	.500 x .250 x .126	C	DW14C02
PCEA	D	2PB17	68	.500 x .250 x .126	C	DW14C03
PCEA	D	3PB17	68	.500 x .250 x .126	C	DW14C04
PCEA	D	3PB23	68	.500 x .250 x .126	C	DW14C05
PCEA	D	3PB25	68	.500 x .250 x .126	C	DW15C01
PCEA	D	4PB17	68	.500 x .250 x .126	C	DW15C02
PCEA	D	4PB24	68	.500 x .250 x .126	C	DW15C03
PCEA	D	Spare 1	68	.500 x .250 x .126	C	DW15C04
PCEA	D	Spare 2	68	.500 x .250 x .126	C	DW15C05
PCEA	D	1PB8	20	.250 x .250	D	DW12D01
PCEA	D	1PB13	20	.250 x .250	D	DW12D03
PCEA	D	2PB4	20	.250 x .250	D	DW12D04
PCEA	D	2PB5	20	.250 x .250	D	DW12D05
PCEA	D	2PB10	20	.250 x .250	D	DW12D07
PCEA	D	2PB14	20	.250 x .250	D	DW12D09
PCEA	D	3PB3	20	.250 x .250	D	DW12D10
PCEA	D	3PB7	20	.250 x .250	D	DW13D02
PCEA	D	3PB14	20	.250 x .250	D	DW13D04
PCEA	D	4PB1	20	.250 x .250	D	DW13D05
PCEA	D	4PB5	20	.250 x .250	D	DW13D06
PCEA	D	4PB9	20	.250 x .250	D	DW13D08
PCEA	D	Spare 1	20	.250 x .250	D	DW13D09
PCEA	D	Spare 1	20	.250 x .250	D	DW13D10

Table 12. Grade IG-110 AGC-1 creep specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
IG-110	E	1S7	37	.500 x 1.000	Creep	EW2-01
IG-110	E	1S9	37	.500 x 1.000	Creep	EW2-02
IG-110	E	1U7	53	.500 x 1.000	Creep	EW2-03
IG-110	E	1U9	53	.500 x 1.000	Creep	EW4-01
IG-110	E	2S5	37	.500 x 1.000	Creep	EW4-02
IG-110	E	2S7	37	.500 x 1.000	Creep	EW5-01
IG-110	E	2U5	53	.500 x 1.000	Creep	EW5-02
IG-110	E	2U7	53	.500 x 1.000	Creep	EW5-03
IG-110	E	3S9	37	.500 x 1.000	Creep	EW6-01
IG-110	E	3U9	53	.500 x 1.000	Creep	EW6-02
IG-110	E	4S4	37	.500 x 1.000	Creep	EW6-03
IG-110	E	4S9	37	.500 x 1.000	Creep	EW7-01
IG-110	E	4U4	53	.500 x 1.000	Creep	EW7-03
IG-110	E	4U9	53	.500 x 1.000	Creep	EW8-01
IG-110	E	5S1	37	.500 x 1.000	Creep	EW8-02
IG-110	E	5S13	37	.500 x 1.000	Creep	EW8-03
IG-110	E	5U1	53	.500 x 1.000	Creep	EW9-01
IG-110	E	5U12	53	.500 x 1.000	Creep	EW9-02
IG-110	E	6S14	37	.500 x 1.000	Creep	EW9-03
IG-110	E	6U13	53	.500 x 1.000	Creep	EW10-01
IG-110	E	Spare 1	53	.500 x 1.000	Creep	EW10-02
IG-110	E	Spare 2	53	.500 x 1.000	Creep	EW10-03

Table 13. Grade IG-110 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
IG-110	E	1PB21	67	.500 x .250 x .126	C	EW13C01
IG-110	E	2PB21	67	.500 x .250 x .126	C	EW13C02
IG-110	E	2PB23	67	.500 x .250 x .126	C	EW13C03
IG-110	E	3PB21	67	.500 x .250 x .126	C	EW13C04
IG-110	E	4PB21	67	.500 x .250 x .126	C	EW14C01
IG-110	E	Spare 1	67	.500 x .250 x .126	C	EW14C04
IG-110	E	Spare 2	67	.500 x .250 x .126	C	EW14C05
IG-110	E	1PB6	19	.250 x .250	D	EW11D03
IG-110	E	2PB1	19	.250 x .250	D	EW11D04
IG-110	E	3PB10	19	.250 x .250	D	EW11D06
IG-110	E	4PB13	19	.250 x .250	D	EW11D10
IG-110	E	Spare 1	19	.250 x .250	D	EW12D01
IG-110	E	Spare 2	19	.250 x .250	D	EW12D03

Table 14. Grade IG-430 AGC-1 creep specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
IG-430	F	1S5	36	.500 x 1.000	Creep	FW1-01
IG-430	F	1S10	36	.500 x 1.000	Creep	FW1-02
IG-430	F	1U5	51	.500 x 1.000	Creep	FW1-03
IG-430	F	1U10	51	.500 x 1.000	Creep	FW2-01
IG-430	F	2S3	36	.500 x 1.000	Creep	FW2-02
IG-430	F	2S9	36	.500 x 1.000	Creep	FW2-03
IG-430	F	2S15	36	.500 x 1.000	Creep	FW3-01
IG-430	F	2U3	51	.500 x 1.000	Creep	FW3-02
IG-430	F	2U9	51	.500 x 1.000	Creep	FW3-03
IG-430	F	2U14	51	.500 x 1.000	Creep	FW4-01
IG-430	F	3S3	36	.500 x 1.000	Creep	FW4-02
IG-430	F	3S4	36	.500 x 1.000	Creep	FW4-03
IG-430	F	3S5	36	.500 x 1.000	Creep	FW5-01
IG-430	F	3S7	36	.500 x 1.000	Creep	FW5-02
IG-430	F	3U3	51	.500 x 1.000	Creep	FW5-03
IG-430	F	3U4	51	.500 x 1.000	Creep	FW7-01
IG-430	F	3U5	51	.500 x 1.000	Creep	FW7-02
IG-430	F	3U7	51	.500 x 1.000	Creep	FW7-03
IG-430	F	4S3	36	.500 x 1.000	Creep	FW8-01
IG-430	F	4S10	36	.500 x 1.000	Creep	FW8-02
IG-430	F	4U3	51	.500 x 1.000	Creep	FW8-03
IG-430	F	4U10	51	.500 x 1.000	Creep	FW9-01
IG-430	F	5S2	36	.500 x 1.000	Creep	FW9-02
IG-430	F	5S10	36	.500 x 1.000	Creep	FW9-03
IG-430	F	5U2	51	.500 x 1.000	Creep	FW10-01
IG-430	F	5U10	51	.500 x 1.000	Creep	FW10-02
IG-430	F	6S2	36	.500 x 1.000	Creep	FW10-03
IG-430	F	6S7	36	.500 x 1.000	Creep	FW11-01
IG-430	F	6S10	36	.500 x 1.000	Creep	FW11-02
IG-430	F	6U2	51	.500 x 1.000	Creep	FW11-03
IG-430	F	6U7	51	.500 x 1.000	Creep	FW12-01
IG-430	F	6U10	51	.500 x 1.000	Creep	FW12-02
IG-430	F	Spare 1	51	.500 x 1.000	Creep	FW13-01
IG-430	F	Spare 2	51	.500 x 1.000	Creep	FW13-02

FW1-02 was subsequently rejected upon receipt inspection at INL

Table 15. Grade IG-430 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
IG-430	F	1PB19	69	.500 x .250 x .126	C	FW18C01
IG-430	F	1PB23	69	.500 x .250 x .126	C	FW18C02
IG-430	F	2PB19	69	.500 x .250 x .126	C	FW18C03
IG-430	F	2PB25	69	.500 x .250 x .126	C	FW18C04
IG-430	F	3PB19	69	.500 x .250 x .126	C	FW18C06
IG-430	F	3PB24	69	.500 x .250 x .126	C	FW19C01
IG-430	F	4PB19	69	.500 x .250 x .126	C	FW19C02
IG-430	F	Spare 1	69	.500 x .250 x .126	C	FW19C04
IG-430	F	Spare 2	69	.500 x .250 x .126	C	FW19C05
IG-430	F	1PB10	21	.250 x .250	D	FW16D01
IG-430	F	1PB15	21	.250 x .250	D	FW16D02
IG-430	F	2PB3	21	.250 x .250	D	FW16D03
IG-110	F	2PB7	21	.250 x .250	D	FW16D04
IG-430	F	2PB8	21	.250 x .250	D	FW16D05
IG-430	F	2PB12	21	.250 x .250	D	FW16D07
IG-430	F	3PB2	21	.250 x .250	D	FW16D08
IG-430	F	3PB6	21	.250 x .250	D	FW17D01
IG-430	F	4PB3	21	.250 x .250	D	FW17D03
IG-430	F	4PB7	21	.250 x .250	D	FW17D04
IG-430	F	4PB11	21	.250 x .250	D	FW17D05
IG-430	F	Spare 1	21	.250 x .250	D	FW17D06
IG-430	F	Spare 2	21	.250 x .250	D	FW17D07

Table 16. A3 Matrix AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
A3	H	CPB2	62	.500 x .250	A	H-3-1
A3	H	CPB12	62	.500 x .250	A	H-3-2
A3	H	CPB22	62	.500 x .250	A	H-4-1
A3	H	CPB32	62	.500 x .250	A	H-4-2
A3	H	CPB42	62	.500 x .250	A	H-5-1
A3	H	CPB52	62	.500 x .250	A	H-5-2
A3	H	CPB62	62	.500 x .250	A	H-7-1
A3	H	CPB72	62	.500 x .250	A	H-7-2
A3	H	CPB82	62	.500 x .250	A	H-8-1
A3	H	CPB92	62	.500 x .250	A	H-8-2
A3	H	CPB102	62	.500 x .250	A	H-9-1
A3	H	CPB112	62	.500 x .250	A	H-9-2
A3	H	CPB122	62	.500 x .250	A	H-10-1
A3	H	CPB132	62	.500 x .250	A	H-10-2
A3	H	CPB142	62	.500 x .250	A	H-12-1
A3	H	CPB152	62	.500 x .250	A	H-12-2
A3	H	CPB162	62	.500 x .250	A	H-13-1
A3	H	CPB172	62	.500 x .250	A	H-13-2
A3	H	CPB182	62	.500 x .250	A	H-14-1
A3	H	CPB192	62	.500 x .250	A	H-14-2
A3	H	Spare 1	62	.500 x .250	A	H-15-1
A3	H	Spare 2	62	.500 x .250	A	H-15-2
A3	H	5PB22	39	.500 x .250 x .126	C	H-16-1
A3	H	6PB17	39	.500 x .250 x .126	C	H-16-2
A3	H	6PB22	39	.500 x .250 x .126	C	H-17-1
A3	H	Spare 1	39	.500 x .250 x .126	C	H-18-1
A3	H	Spare 2	39	.500 x .250 x .126	C	H-18-2
A3	H	5PB2	23	.250 x .250	D	H-21-1
A3	H	6PB6	23	.250 x .250	D	H-21-2
A3	H	6PB14	23	.250 x .250	D	H-22-1
A3	H	Spare 1	23	.250 x .250	D	H-22-2
A3	H	Spare 2	23	.250 x .250	D	H-23-2

Table 17. Grade HLM AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
HLM	J	CPB3	54	.500 x .250 x .081	B	J1B03
HLM	J	CPB13	54	.500 x .250 x .081	B	J1B04
HLM	J	CPB23	54	.500 x .250 x .081	B	J1B05
HLM	J	CPB33	54	.500 x .250 x .081	B	J1B06
HLM	J	CPB43	54	.500 x .250 x .081	B	J1B07
HLM	J	CPB53	54	.500 x .250 x .081	B	J2B01
HLM	J	CPB63	54	.500 x .250 x .081	B	J2B03
HLM	J	CPB73	54	.500 x .250 x .081	B	J2B04
HLM	J	CPB83	54	.500 x .250 x .081	B	J2B05
HLM	J	CPB93	54	.500 x .250 x .081	B	J2B06
HLM	J	CPB103	54	.500 x .250 x .081	B	J5B01
HLM	J	CPB113	54	.500 x .250 x .081	B	J5B02
HLM	J	CPB123	54	.500 x .250 x .081	B	J5B04
HLM	J	CPB133	54	.500 x .250 x .081	B	J5B05
HLM	J	CPB143	54	.500 x .250 x .081	B	J5B06
HLM	J	CPB153	54	.500 x .250 x .081	B	J6B01
HLM	J	CPB163	54	.500 x .250 x .081	B	J6B02
HLM	J	CPB173	54	.500 x .250 x .081	B	J6B03
HLM	J	CPB183	54	.500 x .250 x .081	B	J6B05
HLM	J	Spare 1	54	.500 x .250 x .081	B	J6B06
HLM	J	Spare 2	54	.500 x .250 x .081	B	J6B08
HLM	J	6PB18	40	.500 x .250 x .126	C	J3C01
HLM	J	6PB24	40	.500 x .250 x .126	C	J3C04
HLM	J	Spare 1	40	.500 x .250 x .126	C	J7C03
HLM	J	Spare 2	40	.500 x .250 x .126	C	J7C04
HLM	J	5PB3	24	.250 x .250	D	J4D01
HLM	J	6PB7	24	.250 x .250	D	J4D03
HLM	J	6PB13	24	.250 x .250	D	J4D04
HLM	J	Spare 1	24	.250 x .250	D	J8D01
HLM	J	Spare 2	24	.250 x .250	D	J8D09

Table 18. Grade PGX AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
PGX	K	CPB4	55	.500 x .250 x .081	B	K2B01
PGX	K	CPB14	55	.500 x .250 x .081	B	K2B02
PGX	K	CPB24	55	.500 x .250 x .081	B	K2B03
PGX	K	CPB34	55	.500 x .250 x .081	B	K2B04
PGX	K	CPB44	55	.500 x .250 x .081	B	K2B05
PGX	K	CPB54	55	.500 x .250 x .081	B	K2B06
PGX	K	CPB64	55	.500 x .250 x .081	B	K2B07
PGX	K	CPB74	55	.500 x .250 x .081	B	K3B01
PGX	K	CPB84	55	.500 x .250 x .081	B	K3B02
PGX	K	CPB94	55	.500 x .250 x .081	B	K3B03
PGX	K	CPB104	55	.500 x .250 x .081	B	K3B04
PGX	K	CPB114	55	.500 x .250 x .081	B	K3B05
PGX	K	CPB124	55	.500 x .250 x .081	B	K3B06
PGX	K	CPB134	55	.500 x .250 x .081	B	K3B07
PGX	K	CPB144	55	.500 x .250 x .081	B	K6B01
PGX	K	CPB154	55	.500 x .250 x .081	B	K6B02
PGX	K	CPB164	55	.500 x .250 x .081	B	K6B03
PGX	K	CPB174	55	.500 x .250 x .081	B	K6B04
PGX	K	CPB184	55	.500 x .250 x .081	B	K6B05
PGX	K	Spare 1	55	.500 x .250 x .081	B	K6B06
PGX	K	Spare 2	55	.500 x .250 x .081	B	K6B07
PGX	K	6PB19	41	.500 x .250 x .126	C	K4C01
PGX	K	Spare 1	41	.500 x .250 x .126	C	K4C02
PGX	K	Spare 2	41	.500 x .250 x .126	C	K5C01
PGX	K	5PB4	25	.250 x .250	D	K1D01
PGX	K	6PB8	25	.250 x .250	D	K1D02
PGX	K	6PB12	25	.250 x .250	D	K1D03
PGX	K	Spare 1	25	.250 x .250	D	K1D04
PGX	K	Spare 2	25	.250 x .250	D	K1D05

Table 19. Grade PPEA AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
PPEA	L	CPB5	56	.500 x .250 x .081	B	L2B02
PPEA	L	CPB15	56	.500 x .250 x .081	B	L2B03
PPEA	L	CPB25	56	.500 x .250 x .081	B	L2B04
PPEA	L	CPB35	56	.500 x .250 x .081	B	L2B05
PPEA	L	CPB45	56	.500 x .250 x .081	B	L2B06
PPEA	L	CPB55	56	.500 x .250 x .081	B	L2B07
PPEA	L	CPB65	56	.500 x .250 x .081	B	L2B08
PPEA	L	CPB75	56	.500 x .250 x .081	B	L3B03
PPEA	L	CPB85	56	.500 x .250 x .081	B	L3B04
PPEA	L	CPB95	56	.500 x .250 x .081	B	L3B05
PPEA	L	CPB105	56	.500 x .250 x .081	B	L3B06
PPEA	L	CPB115	56	.500 x .250 x .081	B	L3B07
PPEA	L	CPB125	56	.500 x .250 x .081	B	L3B08
PPEA	L	CPB135	56	.500 x .250 x .081	B	L3B09
PPEA	L	CPB145	56	.500 x .250 x .081	B	L6B01
PPEA	L	CPB155	56	.500 x .250 x .081	B	L6B02
PPEA	L	CPB165	56	.500 x .250 x .081	B	L6B03
PPEA	L	CPB175	56	.500 x .250 x .081	B	L6B04
PPEA	L	CPB185	56	.500 x .250 x .081	B	L6B05
PPEA	L	Spare 1	56	.500 x .250 x .081	B	L6B06
PPEA	L	Spare 2	56	.500 x .250 x .081	B	L6B07
PPEA	L	5PB25	42	.500 x .250 x .126	C	L4C01
PPEA	L	6PB20	42	.500 x .250 x .126	C	L4C02
PPEA	L	Spare 1	42	.500 x .250 x .126	C	L5C01
PPEA	L	Spare 2	42	.500 x .250 x .126	C	L5C02
PPEA	L	5PB5	26	.250 x .250	D	L1D01
PPEA	L	5PB15	26	.250 x .250	D	L1D02
PPEA	L	6PB9	26	.250 x .250	D	L1D03
PPEA	L	Spare 1	26	.250 x .250	D	L1D04
PPEA	L	Spare 2	26	.250 x .250	D	L1D05

Table 20. Grade NBG-25 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
NBG-25	M	CPB6	57	.500 x .250 x .081	B	M3B01
NBG-25	M	CPB16	57	.500 x .250 x .081	B	M3B02
NBG-25	M	CPB26	57	.500 x .250 x .081	B	M3B03
NBG-25	M	CPB36	57	.500 x .250 x .081	B	M3B04
NBG-25	M	CPB46	57	.500 x .250 x .081	B	M3B05
NBG-25	M	CPB56	57	.500 x .250 x .081	B	M4B01
NBG-25	M	CPB66	57	.500 x .250 x .081	B	M4B02
NBG-25	M	CPB76	57	.500 x .250 x .081	B	M4B03
NBG-25	M	CPB86	57	.500 x .250 x .081	B	M4B04
NBG-25	M	CPB96	57	.500 x .250 x .081	B	M4B06
NBG-25	M	CPB106	57	.500 x .250 x .081	B	M7B01
NBG-25	M	CPB116	57	.500 x .250 x .081	B	M7B02
NBG-25	M	CPB126	57	.500 x .250 x .081	B	M7B03
NBG-25	M	CPB136	57	.500 x .250 x .081	B	M7B04
NBG-25	M	CPB146	57	.500 x .250 x .081	B	M7B07
NBG-25	M	CPB156	57	.500 x .250 x .081	B	M8B01
NBG-25	M	CPB166	57	.500 x .250 x .081	B	M8B03
NBG-25	M	CPB176	57	.500 x .250 x .081	B	M8B04
NBG-25	M	CPB186	57	.500 x .250 x .081	B	M8B05
NBG-25	M	Spare 1	57	.500 x .250 x .081	B	M8B06
NBG-25	M	Spare 2	57	.500 x .250 x .081	B	M8B09
NBG-25	M	5PB16	43	.500 x .250 x .126	C	M2C01
NBG-25	M	5PB24	43	.500 x .250 x .126	C	M2C02
NBG-25	M	Spare 1	43	.500 x .250 x .126	C	M2C04
NBG-25	M	Spare 2	43	.500 x .250 x .126	C	M2C05
NBG-25	M	5PB6	27	.250 x .250	D	M1D01
NBG-25	M	5PB14	27	.250 x .250	D	M1D02
NBG-25	M	6PB10	27	.250 x .250	D	M1D03
NBG-25	M	Spare 1	27	.250 x .250	D	M1D04
NBG-25	M	Spare 2	27	.250 x .250	D	M1D05

Table 21. Grade 2020 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
S-2020	N	CPB7	58	.500 x .250 x .081	B	N1B03
S-2020	N	CPB17	58	.500 x .250 x .081	B	N1B04
S-2020	N	CPB27	58	.500 x .250 x .081	B	N1B05
S-2020	N	CPB37	58	.500 x .250 x .081	B	N1B06
S-2020	N	CPB47	58	.500 x .250 x .081	B	N1B08
S-2020	N	CPB57	58	.500 x .250 x .081	B	N2B04
S-2020	N	CPB67	58	.500 x .250 x .081	B	N2B05
S-2020	N	CPB77	58	.500 x .250 x .081	B	N2B06
S-2020	N	CPB87	58	.500 x .250 x .081	B	N2B07
S-2020	N	CPB97	58	.500 x .250 x .081	B	N2B08
S-2020	N	CPB107	58	.500 x .250 x .081	B	N5B01
S-2020	N	CPB117	58	.500 x .250 x .081	B	N5B02
S-2020	N	CPB127	58	.500 x .250 x .081	B	N5B03
S-2020	N	CPB137	58	.500 x .250 x .081	B	N5B04
S-2020	N	CPB147	58	.500 x .250 x .081	B	N5B05
S-2020	N	CPB157	58	.500 x .250 x .081	B	N6B02
S-2020	N	CPB167	58	.500 x .250 x .081	B	N6B03
S-2020	N	CPB177	58	.500 x .250 x .081	B	N6B04
S-2020	N	CPB187	58	.500 x .250 x .081	B	N6B05
S-2020	N	Spare 1	58	.500 x .250 x .081	B	N6B07
S-2020	N	Spare 2	58	.500 x .250 x .081	B	N6B08
S-2020	N	5PB17	44	.500 x .250 x .126	C	N3C01
S-2020	N	6PB23	44	.500 x .250 x .126	C	N3C02
S-2020	N	Spare 1	44	.500 x .250 x .126	C	N7C01
S-2020	N	Spare 2	44	.500 x .250 x .126	C	N7C02
S-2020	N	5PB7	28	.250 x .250	D	N4D01
S-2020	N	5PB13	28	.250 x .250	D	N4D02
S-2020	N	6PB4	28	.250 x .250	D	N4D03
S-2020	N	Spare 1	28	.250 x .250	D	N8D01
S-2020	N	Spare 2	28	.250 x .250	D	N8D02

Table 22. Grade PCIB AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
PCIB	P	CPB8	59	.500 x .250 x .081	B	P1B02
PCIB	P	CPB18	59	.500 x .250 x .081	B	P1B04
PCIB	P	CPB28	59	.500 x .250 x .081	B	P1B05
PCIB	P	CPB38	59	.500 x .250 x .081	B	P1B06
PCIB	P	CPB48	59	.500 x .250 x .081	B	P1B07
PCIB	P	CPB58	59	.500 x .250 x .081	B	P1B08
PCIB	P	CPB68	59	.500 x .250 x .081	B	P1B10
PCIB	P	CPB78	59	.500 x .250 x .081	B	P3B04
PCIB	P	CPB88	59	.500 x .250 x .081	B	P3B05
PCIB	P	CPB98	59	.500 x .250 x .081	B	P3B06
PCIB	P	CPB108	59	.500 x .250 x .081	B	P3B07
PCIB	P	CPB118	59	.500 x .250 x .081	B	P3B08
PCIB	P	CPB128	59	.500 x .250 x .081	B	P3B09
PCIB	P	CPB138	59	.500 x .250 x .081	B	P3B10
PCIB	P	CPB148	59	.500 x .250 x .081	B	P4B01
PCIB	P	CPB158	59	.500 x .250 x .081	B	P4B02
PCIB	P	CPB168	59	.500 x .250 x .081	B	P4B03
PCIB	P	CPB178	59	.500 x .250 x .081	B	P4B04
PCIB	P	CPB188	59	.500 x .250 x .081	B	P4B05
PCIB	P	Spare 1	59	.500 x .250 x .081	B	P4B07
PCIB	P	Spare 2	59	.500 x .250 x .081	B	P4B10
PCIB	P	5PB18	45	.500 x .250 x .126	C	P2C02
PCIB	P	6PB25	45	.500 x .250 x .126	C	P2C03
PCIB	P	Spare 1	45	.500 x .250 x .126	C	P2C06
PCIB	P	Spare 2	45	.500 x .250 x .126	C	P2C08
PCIB	P	5PB8	29	.250 x .250	D	P5D01
PCIB	P	5PB12	29	.250 x .250	D	P5D02
PCIB	P	6PB3	29	.250 x .250	D	P5D03
PCIB	P	Spare 1	29	.250 x .250	D	P5D05
PCIB	P	Spare 2	29	.250 x .250	D	P5D06

Table 23. Grade BAN AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
BAN	R	CPB9	60	.500 x .250 x .081	B	R2B01A
BAN	R	CPB19	60	.500 x .250 x .081	B	R2B03A
BAN	R	CPB29	60	.500 x .250 x .081	B	R2B06A
BAN	R	CPB39	60	.500 x .250 x .081	B	R2B07A
BAN	R	CPB49	60	.500 x .250 x .081	B	R2B08A
BAN	R	CPB59	60	.500 x .250 x .081	B	R2B09A
BAN	R	CPB69	60	.500 x .250 x .081	B	R2B10A
BAN	R	CPB79	60	.500 x .250 x .081	B	R3B01A
BAN	R	CPB89	60	.500 x .250 x .081	B	R3B02A
BAN	R	CPB99	60	.500 x .250 x .081	B	R3B03A
BAN	R	CPB109	60	.500 x .250 x .081	B	R3B04A
BAN	R	CPB119	60	.500 x .250 x .081	B	R3B06A
BAN	R	CPB129	60	.500 x .250 x .081	B	R3B07A
BAN	R	CPB139	60	.500 x .250 x .081	B	R3B08A
BAN	R	CPB149	60	.500 x .250 x .081	B	R6B01A
BAN	R	CPB159	60	.500 x .250 x .081	B	R6B02A
BAN	R	CPB169	60	.500 x .250 x .081	B	R6B04A
BAN	R	CPB179	60	.500 x .250 x .081	B	R6B06A
BAN	R	CPB189	60	.500 x .250 x .081	B	R6B08A
BAN	R	Spare 1	60	.500 x .250 x .081	B	R6B09A
BAN	R	Spare 2	60	.500 x .250 x .081	B	R6B10A
BAN	R	1PB22	46	.500 x .250 x .126	C	R4C01A
BAN	R	2PB22	46	.500 x .250 x .126	C	R4C04A
BAN	R	3PB22	46	.500 x .250 x .126	C	R4C07A
BAN	R	4PB22	46	.500 x .250 x .126	C	R4C08A
BAN	R	5PB19	46	.500 x .250 x .126	C	R5C01A
BAN	R	5PB23	46	.500 x .250 x .126	C	R5C02A
BAN	R	Spare 1	46	.500 x .250 x .126	C	R5C03A
BAN	R	Spare 2	46	.500 x .250 x .126	C	R5C05A
BAN	R	5PB9	30	.250 x .250	D	R1D01A
BAN	R	5PB11	30	.250 x .250	D	R1D02A
BAN	R	6PB2	30	.250 x .250	D	R1D03A
BAN	R	Spare 1	30	.250 x .250	D	R1D04A
BAN	R	Spare2	30	.250 x .250	D	R1D05A

Table 24. Grade NBG-10 AGC-1 piggy-back specimens examined and reported here

Specimen Types (INL Detail Numbers and Corresponding ORNL Specimen Types)						
Graphite Grade	Code Letter	Sample Location	INL Dwg. Detail No. (Ref: INL Dwg. 630431)	Dimensions (OD x H x ID)	Specimen Type	Specimen ID Number
NBG-10	S	CPB10	61	.500 x .250 x .081	B	S1B01
NBG-10	S	CPB20	61	.500 x .250 x .081	B	S1B03
NBG-10	S	CPB30	61	.500 x .250 x .081	B	S1B04
NBG-10	S	CPB40	61	.500 x .250 x .081	B	S1B07
NBG-10	S	CPB50	61	.500 x .250 x .081	B	S1B08
NBG-10	S	CPB60	61	.500 x .250 x .081	B	S1B09
NBG-10	S	CPB70	61	.500 x .250 x .081	B	S1B10
NBG-10	S	CPB80	61	.500 x .250 x .081	B	S3B01
NBG-10	S	CPB90	61	.500 x .250 x .081	B	S3B03
NBG-10	S	CPB100	61	.500 x .250 x .081	B	S3B04
NBG-10	S	CPB110	61	.500 x .250 x .081	B	S3B07
NBG-10	S	CPB120	61	.500 x .250 x .081	B	S3B08
NBG-10	S	CPB130	61	.500 x .250 x .081	B	S3B09
NBG-10	S	CPB140	61	.500 x .250 x .081	B	S3B10
NBG-10	S	CPB150	61	.500 x .250 x .081	B	S4B01
NBG-10	S	CPB160	61	.500 x .250 x .081	B	S4B03
NBG-10	S	CPB170	61	.500 x .250 x .081	B	S4B04
NBG-10	S	CPB180	61	.500 x .250 x .081	B	S4B07
NBG-10	S	CPB190	61	.500 x .250 x .081	B	S4B08
NBG-10	S	Spare 1	61	.500 x .250 x .081	B	S4B09
NBG-10	S	Spare 2	61	.500 x .250 x .081	B	S4B10
NBG-10	S	5PB20	47	.500 x .250 x .126	C	S2C01
NBG-10	S	Spare 1	47	.500 x .250 x .126	C	S2C02
NBG-10	S	Spare 2	47	.500 x .250 x .126	C	S2C03
NBG-10	S	5PB10	31	.250 x .250	D	S5D01
NBG-10	S	6PB1	31	.250 x .250	D	S5D02
NBG-10	S	6PB11	31	.250 x .250	D	S5D03
NBG-10	S	Spare 1	31	.250 x .250	D	S5D04
NBG-10	S	Spare 2	31	.250 x .250	D	S5D05

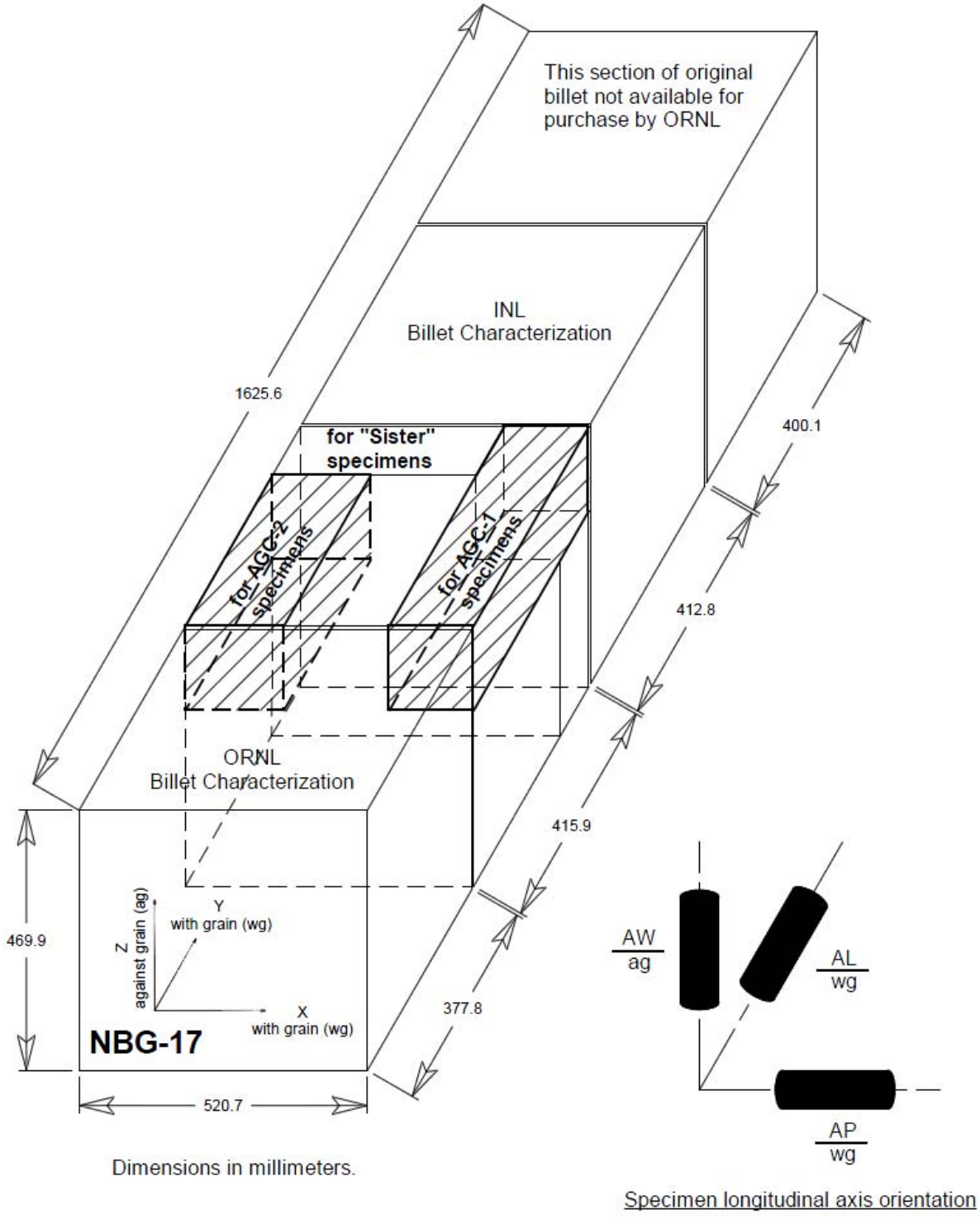

Figure 2. Billet cutting plan for NBG-17 (AGC-2 block retained for future use)

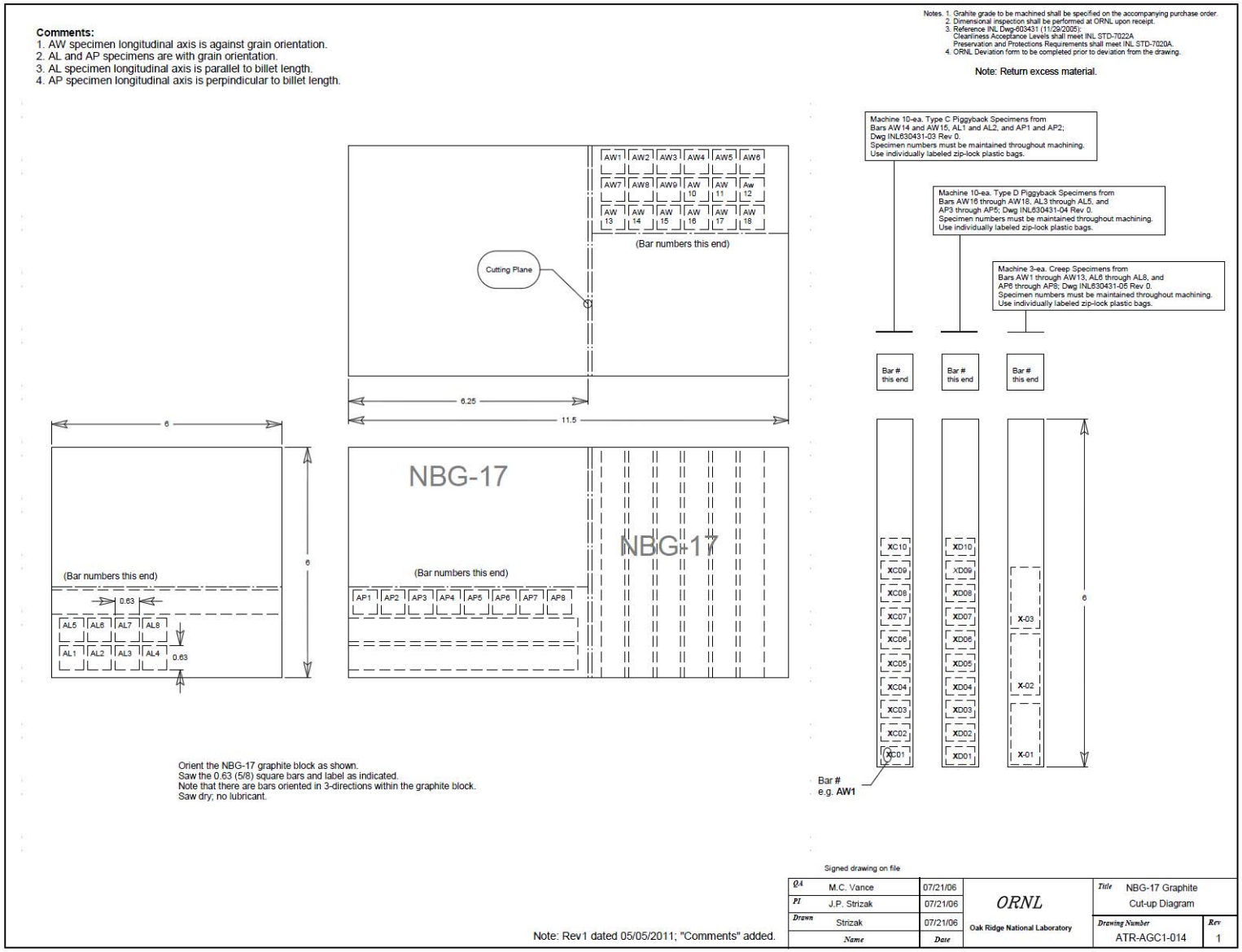

Figure 3. Specimen extraction plan for NBG-17 graphite

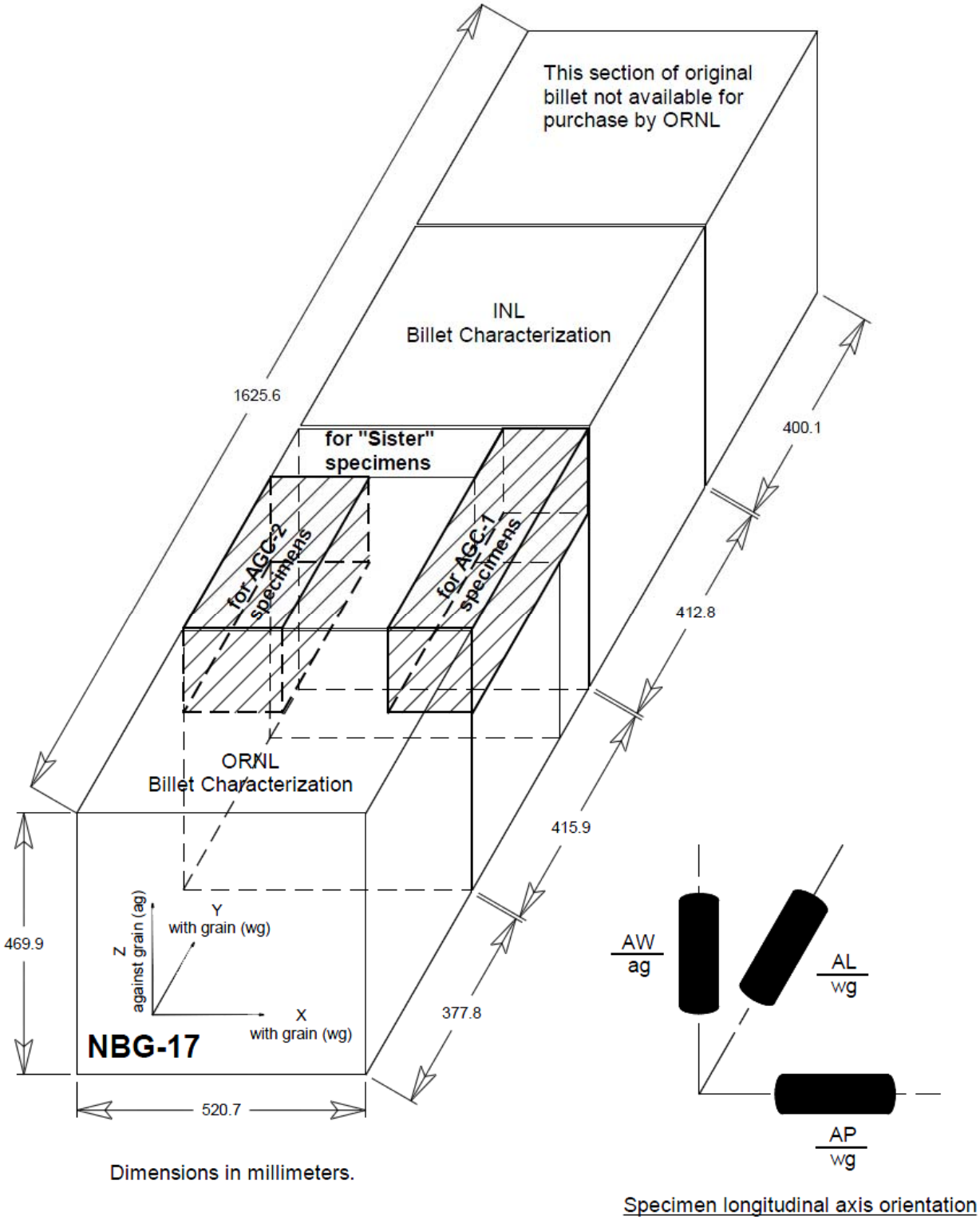

Figure 4. Billet cutting plan for NBG-18 (AGC-2 block retained for future use)

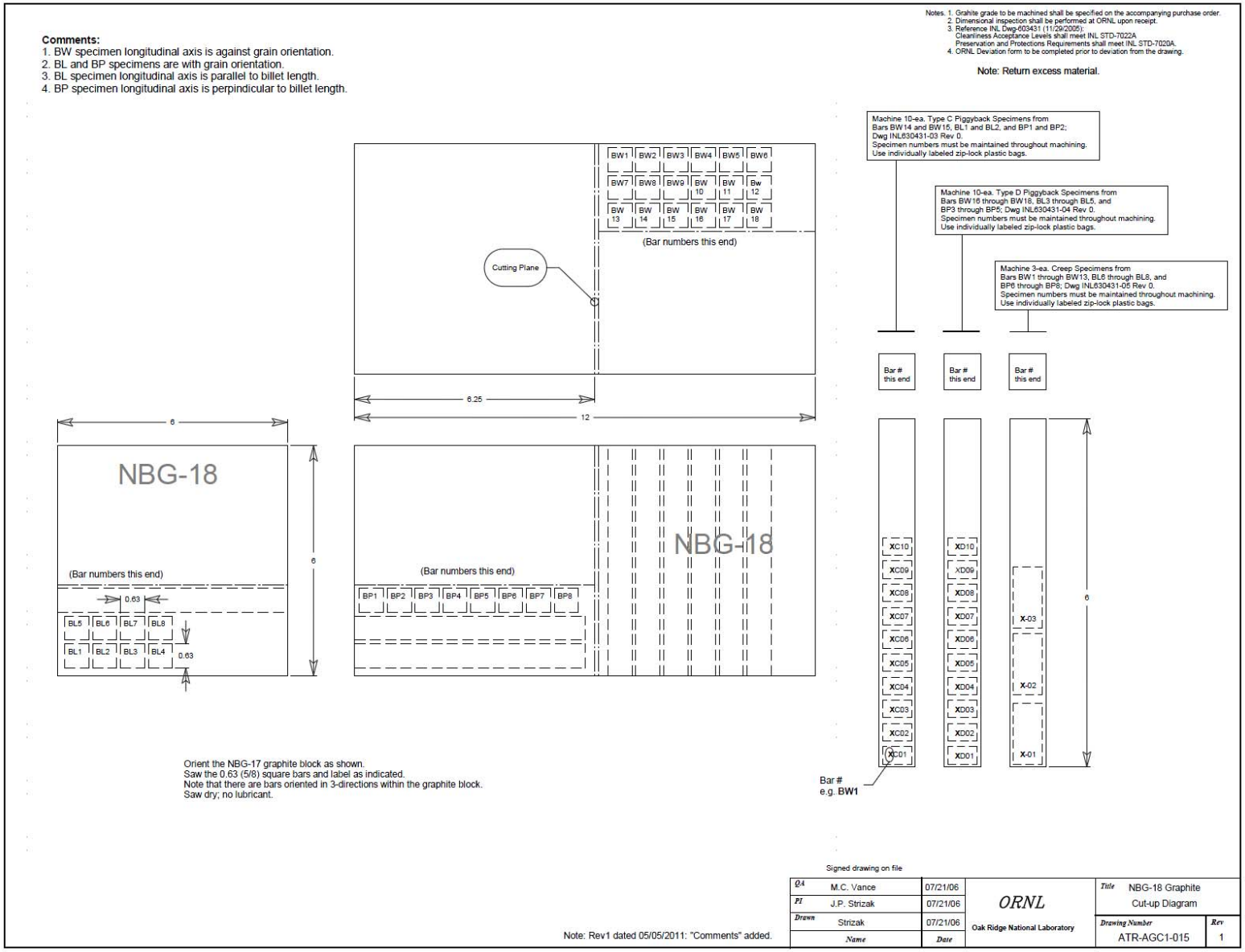

Figure 5. Specimen extraction plan for NBG-18 graphite

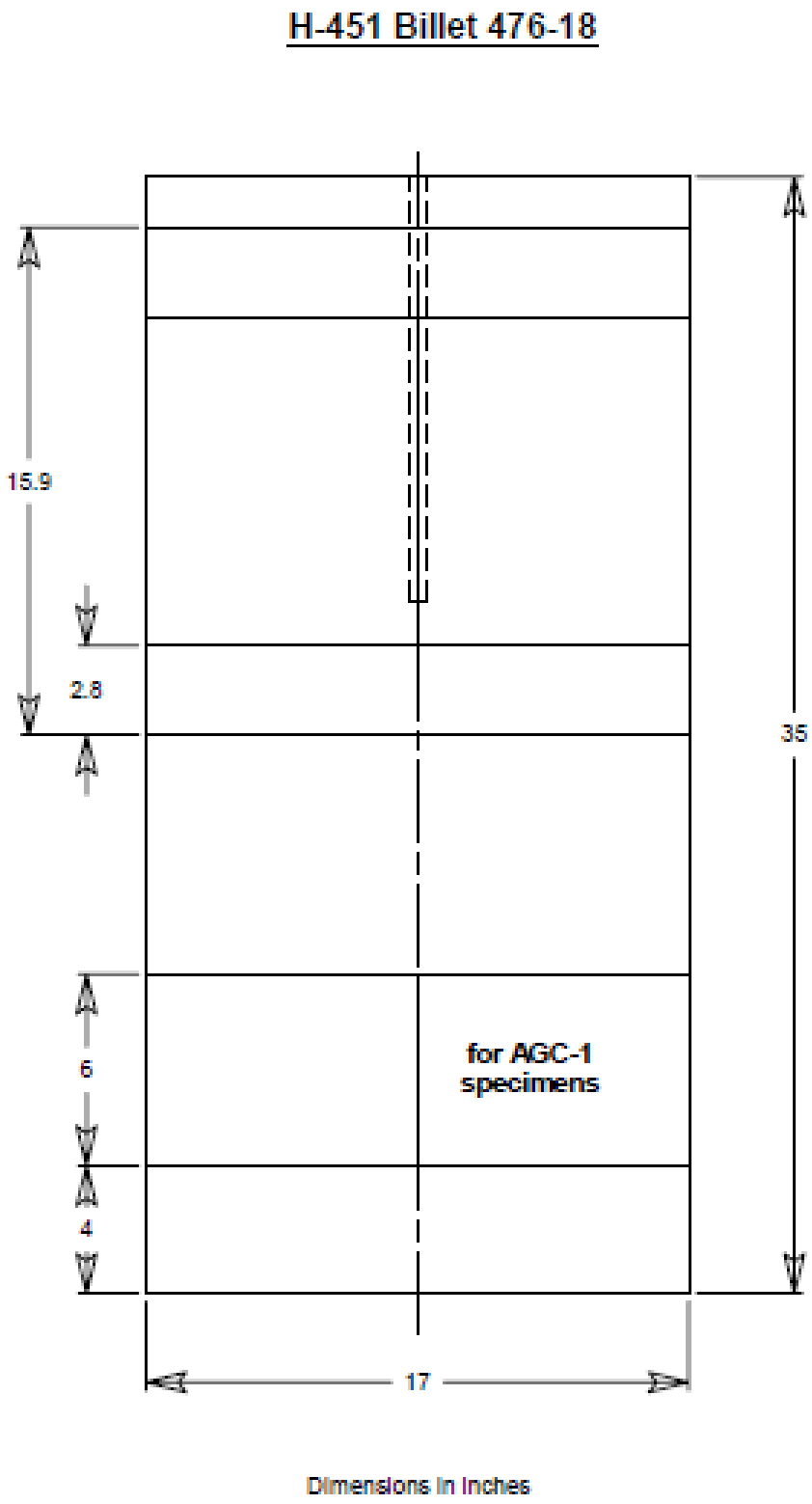

Figure 6. Billet cutting plan for H-451 (billet No. 476-18)

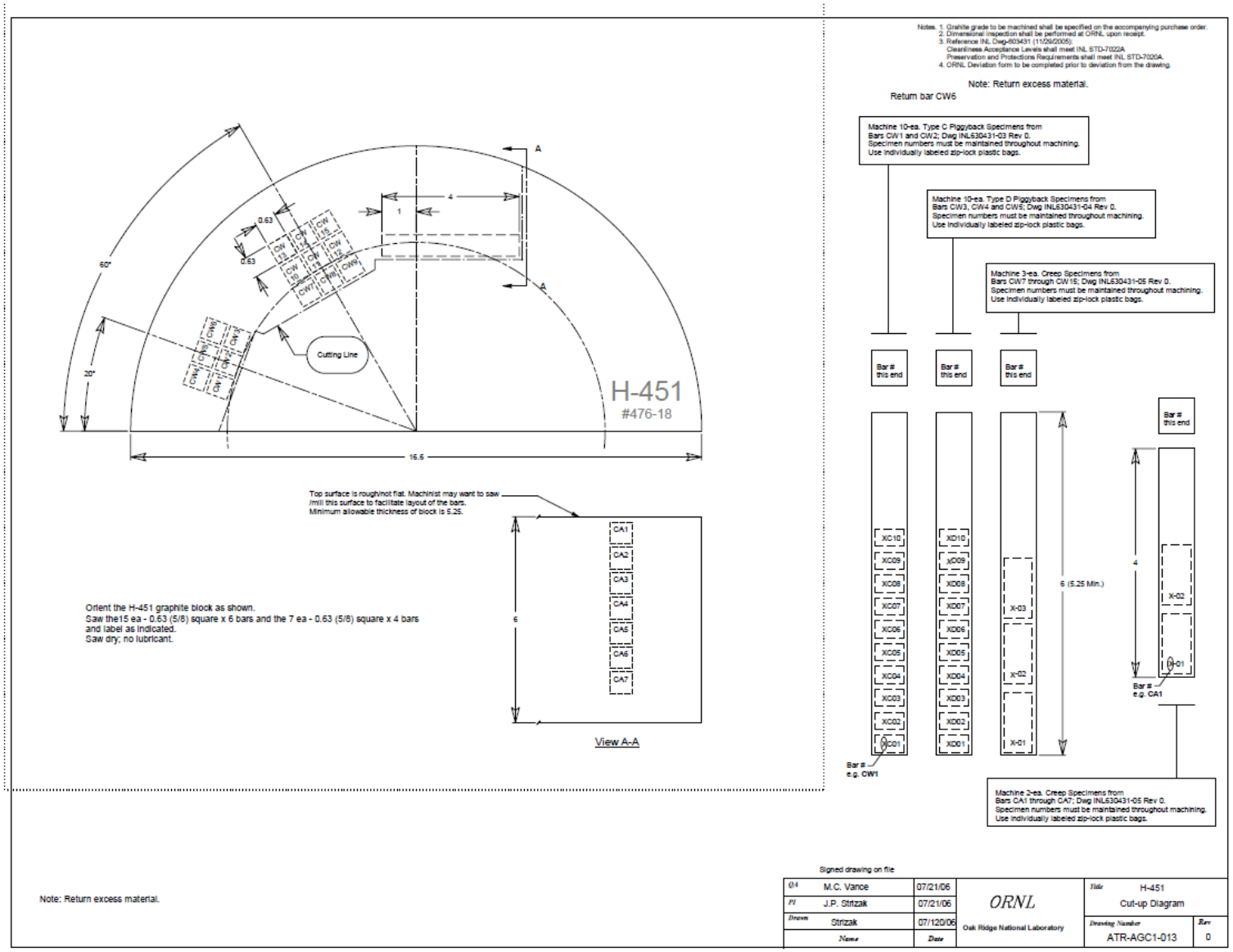

Figure 7. Specimen extraction plan for H-451 graphite

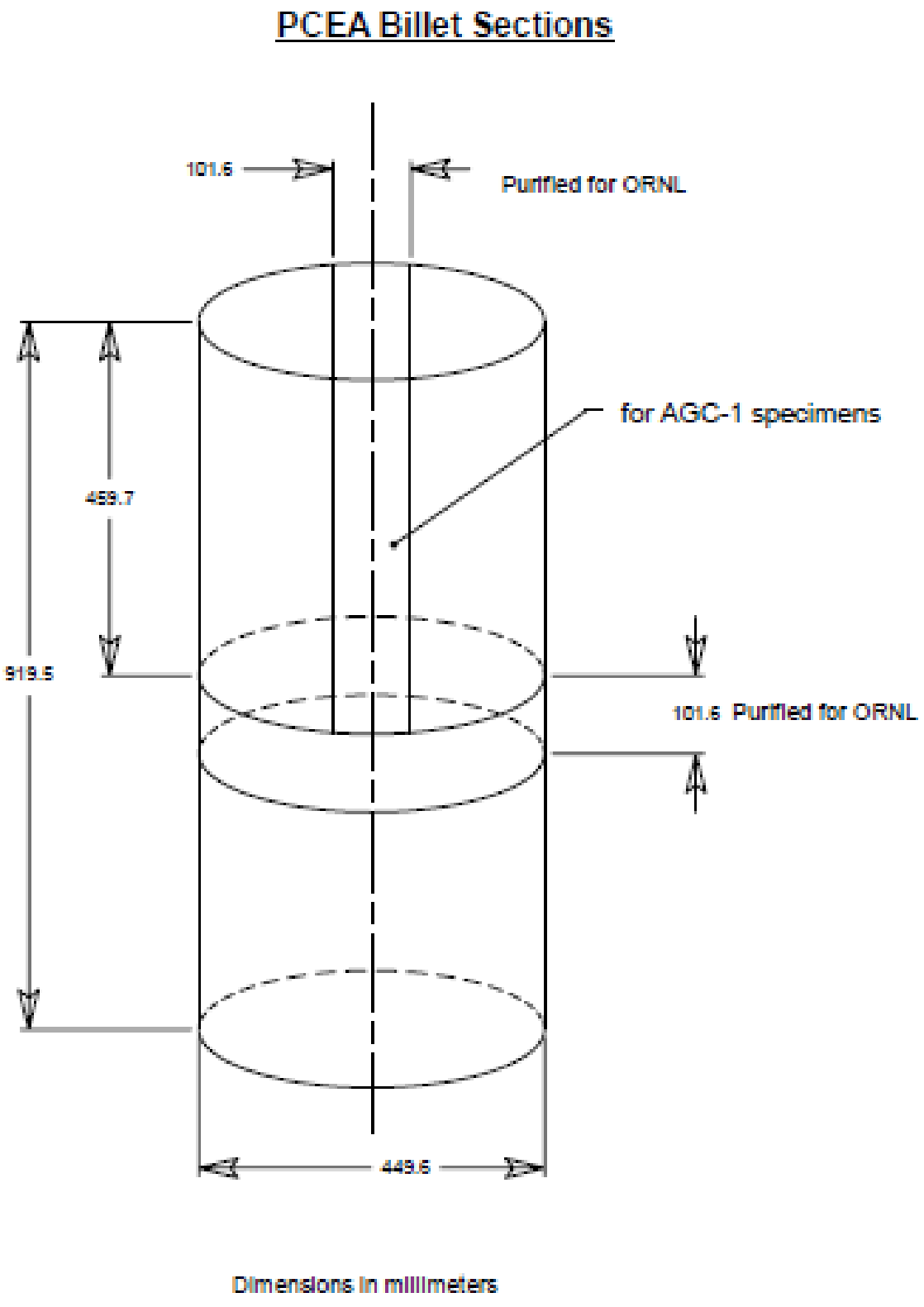

Figure 8. Billet cutting plan for PCEA

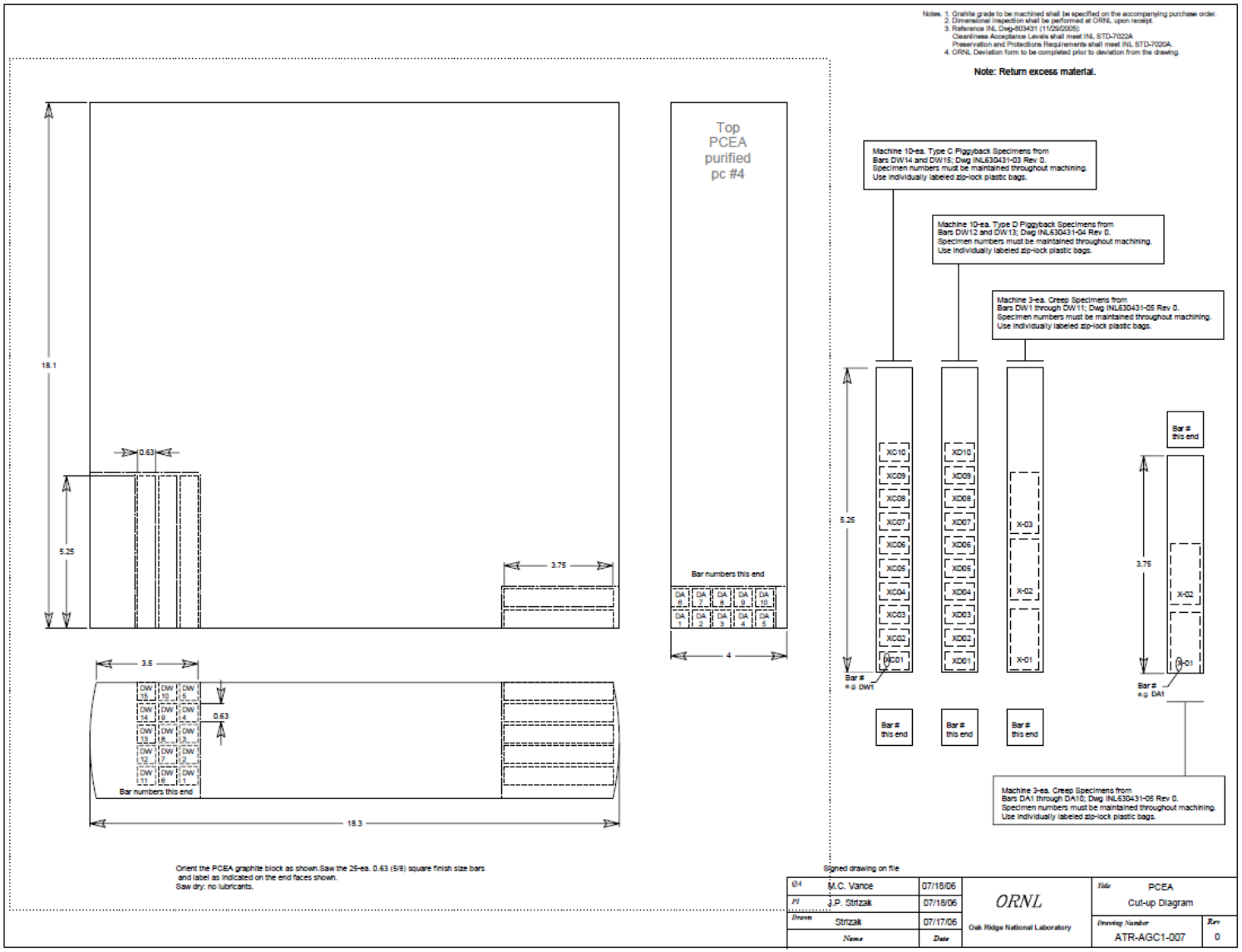

Figure 9. Specimen extraction plan for PCEA graphite

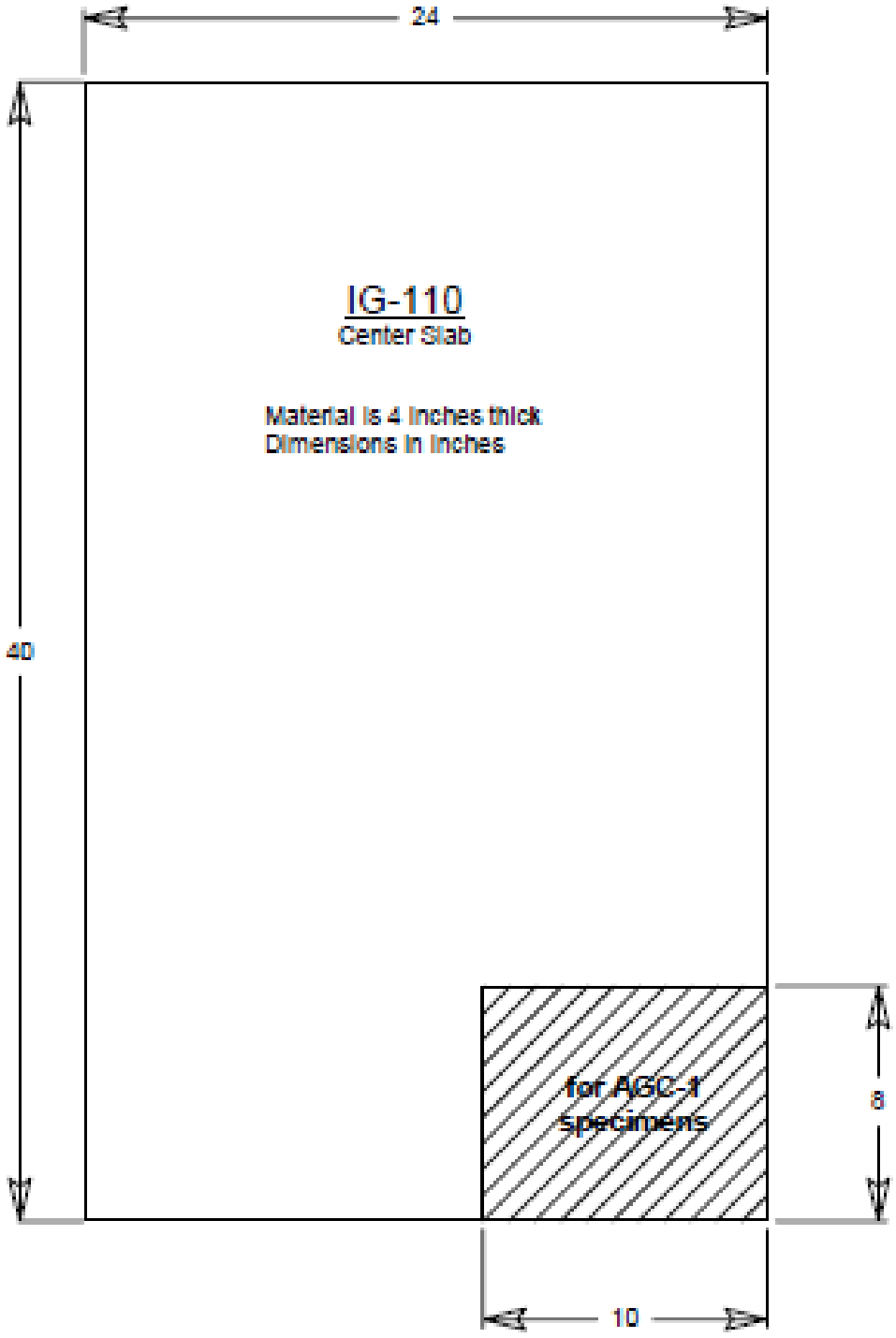

Figure 10. Billet cutting plan for IG-110

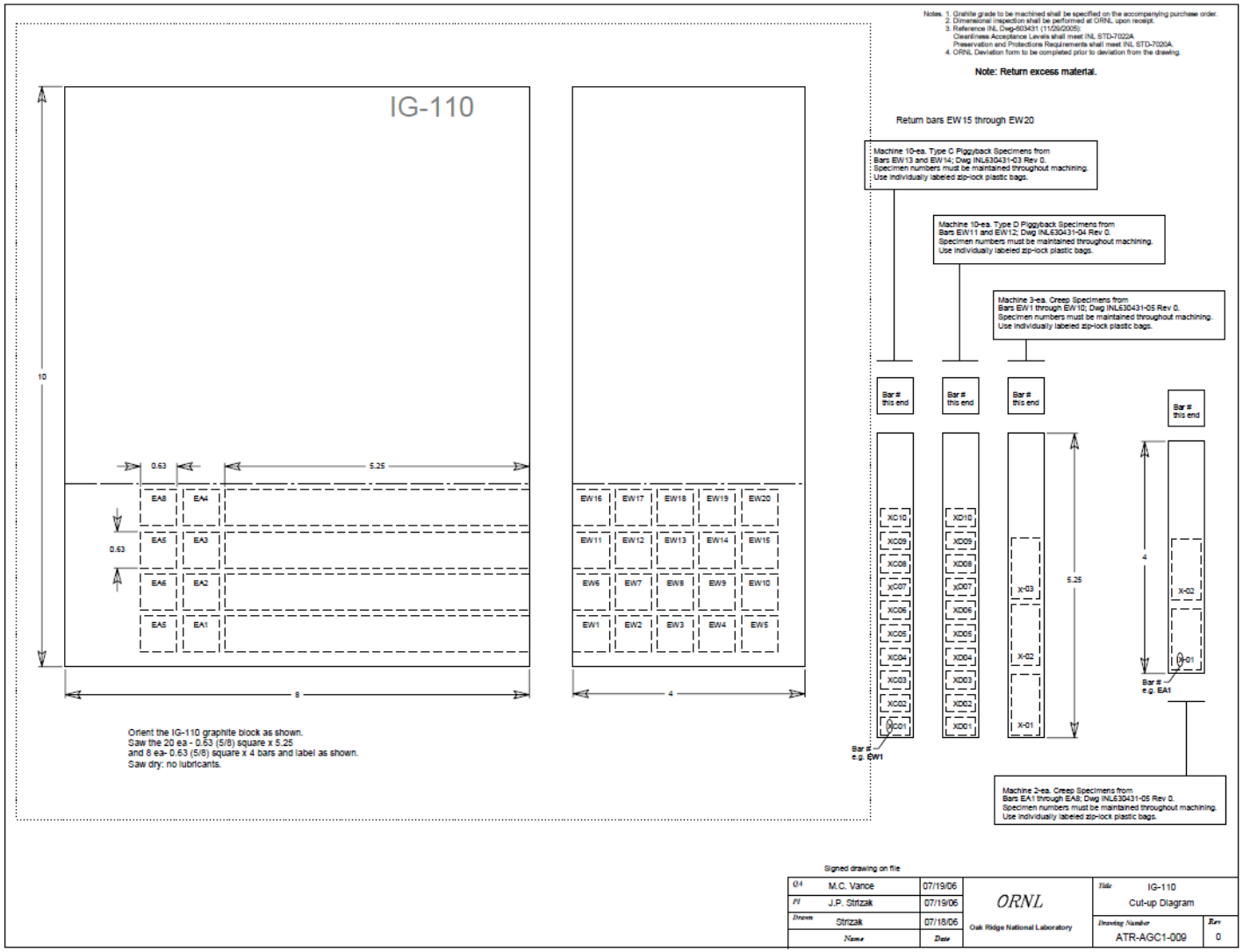

Figure 11. Specimen extraction plan for IG-110 graphite

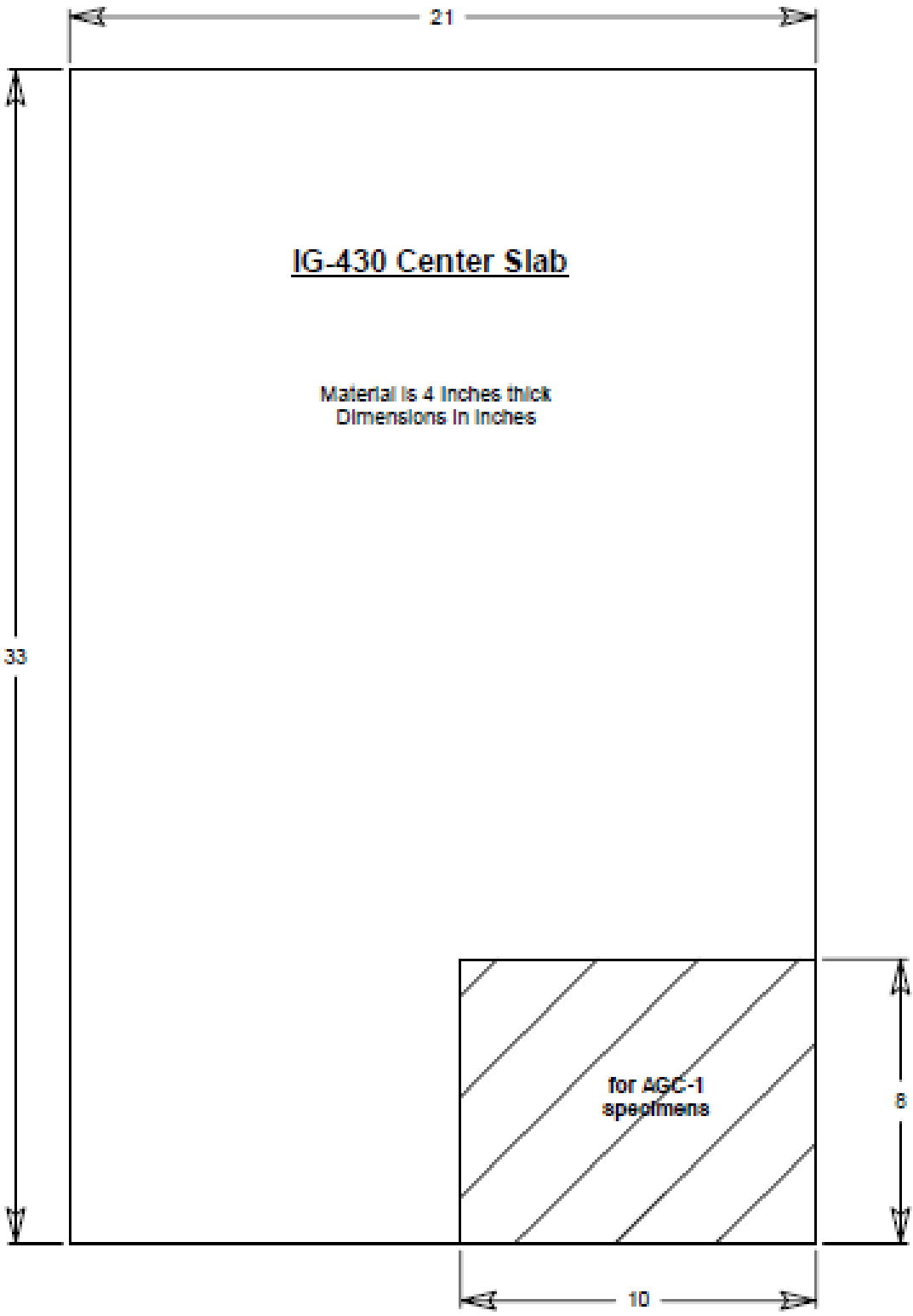

Figure 12. Billet cutting plan for IG-430

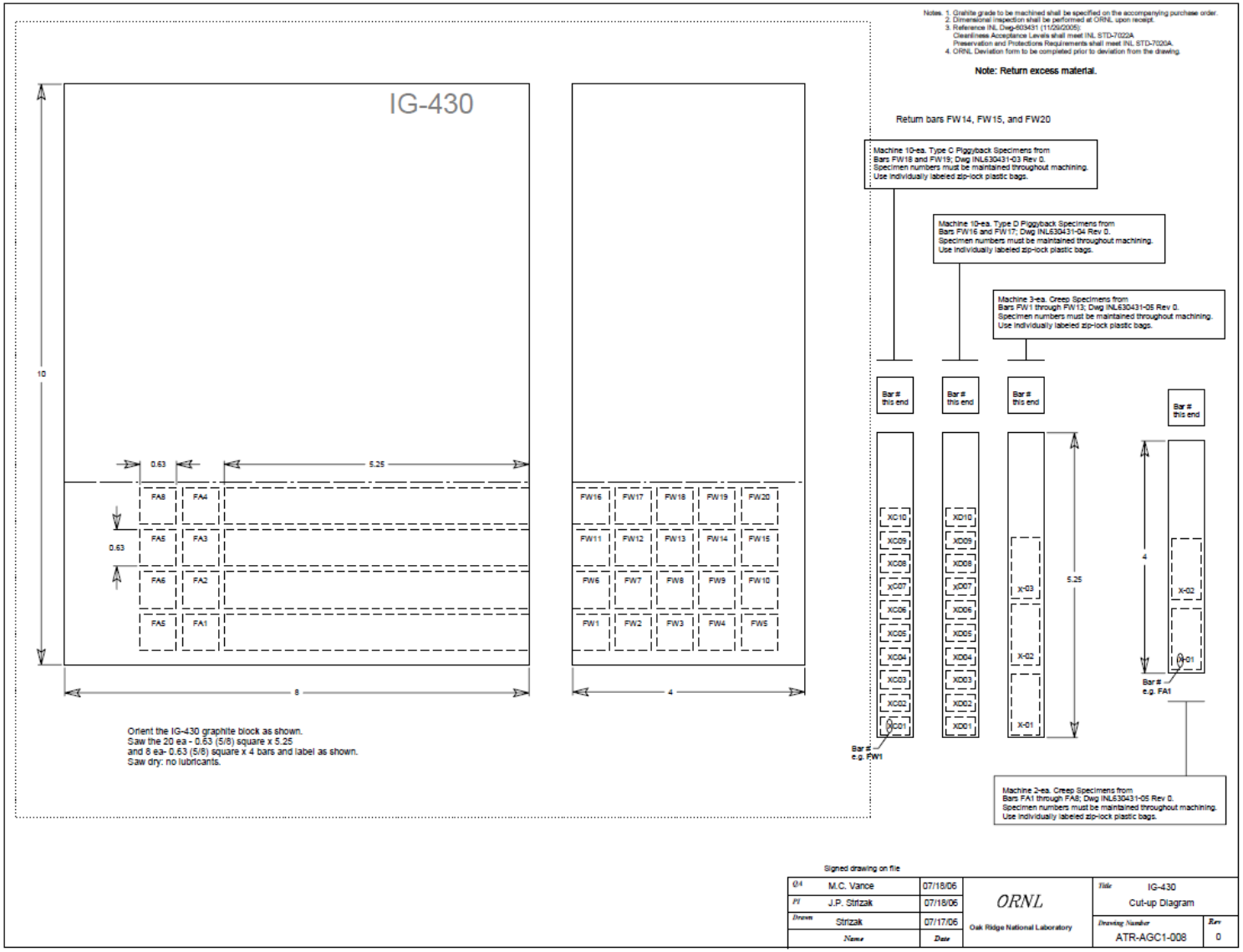

Figure 13. Specimen extraction plan for IG-430 graphite

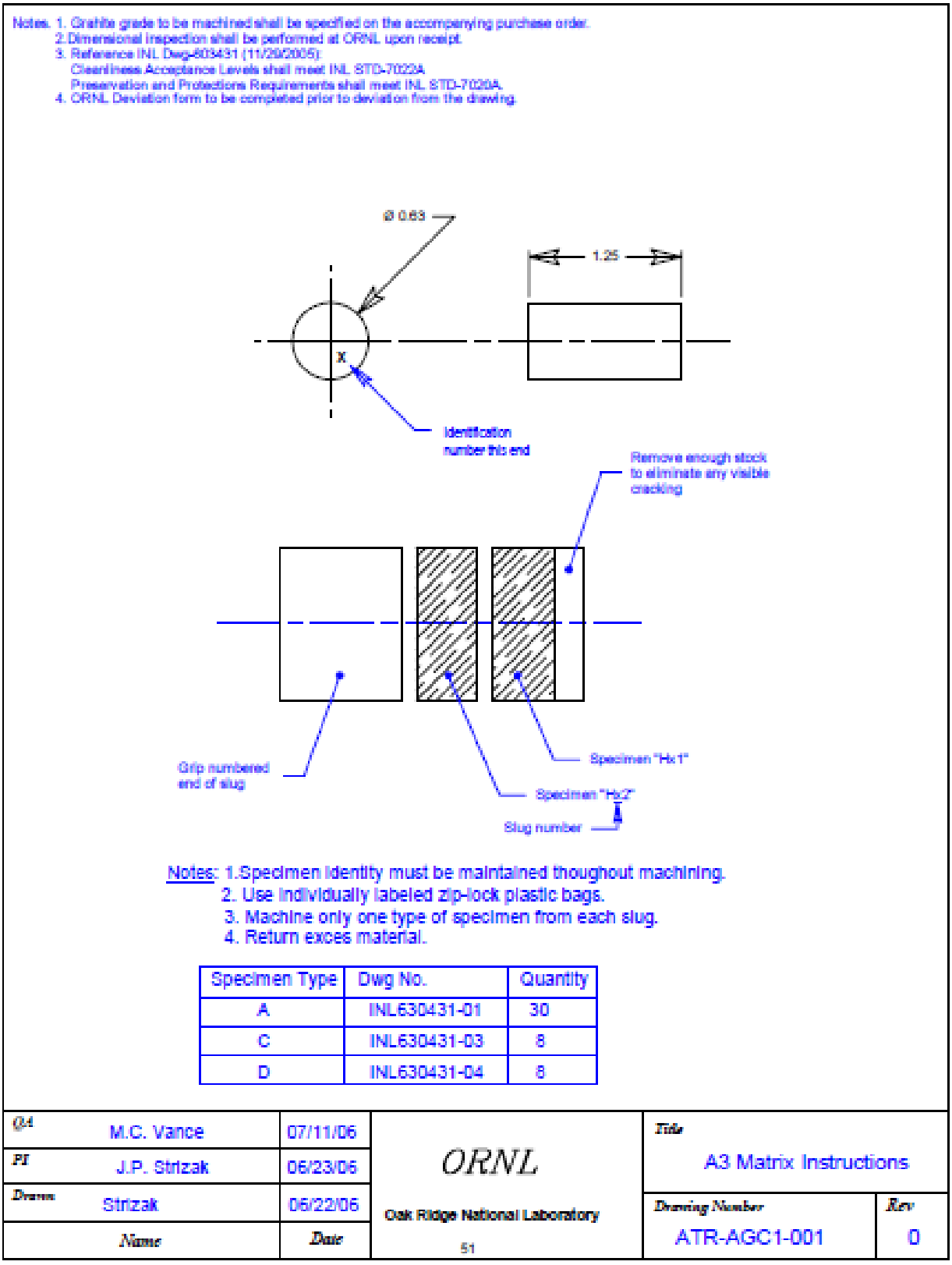

Figure 14. Specimen cutting plan for A3 Matrix Material

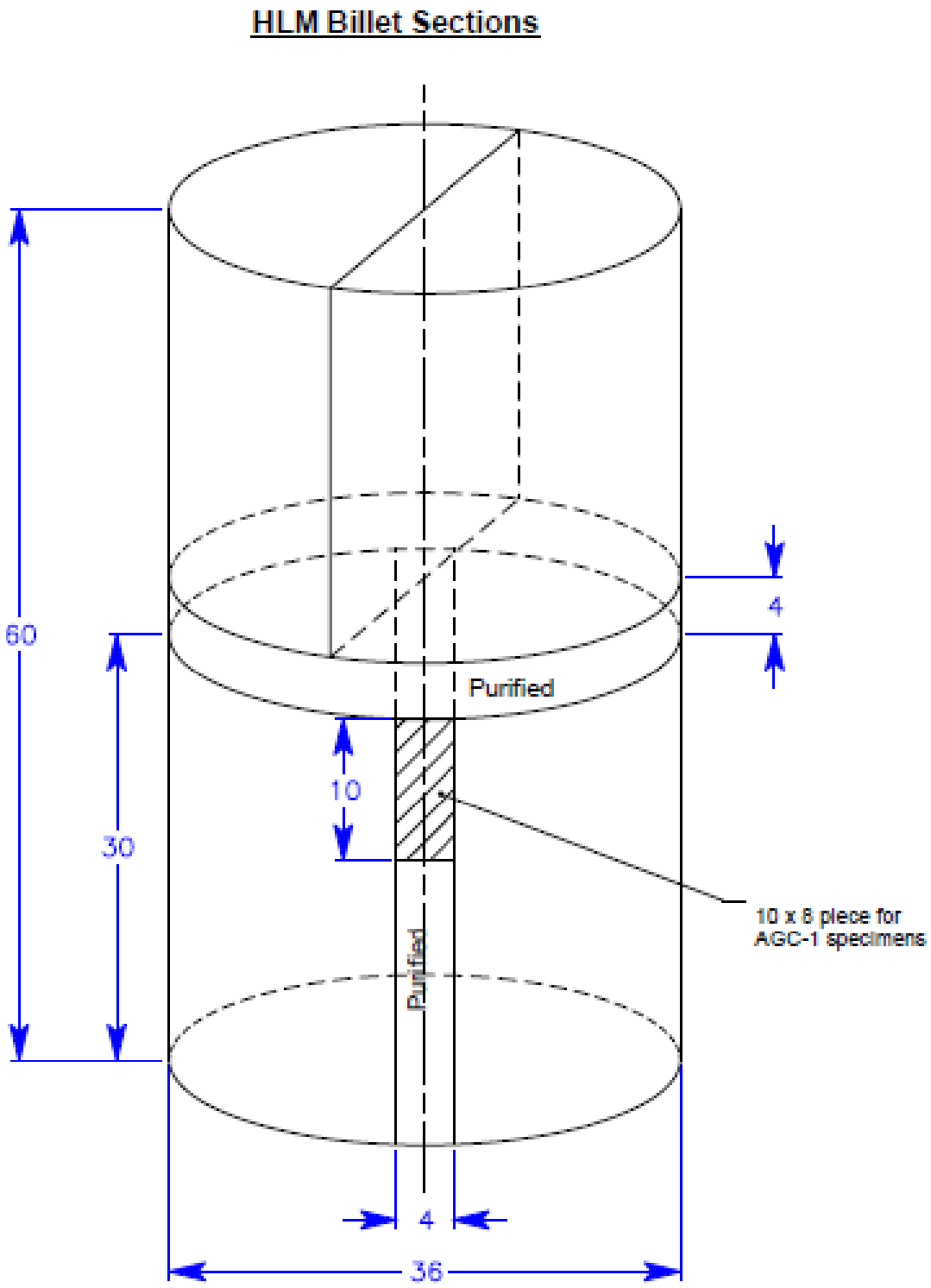

Figure 15. Billet cutting plan for HLM

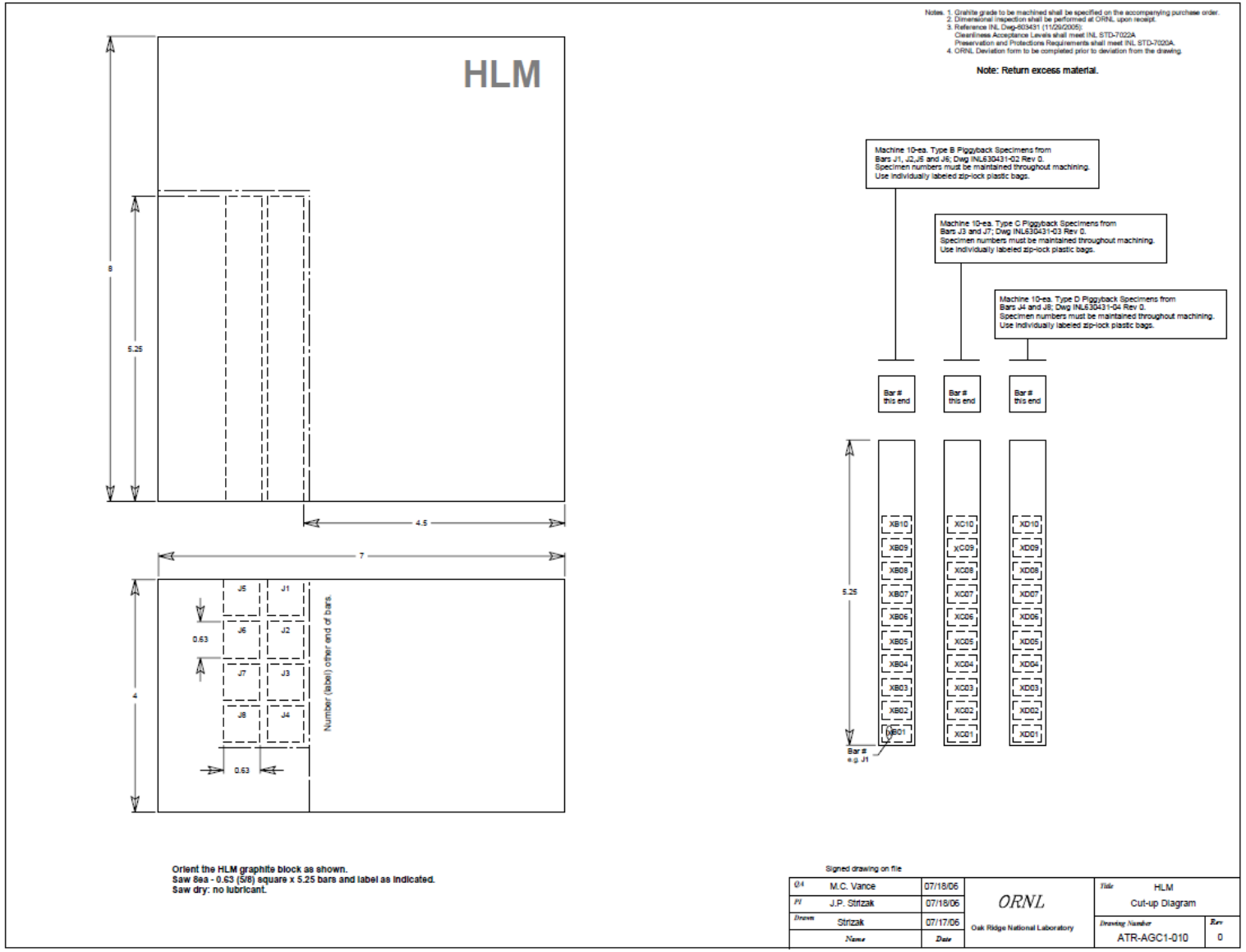

Figure 16. Specimen extraction plan for HLM graphite

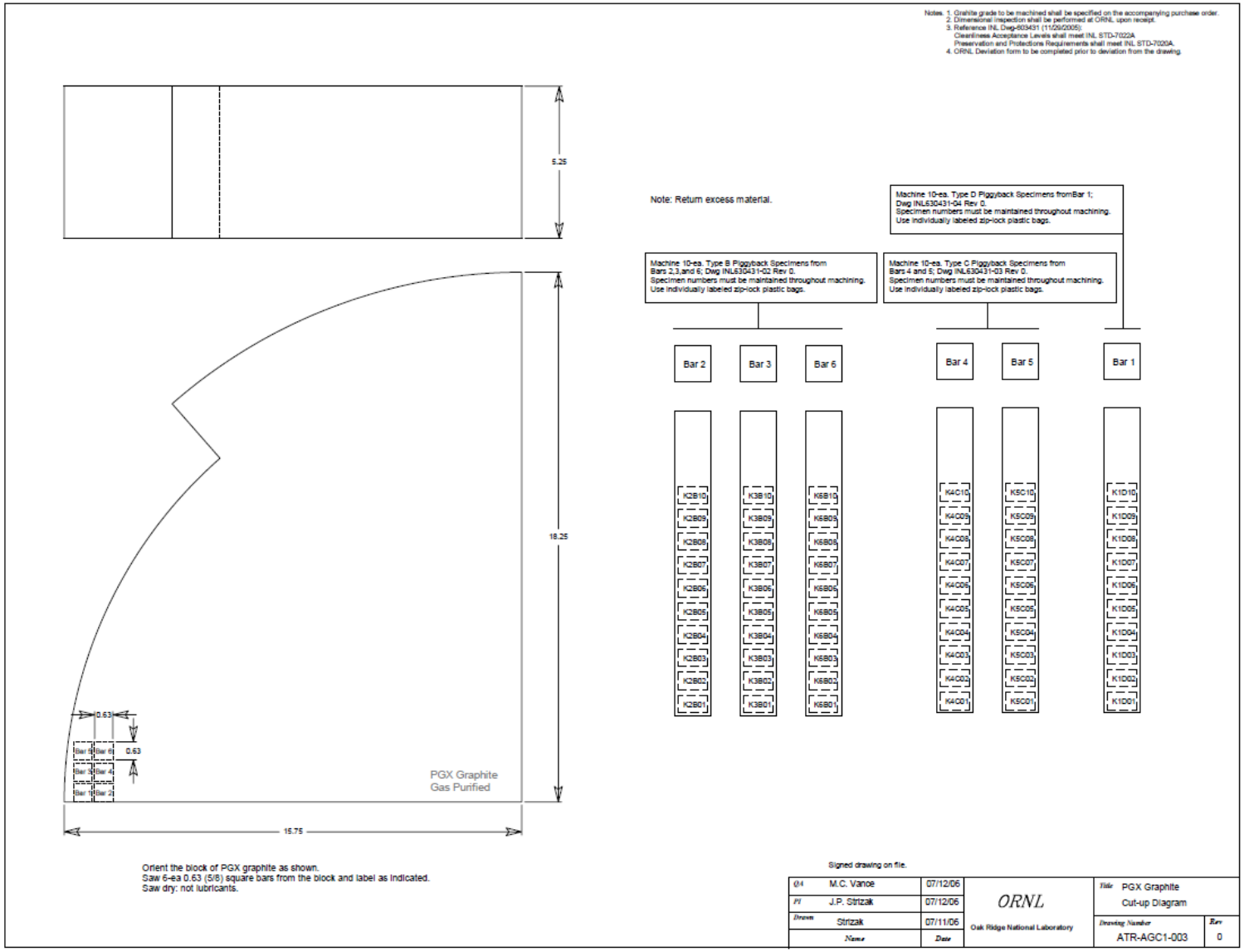

Figure 17. Specimen extraction plan for PGX graphite

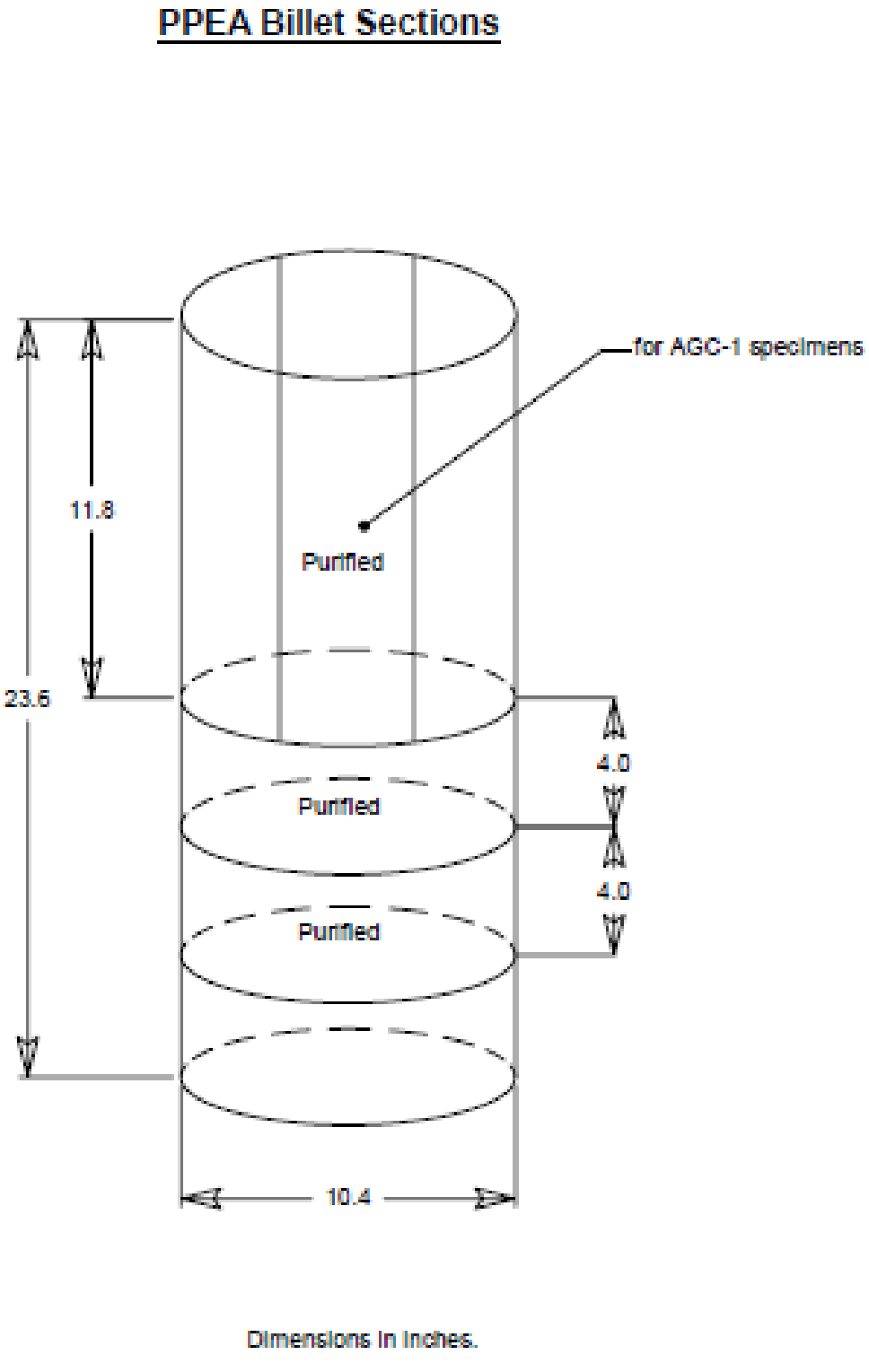

Figure 18. Billet cutting plan for PPEA

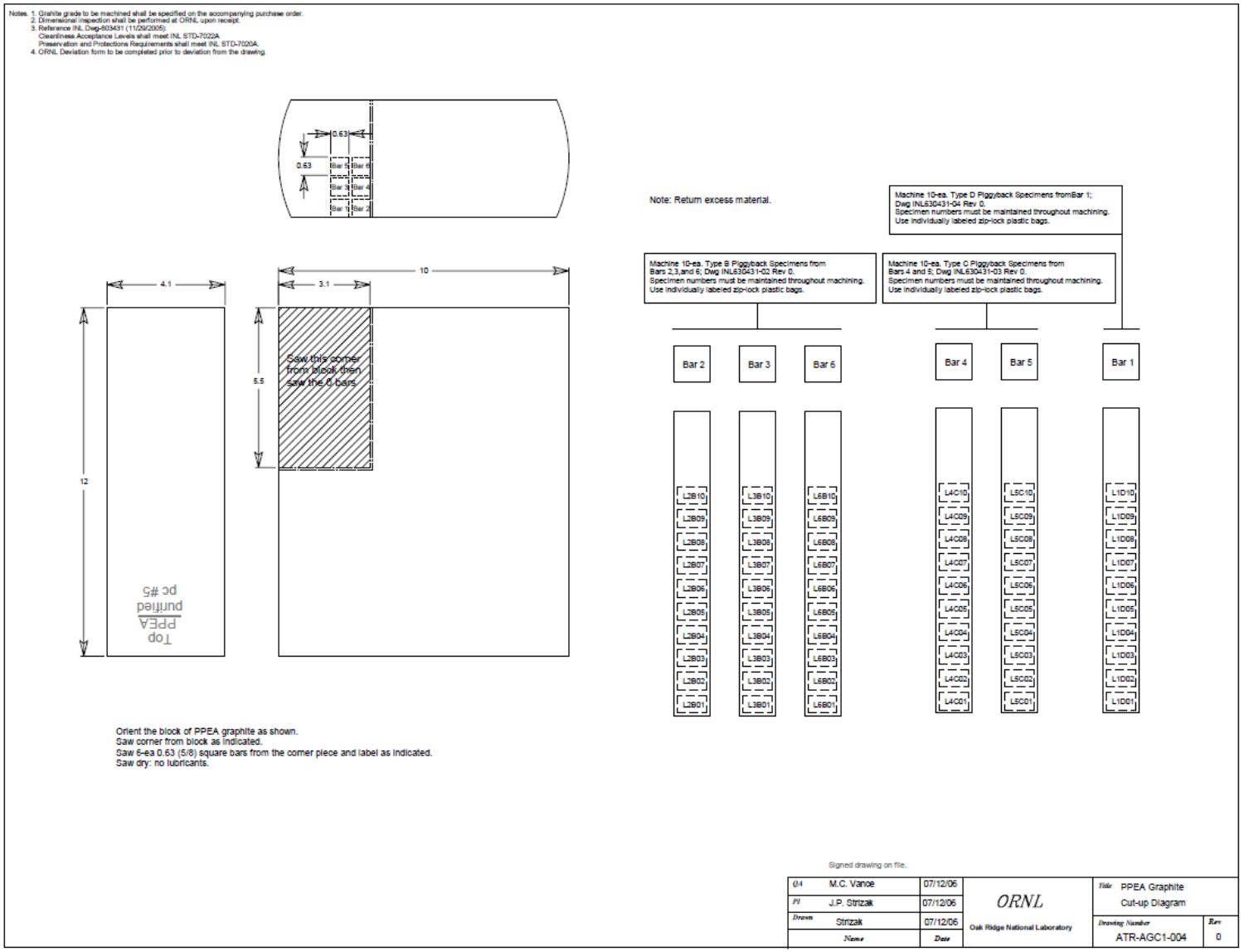

Figure 19. Specimen extraction plan for PPEA graphite

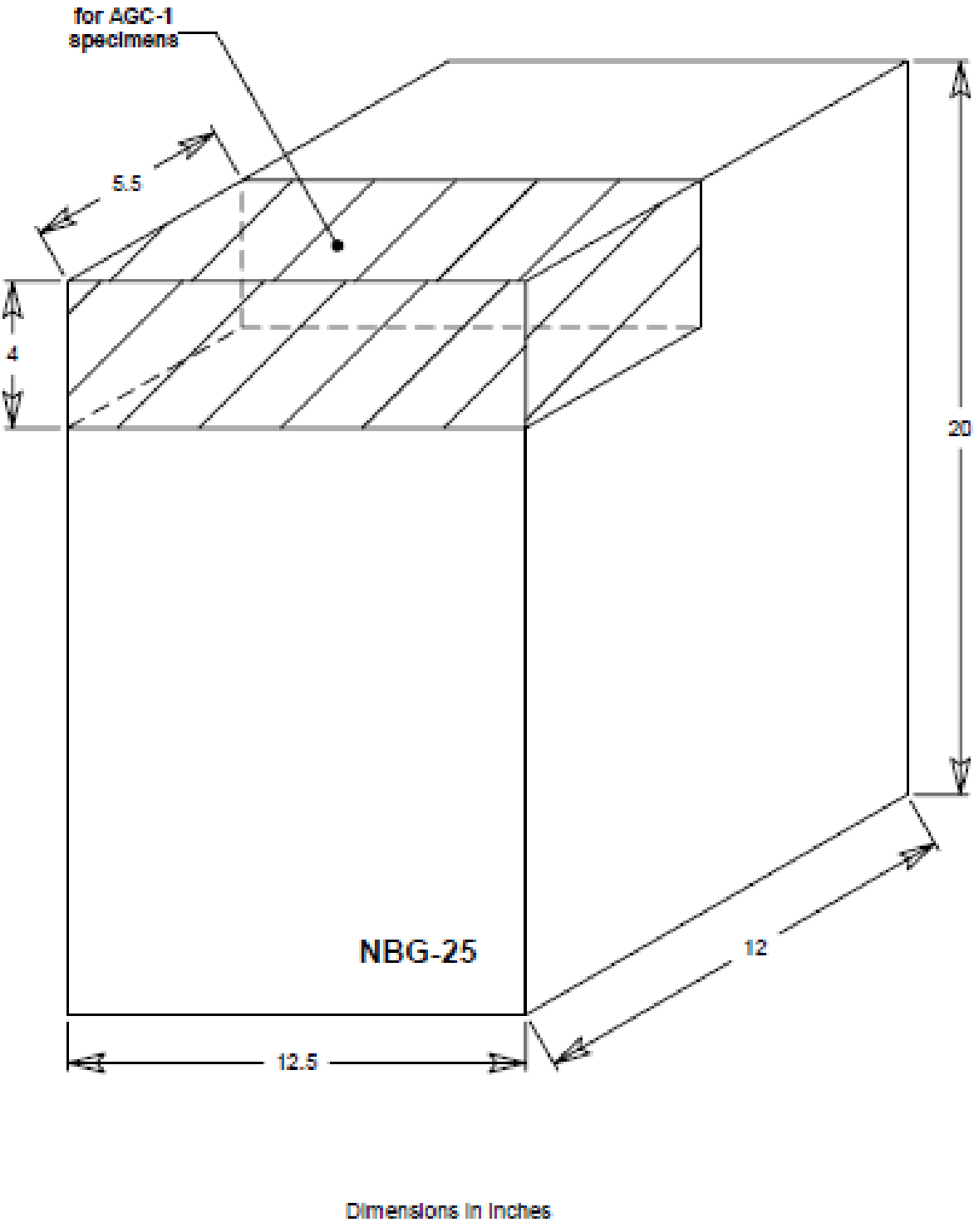

Figure 20. Billet cutting plan for NBG-25

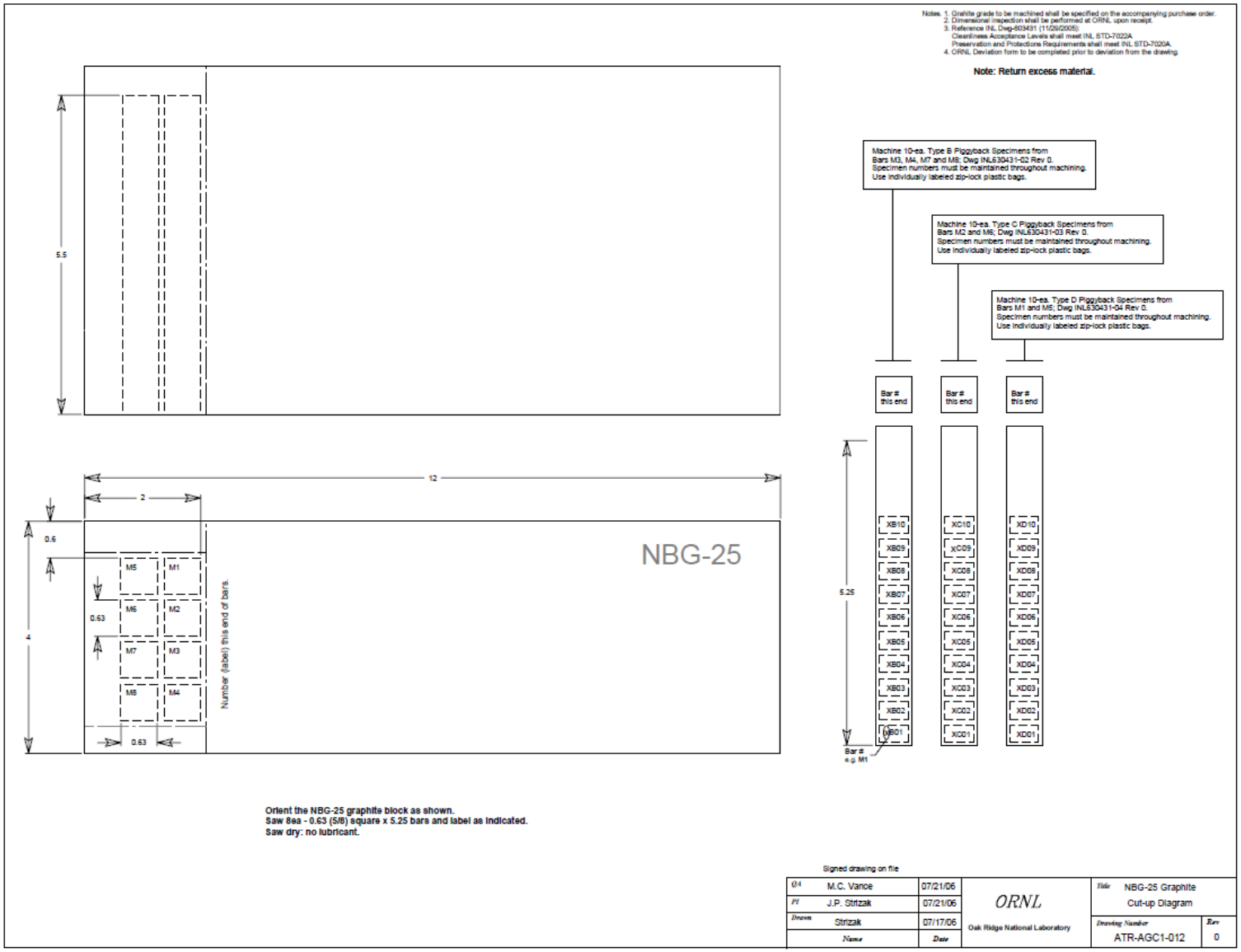

Figure 21. Specimen extraction plan for NBG-25 graphite

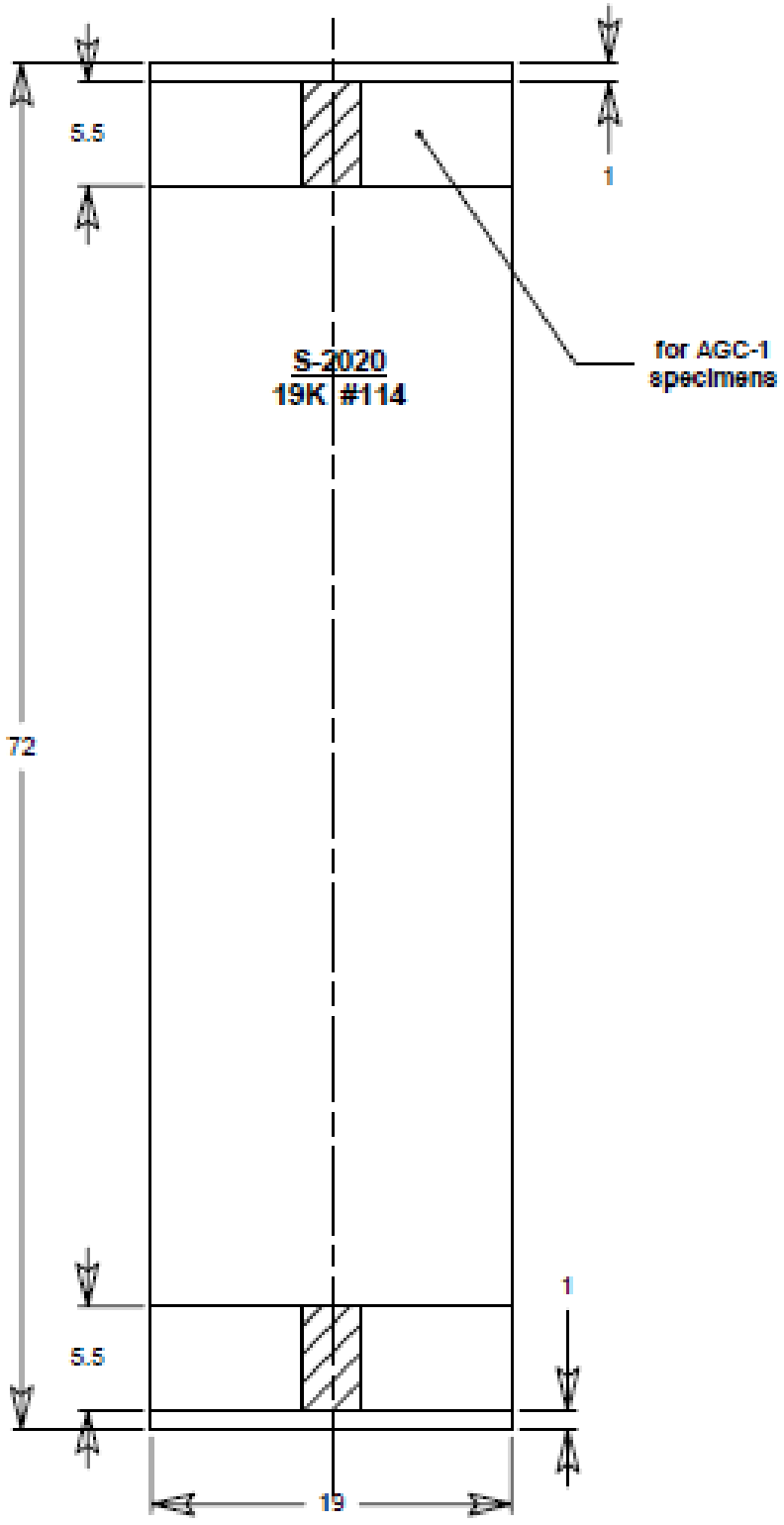

Figure 22. Billet cutting plan for S-2020

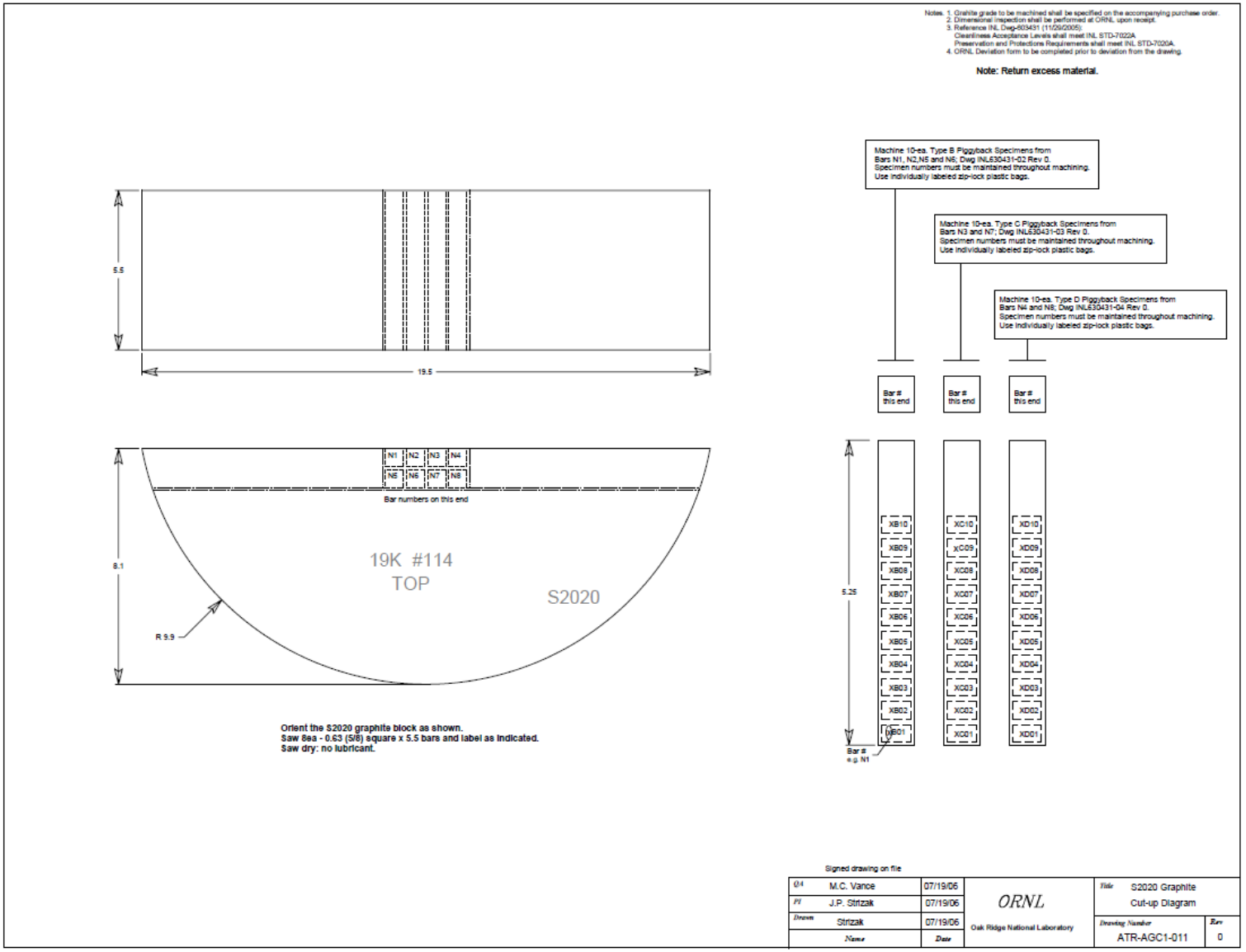

Figure 23. Specimen extraction plan for S-2020 graphite

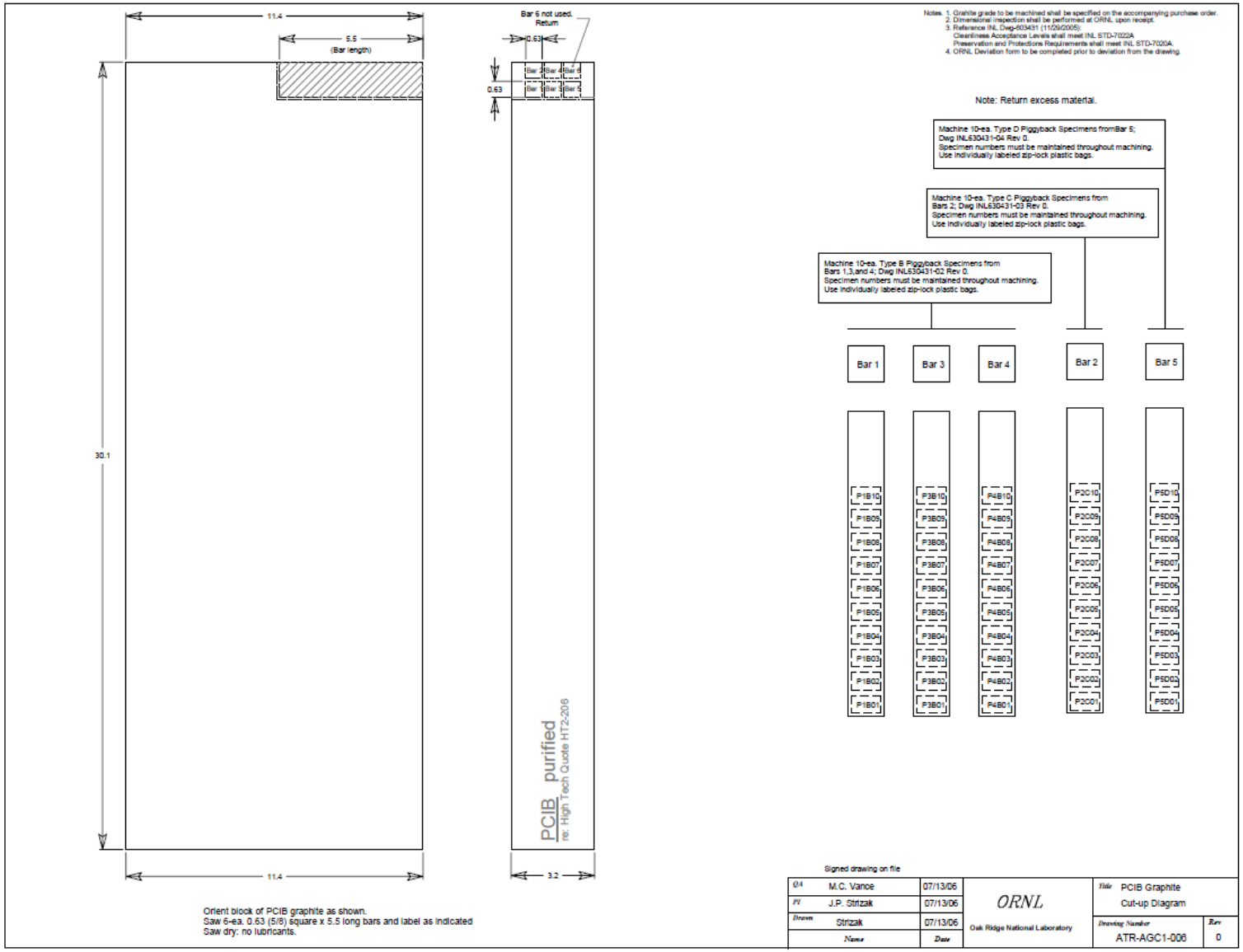

Figure 24. Specimen extraction plan for PCIB graphite

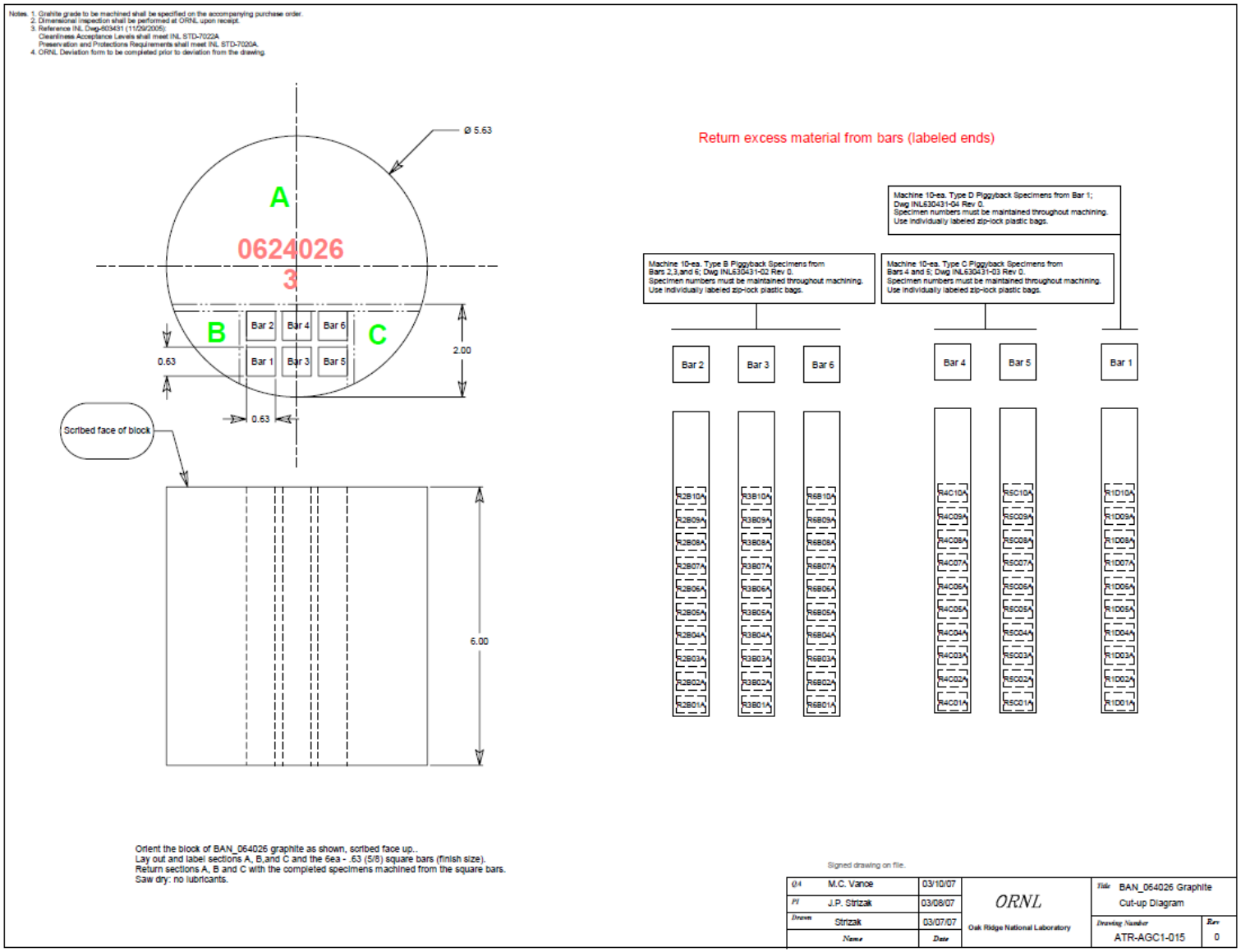

Figure 25. Specimen extraction plan for BAN graphite

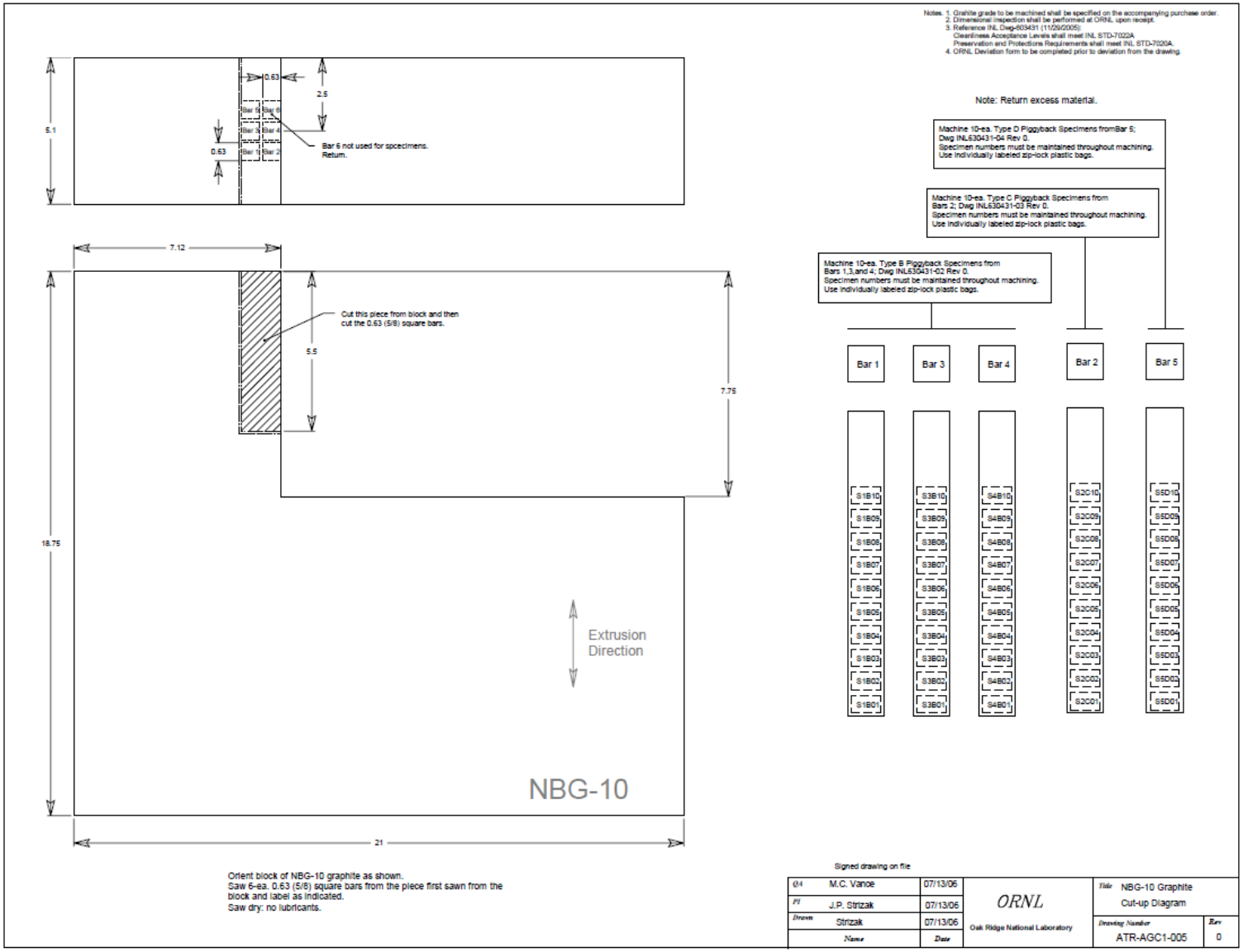

Figure 26. Specimen extraction plan for NBG-10 graphite

2.3 Preirradiation Examination Workflow

All machined specimens were subjected to visual inspection to check for damage and confirm the clarity of the laser marking, and full dimensional inspection. Those specimens to be encapsulated in AGC-1 were set aside and only non-destructive testing was performed on them. The remaining specimens (controls) were tested to determine key physical properties as detailed below. Where possible, the testing was carried out in accordance with the appropriate American Society for Testing and Materials (ASTM) specification(s). Fig. 27 shows the preirradiation test program schematically. Non-destructive measurements performed included: dimensions; Specimen Mass (hence bulk density); elastic modulus by the dynamic (fundamental frequency) technique and sonic velocity method, yielding Young's modulus, Shear modulus and Poisson's ratio; thermal flash diffusivity at room temperature, and hence the thermal conductivity (elevated temperature diffusivity/conductivity was measured on sister samples [6]); thermal expansion (25-800°C) and hence the coefficient of thermal expansion (1-inch long creep specimens only); and electrical resistivity (potentially useful as an indicator of structure and crystallinity). These measurements were made on all of the specimens to be encapsulated in AGC-1, with the exception of the elevated temperature thermal diffusivity which will be performed on a statistically representative sample of the sister specimens [6]. Additional destructive tests performed on companion/sister samples included: X-ray diffraction (XRD) on powdered samples of the graphites (and hence the crystallographic parameters a, c, l_a, l_c); microstructural characterization via optical microscopy, scanning electron microscopy, and Hg-porosymmetry (pore size distributions); finally, strength tests of the specimens, the test type being dependent upon the specimen geometry, provided compressive and flexural strength data (see sister specimens testing data report [6]).

The determination of which tests were applied to which specimens was influenced by a number of considerations, including sample geometry, graphite texture, statistical factors, test equipment availability, test duration and complexity, and cost/budget. Analysis of the preirradiation data should take into account factors such as statistical variations, textural effects, and volume effects (irradiation specimens are of necessity very small volume).

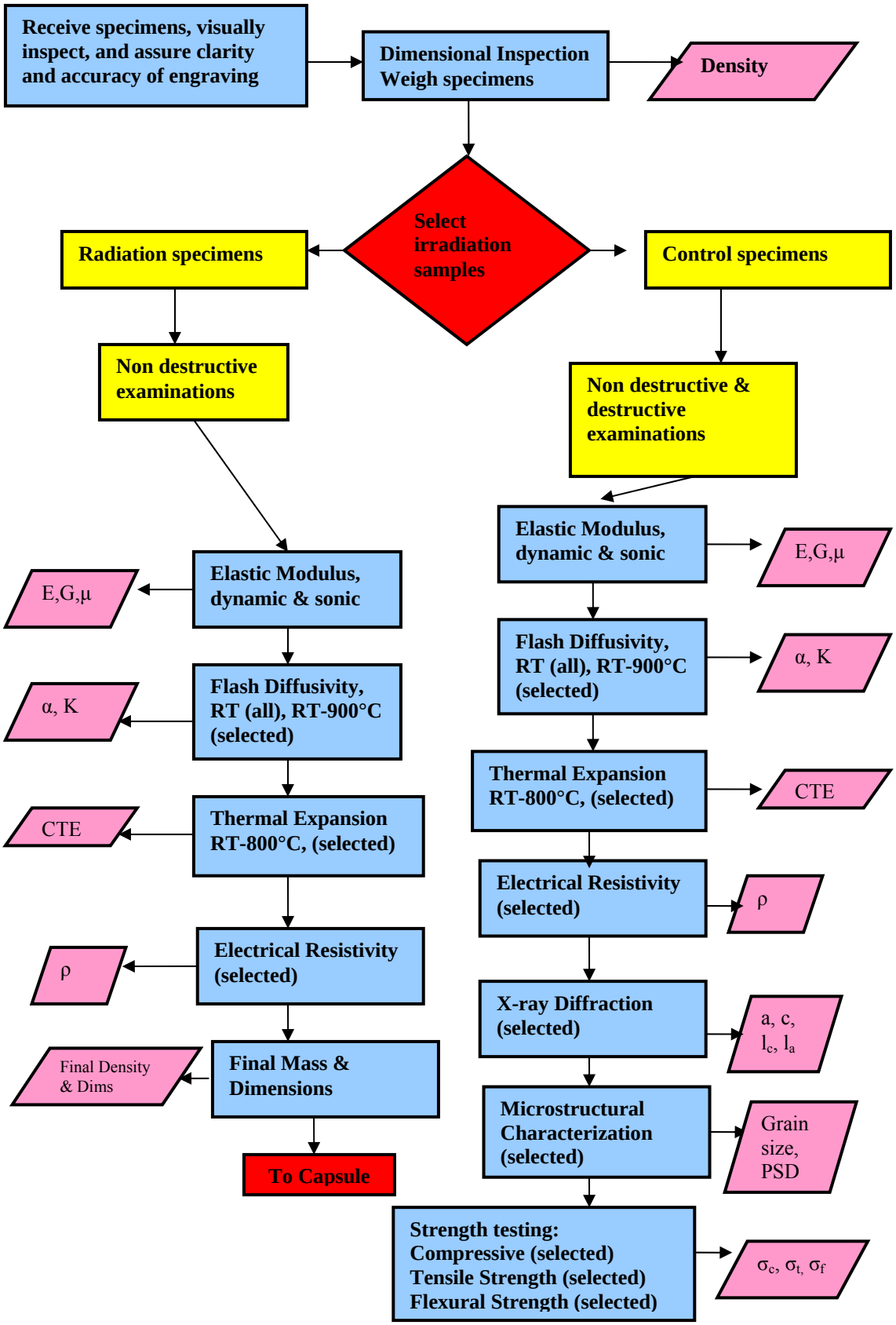

Fig. 27. Pre-irradiation data process flow chart for irradiation creep experiment AGC-1

2.4 Pre-Irradiation Examination, Dimensions and Density

The specimens were cleaned, dried in a lab oven for a minimum of 2 hours at 110°C, and cooled to room temperature in a desiccator prior to testing.

i. Dimensions

Dimensional inspection was conducted using a detailed measurement scheme (Figs 28 and 29) to determine (a) conformity to the drawing and (b) initial sample dimensions for thermal testing. Subsequent to thermal expansion testing (1-inch long creep samples only) the dimensions were recorded again using a detailed measurement scheme. All measurements were made using calibrated instruments. Calibration certificates have been provided elsewhere [1].

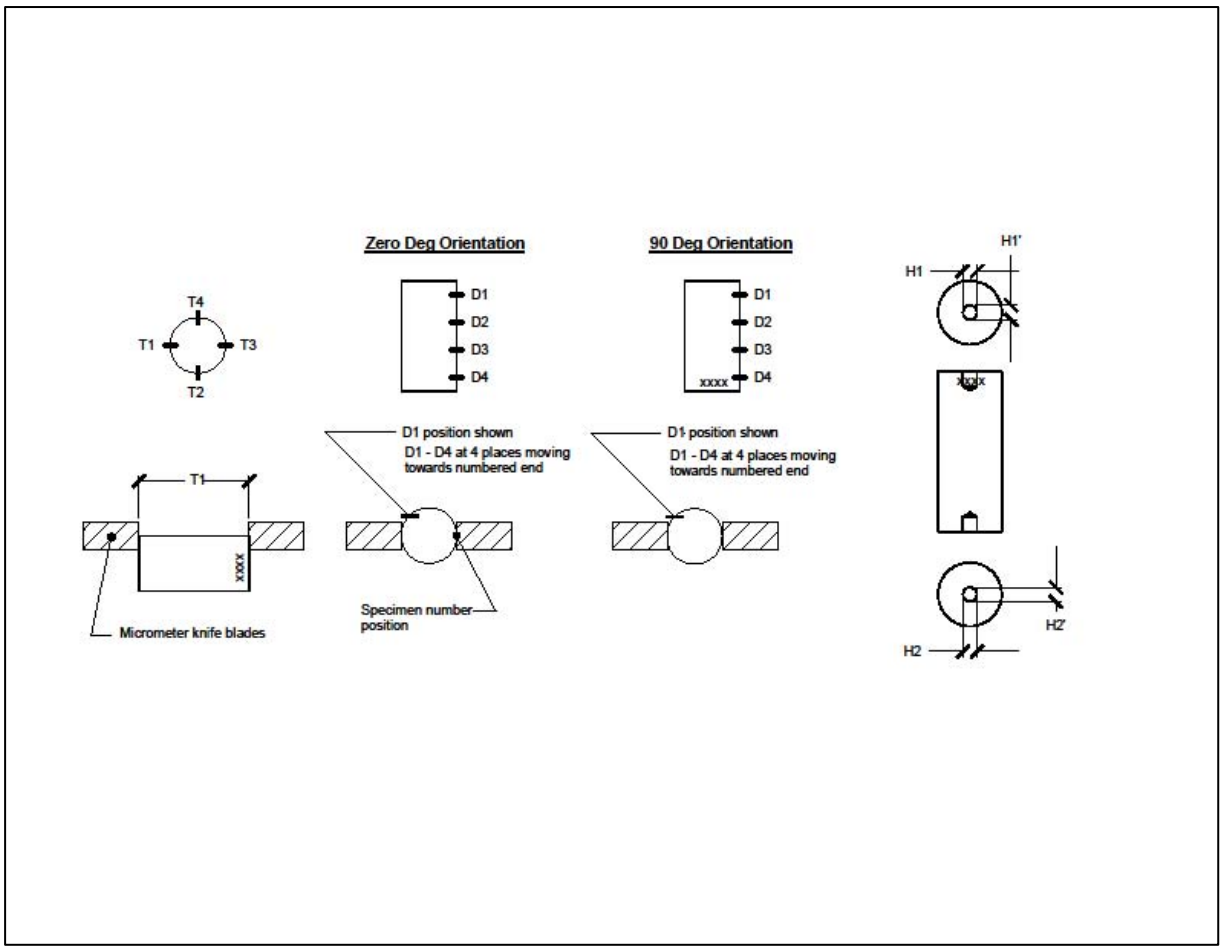

Fig. 28. Measurement scheme employed for creep specimens (both initial and final dimensions)

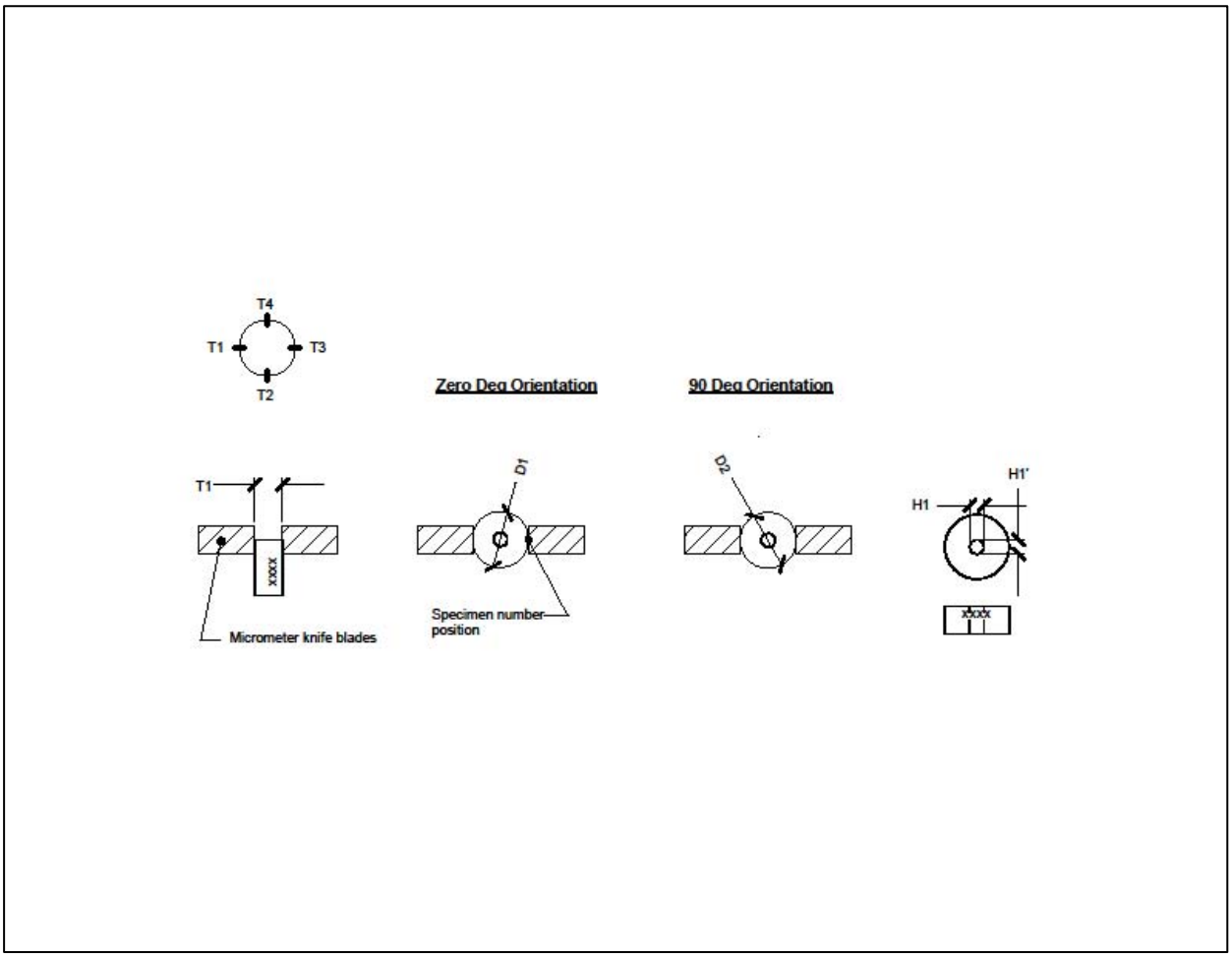

Fig. 29. Measurement scheme employed for piggy back specimens

The following properties were determined experimentally during this work:

ii. Density

Density was determined by mensuration and Specimen Mass determinations on all AGC-1 specimens. Specimen Mass measurements were made using a Mettler Microbalance model AT 261 (ID No. X-522314). The balance is periodically calibrated using National Institute of Standards and Technology traceable standards. Calibration certificates have been provided elsewhere [1].

2.5 Pre-Irradiation Examination, Flexural Dynamic Young's Modulus

The flexural dynamic elastic (Young's) modulus was determined on creep specimens using the fundamental frequency method in accordance with ASTM method C 747 [7] using a GrindoSonic Mk5, S/N 0620843 (Fig. 30). The specimens were vibrated in the flexure mode. Each specimen was measured ten times to generate a mean fundamental frequency for calculation of the flexural dynamic Young's modulus. Fig. 29 shows the experimental apparatus. During testing the test laboratory air temperature was 72-77 °F, with 49-54% humidity. The flexural dynamic Young's modulus is given by ASTM C 1295 [8] as:

$$E = 1.6067\left(\frac{L^3}{D^4}\right)\left(Mf_f^2\right)T_1' \tag{1}$$

where L is the specimen length (mm), D is the specimen diameter (mm), M is the specimen mass (g), f_f is the fundamental frequency in Hz, and T_1' is a geometric factor for rods whose (L/D)<20 and is given by:

$$T_1' = 1 + 4.939(1 + 0.0752\mu + 0.8109\mu^2)(D/L)^2 - 0.4883(D/L)^4 - \left[\frac{4.691(1 + 0.2023\mu + 2.173\mu^2)(D/L)^4}{1.00 + 4.754(1 + 0.1408\mu + 1.536\mu^2)(D/L)^2}\right] \tag{2}$$

where D is the specimen diameter (mm), L is the specimen length (mm), and μ is Poisson's ratio (taken here as 0.16667).

Figure 30. GrindoSonic Mk5 fundamental frequency modulus system

2.6. Pre-Irradiation Examination, Sonic Elastic Constants

Young's modulus, shear modulus, and Poisson's ratio were determined ultrasonically on all 1-inch long creep specimens prior to testing in accordance with C 769 "Standard Test Method for Sonic Velocity in Manufactured Carbon and Graphite Materials for use in obtaining an

Approximate Young's Modulus" [9]. Young's modulus (E) was calculated from the velocity of a longitudinal sound wave and the Shear modulus (G) was calculated from the velocity of a shear sound wave. The velocity was calculated from measurements of the time of flight of a sound wave over a known specimen length. The experimental apparatus is shown in Fig. 31. The ultrasonic probes had a frequency of 2.25 MHz (Table 25) and were ½ inch diameter.

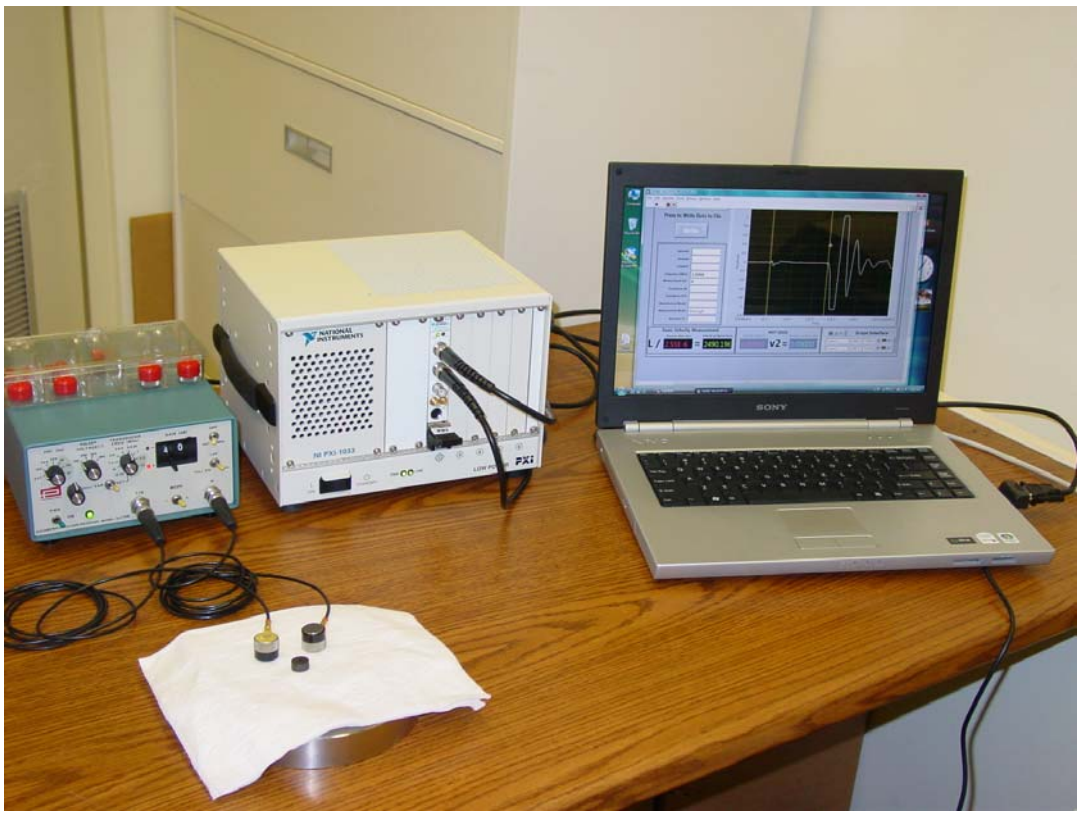

Figure 31. Ultrasonic velocity determination apparatus

Table 25. Ultrasonic transducer details

Manufacturer	Model	Frequency	Serial No.	Wave Type
Panametrics	V106	2.25 MHz	593888	Longitudinal
Panametrics	V106	2.25 MHz	593889	Longitudinal
Panametrics	V154	2.25 MHz	589864	Shear
Panametrics	V154	2.25 MHz	598869	Shear

The experimental apparatus consisted of a Panametrics square wave pulser/receiver model 5077PD, S/N 01133702 integrated with a National Instruments Dual Trace Oscilloscope Card,

Model PXI-5122, and read with LabView software. The couplant used between the sample and the probes was ULTRAGEL II by SonoTech. The lab/room air temperature was 72-77 °F, 49-54% humidity.

Elastic Moduli are determined from measurements of sonic velocity (shear and longitudinal). The moduli are calculated from eqs. 3 through 8:

ATSM C769 gives the **approximate** Young's modulus as

$$E = \rho \cdot v^2 \tag{3}$$

where E = Young's Modulus (Pa)
ρ = specimen bulk density (kg/m^3)
v = Longitudinal sonic velocity in the specimen (m/s)

However, Young's Modulus may be more precisely calculated for anisotropic materials from

$$E = \rho \cdot v^2 \cdot [(1+\mu)(1-2\mu)/(1-\mu)] \tag{4}$$

where E = Young's Modulus (Pa)
ρ = specimen bulk density (kg/m^3)
v = Longitudinal sonic velocity in the specimen (m/s), and
μ = Poisson's ratio.

Since Poisson's ratio is unknown for each of these materials it must first be calculated from:

$$\mu = \frac{1 - \left[2(V_s / V_l)^2\right]}{2 - \left[2(V_s / V_l)^2\right]} \tag{5}$$

where v_s and v_l are the measured shear and longitudinal velocities (m/s) respectively.

Shear modulus, G, is calculated from:

$$G = (v_s)^2 \cdot \rho \quad (6)$$

where v_s is the measured shear sonic velocity (m/s) and ρ is the specimen bulk density (kg/m^3).

Given E and G, μ may also be calculated from the relationship (for isotropic materials only)

$$E = 2G(1+ \mu) \quad (7)$$

The specimen size should be sufficiently large compared to the wavelength of sound in the material.

The wavelength (m) is given by

$$\lambda = c/f \quad (8)$$

where c is the velocity of sound in graphite (~2600 m/s) and f is the frequency of the sound wave. Thus a 2.25 MHz probe would produce a sound wave with a wavelength of 1.16 mm. In previous graphite irradiation experiments we have found that cylindrical specimens as small as 6 mm length can satisfactorily be tested to determine the velocities and hence elastic constants. Typically, the shear wave velocity is measured with the probes in two orientations, 0° and rotated 90° on the same face of the specimen, and the two values averaged to calculate the elastic constants.

2.7 Pre-Irradiation Examination, Ambient Temperature Thermal Conductivity

Ambient temperature thermal diffusivity measurements were conducted on piggy-back samples. Measurements were made on an Anter FlashLine 3000 Xenon lamp flash diffusivity measurement system (Anter Model: FL-5000(71), S/N Q01551-5306-6/01). The Clark and Taylor model was used to calculate the diffusivity for the signal half-rise time. Fig. 32 shows the experimental apparatus. Testing was conducted in accordance with the method prescribed in ASTM E1461 [10] and C781 Appendix 6 [11]. The thermal conductivity was calculated from:

$$\lambda = \alpha \cdot C_p \cdot \rho \tag{9}$$

where:

λ = thermal conductivity, W.m/K,

α = diffusivity, m^2/s,

C_p = specific heat, J/kg.K, and

ρ = density, kg/m^3.

Specific heat was calculated from the equation provided in ASTM C 781 (2008) Appendix 6, where the specific heat, C_p (J/kg.K) is given as:

$$C_p = \frac{1}{11.07T^{-1.644} + 0.0003688T^{0.02191}} \tag{10}$$

where T is the temperature in Kelvin.

The exact test temperature (~21°C, 294K) was recorded and the appropriate value of the specific heat of graphite was calculated from eq. (10) and used here for the calculation of ambient temperature thermal conductivity.

Figure 32. Anter FlashLine 5000 Xenon-lamp thermal diffusivity measurement system

2.8 Pre-Irradiation Examination, Thermal Expansion

Thermal expansion testing was performed using a Workhorse-1 dilatometer (Fig. 33) supplied by Anter Inc in accordance with ASTM E 228 [12]. The 1-inch long creep (and control) samples only were heated from 21 to 800°C at a rate of 5°C/minute with a 30 minutes dwell time at each increment of 100°C after which the expansion was recorded.

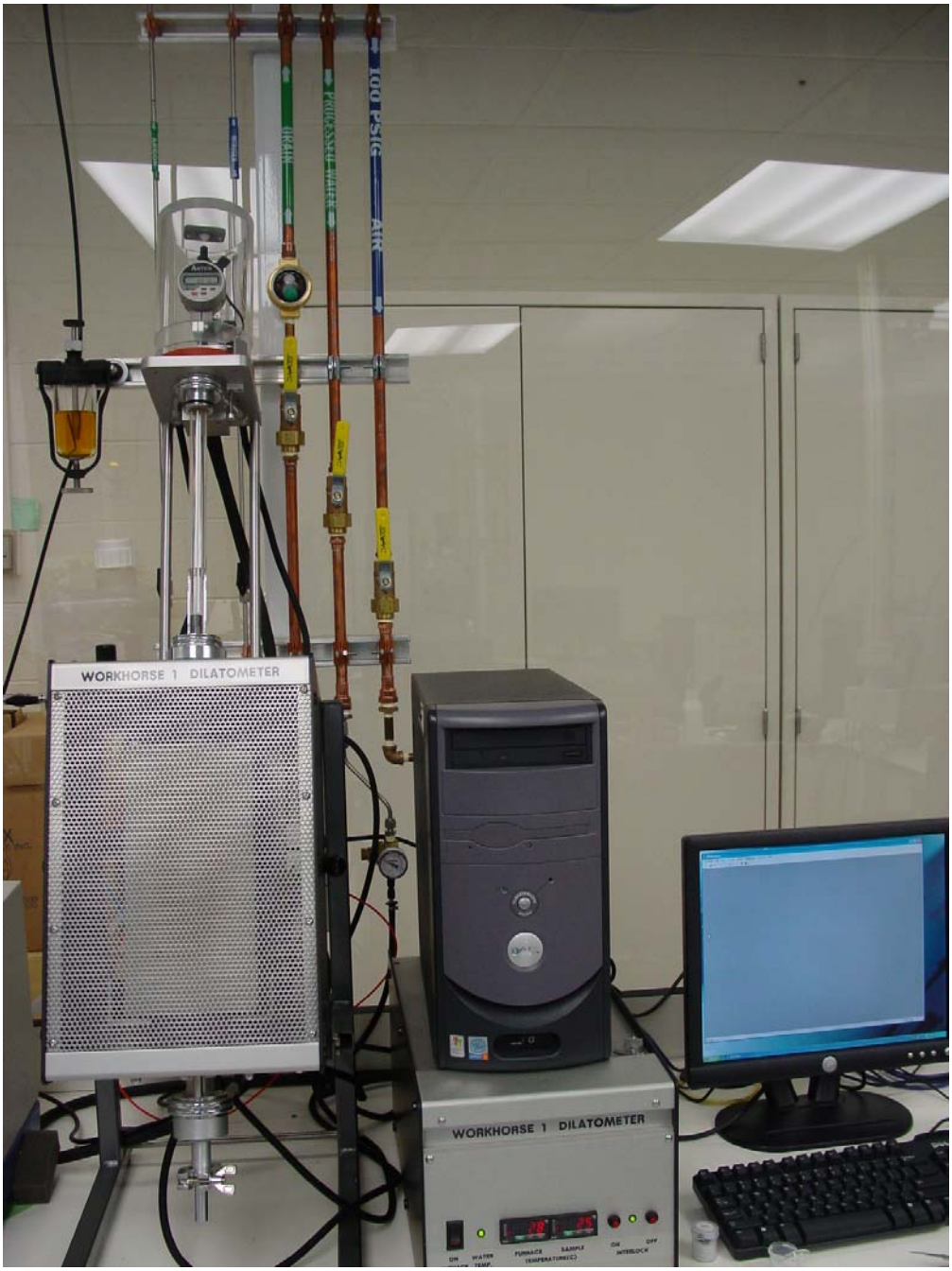

Fig. 33. Anter dilatometer used for measurements of thermal expansion

Two additional parameters are derived from the thermal expansion, namely the instantaneous coefficient of thermal expansion (reported at temperature intervals of 100°C commencing at a measurement temperature of 100°C), and the average CTE over the temperature interval room temperature and measurement temperature, again reported at discrete temperature intervals of 100°C beginning at a measurement temperature 100°C.

Periodic calibration checks were performed during the course of this testing by running a certified Crystallox standard also supplied by Anter Inc. Typical calibration results are shown in Figure 34. The measured thermal expansion for the standard (Fig. 34) duplicated the theoretical expansion of the standard.

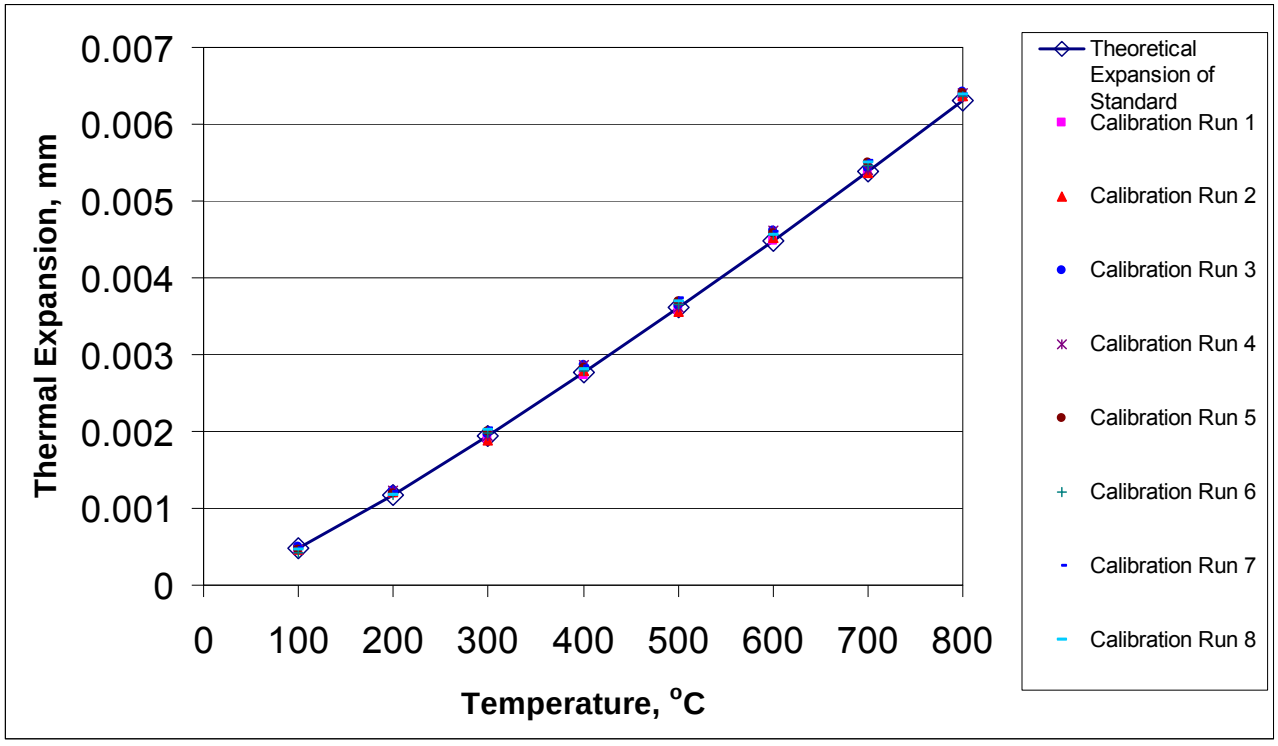

Fig. 34. Crystallox standard calibration thermal expansion data for the ANTER Workhorse-1 dilatometer

2.9 Pre-Irradiation Examination, Electrical Resistivity

Electrical resistivity was determined in accordance with ASTM Standard C611 – 98 (reapproved 2005), "Standard Test Method for Electrical Resistivity of Manufactured Carbon and Graphite Articles at Room Temperature" [13]. The test setup employed a Keithley 2400 Source Meter (current supply), and a Keithley 2182 Nanovoltmeter. A pair of probes (knife edges) for applying the electrical current through the specimen and another pair of probes for measuring the potential was mounted in an insulating, Plexiglas block. The magnitude of the current was low, and the time that the current was allowed to flow through the specimen was kept short such that the temperature rise in the specimen was negligible, and consequently the resistance of the specimen was not changed. Multiple resistivity measurements were made on each specimen to determine an average value.

The electrical resistivity, ρ, is calculated from:

$$\rho = \frac{R \cdot A}{L} \quad (\Omega.\text{m}) \tag{11}$$

where: A = cross-sectional area, m^2

L = gauge length, m

R = resistance, Ω

and is given by $R = (V_x/I)$ where V_x is the mean voltage (V) and I is the current (A).

The current contacts were on the end faces of the specimen (nominally 1.000 inch apart), and the probe location for voltage readings was fixed at 0.49661 in. The electrical resistivity apparatus is shown in Figs. 35 and 36. The creep specimens were dried in a lab oven for a minimum of 2 h at 110 °C and cooled to room temperature in a desiccator prior to determining the electrical resistivity.

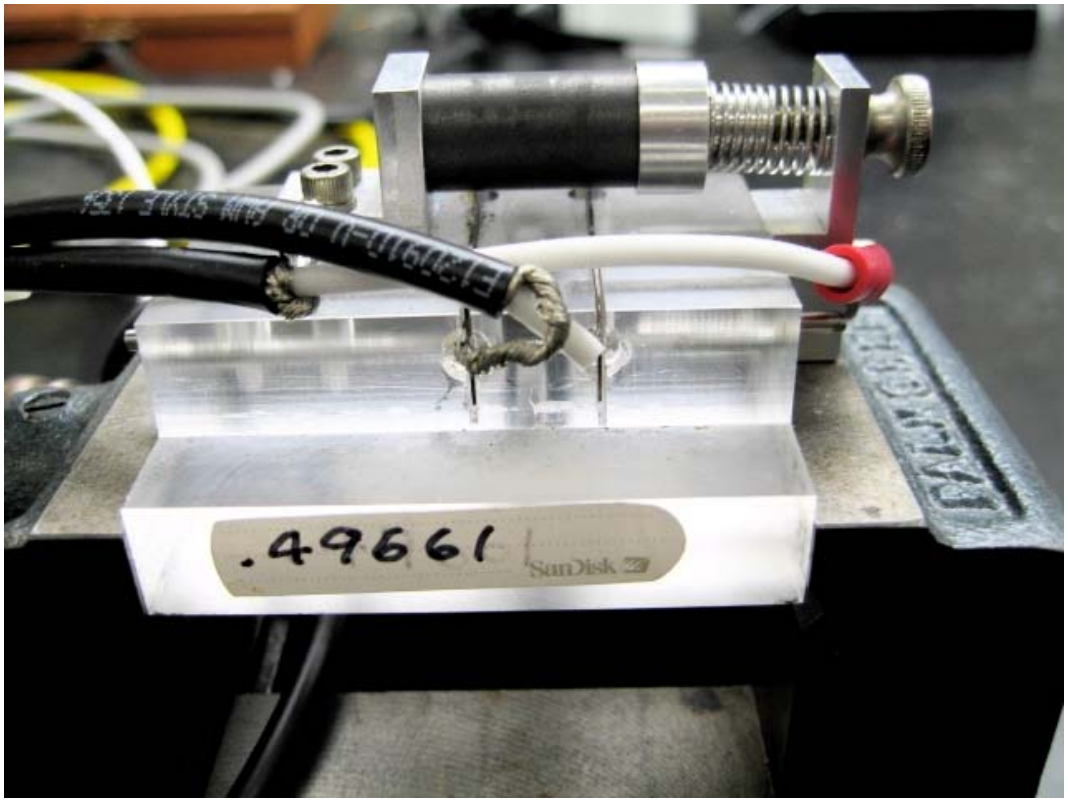

Fig. 35. Electrical resistivity fixture

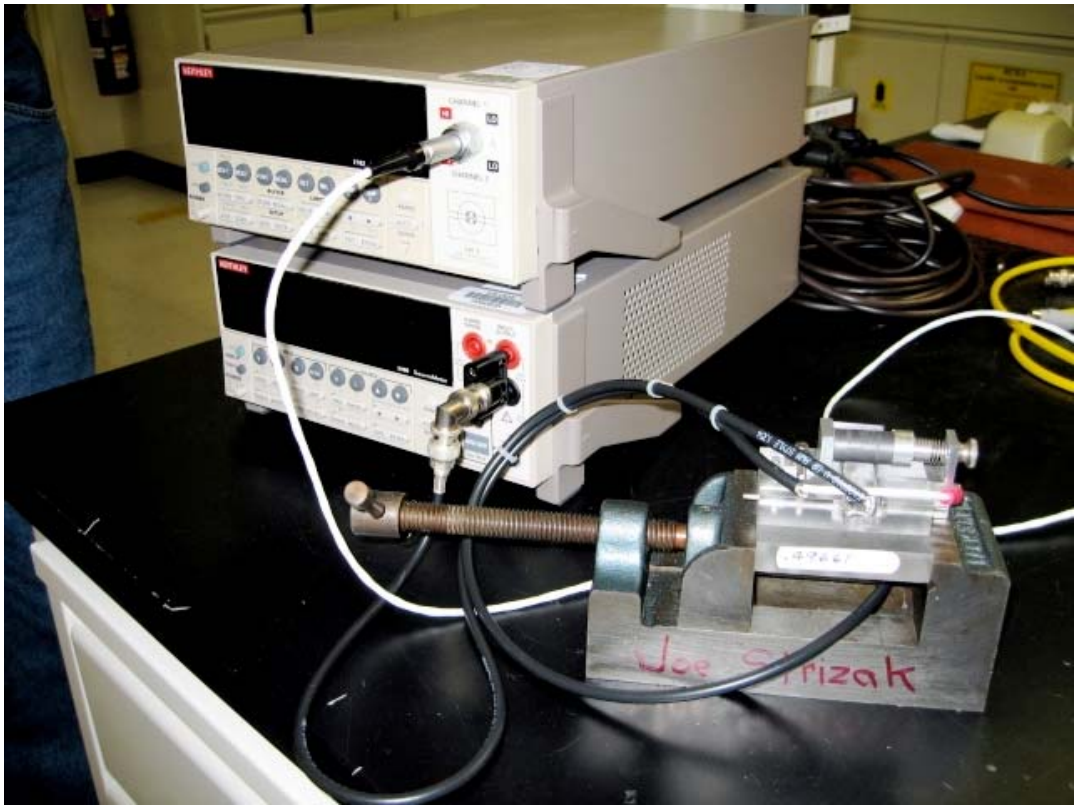

Fig. 36. Electrical resistivity apparatus

2.10 Revised AGC-1 Capsule Layout and Specimen Locations

As discussed previously AGC-1 design changes forced a revision in the capsule layout. The revised layout and capsule positions [3] are reported here in Tables 26-31. The capsule location is given in the left-hand column of the tables. The right most columns in Tables 26-31 report the unstressed companion sample location. The redesign forced a relocation of the specimens to assure that there were a representative number of specimens for each grade at each of the revised stress levels. Consequently, the specimens engraved unique identification number (fourth column) no longer matches its capsule location. Tables 26-31 also report the estimated fast neutron flux and dose for each specimen in AGC-1 based upon known flux profiles from previous reactor experience. The actual dose to each sample will be reported after irradiation testing. The algorithm used to calculate the fast neutron dose to each specimen will be calibrated by the INL against the results of the flux wires contained in the capsule during post irradiation examination.

Table 26. The new AGC-1 capsule layout for channel 1 (North) [2.5 ksi]

NEW AGC-1 Channel 1 (NORTH) Layout [2.5 ksi]											
Location in Capsule	Sample Type	Graphite Grade	Secimen ID	Dimensions, ins		Cumulative stack distance from Core bottom	Sample mid line distance from core bottom	Fast Flux, 10^14 n/cm2-s [E>0.1MeV]	Nominal Dose		Companion Sample Position
				Length	JPS Spec Number				n/cm2 [E>0.1 MeV]	dpa	
	Insulation										
	Thimble top										
	Thimble Bottom			0.25		44.25	44.125	1.344	4.39E+21	3.20	
Spacer	Guide/spacer	NBG-25		0.25		44	43.875	1.397	4.56E+21	3.33	
1S15	stressed creep	NBG-17	1S12	1	AW1-03	43.75	43.25	1.529	4.99E+21	3.64	1U14
Spacer	Guide/spacer	NBG-25		0.25		42.75	42.625	1.657	5.41E+21	3.95	
1S14	stressed creep	NBG-18	SPARE1W, BW12-02	1	BW12-02	42.5	42	1.783	5.82E+21	4.25	1U13
Spacer	Guide/spacer	NBG-25		0.25		41.5	41.375	1.905	6.22E+21	4.54	
1S13	stressed creep	PCEA	1S14	1	DW1-03	41.25	40.75	2.025	6.61E+21	4.83	1U12
Spacer	Guide/spacer	NBG-25		0.25		40.25	40.125	2.141	6.99E+21	5.10	
1S12	stressed creep	IG-110	1S9	1	EW2-02	40	39.5	2.254	7.36E+21	5.37	1U11
Spacer	Guide/spacer	NBG-25		0.25		39	38.875	2.364	7.72E+21	5.64	
1S11	stressed creep	IG-110	1S7	1	EW2-01	38.75	38.25	2.471	8.07E+21	5.89	1U11
Spacer	Guide/spacer	NBG-25		0.25		37.75	37.625	2.574	8.41E+21	6.14	
1S10	stressed creep	H-451	1S15	1	CW7-03	37.5	37	2.674	8.73E+21	6.38	1U10
Spacer	Guide/spacer	NBG-25		0.25		36.5	36.375	2.770	9.05E+21	6.61	
1S9	stressed creep	IG-430	SPARE1, FW13-01	1	FW13-01	36.25	35.75	2.863	9.35E+21	6.83	1U9
Spacer	Guide/spacer	NBG-25		0.25		35.25	35.125	2.953	9.64E+21	7.04	
1S8	stressed creep	NBG-17	1S11	1	AW1-02	35	34.5	3.039	9.92E+21	7.24	1U8
Spacer	Guide/spacer	NBG-25		0.25		34	33.875	3.121	1.02E+22	7.44	
1S7	stressed creep	NBG-18	3S2	1	BW3-02	33.75	33.25	3.200	1.04E+22	7.63	1U7
Spacer	Guide/spacer	NBG-25		0.25		32.75	32.625	3.274	1.07E+22	7.81	
1S6	stressed creep	PCEA(AG)	4S1	1	DA6-02	32.5	32	3.346	1.09E+22	7.98	1U6
Spacer	Guide/spacer	NBG-25		0.25		31.5	31.375	3.413	1.11E+22	8.14	

1S5	stressed creep	NBG-17	1S3	1	AW1-01	31.25	30.75	3.476	1.14E+22	8.29	1U5
Spacer	Guide/spacer	NBG-25		0.25		30.25	30.125	3.536	1.15E+22	8.43	
1S4	stressed creep	NBG-18	1S4	1	BW1-01	30	29.5	3.591	1.17E+22	8.56	1U4
Spacer	Guide/spacer	NBG-25		0.25		29	28.875	3.643	1.19E+22	8.69	
1S3	stressed creep	PCEA	1S2	1	DW1-01	28.75	28.25	3.690	1.21E+22	8.80	1U3
Spacer	Guide/spacer	NBG-25		0.25		27.75	27.625	3.734	1.22E+22	8.90	
1S2	stressed creep	IG-430	1S5	1	FW1-01	27.5	27	3.773	1.23E+22	9.00	1U2
Spacer	Guide/spacer	NBG-25		0.25		26.5	26.375	3.808	1.24E+22	9.08	
1S1	stressed creep	H-451	1S8	1	CW7-01	26.25	25.75	3.839	1.25E+22	9.15	1U1
Spacer	Guide/spacer	NBG-25		0.25		25.25	25.125	3.866	1.26E+22	9.22	
Plug	Core center plug	NBG-25		1		25	24.5	3.888	1.27E+22	9.27	
Core Center Line											
Plug	Core center plug	NBG-25		1		24	23.5	3.914	1.28E+22	9.33	
GAP	GAP			0.25		23	22.875	3.925	1.28E+22	9.36	
Spacer	Guide/spacer	NBG-25		0.25		22.75	22.625	3.928	1.28E+22	9.37	
1PB16	Piggy Back	NBG-17	1PB16	0.25	AW14C-01	22.5	22.375	3.930	1.28E+22	9.37	
Spacer	Guide/spacer	NBG-25		0.25		22.25	22.125	3.932	1.28E+22	9.37	
1PB17	Piggy Back	PCEA	1PB17	0.25	DW14C-01	22	21.875	3.933	1.28E+22	9.38	FLUX CL
Spacer	Guide/spacer	NBG-25		0.25		21.75	21.625	3.933	1.28E+22	9.38	
1PB18	Piggy Back	NBG-18	1PB18	0.25	BW14C-01	21.5	21.375	3.932	1.28E+22	9.38	
Spacer	Guide/spacer	NBG-25		0.25		21.25	21.125	3.931	1.28E+22	9.37	
1PB19	Piggy Back	IG-430	1PB19	0.25	FW18C-01	21	20.875	3.929	1.28E+22	9.37	
Spacer	Guide/spacer	NBG-25		0.25		20.75	20.625	3.926	1.28E+22	9.36	
1PB20	Piggy Back	HOPG	1PB20	0.25	UNKNOWN	20.5	20.375	3.923	1.28E+22	9.35	
Spacer	Guide/spacer	NBG-25		0.25		20.25	20.125	3.918	1.28E+22	9.34	
1PB21	Piggy Back	IG-110	1PB21	0.25	EW13C-01	20	19.875	3.913	1.28E+22	9.33	
Spacer	Guide/spacer	NBG-25		0.25		19.75	19.625	3.907	1.28E+22	9.32	
1PB22	Piggy Back	BAN	1PB22	0.25	R4C01A	19.5	19.375	3.901	1.27E+22	9.30	
Spacer	Guide/spacer	NBG-25		0.25		19.25	19.125	3.893	1.27E+22	9.28	
1U1	unstressed control	H-451	1U8	1	CW8-02	19	18.5	3.872	1.26E+22	9.23	1S1
Spacer	Guide/spacer	NBG-25		0.25		18	17.875	3.845	1.26E+22	9.17	
1U2	unstressed control	IG-430	1U5	1	FW1-03	17.75	17.25	3.813	1.25E+22	9.09	1S2
Spacer	Guide/spacer	NBG-25		0.25		16.75	16.625	3.777	1.23E+22	9.00	

1U3	unstressed control	PCEA	1U2	1	DW2-01	16.5	16	3.735	1.22E+22	8.91	1S3
Spacer	Guide/spacer	NBG-25		0.25		15.5	15.375	3.689	1.20E+22	8.80	
1U4	unstressed control	NBG-18	1U4	1	BW1-03	15.25	14.75	3.638	1.19E+22	8.67	1S4
Spacer	Guide/spacer	NBG-25		0.25		14.25	14.125	3.581	1.17E+22	8.54	
1U5	unstressed control	NBG-17	1U3	1	AW2-01	14	13.5	3.519	1.15E+22	8.39	1S5
Spacer	Guide/spacer	NBG-25		0.25		13	12.875	3.452	1.13E+22	8.23	
1U6	unstressed control	PCEA(AG)	3S6	1	DA6-01	12.75	12.25	3.380	1.10E+22	8.06	1S6
Spacer	Guide/spacer	NBG-25		0.25		11.75	11.625	3.302	1.08E+22	7.87	
1U7	unstressed control	NBG-18	3U2	1	BW5-02	11.5	11	3.219	1.05E+22	7.67	1S7
Spacer	Guide/spacer	NBG-25		0.25		10.5	10.375	3.131	1.02E+22	7.46	
1U8	unstressed control	NBG-17	1U11	1	AW2-02	10.25	9.75	3.037	9.92E+21	7.24	1S8
Spacer	Guide/spacer	NBG-25		0.25		9.25	9.125	2.938	9.59E+21	7.00	
1U9	unstressed control	IG-430	1U10	1	FW2-01	9	8.5	2.833	9.25E+21	6.75	1S9
Spacer	Guide/spacer	NBG-25		0.25		8	7.875	2.722	8.89E+21	6.49	
1U10	unstressed control	H-451	1U14	1	CW8-03	7.75	7.25	2.606	8.51E+21	6.21	1S10
Spacer	Guide/spacer	NBG-25		0.25		6.75	6.625	2.484	8.11E+21	5.92	
1U11	unstressed control	IG-110	1U7	1	EW2-03	6.5	6	2.357	7.70E+21	5.62	1S11/12
Spacer	Guide/spacer	NBG-25		0.25		5.5	5.375	2.223	7.26E+21	5.30	
1U12	unstressed control	PCEA	1U13	1	DW2-03	5.25	4.75	2.084	6.81E+21	4.97	1S13
Spacer	Guide/spacer	NBG-25		0.25		4.25	4.125	1.939	6.33E+21	4.62	
1U13	unstressed control	NBG-18	1U1	1	BW1-02	4	3.5	1.788	5.84E+21	4.26	1S14
Spacer	Guide/spacer	NBG-25		0.25		3	2.875	1.631	5.33E+21	3.89	
1U14	unstressed control	NBG-17	1U12	1	AW2-03	2.75	2.25	1.468	4.79E+21	3.50	1S15
Spacer	Guide/spacer	NBG-25		0.25		1.75	1.625	1.299	4.24E+21	3.10	
1PB23	Piggy Back	IG-430	1PB23	0.25	FW18C-02	1.5	1.375	1.230	4.02E+21	2.93	
Spacer	Guide/spacer	NBG-25		0.25		1.25	1.125	1.159	3.79E+21	2.76	
1PB24	Piggy Back	PCEA	1PB24	0.25	DW14C-02	1	0.875	1.088	3.55E+21	2.59	
Spacer	Guide/spacer	NBG-25		0.25		0.75	0.625	1.016	3.32E+21	2.42	
1PB25	Piggy Back	NBG-18	1PB25	0.25	BW14C-02	0.5	0.375	0.943	3.08E+21	2.25	
Spacer	Guide/spacer	NBG-25		0.25		0.25	0.125	0.868	2.84E+21	2.07	End of core

Table 27. The new AGC-1 capsule layout for channel 2 (North-East) [2 ksi]

New AGC-1 Channel 2 (NORTH EAST) Layout [2 ksi]											
Location in Capsule	Sample Type	Graphite Grade	Secimen ID	Dimensions, ins		Cumulative stack distance from Core bottom	Sample mid line distance from core bottom	Fast Flux, 10^14 n/cm2-s [E>0.1MeV]	Nominal Dose		Companion Sample Position
				Length	JPS Spec Number				n/cm2 [E>0.1 MeV]	dpa	
	Insulation										
	Thimble top										
	Thimble Bottom			0.25		44.25	44.125	1.266	4.13E+21	3.02	
Spacer	Guide/spacer	NBG-25		0.25		44	43.875	1.318	4.30E+21	3.14	
2S15	stressed creep	NBG-17	2U4	1	AW4-02	43.75	43.25	1.447	4.73E+21	3.45	2U14
Spacer	Guide/spacer	NBG-25		0.25		42.75	42.625	1.574	5.14E+21	3.75	
2S14	stressed creep	NBG-18	5U5	1	BW9-03	42.5	42	1.697	5.54E+21	4.05	2U13
Spacer	Guide/spacer	NBG-25		0.25		41.5	41.375	1.817	5.94E+21	4.33	
2S13	stressed creep	PCEA	2S14	1	DW3-03	41.25	40.75	1.934	6.32E+21	4.61	2U12
Spacer	Guide/spacer	NBG-25		0.25		40.25	40.125	2.048	6.69E+21	4.88	
2S12	stressed creep	IG-430	2S15	1	FW3-01	40	39.5	2.159	7.05E+21	5.15	2U11
Spacer	Guide/spacer	NBG-25		0.25		39	38.875	2.267	7.40E+21	5.40	
2S11	stressed creep	IG-430	2S9	1	FW2-03	38.75	38.25	2.371	7.74E+21	5.65	2U11
Spacer	Guide/spacer	NBG-25		0.25		37.75	37.625	2.472	8.07E+21	5.89	
2S10	stressed creep	NBG-17	2S6	1	AW4-01	37.5	37	2.570	8.39E+21	6.13	2U10
Spacer	Guide/spacer	NBG-25		0.25		36.5	36.375	2.664	8.70E+21	6.35	
2S9	stressed creep	NBG-18	2S11	1	BW2-02	36.25	35.75	2.755	9.00E+21	6.57	2U9
Spacer	Guide/spacer	NBG-25		0.25		35.25	35.125	2.842	9.28E+21	6.78	
2S8	stressed creep	PCEA	2S8	1	DW3-02	35	34.5	2.926	9.56E+21	6.98	2U8
Spacer	Guide/spacer	NBG-25		0.25		34	33.875	3.006	9.82E+21	7.17	
2S7	stressed creep	IG-110	2S7	1	EW5-01	33.75	33.25	3.082	1.01E+22	7.35	2U7
Spacer	Guide/spacer	NBG-25		0.25		32.75	32.625	3.155	1.03E+22	7.52	
2S6	stressed creep	H-451	2S13	1	CW9-01	32.5	32	3.225	1.05E+22	7.69	2U6
Spacer	Guide/spacer	NBG-25		0.25		31.5	31.375	3.290	1.07E+22	7.84	
2S5	stressed creep	IG-430	2S3	1	FW2-02	31.25	30.75	3.352	1.09E+22	7.99	2U5
Spacer	Guide/spacer	NBG-25		0.25		30.25	30.125	3.409	1.11E+22	8.13	

2S4	stressed creep	NBG-17(AG)	2S4	1	AL6-02	30	29.5	3.463	1.13E+22	8.26	2U4
Spacer	Guide/spacer	NBG-25		0.25		29	28.875	3.513	1.15E+22	8.38	
2S3	stressed creep	NBG-18	2S2	1	BW2-01	28.75	28.25	3.559	1.16E+22	8.49	2U3
Spacer	Guide/spacer	NBG-25		0.25		27.75	27.625	3.601	1.18E+22	8.59	
2S2	stressed creep	PCEA	2S1	1	DW3-01	27.5	27	3.639	1.19E+22	8.68	2U2
Spacer	Guide/spacer	NBG-25		0.25		26.5	26.375	3.673	1.20E+22	8.76	
2S1	stressed creep	H-451	6S5	1	CW13-02	26.25	25.75	3.703	1.21E+22	8.83	2U1
Spacer	Guide/spacer	NBG-25		0.25		25.25	25.125	3.729	1.22E+22	8.89	
Plug	Core center plug			1		25	24.5	3.750	1.22E+22	8.94	
Core Center Line											
Plug	Core center plug			1		24	23.5	3.775	1.23E+22	9.00	
GAP	GAP			0.25		23	22.875	3.785	1.24E+22	9.03	
Spacer	Guide/spacer	NBG-25		0.25		22.75	22.625	3.788	1.24E+22	9.03	
2PB16	Piggy Back	NBG-17	2PB16	0.25	AW14C-02	22.5	22.375	3.790	1.24E+22	9.04	
Spacer	Guide/spacer	NBG-25		0.25		22.25	22.125	3.792	1.24E+22	9.04	
2PB17	Piggy Back	PCEA	2PB17	0.25	DW14C-03	22	21.875	3.793	1.24E+22	9.04	FLUX CL
Spacer	Guide/spacer	NBG-25		0.25		21.75	21.625	3.793	1.24E+22	9.04	
2PB18	Piggy Back	NBG-18	2PB18	0.25	BW14C-03	21.5	21.375	3.792	1.24E+22	9.04	
Spacer	Guide/spacer	NBG-25		0.25		21.25	21.125	3.791	1.24E+22	9.04	
2PB19	Piggy Back	IG-430	2PB19	0.25	FW18C-03	21	20.875	3.788	1.24E+22	9.03	
Spacer	Guide/spacer	NBG-25		0.25		20.75	20.625	3.786	1.24E+22	9.03	
2PB20	Piggy Back	H-451	2PB20	0.25	CW1C-02	20.5	20.375	3.782	1.24E+22	9.02	
Spacer	Guide/spacer	NBG-25		0.25		20.25	20.125	3.778	1.23E+22	9.01	
2PB21	Piggy Back	IG-110	2PB21	0.25	EW13C-02	20	19.875	3.773	1.23E+22	8.99	
Spacer	Guide/spacer	NBG-25		0.25		19.75	19.625	3.767	1.23E+22	8.98	
2PB22	Piggy Back	BAN	2PB22	0.25	R4C04A	19.5	19.375	3.761	1.23E+22	8.97	
Spacer	Guide/spacer	NBG-25		0.25		19.25	19.125	3.753	1.23E+22	8.95	
2U1	unstressed control	H-451	4U2	1	CW11-03	19	18.5	3.732	1.22E+22	8.90	2S1
Spacer	Guide/spacer	NBG-25		0.25		18	17.875	3.706	1.21E+22	8.84	
2U2	unstressed control	PCEA	2U1	1	DW4-03	17.75	17.25	3.675	1.20E+22	8.76	2S2

Spacer	Guide/spacer	NBG-25		0.25		16.75	16.625	3.640	1.19E+22	8.68	
2U3	unstressed control	NBG-18	2U2	1	BW2-03	16.5	16	3.599	1.18E+22	8.58	2S3
Spacer	Guide/spacer	NBG-25		0.25		15.5	15.375	3.554	1.16E+22	8.47	
2U4	unstressed control	NBG-17(AG)	1S13	1	AL6-01	15.25	14.75	3.504	1.14E+22	8.35	2S4
Spacer	Guide/spacer	NBG-25		0.25		14.25	14.125	3.449	1.13E+22	8.22	
2U5	unstressed control	IG-430	2U3	1	FW3-02	14	13.5	3.389	1.11E+22	8.08	2S5
Spacer	Guide/spacer	NBG-25		0.25		13	12.875	3.324	1.09E+22	7.93	
2U6	unstressed control	H-451	2U12	1	CW9-01	12.75	12.25	3.254	1.06E+22	7.76	2S6
Spacer	Guide/spacer	NBG-25		0.25		11.75	11.625	3.179	1.04E+22	7.58	
2U7	unstressed control	IG-110	2U7	1	EW5-03	11.5	11	3.099	1.01E+22	7.39	2S7
Spacer	Guide/spacer	NBG-25		0.25		10.5	10.375	3.014	9.84E+21	7.18	
2U8	unstressed control	PCEA	2U8	1	DW4-01	10.25	9.75	2.923	9.55E+21	6.97	2S8
Spacer	Guide/spacer	NBG-25		0.25		9.25	9.125	2.827	9.23E+21	6.74	
2U9	unstressed control	NBG-18	2U11	1	BW3-01	9	8.5	2.726	8.90E+21	6.50	2S9
Spacer	Guide/spacer	NBG-25		0.25		8	7.875	2.619	8.55E+21	6.24	
2U10	unstressed control	NBG-17	2U6	1	AW4-03	7.75	7.25	2.507	8.19E+21	5.98	2S10
Spacer	Guide/spacer	NBG-25		0.25		6.75	6.625	2.390	7.80E+21	5.70	
2U11	unstressed control	1G-430	2U9	1	FW3-03	6.5	6	2.267	7.40E+21	5.40	2S11/12
Spacer	Guide/spacer	NBG-25		0.25		5.5	5.375	2.138	6.98E+21	5.10	
2U12	unstressed control	PCEA	2U13	1	DW5-01	5.25	4.75	2.004	6.55E+21	4.78	2S13
Spacer	Guide/spacer	NBG-25		0.25		4.25	4.125	1.864	6.09E+21	4.44	
2U13	unstressed control	NBG-18	6U3	1	BW11-02	4	3.5	1.719	5.61E+21	4.10	2S14
Spacer	Guide/spacer	NBG-25		0.25		3	2.875	1.568	5.12E+21	3.74	
2U14	unstressed control	NBG-17	2U10	1	AW5-01	2.75	2.25	1.411	4.61E+21	3.36	2S15
Spacer	Guide/spacer	NBG-25		0.25		1.75	1.625	1.249	4.08E+21	2.98	
2PB23	Piggy Back	IG-110	2PB23	0.25	EW13C-03	1.5	1.375	1.182	3.86E+21	2.82	
Spacer	Guide/spacer	NBG-25		0.25		1.25	1.125	1.114	3.64E+21	2.66	
2PB24	Piggy Back	NBG-18	2PB24	0.25	BW14C-04	1	0.875	1.046	3.42E+21	2.49	
Spacer	Guide/spacer	NBG-25		0.25		0.75	0.625	0.976	3.19E+21	2.33	
2PB25	Piggy Back	IG-430	2PB25	0.25	FW18C-04	0.5	0.375	0.906	2.96E+21	2.16	
Spacer	Guide/spacer	NGB-25		0.25		0.25	0.125	0.834	2.73E+21	1.99	End of core

Table 28. The new AGC-1 capsule layout for channel 3 (South-East) [3 ksi]

New AGC-1 Channel 3 (SOUTH-EAST) Layout [3 ksi]											
Location in Capsule	Sample Type	Graphite Grade	Secimen ID	Dimensions, ins		Cumulative stack distance from Core bottom	Sample mid line distance from core bottom	Fast Flux, 10^14 n/cm2-s [E>0.1MeV]	Nominal Dose		Companion Sample Position
				Length	JPS Spec Number				n/cm2 [E>0.1 MeV]	dpa	
	Insulation										
	Thimble top										
	Thimble Bottom			0.25		44.25	44.125	1.129	3.69E+21	2.69	
Spacer	Guide/spacer	NBG-25		0.25		44	43.875	1.176	3.84E+21	2.80	
3S15	stressed creep	NBG-17	3S13	1	AW5-02	43.75	43.25	1.292	4.22E+21	3.08	3U14
Spacer	Guide/spacer	NBG-25		0.25		42.75	42.625	1.405	4.59E+21	3.35	
3S14	stressed creep	IG-430	3S7	1	FW5-02	42.5	42	1.515	4.95E+21	3.61	3U13
Spacer	Guide/spacer	NBG-25		0.25		41.5	41.375	1.623	5.30E+21	3.87	
3S13	stressed creep	IG-430	3S5	1	FW5-01	41.25	40.75	1.727	5.64E+21	4.12	3U12
Spacer	Guide/spacer	NBG-25		0.25		40.25	40.125	1.829	5.97E+21	4.36	
3S12	stressed creep	IG-110	1U9	1	EW4-01	40	39.5	1.928	6.30E+21	4.60	3U11
Spacer	Guide/spacer	NBG-25		0.25		39	38.875	2.024	6.61E+21	4.83	
3S11	stressed creep	1G-110	3S9	1	EW6-01	38.75	38.25	2.117	6.91E+21	5.05	3U11
Spacer	Guide/spacer	NBG-25		0.25		37.75	37.625	2.207	7.21E+21	5.26	
3S10	stressed creep	NBG-18	3S14	1	BW5-01	37.5	37	2.293	7.49E+21	5.47	3U10
Spacer	Guide/spacer	NBG-25		0.25		36.5	36.375	2.377	7.76E+21	5.67	
3S9	stressed creep	PCEA	3S15	1	DW5-02	36.25	35.75	2.458	8.03E+21	5.86	3U9
Spacer	Guide/spacer	NBG-25		0.25		35.25	35.125	2.535	8.28E+21	6.04	
3S8	stressed creep	NBG-17	AW13-02, SPARE 1W	1	AW13-02	35	34.5	2.609	8.52E+21	6.22	3U8
Spacer	Guide/spacer	NBG-25		0.25		34	33.875	2.680	8.75E+21	6.39	
3S7	stressed creep	NBG-18	3S11	1	BW3-03	33.75	33.25	2.748	8.97E+21	6.55	3U7
Spacer	Guide/spacer	NBG-25		0.25		32.75	32.625	2.813	9.19E+21	6.71	
3S6	stressed creep	PCEA	DW11-01, SPARE 1W	1	DW11-01	32.5	32	2.874	9.39E+21	6.85	3U6
Spacer	Guide/spacer	NBG-25		0.25		31.5	31.375	2.931	9.57E+21	6.99	

3S5	stressed creep	H-451	3S10	1	CW10-01	31.25	30.75	2.986	9.75E+21	7.12	3U5
Spacer	Guide/spacer	NBG-25		0.25		30.25	30.125	3.037	9.92E+21	7.24	
3S4	stressed creep	1G-430	3S4	1	FW4-03	30	29.5	3.084	1.01E+22	7.35	3U4
Spacer	Guide/spacer	NBG-25		0.25		29	28.875	3.128	1.02E+22	7.46	
3S3	stressed creep	NBG-17	EW10-02, SPARE1	1	EW10-02	28.75	28.25	3.168	1.03E+22	7.55	3U3
Spacer	Guide/spacer	NBG-25		0.25		27.75	27.625	3.205	1.05E+22	7.64	
3S2	stressed creep	NBG-18(AG)	3S12	1	BL6-03	27.5	27	3.238	1.06E+22	7.72	3U2
Spacer	Guide/spacer	NBG-25		0.25		26.5	26.375	3.268	1.07E+22	7.79	
3S1	stressed creep	H-451	3S1	1	CW9-03	26.25	25.75	3.294	1.08E+22	7.85	3U1
Spacer	Guide/spacer	NBG-25		0.25		25.25	25.125	3.316	1.08E+22	7.91	
Plug	Core center plug			1		25	24.5	3.334	1.09E+22	7.95	
Core Center Line											
Plug	Core center plug			1		24	23.5	3.356	1.10E+22	8.00	
GAP	GAP			0.25		23	22.875	3.365	1.10E+22	8.02	
Spacer	Guide/spacer	NBG-25		0.25		22.75	22.625	3.367	1.10E+22	8.03	
3PB16	Piggy Back	NBG-17	3PB16	0.25	AW14C-04	22.5	22.375	3.369	1.10E+22	8.03	
Spacer	Guide/spacer	NBG-25		0.25		22.25	22.125	3.370	1.10E+22	8.03	
3PB17	Piggy Back	PCEA	3PB17	0.25	DW14C-04	22	21.875	3.370	1.10E+22	8.03	FLUX CL
Spacer	Guide/spacer	NBG-25		0.25		21.75	21.625	3.370	1.10E+22	8.03	
3PB18	Piggy Back	NBG-18	3PB18	0.25	BW14C-05	21.5	21.375	3.369	1.10E+22	8.03	
Spacer	Guide/spacer	NBG-25		0.25		21.25	21.125	3.368	1.10E+22	8.03	
3PB19	Piggy Back	IG-430	3PB19	0.25	FW18C-06	21	20.875	3.366	1.10E+22	8.02	
Spacer	Guide/spacer	NBG-25		0.25		20.75	20.625	3.363	1.10E+22	8.02	
3PB20	Piggy Back	H-451	3PB20	0.25	CW1C-03	20.5	20.375	3.359	1.10E+22	8.01	
Spacer	Guide/spacer	NBG-25		0.25		20.25	20.125	3.355	1.10E+22	8.00	
3PB21	Piggy Back	IG-110	3PB21	0.25	EW13C-04	20	19.875	3.351	1.09E+22	7.99	
Spacer	Guide/spacer	NBG-25		0.25		19.75	19.625	3.345	1.09E+22	7.98	
3PB22	Piggy Back	BAN	3PB22	0.25	R4C07A	19.5	19.375	3.340	1.09E+22	7.96	
Spacer	Guide/spacer	NBG-25		0.25		19.25	19.125	3.333	1.09E+22	7.95	
3U1	unstressed control	H-451	3U1	1	CW10-02	19	18.5	3.314	1.08E+22	7.90	3S1

Spacer	Guide/spacer	NBG-25		0.25		18	17.875	3.290	1.07E+22	7.84	
3U2	unstressed control	NBG-18(AG)	2S12	1	BL6-02	17.75	17.25	3.262	1.07E+22	7.78	3S2
Spacer	Guide/spacer	NBG-25		0.25		16.75	16.625	3.231	1.06E+22	7.70	
3U3	unstressed control	NBG-17	EW10-03, SPARE 2	1	EW10-03	16.5	16	3.195	1.04E+22	7.62	3S3
Spacer	Guide/spacer	NBG-25		0.25		15.5	15.375	3.154	1.03E+22	7.52	
3U4	unstressed control	IG-430	3U4	1	FW7-01	15.25	14.75	3.110	1.02E+22	7.41	3S4
Spacer	Guide/spacer	NBG-25		0.25		14.25	14.125	3.061	1.00E+22	7.30	
3U5	unstressed control	H-451	3U10	1	CW10-03	14	13.5	3.008	9.82E+21	7.17	3S5
Spacer	Guide/spacer	NBG-25		0.25		13	12.875	2.950	9.63E+21	7.03	
3U6	unstressed control	PCEA	3U6	1	DW5-03	12.75	12.25	2.888	9.43E+21	6.88	3S6
Spacer	Guide/spacer	NBG-25		0.25		11.75	11.625	2.821	9.21E+21	6.73	
3U7	unstressed control	NBG-18	3U11	1	BW5-02	11.5	11	2.750	8.98E+21	6.56	3S7
Spacer	Guide/spacer	NBG-25		0.25		10.5	10.375	2.674	8.73E+21	6.38	
3U8	unstressed control	NBG-17	3U8	1	AW5-03	10.25	9.75	2.594	8.47E+21	6.18	3S8
Spacer	Guide/spacer	NBG-25		0.25		9.25	9.125	2.509	8.20E+21	5.98	
3U9	unstressed control	PCEA	3U14	1	DW6-01	9	8.5	2.420	7.90E+21	5.77	3S9
Spacer	Guide/spacer	NBG-25		0.25		8	7.875	2.326	7.60E+21	5.54	
3U10	unstressed control	NBG-18	3U13	1	BW7-01	7.75	7.25	2.227	7.27E+21	5.31	3S10
Spacer	Guide/spacer	NBG-25		0.25		6.75	6.625	2.123	6.93E+21	5.06	
3U11	unstressed control	IG-110	3U9	1	EW6-02	6.5	6	2.015	6.58E+21	4.80	3S11/12
Spacer	Guide/spacer	NBG-25		0.25		5.5	5.375	1.902	6.21E+21	4.53	
3U12	unstressed control	IG-430	3U5	1	FW7-02	5.25	4.75	1.784	5.83E+21	4.25	3S13
Spacer	Guide/spacer	NBG-25		0.25		4.25	4.125	1.661	5.42E+21	3.96	
3U13	unstressed control	IG-430	3U7	1	FW7-03	4	3.5	1.533	5.01E+21	3.65	3S14
Spacer	Guide/spacer	NBG-25		0.25		3	2.875	1.400	4.57E+21	3.34	
3U14	unstressed control	NBG-17	3U12	1	AW6-01	2.75	2.25	1.262	4.12E+21	3.01	3S15
Spacer	Guide/spacer	NBG-25		0.25		1.75	1.625	1.120	3.66E+21	2.67	
3PB23	Piggy Back	PCEA	3PB23	0.25	DW14C-05	1.5	1.375	1.061	3.47E+21	2.53	
Spacer	Guide/spacer	NBG-25		0.25		1.25	1.125	1.002	3.27E+21	2.39	
3PB24	Piggy Back	IG-430	3PB24	0.25	FW19C-01	1	0.875	0.941	3.07E+21	2.24	
Spacer	Guide/spacer	NBG-25		0.25		0.75	0.625	0.880	2.88E+21	2.10	

3PB25	Piggy Back	PCEA	3PB25	0.25	DW15C-01	0.5	0.375	0.819	2.67E+21	1.95	
Spacer	Guide/spacer	NBG-25		0.25		0.25	0.125	0.756	2.47E+21	1.80	End of core

Table 29. The new AGC-1 capsule layout for channel 4 (South) [2.5 ksi]

New AGC-1 Channel 4 (SOUTH) Layout [2.5 ksi]											
Location in Capsule	Sample Type	Graphite Grade	Secimen ID	Dimensions, ins		Cumulative stack distance from Core bottom	Sample mid line distance from core bottom	Fast Flux, 10^14 n/cm2-s [E>0.1MeV]	Nominal Dose		Companion Sample Position
				Length	JPS Spec Number				n/cm2 [E>0.1 MeV]	dpa	
	Insulation										
	Thimble top										
	Thimble Bottom			0.25		44.25	44.125	1.061	3.46E+21	2.53	
Spacer	Guide/spacer	NBG-25		0.25		44	43.875	1.104	3.61E+21	2.63	
4S15	stressed creep	NBG-17	4S12	1	AW6-03	43.75	43.25	1.211	3.96E+21	2.89	4U14
Spacer	Guide/spacer	NBG-25		0.25		42.75	42.625	1.315	4.30E+21	3.14	
4S14	stressed creep	NBG-18	4S14	1	BW7-03	42.5	42	1.417	4.63E+21	3.38	4U13
Spacer	Guide/spacer	NBG-25		0.25		41.5	41.375	1.516	4.95E+21	3.62	
4S13	stressed creep	PCEA(AG)	4S6	1	DA7-01	41.25	40.75	1.613	5.27E+21	3.85	4U12
Spacer	Guide/spacer	NBG-25		0.25		40.25	40.125	1.707	5.57E+21	4.07	
4S12	stressed creep	H-451	4S13	1	CW11-02	40	39.5	1.798	5.87E+21	4.29	4U11
Spacer	Guide/spacer	NBG-25		0.25		39	38.875	1.887	6.16E+21	4.50	
4S11	stressed creep	H-451	4S2	1	CW11-01	38.75	38.25	1.973	6.44E+21	4.70	4U11
Spacer	Guide/spacer	NBG-25		0.25		37.75	37.625	2.056	6.71E+21	4.90	
4S10	stressed creep	NBG-17	4S8	1	AW6-02	37.5	37	2.136	6.98E+21	5.09	4U10
Spacer	Guide/spacer	NBG-25		0.25		36.5	36.375	2.214	7.23E+21	5.28	
4S9	stressed creep	IG-430	4S10	1	FW8-02	36.25	35.75	2.288	7.47E+21	5.46	4U9
Spacer	Guide/spacer	NBG-25		0.25		35.25	35.125	2.360	7.71E+21	5.63	
4S8	stressed creep	NBG-18	BW12-03, SPARE 2W	1	BW12-03	35	34.5	2.429	7.93E+21	5.79	4U8
Spacer	Guide/spacer	NBG-25		0.25		34	33.875	2.495	8.15E+21	5.95	
4S7	stressed creep	PCEA	4S15	1	DW6-02	33.75	33.25	2.558	8.35E+21	6.10	4U7
Spacer	Guide/spacer	NBG-25		0.25		32.75	32.625	2.617	8.55E+21	6.24	
4S6	stressed creep	IG-430	3S3	1	FW4-02	32.5	32	2.674	8.73E+21	6.38	4U6
Spacer	Guide/spacer	NBG-25		0.25		31.5	31.375	2.728	8.91E+21	6.50	
4S5	stressed creep	NBG-18	4S5	1	BW7-02	31.25	30.75	2.778	9.07E+21	6.62	4U5

Spacer	Guide/spacer	NBG-25		0.25		30.25	30.125	2.825	9.23E+21	6.74	
4S4	stressed creep	IG-110	4S9	1	EW7-01	30	29.5	2.870	9.37E+21	6.84	4U4
Spacer	Guide/spacer	NBG-25		0.25		29	28.875	2.910	9.50E+21	6.94	
4S3	stressed creep	PCEA	4U1	1	DW6-03	28.75	28.25	2.948	9.63E+21	7.03	4U3
Spacer	Guide/spacer	NBG-25		0.25		27.75	27.625	2.982	9.74E+21	7.11	
4S2	stressed creep	IG-430	4S3	1	FW8-01	27.5	27	3.013	9.84E+21	7.18	4U2
Spacer	Guide/spacer	NBG-25		0.25		26.5	26.375	3.041	9.93E+21	7.25	
4S1	stressed creep	IG-110	4S4	1	EW6-03	26.25	25.75	3.065	1.00E+22	7.31	4U1
Spacer	Guide/spacer	NBG-25		0.25		25.25	25.125	3.085	1.01E+22	7.36	
Plug	Core center plug			1		25	24.5	3.102	1.01E+22	7.40	
Core Center Line											
Plug	Core center plug			1		24	23.5	3.123	1.02E+22	7.44	
GAP	GAP			0.25		23	22.875	3.130	1.02E+22	7.46	
Spacer	Guide/spacer	NBG-25		0.25		22.75	22.625	3.133	1.02E+22	7.47	
4PB16	Piggy Back	NBG-17	4PB16	0.25	AW15C-02	22.5	22.375	3.134	1.02E+22	7.47	
Spacer	Guide/spacer	NBG-25		0.25		22.25	22.125	3.135	1.02E+22	7.47	
4PB17	Piggy Back	PCEA	4PB17	0.25	DW15C-02	22	21.875	3.136	1.02E+22	7.48	FLUX CL
Spacer	Guide/spacer	NBG-25		0.25		21.75	21.625	3.135	1.02E+22	7.48	
4PB18	Piggy Back	NBG-18	4PB18	0.25	BW15C-02	21.5	21.375	3.135	1.02E+22	7.47	
Spacer	Guide/spacer	NBG-25		0.25		21.25	21.125	3.133	1.02E+22	7.47	
4PB19	Piggy Back	IG-430	4PB19	0.25	FW19C-02	21	20.875	3.131	1.02E+22	7.47	
Spacer	Guide/spacer	NBG-25		0.25		20.75	20.625	3.129	1.02E+22	7.46	
4PB20	Piggy Back	H-451	4PB20	0.25	CW1C-04	20.5	20.375	3.126	1.02E+22	7.45	
Spacer	Guide/spacer	NBG-25		0.25		20.25	20.125	3.122	1.02E+22	7.44	
4PB21	Piggy Back	IG-110	4PB21	0.25	EW14C-01	20	19.875	3.118	1.02E+22	7.43	
Spacer	Guide/spacer	NBG-25		0.25		19.75	19.625	3.113	1.02E+22	7.42	
4PB22	Piggy Back	BAN	4PB22	0.25	R4C08A	19.5	19.375	3.107	1.01E+22	7.41	
Spacer	Guide/spacer	NBG-25		0.25		19.25	19.125	3.101	1.01E+22	7.39	
4U1	unstressed control	IG-110	4U4	1	EW7-03	19	18.5	3.083	1.01E+22	7.35	4S1
Spacer	Guide/spacer	NBG-25		0.25		18	17.875	3.061	1.00E+22	7.30	
4U2	unstressed control	IG-430	4U3	1	FW8-03	17.75	17.25	3.036	9.91E+21	7.24	4S2

Spacer	Guide/spacer	NBG-25		0.25		16.75	16.625	3.006	9.82E+21	7.17	
4U3	unstressed control	PCEA	4U6	1	DW7-01	16.5	16	2.972	9.71E+21	7.09	4S3
Spacer	Guide/spacer	NBG-25		0.25		15.5	15.375	2.935	9.58E+21	7.00	
4U4	unstressed control	IG-110	4U9	1	EW8-01	15.25	14.75	2.893	9.45E+21	6.90	4S4
Spacer	Guide/spacer	NBG-25		0.25		14.25	14.125	2.847	9.30E+21	6.79	
4U5	unstressed control	NBG-18	4U5	1	BW8-01	14	13.5	2.798	9.14E+21	6.67	4S5
Spacer	Guide/spacer	NBG-25		0.25		13	12.875	2.744	8.96E+21	6.54	
4U6	unstressed control	IG-430	3U3	1	FW5-03	12.75	12.25	2.686	8.77E+21	6.40	4S6
Spacer	Guide/spacer	NBG-25		0.25		11.75	11.625	2.624	8.57E+21	6.26	
4U7	unstressed control	PCEA	4U14	1	DW7-02	11.5	11	2.557	8.35E+21	6.10	4S7
Spacer	Guide/spacer	NBG-25		0.25		10.5	10.375	2.487	8.12E+21	5.93	
4U8	unstressed control	NBG-18	4U7	1	BW8-02	10.25	9.75	2.412	7.88E+21	5.75	4S8
Spacer	Guide/spacer	NBG-25		0.25		9.25	9.125	2.332	7.62E+21	5.56	
4U9	unstressed control	IG-430	4U10	1	FW9-01	9	8.5	2.249	7.34E+21	5.36	4S9
Spacer	Guide/spacer	NBG-25		0.25		8	7.875	2.161	7.06E+21	5.15	
4U10	unstressed control	NBG-17	4U8	1	AW7-01	7.75	7.25	2.068	6.75E+21	4.93	4S10
Spacer	Guide/spacer	NBG-25		0.25		6.75	6.625	1.971	6.44E+21	4.70	
4U11	unstressed control	H-451	4U12	1	CW12-01	6.5	6	1.870	6.11E+21	4.46	4S11/12
Spacer	Guide/spacer	NBG-25		0.25		5.5	5.375	1.764	5.76E+21	4.21	
4U12	unstressed control	PCEA (AG)	5S11	1	DA7-02	5.25	4.75	1.654	5.40E+21	3.94	4S13
Spacer	Guide/spacer	NBG-25		0.25		4.25	4.125	1.539	5.02E+21	3.67	
4U13	unstressed control	NBG-18	4U13	1	BW8-03	4	3.5	1.419	4.63E+21	3.38	4S14
Spacer	Guide/spacer	NBG-25		0.25		3	2.875	1.294	4.23E+21	3.09	
4U14	unstressed control	NBG-17	4U11	1	AW7-02	2.75	2.25	1.165	3.81E+21	2.78	4S15
Spacer	Guide/spacer	NBG-25		0.25		1.75	1.625	1.032	3.37E+21	2.46	
4PB23	Piggy Back	NBG-18	4PB23	0.25	BW15C-03	1.5	1.375	0.977	3.19E+21	2.33	
Spacer	Guide/spacer	NBG-25		0.25		1.25	1.125	0.921	3.01E+21	2.20	
4PB24	Piggy Back	PCEA	4PB24	0.25	DW15C-03	1	0.875	0.865	2.82E+21	2.06	
Spacer	Guide/spacer	NBG-25		0.25		0.75	0.625	0.808	2.64E+21	1.93	
4PB25	Piggy Back	NBG-18	4PB25	0.25	BW15C-04	0.5	0.375	0.750	2.45E+21	1.79	
Spacer	Guide/spacer	NBG-25		0.25		0.25	0.125	0.691	2.26E+21	1.65	End of core

Table 30. The new AGC-1 capsule layout for channel 5 (South-West) [2 ksi]

New AGC-1 Channel 5 (SOUTH-WEST) Layout [2 ksi]											
Location in Capsule	Sample Type	Graphite Grade	Secimen ID	Dimensions, ins		Cumulative stack distance from Core bottom	Sample mid line distance from core bottom	Fast Flux, 10^14 n/cm2-s [E>0.1MeV]	Nominal Dose		Companion Sample Position
				Length	JPS Spec Number				n/cm2 [E>0.1 MeV]	dpa	
	Insulation										
	Thimble top										
	Thimble Bottom			0.25		44.25	44.125	1.165	3.80E+21	2.78	
Spacer	Guide/spacer	NBG-25		0.25		44	43.875	1.212	3.96E+21	2.89	
5S15	stressed creep	IG-430	6U7	1	FW12-01	43.75	43.25	1.327	4.33E+21	3.16	5U14
Spacer	Guide/spacer	NBG-25		0.25		42.75	42.625	1.439	4.70E+21	3.43	
5S14	stressed creep	IG-110	5S13	1	EW8-03	42.5	42	1.548	5.06E+21	3.69	5U13
Spacer	Guide/spacer	NBG-25		0.25		41.5	41.375	1.655	5.40E+21	3.95	
5S13	stressed creep	PCEA	5S12	1	DW8-02	41.25	40.75	1.759	5.74E+21	4.19	5U12
Spacer	Guide/spacer	NBG-25		0.25		40.25	40.125	1.860	6.07E+21	4.43	
5S12	stressed creep	H-451	6U5	1	CW14-01	40	39.5	1.958	6.39E+21	4.67	5U11
Spacer	Guide/spacer	NBG-25		0.25		39	38.875	2.053	6.70E+21	4.89	
5S11	stressed creep	H-451	5S7	1	CW12-02	38.75	38.25	2.145	7.00E+21	5.11	5U11
Spacer	Guide/spacer	NBG-25		0.25		37.75	37.625	2.234	7.30E+21	5.33	
5S10	stressed creep	NBG-17(AG)	3S8	1	AL8-01	37.5	37	2.320	7.58E+21	5.53	5U10
Spacer	Guide/spacer	NBG-25		0.25		36.5	36.375	2.403	7.85E+21	5.73	
5S9	stressed creep	NBG-18	5S15	1	BW9-02	36.25	35.75	2.483	8.11E+21	5.92	5U9
Spacer	Guide/spacer	NBG-25		0.25		35.25	35.125	2.559	8.36E+21	6.10	
5S8	stressed creep	PCEA	5S9	1	DW8-01	35	34.5	2.633	8.60E+21	6.28	5U8
Spacer	Guide/spacer	NBG-25		0.25		34	33.875	2.703	8.83E+21	6.44	
5S7	stressed creep	NBG-17	5S14	1	AW9-01	33.75	33.25	2.770	9.05E+21	6.60	5U7
Spacer	Guide/spacer	NBG-25		0.25		32.75	32.625	2.833	9.25E+21	6.76	
5S6	stressed creep	NBG-18	5S8	1	BW9-01	32.5	32	2.894	9.45E+21	6.90	5U6
Spacer	Guide/spacer	NBG-25		0.25		31.5	31.375	2.951	9.64E+21	7.03	
5S5	stressed creep	IG-430	5S10	1	FW9-03	31.25	30.75	3.004	9.81E+21	7.16	5U5

Spacer	Guide/spacer	NBG-25		0.25		30.25	30.125	3.054	9.97E+21	7.28	
5S4	stressed creep	PCEA	5S4	1	DW7-03	30	29.5	3.101	1.01E+22	7.39	5U4
Spacer	Guide/spacer	NBG-25		0.25		29	28.875	3.144	1.03E+22	7.50	
5S3	stressed creep	NBG-17	5S6	1	AW7-03	28.75	28.25	3.184	1.04E+22	7.59	5U3
Spacer	Guide/spacer	NBG-25		0.25		27.75	27.625	3.220	1.05E+22	7.68	
5S2	stressed creep	IG-430	5S2	1	FW9-02	27.5	27	3.252	1.06E+22	7.75	5U2
Spacer	Guide/spacer	NBG-25		0.25		26.5	26.375	3.281	1.07E+22	7.82	
5S1	stressed creep	IG-110	5S1	1	EW8-02	26.25	25.75	3.306	1.08E+22	7.88	5U1
Spacer	Guide/spacer	NBG-25		0.25		25.25	25.125	3.327	1.09E+22	7.93	
Plug	Core center plug	NBG-25		1		25	24.5	3.345	1.09E+22	7.97	
Core Center Line											
Plug	Core center plug	NBG-25		1		24	23.5	3.365	1.10E+22	8.02	
GAP	GAP			0.25		23	22.875	3.373	1.10E+22	8.04	
Spacer	Guide/spacer	NBG-25		0.25		22.75	22.625	3.375	1.10E+22	8.05	
5PB16	Piggy Back	NBG-25	5PB16	0.25	M2C-01	22.5	22.375	3.376	1.10E+22	8.05	
Spacer	Guide/spacer	NBG-25		0.25		22.25	22.125	3.377	1.10E+22	8.05	
5PB17	Piggy Back	S-2020	5PB17	0.25	N3C-01	22	21.875	3.377	1.10E+22	8.05	FLUX CL
Spacer	Guide/spacer	NBG-25		0.25		21.75	21.625	3.376	1.10E+22	8.05	
5PB18	Piggy Back	PCIB	5PB18	0.25	P2C-02	21.5	21.375	3.375	1.10E+22	8.05	
Spacer	Guide/spacer	NBG-25		0.25		21.25	21.125	3.373	1.10E+22	8.04	
5PB19	Piggy Back	BAN	5PB19	0.25	R5C01A	21	20.875	3.371	1.10E+22	8.04	
Spacer	Guide/spacer	NBG-25		0.25		20.75	20.625	3.368	1.10E+22	8.03	
5PB20	Piggy Back	NBG-10	5PB20	0.25	S2C-01	20.5	20.375	3.364	1.10E+22	8.02	
Spacer	Guide/spacer	NBG-25		0.25		20.25	20.125	3.360	1.10E+22	8.01	
5PB21	Piggy Back	HOPG	5PB21	0.25	UNKNOWN	20	19.875	3.355	1.10E+22	8.00	
Spacer	Guide/spacer	NBG-25		0.25		19.75	19.625	3.349	1.09E+22	7.98	
5PB22	Piggy Back	A3	5PB22	0.25	H-16-1	19.5	19.375	3.343	1.09E+22	7.97	
Spacer	Guide/spacer	NBG-25		0.25		19.25	19.125	3.336	1.09E+22	7.95	
5U1	unstressed control	IG-110	5U1	1	EW9-01	19	18.5	3.316	1.08E+22	7.91	5S1
Spacer	Guide/spacer	NBG-25		0.25		18	17.875	3.291	1.07E+22	7.85	
5U2	unstressed control	IG-430	5U2	1	FW10-01	17.75	17.25	3.263	1.07E+22	7.78	5S2
Spacer	Guide/spacer	NBG-25		0.25		16.75	16.625	3.230	1.06E+22	7.70	
5U3	unstressed control	NBG-17	5U6	1	AW9-03	16.5	16	3.193	1.04E+22	7.61	5S3

Spacer	Guide/spacer	NBG-25		0.25		15.5	15.375	3.152	1.03E+22	7.52	
5U4	unstressed control	PCEA	5U4	1	DW8-03	15.25	14.75	3.107	1.01E+22	7.41	5S4
Spacer	Guide/spacer	NBG-25		0.25		14.25	14.125	3.057	9.98E+21	7.29	
5U5	unstressed control	IG-430	5U10	1	FW10-02	14	13.5	3.003	9.81E+21	7.16	5S5
Spacer	Guide/spacer	NBG-25		0.25		13	12.875	2.945	9.62E+21	7.02	
5U6	unstressed control	NBG-18	5U8	1	BW10-01	12.75	12.25	2.882	9.41E+21	6.87	5S6
Spacer	Guide/spacer	NBG-25		0.25		11.75	11.625	2.814	9.19E+21	6.71	
5U7	unstressed control	NBG-17	5U13	1	AW10-01	11.5	11	2.742	8.96E+21	6.54	5S7
Spacer	Guide/spacer	NBG-25		0.25		10.5	10.375	2.666	8.71E+21	6.36	
5U8	unstressed control	PCEA	5U9	1	DW9-01	10.25	9.75	2.585	8.44E+21	6.16	5S8
Spacer	Guide/spacer	NBG-25		0.25		9.25	9.125	2.499	8.16E+21	5.96	
5U9	unstressed control	NBG-18	5U14	1	BW10-02	9	8.5	2.409	7.87E+21	5.74	5S9
Spacer	Guide/spacer	NBG-25		0.25		8	7.875	2.314	7.56E+21	5.52	
5U10	unstressed control	NBG-17(AG)	4S11	1	AL8-02	7.75	7.25	2.214	7.23E+21	5.28	5S10
Spacer	Guide/spacer	NBG-25		0.25		6.75	6.625	2.110	6.89E+21	5.03	
5U11	unstressed control	H-451	5U7	1	CW13-01	6.5	6	2.001	6.53E+21	4.77	5S11/12
Spacer	Guide/spacer	NBG-25		0.25		5.5	5.375	1.887	6.16E+21	4.50	
5U12	unstressed control	PCEA	5U11	1	DW9-02	5.25	4.75	1.768	5.77E+21	4.22	5S13
Spacer	Guide/spacer	NBG-25		0.25		4.25	4.125	1.644	5.37E+21	3.92	
5U13	unstressed control	IG-110	5U12	1	EW9-02	4	3.5	1.516	4.95E+21	3.61	5S14
Spacer	Guide/spacer	NBG-25		0.25		3	2.875	1.382	4.51E+21	3.30	
5U14	unstressed control	IG-430	2U14	1	FW4-01	2.75	2.25	1.244	4.06E+21	2.96	5S15
Spacer	Guide/spacer	NBG-25		0.25		1.75	1.625	1.100	3.59E+21	2.62	
5PB23	Piggy Back	BAN	5PB23	0.25	R5CO2A	1.5	1.375	1.041	3.40E+21	2.48	
Spacer	Guide/spacer	NBG-25		0.25		1.25	1.125	0.981	3.21E+21	2.34	
5PB24	Piggy Back	NBG-25	5PB24	0.25	M2C-02	1	0.875	0.921	3.01E+21	2.20	
Spacer	Guide/spacer	NBG-25		0.25		0.75	0.625	0.860	2.81E+21	2.05	
5PB25	Piggy Back	PPEA	5PB25	0.25	L4C-01	0.5	0.375	0.798	2.60E+21	1.90	
Spacer	Guide/spacer	NBG-25		0.25		0.25	0.125	0.735	2.40E+21	1.75	End of core

Table 31. The new AGC-1 capsule layout for channel 6 (North-West) [3 ksi]

New AGC-1 Channel 6 (NORTH-WEST) Layout [3 ksi]											
Location in Capsule	Sample Type	Graphite Grade	Secimen ID	Dimensions, ins		Cumulative stack distance from Core bottom	Sample mid line distance from core bottom	Fast Flux, 10^14 n/cm2-s [E>0.1MeV]	Nominal Dose		Companion Sample Position
				Length	JPS Spec No				n/cm2 [E>0.1 MeV]	dpa	
	Insulation										
	Thimble top										
	Thimble Bottom			0.25		44.25	44.125	1.313	4.29E+21	3.13	
Spacer	Guide/spacer	NBG-25		0.25		44	43.875	1.365	4.46E+21	3.25	
6S15	stressed creep	NBG-17	6S15	1	AW12-01	43.75	43.25	1.492	4.87E+21	3.56	6U14
Spacer	Guide/spacer	NBG-25		0.25		42.75	42.625	1.616	5.28E+21	3.85	
6S14	stressed creep	NBG-18(AG)	4S7	1	BL7-01	42.5	42	1.737	5.67E+21	4.14	6U13
Spacer	Guide/spacer	NBG-25		0.25		41.5	41.375	1.855	6.06E+21	4.42	
6S13	stressed creep	PCEA	6S11	1	DW10-01	41.25	40.75	1.970	6.43E+21	4.70	6U12
Spacer	Guide/spacer	NBG-25		0.25		40.25	40.125	2.081	6.80E+21	4.96	
6S12	stressed creep	IG-430	6S10	1	FW11-02	40	39.5	2.190	7.15E+21	5.22	6U11
Spacer	Guide/spacer	NBG-25		0.25		39	38.875	2.295	7.49E+21	5.47	
6S11	stressed creep	IG-430	6S7	1	FW11-01	38.75	38.25	2.397	7.83E+21	5.71	6U11
Spacer	Guide/spacer	NBG-25		0.25		37.75	37.625	2.495	8.15E+21	5.95	
6S10	stressed creep	H-451	6S9	1	CW13-03	37.5	37	2.590	8.46E+21	6.18	6U10
Spacer	Guide/spacer	NBG-25		0.25		36.5	36.375	2.682	8.76E+21	6.39	
6S9	stressed creep	IG-110	6S14	1	EW9-03	36.25	35.75	2.770	9.05E+21	6.61	6U9
Spacer	Guide/spacer	NBG-25		0.25		35.25	35.125	2.855	9.33E+21	6.81	
6S8	stressed creep	NBG-17	6S8	1	AW10-03	35	34.5	2.937	9.59E+21	7.00	6U8
Spacer	Guide/spacer	NBG-25		0.25		34	33.875	3.014	9.84E+21	7.19	
6S7	stressed creep	NBG-18	6S13	1	BW11-01	33.75	33.25	3.088	1.01E+22	7.36	6U7
Spacer	Guide/spacer	NBG-25		0.25		32.75	32.625	3.159	1.03E+22	7.53	
6S6	stressed creep	PCEA	1S6	1	DW1-02	32.5	32	3.226	1.05E+22	7.69	6U6
Spacer	Guide/spacer	NBG-25		0.25		31.5	31.375	3.289	1.07E+22	7.84	
6S5	stressed creep	IG-110	2S5	1	EW4-02	31.25	30.75	3.348	1.09E+22	7.98	6U5

Spacer	Guide/spacer	NBG-25		0.25		30.25	30.125	3.404	1.11E+22	8.12	
6S4	stressed creep	NBG-17	6S1	1	AW10-02	30	29.5	3.455	1.13E+22	8.24	6U4
Spacer	Guide/spacer	NBG-25		0.25		29	28.875	3.503	1.14E+22	8.35	
6S3	stressed creep	NBG-18	6S6	1	BW10-03	28.75	28.25	3.547	1.16E+22	8.46	6U3
Spacer	Guide/spacer	NBG-25		0.25		27.75	27.625	3.587	1.17E+22	8.55	
6S2	stressed creep	PCEA	6S4	1	DW9-03	27.5	27	3.623	1.18E+22	8.64	6U2
Spacer	Guide/spacer	NBG-25		0.25		26.5	26.375	3.655	1.19E+22	8.71	
6S1	stressed creep	1G-430	6S2	1	FW10-03	26.25	25.75	3.683	1.20E+22	8.78	6U1
Spacer	Guide/spacer	NBG-25		0.25		25.25	25.125	3.707	1.21E+22	8.84	
Plug	Core center plug			1		25	24.5	3.726	1.22E+22	8.88	
Core Center Line											
Plug	Core center plug			1		24	23.5	3.749	1.22E+22	8.94	
GAP	GAP			0.25		23	22.875	3.757	1.23E+22	8.96	
Spacer	Guide/spacer	NBG-25		0.25		22.75	22.625	3.760	1.23E+22	8.96	
6PB16	Piggy Back	HOPG	6PB16	0.25	UNKNOWN	22.5	22.375	3.761	1.23E+22	8.97	
Spacer	Guide/spacer	NBG-25		0.25		22.25	22.125	3.762	1.23E+22	8.97	
6PB17	Piggy Back	A3	6PB17	0.25	H-16-2	22	21.875	3.762	1.23E+22	8.97	FLUX CL
Spacer	Guide/spacer	NBG-25		0.25		21.75	21.625	3.762	1.23E+22	8.97	
6PB18	Piggy Back	HLM	6PB18	0.25	J3C-01	21.5	21.375	3.760	1.23E+22	8.97	
Spacer	Guide/spacer	NBG-25		0.25		21.25	21.125	3.758	1.23E+22	8.96	
6PB19	Piggy Back	PGX	6PB19	0.25	K4C-01	21	20.875	3.756	1.23E+22	8.95	
Spacer	Guide/spacer	NBG-25		0.25		20.75	20.625	3.752	1.23E+22	8.95	
6PB20	Piggy Back	PPEA	6PB20	0.25	L4C-02	20.5	20.375	3.748	1.22E+22	8.94	
Spacer	Guide/spacer	NBG-25		0.25		20.25	20.125	3.744	1.22E+22	8.93	
6PB21	Piggy Back	H-451	6PB21	0.25	CW2C-01	20	19.875	3.738	1.22E+22	8.91	
Spacer	Guide/spacer	NBG-25		0.25		19.75	19.625	3.732	1.22E+22	8.90	
6PB22	Piggy Back	A3	6PB22	0.25	H-17-1	19.5	19.375	3.725	1.22E+22	8.88	
Spacer	Guide/spacer	NBG-25		0.25		19.25	19.125	3.717	1.21E+22	8.86	
6U1	unstressed control	1G-430	6U2	1	FW11-03	19	18.5	3.695	1.21E+22	8.81	6S1
Spacer	Guide/spacer	NBG-25		0.25		18	17.875	3.668	1.20E+22	8.75	
6U2	unstressed control	PCEA	6U4	1	DW10-03	17.75	17.25	3.637	1.19E+22	8.67	6S2
Spacer	Guide/spacer	NBG-25		0.25		16.75	16.625	3.601	1.18E+22	8.58	
6U3	unstressed control	NBG-18	6U6	1	BW11-03	16.5	16	3.560	1.16E+22	8.49	6S3

Spacer	Guide/spacer	NBG-25		0.25		15.5	15.375	3.514	1.15E+22	8.38	
6U4	unstressed control	NBG-17	5U3	1	AW9-02	15.25	14.75	3.464	1.13E+22	8.26	6S4
Spacer	Guide/spacer	NBG-25		0.25		14.25	14.125	3.409	1.11E+22	8.13	
6U5	unstressed control	IG-110	2U5	1	EW5-02	14	13.5	3.349	1.09E+22	7.98	6S5
Spacer	Guide/spacer	NBG-25		0.25		13	12.875	3.284	1.07E+22	7.83	
6U6	unstressed control	PCEA	1U6	1	DW2-02	12.75	12.25	3.214	1.05E+22	7.66	6S6
Spacer	Guide/spacer	NBG-25		0.25		11.75	11.625	3.140	1.03E+22	7.49	
6U7	unstressed control	NBG-18	6U12	1	BW12-01	11.5	11	3.060	9.99E+21	7.30	6S7
Spacer	Guide/spacer	NBG-25		0.25		10.5	10.375	2.975	9.72E+21	7.09	
6U8	unstressed control	NBG-17	6U8	1	AW12-03	10.25	9.75	2.885	9.42E+21	6.88	6S8
Spacer	Guide/spacer	NBG-25		0.25		9.25	9.125	2.790	9.11E+21	6.65	
6U9	unstressed control	IG-110	6U13	1	EW10-01	9	8.5	2.690	8.79E+21	6.41	6S9
Spacer	Guide/spacer	NBG-25		0.25		8	7.875	2.585	8.44E+21	6.16	
6U10	unstressed control	H-451	6U9	1	CW14-02	7.75	7.25	2.474	8.08E+21	5.90	6S10
Spacer	Guide/spacer	NBG-25		0.25		6.75	6.625	2.359	7.70E+21	5.62	
6U11	unstressed control	IG-430	6U10	1	FW12-02	6.5	6	2.238	7.31E+21	5.33	6S11/12
Spacer	Guide/spacer	NBG-25		0.25		5.5	5.375	2.111	6.89E+21	5.03	
6U12	unstressed control	PCEA	6U11	1	DW10-02	5.25	4.75	1.979	6.46E+21	4.72	6S13
Spacer	Guide/spacer	NBG-25		0.25		4.25	4.125	1.842	6.02E+21	4.39	
6U13	unstressed control	NBG-18(AG)	5S5	1	BL7-02	4	3.5	1.699	5.55E+21	4.05	6S14
Spacer	Guide/spacer	NBG-25		0.25		3	2.875	1.551	5.06E+21	3.70	
6U14	unstressed control	NBG-17	6U14	1	AW13-01	2.75	2.25	1.397	4.56E+21	3.33	6S15
Spacer	Guide/spacer	NBG-25		0.25		1.75	1.625	1.238	4.04E+21	2.95	
6PB23	Piggy Back	S-2020	6PB23	0.25	N3C-02	1.5	1.375	1.172	3.83E+21	2.79	
Spacer	Guide/spacer	NBG-25		0.25		1.25	1.125	1.106	3.61E+21	2.64	
6PB24	Piggy Back	HLM	6PB24	0.25	J3C-04	1	0.875	1.039	3.39E+21	2.48	
Spacer	Guide/spacer	NBG-25		0.25		0.75	0.625	0.971	3.17E+21	2.31	
6PB25	Piggy Back	PCIB	6PB25	0.25	P2C-03	0.5	0.375	0.902	2.95E+21	2.15	
Spacer	Guide/spacer	NBG-25		0.25		0.25	0.125	0.832	2.72E+21	1.98	End of core

3 Results and Discussion

3.1. Pre-irradiation Examination, Dimensions and Density

Pre-irradiation specimen dimensional data is used to determine the effects of neutron irradiation on dimensional change of graphites (for the various grades and orientations). Moreover, the effect of stress on the dimensional change of the graphite (i.e., irradiation induced creep) is also determined from the changes in the dimensions of the irradiated stressed specimens compared to the irradiated unstressed specimens. The dimensions of the creep and piggy-back specimens are reported in the tables contained in Appendix 1 through 21. Additionally the specimen Specimen Mass is reported along with the calculated bulk density in Appendix 1 through 21.

During evaluation of the dimensional data sets several data inconsistencies were noted. Grade IG-430 graphite specimen FW703 had initial length value T3 erroneously reported as 088850 in. The other length values for this specimen (T1, T2, and T4) were correctly recorded as 0.999XX in. Moreover, if the specimen T3 length had really been 0.88850 the specimen would have been rejected as being outside of tolerance limits (0.998-1.00 in.). Consequently, this error was corrected and FW703 initial T3 is now recorded as 0.99950 in. (Appendix 27). The revision of this dimension, and the initial mean length, is of no consequence for the physical properties subsequently determined. Grade IG-110 graphite specimen EW9-02 final length values T1 and T4 were entered as 0.99975 and 0.99980, respectively. The data returned a growth on of ~0.00030 in.). This specimen was the only one from the entire IG-110 data set to exhibit growth after measuring thermal expansion. Evaluation of the data set suggest that that final dimensions T1 and T4 were miss-keyed and should have been entered as 0.99875 in. and 0.99880 in., respectively. Correction of these two dimensions modifies the thermally induced dimensional change to -0.00019 in., and corrects the density to 1.7660 g/cm^3. Since the change for this specimen is in the "final' dimensions correction must also be made to the sonic velocity data set (and derived elastic constants) and the electrical resistivity data. Appropriate corrections have been made to the appended data tables and the electronic files. Finally, grade NBG-18 graphite specimen BW203 had its initial diameter D1^{90} entered as 0.55120 in. The seven other diameter measurements (Appendix 29) were reported as 0.50XXX. The specimen tolerance is from 0.500

in. to 0.502 in., consequently, this specimen would have been rejected had the $D1^{90}$ dimension actually been 0.55120 in. This is clearly a miss-type, the correct $D1^{90}$ dimension being 0.50120 in. The corrected value is shown in Appendix 29 and in the electronic data record. Since this correction is in the initial dimensions it has no impact on calculated physical properties.

The creep and control specimens (nominally 1-inch long) were subjected to dimensional measurements before and after thermal expansion measurements. The thermal excursion to 800°C was considered sufficiently large that permanent dimensional changes could occur. Appendices 22 through 33 report the initial and final (post thermal excursion) specimen dimensions (length and diameter), and the difference between the two dimensions for the six major graphite grades (NBG-18, NBG-17, H-451, PCEA, IG-110, IG-430). The dimensional change is shown graphically for the six major grades in Figs. 37 through 42 (specimen length) and 43-48 (specimen diameter).

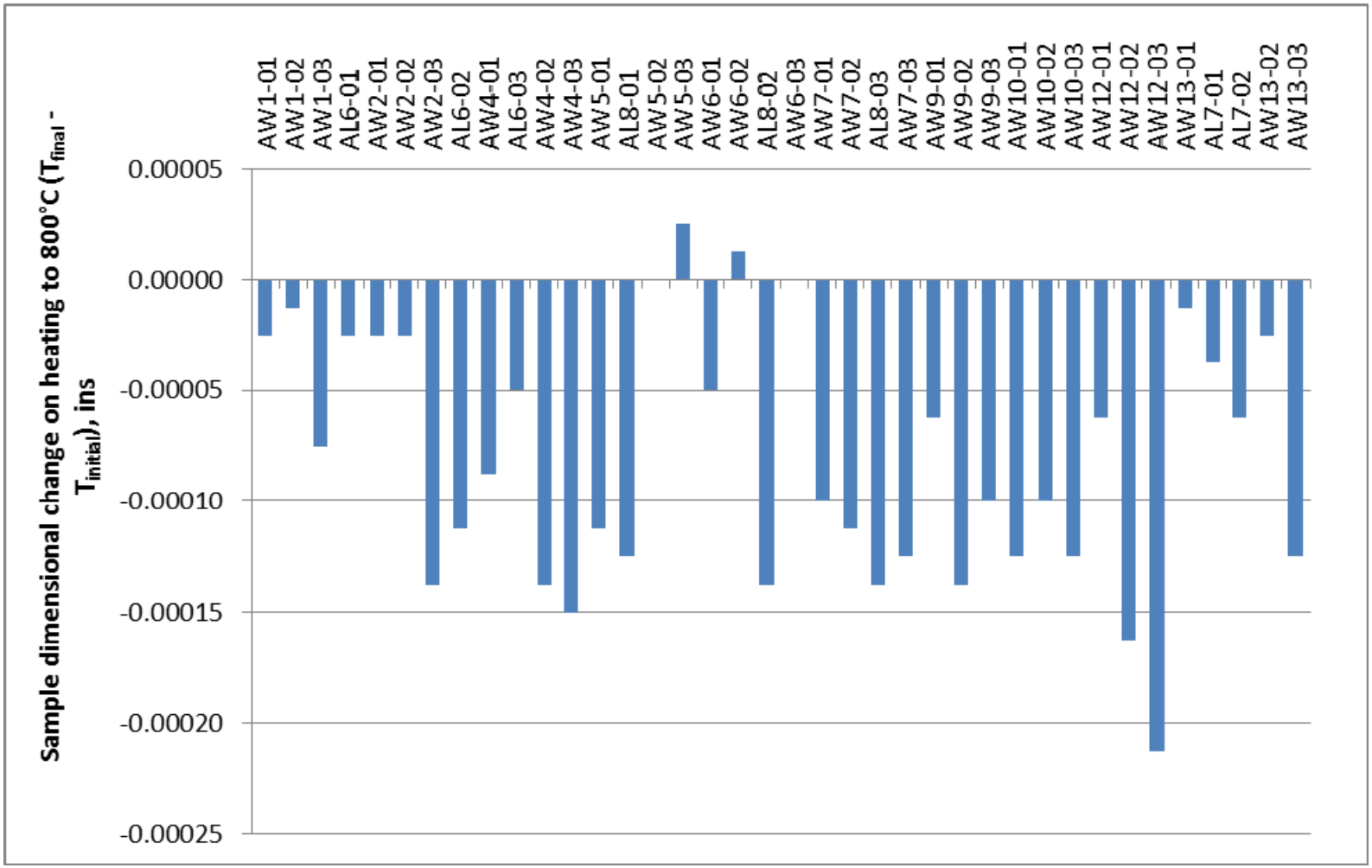

Fig. 37. Dimensional change resulting from heating to 800°C (final length –initial length) for NBG-17 creep specimens

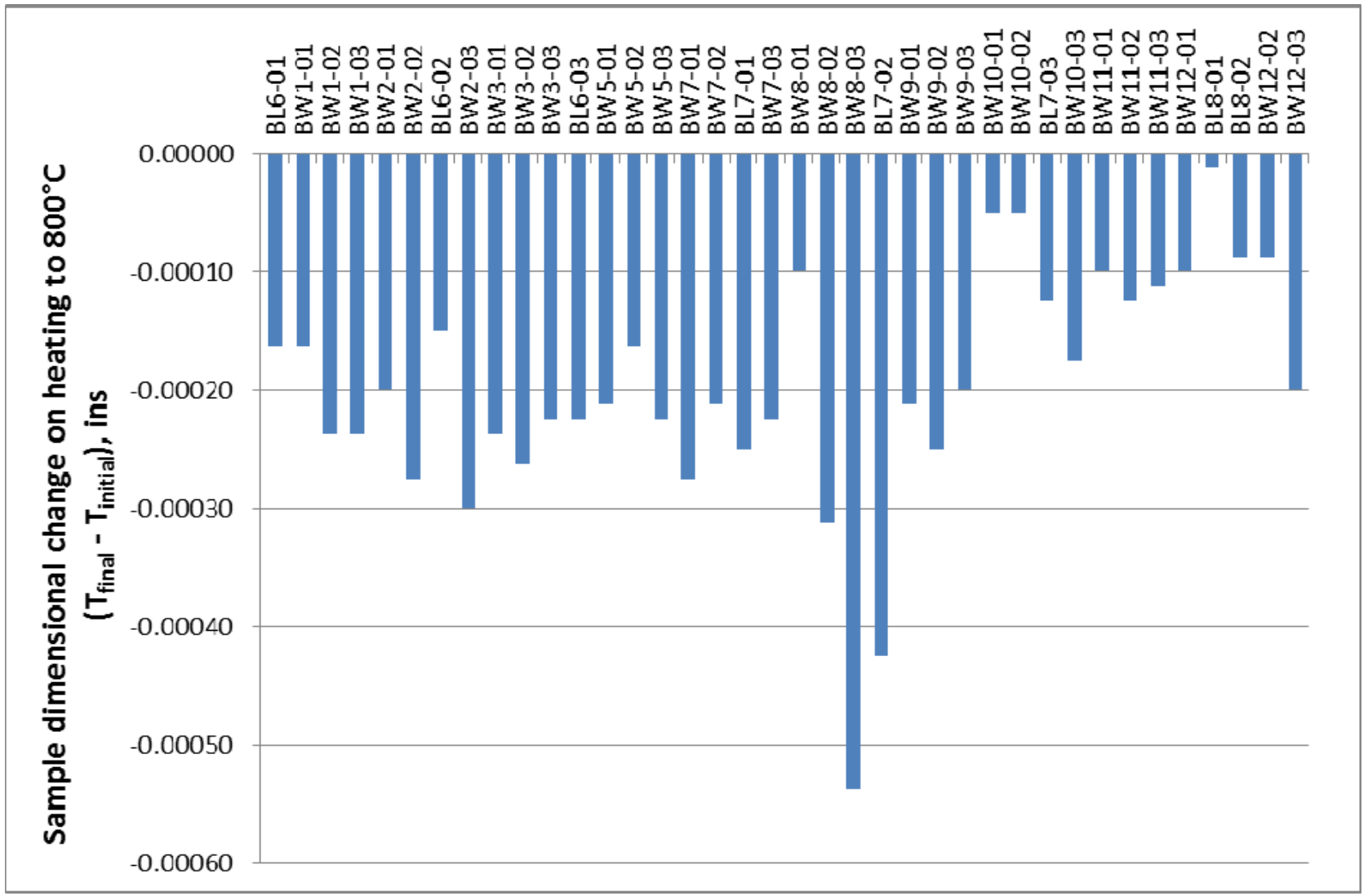

Fig. 38. Dimensional change resulting from heating to 800°C (final length –initial length) for NBG-18 creep specimens

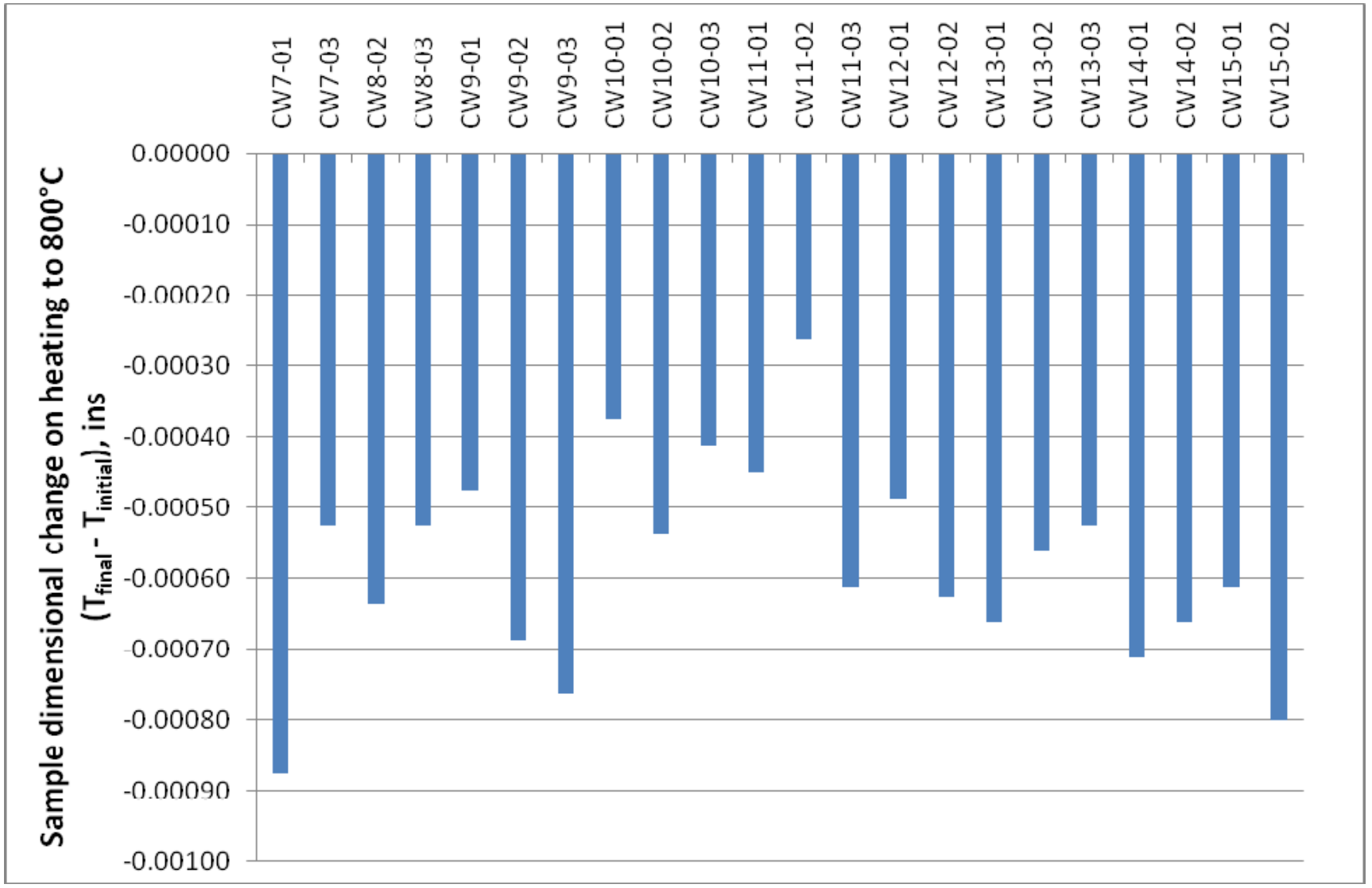

Fig. 39. Dimensional change resulting from heating to 800°C (final length –initial length) for H-451 creep specimens

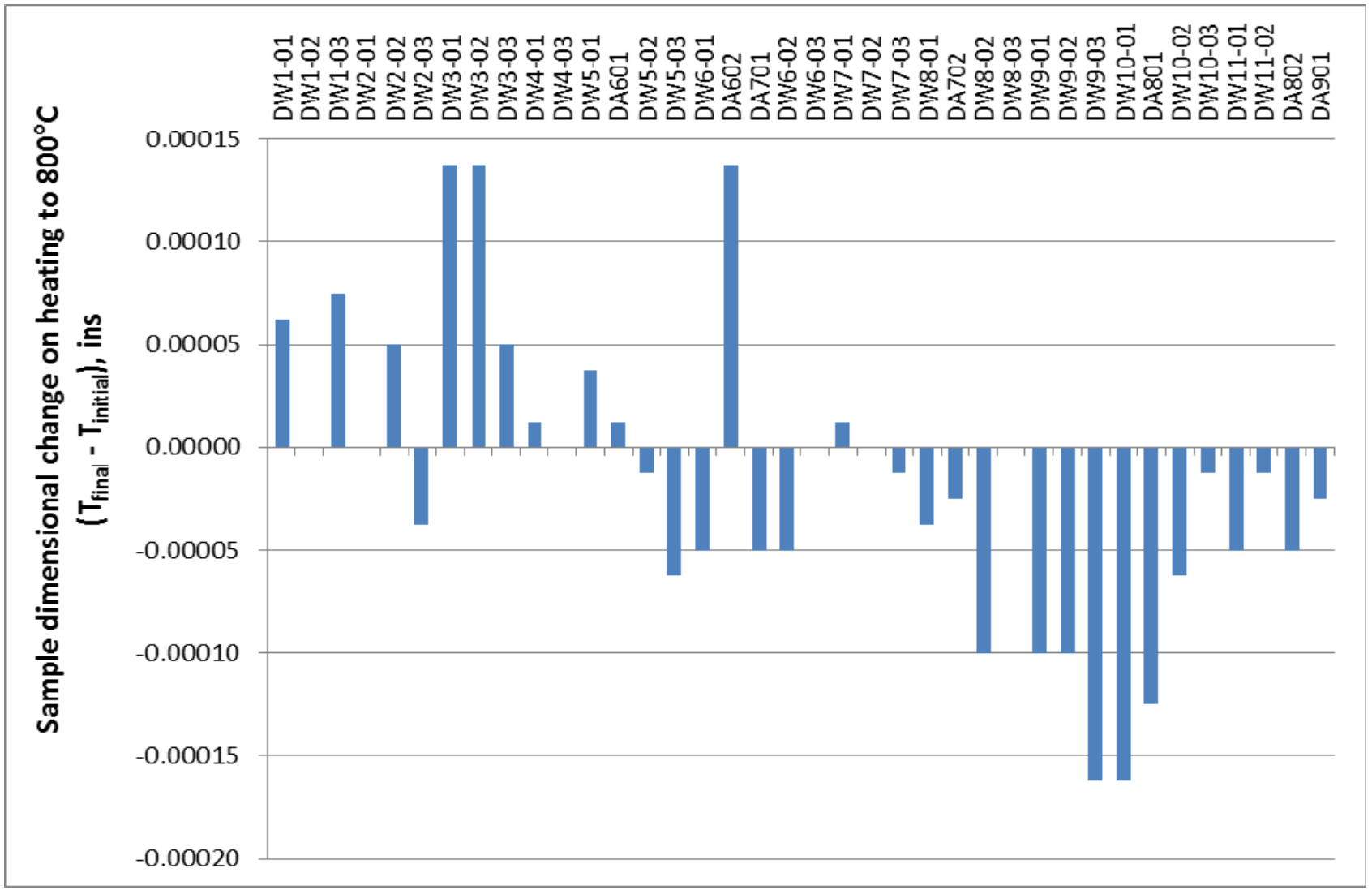

Fig. 40. Dimensional change resulting from heating to 800°C (final length –initial length) for PCEA creep specimens

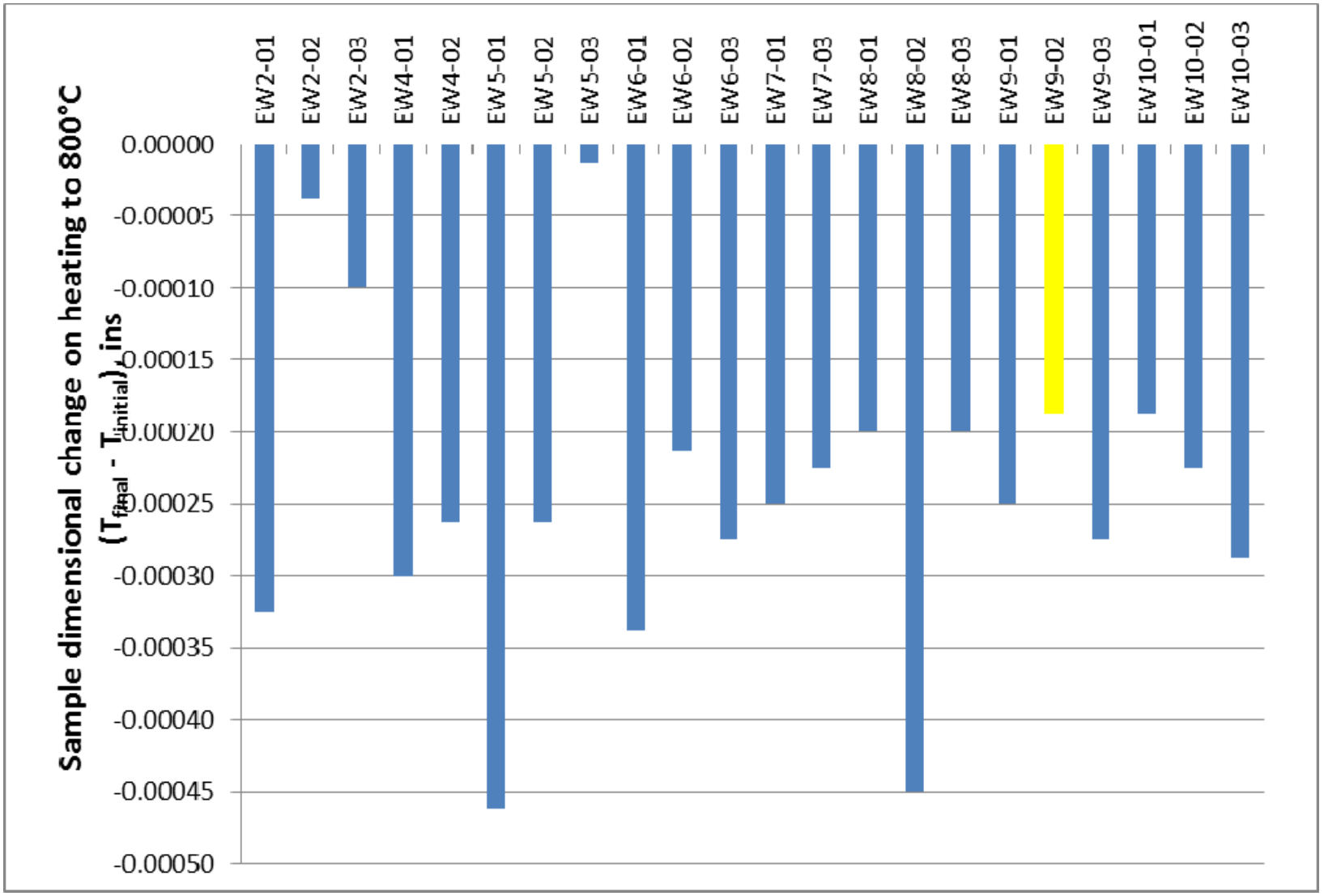

Fig. 41. Dimensional change resulting from heating to 800°C (final length –initial length) for IG-110 creep specimens

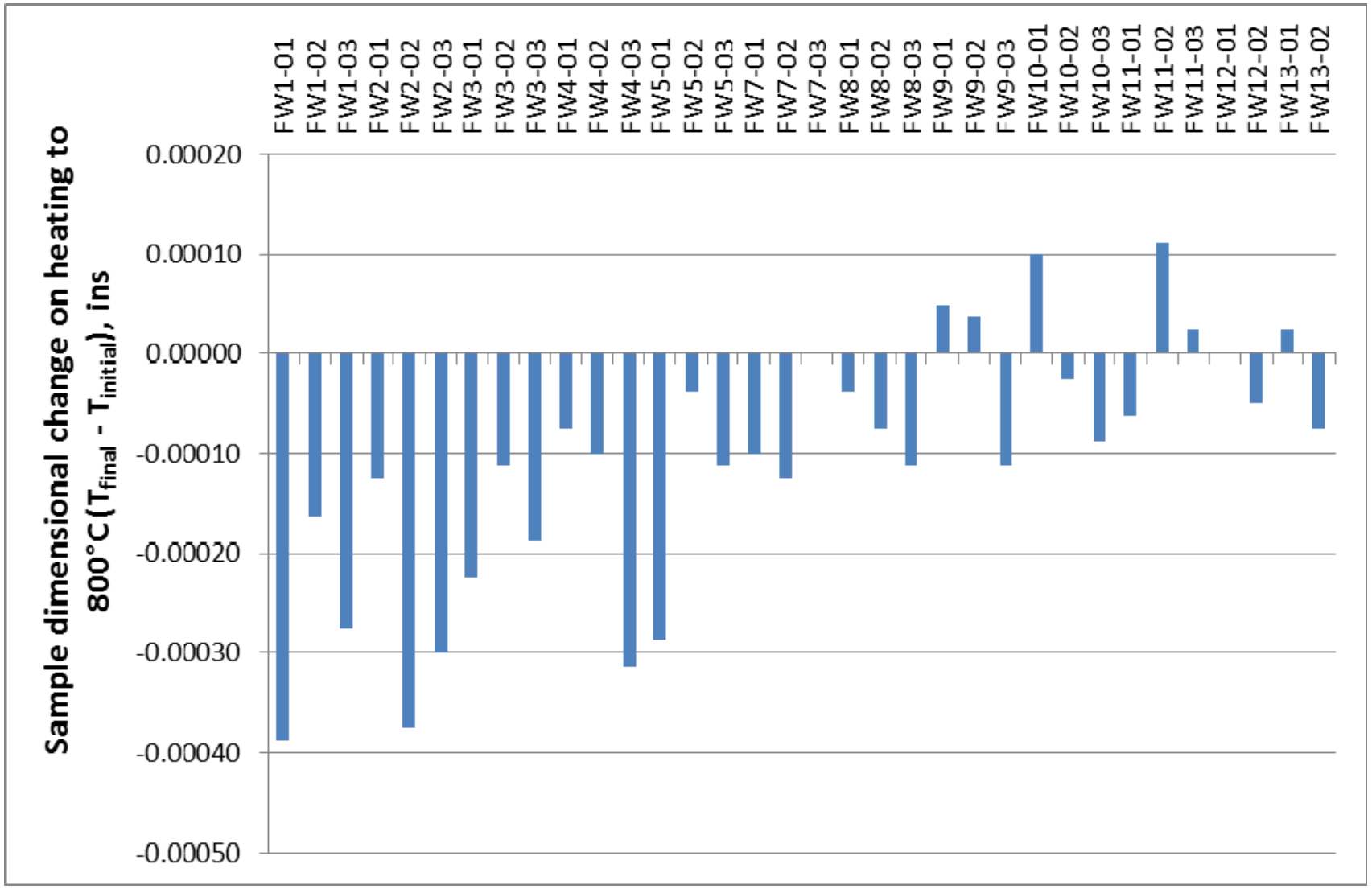

Fig. 42. Dimensional change resulting from heating to 800°C (final length –initial length) for IG-430 creep specimens

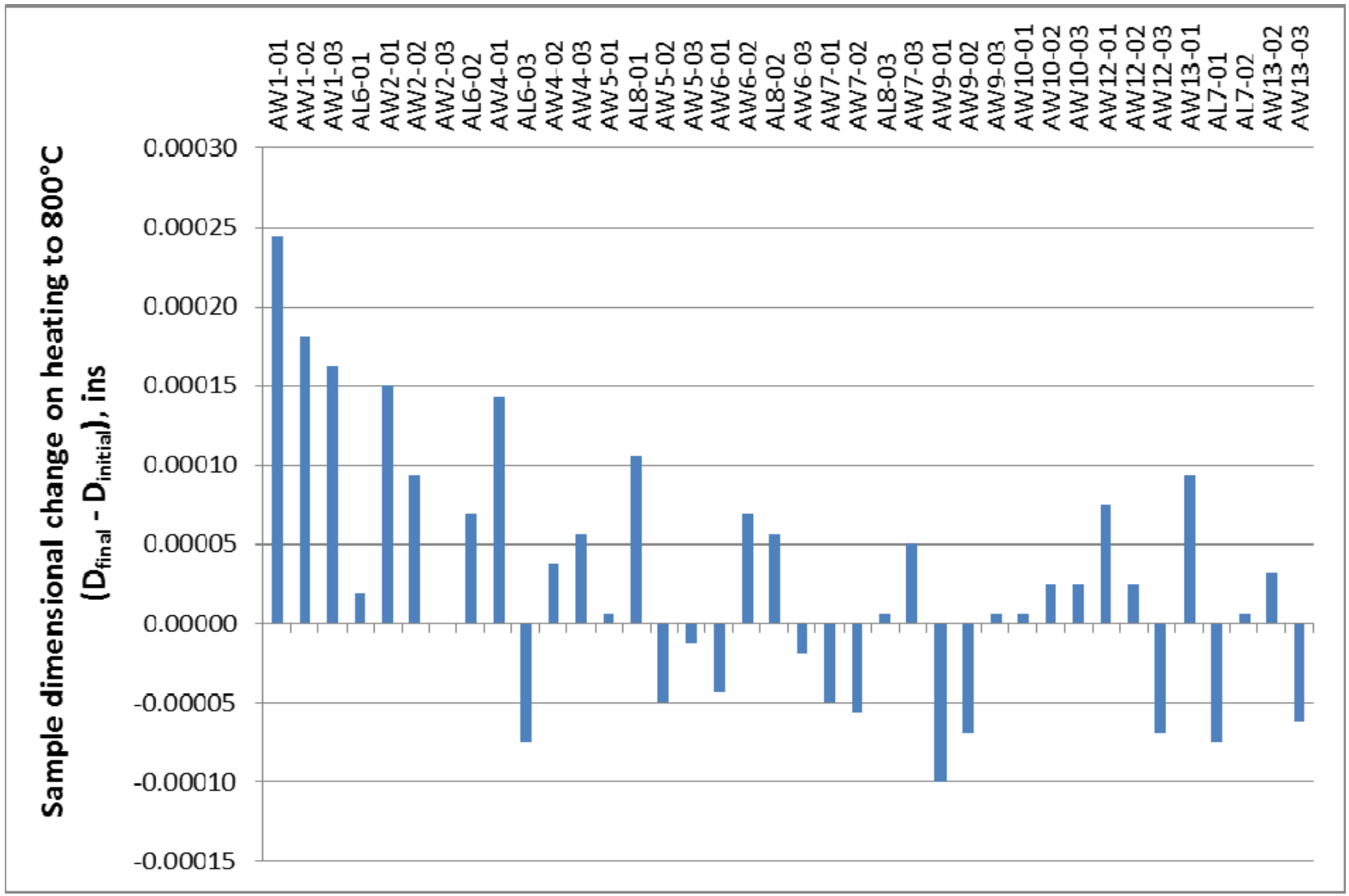

Fig. 43. Dimensional change resulting from heating to 800°C (final diameter –initial diameter) for NBG-17 creep specimens

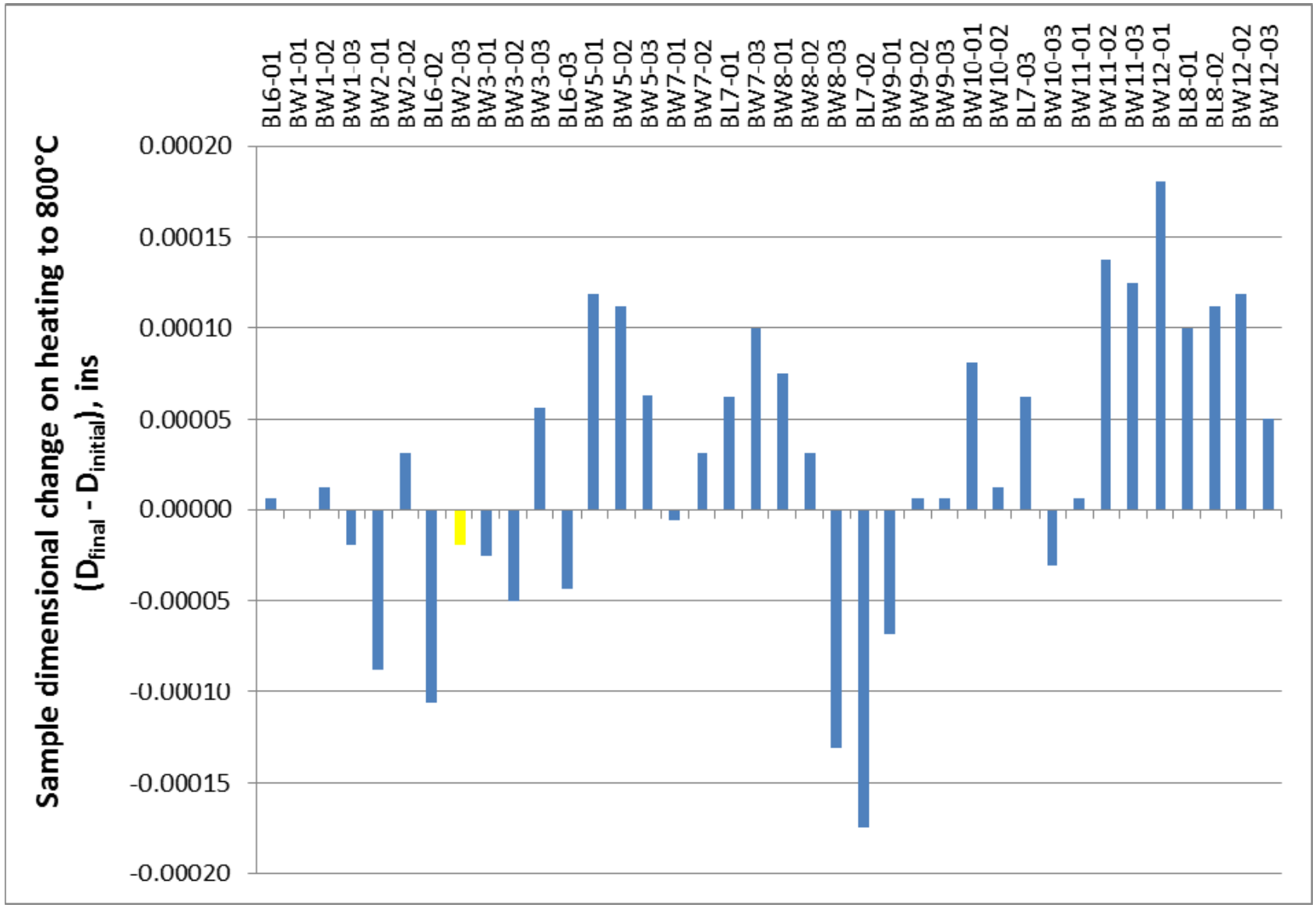

Fig. 44. Dimensional change resulting from heating to 800°C (final diameter –initial diameter) for NBG-18 creep specimens

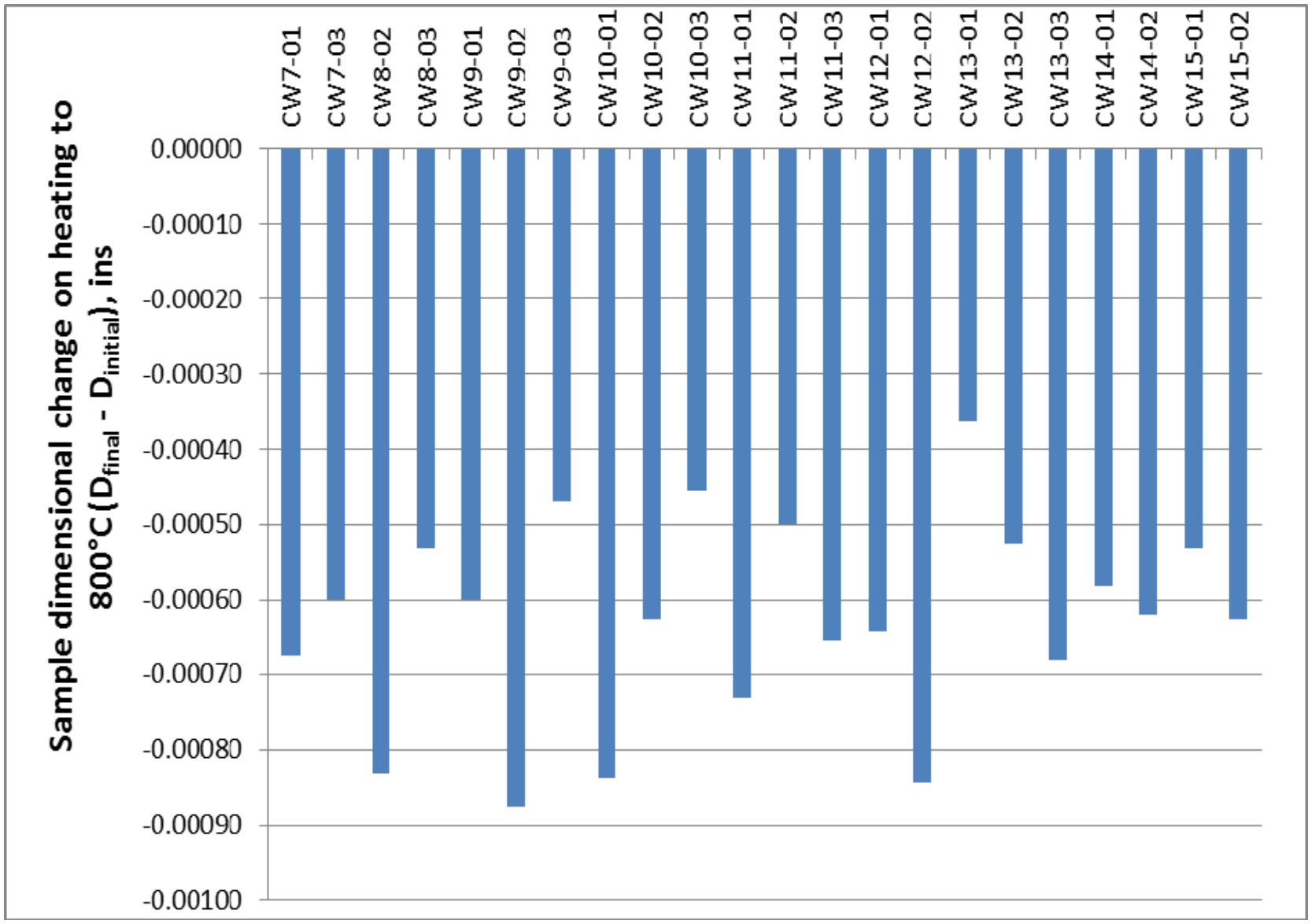

Fig. 45. Dimensional change resulting from heating to 800°C (final diameter –initial diameter) for H-451 creep specimens

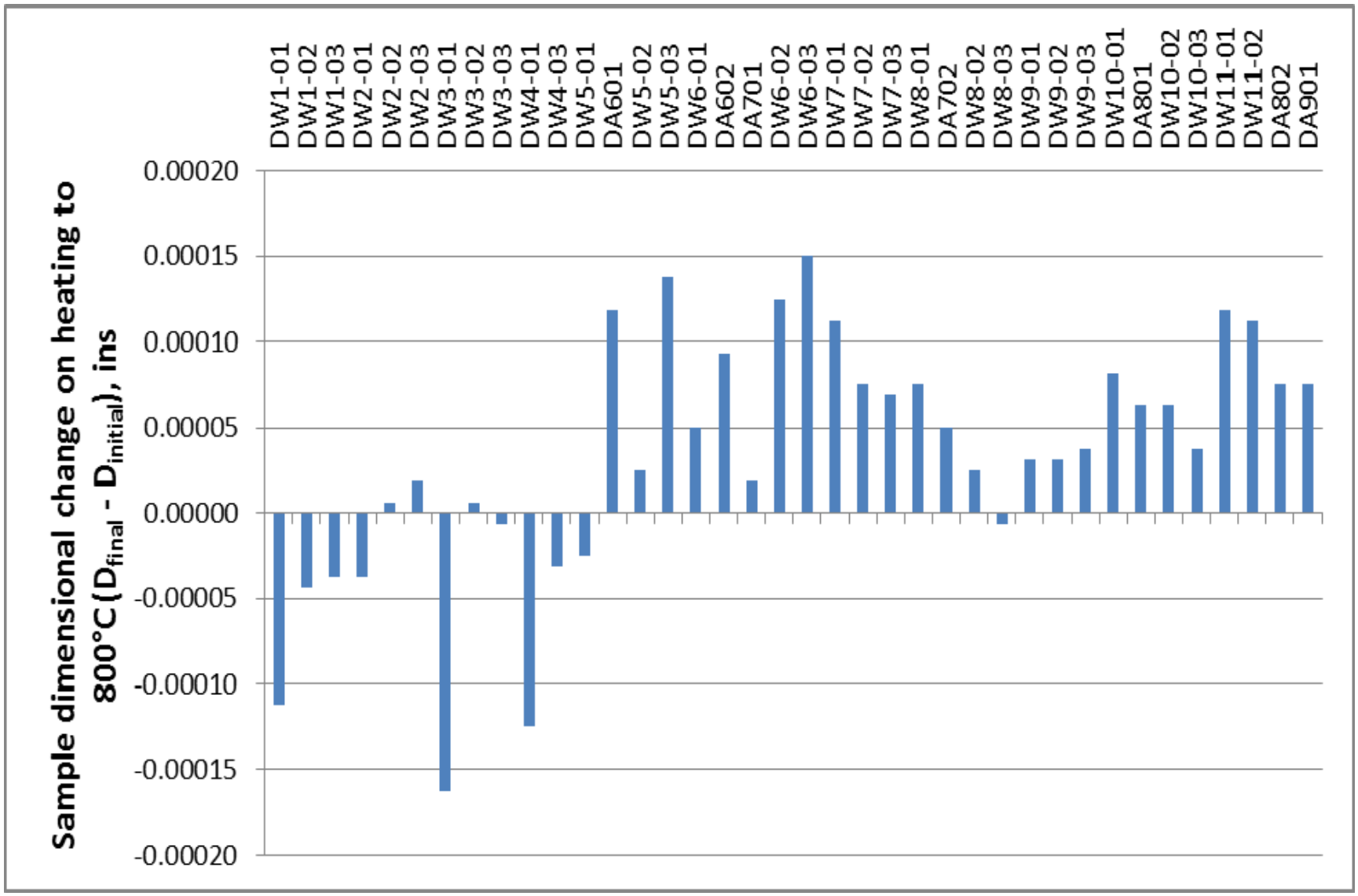

Fig. 46. Dimensional change resulting from heating to 800°C (final diameter –initial diameter) for PCEA creep specimens

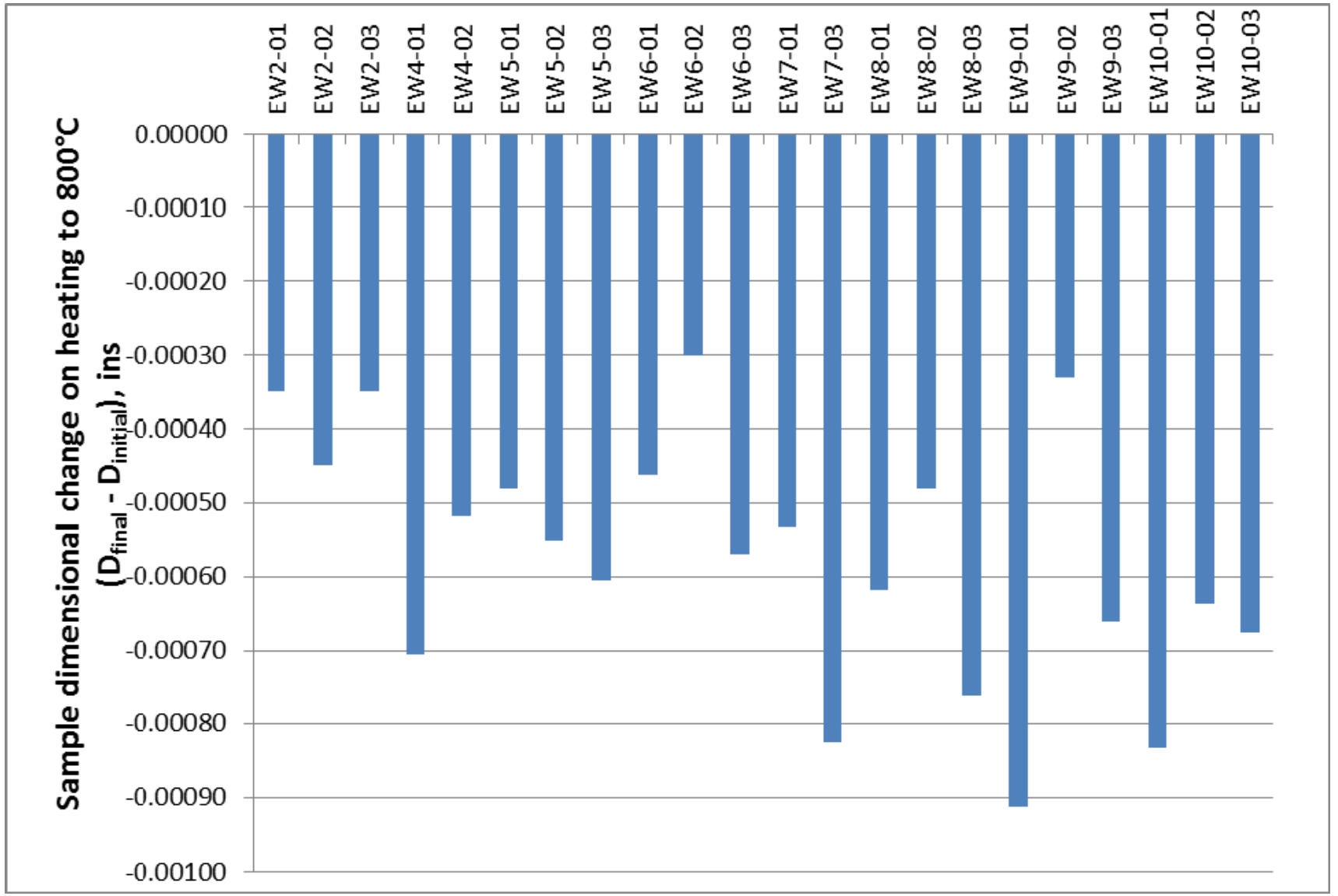

Fig. 47. Dimensional change resulting from heating to 800°C (final diameter –initial diameter) for IG-110 creep specimens

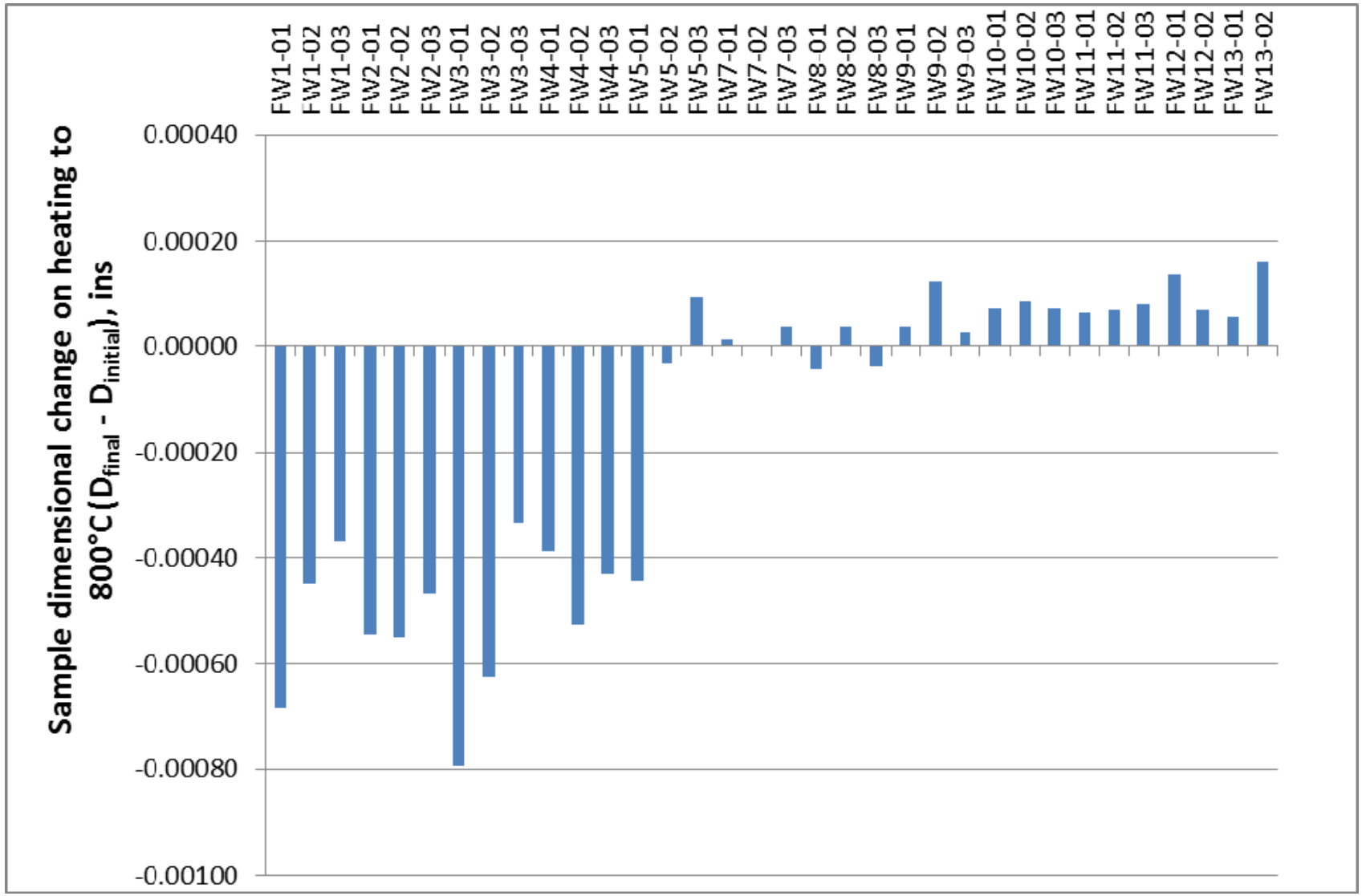

Fig. 48. Dimensional change resulting from heating to 800°C (final diameter –initial diameter) for IG-430 creep specimens

From Figs 37-48, small, but measurable dimensional changes are observed as a result of the thermal excursion associated with thermal expansion measurement. The dimensional changes, predominantly shrinkages, were as large as > 0.0008 in. over the 1.000 in. specimen length and > 0.0007 in. over the 0.500 in. specimen diameter. These changes were presumably caused by relaxation of internal residual strains from processing or machining of the specimens. Graphite NBG-18 showed exclusively shrinkage in its length and H-451 and IG-110 exhibited exclusively shrinkage in their length and diameter. Grades NBG-17 and IG-430 displayed predominantly shrinkage in their lengths, whereas grades NBG-17, NBG-18, PCEA, and IG-430 displayed mixed diameter change.

Changes of the magnitude reported here may be significant because the irradiation induced dimensional shrinkage will be small, i.e., < 0.5% over the 1.000 in. specimen length (< 0.005 in. change), as is the case in low dose, 600°C irradiation experiments [14]. In such circumstances, the error associated with not accounting for this thermally induced dimensional shrinkage could exceed 10% of the post irradiation observed dimensional shrinkage. Moreover, the magnitude of the change varied from sample to sample. Thus the impact upon the creep strain calculation could potentially be significant.

Bulk density data (calculated from final dimensions and Specimen Mass) are reported in Appendices 1-21. Evaluation of the data set again indicated several anomalies in the data, presumably due to data transcription errors in the specimen Specimen Mass. One instance of a final length being incorrectly transposed and affecting the calculated density was discussed previously (sample EW9-02). Plots of the individual creep and piggy-back sample densities, and piggy-back only samples densities (by grade) are in Figs. 49 to 55 and Figs 56 to 64, respectively. The data reported have been evaluated and the following corrections have been made.

NBG-17 sample AW14C02 (appendix 7) had a reported Specimen Mass of 1.4003 g, yielding a bulk density of 1.8530 g/cm^3. Inspection of Fig. 49 indicates this density value to be an outlier. A plausible explanation is that the Specimen Mass was incorrectly transposed into the original spreadsheet and should have been entered as 1.4103 g, yielding a density of 1.8662 g/cm^3.

Comparisons of the revised Specimen Mass and density for AW14C02 with adjacent samples AW14C01 and AW15C02 are favorable and suggest strongly the correction is appropriate. IG-110 sample EW8-02 (appendix 5) had a reported Specimen Mass of 5.5562 g, yielding a bulk density of 1.7558 g/cm^3. Inspection of Fig. 54 indicates this density value to be an outlier. A plausible explanation is that the Specimen Mass was incorrectly transposed into the original spreadsheet and should have been entered as 5.5862 g, yielding a density of 1.7653 g/cm^3. Comparisons of the revised Specimen Mass and density for EW8-02 with adjacent samples EW8-01, EW8-03, and EW7-01 and EW7-03 are favorable and suggest strongly the correction is appropriate.

PGX sample K2B03 (appendix 15) had a reported Specimen Mass of 1.3997 g, yielding a bulk density of 1.7814 g/cm^3. Inspection of Fig. 58 indicates this density value to be an outlier. A plausible explanation is that the Specimen Mass was incorrectly transposed into the original spreadsheet and should have been entered as 1.3957 g, yielding a density of 1.7763 g/cm^3. Comparisons of the revised Specimen Mass and density for K2B03 with adjacent samples K2B02, K2B04, and K3B03 are favorable and suggest strongly the correction is appropriate.

PCIB sample P2C03 (appendix 19) had a reported Specimen Mass of 1.3943 g, yielding a bulk density of 1.8484 g/cm^3. Inspection of Fig. 62 indicates this density value to be an outlier. A plausible explanation is that the Specimen Mass was incorrectly transposed into the original spreadsheet and should have been entered as 1.3843 g, yielding a density of 1.8351 g/cm^3. Comparisons of the revised Specimen Mass and density for P2C03 with adjacent sample P2C02 is favorable and suggest the correction is appropriate.

PCEA samples DA702 and DA801 were reported as against-grain orientation samples with densities of 1.8114 and 1.8175 g/cm^3, respectively. However, evaluation of the density data sets for AG and WG PCEA samples suggests that these two samples are actually oriented WG. If these two samples are categorized as WG the mean density for the WG samples (n=43) is 1.834 g/cm^3 and the mean for the AG population (n=5) is 1.7772 g/cm^3. The former is in good agreement with samples DA702 and DA801. Other physical property data for the AG samples

are reported in Table 32 and clearly support the hypothesis that samples DA702 and DA802 are actually WG orientation and not AG orientation.

Table 32. Physical properties of PCEA AG samples

Physical Property	PCEA AG Sample ID						
	DA601	DA602	DA701	DA702	DA801	DA802	DA901
Bulk Density, g/cm^3	1.7814	1.7765	1.7762	1.8114	1.8175	1.776	1.776
Electrical Resistivity, μΩ.m	8.97	9.19	9.18	7.96	7.96	8.88	8.91
E_{dyn}, GPa	8.96	9.66	9.02	10.90	11.30	9.01	8.92
E_{sonic}, GPa	10.99	10.87	11.05	13.08	13.23	11.08	10.00
G_{sonic}, GPa	3.22	3.23	3.38	3.66	3.61	3.21	3.07
Ave CTE (21-800°C), 10^{-6}°C^{-1}	5.62	5.39	5.62	5.21	4.96	5.44	5.58

It appears most likely that these samples were either machined in the wrong orientation or marked incorrectly with an AG sample number during laser marking. This error is unfortunate since sample DA7-02 was installed in AGC-1 as an unstressed control specimen (position 4U12) as a companion to specimen stressed DA7-01 (position 4S13).

Returning to the density plots in Figs. 49 to 64, the above discussed corrections have been made in the Figures and in the Appendices. Moreover, where changes in sample final length and /or density affect subsequent property measurements/calculations, those corrections have also been made in the appropriate data table/appendix, and also in the accompanying evaluated electronic data sets (excel spreadsheets). Corrected original (measured) data cells are highlighted yellow and the corrected data entered in red typeface. Corrected calculated properties are highlighted in yellow (on charts and tables/appendices). The density populations (Fig. 49-64) are reasonable with no outliers that can justifiably be corrected. An unusual density gradient is noted in the NBG-17 density data specimens AW101-03, yet a similar gradient effect is not seen with adjacent specimens AW2-01 to -03. A possible transcription error in recording AW1-01 sample Specimen Mass as 5.8914 g rather than 5.8614 g actually recorded only increases the sample density from 1.8439 g/cm^3 to 1.8533 g/cm^3. The increase is not considered significant, and the density gradient is still exhibited, even after a correction. The sample density does not compare favorably with AW1-02 or AW2-01 (1.8655 g/cm^3) "as is" or if the Specimen Mass were changed. Consequently, the Specimen Mass/density for samples AW1-01 and AW1-02 has been left unaltered. Assuming there is no oxidative Specimen Mass loss while the samples are in

the AGC-1 capsule the post-irradiation Specimen Mass should serve as a check on the samples real Specimen Mass. Sample AW14C02 in Fig. 49 is colored yellow indicating that this density is derived from a corrected Specimen Mass or dimension. No significant differences are seen between with- and against-grain samples.

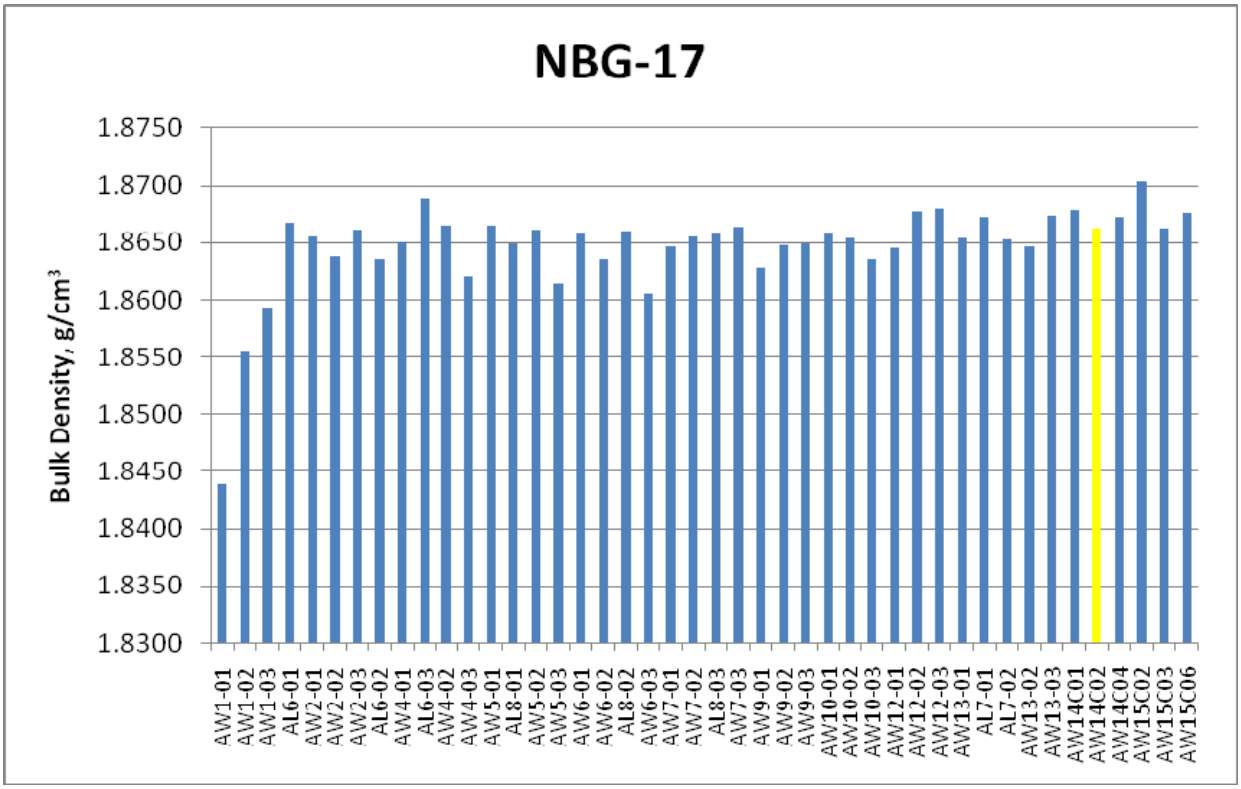

Fig. 49 Individual sample densities for gradeNBG-17 graphite

Fig. 50 reports the densities for samples of NBG-18 graphite. There are no significant outliers in the data set and no significant differences are seen between with- and against-grain samples. Grade H-451 density data are reported in Fig. 51. No outliers are observed. The densities of the "C" geometry samples appear to be slightly greater than from the creep/control samples. The two groups of specimens were machined from different sections of the billet (albeit at identical radius) and thus the differences could be associated with in-billet variations. However, the trend for the "C" geometry specimens to exhibit greater density in reflected in practically all of the graphite grades, and thus is probably a manifestation of the specimen's small volume.

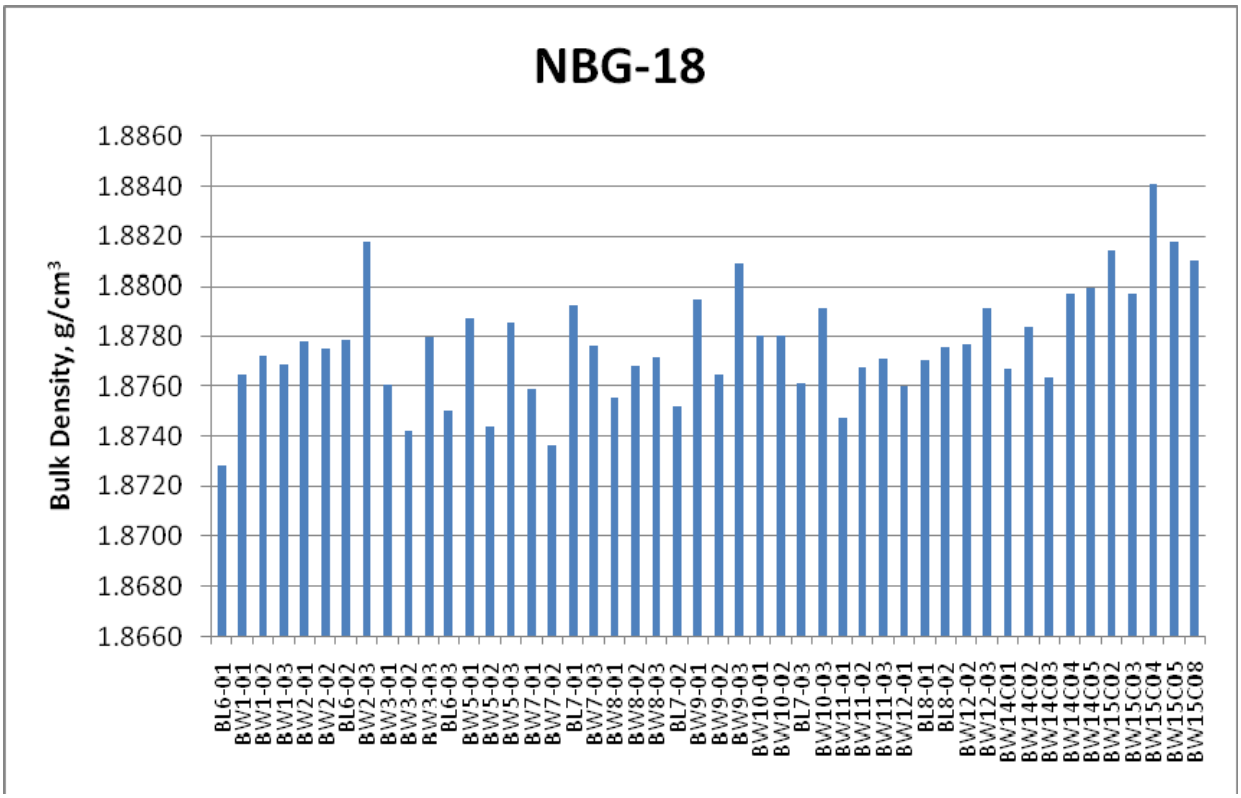

Fig. 50 Individual sample densities for grade NBG-18 graphite

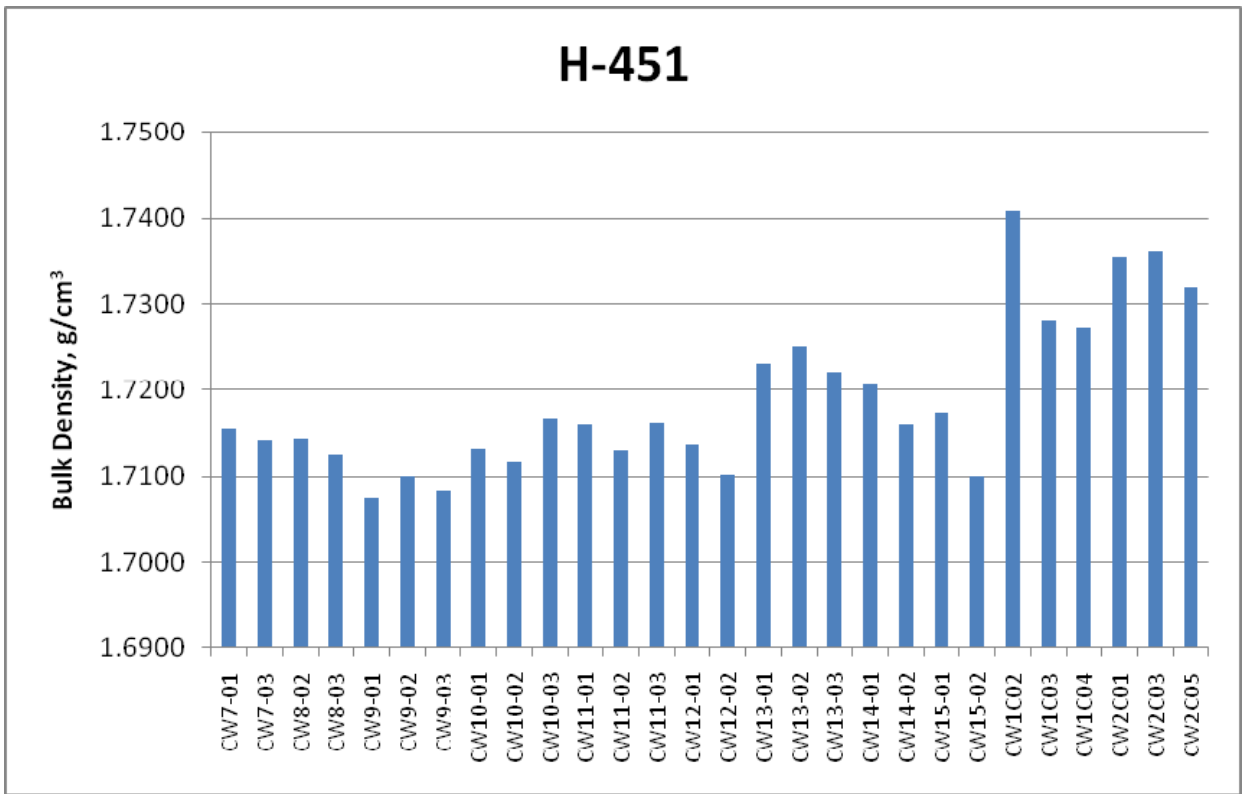

Fig. 51 Individual sample densities for grade H-451 graphite

Figs. 52 and 53 report the density data for grade PCEA. The data are plotted according to sample orientation with respect to the extrusion axis. As discussed previously, samples DA7-01 and DA8-02 are incorrectly marked and are actually with-grain samples. The DA7-01 and DA8-02 sample bars on Fig. 52 are thus colored red. Sample DW5-01 exhibits a lesser density than the population, but no obvious transcription error can be found in the data set. Other physical properties data for DW5-01 indicated that it is indeed a with-grain sample. Moreover, other samples in the DWX-01position also exhibit a lesser density than the neighbors. Consequently, sample DW5-01 density is accepted "as-is" and the Specimen Mass can be checked after irradiation. Again there is a suggestion in the data of a greater density from the "C" geometry samples in Fig. 52. A comparison of Figs. 52 and 53 (see also Fig 65) also indicates a greater density for WG samples than AG samples. This is a manifestation of the preferred orientation in an extruded billet.

Fig. 54 reports the density data set for IG-110 graphite. Sample EW9-02 density is corrected based upon the length transcription error discussed earlier and sample EW8-02 is corrected based upon the sample Specimen Mass transcription error discussed earlier. It is anticipated that the Specimen Mass of sample EW8-02 can be checked post-irradiation. There appears to be no data outliers in the corrected density population. Again the density calculated for the "C" geometry samples was somewhat greater that the creep/control sample population.

Grade IG-430 densities are reported in Fig. 55. There appears to be no data outliers in the density population. Again the density calculated for the "C" geometry samples was somewhat greater that the creep/control sample population.

Figs 56-64 report density populations based on piggy-back samples alone. Fig. 56 reports the density of A3-matrix material. The A3-matrix densities are substantially lower than those of the graphite samples in AGC-1, but all meet the requirement of the specification [15]. There appear to be no data outliers in the corrected density population. Fig. 57 reports the density of the HLM graphite samples. There appears to be no data outliers in the HLM density population.

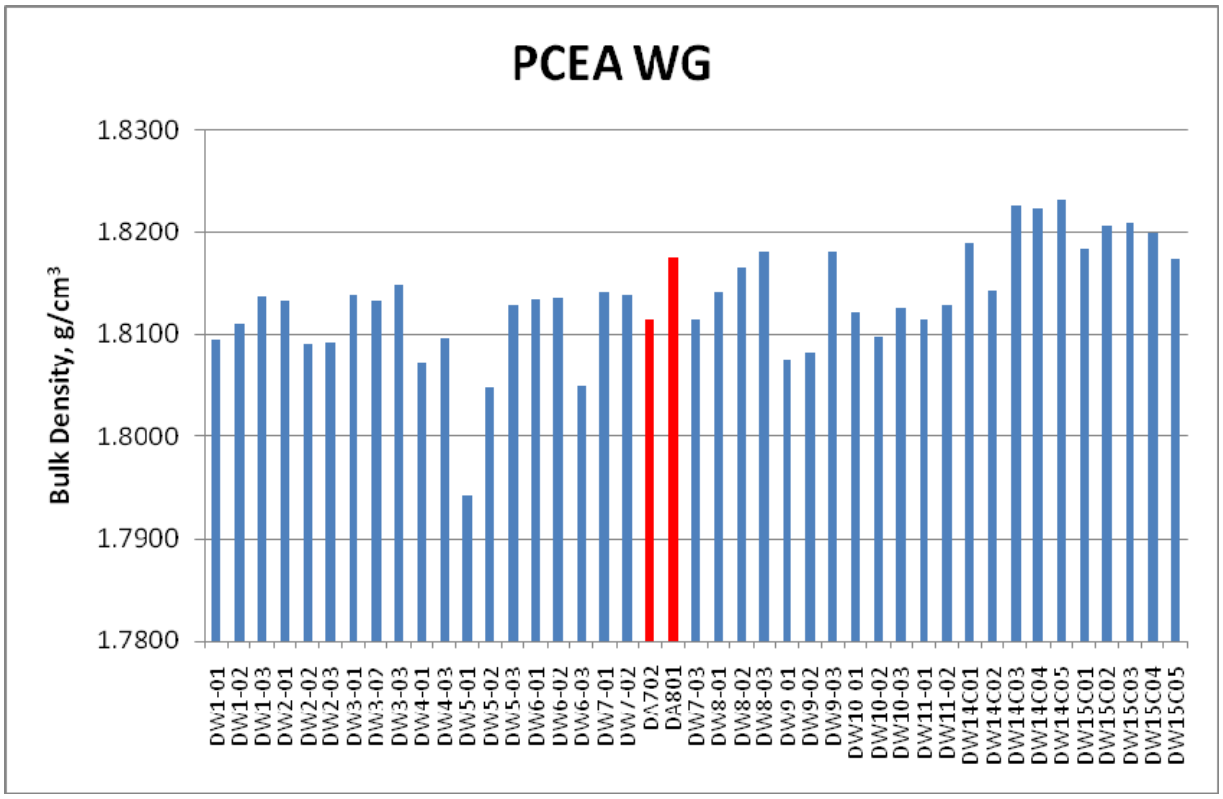

Fig. 52 Individual sample densities for grade PCEA (WG) graphite

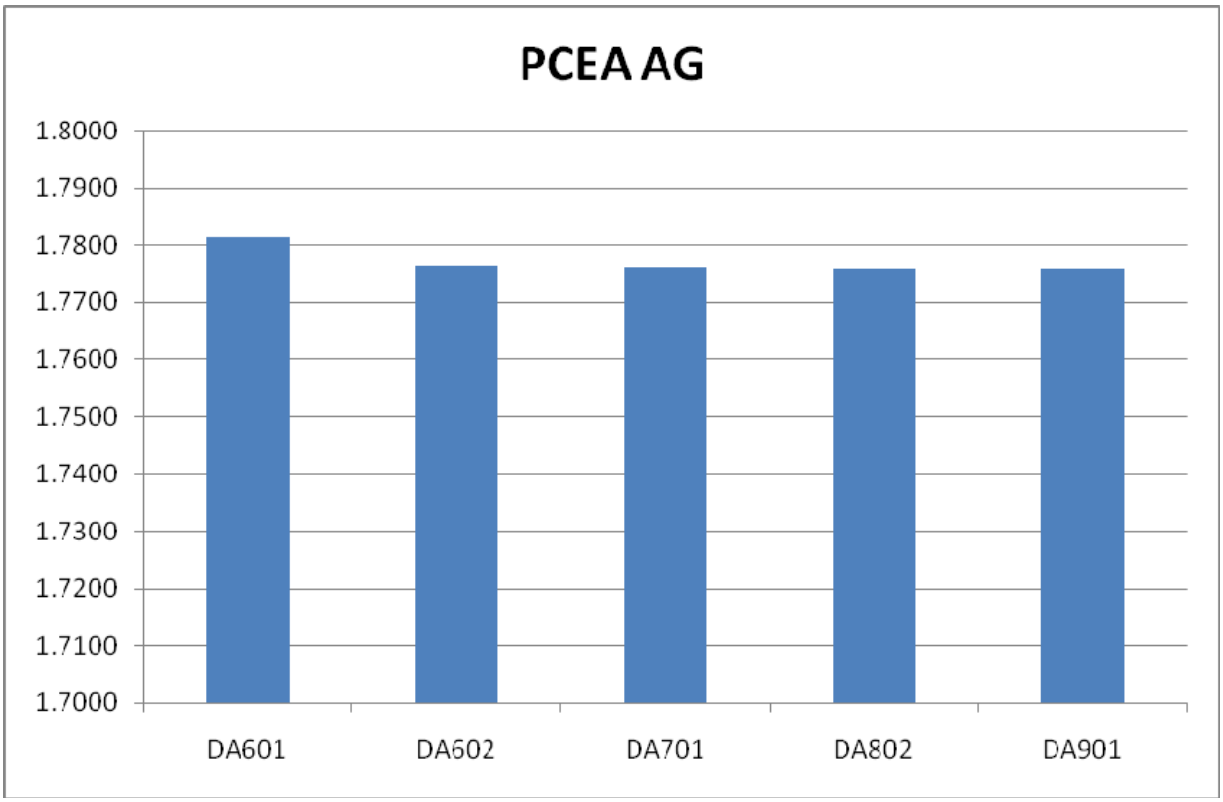

Fig. 53 Individual sample densities for grade PCEA (AG) graphite

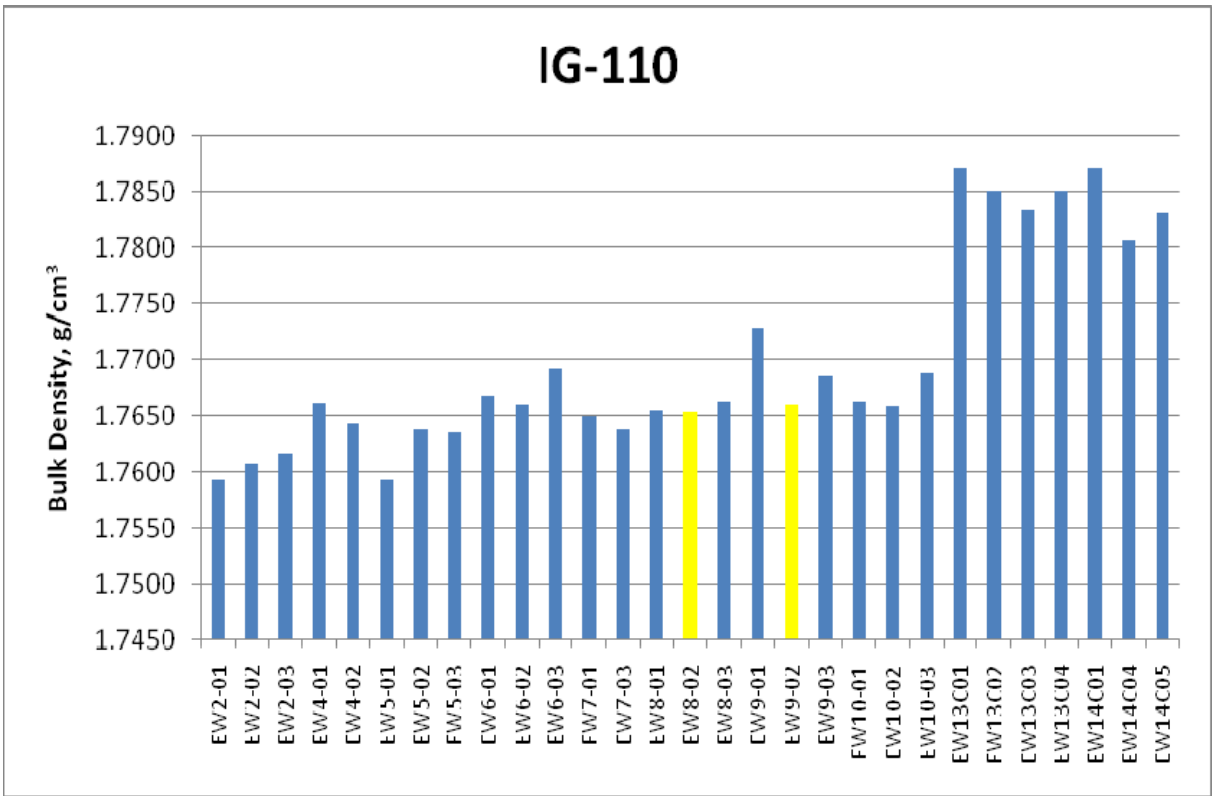

Fig. 54 Individual sample densities for grade IG-110 graphite

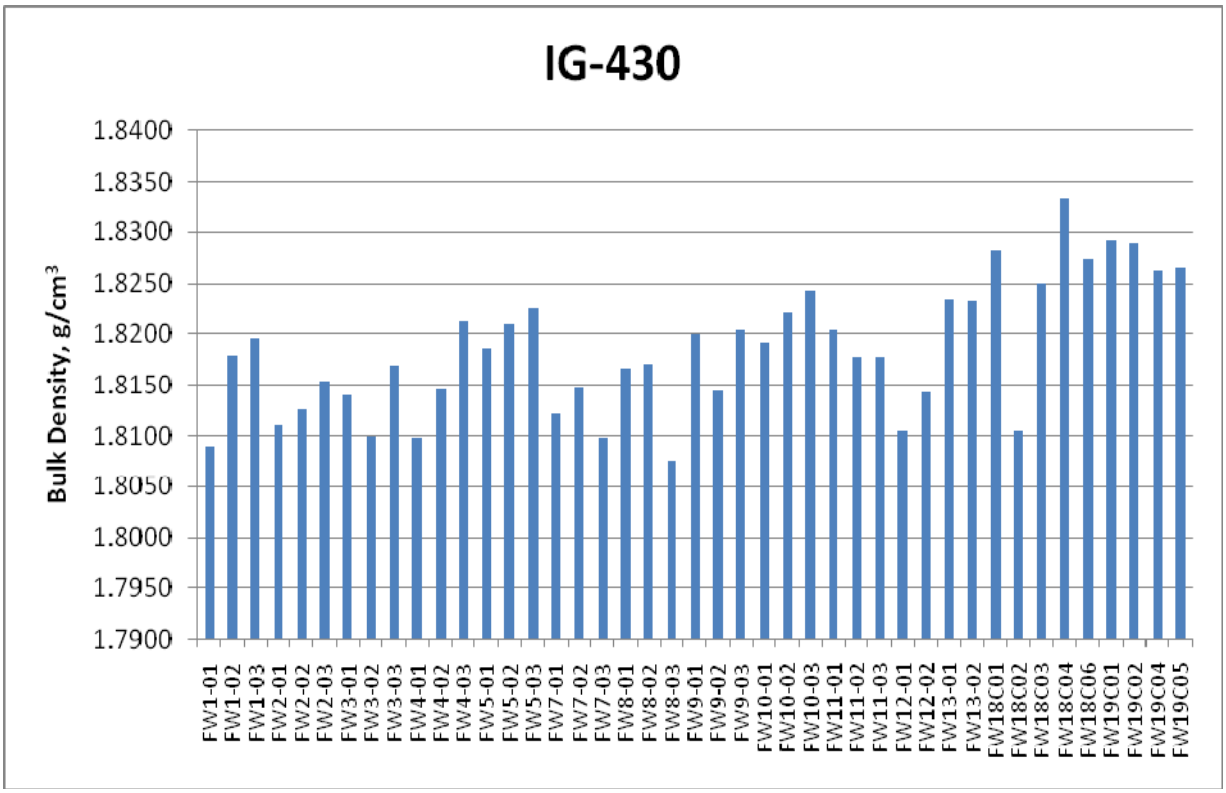

Fig. 55 Individual sample densities for grade IG-430 graphite

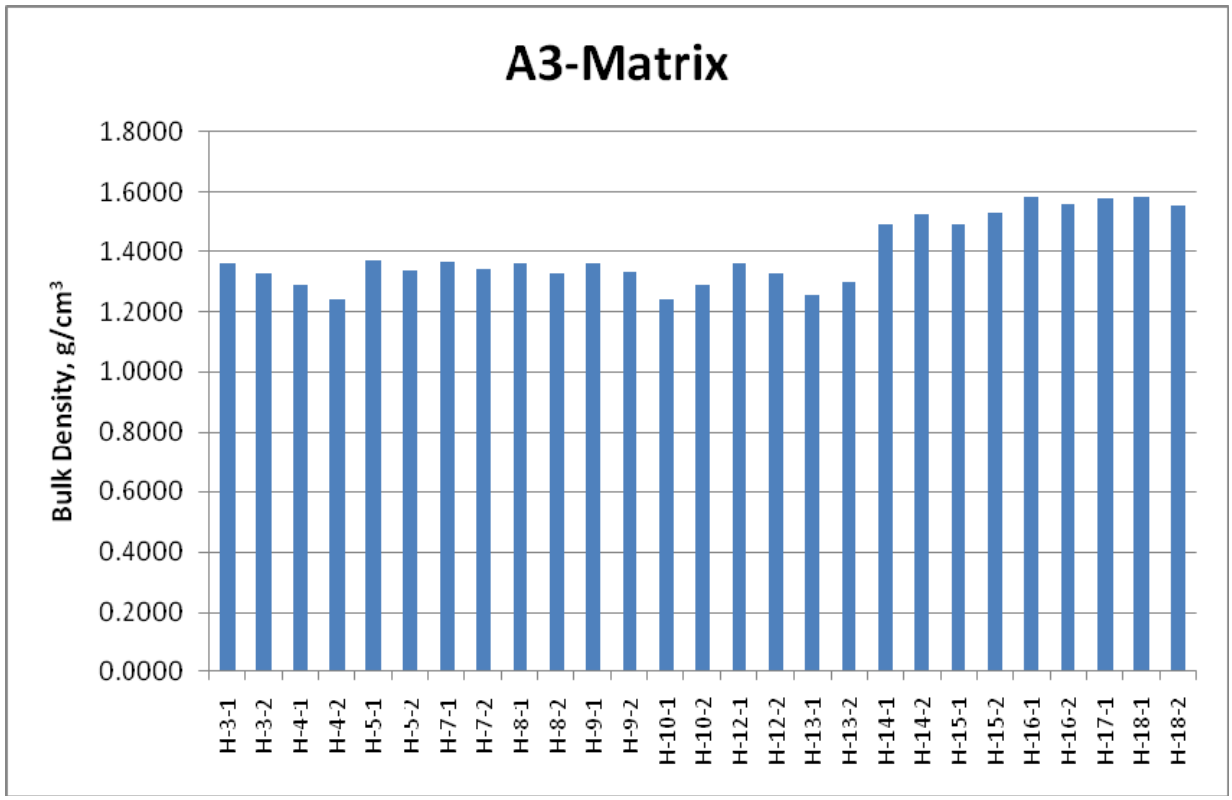

Fig. 56 Individual sample densities for A-3 matrix material

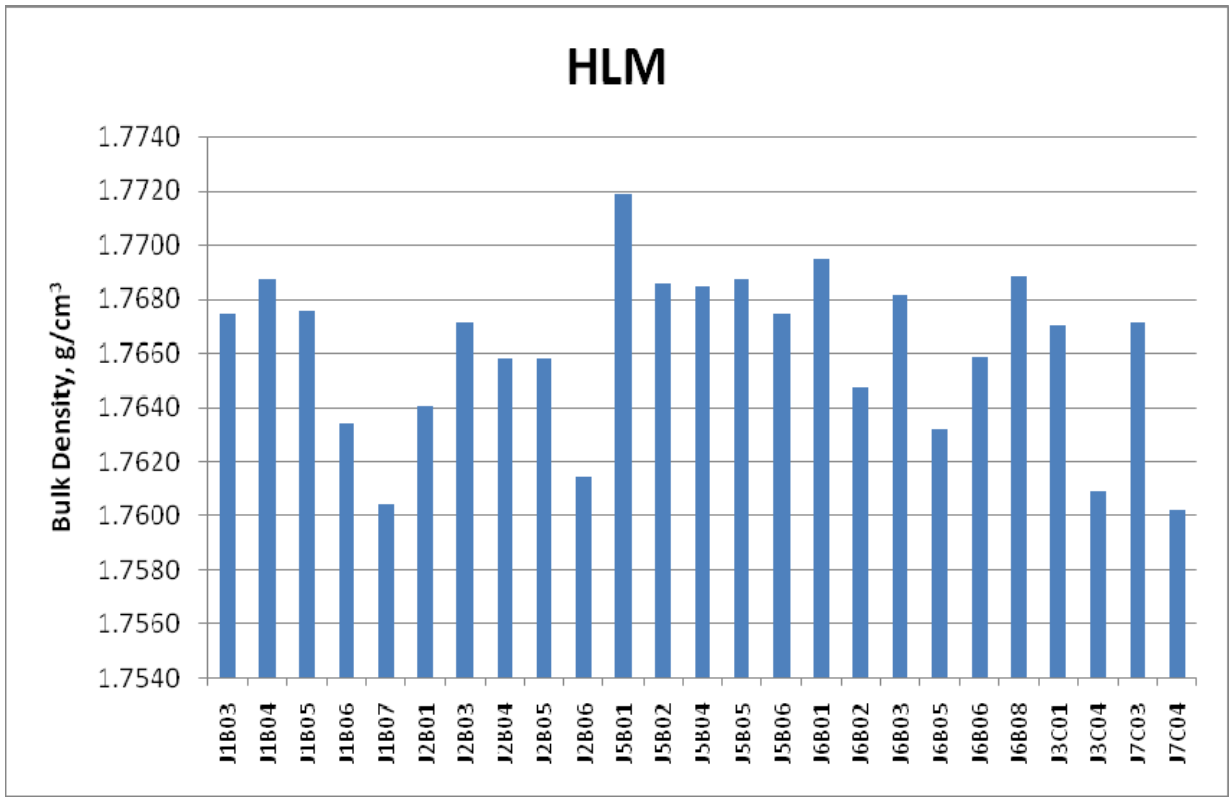

Fig. 57 Individual sample densities for grade HLM graphite

Grade PGX graphite individual sample densities are reported in Fig. 58. Sample K2B03 was noted to display an anomalously high density and this was attributed to a transcription error in the sample Specimen Mass (discussed earlier). There now appears to be no data outliers in the corrected density population. Fig. 59 reports the individual sample densities for grade PPEA graphite. Individual samples cut from PPEA bar 3 (L3BXX designation see Fig. 19), a total of 7 samples (L3B03-L3B09), exhibit a slightly lower density than the other samples in the PPEA population. Generally, there appears to be no data outliers in the PPEA density population.

Grade NBG-25 graphite individual sample densities are reported in Fig. 60. There appears to be no data outliers in the NBG-25 density population. NBG-25 bars M4 and M8 exhibit slightly lower densities than the rest of the population, whereas bars M3 and M7 exhibit slightly greater densities. Bars M3 and M7 were cut from adjacent locations and bars M4 and M8 were cut from adjacent locations. Bars M4 and M8 both being further away from the billet skin. Again the density calculated for the "C" geometry samples was slightly greater that the other samples.

Grade 2020 graphite individual sample densities are reported in Fig. 61. There appears to be no data outliers in the 2020 density population. Fig. 62 reports the individual sample densities for grade PCIB. As discussed earlier the density of sample P2C03 has been corrected based on an incorrectly transposed Specimen Mass. There appears to be no data outliers in the corrected PCIB density population. The individual sample densities for grade BAN graphite are reported in Fig. 63. There appears to be no data outliers in the BAN density population. However, distinct patterns in the density population based on position within the billet may be discerned. The BAN graphite was supplied to us as a pilot scale billet of 5.6 in. diameter. Comparing the density data (Fig. 63) with the specimen extraction plan for BAN (Fig. 25) indicates the existence of a density gradient with the billet center exhibiting a slightly lesser density than the periphery. This is evidenced by bar 2 (R2B01A-10A), bar 6 (R6B01A-10A), and bar 4 (R4C01A-R4C08A) exhibiting a lesser density than bars 3 (R3B01A-R3B08A) and 5 (R5C01A-R5C05A) which were more peripherally located in the billet.

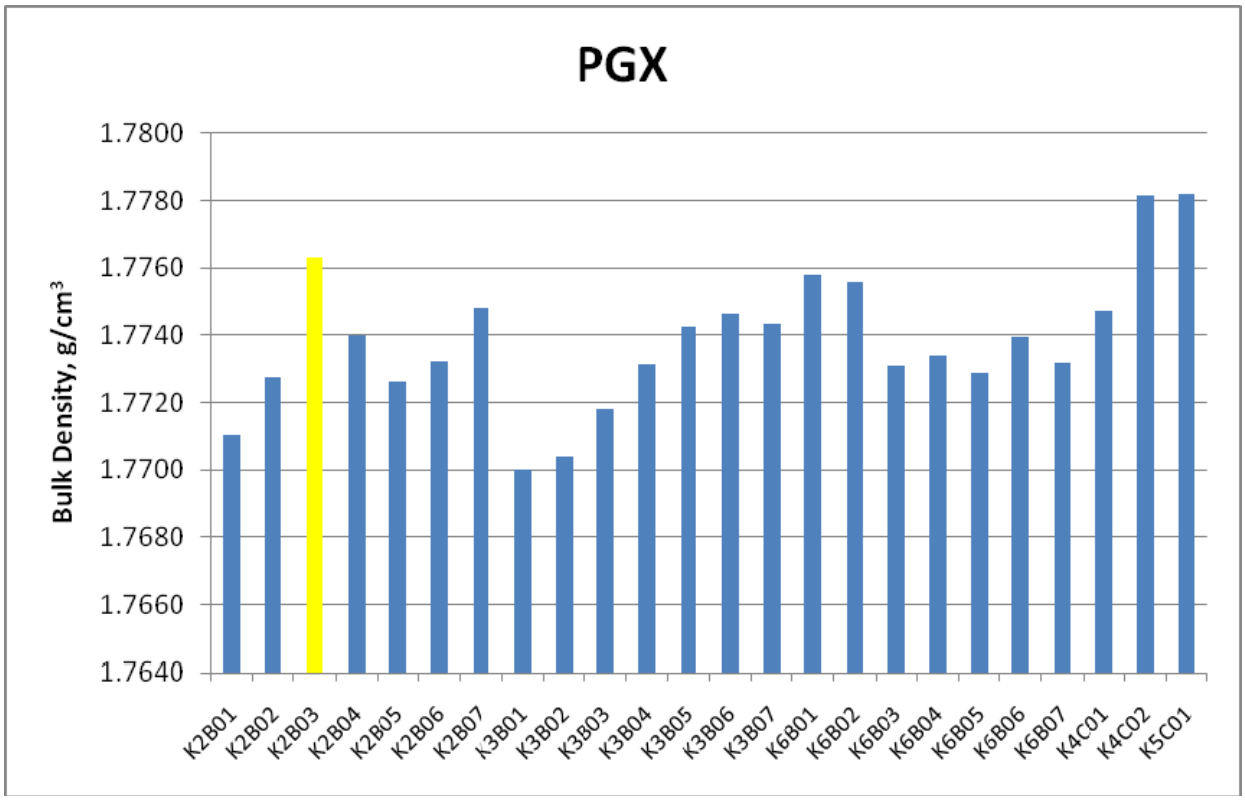

Fig. 58 Individual sample densities for grade PGX graphite

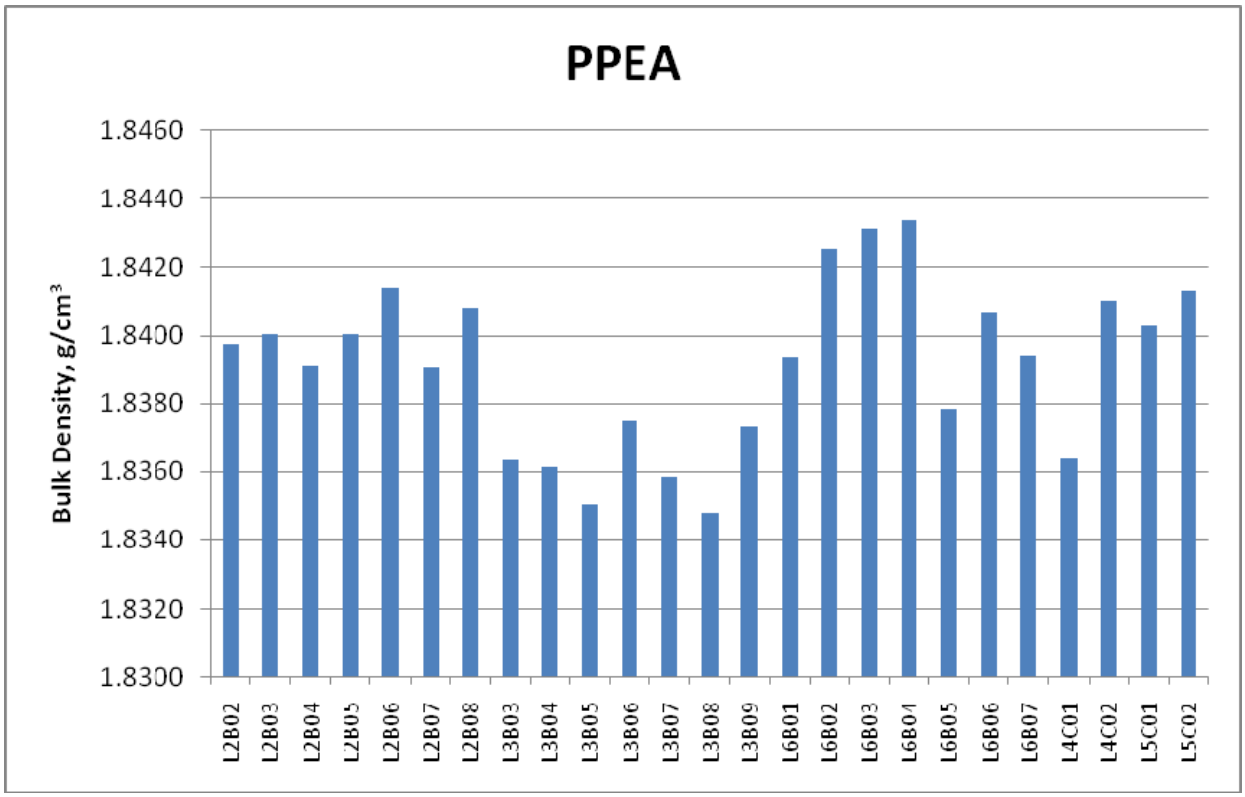

Fig. 59 Individual sample densities for grade PPEA graphite

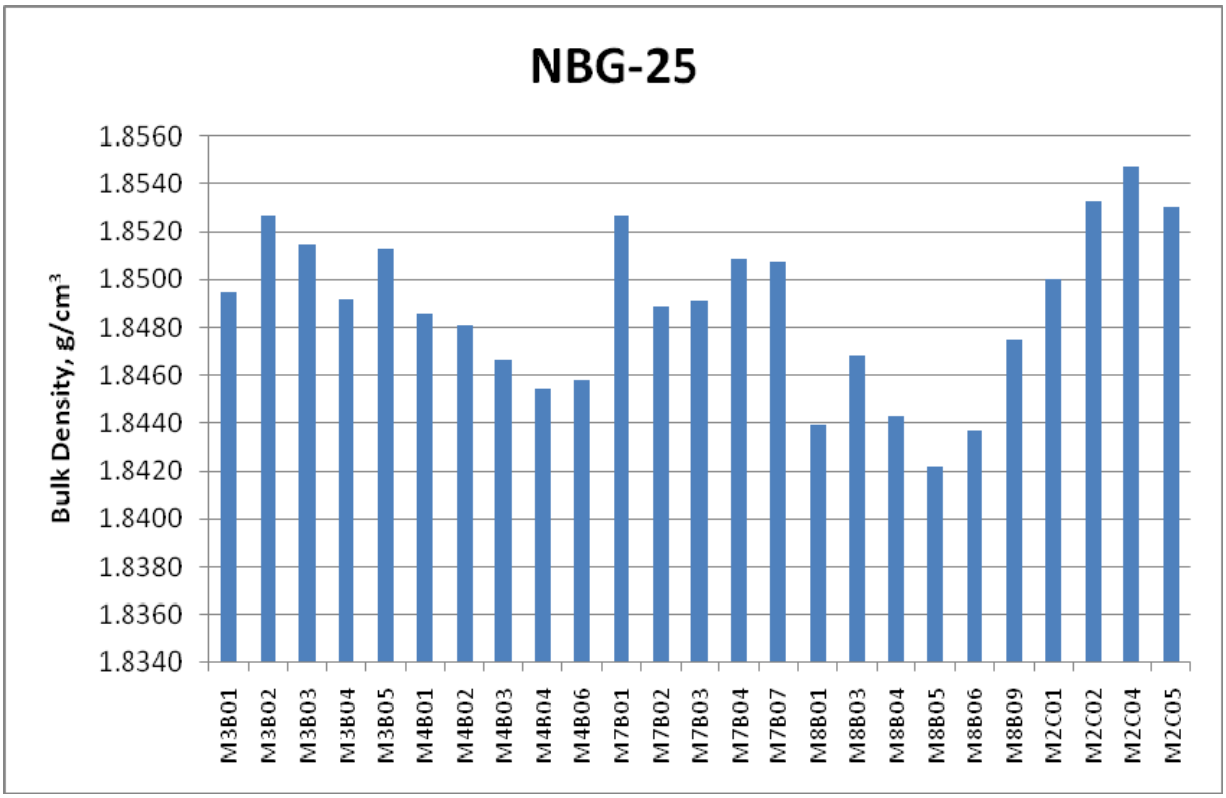

Fig. 60 Individual sample densities for grade NBG-25 graphite

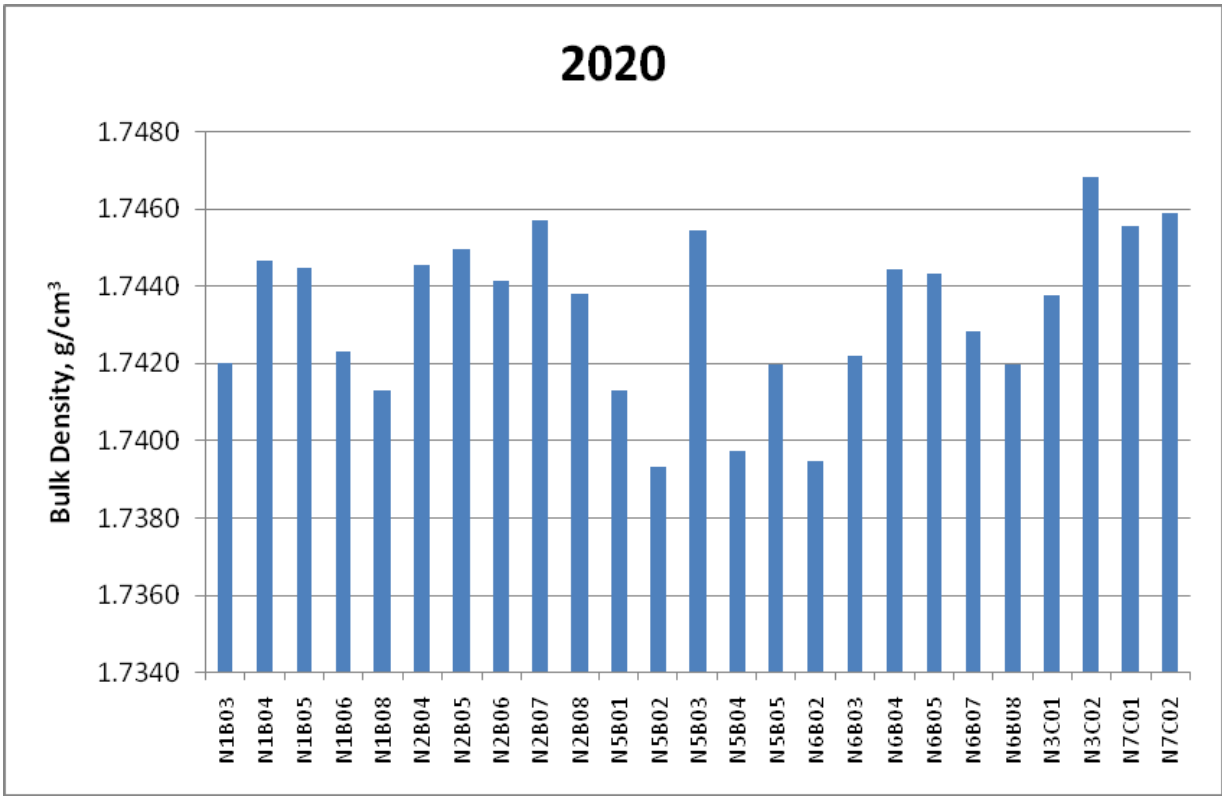

Fig. 61 Individual sample densities for grade 2020 graphite

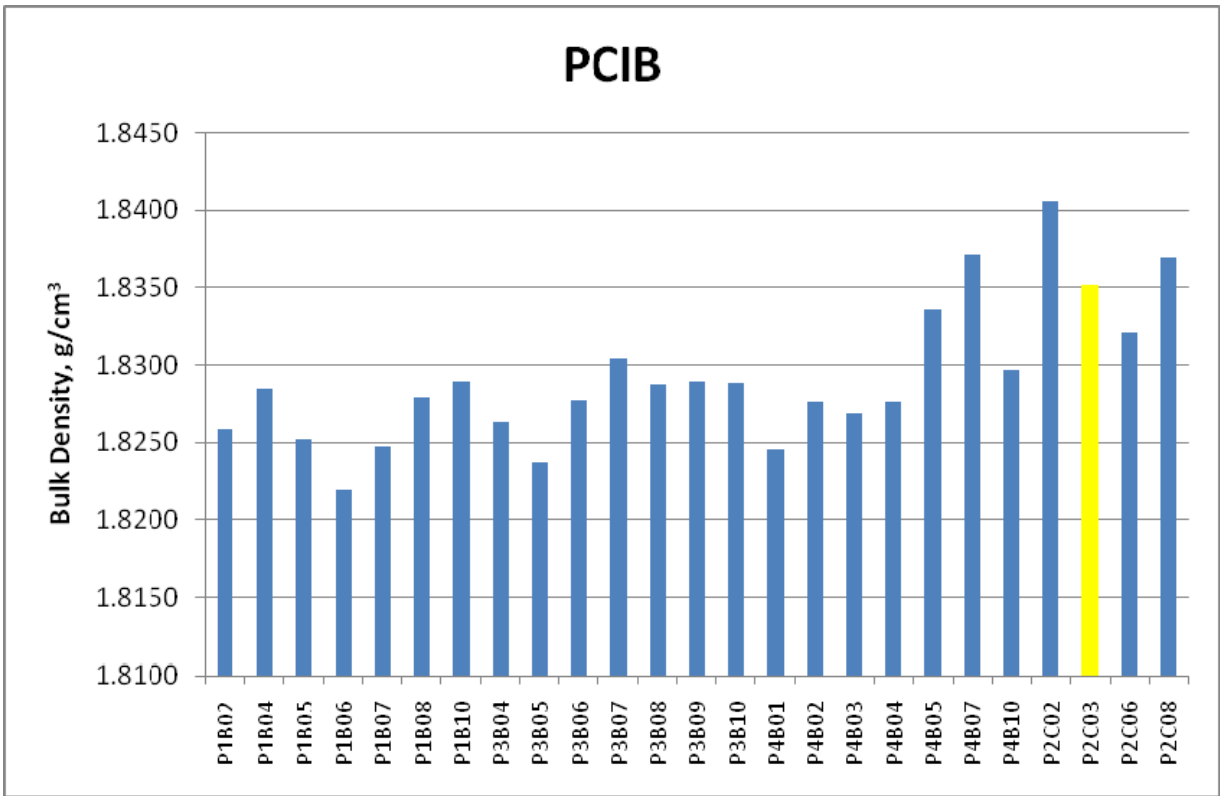

Fig. 62 Individual sample densities for grade PCIB graphite

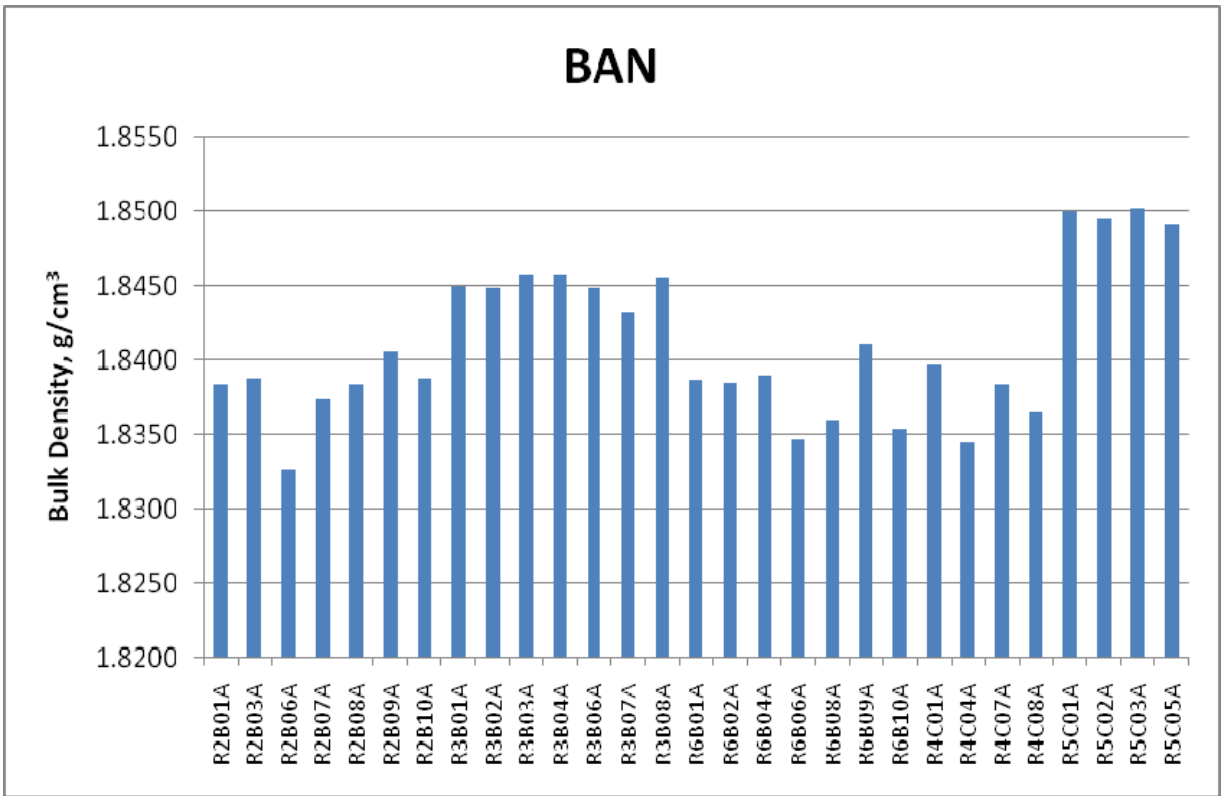

Fig. 63 Individual sample densities for grade BAN graphite

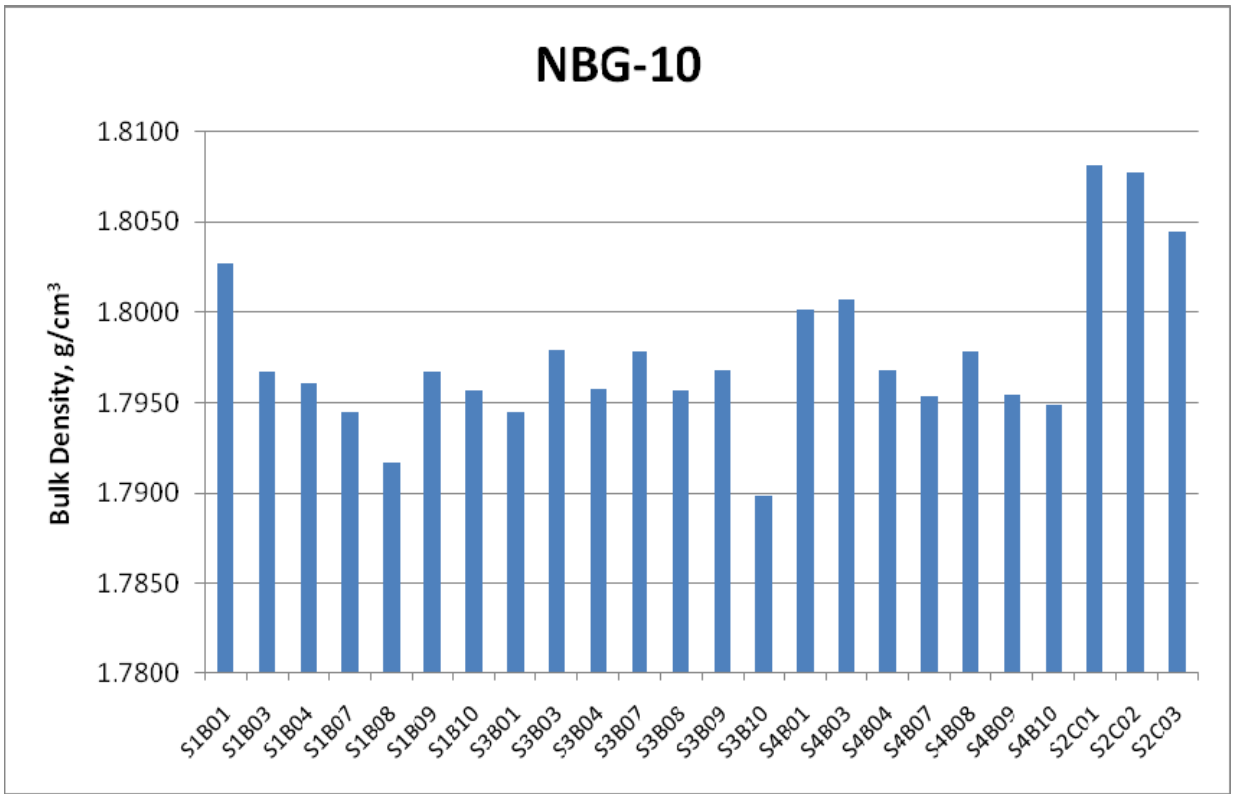

Fig. 64 Individual sample densities for grade NBG-10 graphite

Grade NBG-10 graphite individual sample densities are reported in Fig. 64. There appears to be no data outliers in the NBG-10 density population. Sample S1B01 exhibits a slightly higher density than the general population but there is no obvious transposition error in the data. Again the density calculated for the "C" geometry samples was slightly greater that the other samples.

A check of the calculation method showed no errors in the calculation of density, particulary for the "C" specimens. The equations used for all bulk density calculations were those provided in ASTM standard C559.

Figure 65 compares the mean density for each grade. The error bars represent ±3 standard deviations. With the exception of the low density A3-matrix material the error bar values are very small compared to the mean densities. There is however a significant difference between grade PCEA with-grain and grade PCEA against-grain, which is presumably a manifestation of the texture resulting from the extrusion process. This trend was seen previously in the sister specimen data [6]. Analysis of the data showed two of the PCEA samples were incorrectly

marked as WG samples but actually have AG orientation. This error most likely occurred during machining or engraving and did not become apparent until pre-irradiation data evaluation was conducted. One of these specimens was encapsulated as an unstressed control in AGC-1.

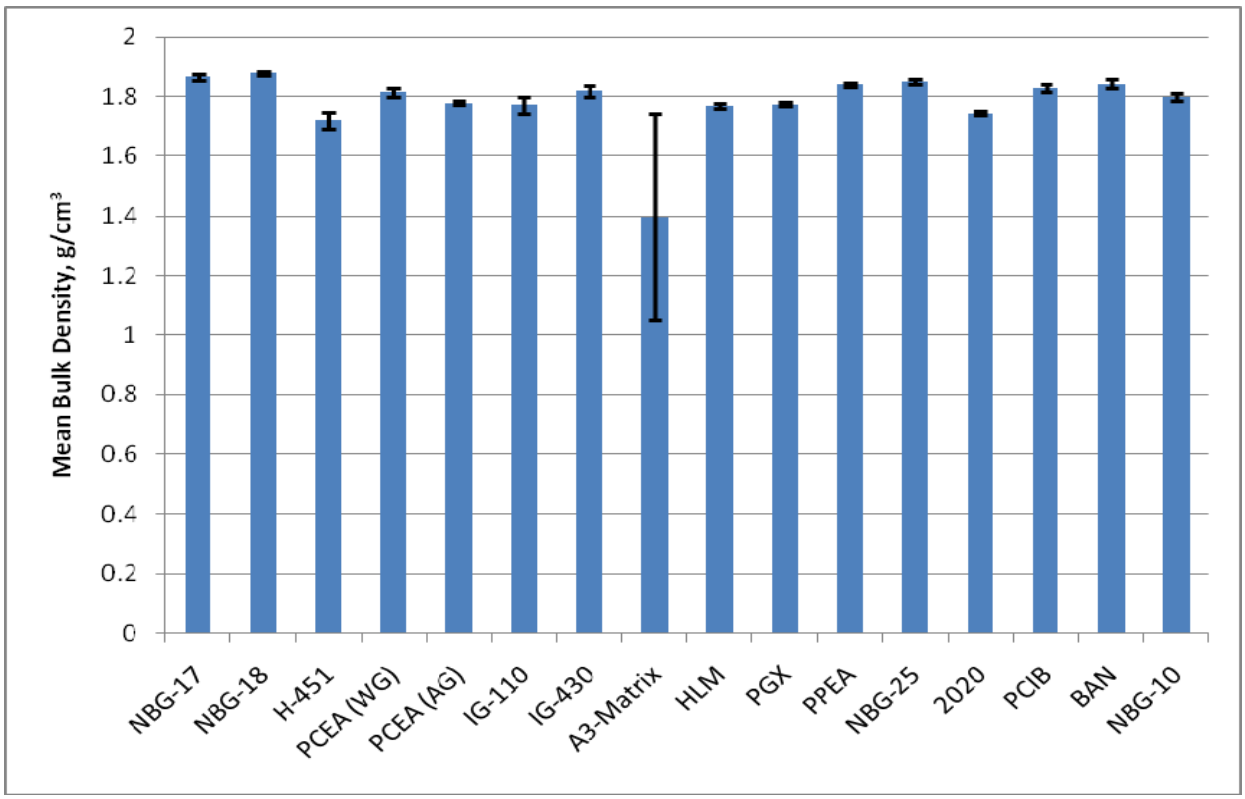

Fig. 65 Comparison plot of mean densities by graphite grade (mean ±3 standard deviations)

Where transcription errors were detected they have been corrected and reported and discussed here. The corrected dimensions and Specimen Masses were carried through subsequent property calculations. Corrected values are highlighted in yellow and are in red typeface. Corrected calculated values are highlighted yellow in the tables and electronic spreadsheets. In the future such transcription errors (albeit very few) will be eliminated by electronic data transfer from the instruments to the data recording device.

Finally, all the graphites reported here meet the ASTM specification requirements [16, 17] for a minimum bulk density of 1.7 g/cm^3. The A3-matrix material samples all meet the requirements of their specification [15], i.e., bulk density > 1.2 g/cm^3.

3.2. Pre-irradiation Examination, Flexural Dynamic Young's Modulus

The fundamental frequency and derived flexural dynamic Young's modulus data for the 1-inch long specimens are in Appendices 24-39. Corrected values are highlighted with corrected raw data highlighted yellow with red type face. A few transcription errors were found in individual frequency data (there were ten measurements per specimen). Three errors in Specimen Mass or dimensions were noted and corrected (these errors were noted in the previous sections and carried forward). Table 33 summarizes the errors found and corrected values of the flexural dynamic Young's modulus. The corrected flexural dynamic Young's modulus data for each grade/orientation is reported in Figs. 66-74.

Table 33. List of errors detected and corrected values for the fundamental frequency and flexural dynamic Young's modulus data

Grade	Sample Number	Uncorrected E, GPa	Error and Correction	Corrected E, GPa
NBG-17	AL6-01	12.4	Frequency 2 entered as 39520 Hz should be 30520 Hz	11.7
NBG-17	AW4-03	10.5	Frequency 2 entered as 20907 Hz should be 29907 Hz	11.2
NBG-17	AW9-01	11.8	Frequency 2 entered as 39733 Hz should be 29733 Hz	11.1
NBG-18	BW1-03	18.3	Ave dia entered as 11.1409 mm should be 12.733 mm	12.1
NBG-18	BW8-03	4.35	Frequency 2 entered as 309856 Hz should be 30985	12.1
NBG-18	BW10-02	10.1	Frequency 1 entered as 3118 Hz, should be 31118 Hz	12.2
PCEA	DA6-02	9.66	Frequency 4 entered as 37446 Hz should be 27446 Hz	8.99
PCEA	DW5-01	10.5	Frequency 3 entered as 29943 Hz should be 29443 Hz	10.5
IG-110	EW 4-01	8.97	Frequency 5 entered as 27598 Hz should be 27498 Hz	8.96
IG-110	EW8-02	8.9	Specimen Mass entered as 5.5862 g should be 5.5556 g	8.94
IG-110	EW9-02	2.62	Ave length entered as 12.7025 mm should be 25.3775 mm	9.21
IG-110	EW10-03	9.29	Frequency 3 entered as 27641 Hz should be 27941 Hz	9.31

As discussed previously (3.1. Density) two of the PCEA specimens (DA7-02 and DA8-01) appear to be with-grain orientation rather than against-grain orientation. These two data points are highlighted in red in Fig. 71.

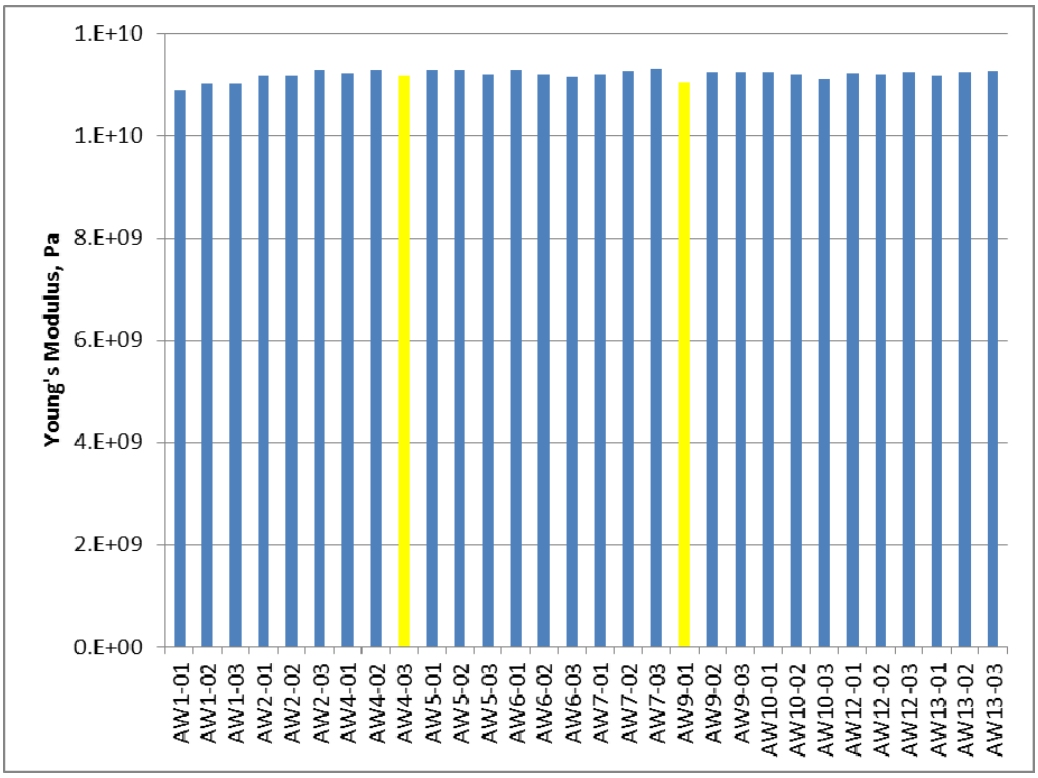

Fig. 66. Flexural dynamic Young's modulus data for NBG-17 (AG) specimens

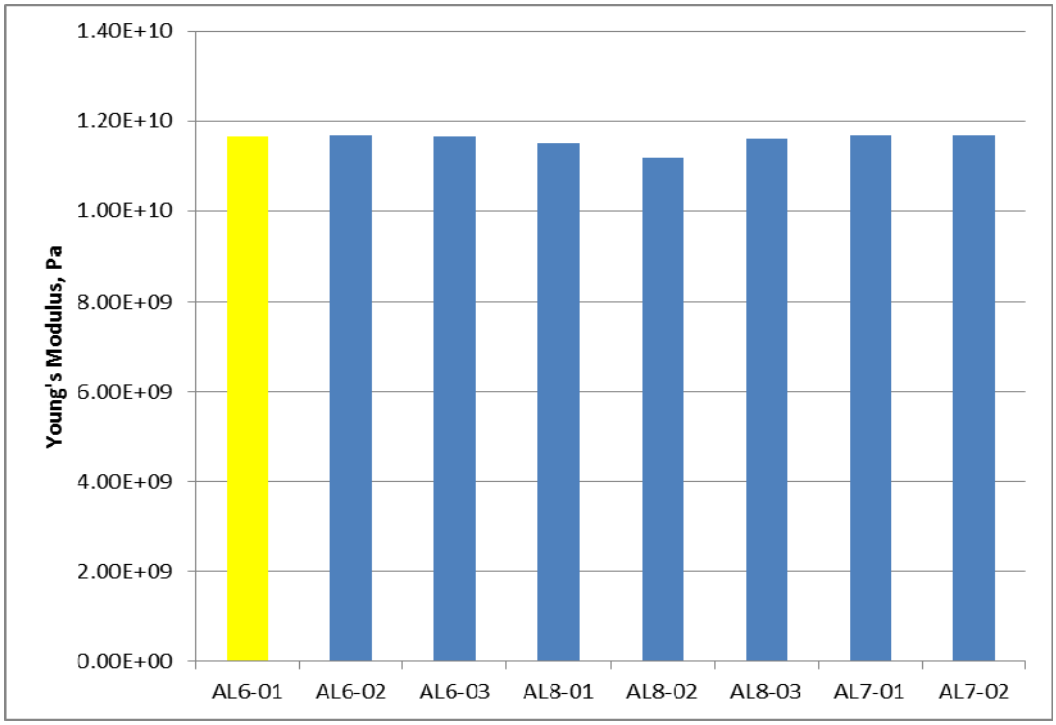

Fig. 67. Flexural dynamic Young's modulus data for NBG-17 (WG) specimens

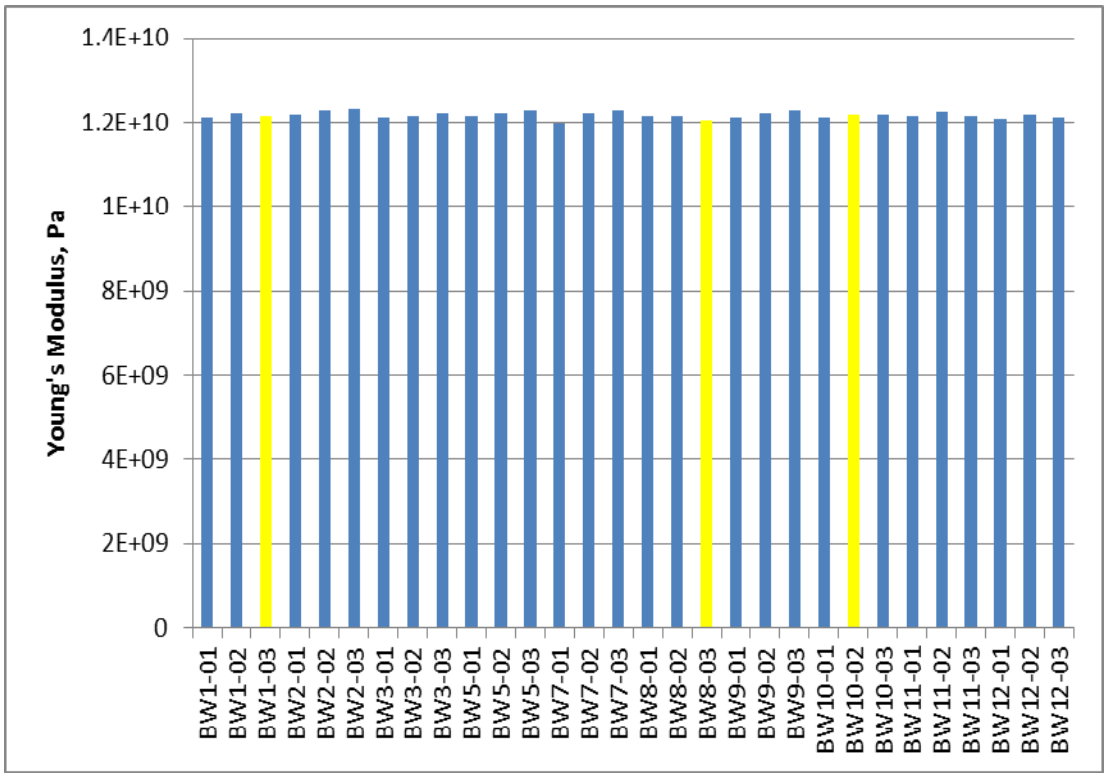

Fig. 68. Flexural dynamic Young's modulus data for NBG-18 (AG) specimens

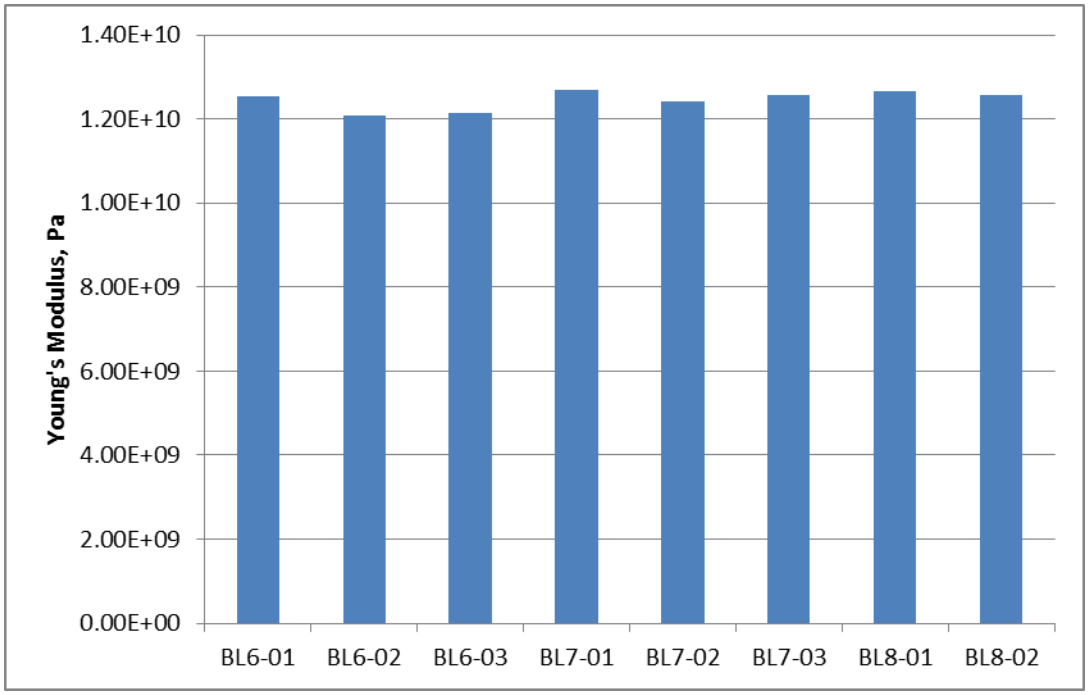

Fig. 69. Flexural dynamic Young's modulus data for NBG-18 (WG) specimens

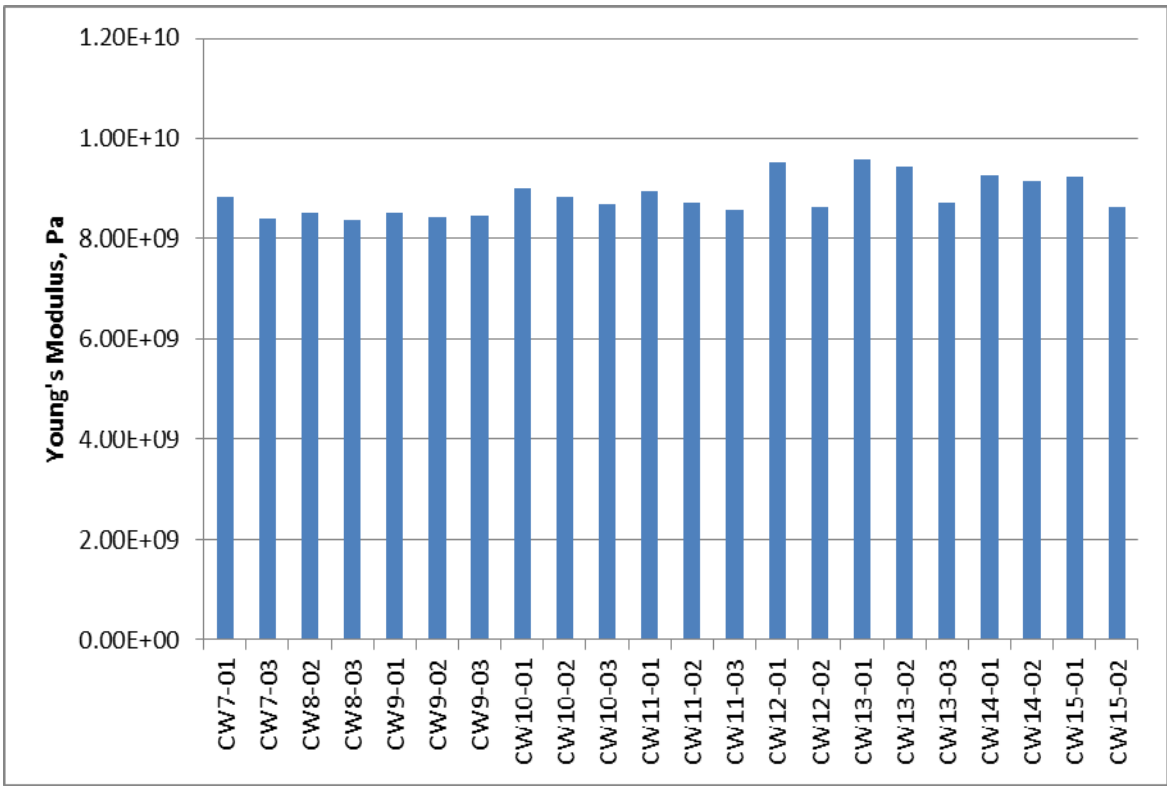

Fig. 70. Flexural dynamic Young's modulus data for H-451 specimens

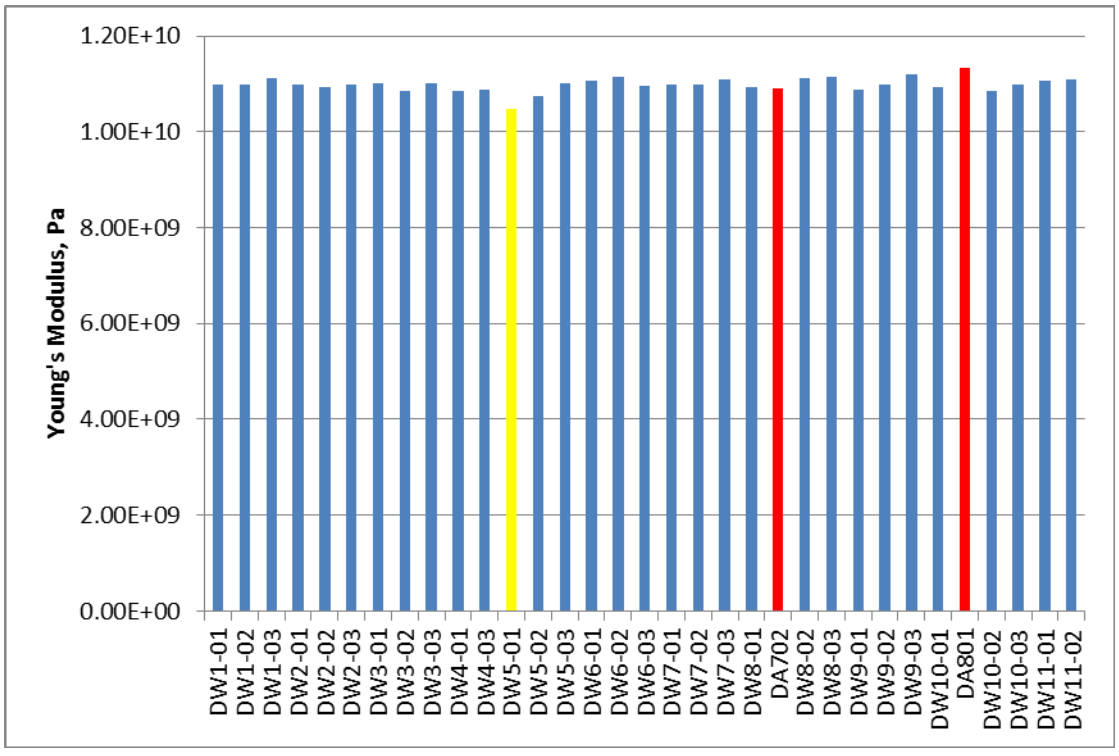

Fig. 71. Flexural dynamic Young's modulus data for PCEA specimens

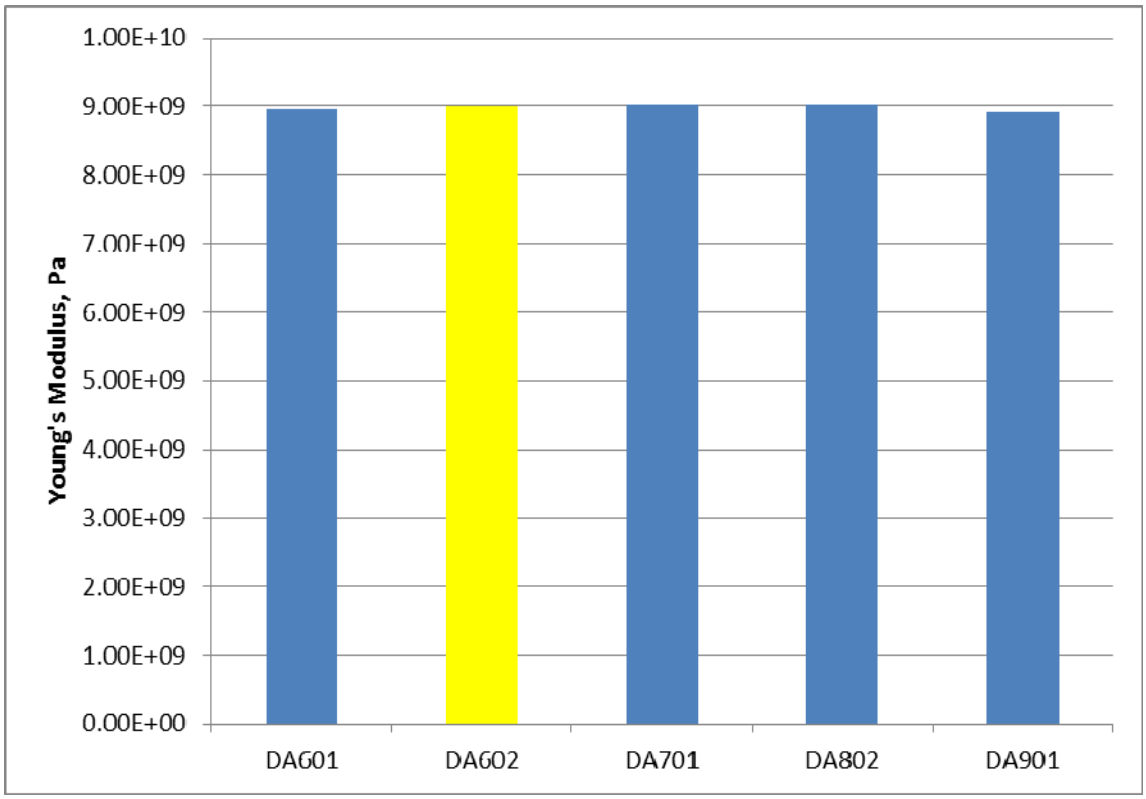

Fig. 72. Flexural dynamic Young's modulus data for PCEA specimens

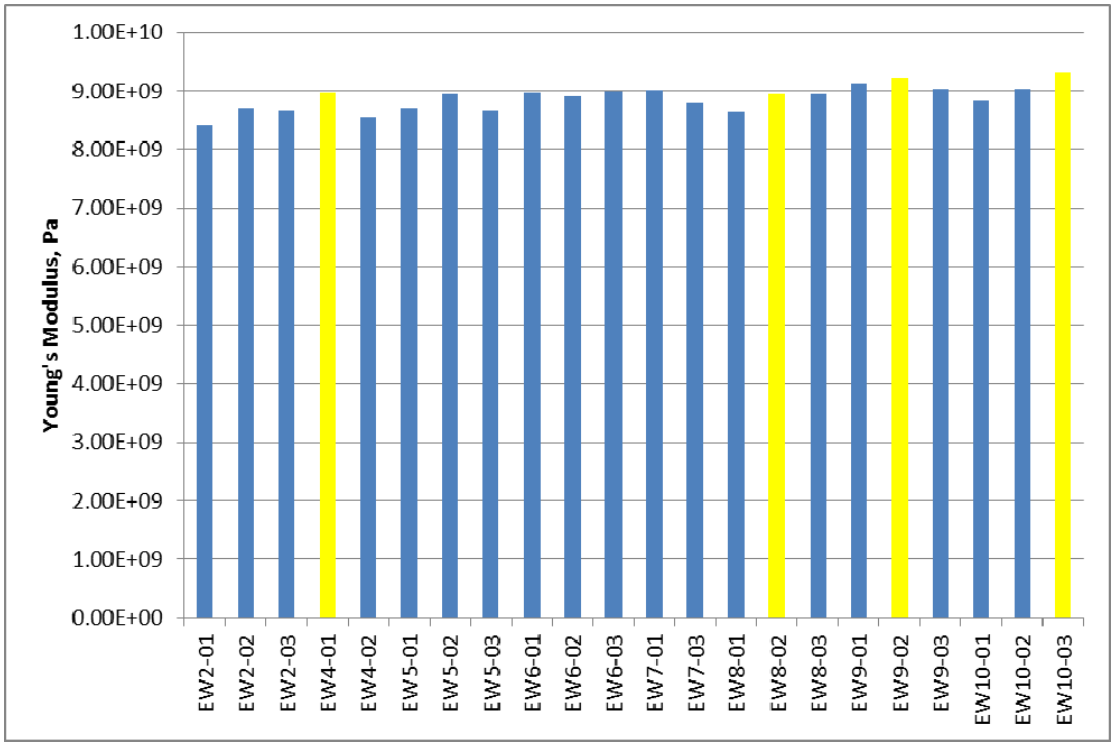

Fig. 73. Flexural dynamic Young's modulus data for IG-110 specimens

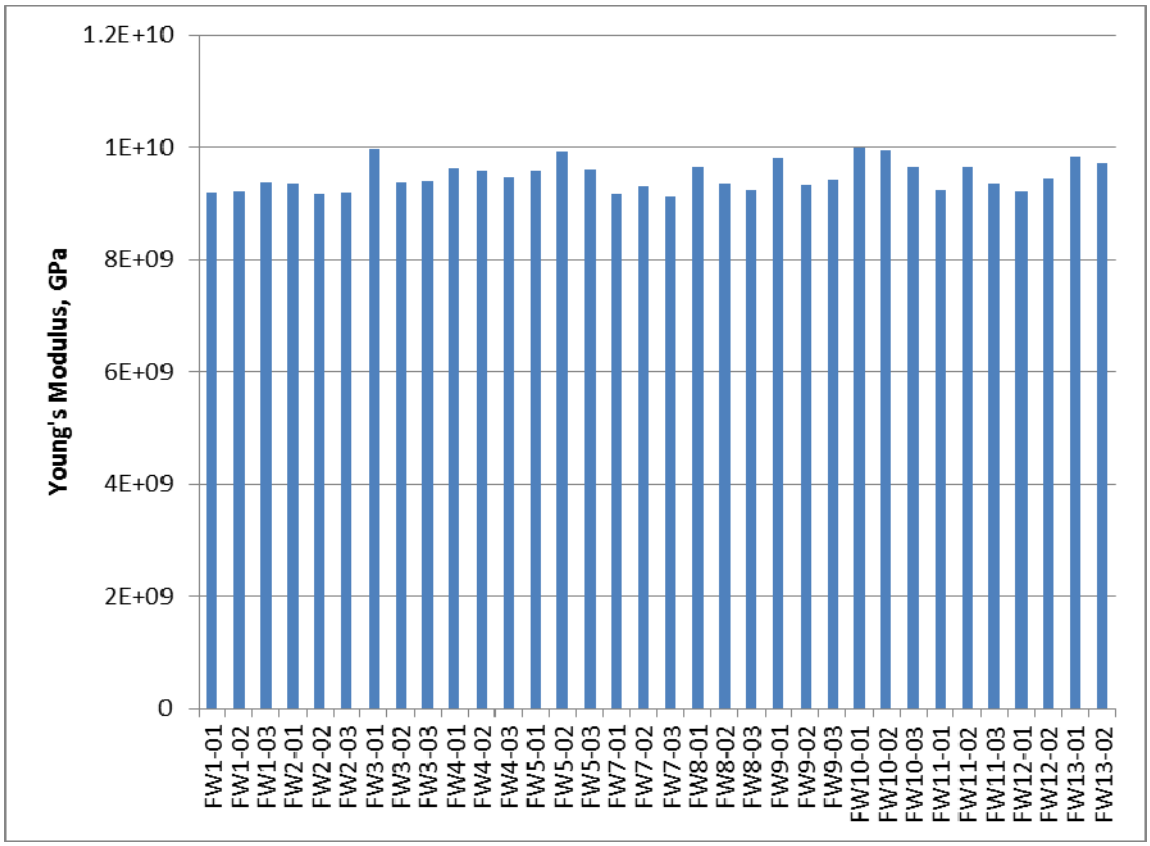

Fig. 74. Flexural dynamic Young's modulus data for IG-430 specimens

The vast majority of the flexural dynamic Young's modulus data is sound and few transcription errors were found. A few high modulus specimens were observed in the IG-430 data set (Figure 74), but no obvious data errors were observed. The flexural dynamic moduli data are summarized by grade and orientation in Fig.75. The ASTM specifications D7219 and D7301 call for the flexural dynamic Young's modulus to be between 8-15 GPa, and thus the graphites reported here are compliant (Fig. 75). The values reported for NBG-17 and -18 indicated these grades exhibit a high degree of isotropy, as noted in the sister specimen report [6].

An evaluation of the cut-up drawings for the NBG-17 and -18 billets reveals that the specimens labeled AW and BW were in fact machined with their major axis against the grain (parallel to the forming direction) and the specimens labeled AL and BL are machined with their major axis with-grain (perpendicular to the forming axis). This is contrary to the experimental plan and revised AGC-1 capsule layout [2, 3] where the indicated orientation was reversed. Therefore,

the majority of the NBG-17 and -18 specimens in AGC-1 are AG orientation (in their major axis) and the specimen diameter is always in a WG orientation.

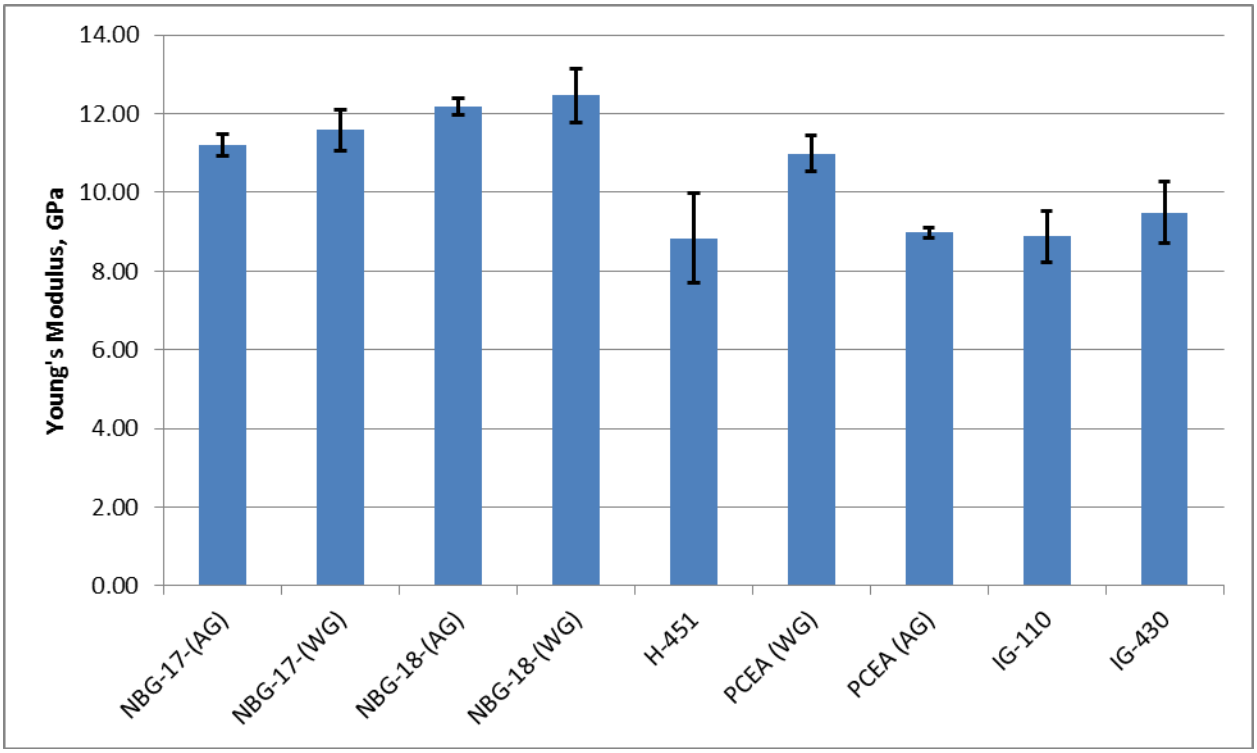

Figure 75. Summary plot of the measured flexural dynamic Young's Modulus by grade and orientation (mean ± 3 st. dev.)

Table 34 reports the dynamic Young's moduli data for the creep specimens tested here and shown in Fig. 75, the dynamic moduli values measured on the "sister" specimens are reported for comparison in Table 35. Both data sets indicated higher moduli for NBG-18 compared to NBG-17, and the anisotropy of PCEA is correctly reflected in both data sets. The creep specimens show $E_{WG} > E_{AG}$ whereas the sister samples indicate the contrary. Both data sets show the moduli of isomolded grade IG-430 was greater than that of isomolded grade IG-110.

Table 34. Summary of flexural dynamic Young's modulus data for the AGC-1 creep samples (by fundamental frequency method)

Grade	Flexural Dynamic Young's Modulus E (GPa)			
	No. of Samples	Mean	St. Dev	± 3SD
NBG-17-(AG)	30	11.19	0.093	0.278
NBG-17-(WG)	8	11.58	0.170	0.510
NBG-18-(AG)	30	12.17	0.072	0.216
NBG-18-(WG)	8	12.46	0.230	0.689
H-451	22	8.84	0.378	1.135
PCEA (WG)	33	10.98	0.149	0.446
PCEA (AG)	5	8.98	0.042	0.127
IG-110	22	8.88	0.218	0.655
IG-430	34	9.48	0.261	0.784

Table 35. Summary of flexural dynamic Young's modulus data for the AGC-1 **sister samples** (by fundamental frequency method) [6]

Graphite Grade	Grain Orientation		Mean Flexural Dynamic Young's Modulus, E (GPa)	Standard Deviation (GPa)	Number of Specimens
	With (WG)	Against (AG)			
NBG-17 (WG)	X		10.828	0.097	27
NBG-17 (AG)		X	11.372	0.073	27
NBG-18 (WG)	X		11.648	0.260	27
NBG-18 (AG)		X	12.108	0.087	27
H-451	X		9.179	0.320	27
PCEA (WG)	X		10.234	0.215	27
PCEA (AG)		X	9.396	0.114	27
IG-110	Isotropic		8.676	0.232	27
IG-430	Isotropic		9.384	0.185	27

3.3. Pre-irradiation Examination, Sonic Elastic Constants

The sonic elastic constants data, longitudinal dynamic Young's modulus (E), Poisson's ratio (μ), and shear dynamic modulus (G), derived from the sonic velocities are reported in Appendices 40-57. Corrected (calculated) values are highlighted in yellow and corrected raw data is additionally in red font. Relatively few corrections have been made, and they are summarized in Table 36. Perhaps the most unfortunate error was in the transposition of densities for the IG-110 creep specimens where the incorrect density has been copied into the original spreadsheet. In addition to the density errors in the IG-110 specimens there were isolated density transposition errors for grades IG-110, NBG-17, PGX, and PCIB. Elastic constants were measured for A3-Matrix with only limited success. The A3-Matrix had low density (1.28-1.58 $g.cm^{-3}$), which made determining the sonic velocities particularly difficult. Consequently, that elastic constant data (from sonic velocity is considered unreliable). Isolated velocity data transcription errors are reported in Table 36 for specimens of grade NBG-18, PCEA (AG), IG-110, 2020, BAN, and NBG-10. These errors have been corrected in the subsequent figures that report the data by grade.

The assessed and corrected data for elastic constants (derived from sonic velocity) are reported in Figs. 76-129. The first group of plots (Figs. 76-102) of elastic constant data (longitudinal dynamic Young's modulus, E, Poisson's ratio, μ, and shear dynamic modulus, G) is for the creep specimens and piggy-back specimens of the major grades, and the second group of plots (Figs. 103-129) reports the elastic constants for the minor grade piggy-back specimens only. Note, the reported sonic longitudinal dynamic Young's modulus is the value corrected for Poisson's ratio effects using the measured longitudinal and shear sonic velocities.

Table 36. List of errors detected and corrected values for the elastic constants (from sonic velocity) data

Grade	Sample Number	Uncorrected Vl, m/s	Uncorrected Vs. (0), m/s	Uncorrected Vs (90), m/s	Uncorrected ρ, Km/m^3	Error and Correction	Corrected E, GPa	Corrected G, GPa	Corrected μ	Corrected E(μ), GPa
NBG-17	AW14CO2				1852.90	Correct density should be 1866.2	14.39	3.12		10.32
IG-110	EW Creep					All EW Series Creep samples have the wrong density entered.				See App. 47
IG-110	EW 8-02					Corrected density should be 1765.26	9.71	3.19		8.02
IG-110	EW 9-02					Corrected density should be 1766.0	10.07	3.24		8.19
PGX	K2B03					Corrected density should be 1776.3	9.94	3.13		7.95
PCIB	P2C03					Corrected density should be 1835.1	11.51	3.97		9.81
NBG-18	BL6-01			1.58E+03		Corrected Vs. (90) should be 1.588E+03	15.78	4.39	0.307	11.48
PCEA	DA802		1.361E+02			Correct Vs(0) should be 1.346E+03		3.179	0.273	8.095
IG-110	EW13C02		1.455E+07			Correct Vs(0) should be 1.455E+03		3.721	0.2192	9.074
2020	N6B04	2.68E+02				Correct Vl should be 2.568E+3	11.51		0.215	10.16
BAN	R6B08A		1.14E+02			Correct Vs(0) 1.414E+3		3.69	0.275	9.4
NBG-10	S1B07		1.44E+02			Correct Vs(0) 1.44E+3		3.78	0.285	9.71

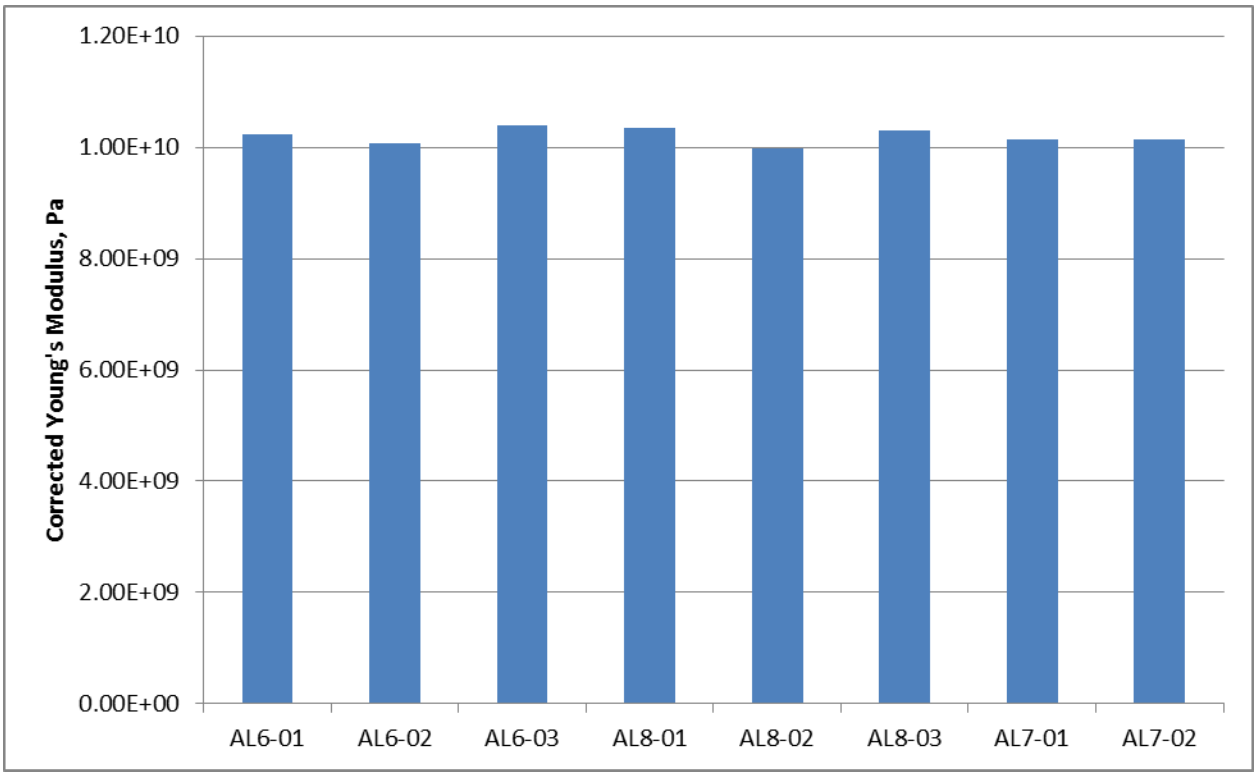

Fig. 76. Longitudinal dynamic Young's modulus (from sonic velocity) for NBG-17 (WG) creep specimens

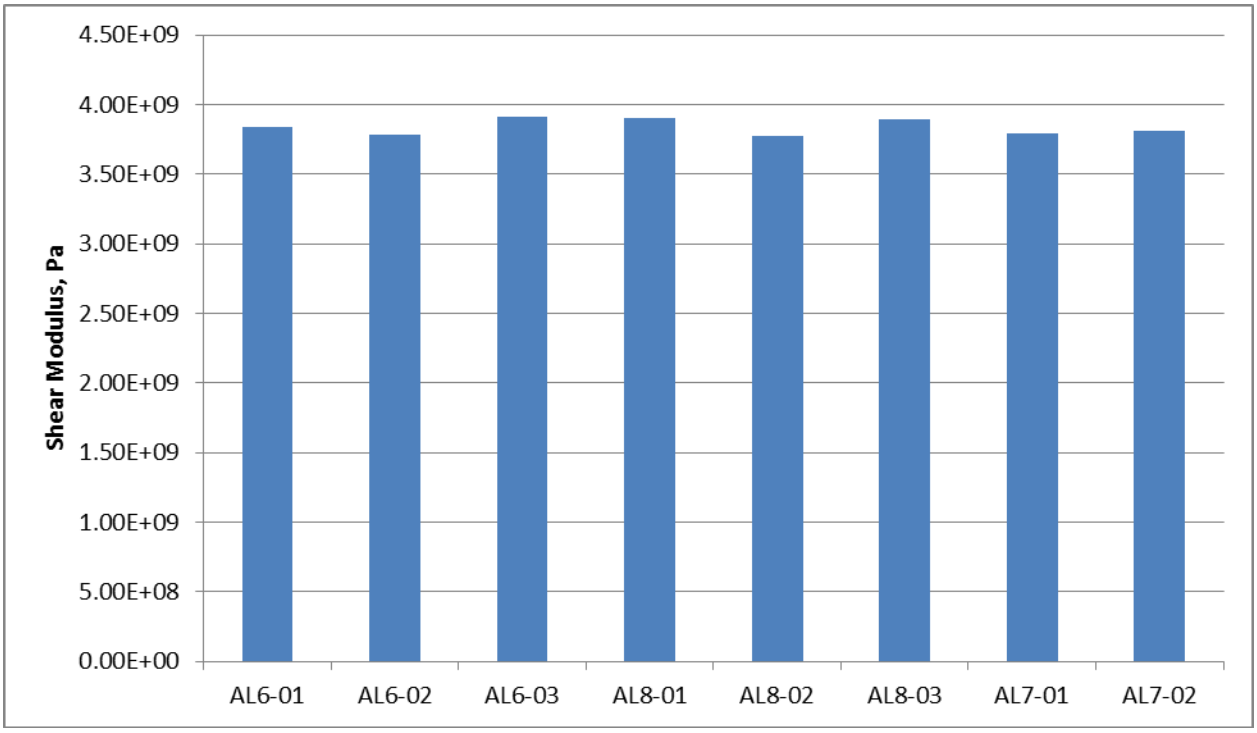

Fig. 77. Shear dynamic modulus (from sonic velocity) for NBG-17 (WG) creep specimens

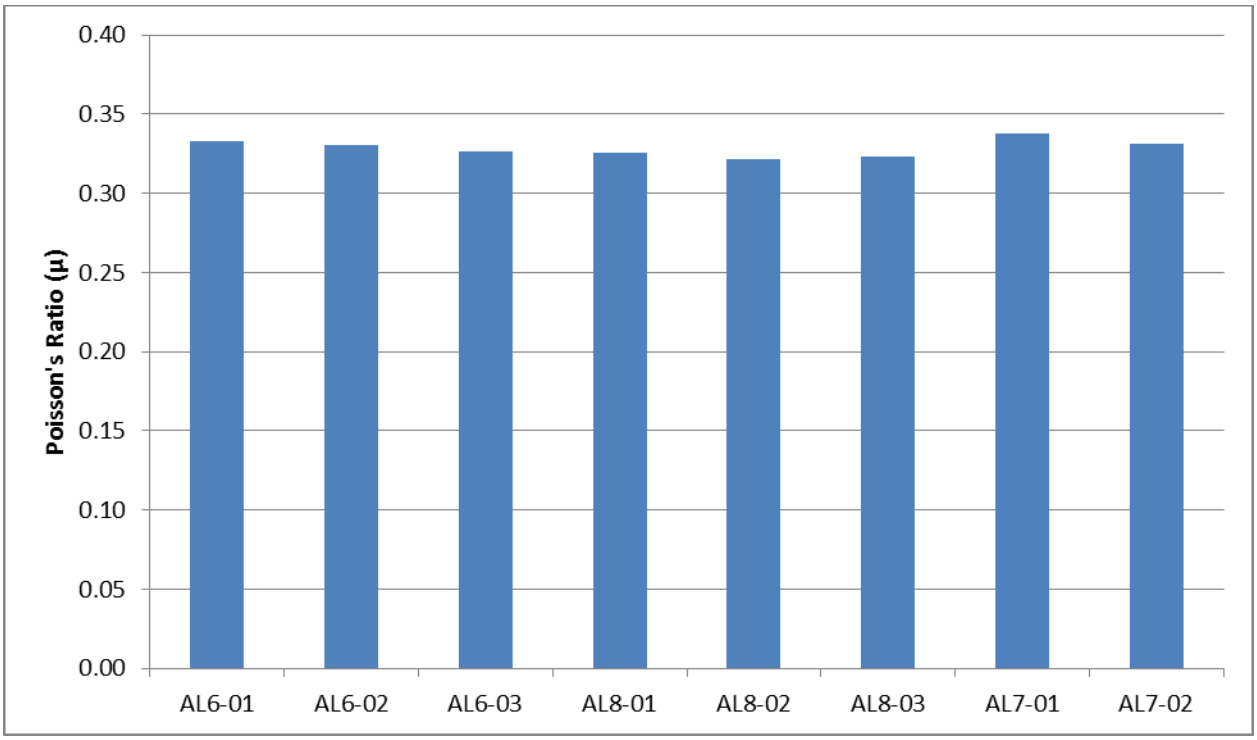

Fig. 78. Poisson's ratio (from sonic velocity) for NBG-17 (WG) creep specimens

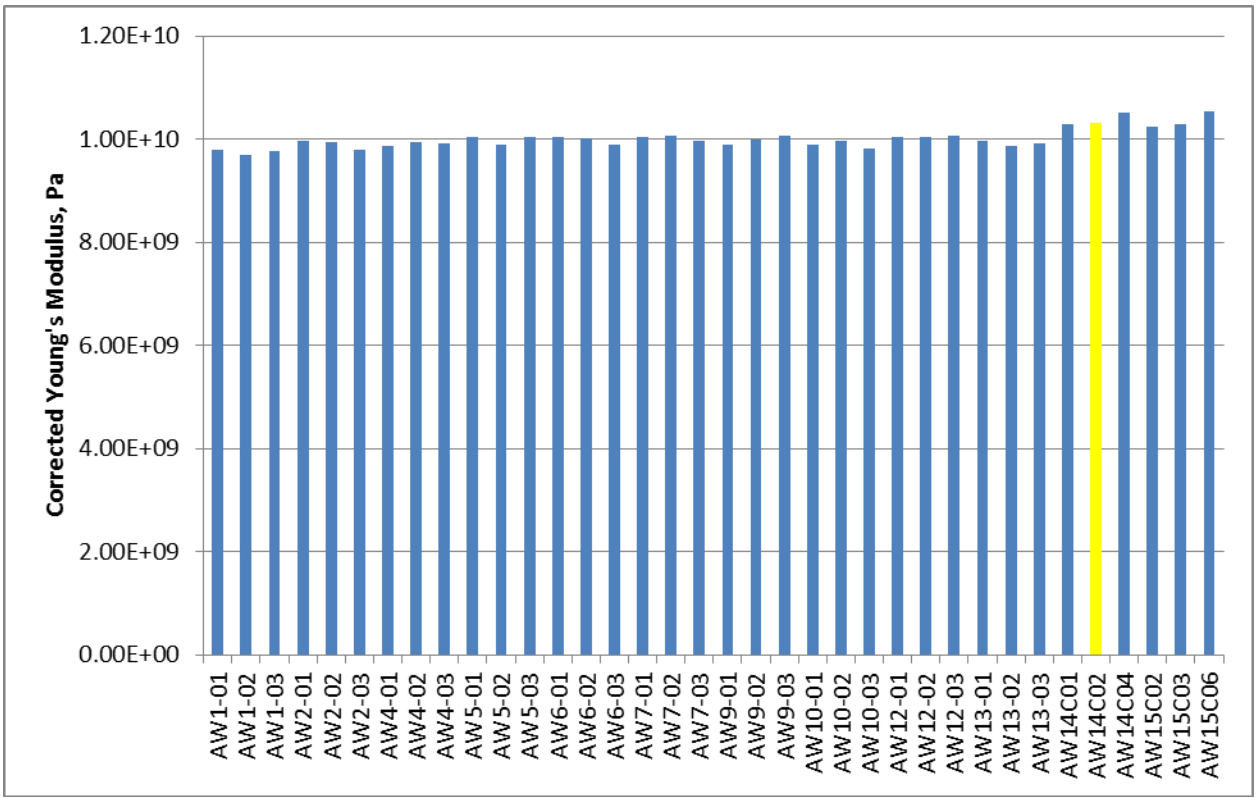

Fig. 79. Longitudinal dynamic Young's modulus (from sonic velocity) for NBG-17 (AG) creep and piggy-back specimens

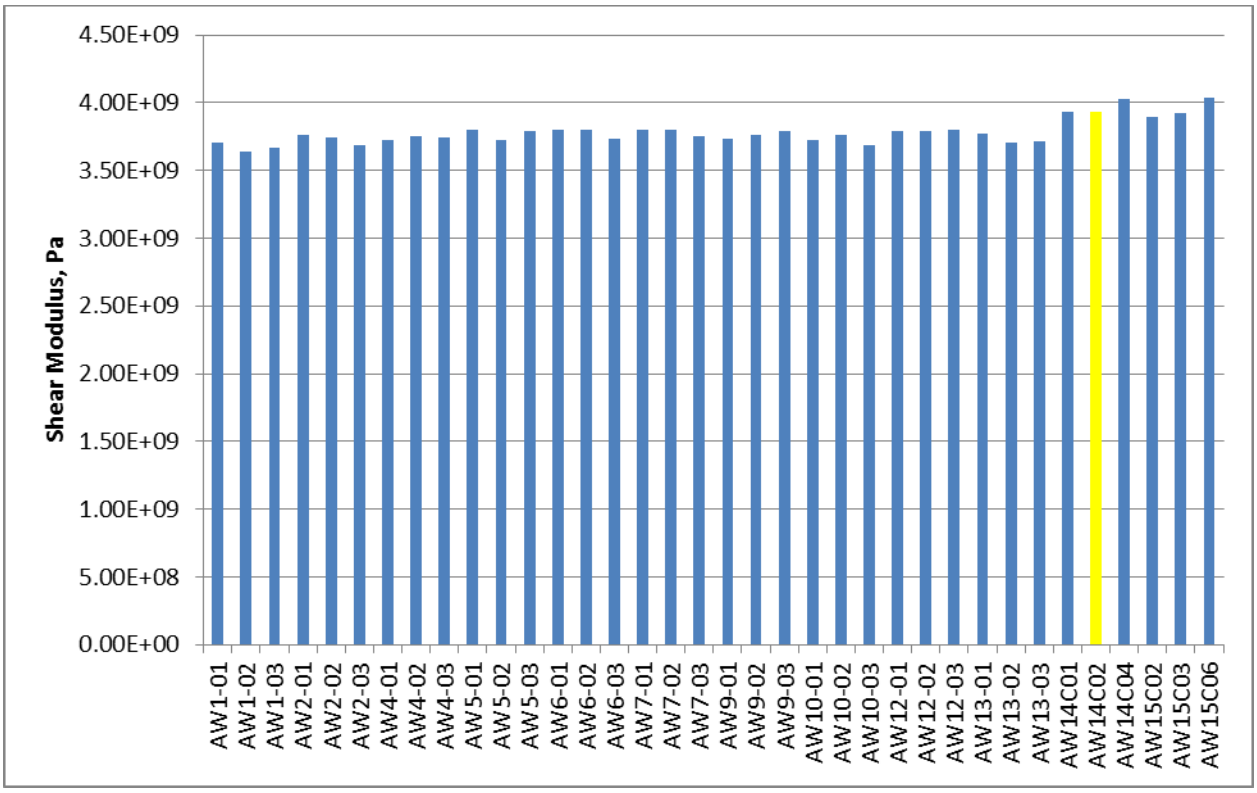

Fig. 80. Shear dynamic modulus (from sonic velocity) for NBG-17 (AG) creep and piggy-back specimens

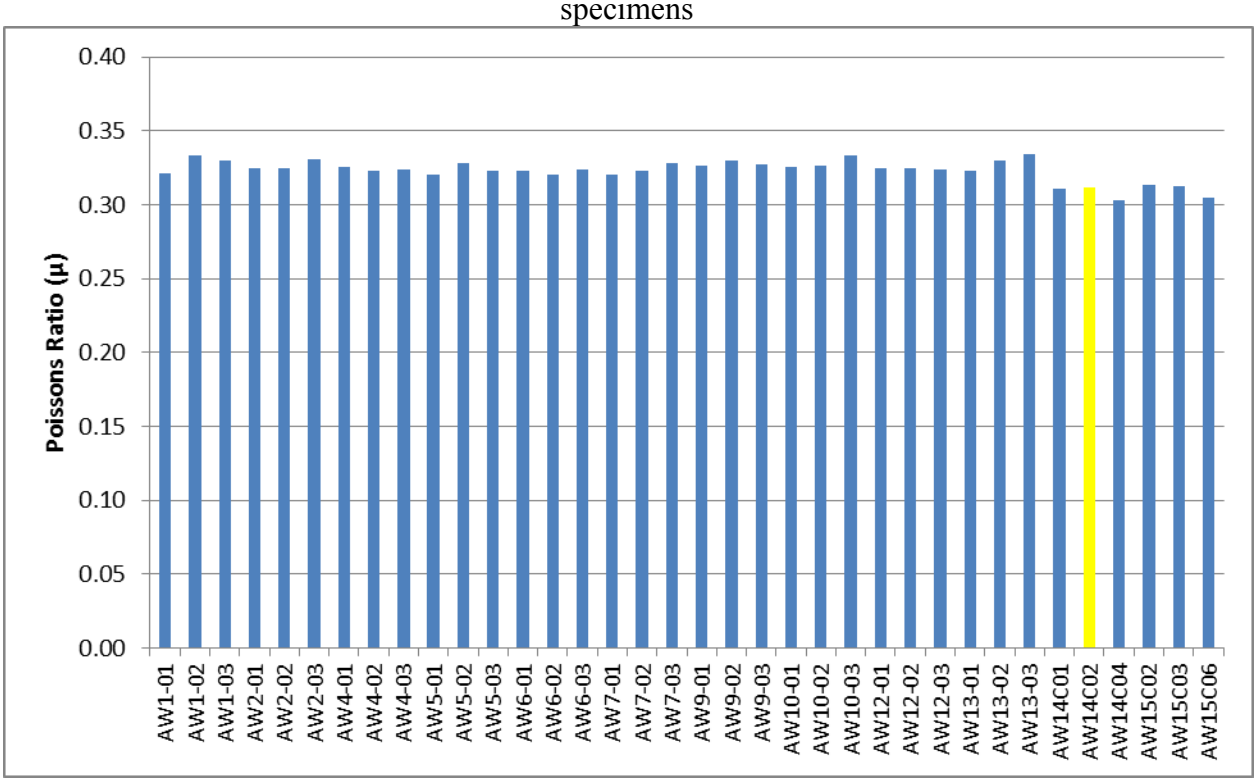

Fig. 81. Poisson's ratio (from sonic velocity) for NBG-17 (AG) creep and piggy-back specimens

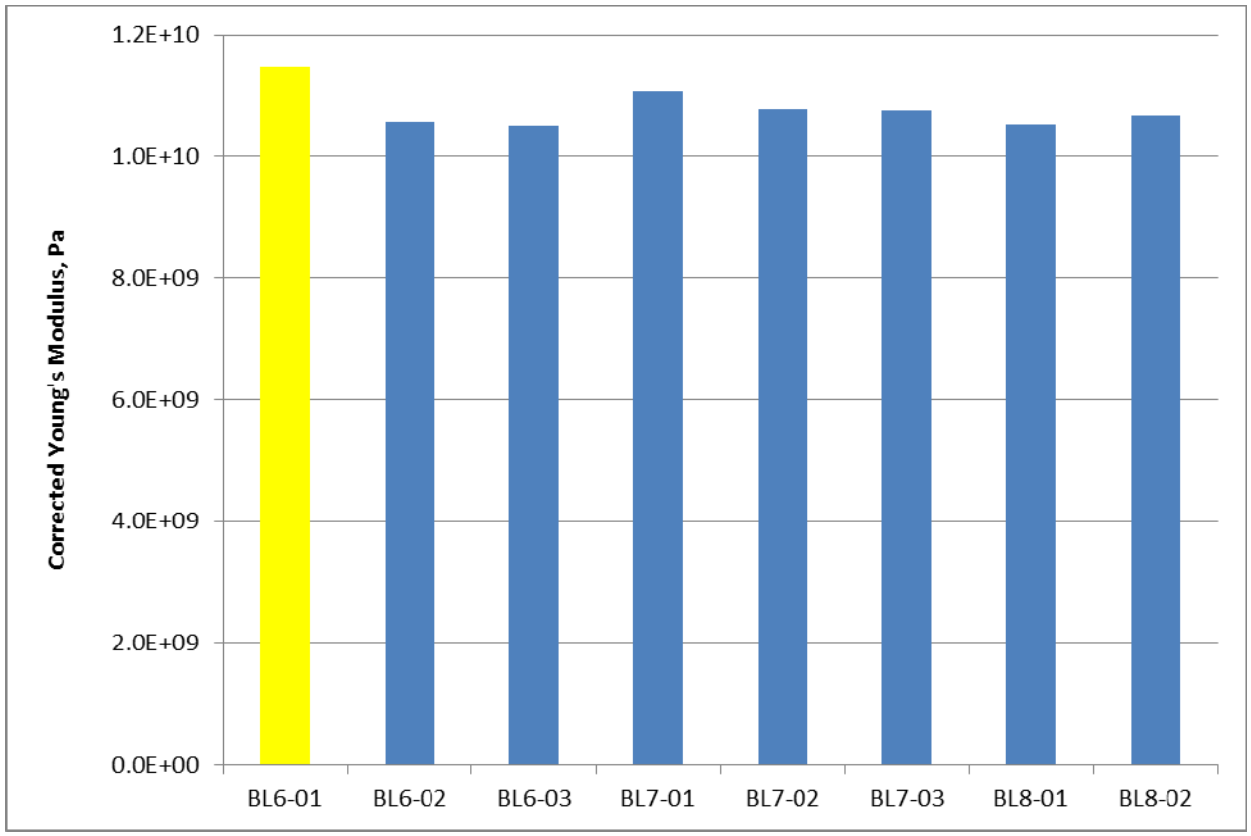

Fig. 82. Longitudinal dynamic Young's modulus (from sonic velocity) for NBG-18 (WG) creep specimens

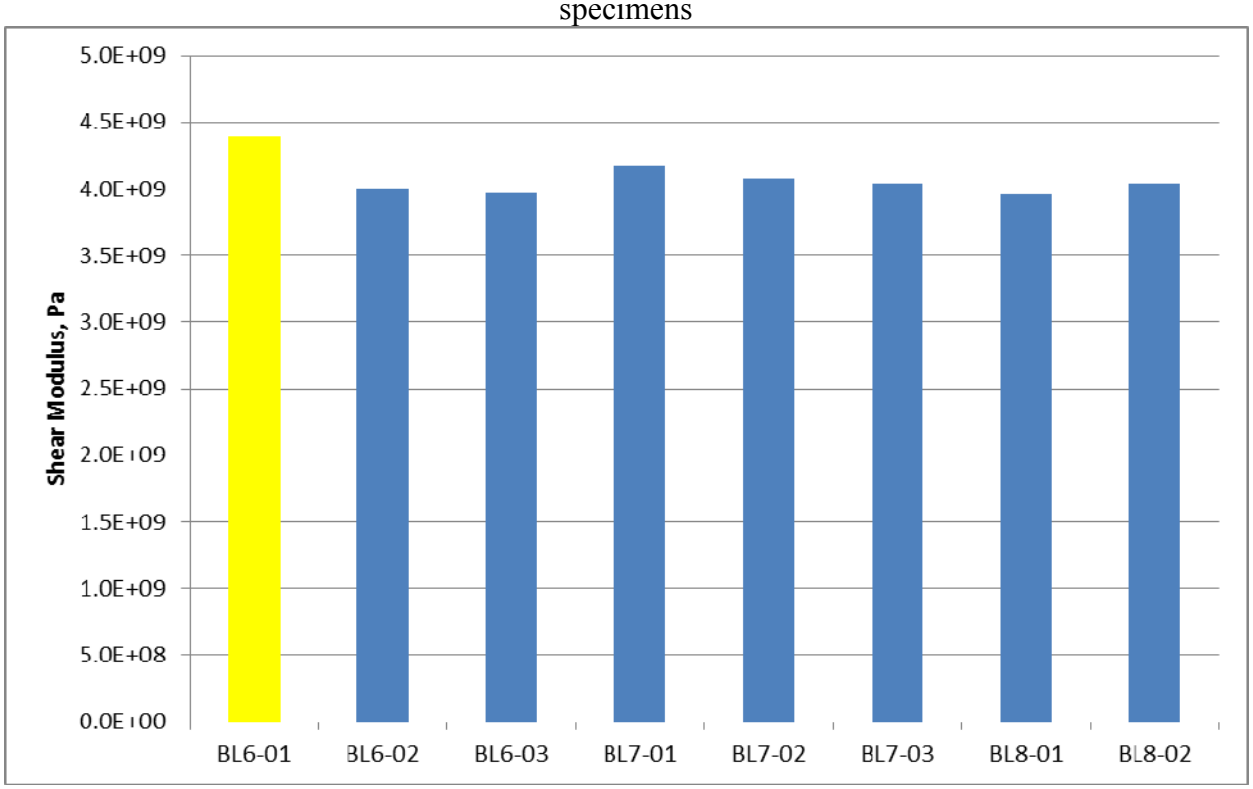

Fig. 83. Shear dynamic modulus (from sonic velocity) for NBG-18 (WG) creep specimens

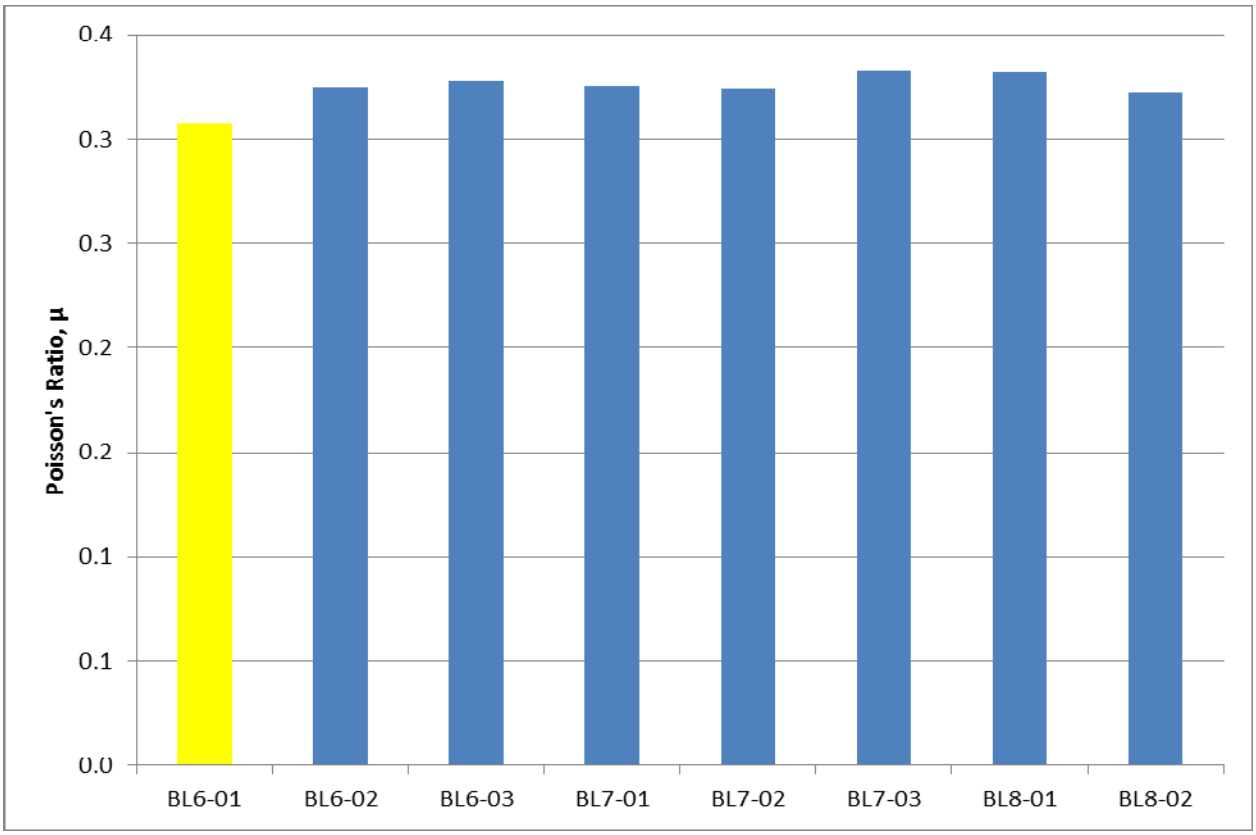

Fig. 84. Poisson's ratio (from sonic velocity) for NBG-18 (WG) creep specimens

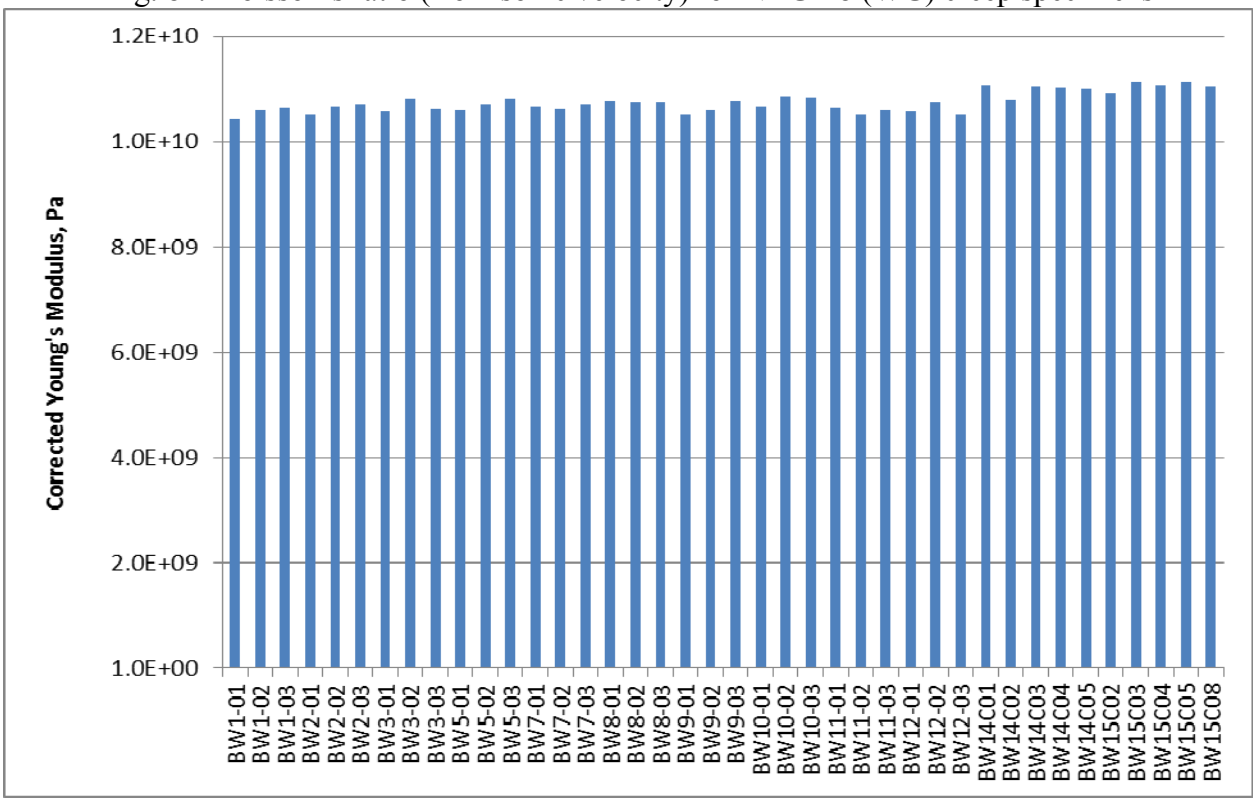

Fig. 85. Longitudinal dynamic Young's modulus (from sonic velocity) for NBG-18 (AG) creep and piggy-back specimens

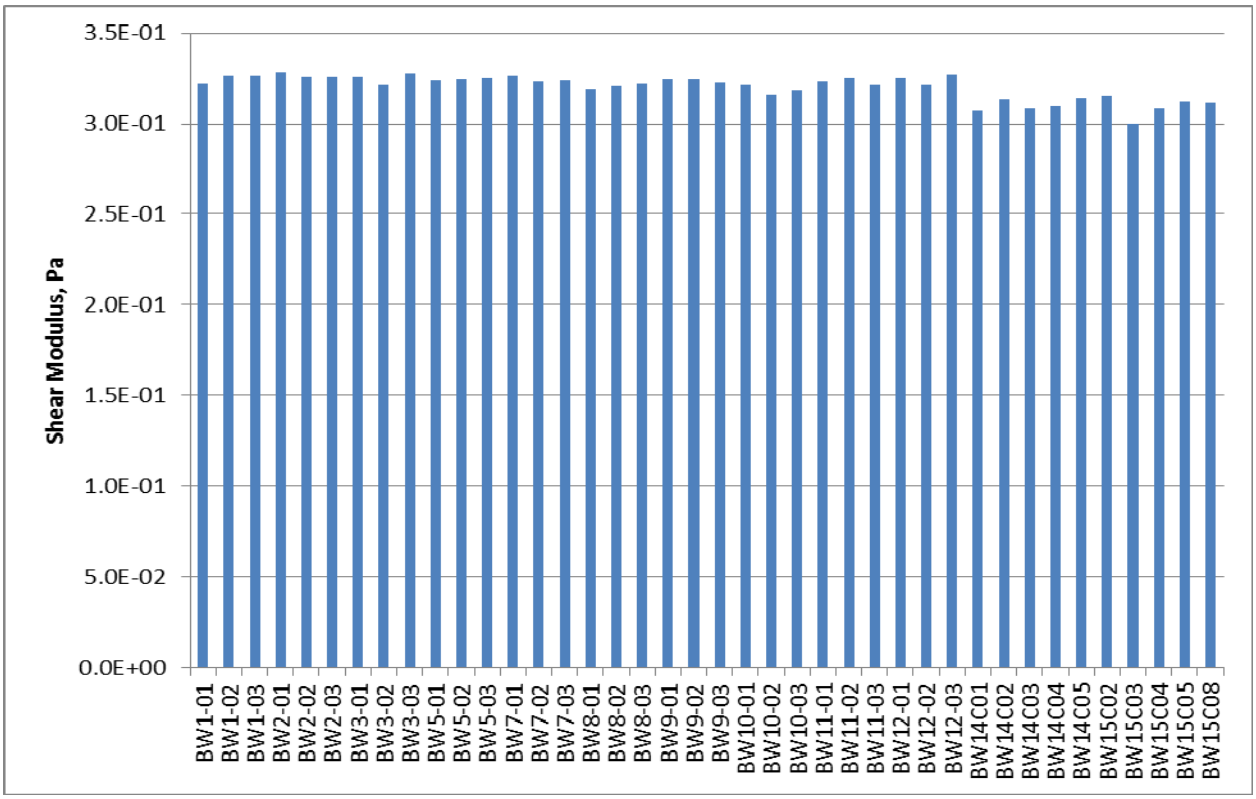

Fig. 86. Shear dynamic modulus (from sonic velocity) for NBG-18 (AG) creep and piggy-back specimens

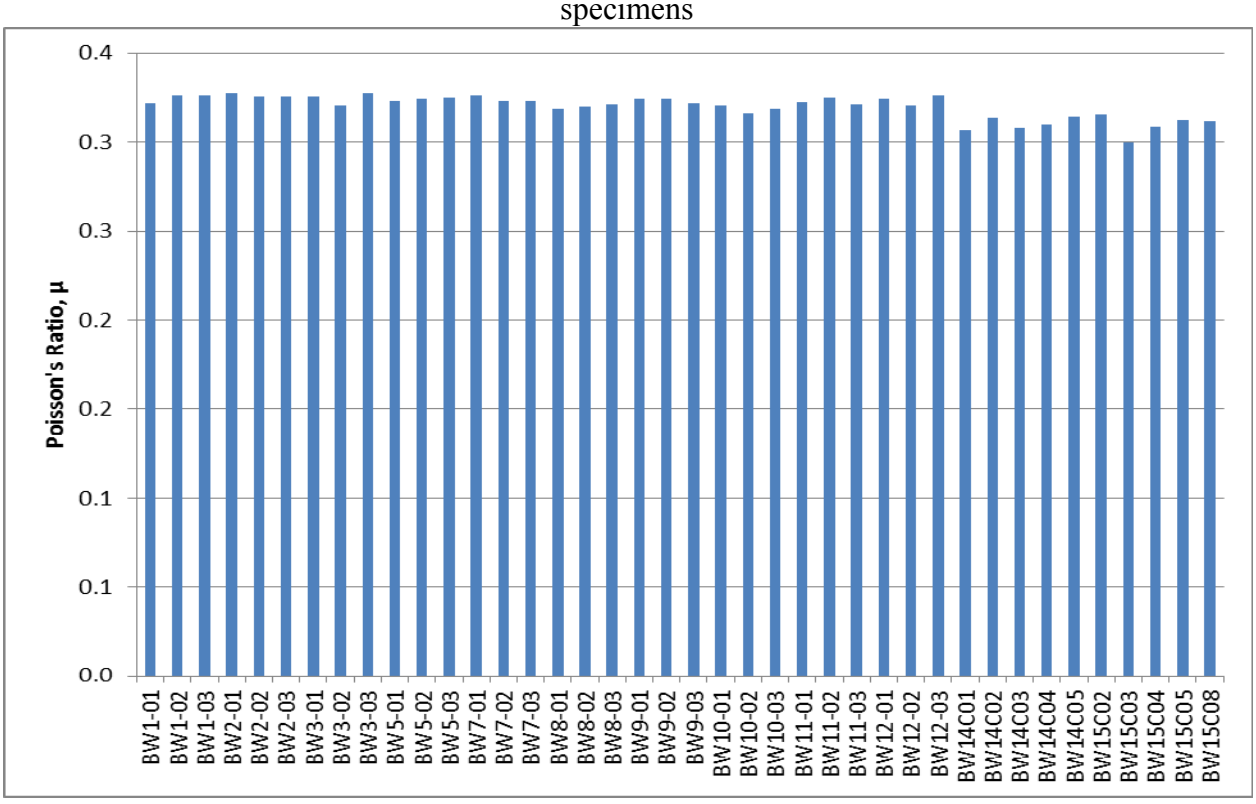

Fig. 87. Poisson's ratio (from sonic velocity) for NBG-18 (AG) creep and piggy-back specimens

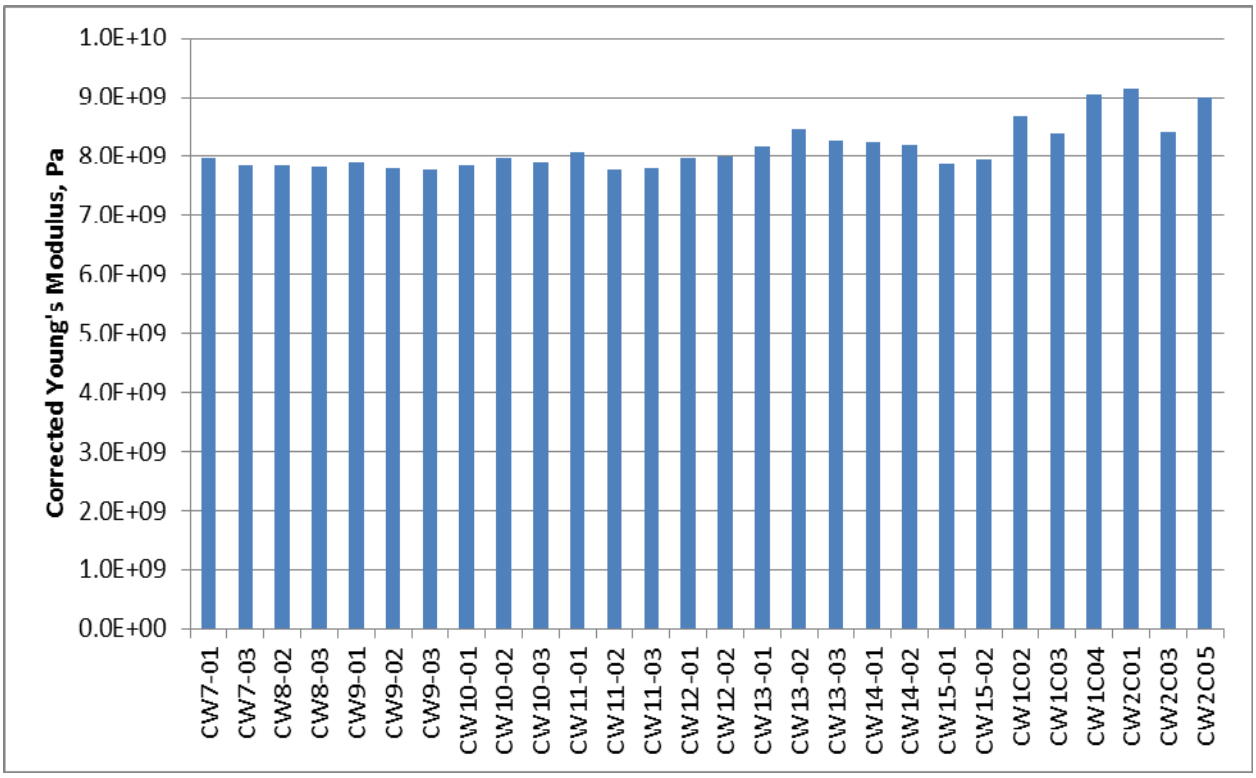

Fig. 88. Longitudinal dynamic Young's modulus (from sonic velocity) for H-451 (AG) creep and piggy-back specimens

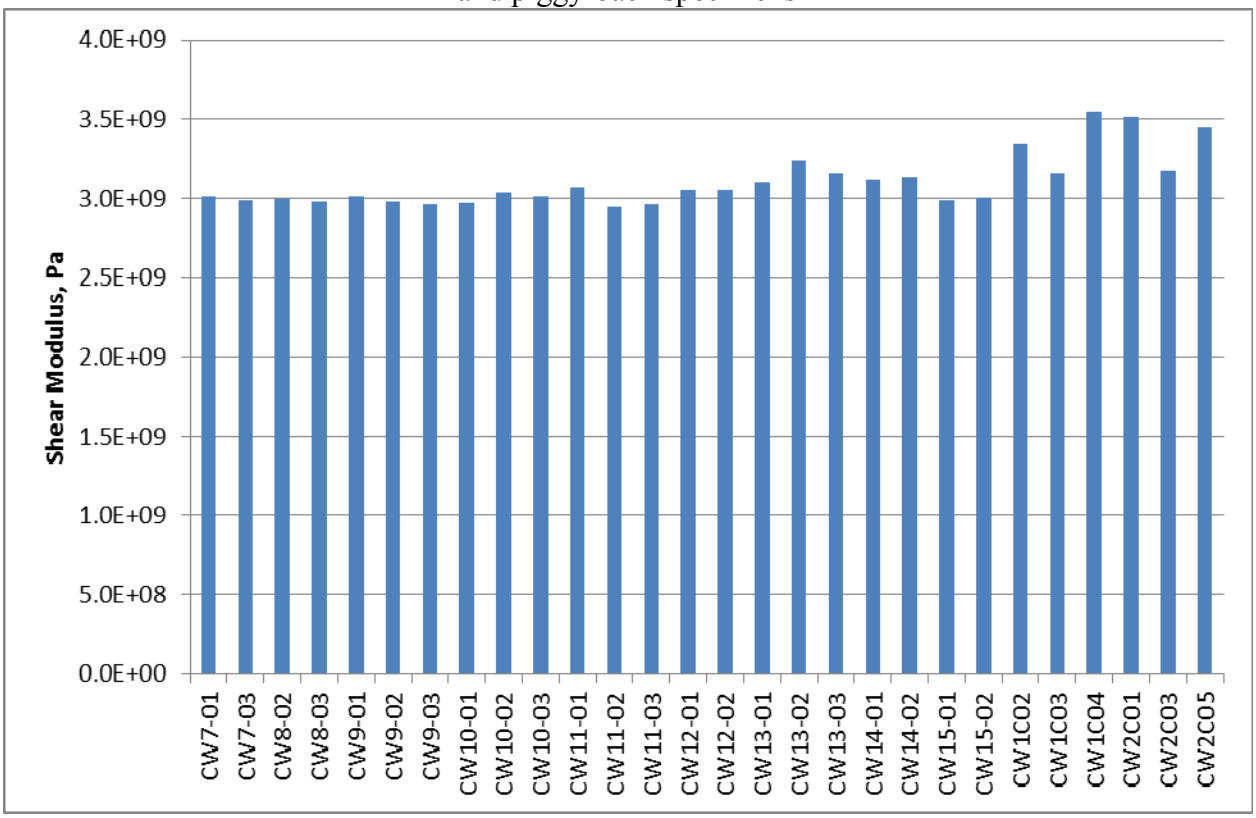

Fig. 89. Shear dynamic modulus (from sonic velocity) for H-451 creep and piggy-back specimens

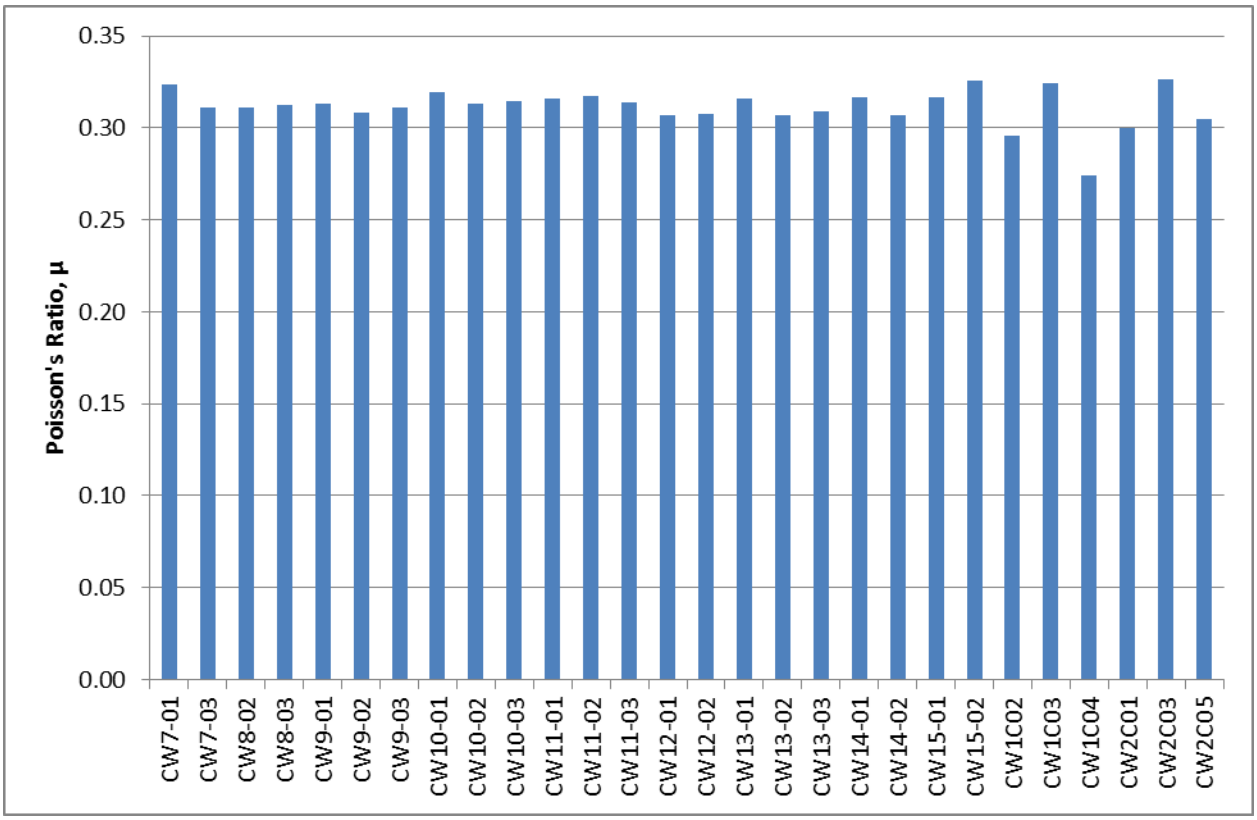

Fig. 90. Poisson's ratio (from sonic velocity) for H-451creep and piggy-back specimens

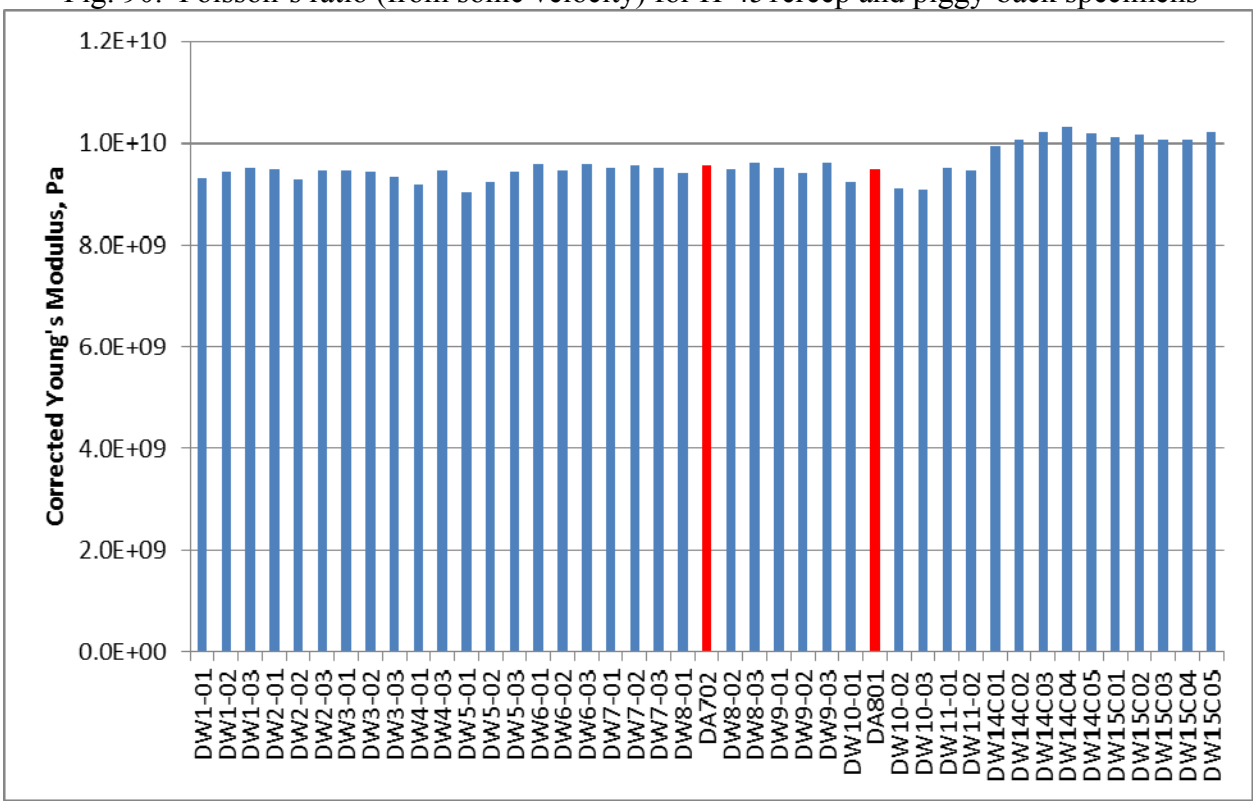

Fig. 91. Longitudinal dynamic Young's modulus (from sonic velocity) for PCEA (WG) creep and piggy-back specimens

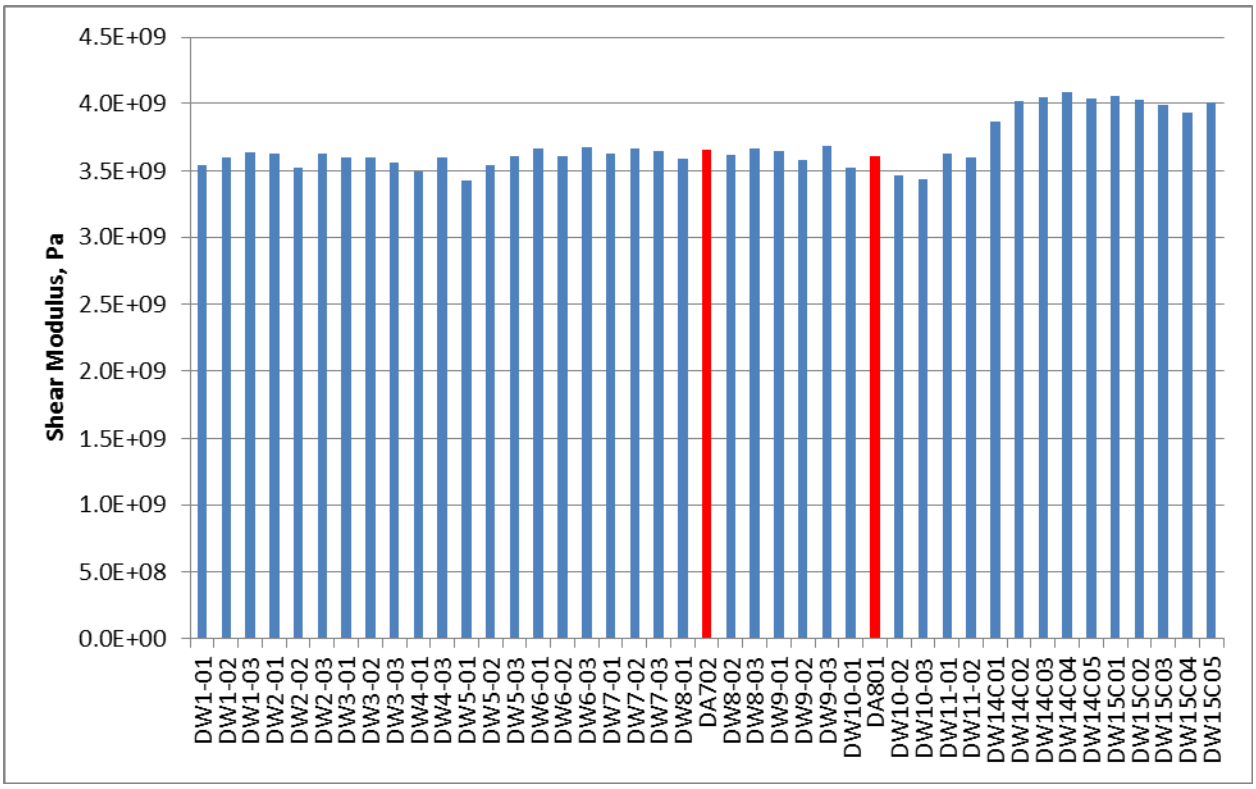

Fig. 92. Shear dynamic modulus (from sonic velocity) for PCEA (WG) creep and piggy-back specimens

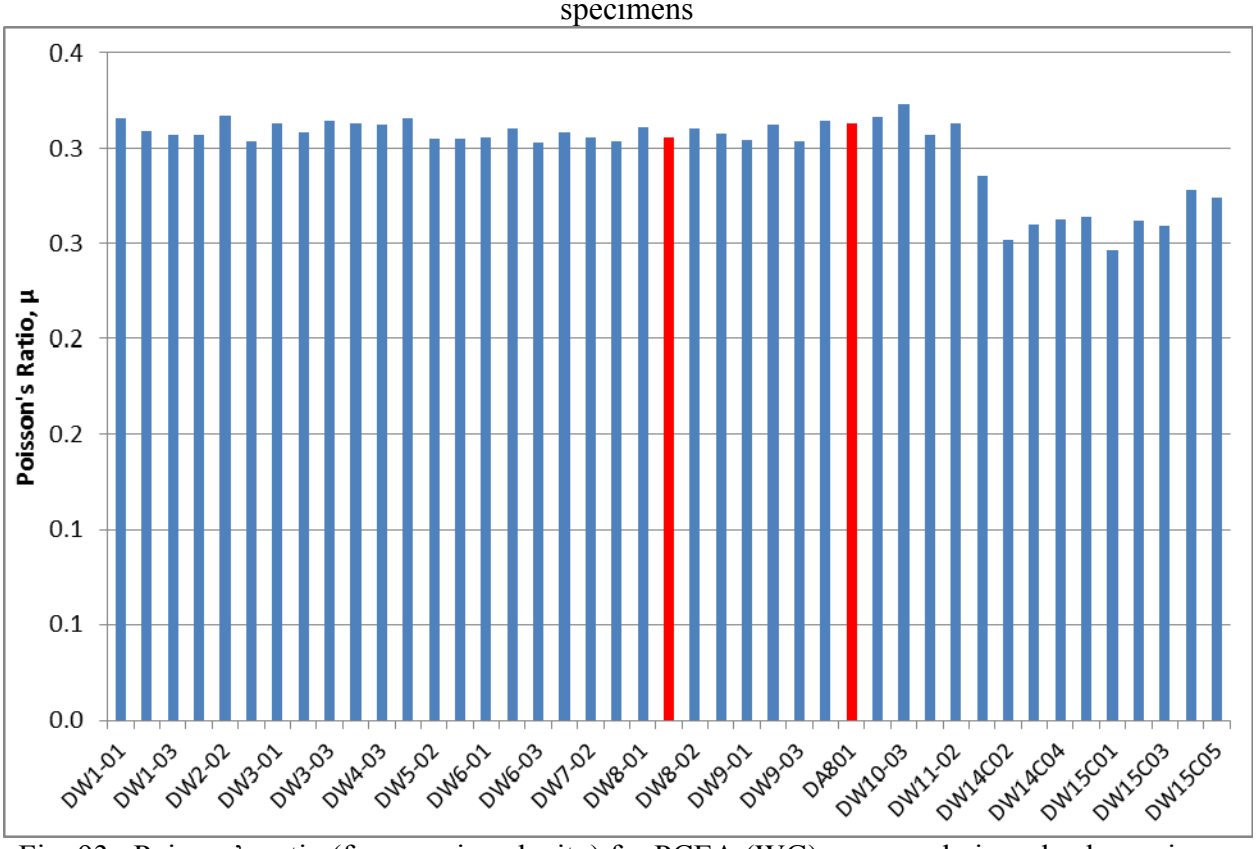

Fig. 93. Poisson's ratio (from sonic velocity) for PCEA (WG) creep and piggy-back specimens

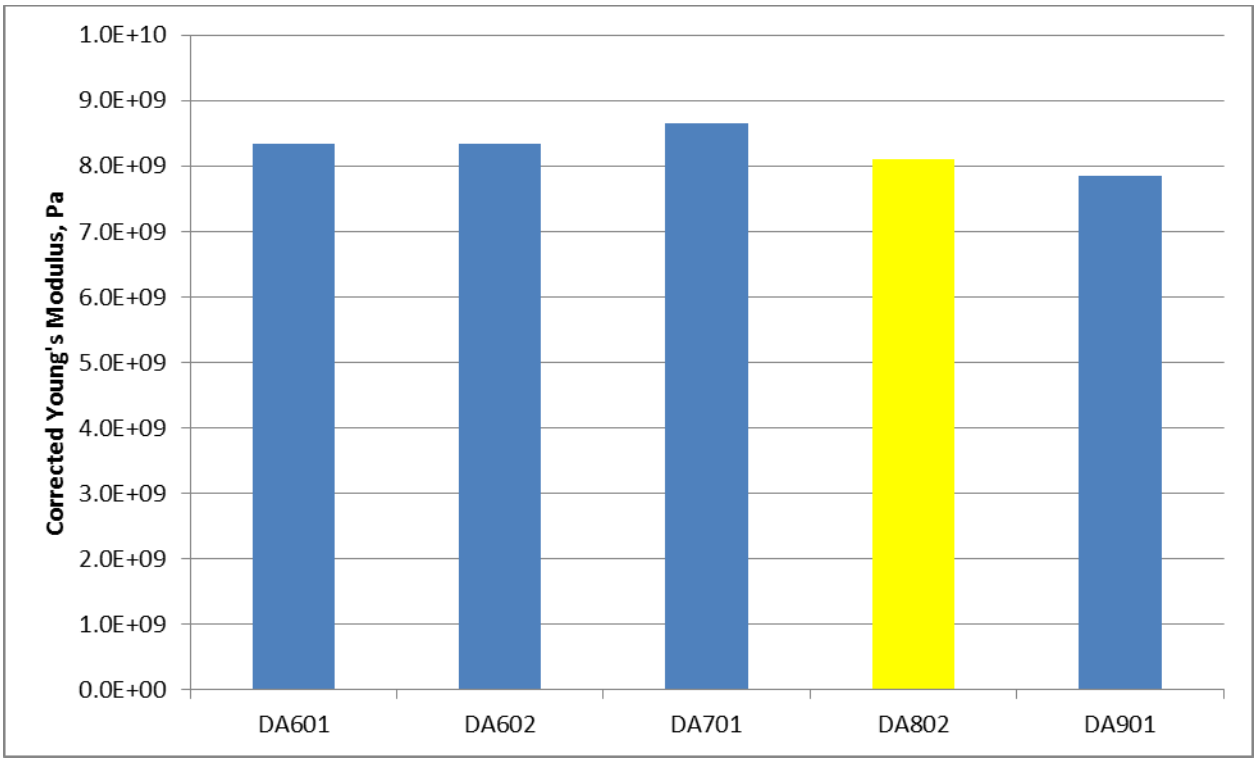

Fig. 94. Longitudinal dynamic Young's modulus (from sonic velocity) for PCEA (AG) creep and piggy-back specimens

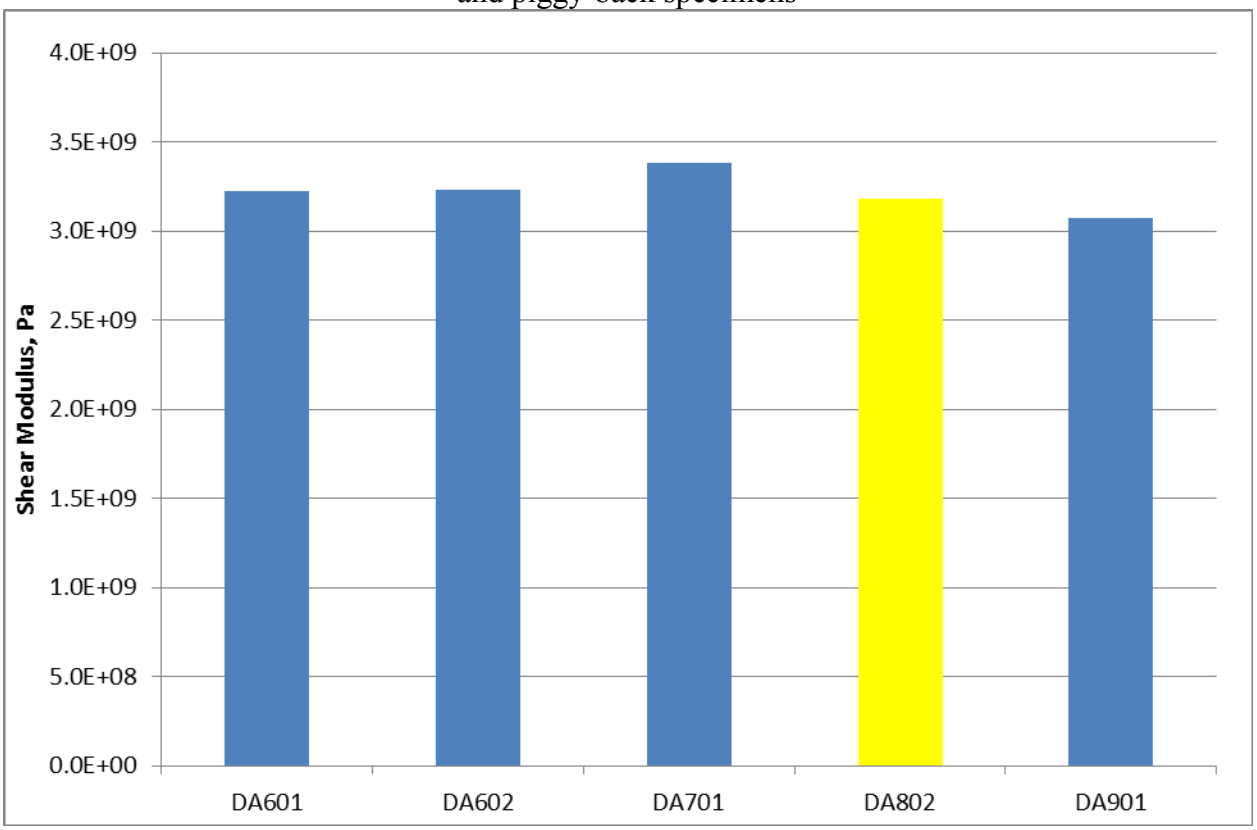

Fig. 95. Shear dynamic modulus (from sonic velocity) for PCEA (AG) creep and piggy-back specimens

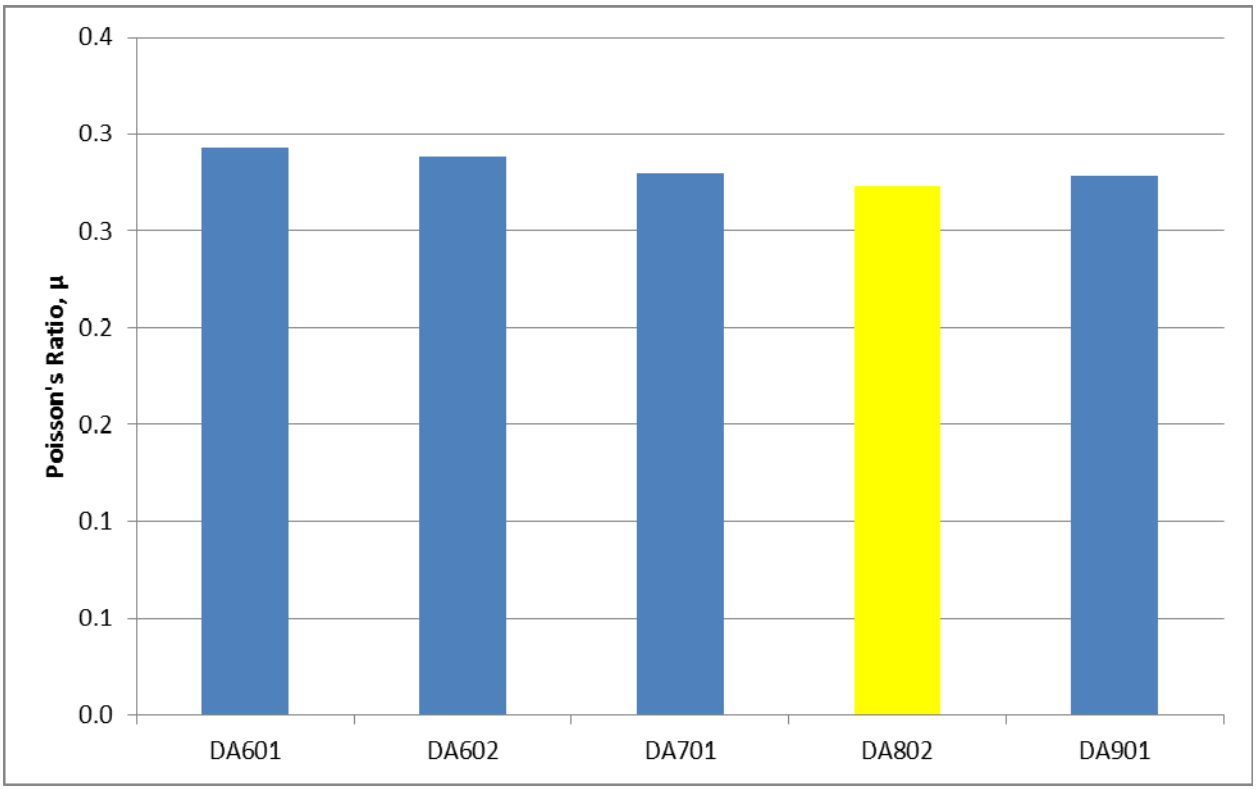

Fig. 96. Poisson's ratio (from sonic velocity) for PCEA (AG) creep and piggy-back specimens

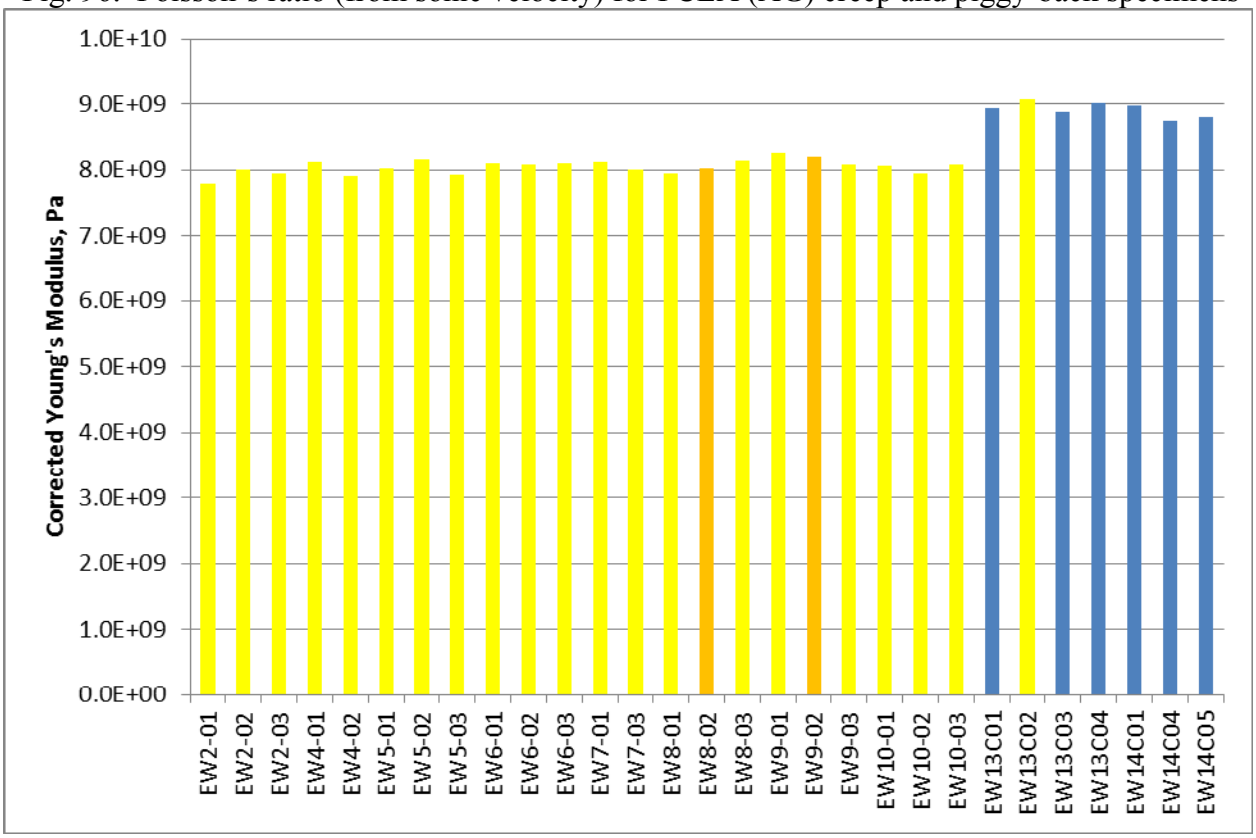

Fig. 97. Longitudinal dynamic Young's modulus (from sonic velocity) for IG-110 creep and piggy-back specimens

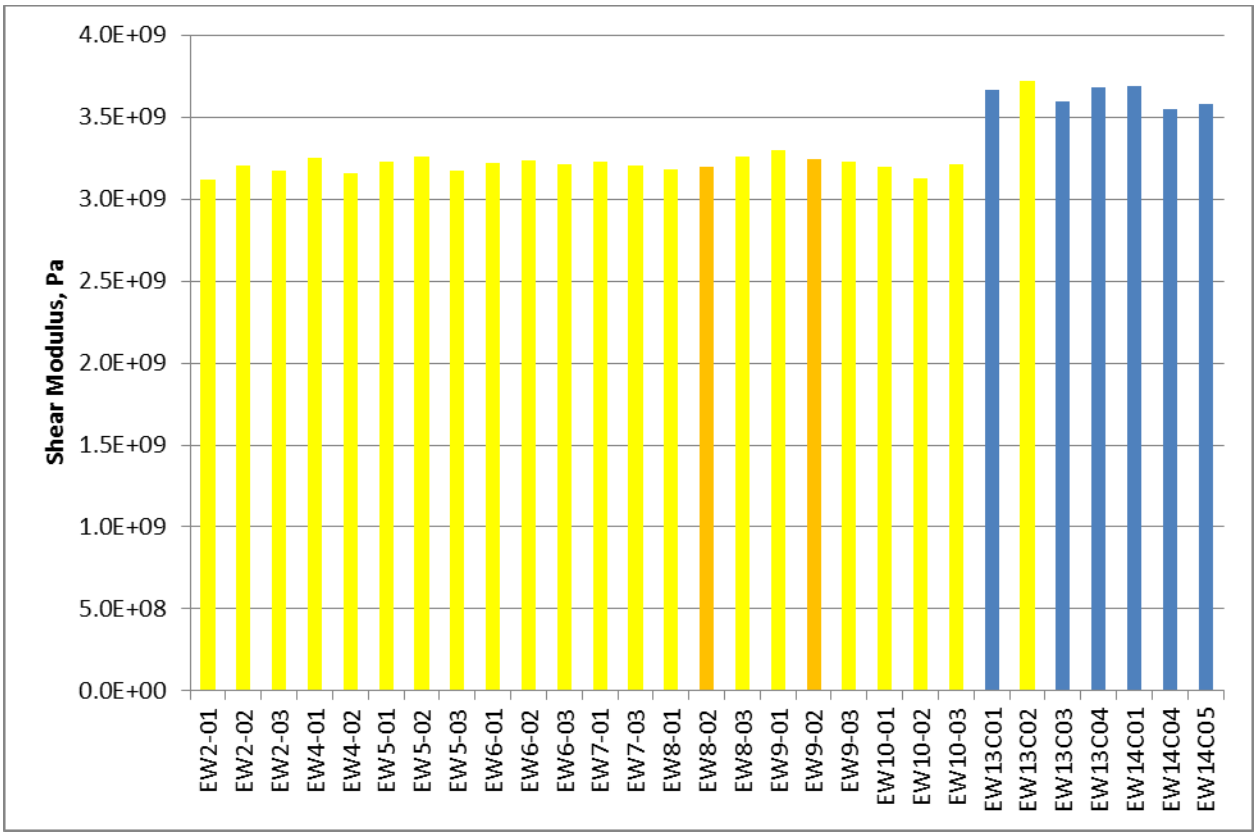

Fig. 98. Shear dynamic modulus (from sonic velocity) for IG-110 creep and piggy-back specimens

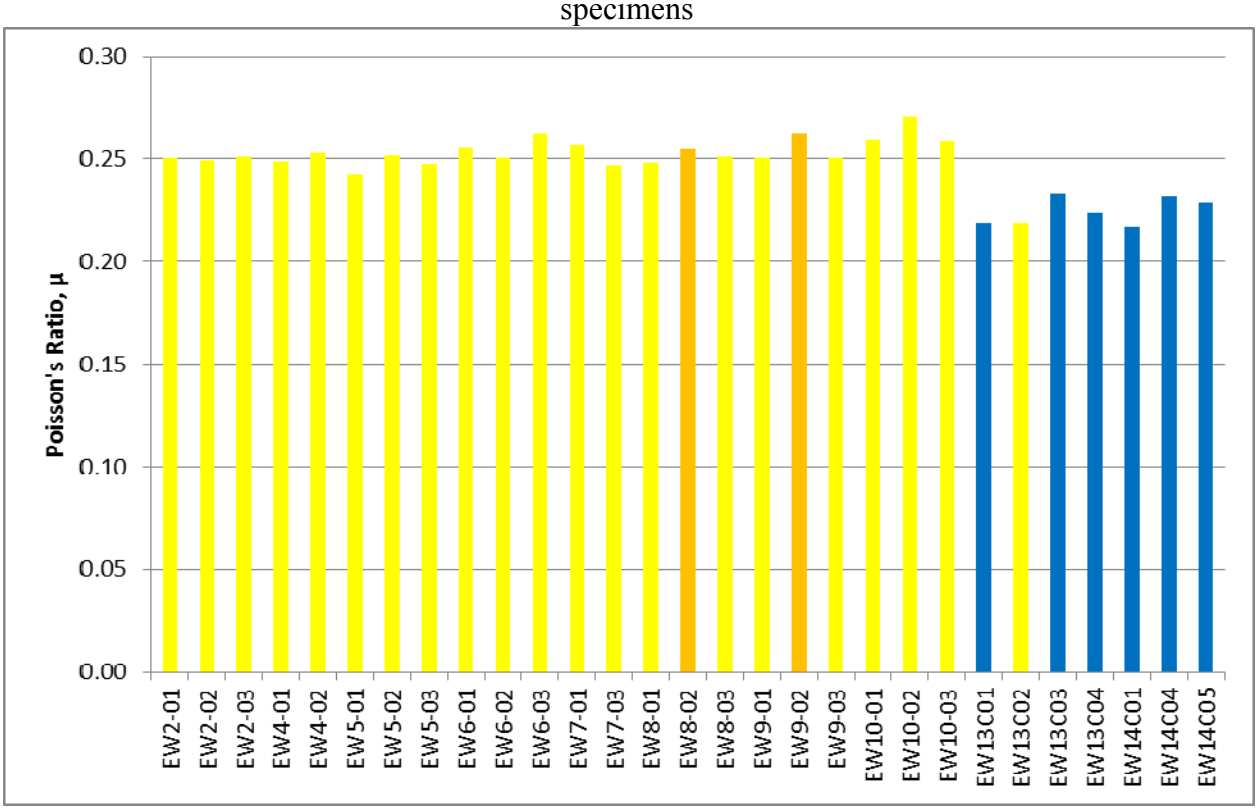

Fig. 99. Poisson's ratio (from sonic velocity) for IG-110 creep and piggy-back

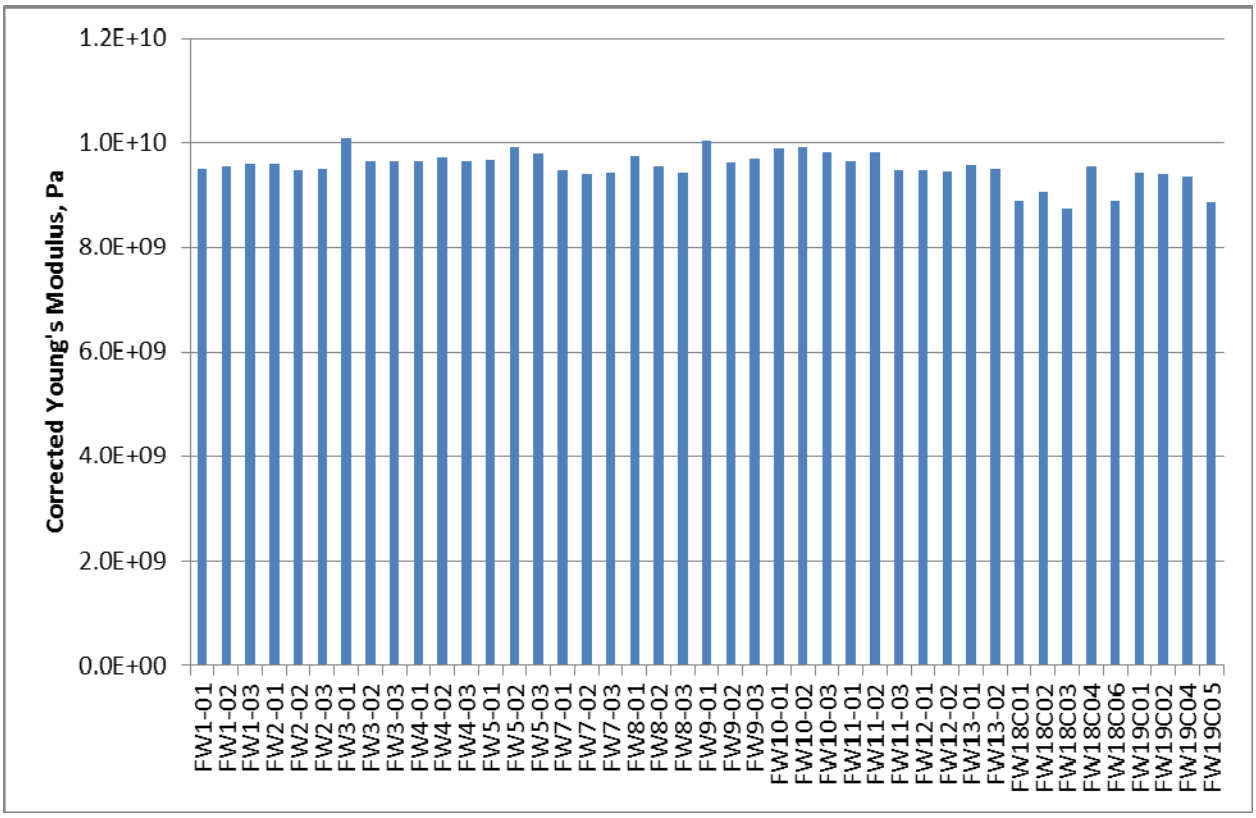

Fig. 100. Longitudinal dynamic Young's modulus (from sonic velocity) for IG-430 creep and piggy-back specimens

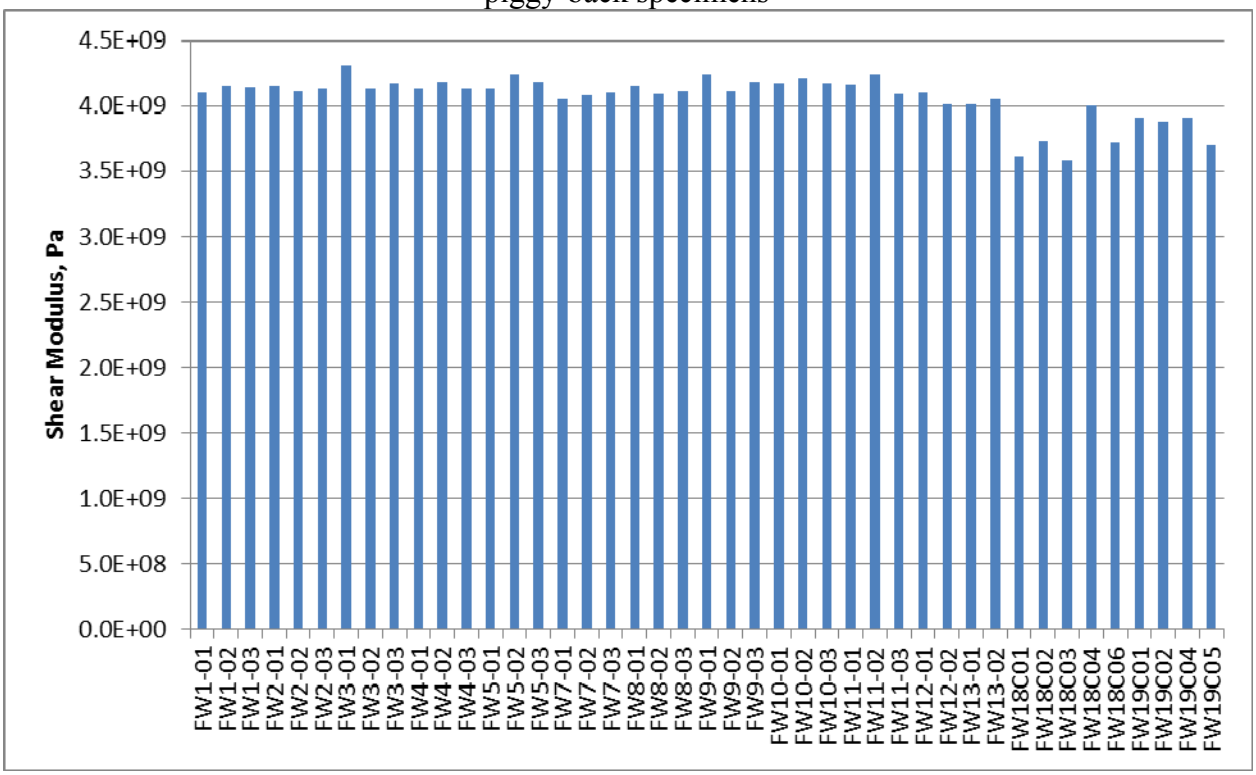

Fig. 101. Shear dynamic modulus (from sonic velocity) for IG-430 creep and piggy-back specimens

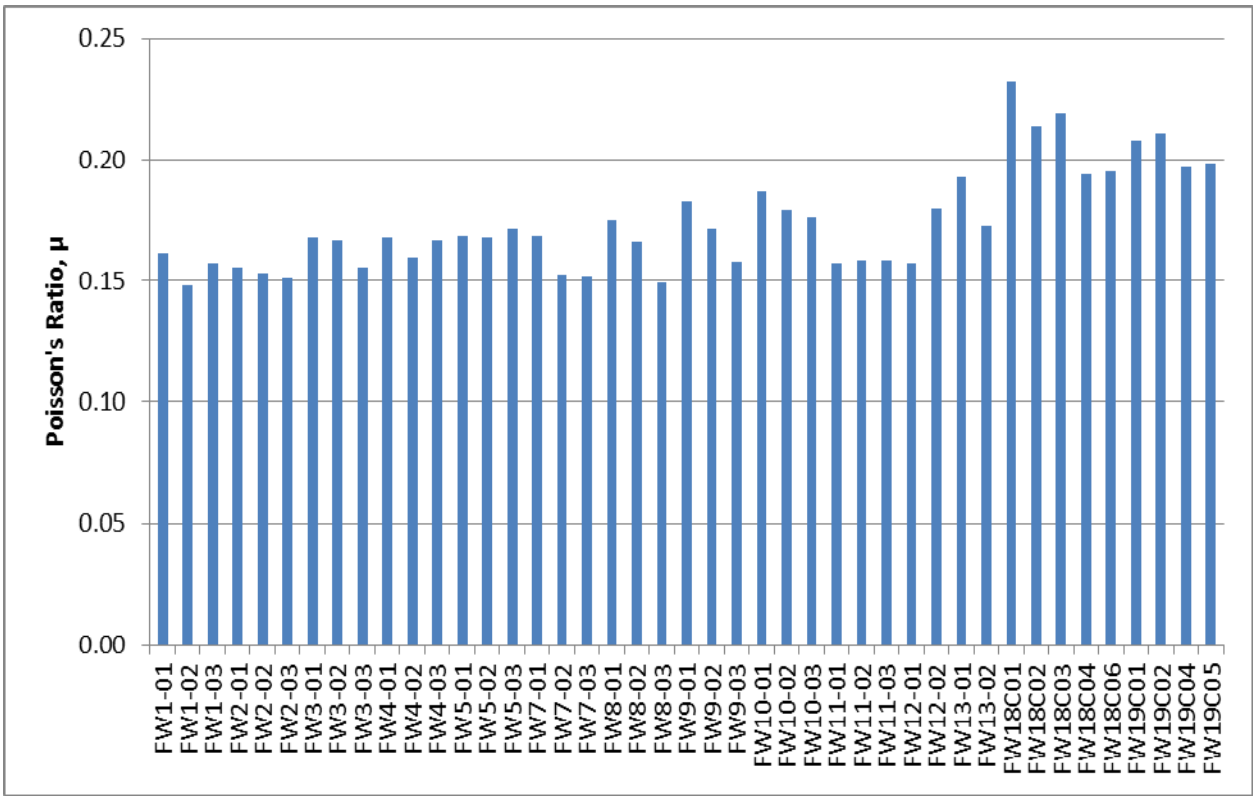

Fig. 102. Poisson's ratio (from sonic velocity) for IG-430 creep and piggy-back

The data in Figs 76-102 reveal some interesting trends. Firstly, there appears to be no bias related to specimen size in the longitudinal sonic velocity data, the smaller piggy-back specimens sometimes return higher velocities and sometime lower velocities than the larger creep specimens (Table 37). There is a clearer trend for the shear velocity being lower for the creep samples compared to the piggy-backs, but the IG-430 shear velocity data is contrary to this trend.

Table 37. A comparison of measured sonic velocities for the creep and piggy-back specimens

	Sonic Velocity (m/s)			
	Longitudinal		Shear	
GRADE	Creep	P-B	Creep	P-B
NBG-17 (AG)	2791	2772	1418	1456
NBG-18 (AG)	2867	2851	1464	1496
H-451	2552	2630	1330	1393
PCEA (WG)	2684	2623	1409	1484
IG-110	2346	2398	1348	1428
IG-430	2384	2370	1509	1439

Secondly, a comparison of the Young's moduli and shear moduli data for the three grades that display slight anisotropy as a result of texture indicates that for the creep specimens only (excluding piggy-back geometry specimens) the WG moduli are always larger than the AG moduli (Table 38). This is expected and would be predicted by the preferred orientation of the filler particles and the bond anisotropy of the crystal regions within the filler particles.

Table 38. Mean sonic elastic constant values for the three grades displaying anisotropy due to texture

GRADE	Elastic Constants (from sound velocity)		
	Young's Modulus(E)	Shear Modulus (G)	PR (μ)
NBG-17 (AG)	9.94	3.75	0.33
NBG-17 (WG)	10.2	3.84	0.33
NBG-18 (AG)	10.66	4.03	0.32
NBG-18 (WG)	10.81	4.08	0.32
PCEA (WG)	9.42	3.6	0.31
PCEA (AG)	8.25	3.22	0.28

There appears to be little anisotropy in the value of Poisson's ratio (μ) based on the mean data presented in Table 38. The elastic constants E and G are calculated from the velocities which did not show a clear trend (Table 37) for variation with specimen geometry. However, the mean Poisson's ratio data (Table 39) clearly shows the value obtained from the piggy-back (smaller) specimens is less than Poisson's ratio value obtained from the creep (larger) specimens.

Table 39. A comparison of mean Poisson's ratio values from creep and piggy-back specimen geometries for the major graphite grades

GRADE	Poisson's Ratio (μ)	
	Creep Specimens	PB Specimens
NBG-17 (AG)	0.33	0.31
NBG-18 (AG)	0.32	0.31
H-451	0.31	0.30
PCEA (WG)	0.31	0.26
IG-110	0.25	0.22
IG-430	0.17	0.21

Finally, we may compare the Young's Moduli data obtained from the longitudinal velocity (E_{Vel}) to that obtained by the fundamental frequency of vibration (E_{dyn}). The mean values for the various grades and orientations are given in Table 40 (again, only the creep specimen geometry is considered). With the exception of grade IG-430 the dynamic Young's moduli (from the fundamental frequency) is greater that the young's moduli obtained from the longitudinal velocity.

Table 40. A comparison of Young's moduli data obtained by the fundamental frequency of vibration and sonic velocity methods

	Young's Moduli, GPa	
GRADE	E_{dyn}	E_{vel}
NBG-17 (AG)	11.19	9.94
NBG-17 (WG)	11.58	10.2
NBG-18 (AG)	12.17	10.66
NBG-18 (WG)	12.46	10.81
H-451	8.84	7.97
PCEA (WG)	10.98	9.42
PCEA (AG)	8.98	8.25
IG-110	8.88	8.04
IG-430	9.84	9.65

Figs. 103 – 105 report the elastic constants determined for the specimens of A3-matrix material. Specimens H14 to H-18 are noted to have significantly greater densities and thus the calculated values of Young's and shear modulus are greater than the remainder of the A3-matrix specimens. The low density also makes the determination of Poisson's ratio for A3-matrix problematic and the data are not considered reliable or accurate.

Plots of elastic constants for the remainder of the secondary (all piggy-back geometry specimens) grades (HLM, PGX, PPEA, NBG-25, 2020, PCIB, BAN and NBG-19) are in Figs. 106 – 129. A summary of the mean elastic constants determined for the secondary grades is provided in Table 41.

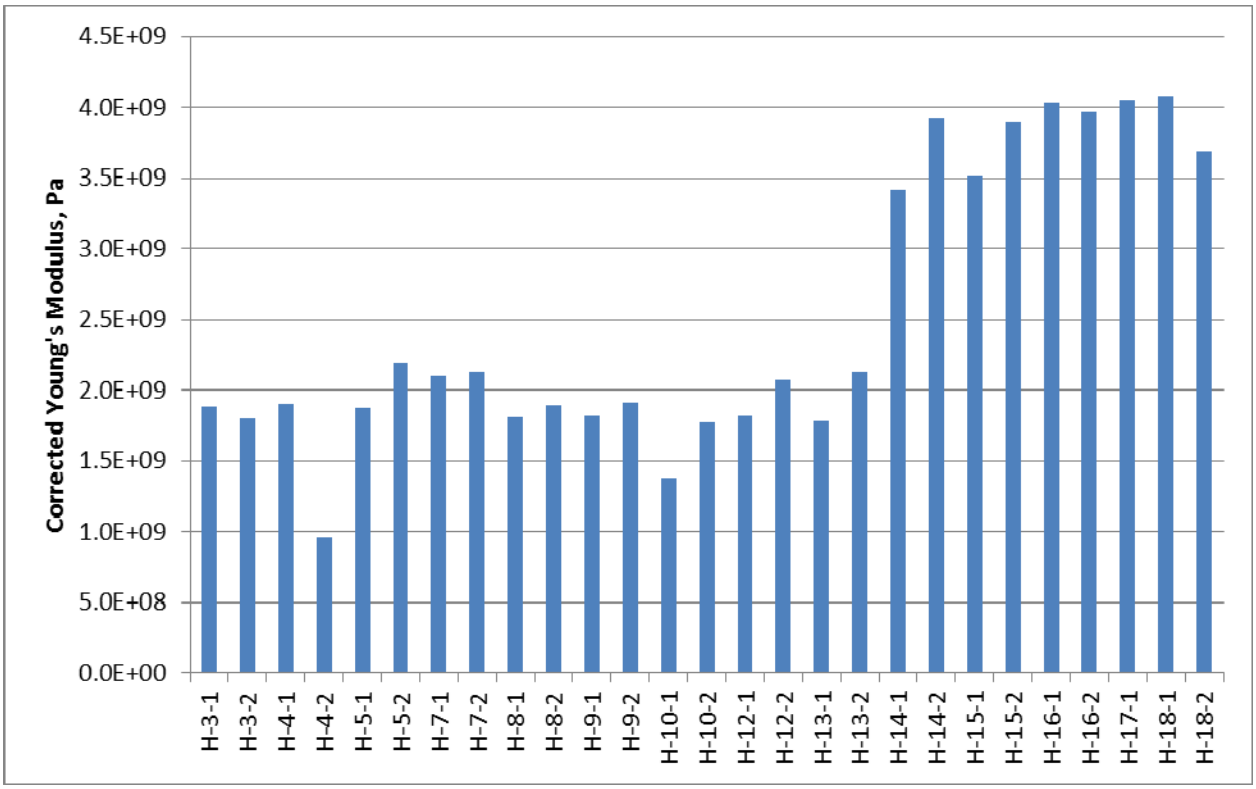

Fig. 103. Longitudinal Dynamic Young's Modulus (from sonic velocity) for A3-matrix piggy-back specimens

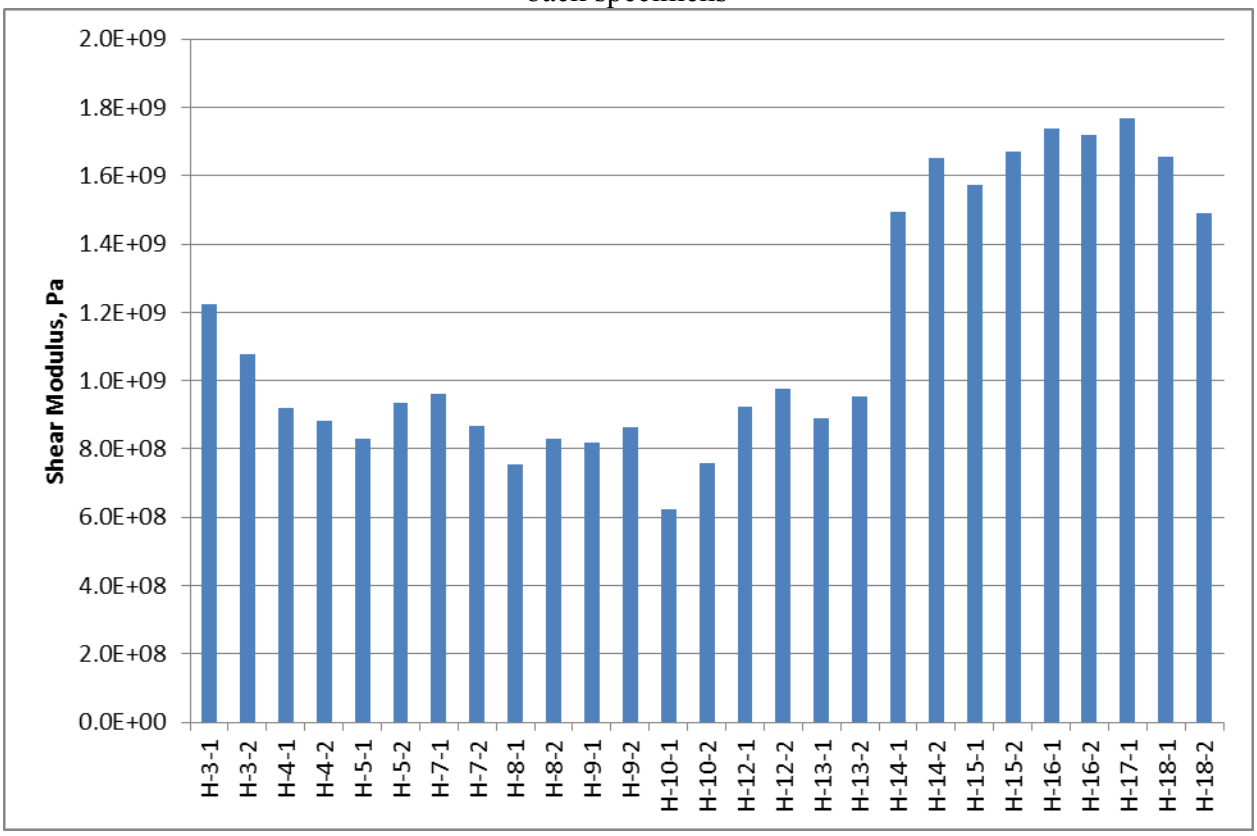

Fig. 104. Shear Dynamic Modulus (from sonic velocity) for A3-matrix piggy-back specimens

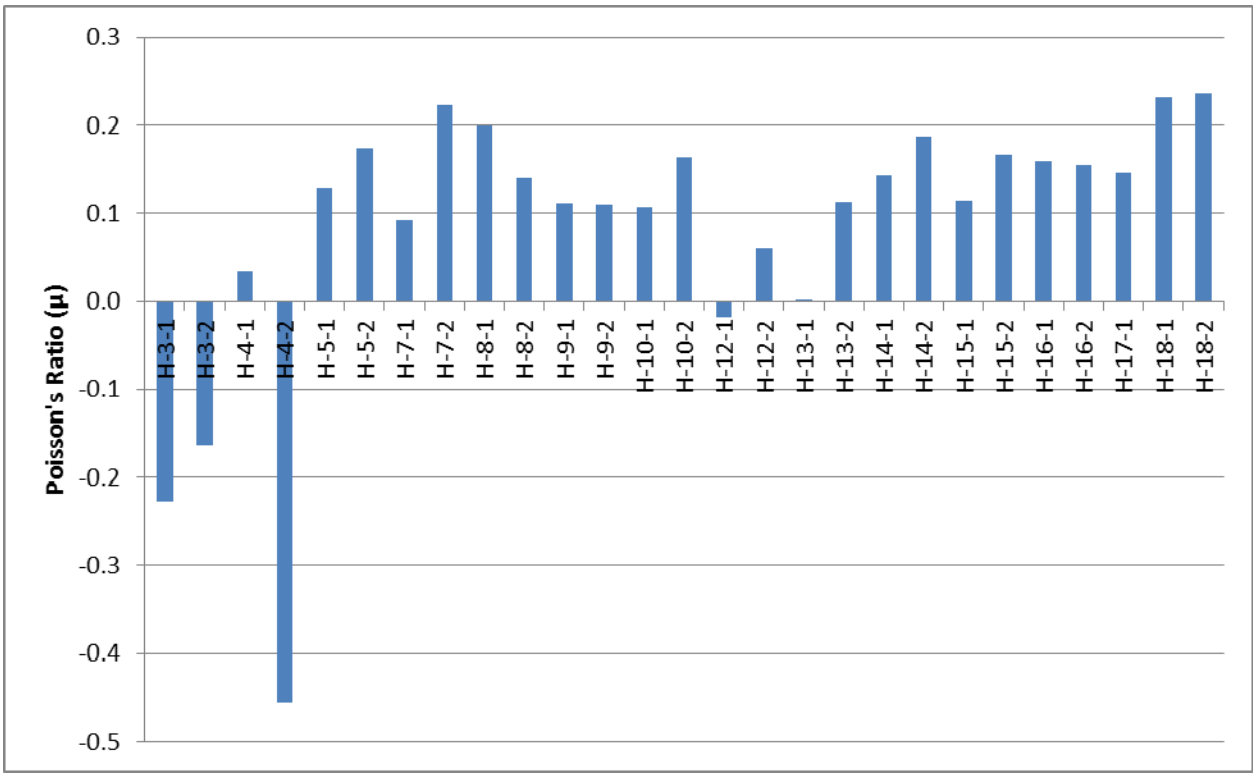

Fig. 105. Poisson's Ratio (from sonic velocity) for A3-matrix piggy-back specimens

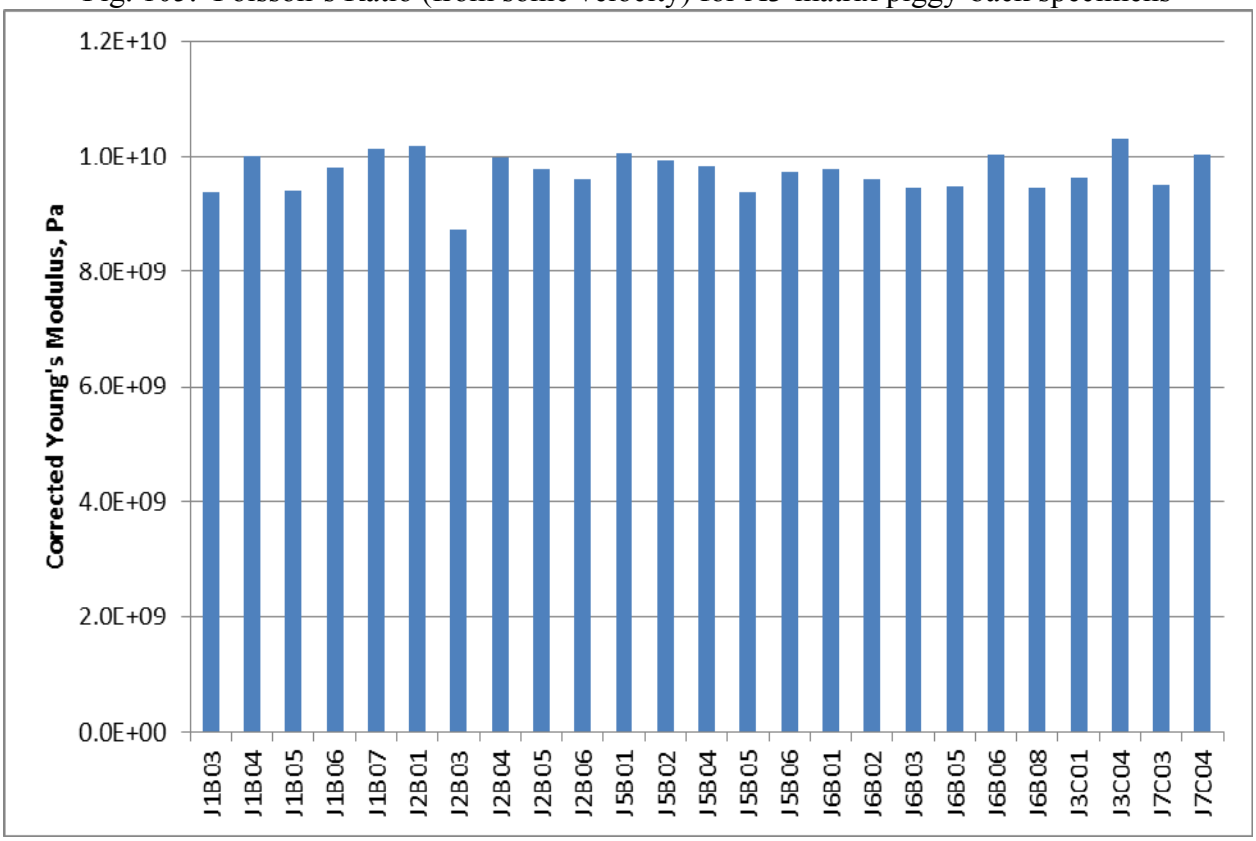

Fig. 106. Longitudinal Dynamic Young's Modulus (from sonic velocity) for HLM piggy-back specimens

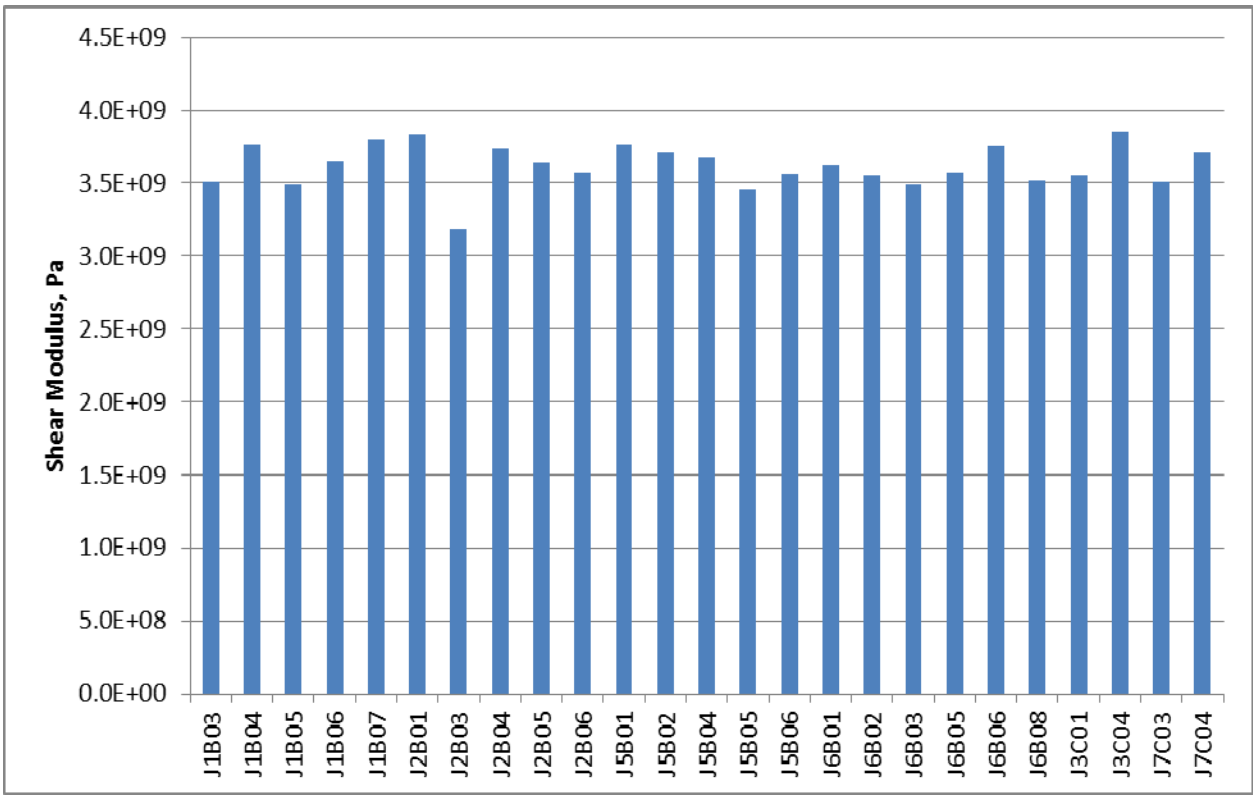

Fig. 107. Shear Dynamic Modulus (from sonic velocity) for HLM piggy-back specimens

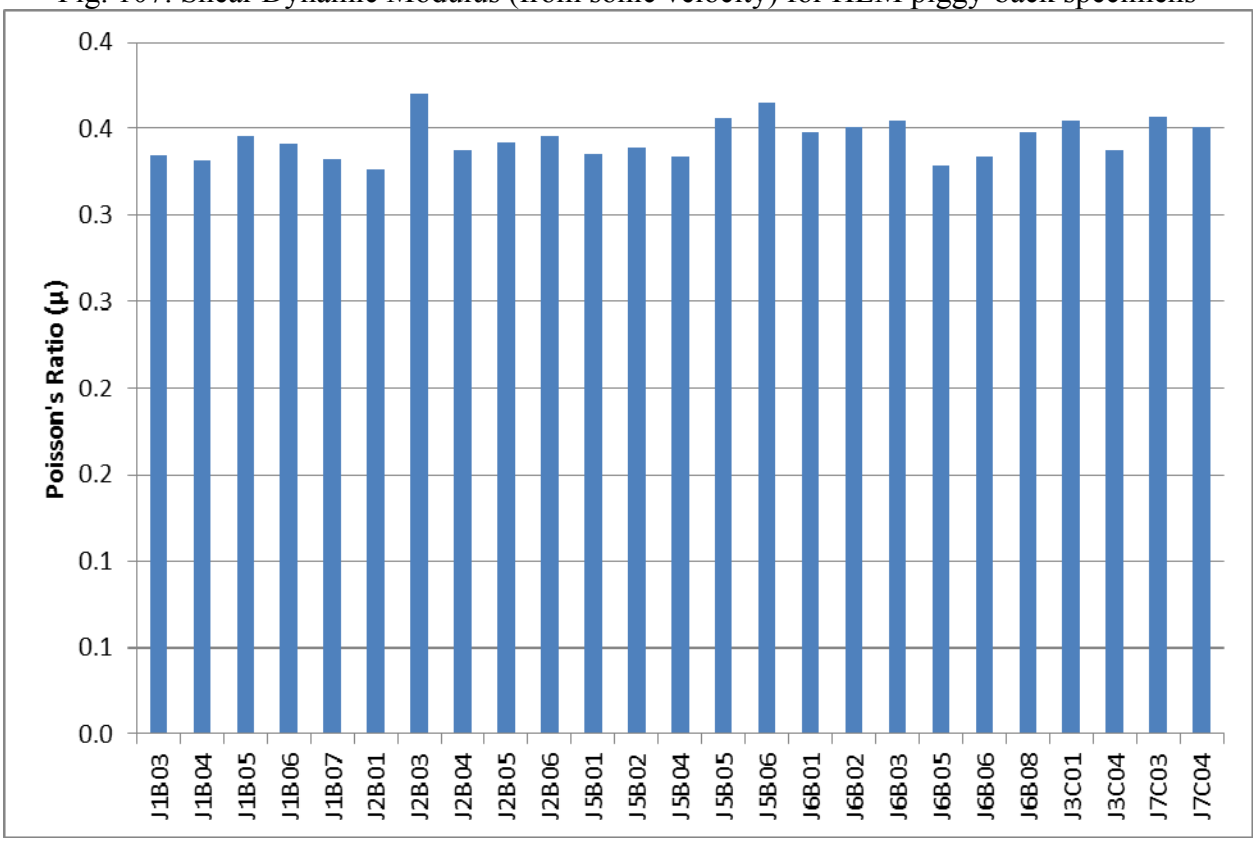

Fig. 108. Poisson's Ratio (from sonic velocity) for HLM piggy-back specimens

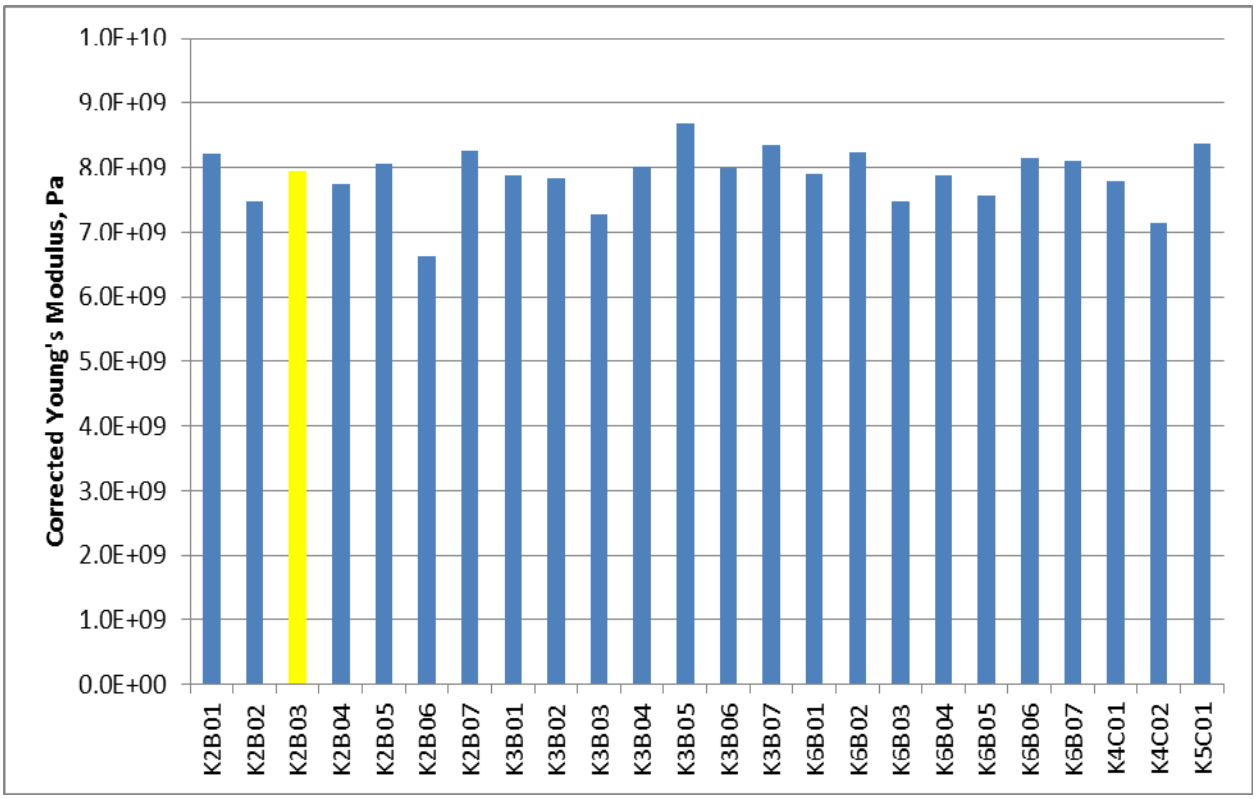

Fig. 109. Longitudinal Dynamic Young's Modulus (from sonic velocity) for PGX piggy-back specimens

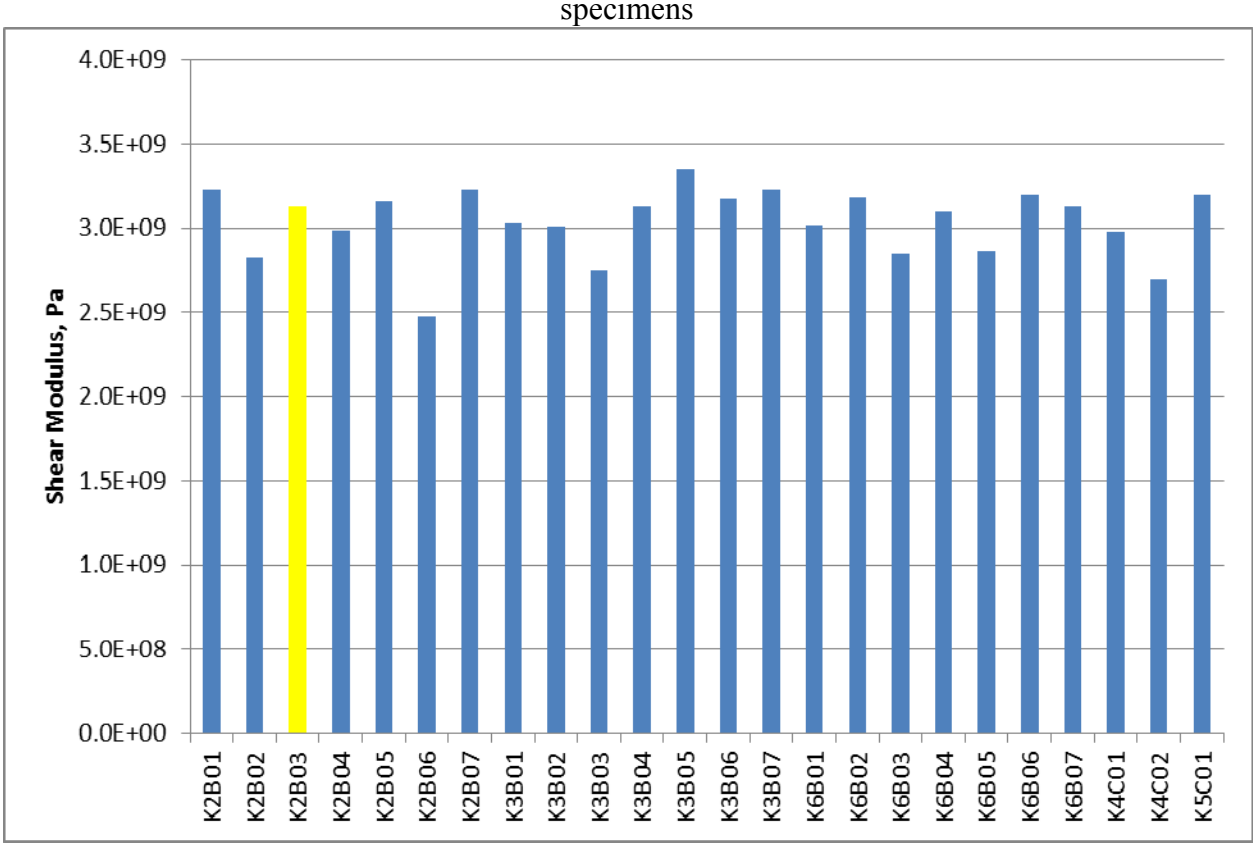

Fig. 110. Shear Dynamic Modulus (from sonic velocity) for PGX piggy-back specimens

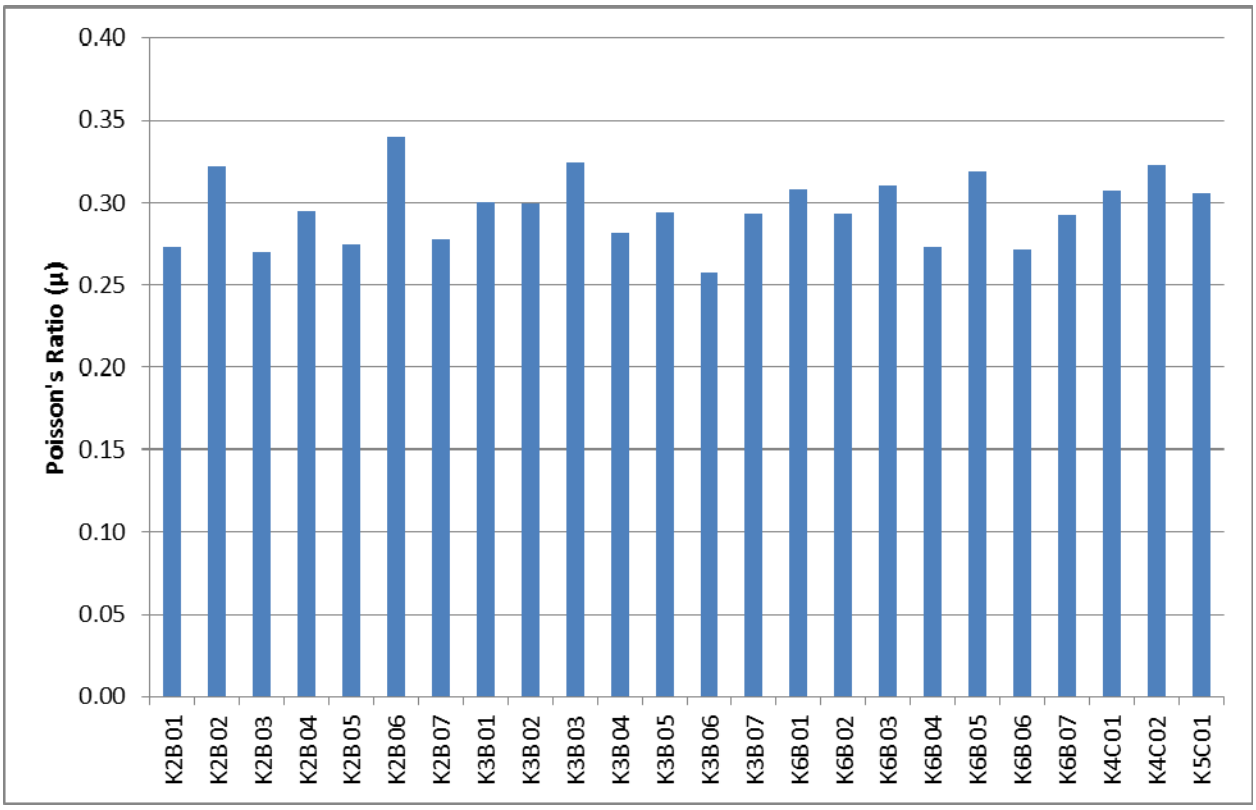

Fig. 111. Poisson's Ratio (from sonic velocity) for PGX piggy-back specimens

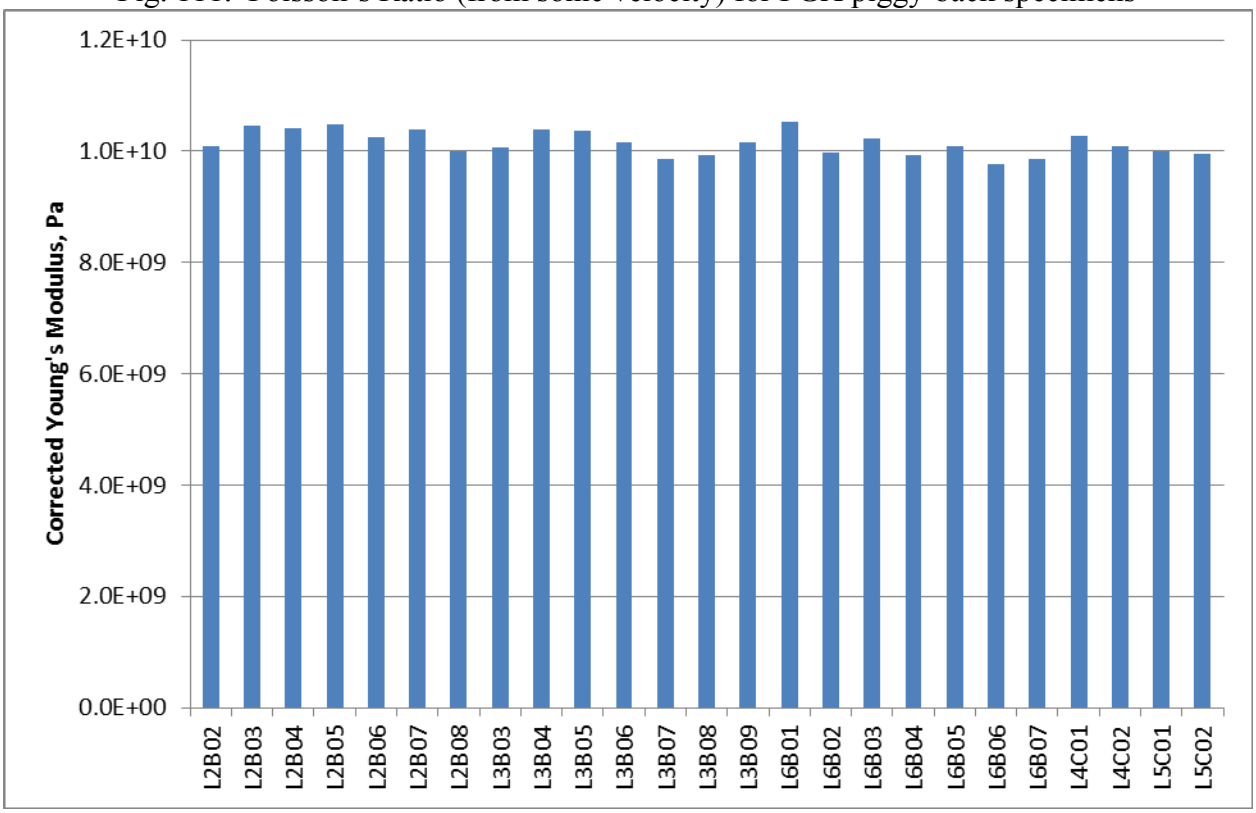

Fig. 112. Longitudinal Dynamic Young's Modulus (from sonic velocity) for PPEA piggy-back specimens

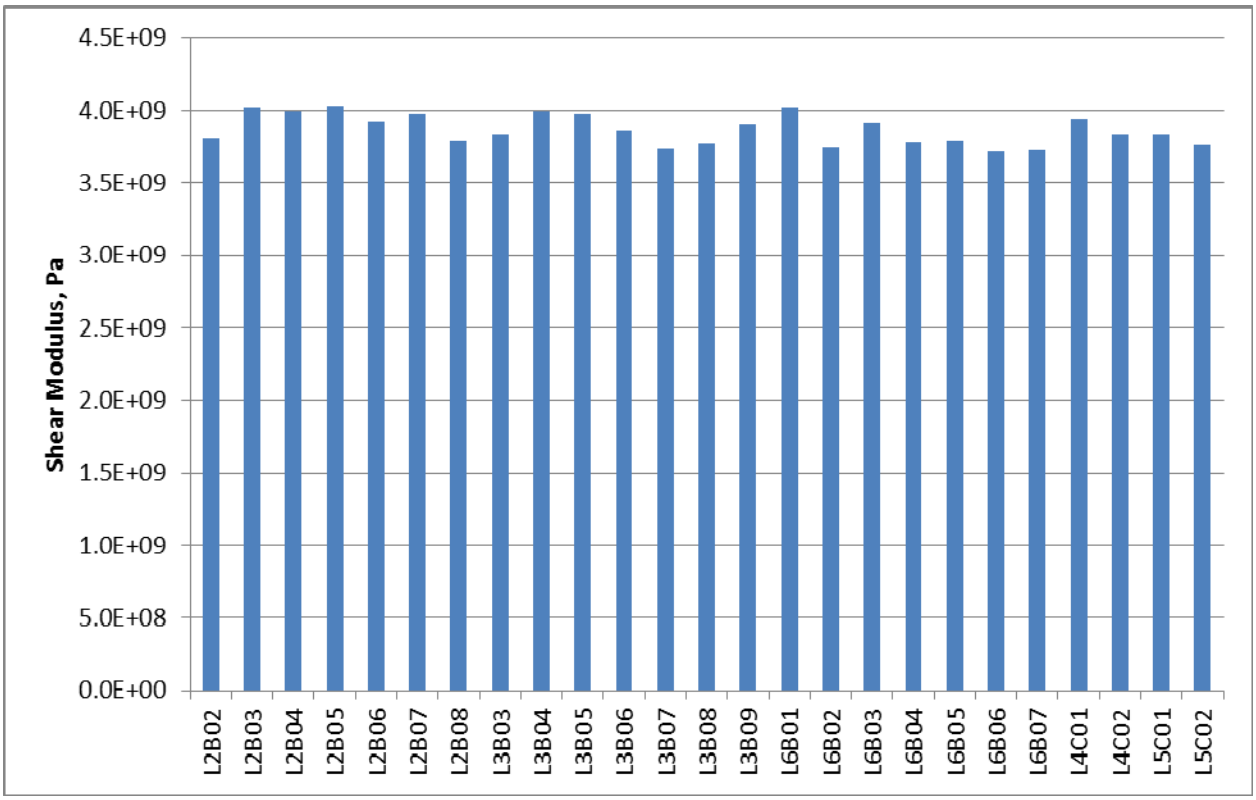

Fig. 113. Shear Dynamic Modulus (from sonic velocity) for PPEA piggy-back specimens

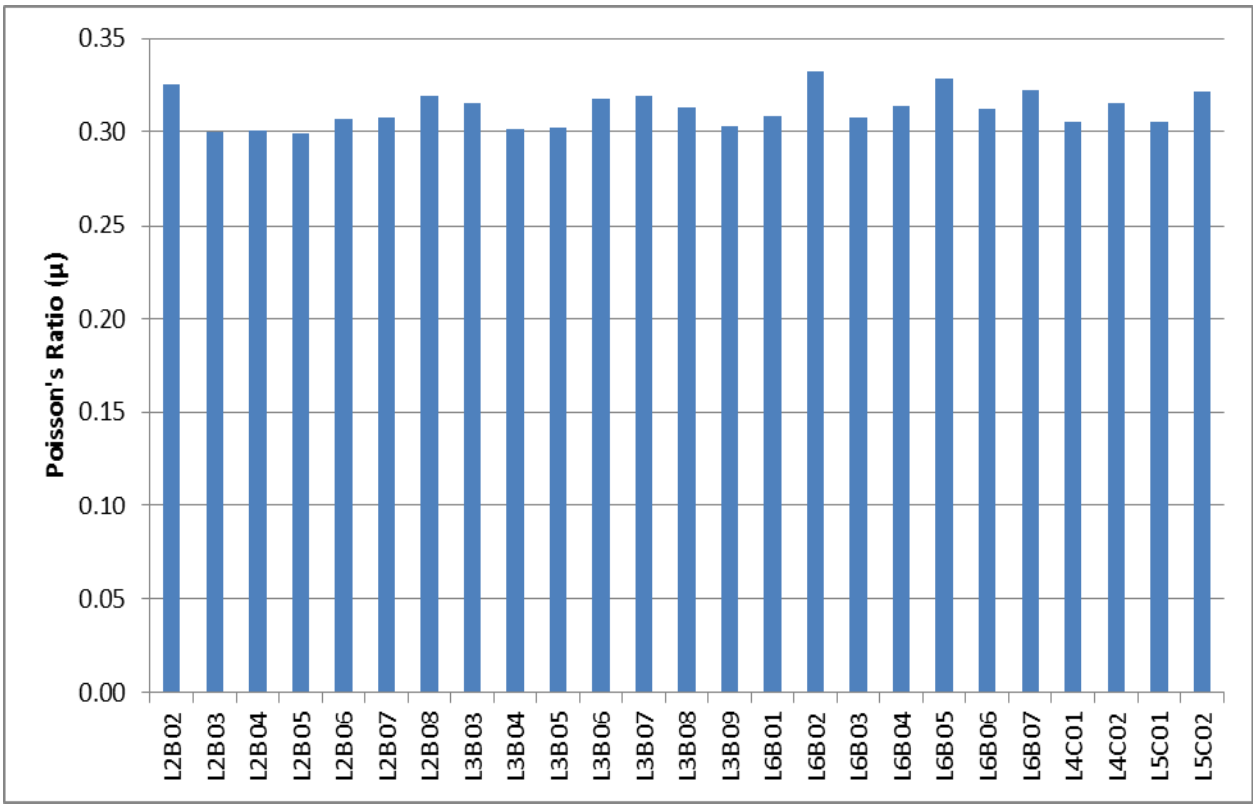

Fig. 114. Poisson's Ratio (from sonic velocity) for PPEA piggy-back specimens

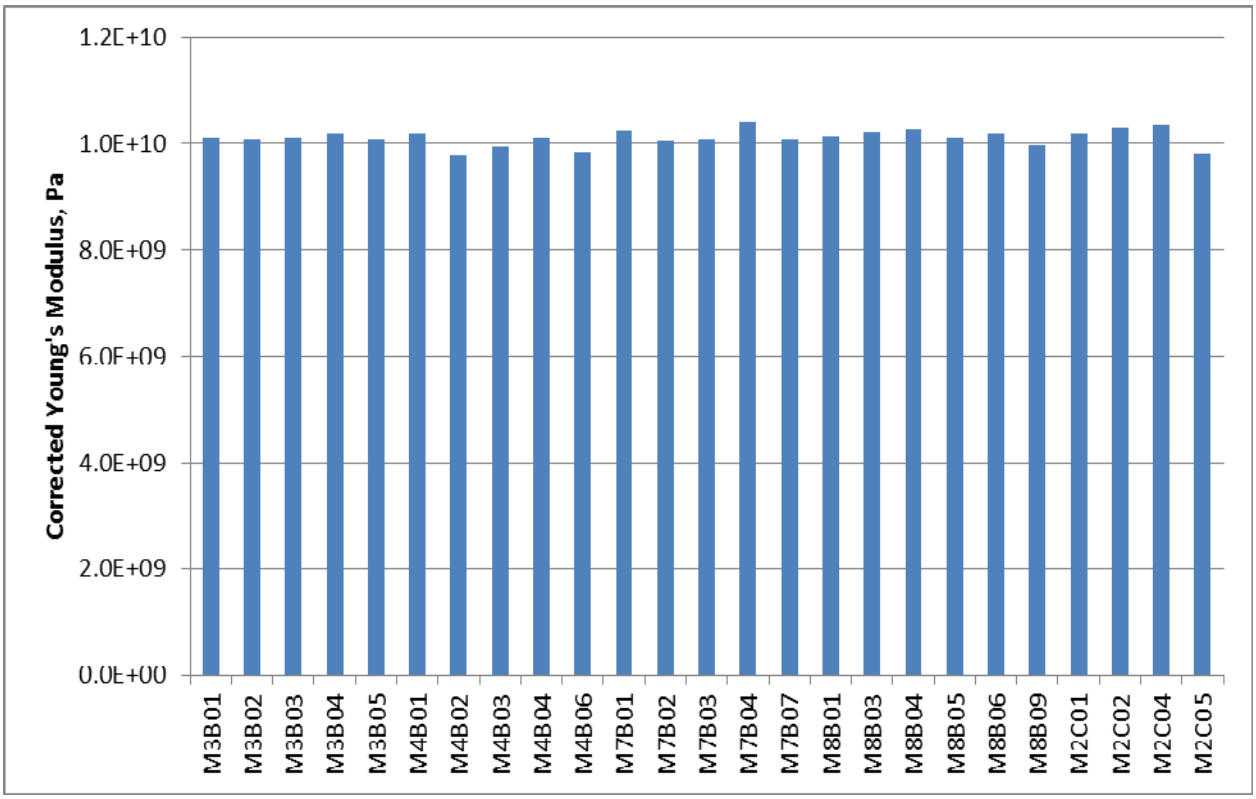

Fig. 115. Longitudinal Dynamic Young's Modulus (from sonic velocity) for NBG-25 piggy-back specimens

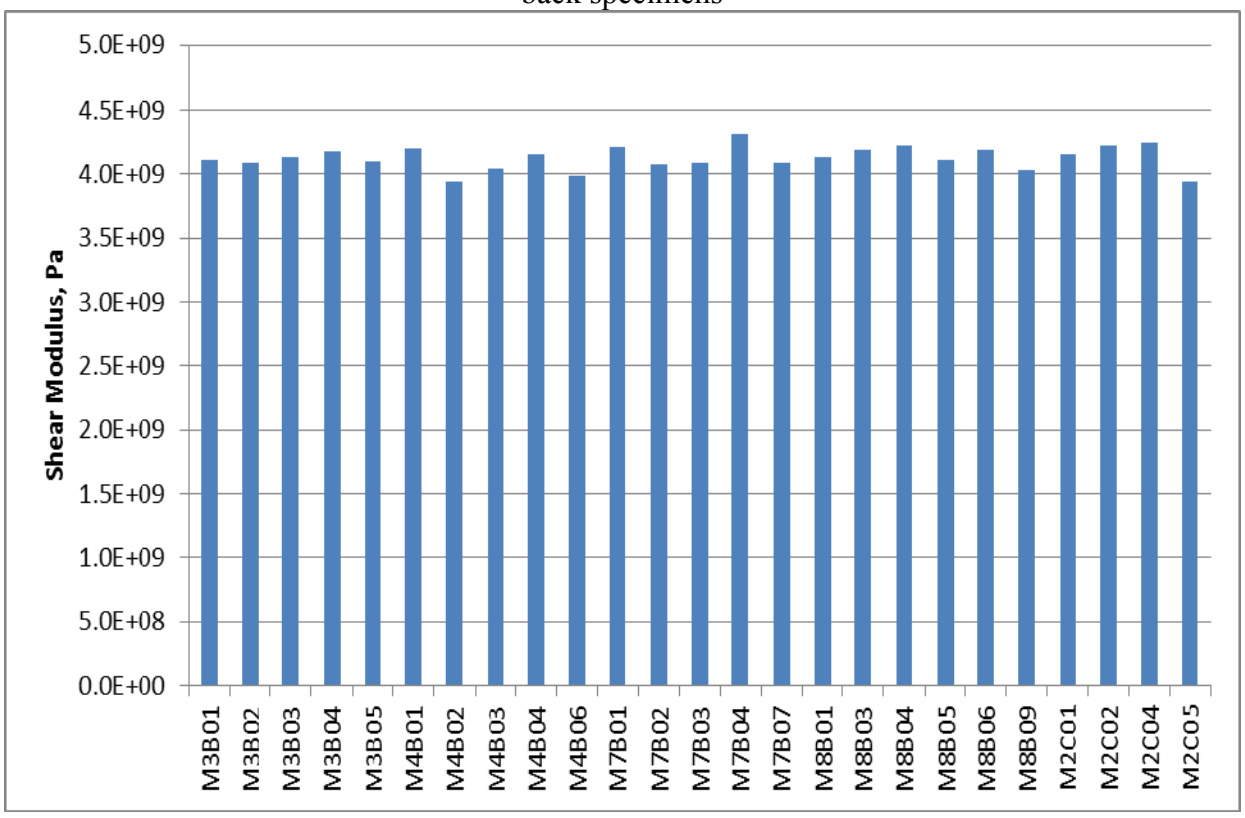

Fig. 116. Shear Dynamic Modulus (from sonic velocity) for NBG-25 piggy-back specimens

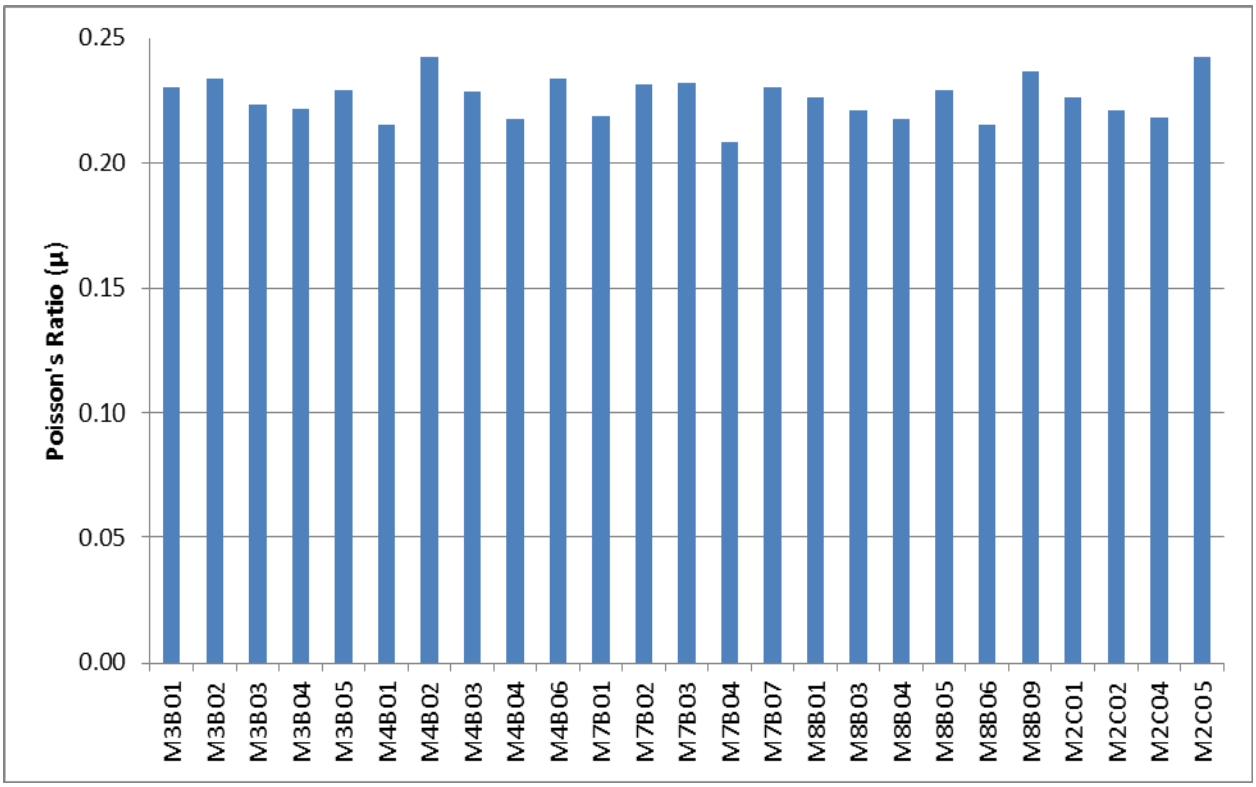

Fig. 117. Poisson's Ratio (from sonic velocity) for NBG-25 piggy-back specimens

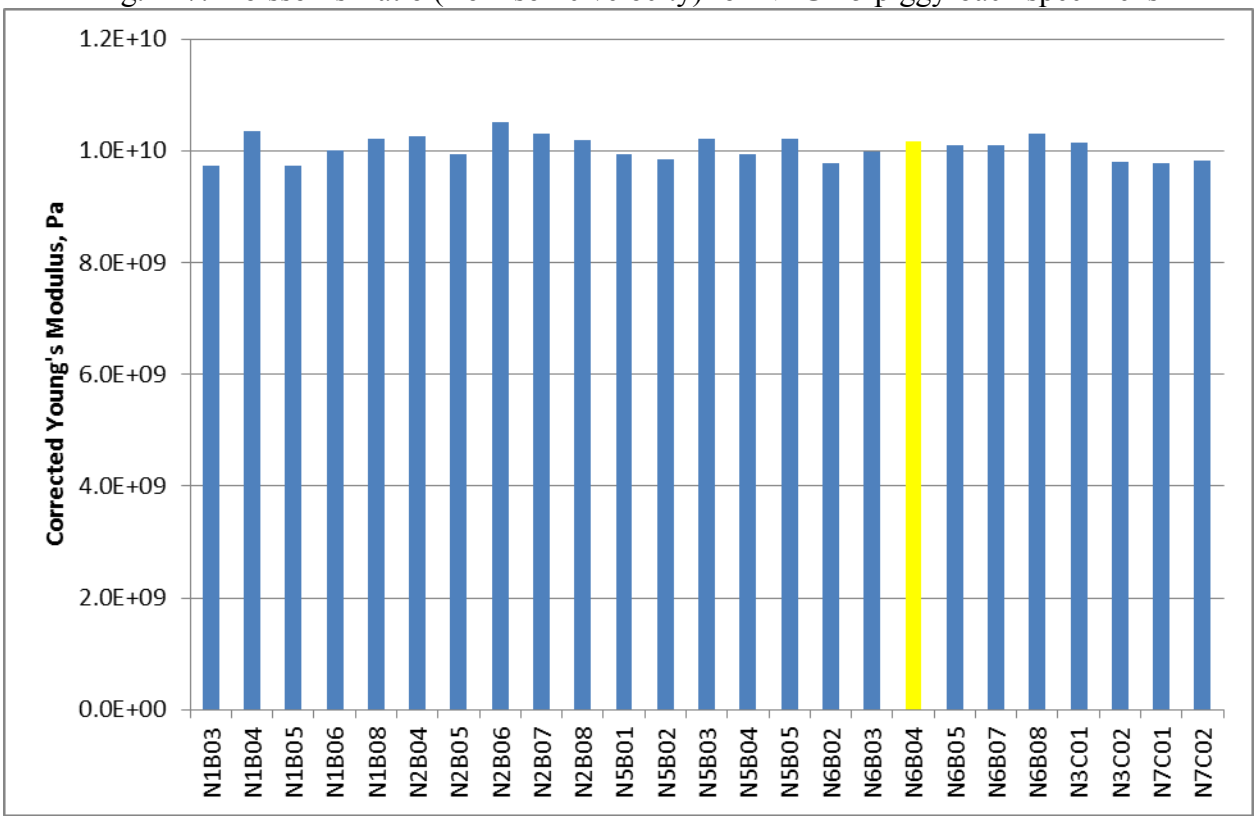

Fig. 118. Longitudinal Dynamic Young's Modulus (from sonic velocity) for 2020 piggy-back specimens

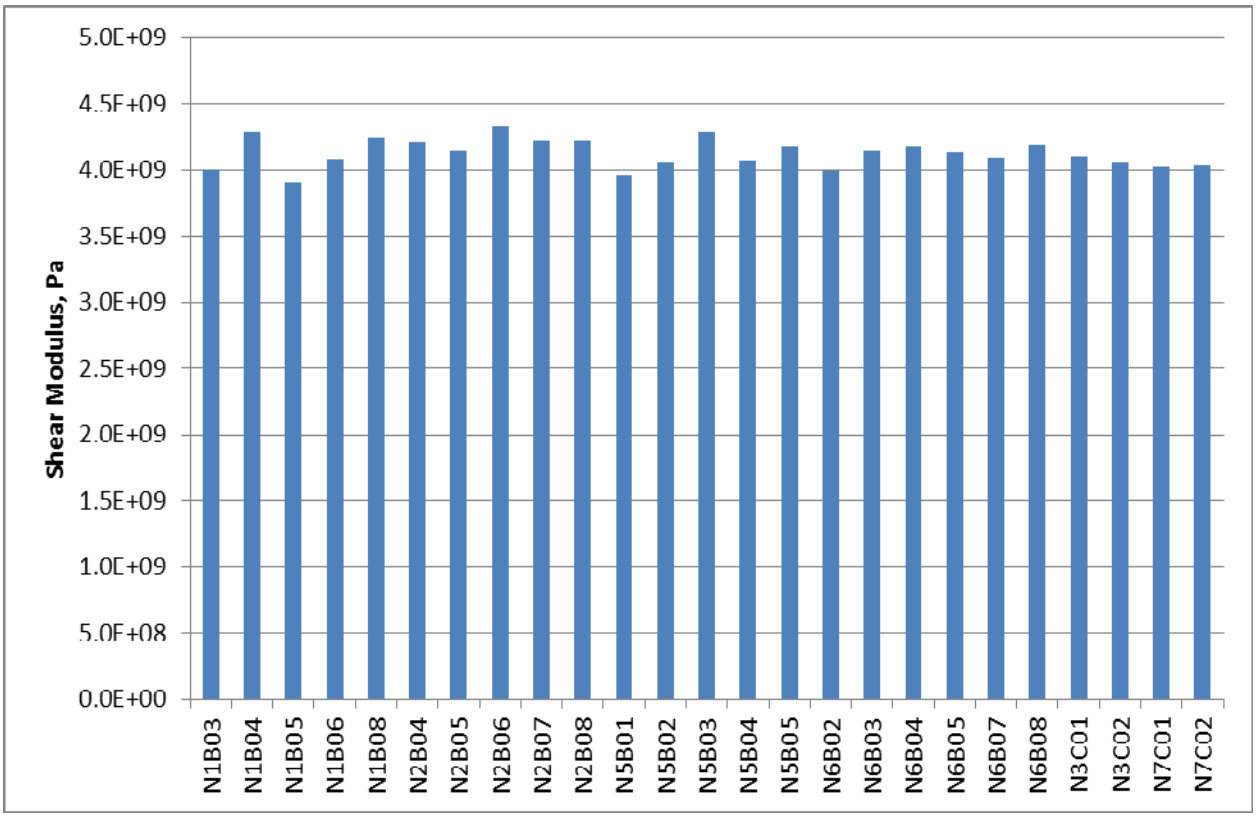

Fig. 119. Shear Dynamic Modulus (from sonic velocity) for 2020 piggy-back specimens

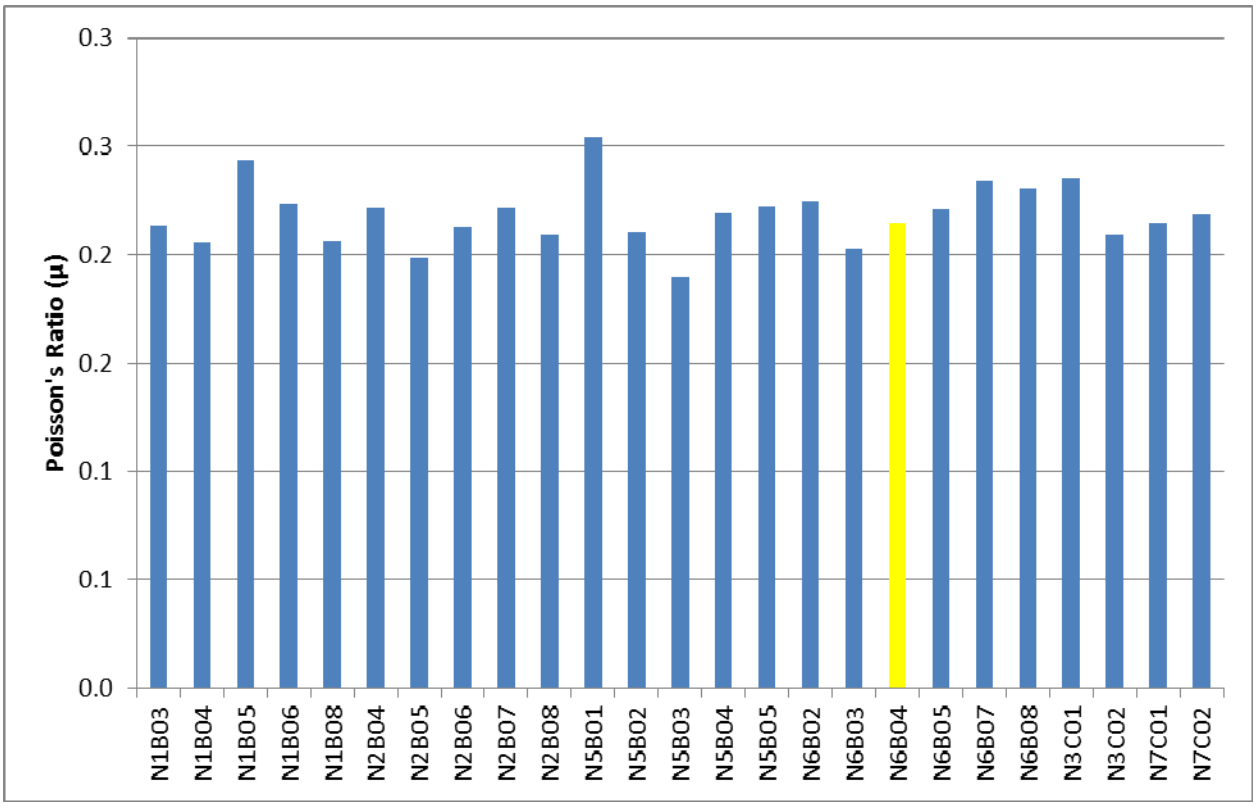

Fig. 120. Poisson's Ratio (from sonic velocity) for 2020 piggy-back specimens

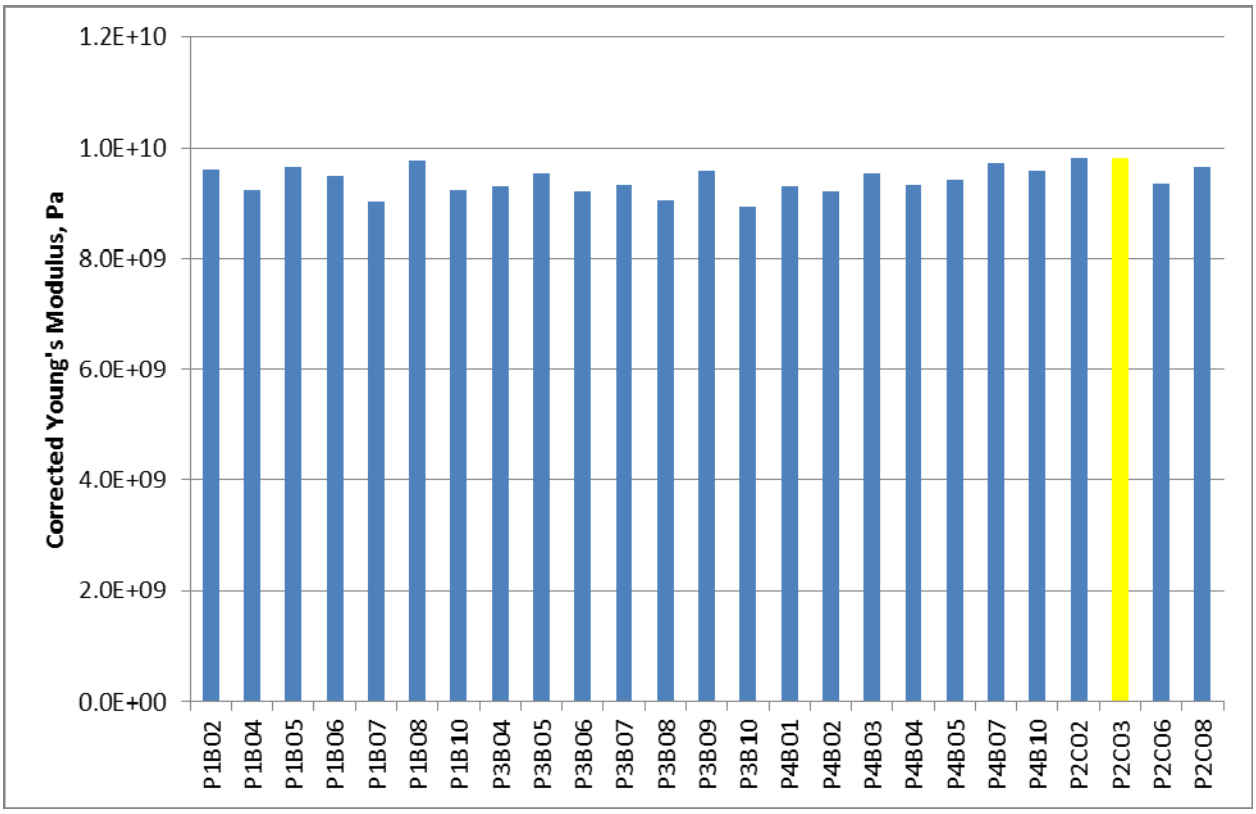

Fig. 121. Longitudinal Dynamic Young's Modulus (from sonic velocity) for PCIB piggy-back specimens

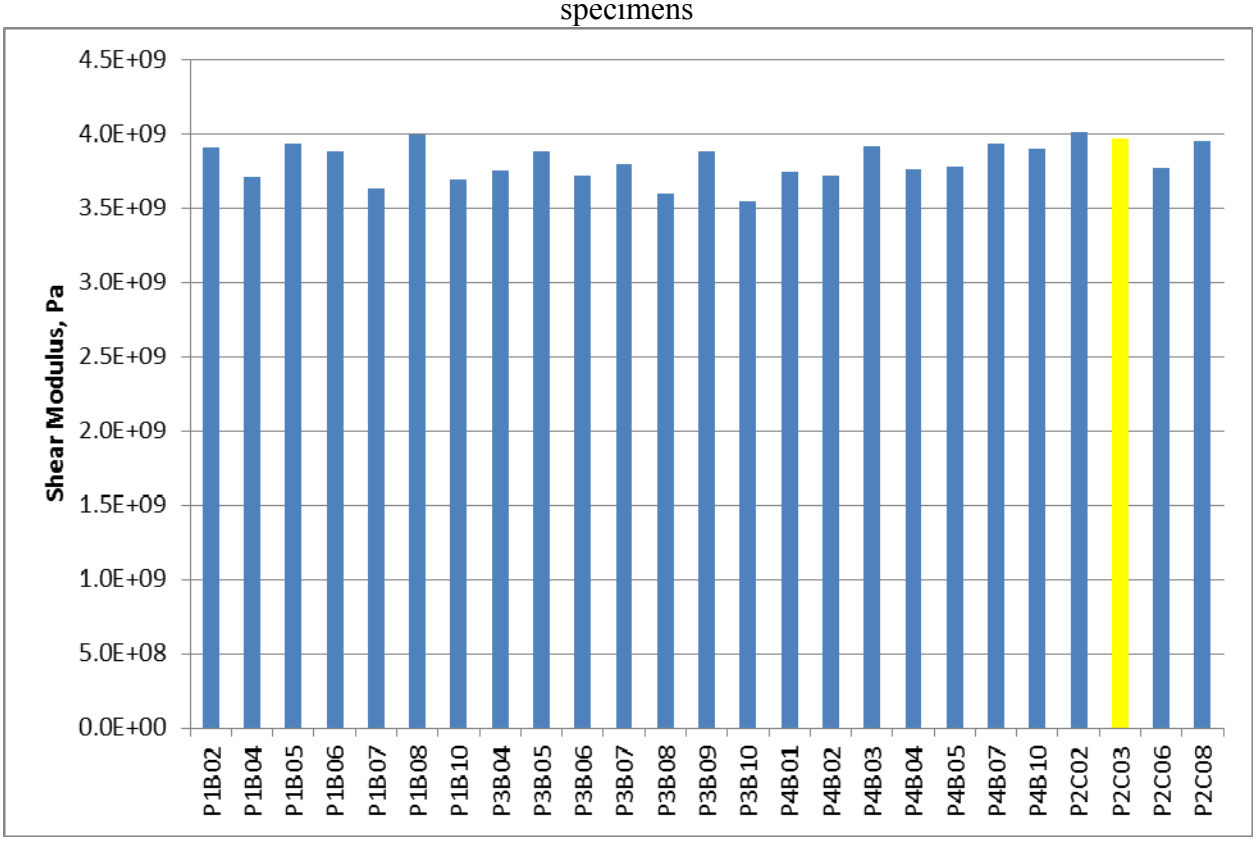

Fig. 122. Shear Dynamic Modulus (from sonic velocity) for PCIB piggy-back specimens

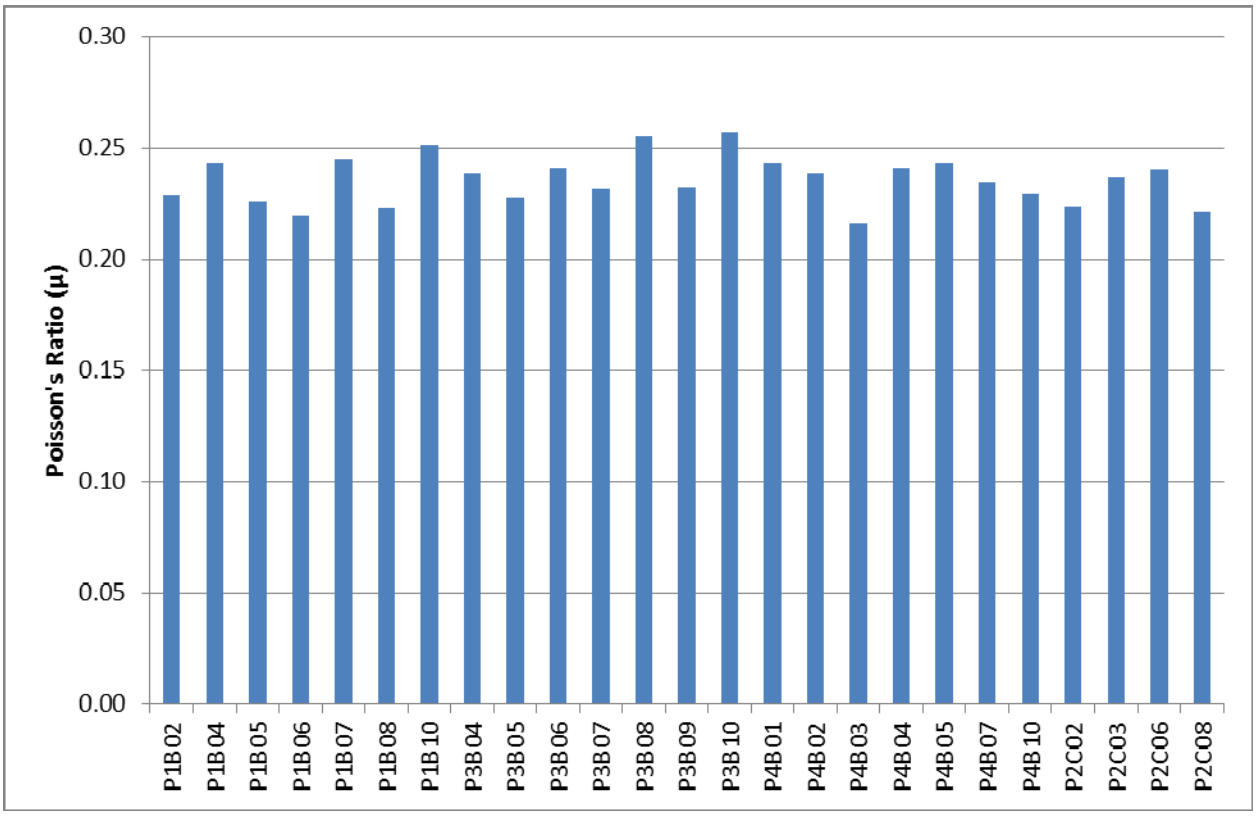

Fig. 123. Poisson's Ratio (from sonic velocity) for PCIB piggy-back specimens

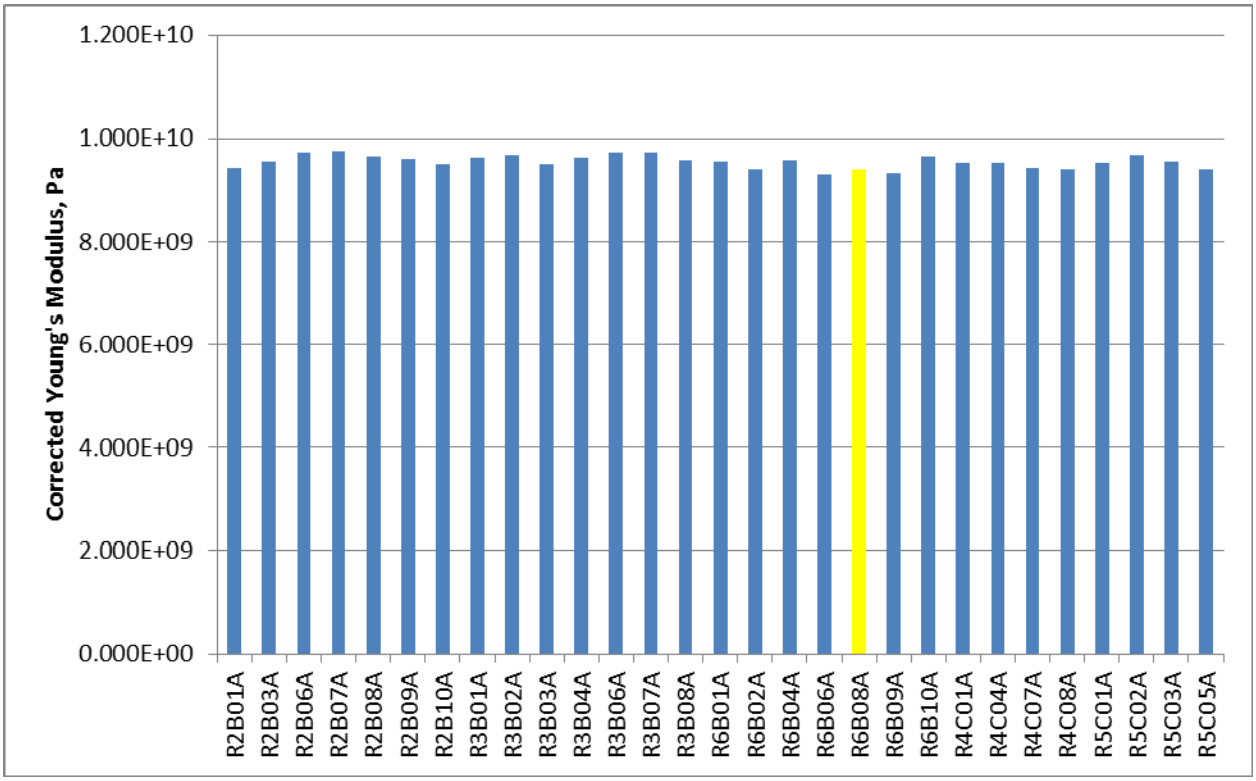

Fig. 124. Longitudinal Dynamic Young's Modulus (from sonic velocity) for BAN piggy-back specimens

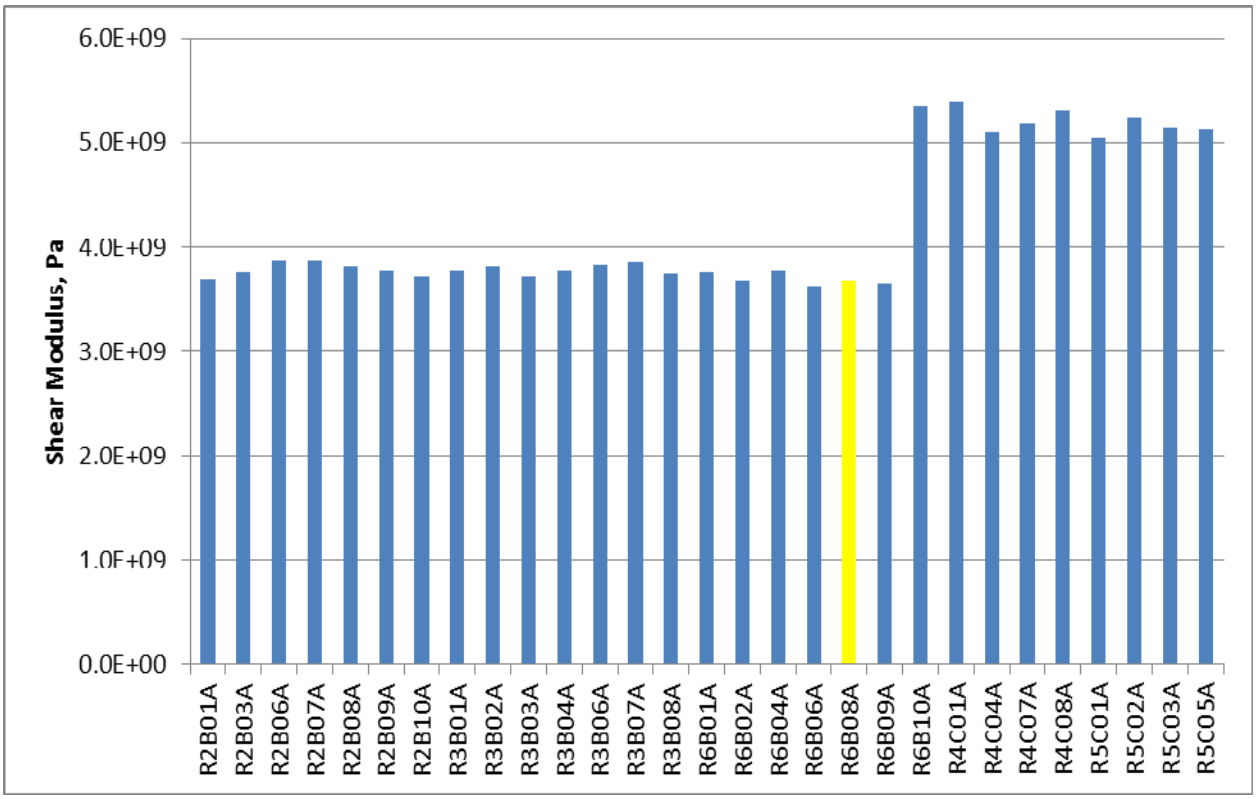

Fig. 125. Shear Dynamic Modulus (from sonic velocity) for BAN piggy-back specimens

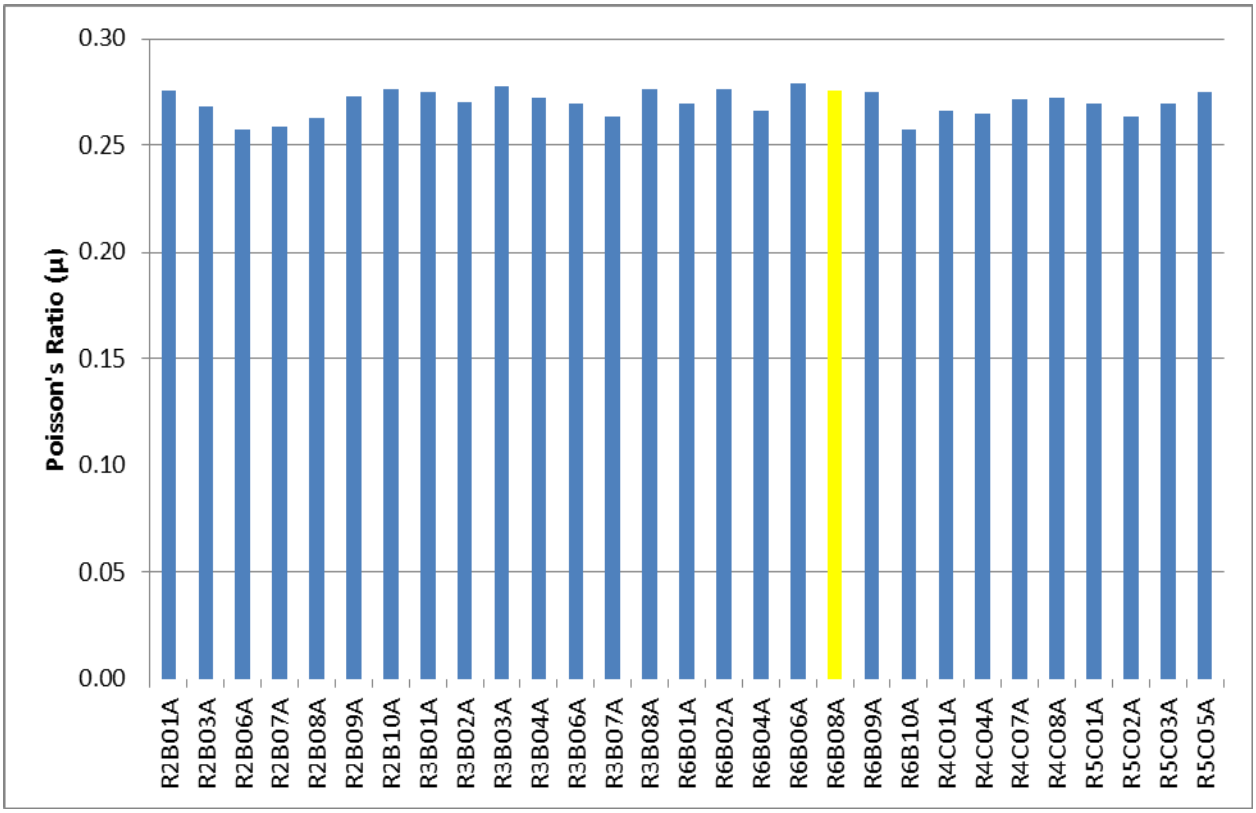

Fig. 126. Poisson's Ratio (from sonic velocity) for BAN piggy-back specimens

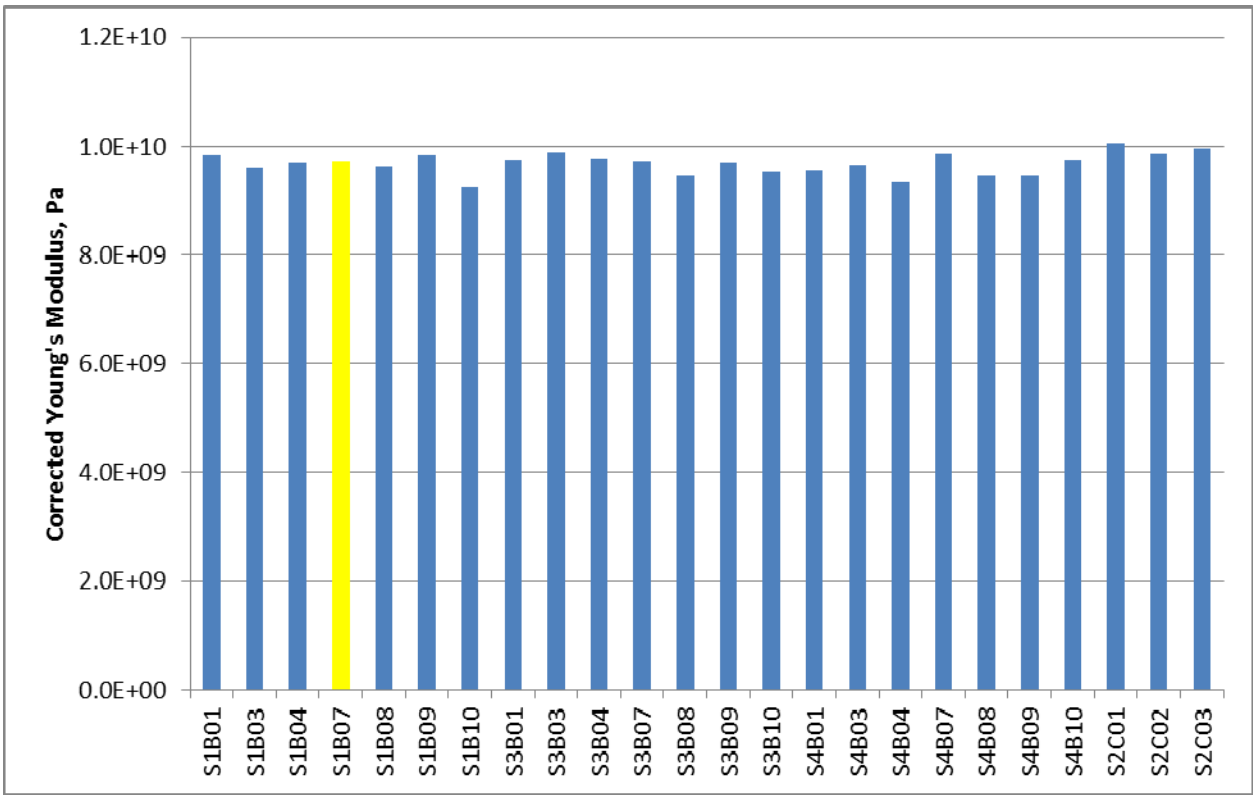

Fig. 127. Longitudinal Dynamic Young's Modulus (from sonic velocity) for NBG-10 piggy-back specimens

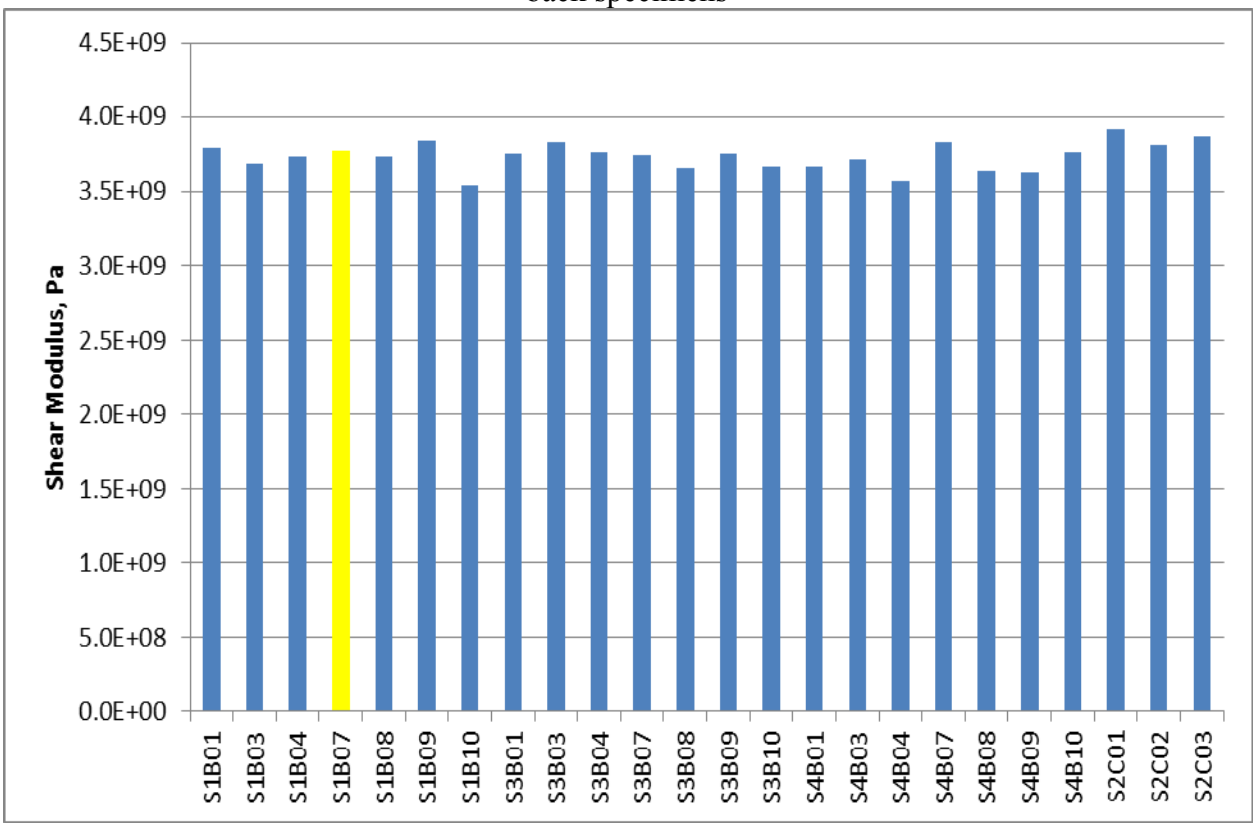

Fig. 128. Shear Dynamic Modulus (from sonic velocity) for NBG-10 piggy-back specimens

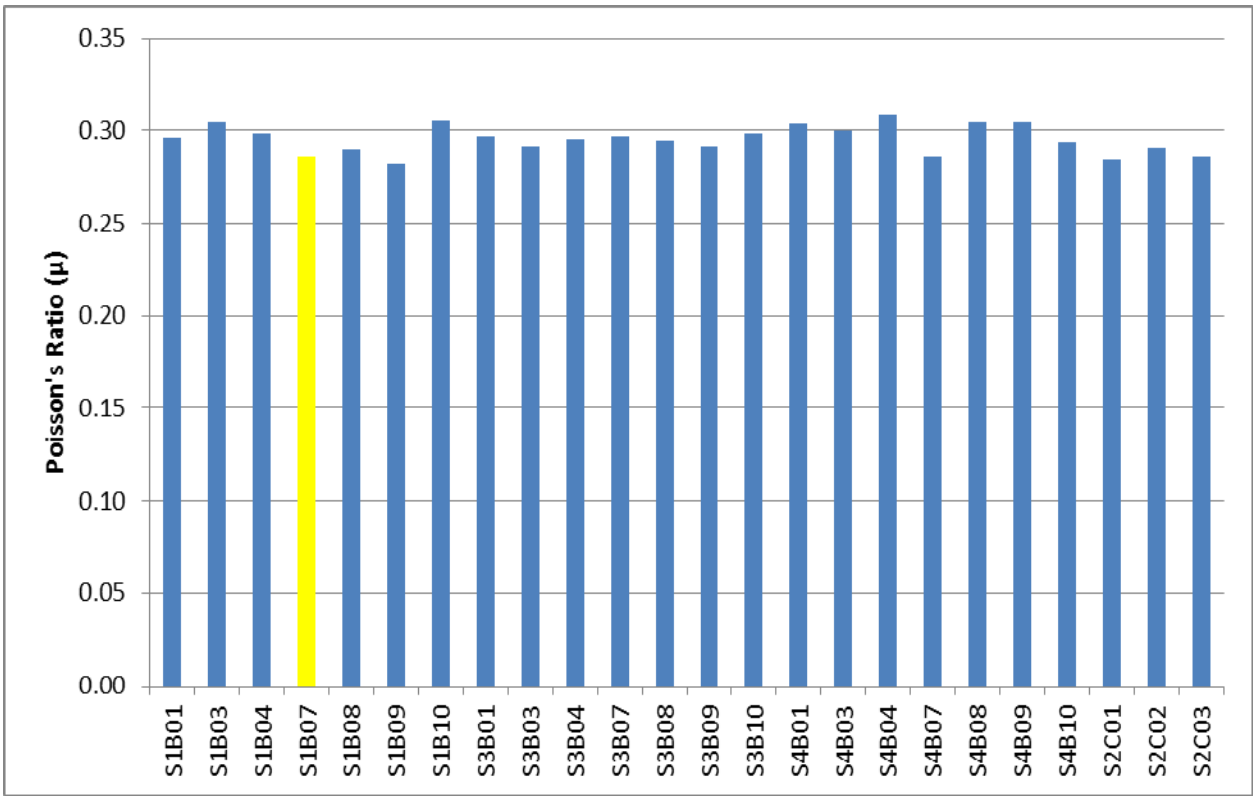

Fig. 129. Poisson's Ratio (from sonic velocity) for NBG-10 piggy-back specimens

Table 41. Mean elastic constants for the secondary grades in capsule AGC-1

GRADE	Elastic Constants (from sound velocity), GPa		
	Dynamic Young's Modulus (E), GPa	Dynamic Shear Modulus (G), GPa	Poisson's Ratio (μ)
HLM	9.73	3.62	0.34
PGX	7.87	3.04	0.3
PPEA	10.15	3.87	0.31
NBG-25	10.12	4.13	0.23
2020	10.05	4.13	0.22
PCIB	9.43	3.82	0.24
BAN	9.54	4.21	0.27
NBG-10	9.68	3.74	0.3

3.4. Pre-Irradiation Examination, Ambient Temperature Thermal Conductivity

The ambient temperature thermal diffusivity was measured experimentally for the solid piggy-back specimens. The raw data for diffusivity was transferred electronically to spreadsheets, negating the need for data transposition. Here we report the thermal conductivity for the graphite specimens calculated from the measured density and specific heat (eq. 9). The specific heat values were calculated from eq. 10 and are reported in Table 42 and Fig. 130.

Table 42. Calculated values of Specific Heat for graphite (from eq, 11)

Temperature		Specific Heat, J/kg.K
°C	K	
19	292	715.7
20	293	718.5
21	294	721.3
22	295	724.1
23	296	726.9
24	297	729.7
25	298	732.5
26	299	735.3
27	300	738.0
28	301	740.8
29	302	743.6

The experimental data are reported in appendices 58-72 and summarized in plots shown in Figs. 131-145. Fig 146 and Table 43 provide an overall comparison of the ambient temperature thermal conductivity of the graphite grades examined here.

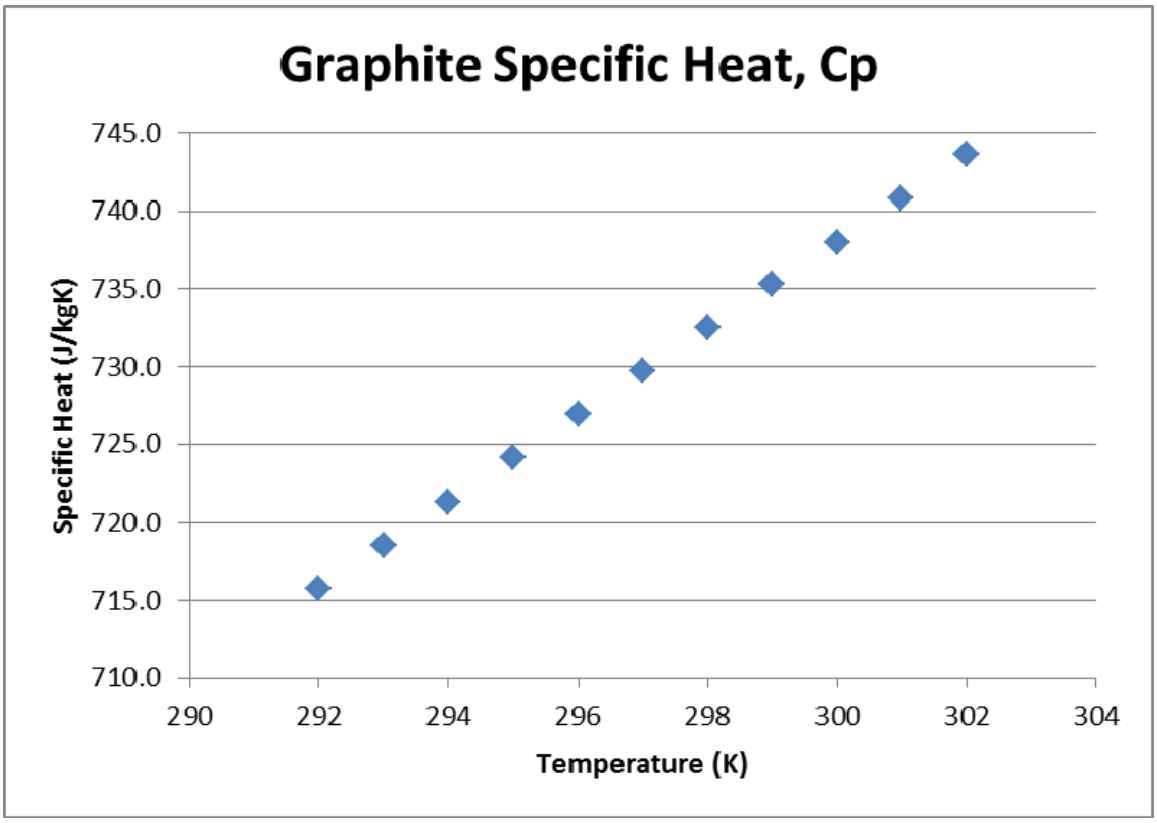

Fig. 130. The variation of Specific Heat with temperature from 292 to 302K

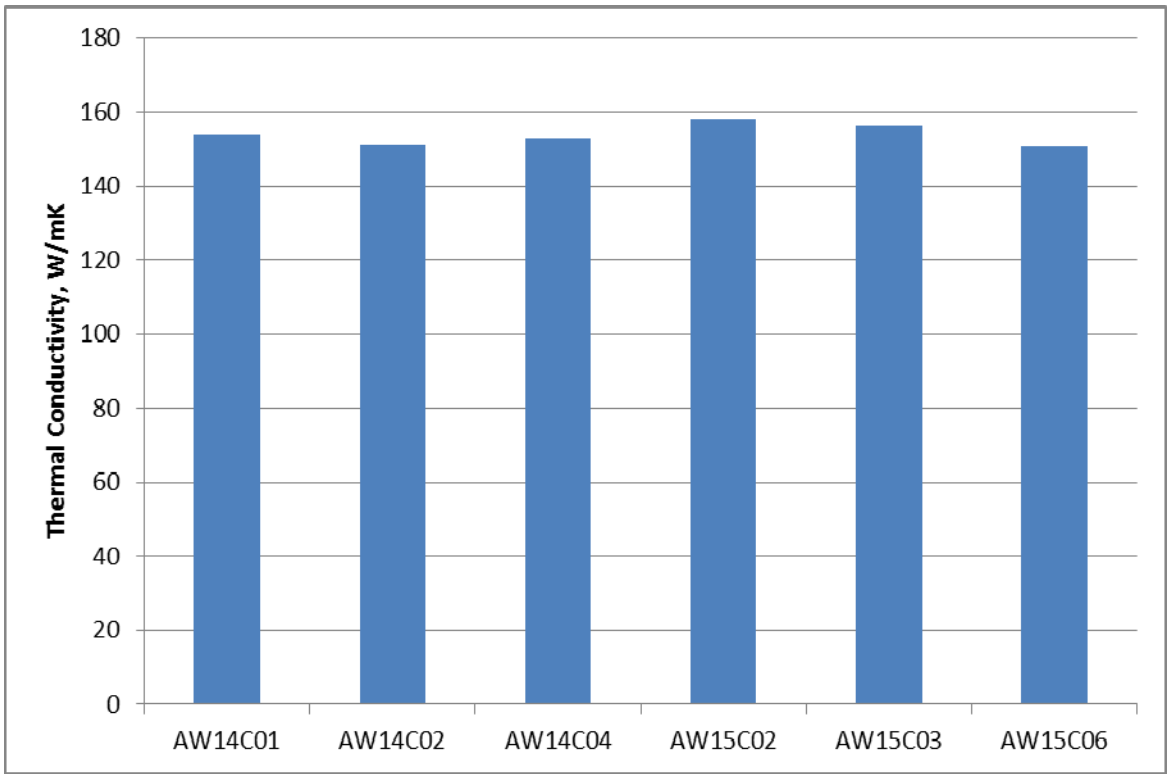

Fig. 131. The ambient temperature thermal conductivity of NBG-17 piggy-back specimens

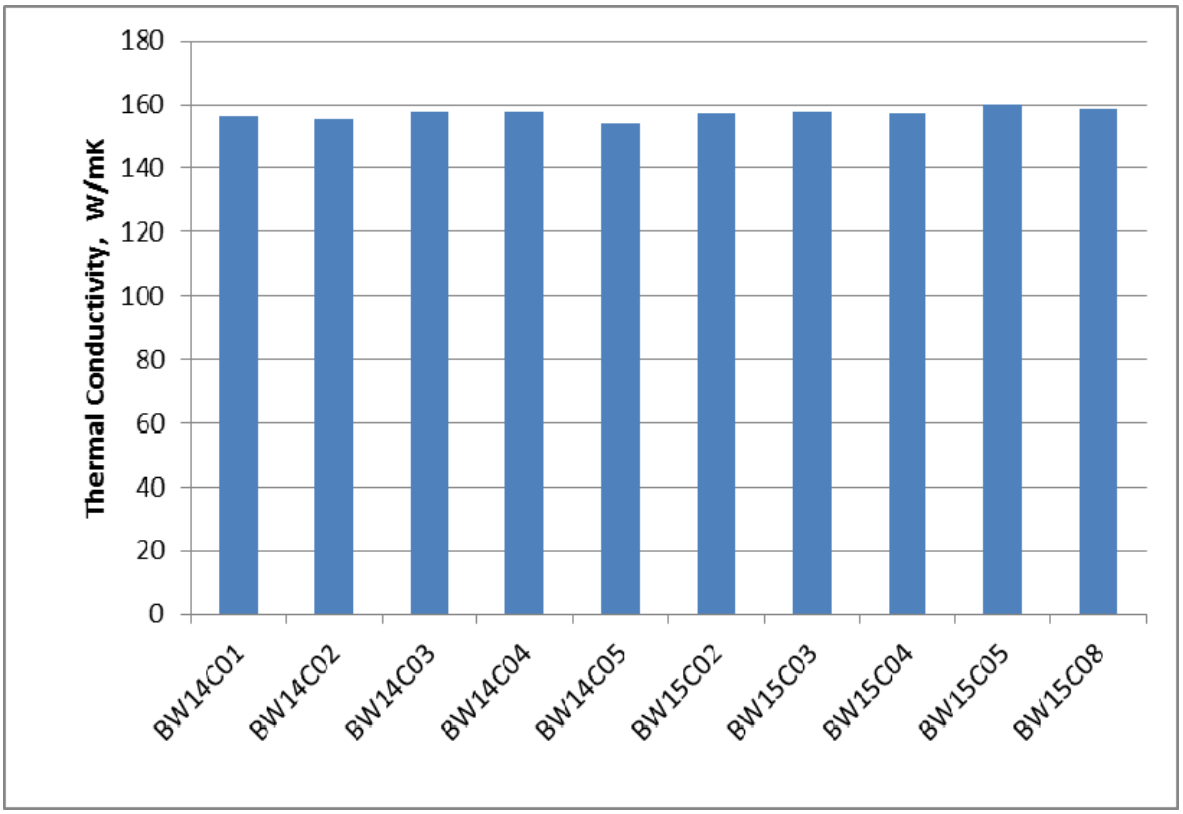

Fig. 132. The ambient temperature thermal conductivity of NBG-18 piggy-back specimens

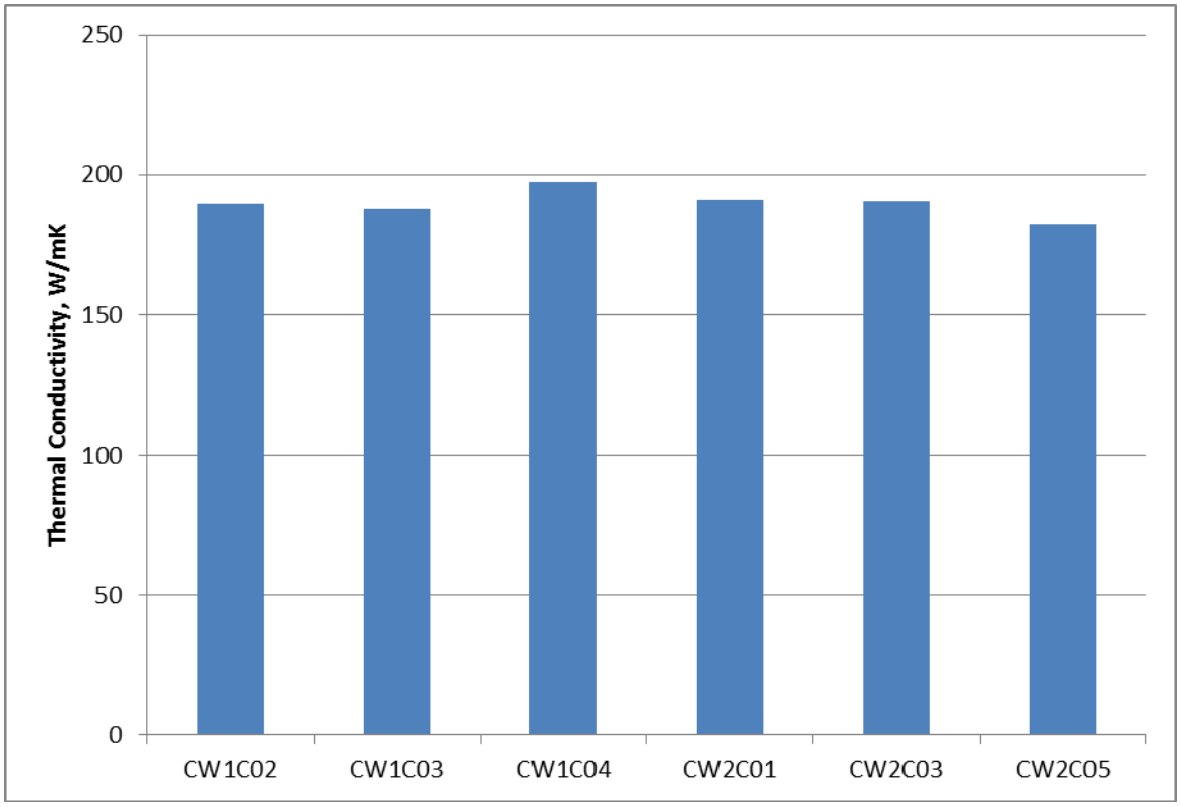

Fig. 133. The ambient temperature thermal conductivity of H-451 piggy-back specimens

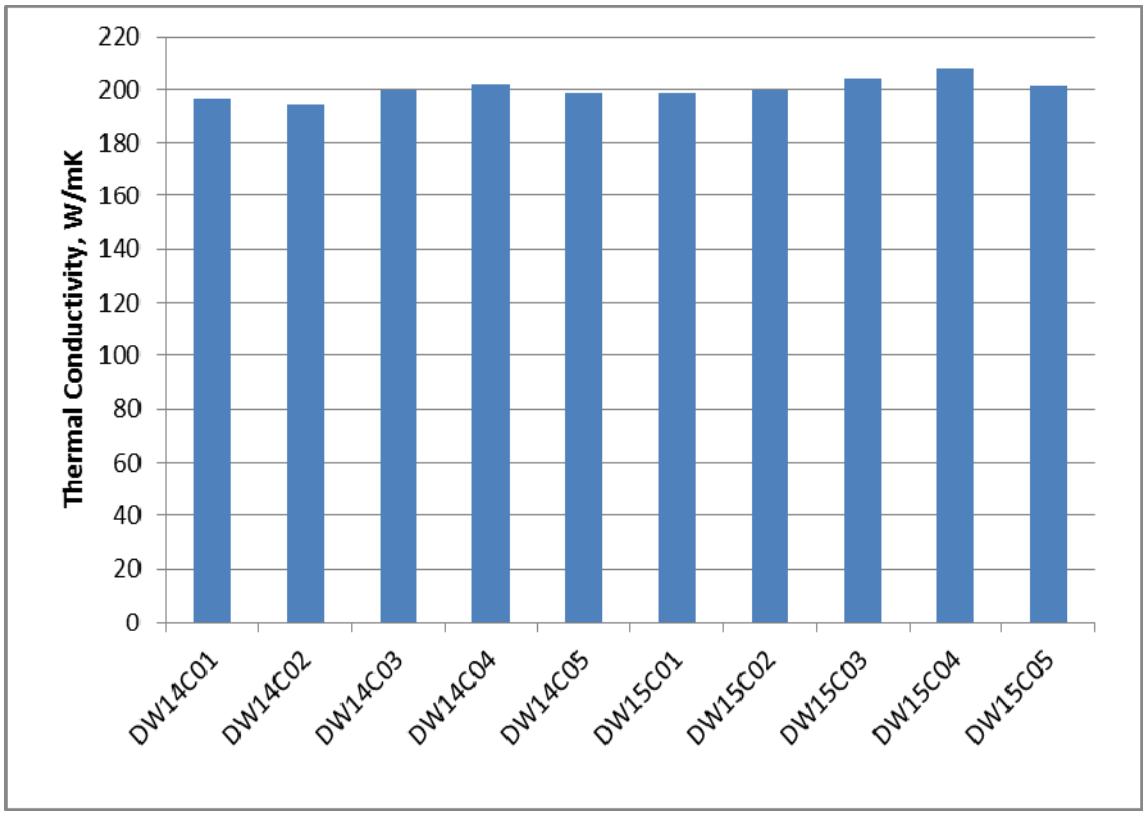

Fig. 134. The ambient temperature thermal conductivity of PCEA (WG) piggy-back specimens

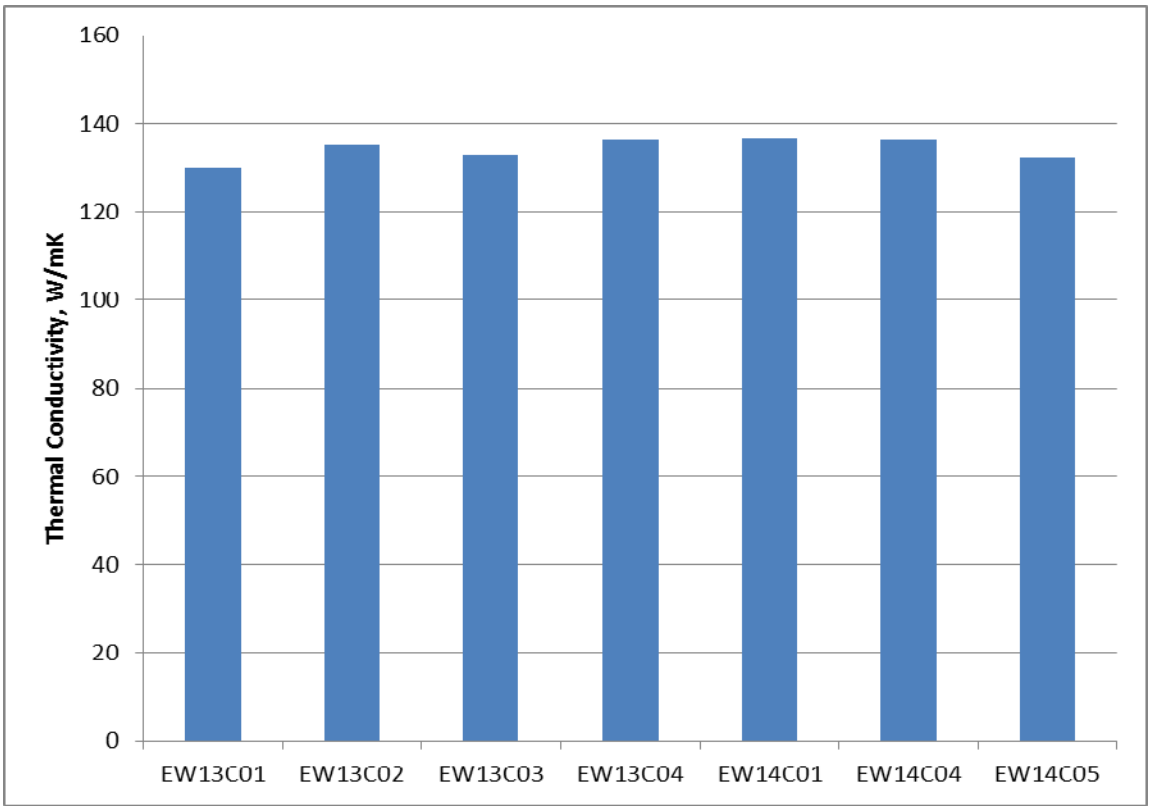

Fig. 135. The ambient temperature thermal conductivity of IG-110 piggy-back specimens

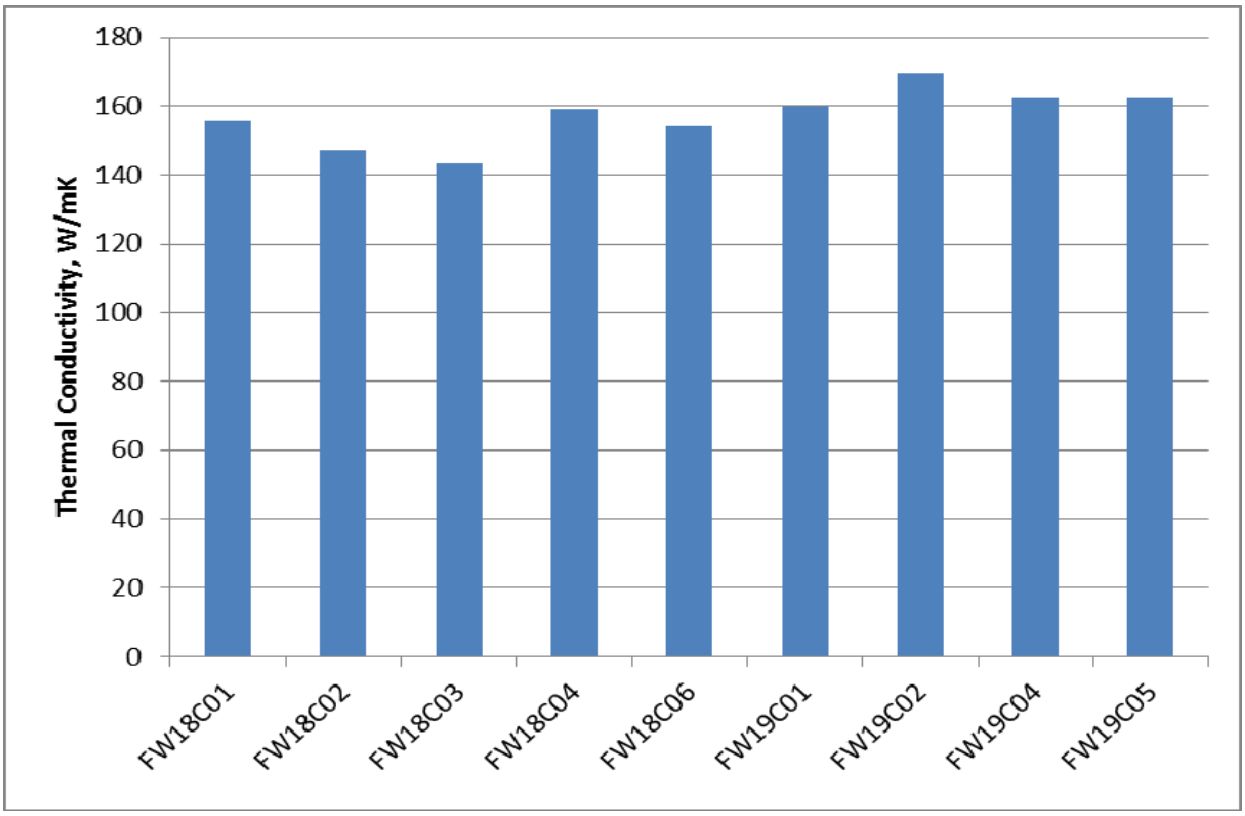

Fig. 136. The ambient temperature thermal conductivity of IG-430 piggy-back specimens

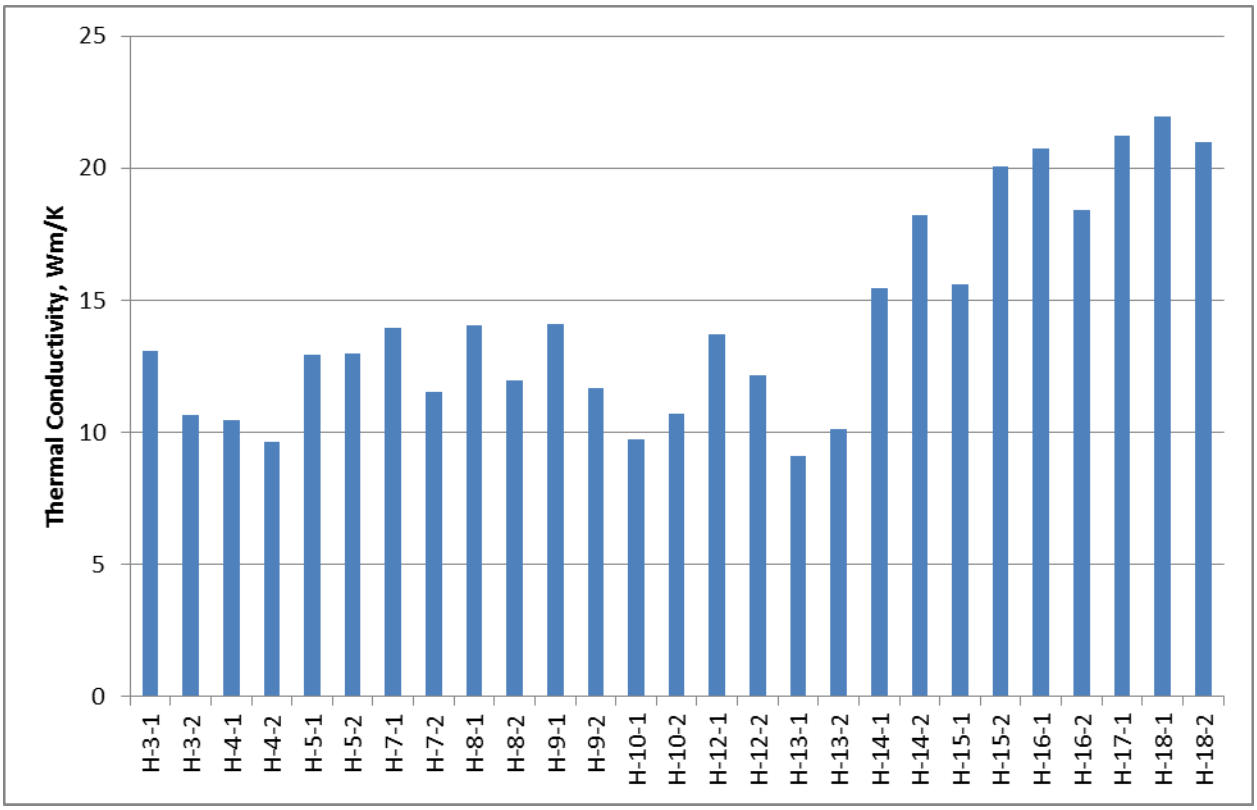

Fig. 137. The ambient temperature thermal conductivity of A3-matrix piggy-back specimens

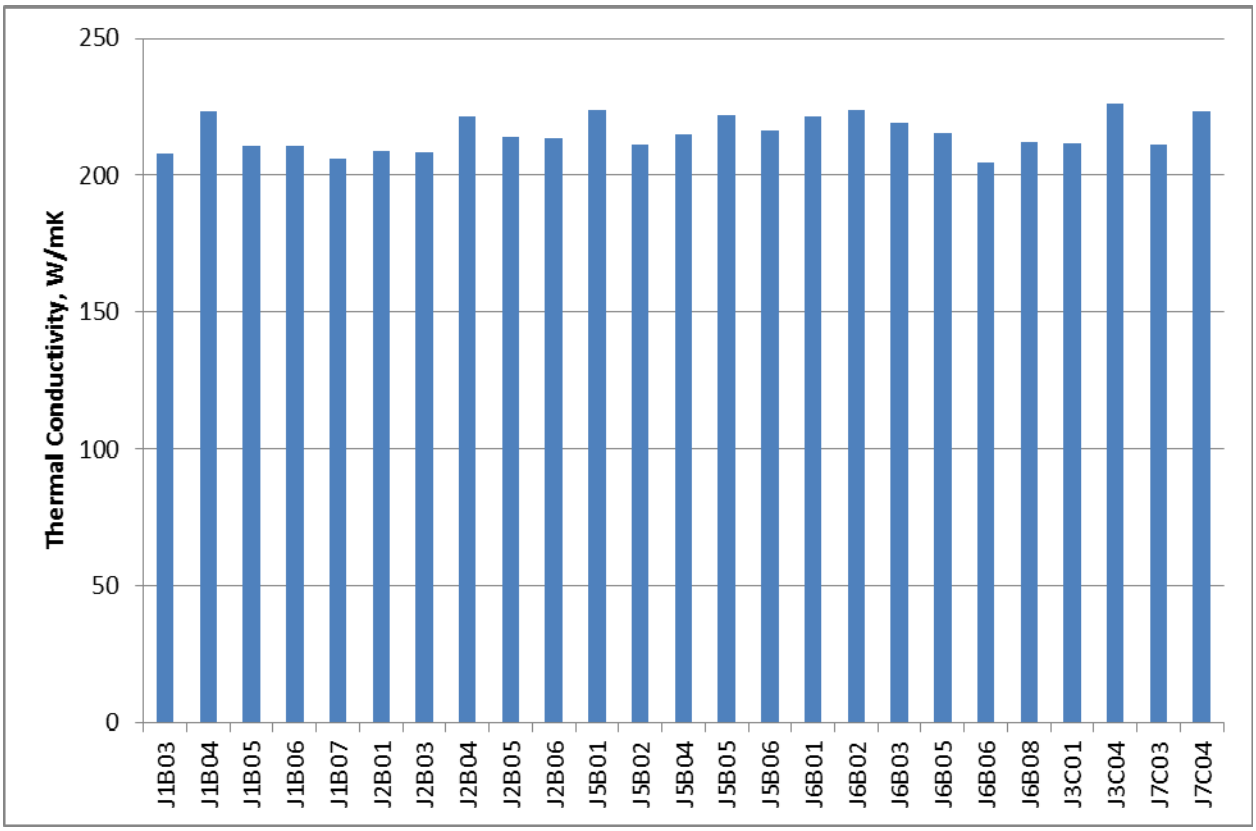

Fig. 138. The ambient temperature thermal conductivity of HLM piggy-back specimens

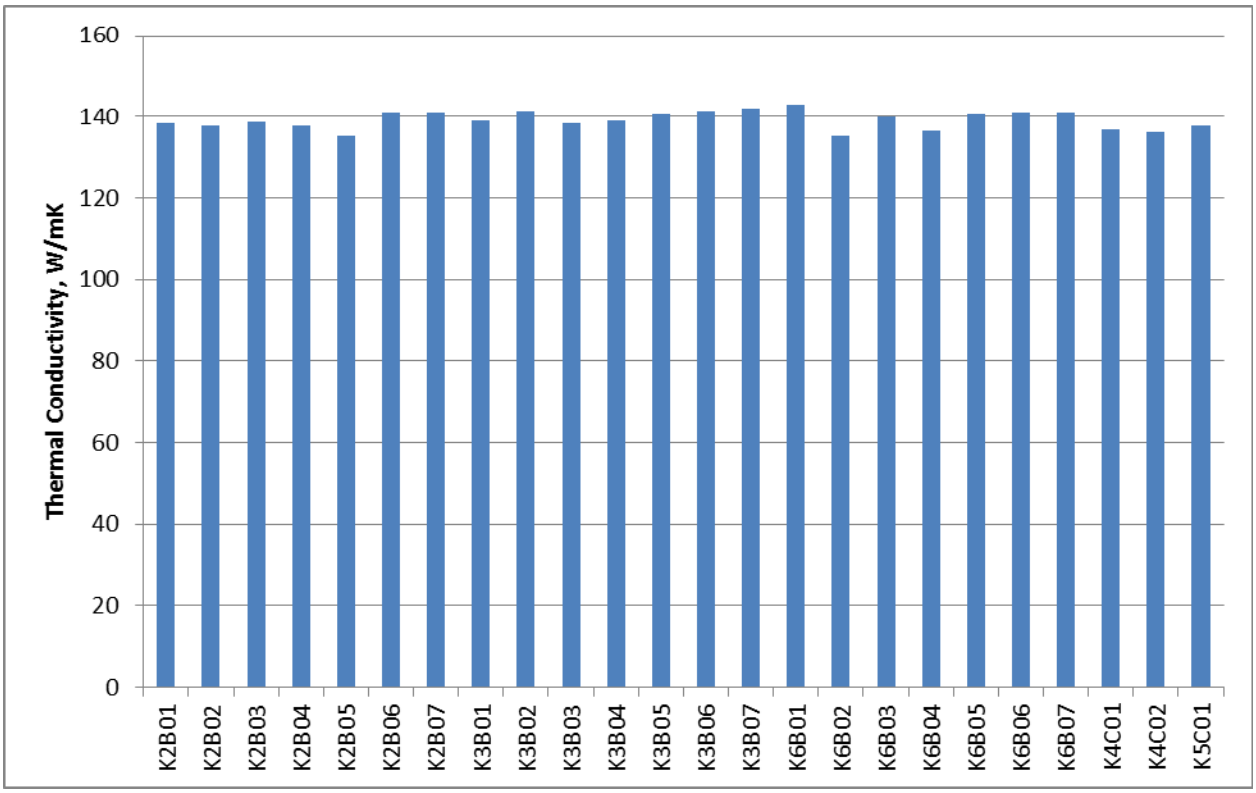

Fig. 139. The ambient temperature thermal conductivity of PGX piggy-back specimens

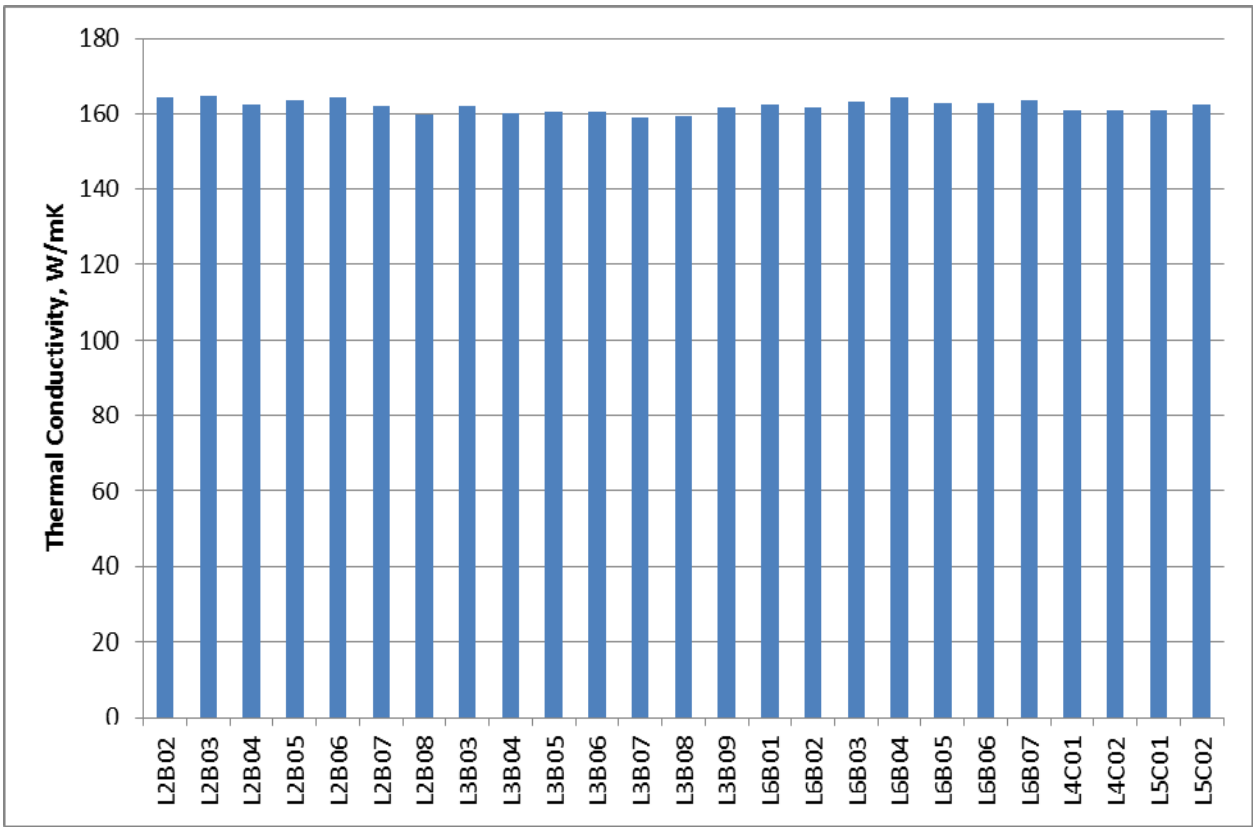

Fig. 140. The ambient temperature thermal conductivity of PPEA piggy-back specimens

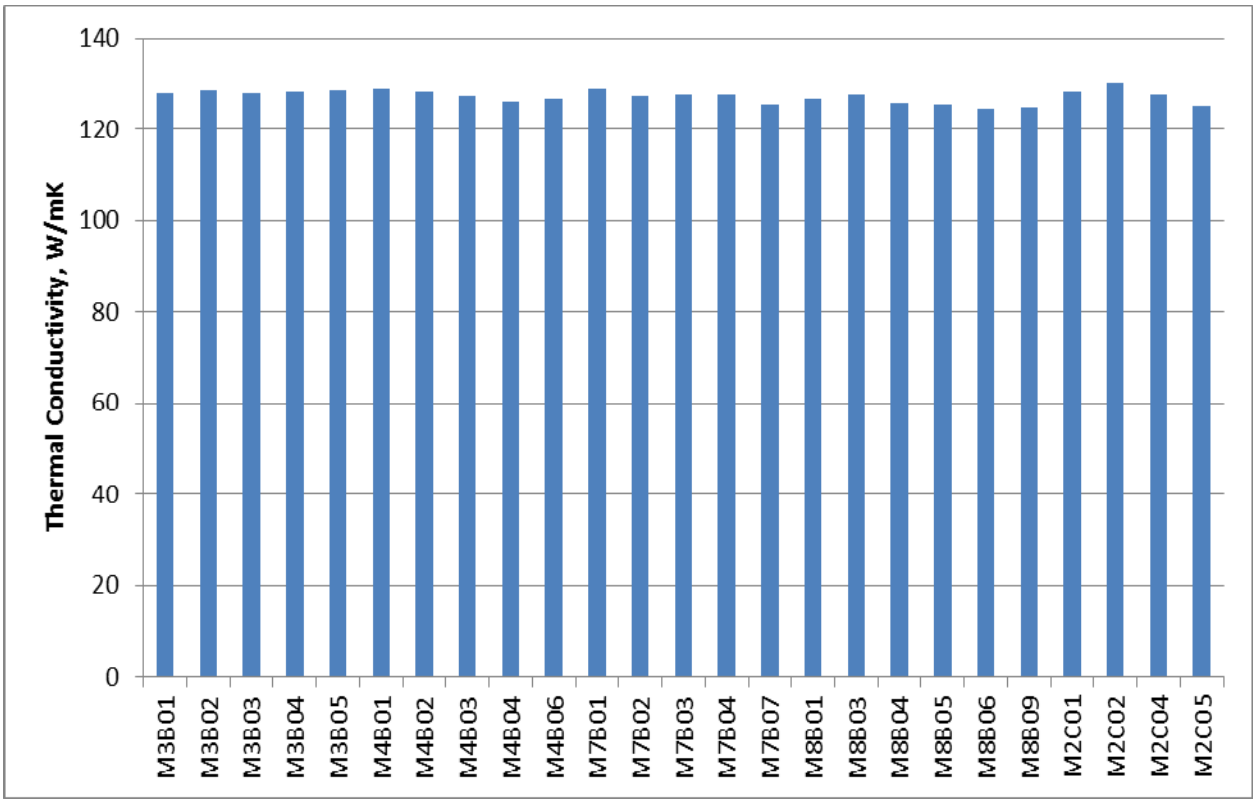

Fig. 141. The ambient temperature thermal conductivity of NBG-25 piggy-back specimens

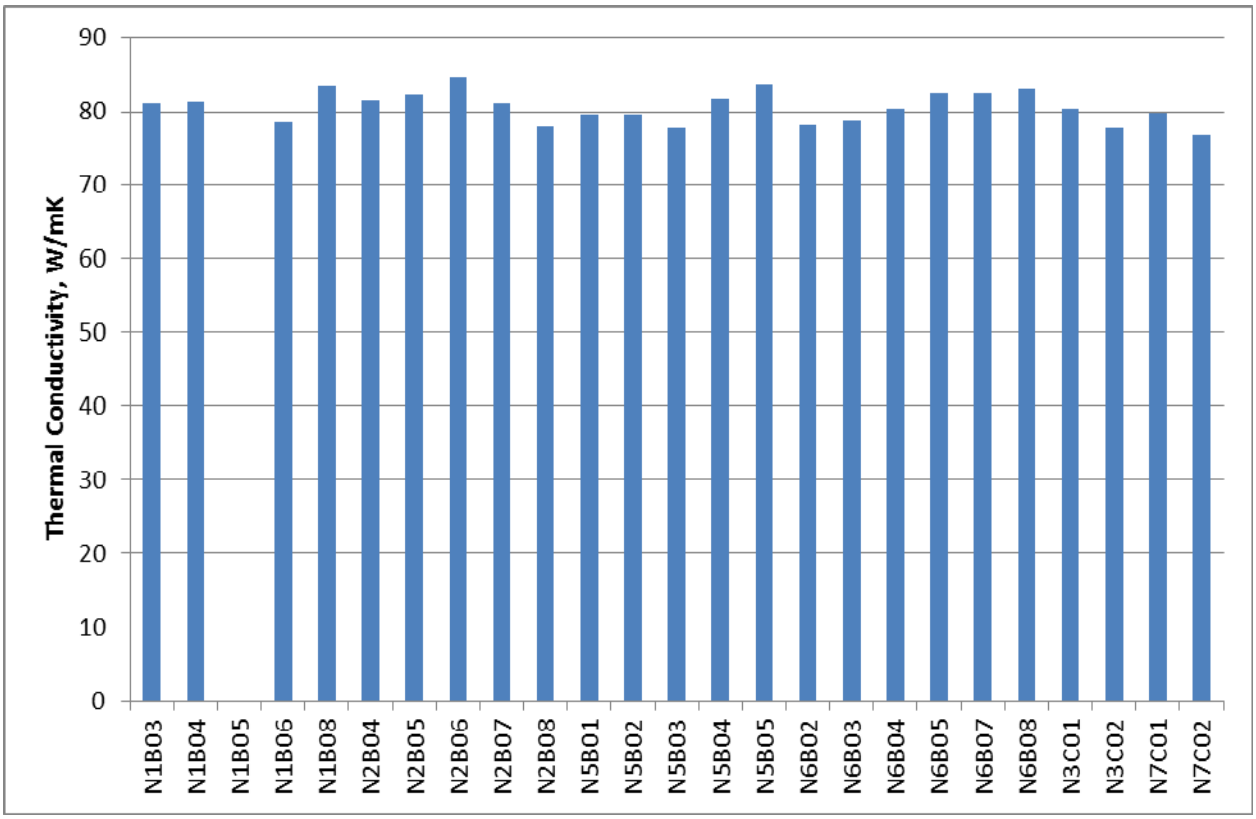

Fig. 142. The ambient temperature thermal conductivity of 2020 piggy-back specimens

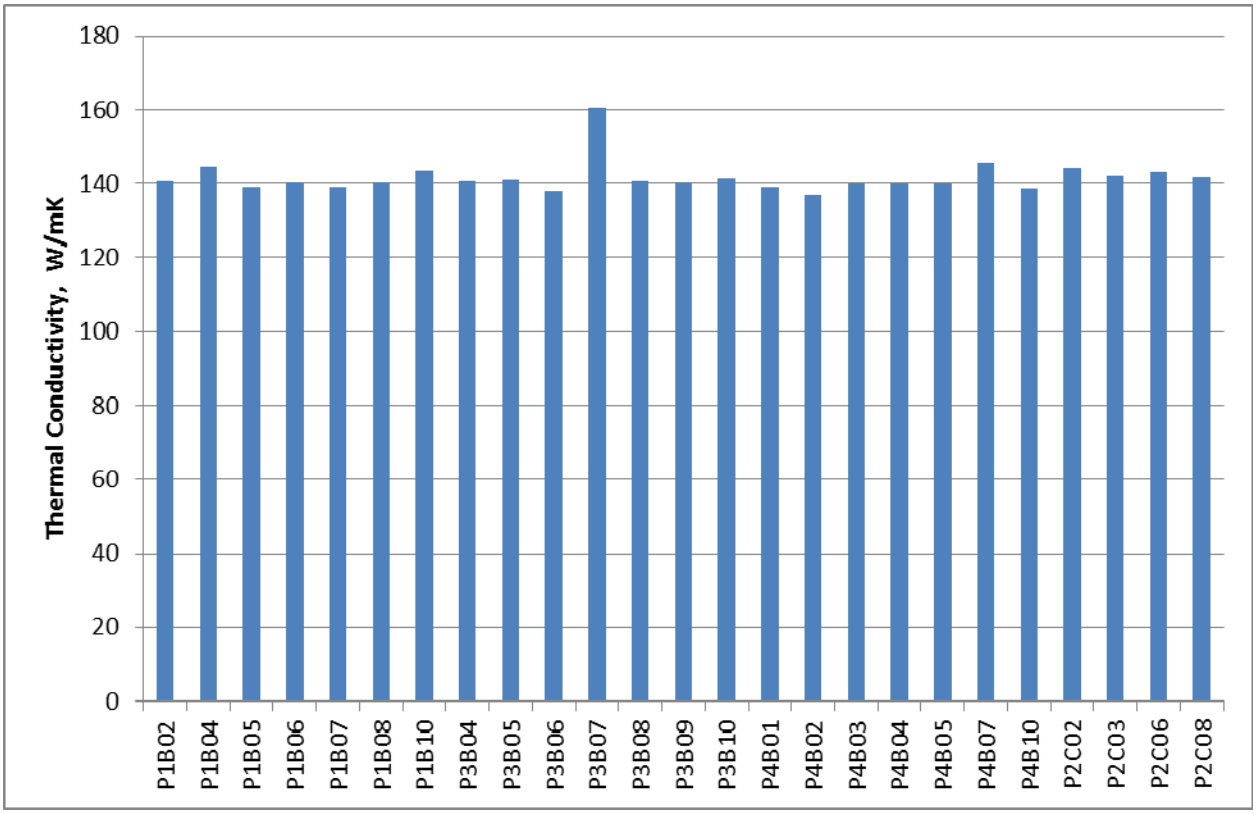

Fig. 143. The ambient temperature thermal conductivity of PCIB piggy-back specimens

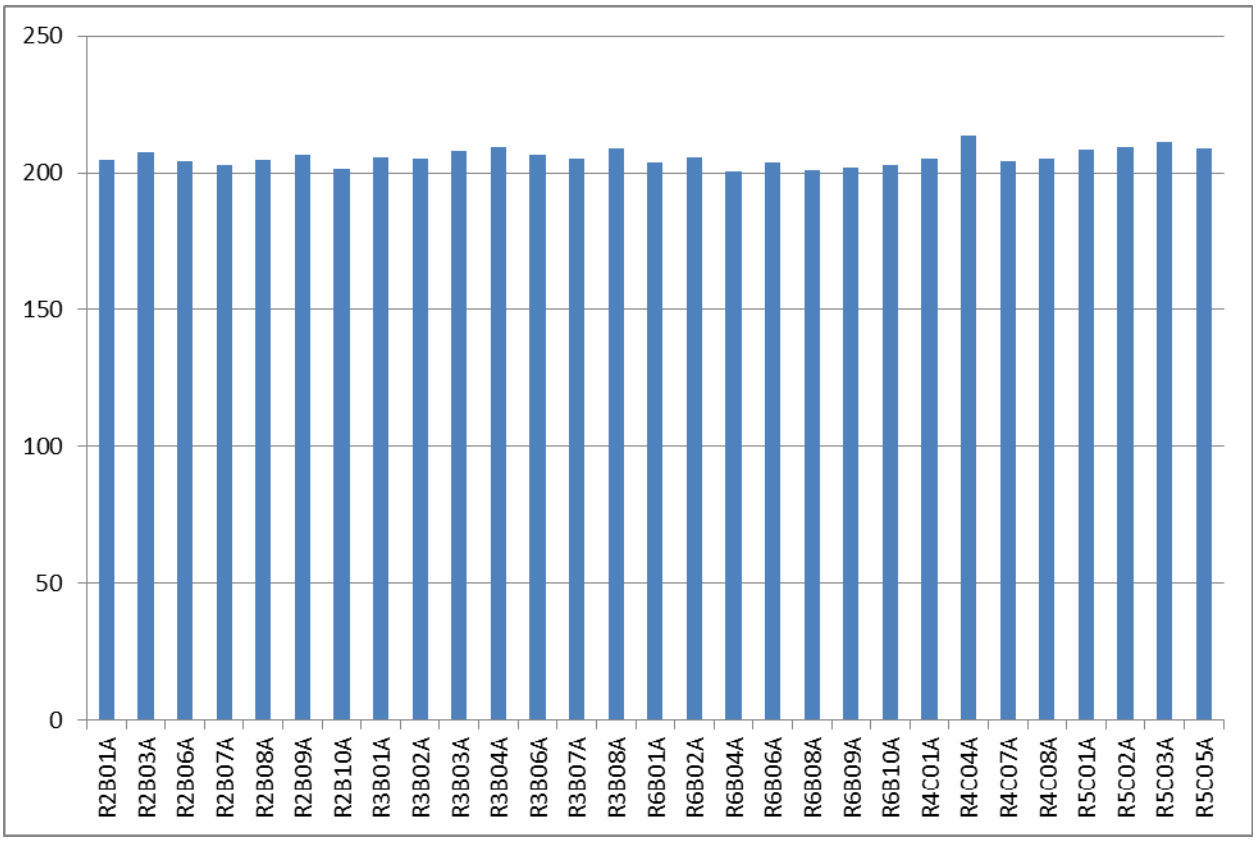

Fig. 144. The ambient temperature thermal conductivity of BAN piggy-back specimens

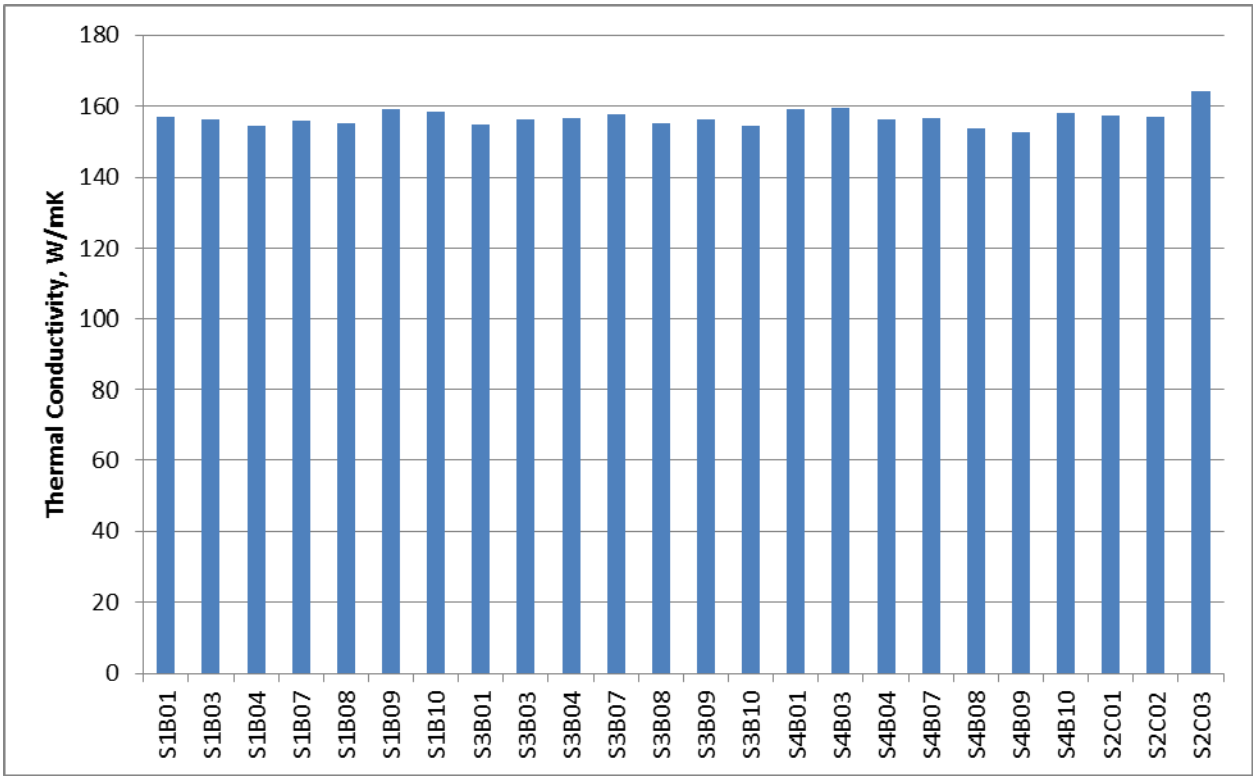

Fig. 145. The ambient temperature thermal conductivity of NBG-10 piggy-back specimens

Table 43. A summary of the mean room temperature thermal conductivity values for the AGC-1 capsule graphite piggy-back specimens

Graphite Grade	Thermal Conductivity (Ambient Temperature) W/mK		
	Mean	St. Dev.	±3 St. Dev.
NBG-17	153.81	2.85	8.55
NBG-18	157.15	1.66	4.98
H-451	189.73	4.92	14.76
PCEA	200.19	3.82	11.46
IG-110	134.25	2.58	7.74
IG-430	157.09	7.97	23.91
A3-Matrix	14.27	4.02	12.06
HLM	215.25	6.4	19.2
PGX	139.14	2.11	6.33
PPEA	162.06	1.6	4.8
NBG-25	127.17	1.44	4.32
2020	80.59	2.15	6.45
PCIB	141.65	4.43	13.29
BAN	205.58	3.12	9.36
NBG-10	156.68	2.43	7.29

No thermal diffusivity data were taken on grade 2020 specimen N1B05 (Fig. 142), presumably due to an oversight. Grade PCIB specimen P3B07 (Fig. 143) exhibits an ambient temperature that appears anomalous. The two diffusivity measurements are in good agreement and the specimen density is representative of this grade and the other specimens within the group. The post-irradiation thermal behavior of this specimen should be monitored closely.

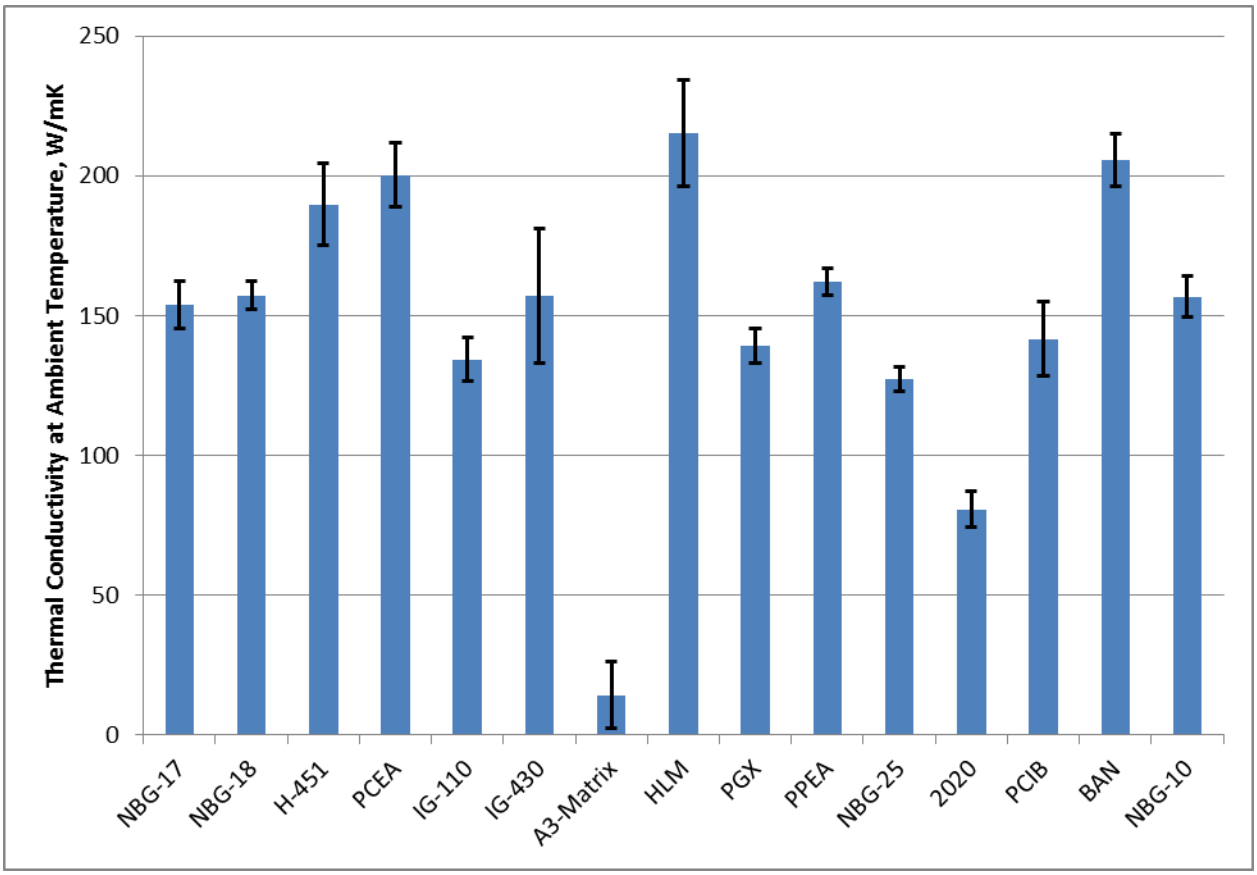

Fig. 146. A comparison of the ambient temperature thermal conductivity of the various graphite grades in AGC-1 (error bars represent ± 3 standard deviation)

The majority of the fully dense graphite exhibited a room temperature thermal conductivity in the range 100-210 W/m.K. Grade 2020 exhibited a particularly low conductivity (80.6 W/m.K). The A3-matrix samples exhibited a mean conductivity of 14.3 W/m.K. The low conductivity can be attributed to several factors such as the low final heat treatment temperature of A3-matrix (~1800°C) which is insufficiently high to graphitize the A3-matrix. Moreover, the density of A3-matrix is substantially lower than the graphite included here (see discussion in Section 3.1). The graphite grades tending to exhibit the greatest room temperature thermal conductivities were the extruded (WG orientation) grades.

3.5. Pre-Irradiation Examination, Thermal Expansion

The creep geometry specimens from the six major grades were subject to thermal expansion measurement over the temperature range 100 to 800°C at 100°C intervals. The data were recorded electronically and then transposed (cut and pasted) into the data package reported earlier [1]. Review of the data revealed only one data package error, namely that the data for NBG-17 specimen AL8-02 was incorrectly copied (a duplicate data set from AL8-03 specimen was erroneously reported). This error was corrected during this analysis and the revised data package is correct. The measurement temperature, thermal expansion, instantaneous coefficient of thermal expansion, and mean coefficient of thermal expansion (CTE) are reported for all the specimens in Appendices 73 to 141. The thermal expansion and mean CTE are plotted in groups, by graphite grade in Figs. 147-208.

The expansion and CTE data for PCEA specimens DA7-02 and DA8-01confirm that these specimens are in fact with-grain orientation rather than against-grain specimens as marked. The data for these two specimens are plotted in Figs 183 and 184 along with other PCEA with-grain specimens and Figs. 187 and 188 with against-grain specimens in order to highlight the differences.

The thermal expansion data sets are remarkably consistent within grades. The mean CTE is somewhat more variable within grades, particularly at the lower measurements temperatures. However, at higher temperatures the within grades variability is markedly reduced. The ASTM specifications for nuclear graphite, D7219 [16] require the with-grain CTE (25-500°C) to be between 3.5 and 5.5 x 10^{-6} $°C^{-1}$. The CTE data reported here are summarized in Table 44 and Fig. 209 which reports the mean CTE (10-500°C) for all the primary grades. Grade NBG-17 (AG) mean CTE (25-500°C) was slightly above this range (5.54 x 10^{-6}). The NBG-17 used here was from a trial batch, not a production batch, and this may have caused the slightly higher CTE. Subsequent production batches of NBG-17 included in the AGC series and baseline program should be monitored closely to assure CTE compliance. For all grades exhibiting texture, the CTE (AG) > CTE (WG), which would be predicted from the crystal CTEs and the preferred crystal orientation.

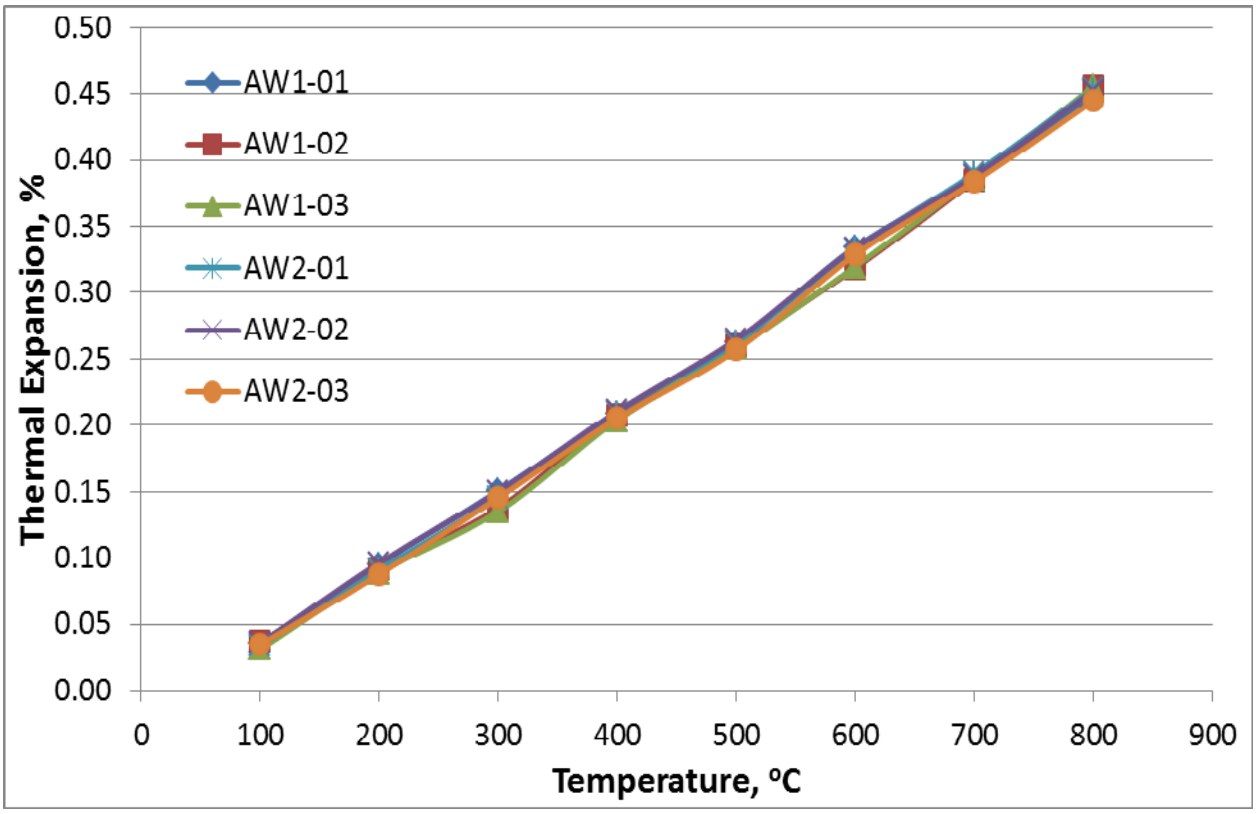

Fig. 147. The thermal expansion behavior of NBG-17 (AG) creep specimens

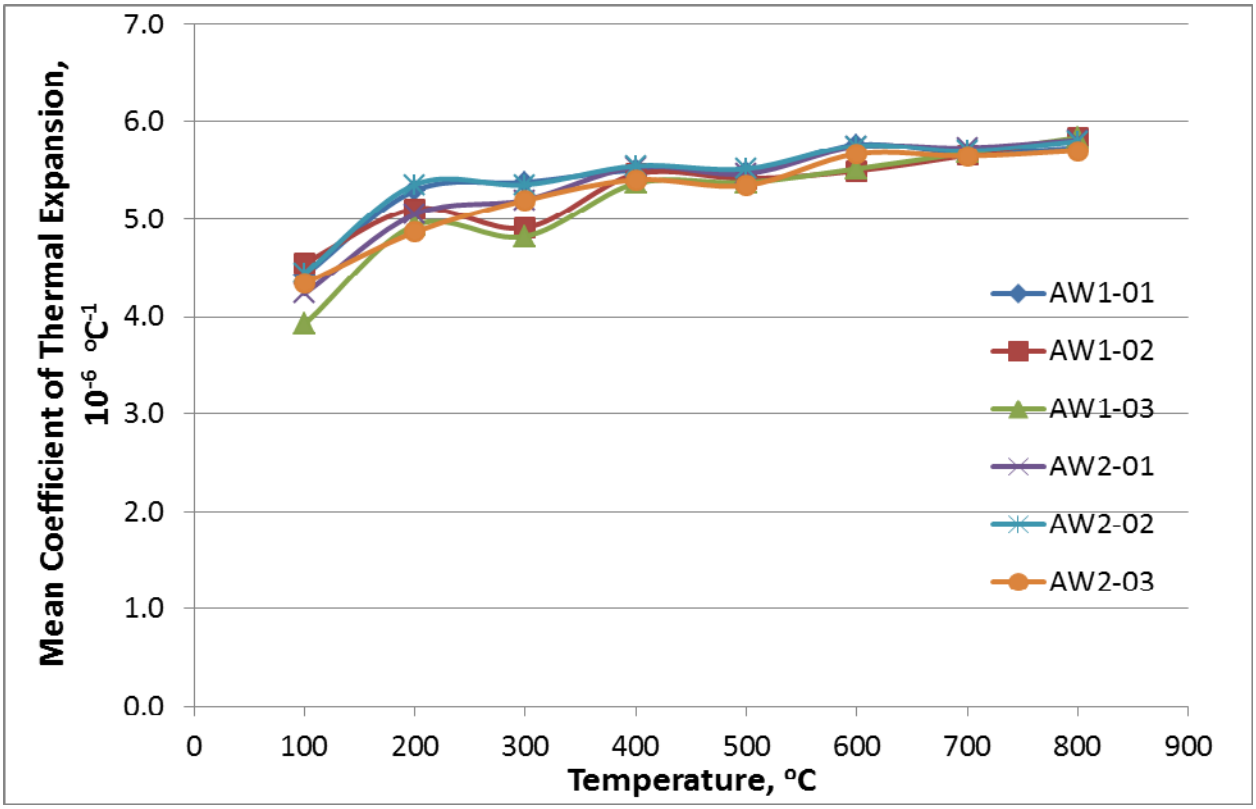

Fig. 148. The mean coefficient of thermal expansion for NBG-17 (AG) creep specimens

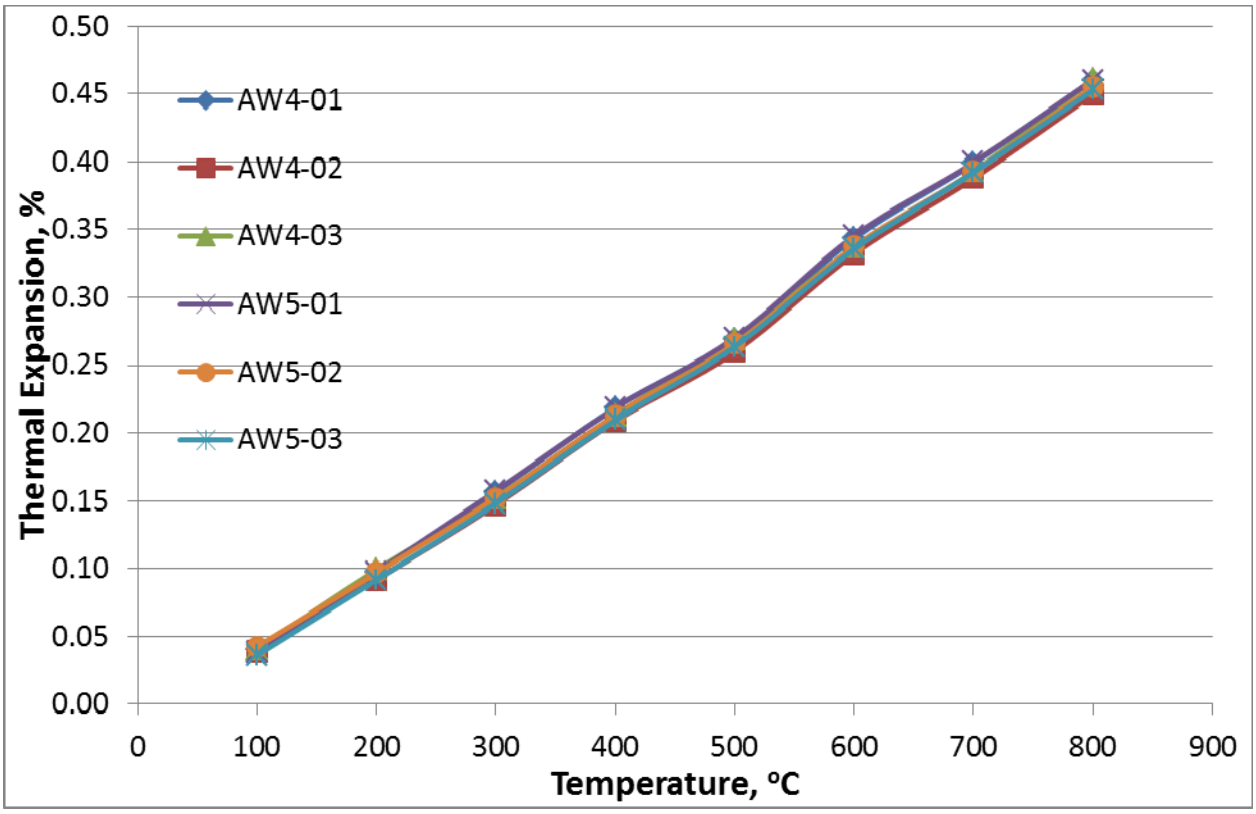

Fig. 149. The thermal expansion behavior of NBG-17 (AG) creep specimens

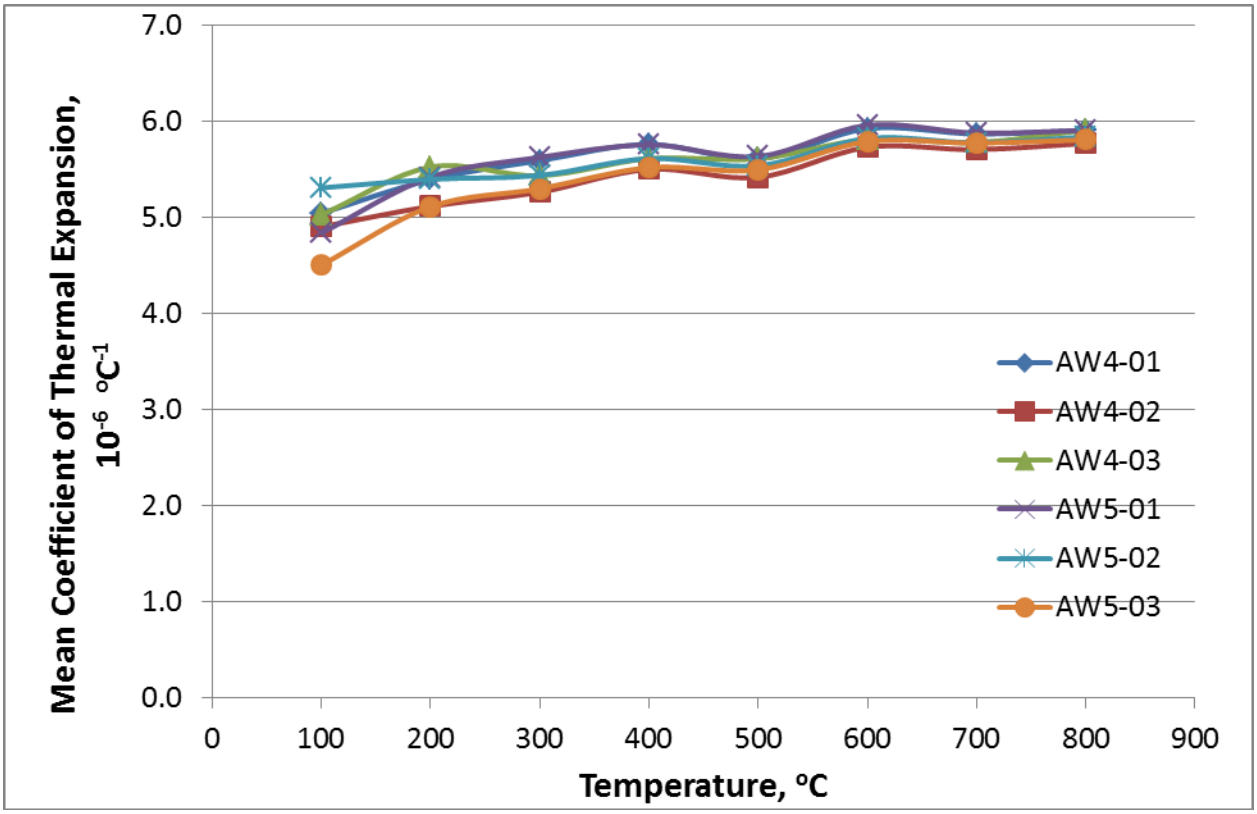

Fig. 150. The mean coefficient of thermal expansion for NBG-17 (AG) creep specimens

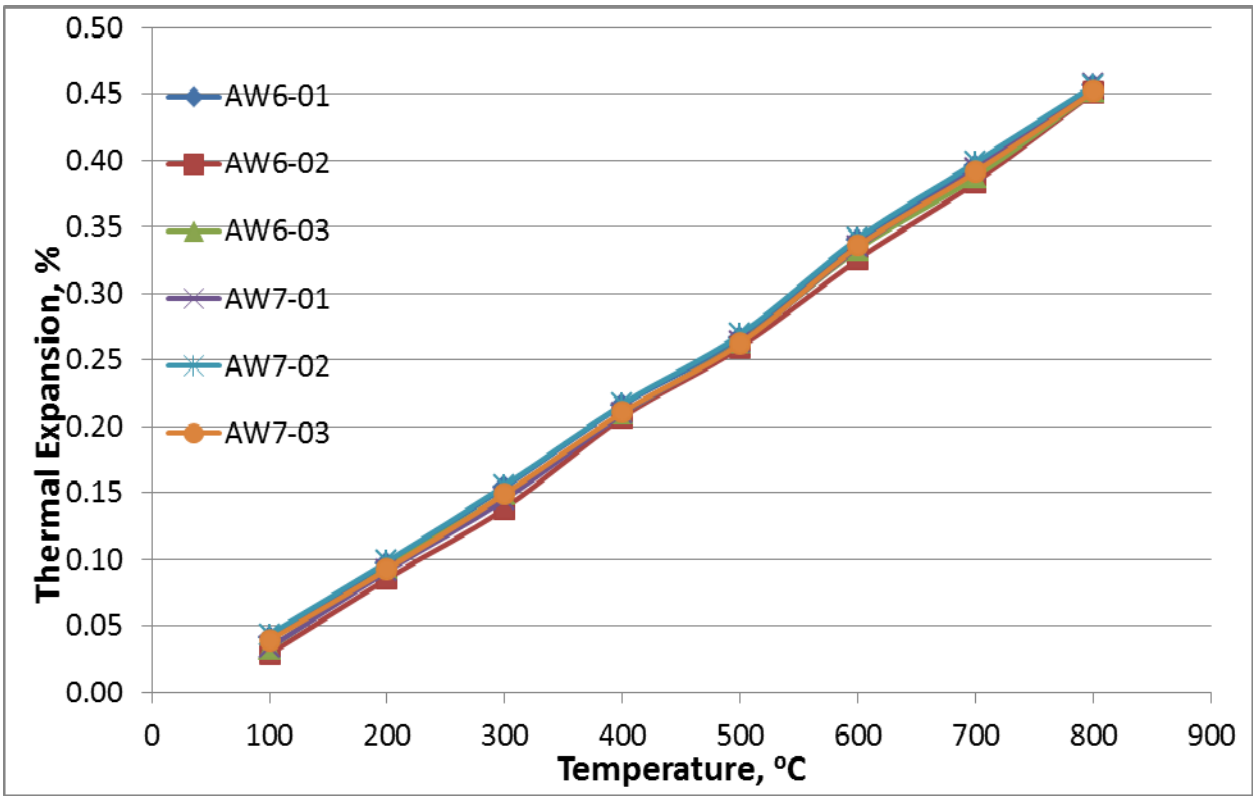

Fig. 151. The thermal expansion behavior of NBG-17 (AG) creep specimens

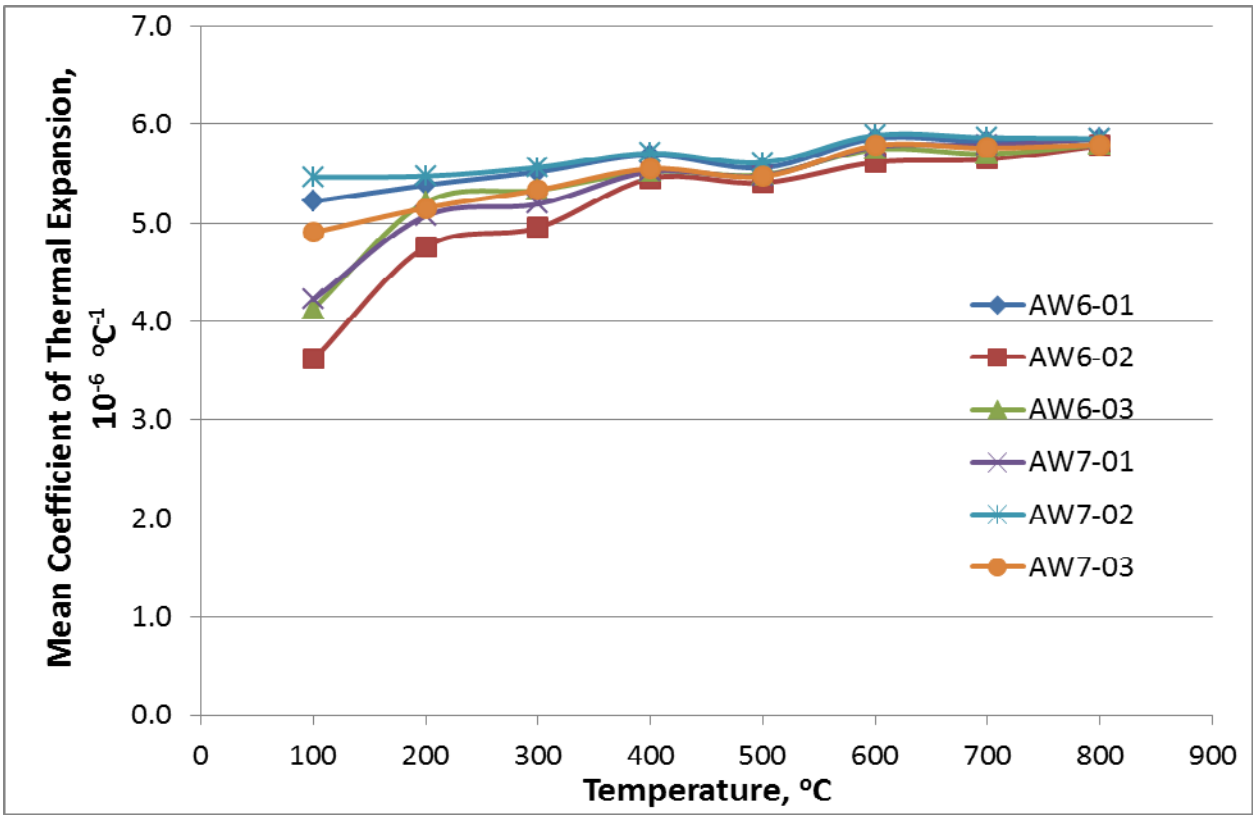

Fig. 152. The mean coefficient of thermal expansion for NBG-17 (AG) creep specimens

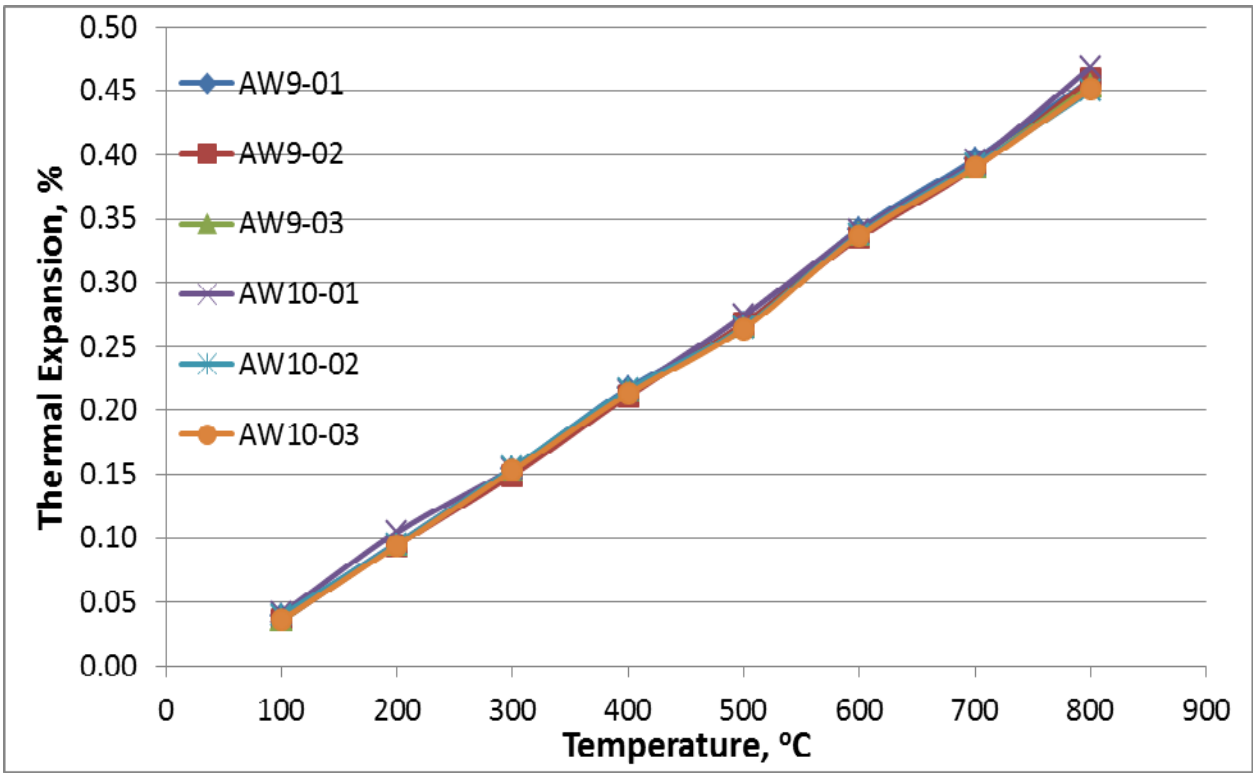

Fig. 153. The thermal expansion behavior of NBG-17 (AG) creep specimens

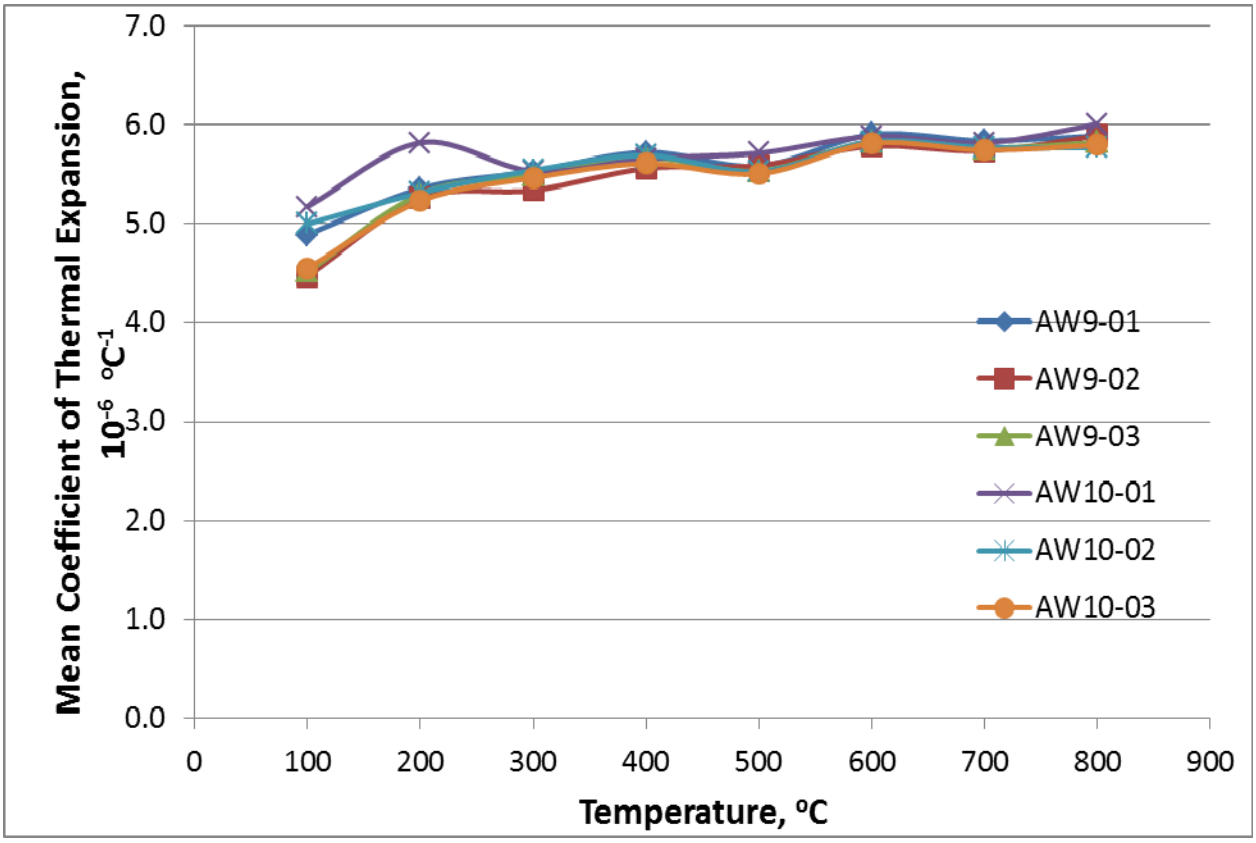

Fig. 154. The mean coefficient of thermal expansion for NBG-17 (AG) creep specimens

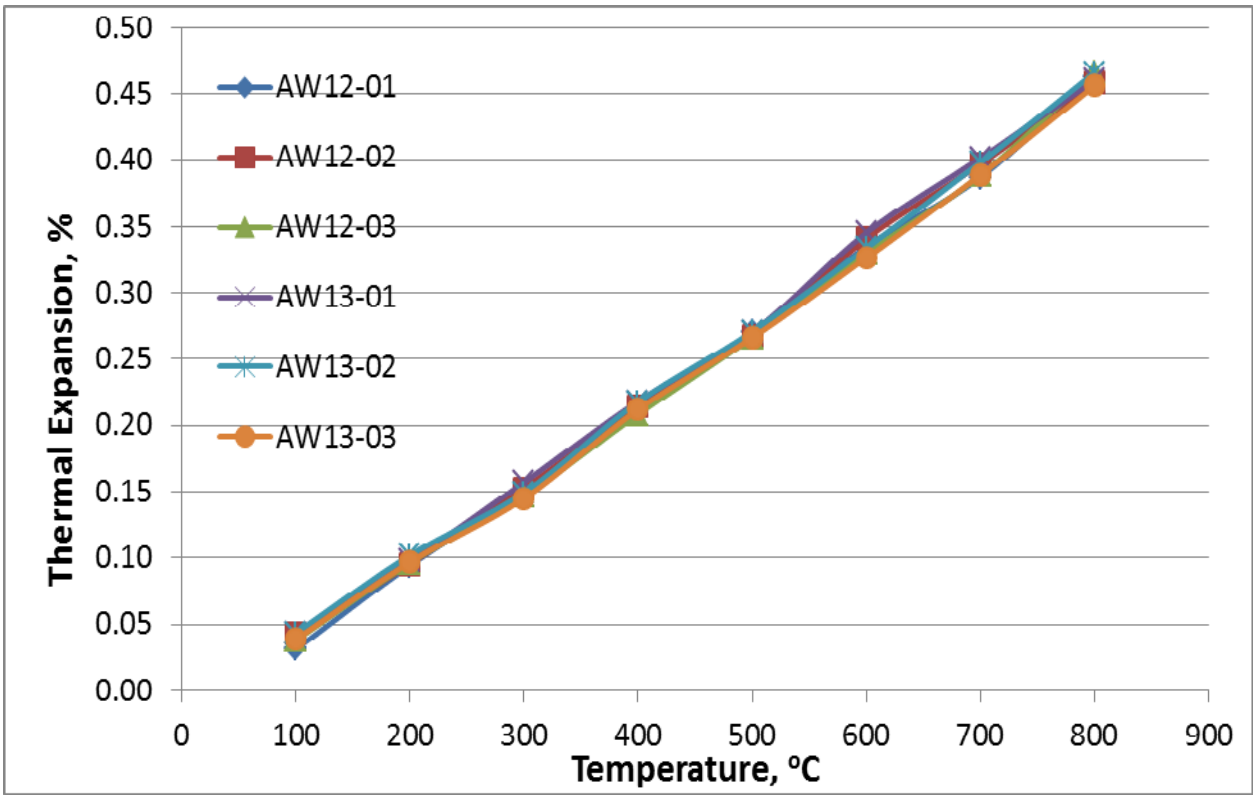

Fig. 155. The thermal expansion behavior of NBG-17 (AG) creep specimens

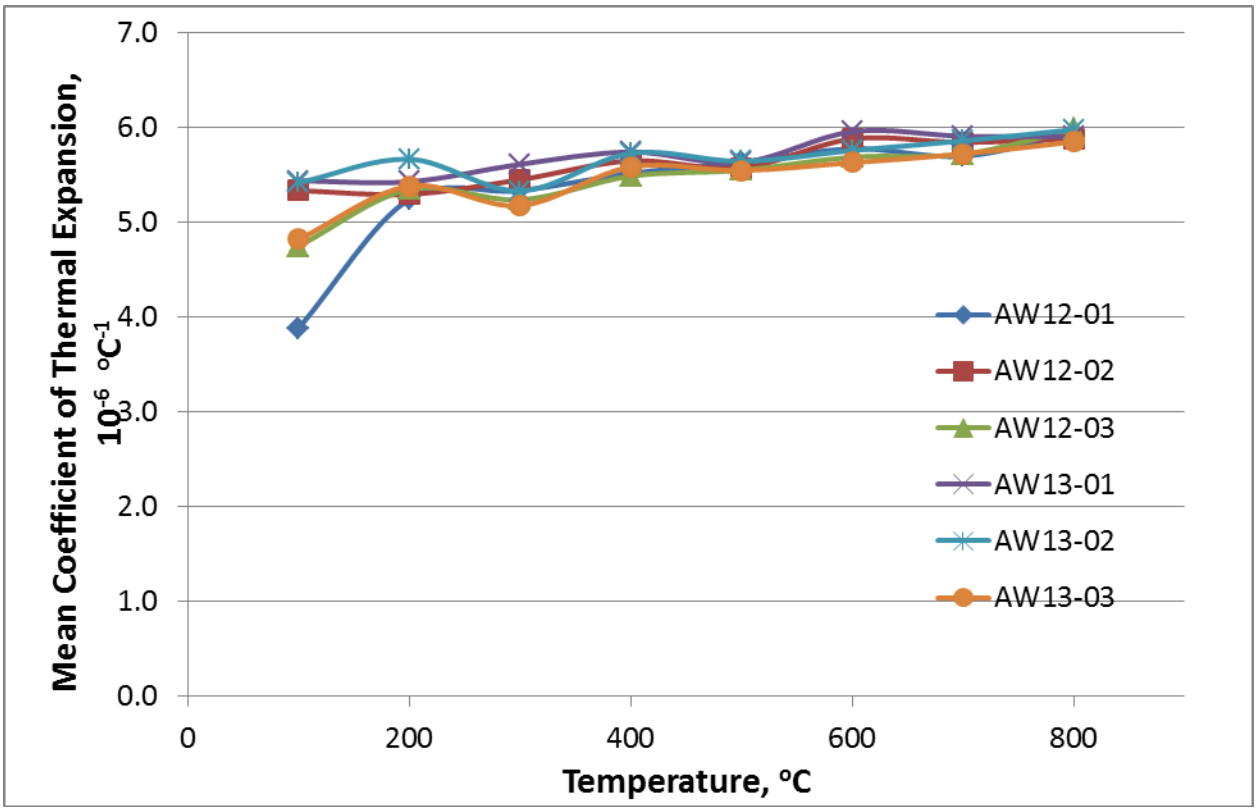

Fig. 156. The mean coefficient of thermal expansion for NBG-17 (AG) creep specimens

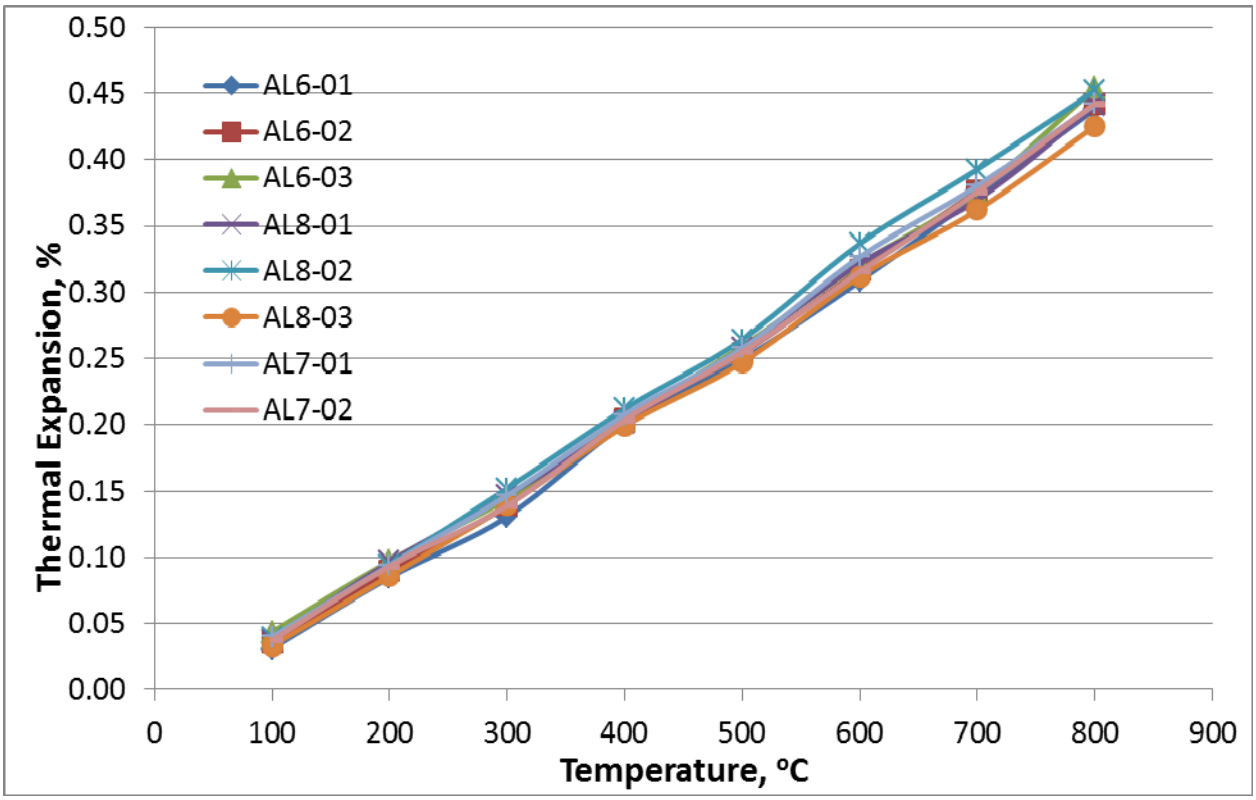

Fig. 157. The thermal expansion behavior of NBG-17 (WG) creep specimens

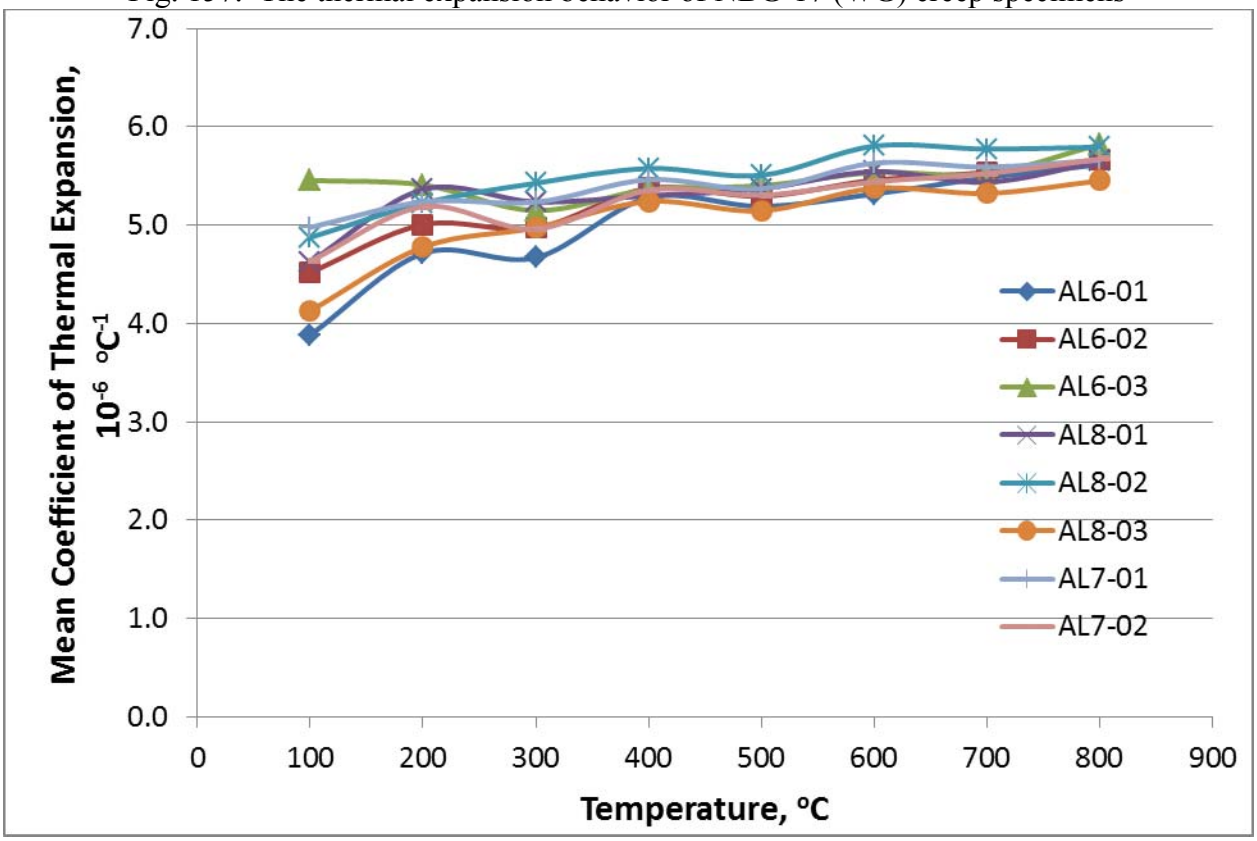

Fig. 158. The mean coefficient of thermal expansion for NBG-17 (WG) creep specimens

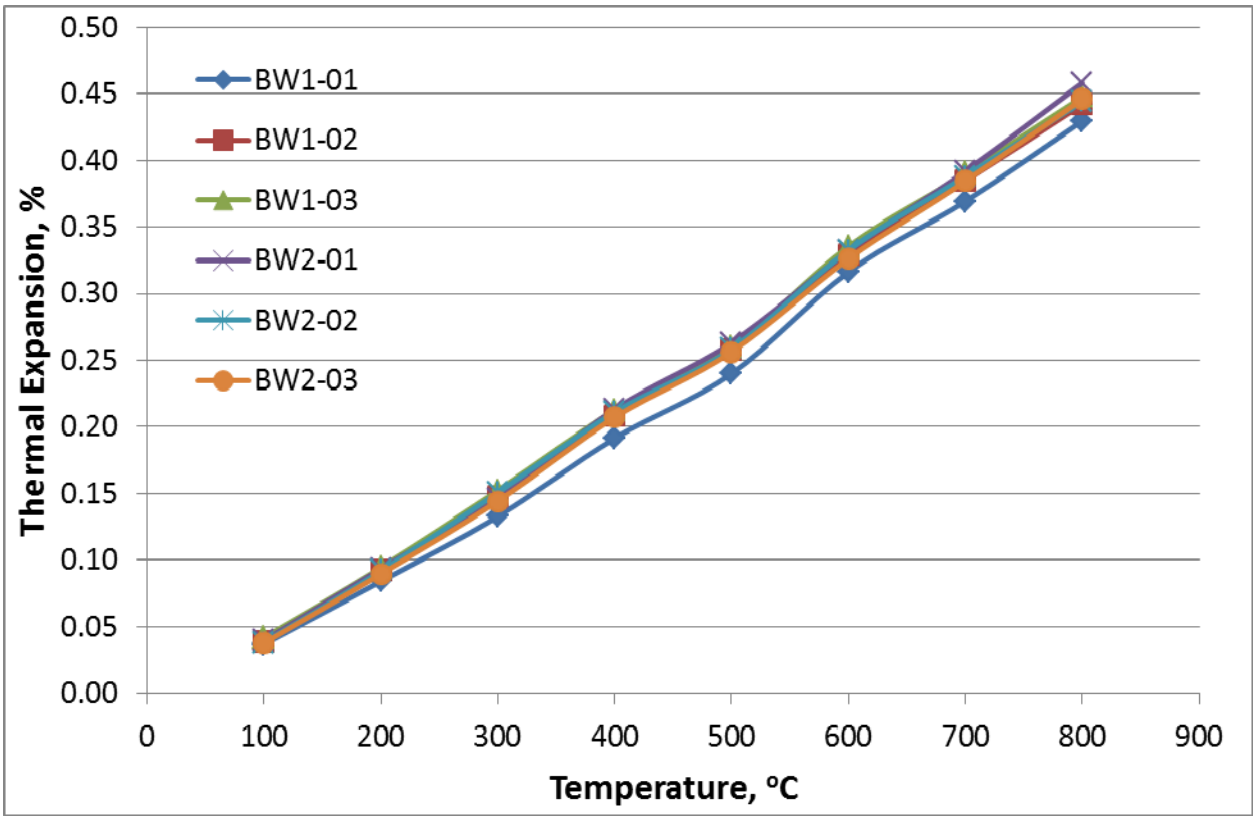

Fig. 159. The thermal expansion behavior of NBG-18 (AG) creep specimens

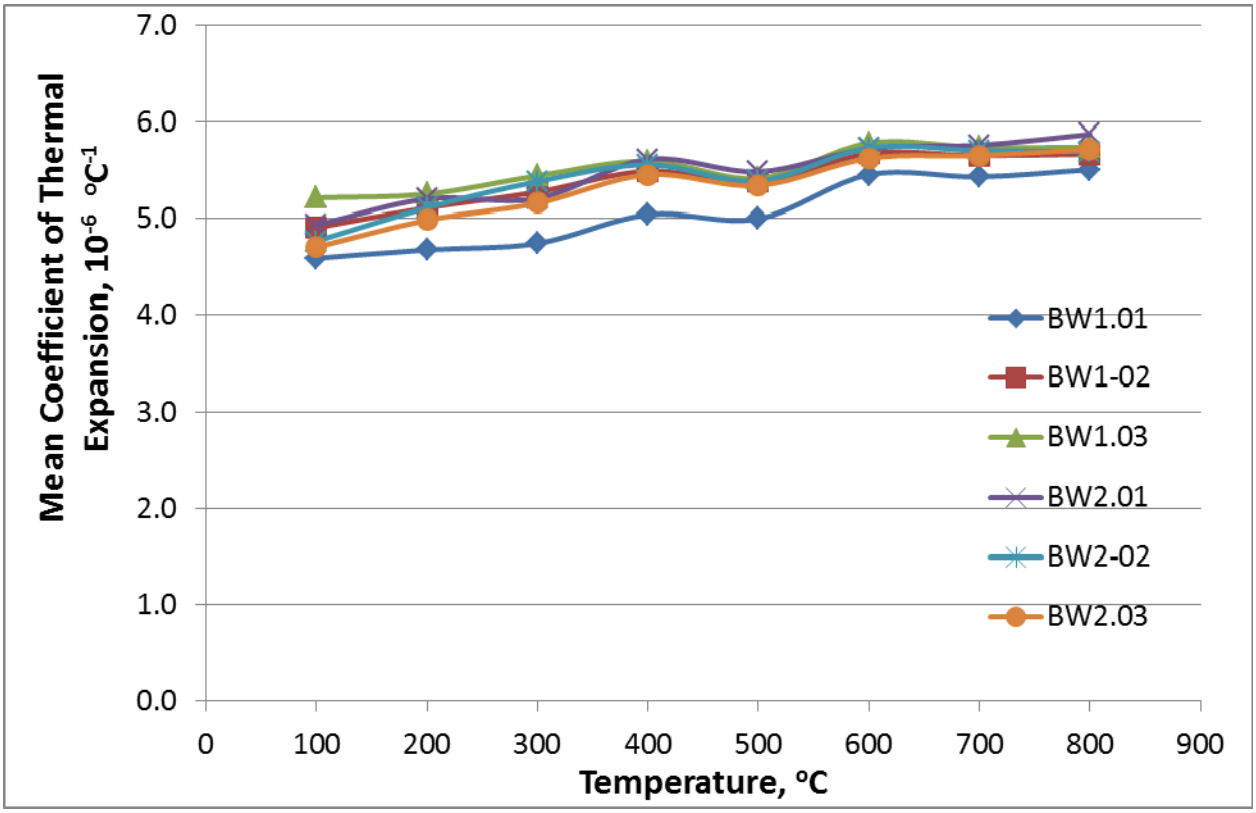

Fig. 160. The mean coefficient of thermal expansion for NBG-18(AG) creep specimens

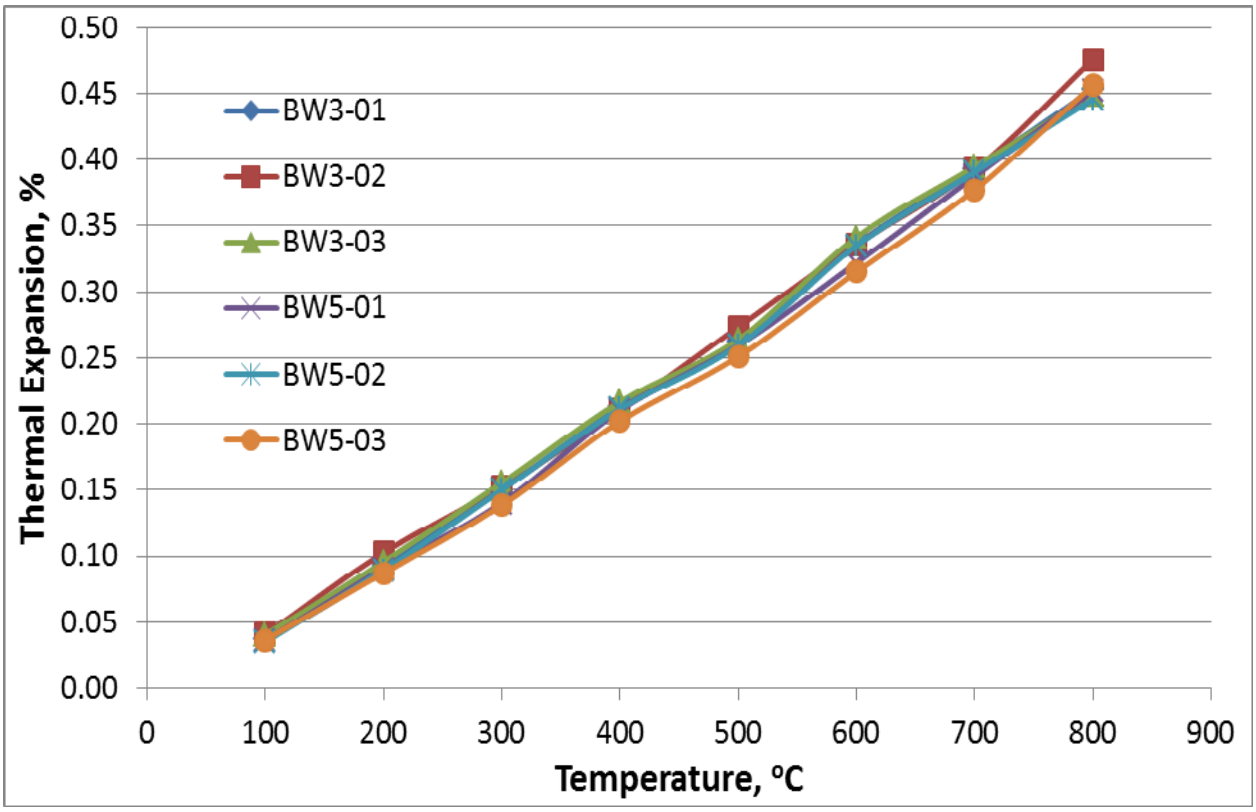

Fig. 161. The thermal expansion behavior of NBG-18 (AG) creep specimens

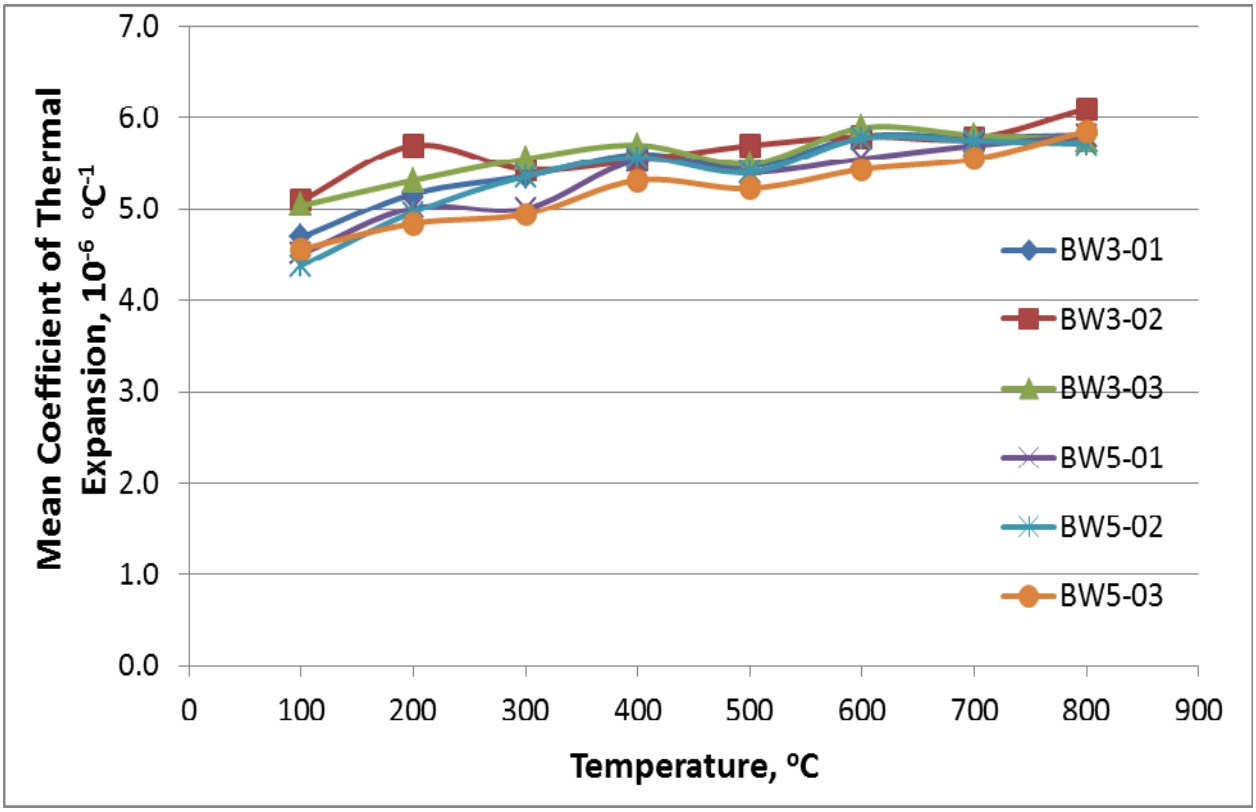

Fig. 162. The mean coefficient of thermal expansion for NBG-18 (AG) creep specimens

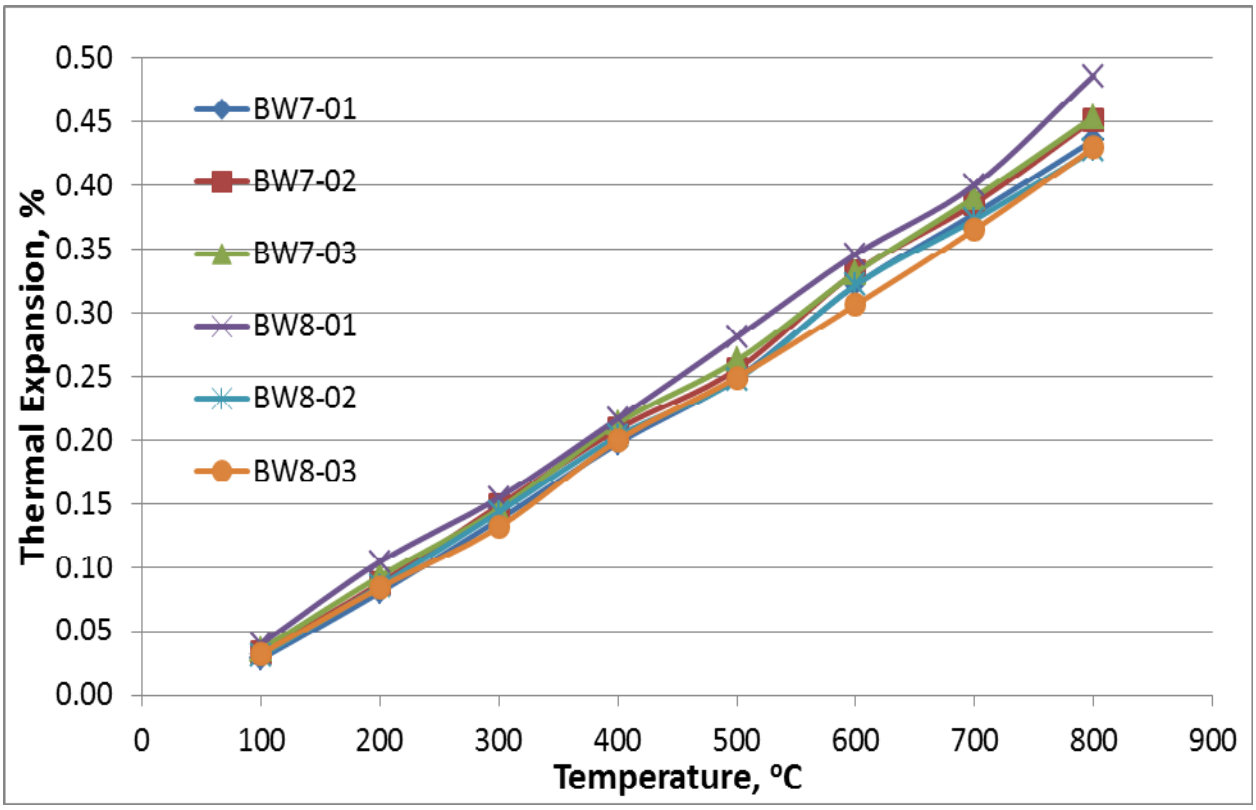

Fig. 163. The thermal expansion behavior of NBG-18 (AG) creep specimens

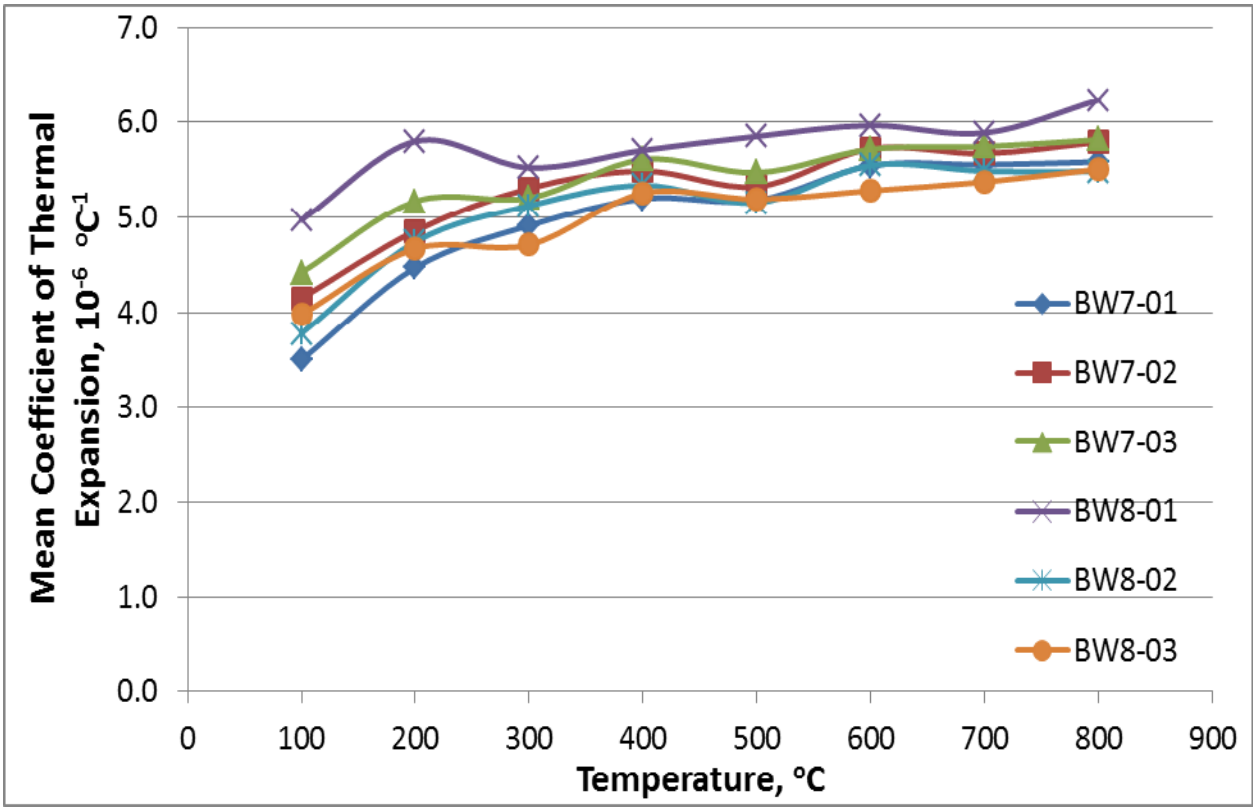

Fig. 164. The mean coefficient of thermal expansion for NBG-18 (AG) creep specimens

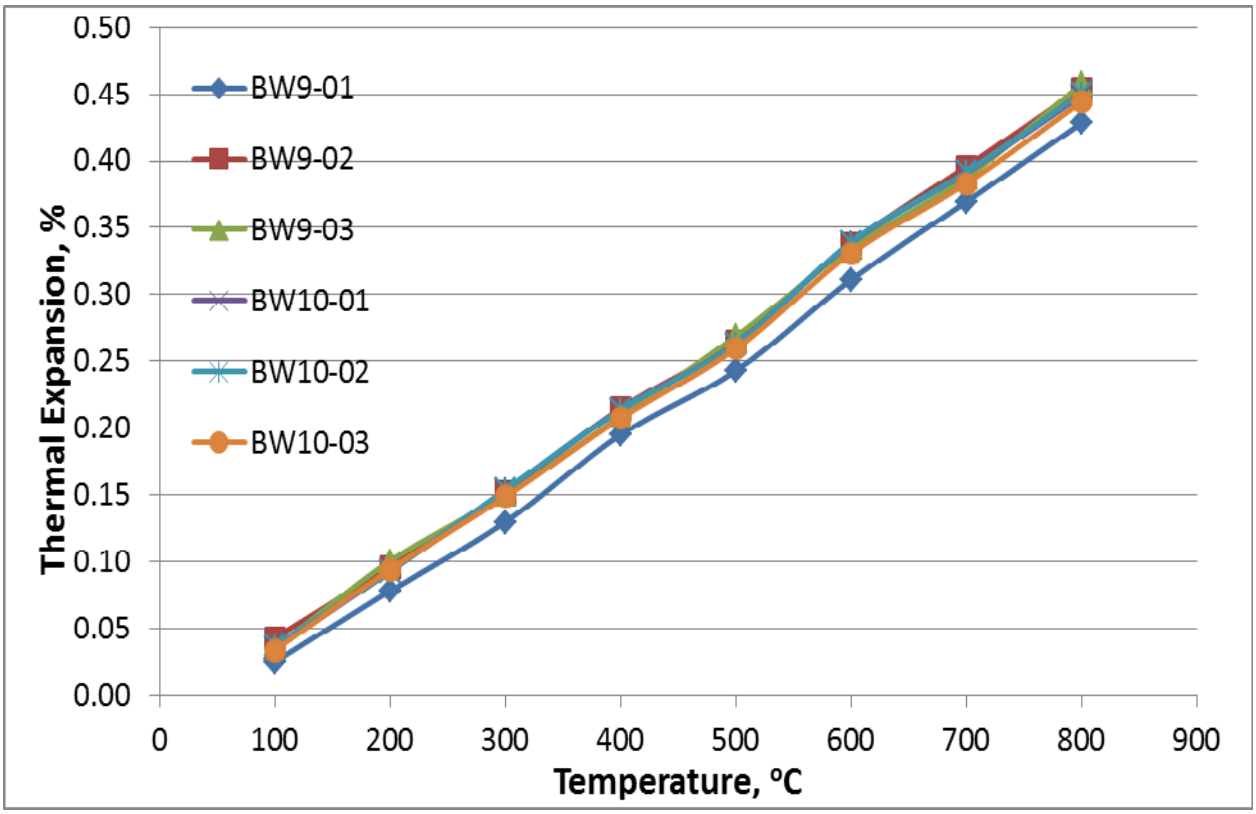

Fig. 165. The thermal expansion behavior of NBG-18 (AG) creep specimens

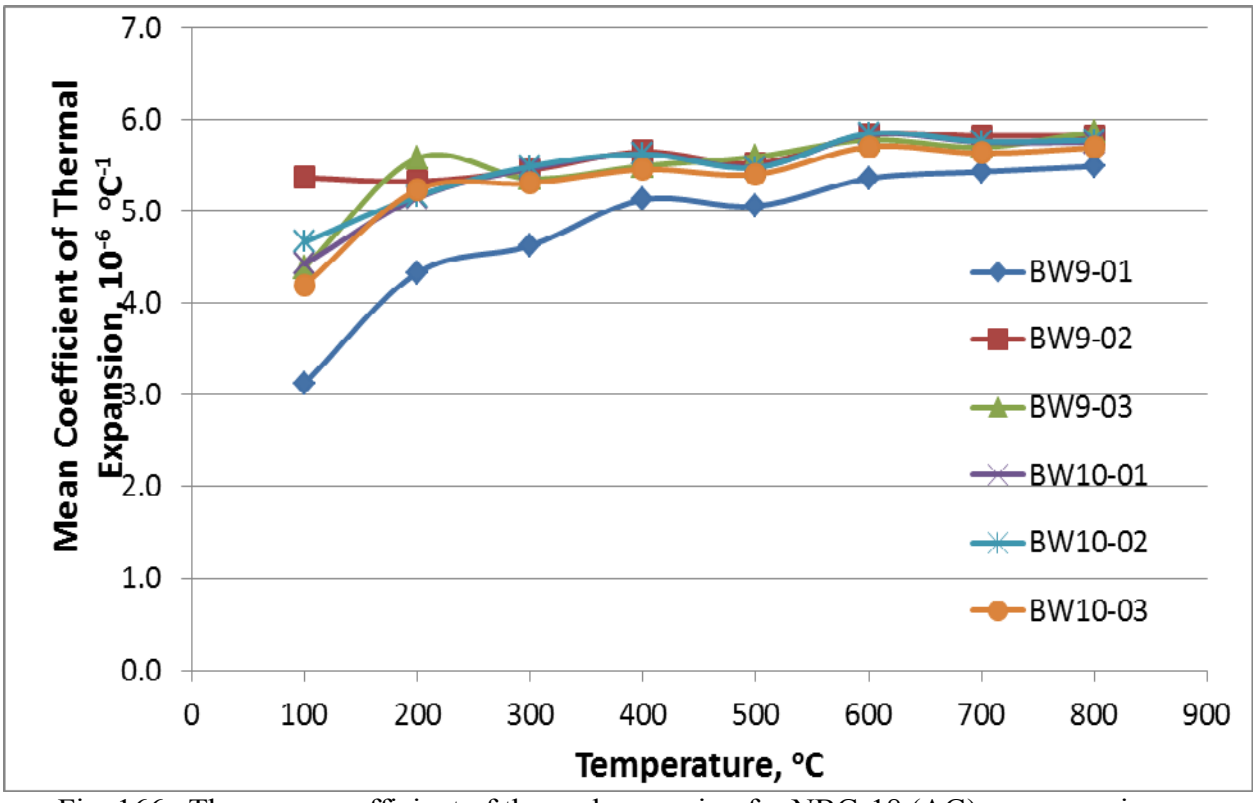

Fig. 166. The mean coefficient of thermal expansion for NBG-18 (AG) creep specimens

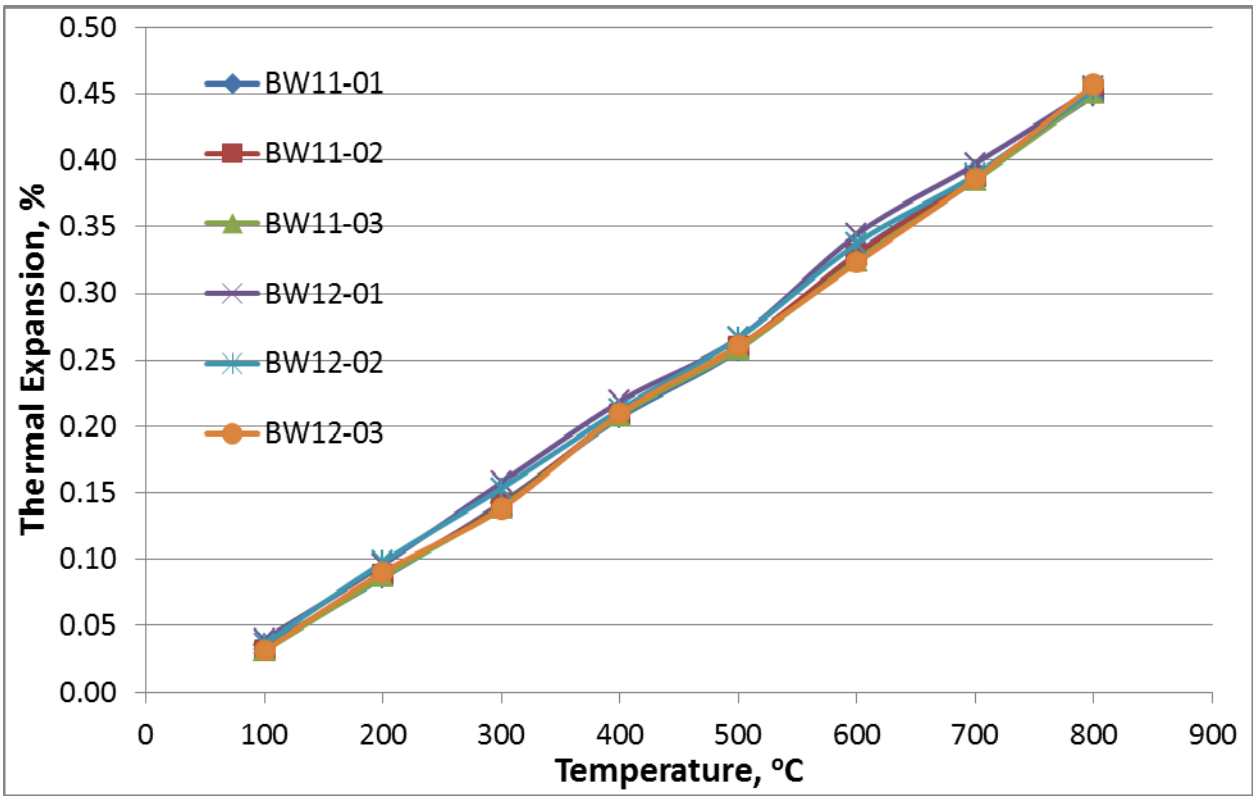

Fig. 167. The thermal expansion behavior of NBG-18 (AG) creep specimens

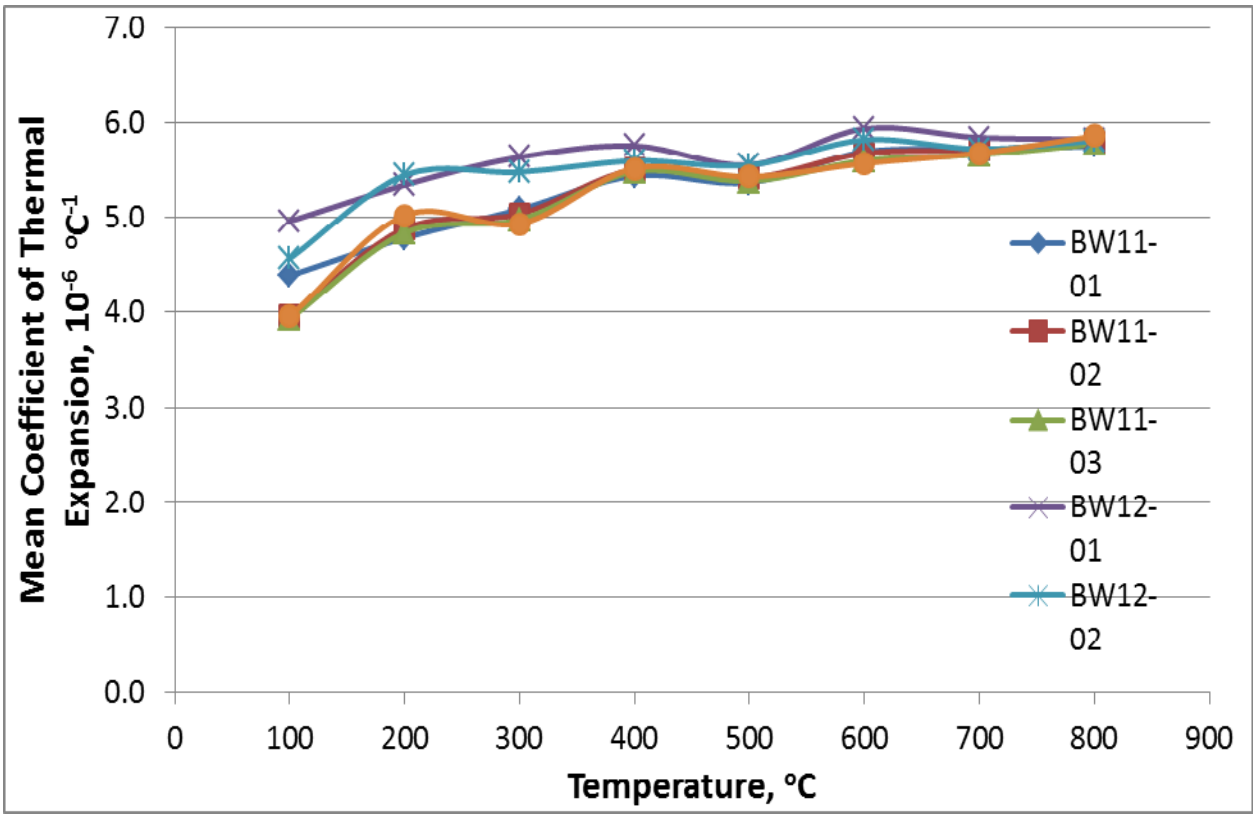

Fig. 168. The mean coefficient of thermal expansion for NBG-18 (AG) creep specimens

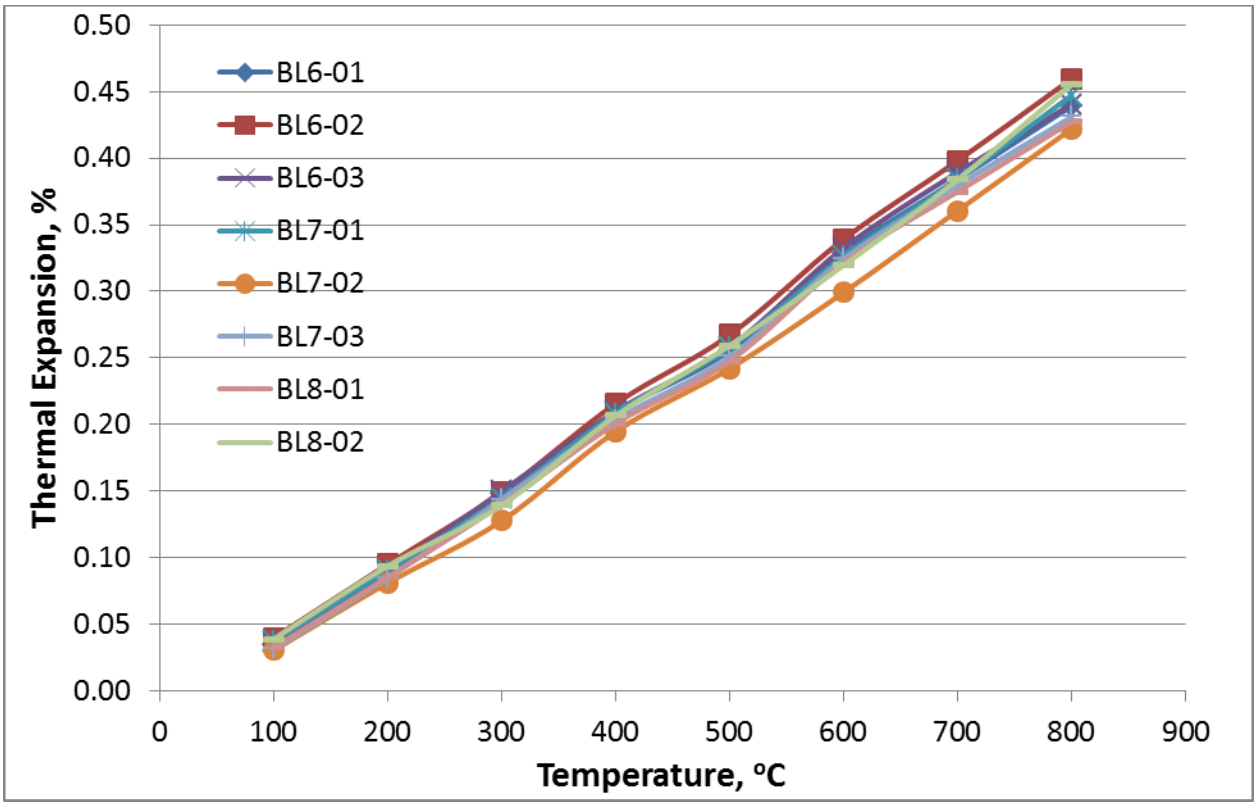

Fig. 169. The thermal expansion behavior of NBG-18 (WG) creep specimens

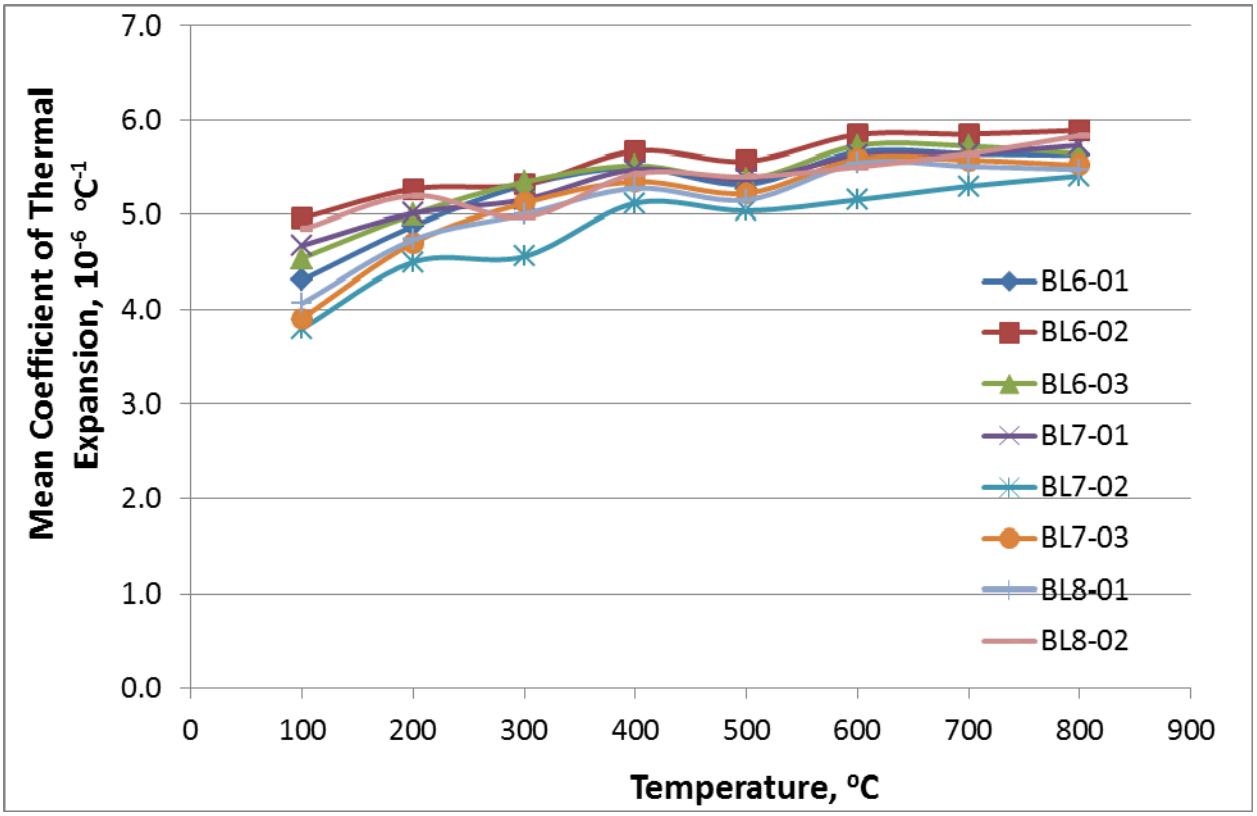

Fig. 170. The mean coefficient of thermal expansion for NBG-18 (WG) creep specimens

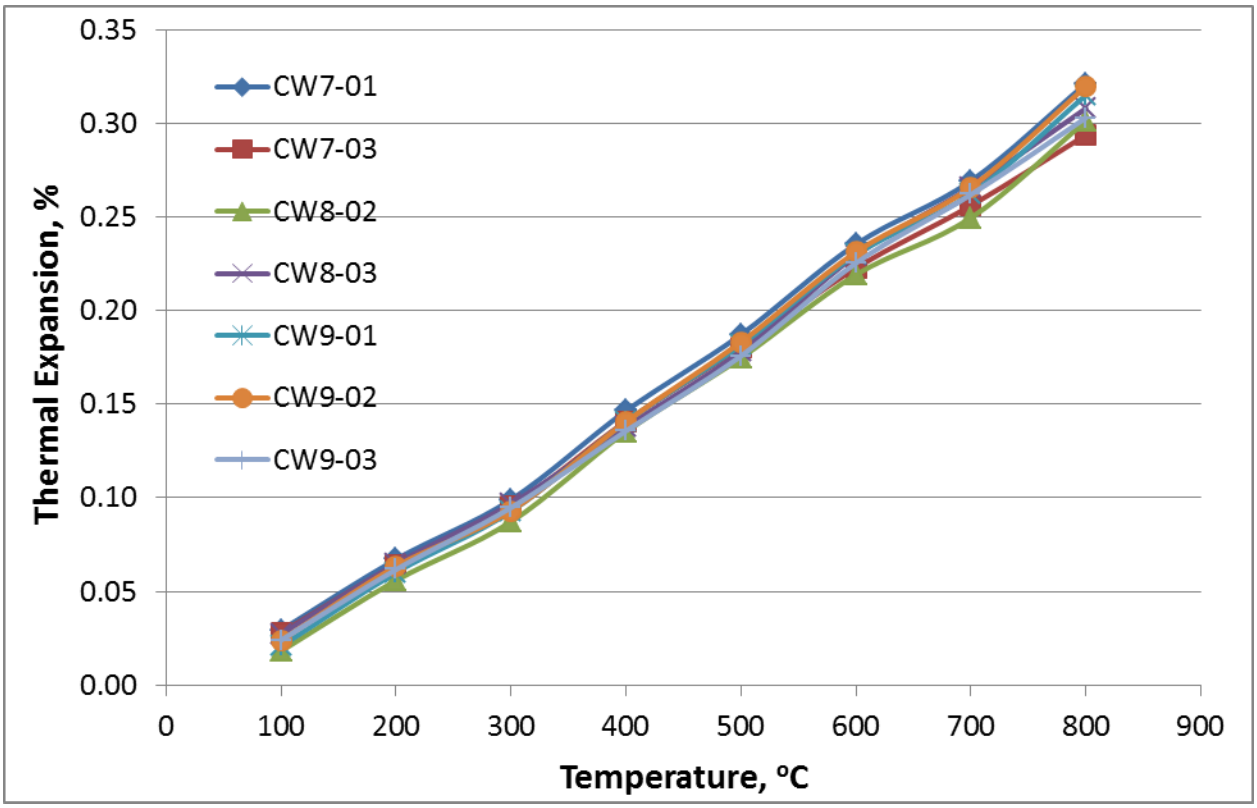

Fig. 171. The thermal expansion behavior of H-451 (WG) creep specimens

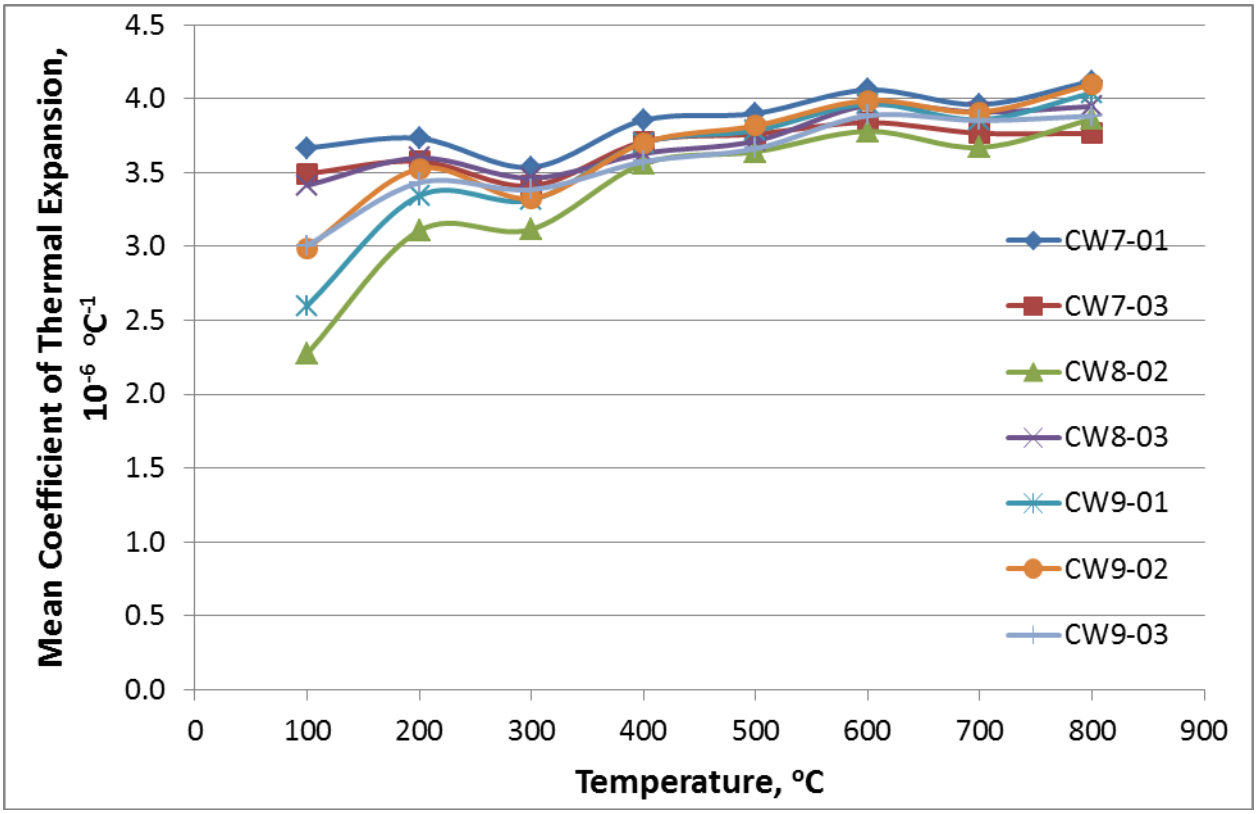

Fig. 172. The mean coefficient of thermal expansion for H-451 (WG) creep specimens

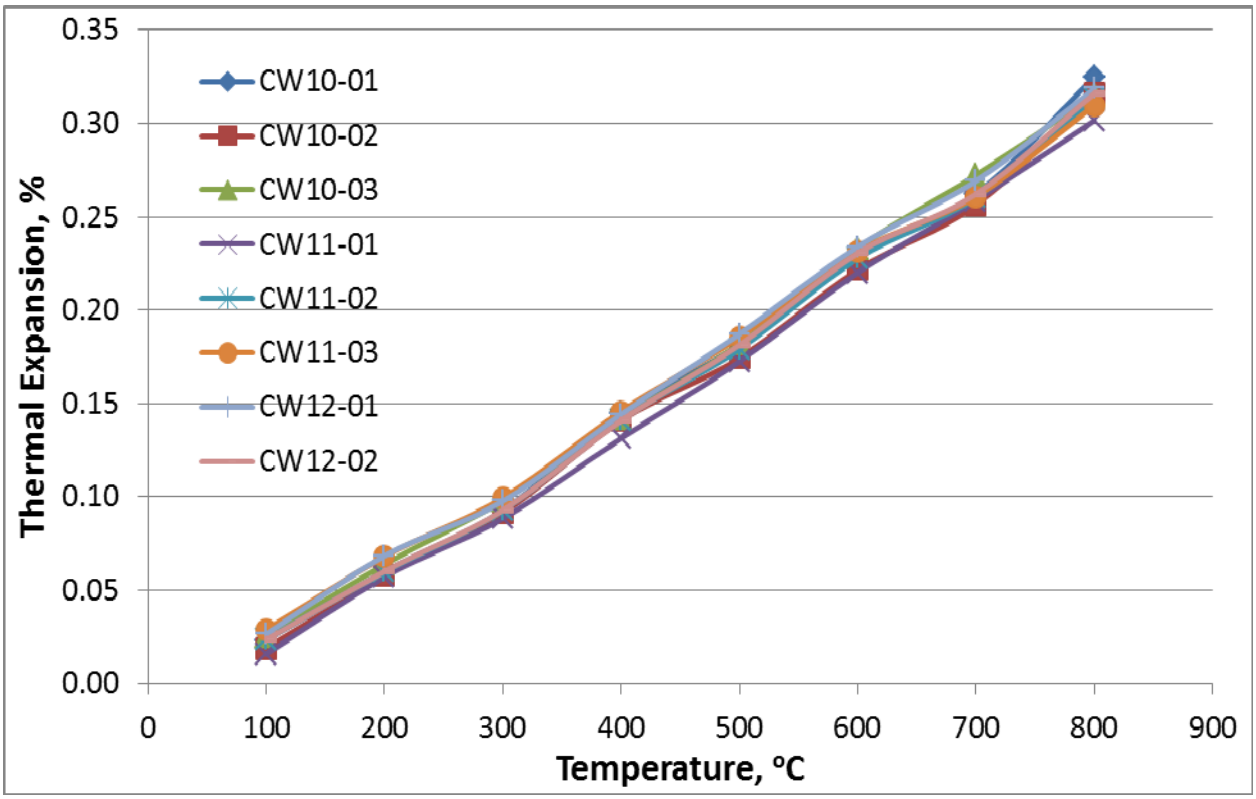

Fig. 173. The thermal expansion behavior of H-451 (WG) creep specimens

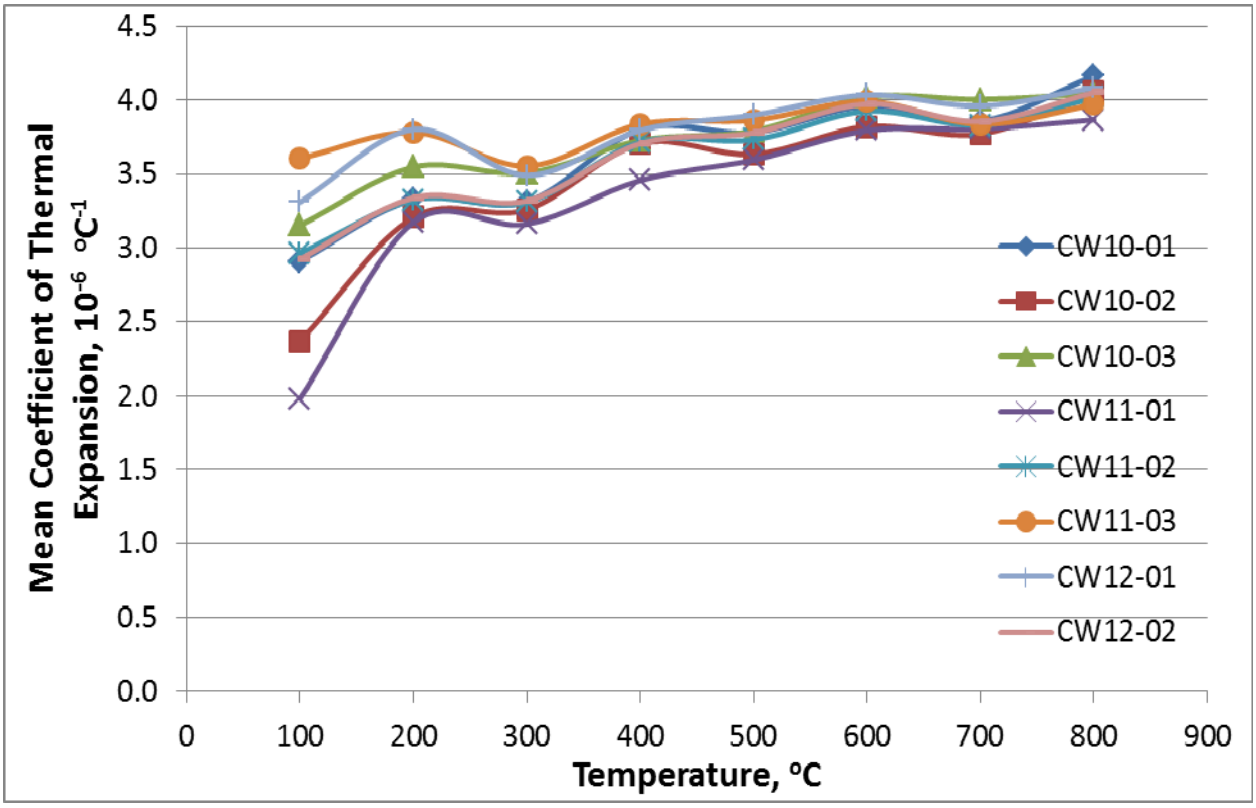

Fig. 174. The mean coefficient of thermal expansion for H-451 (WG) creep specimens

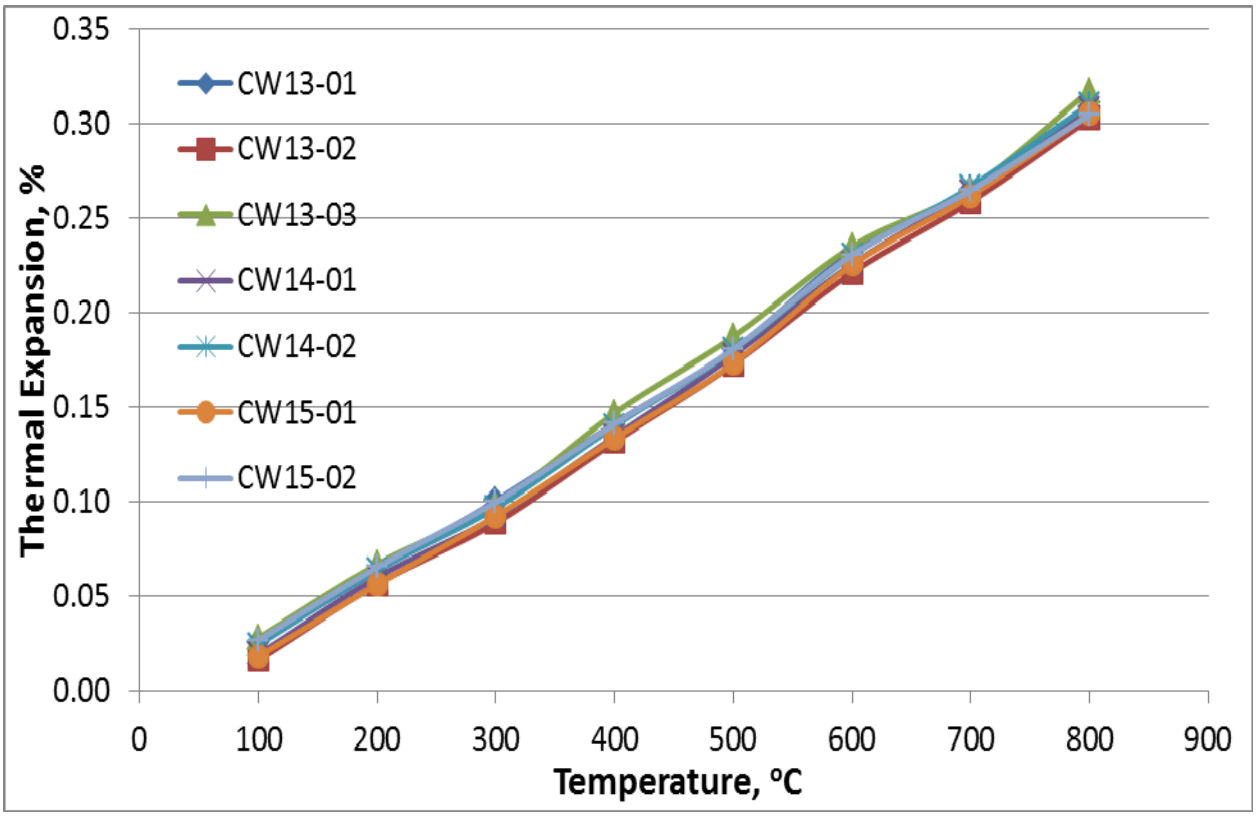

Fig. 175. The thermal expansion behavior of H-451 (WG) creep specimens

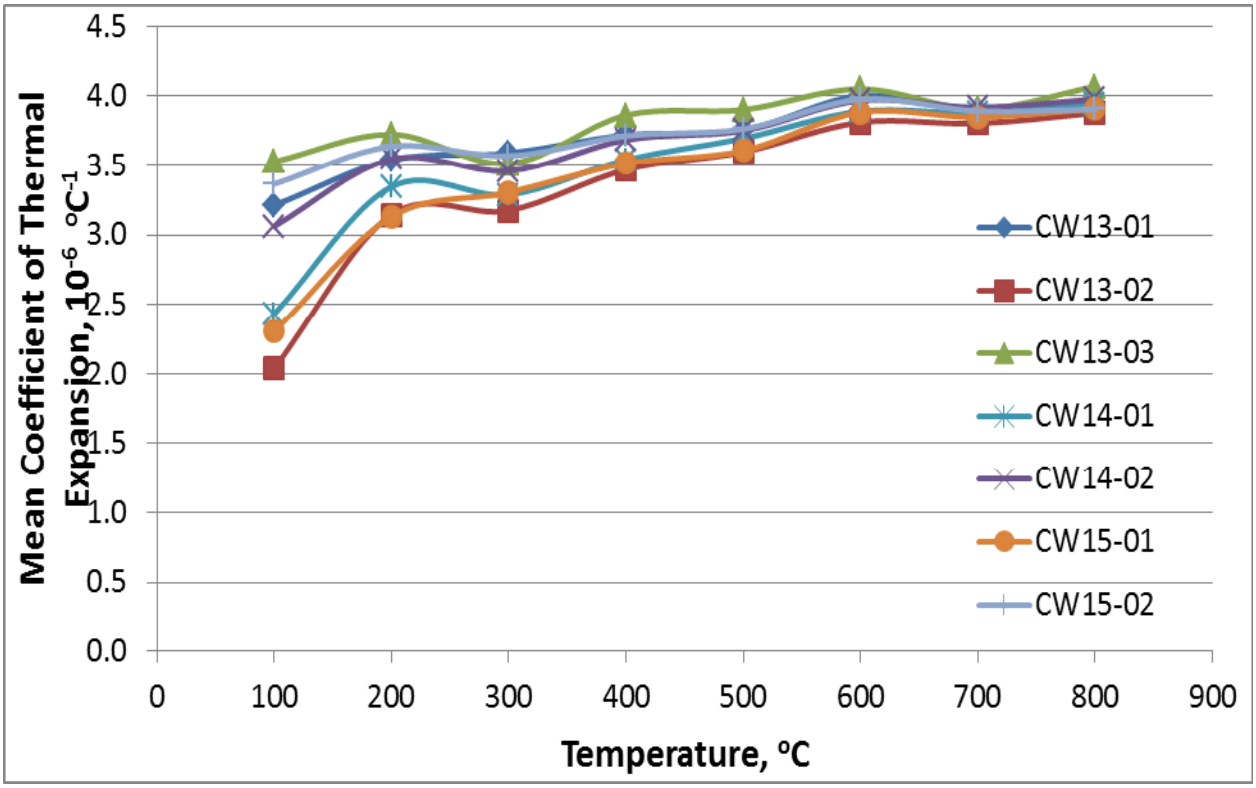

Fig. 176. The mean coefficient of thermal expansion for H-451 (WG) creep specimens

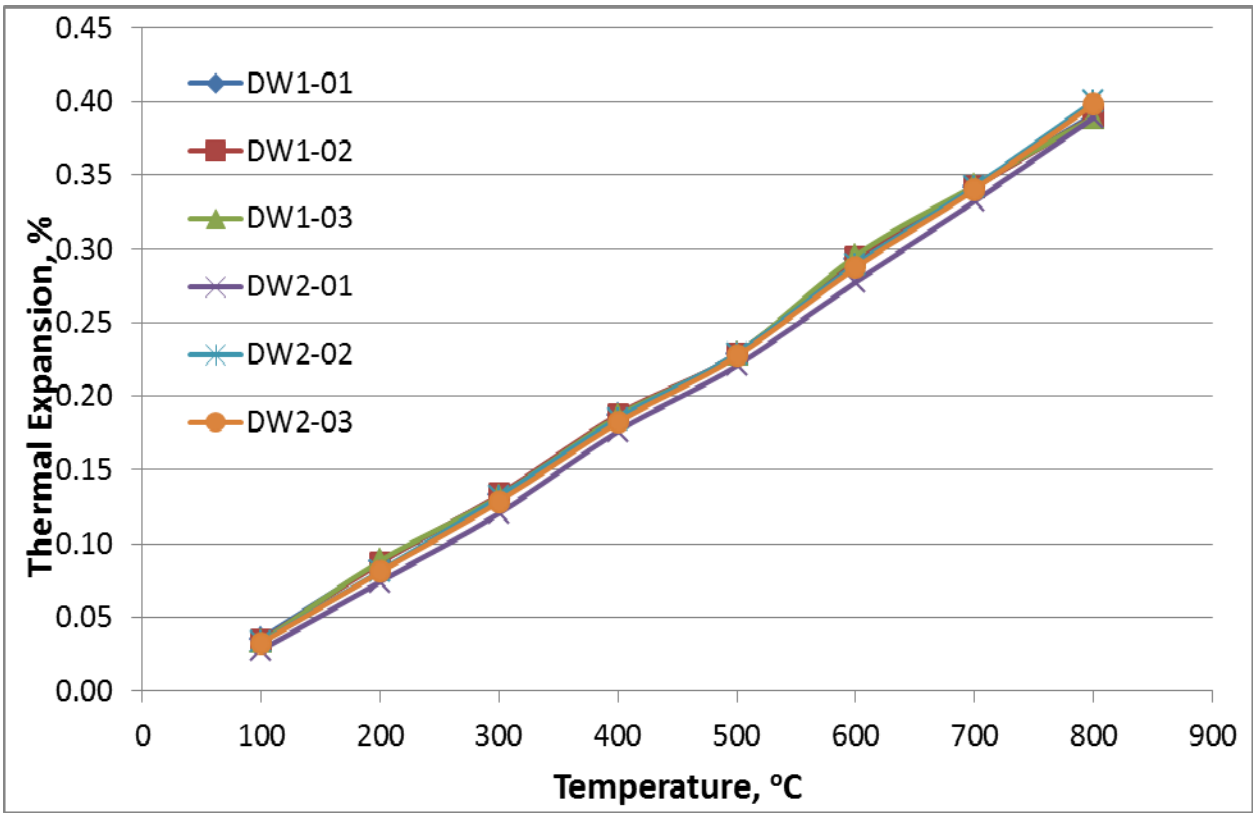

Fig. 177. The thermal expansion behavior of PCEA (WG) creep specimens

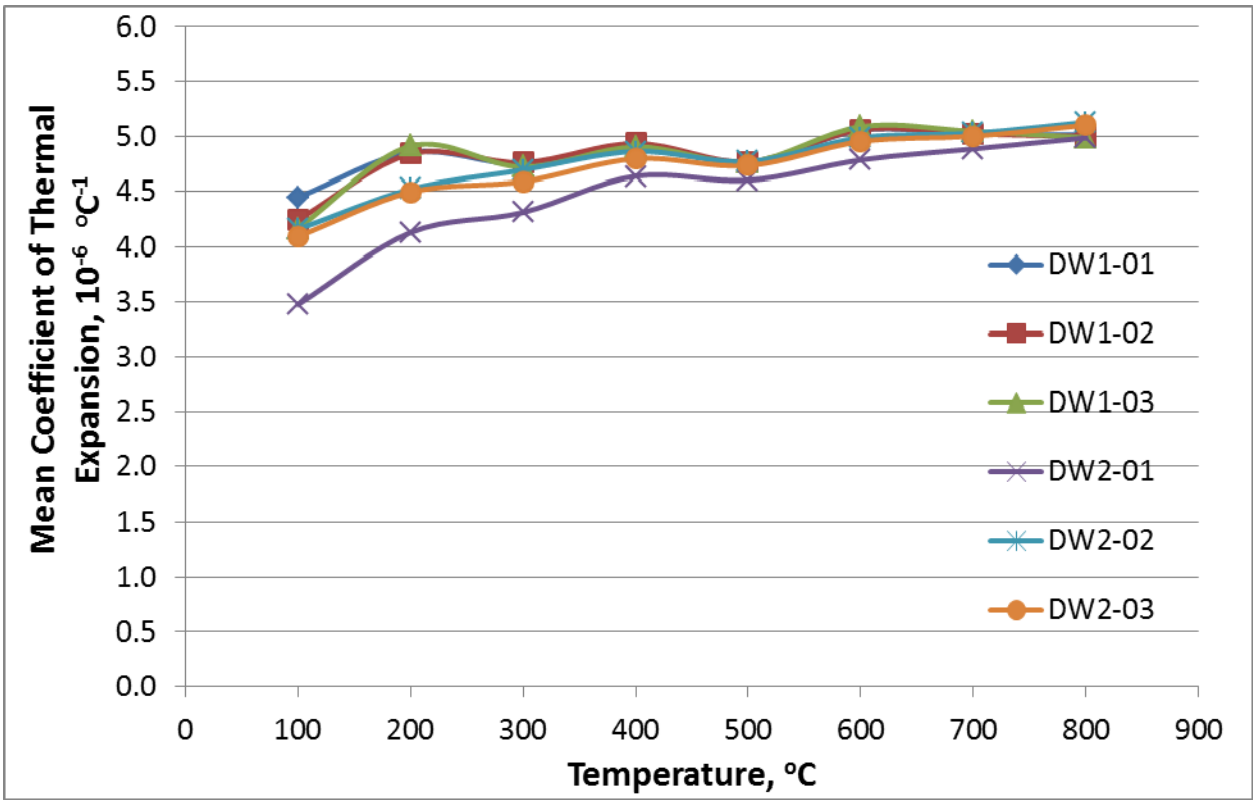

Fig. 178. The mean coefficient of thermal expansion for PCEA (WG) creep specimens

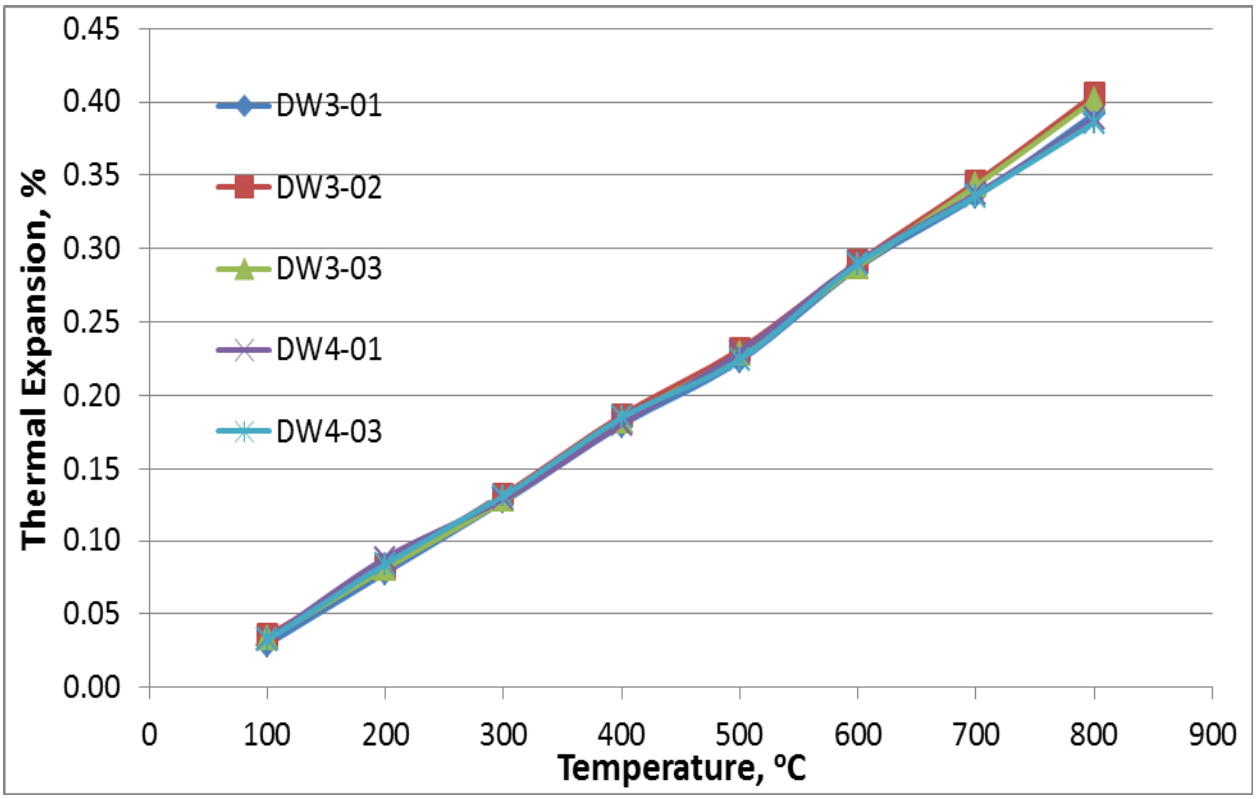

Fig. 179. The thermal expansion behavior of PCEA (WG) creep specimens

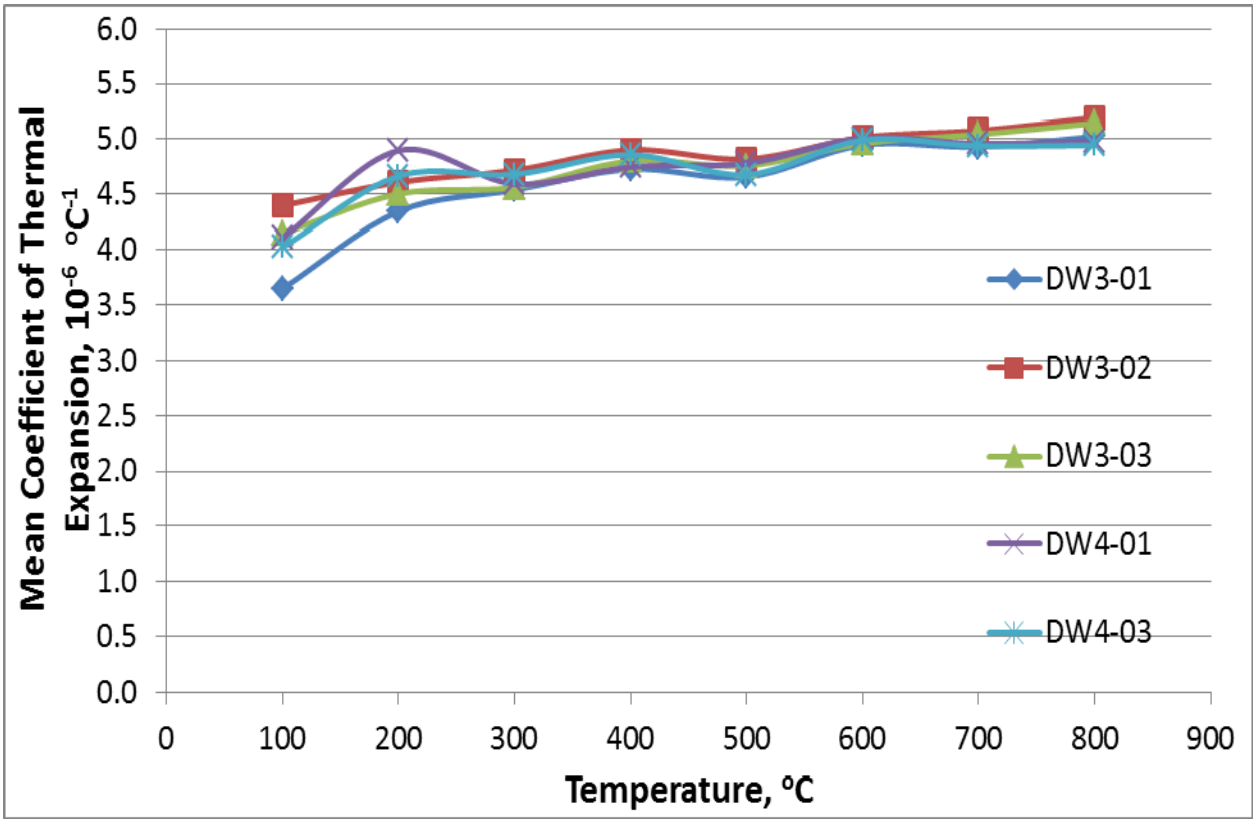

Fig. 180. The mean coefficient of thermal expansion for PCEA (WG) creep specimens

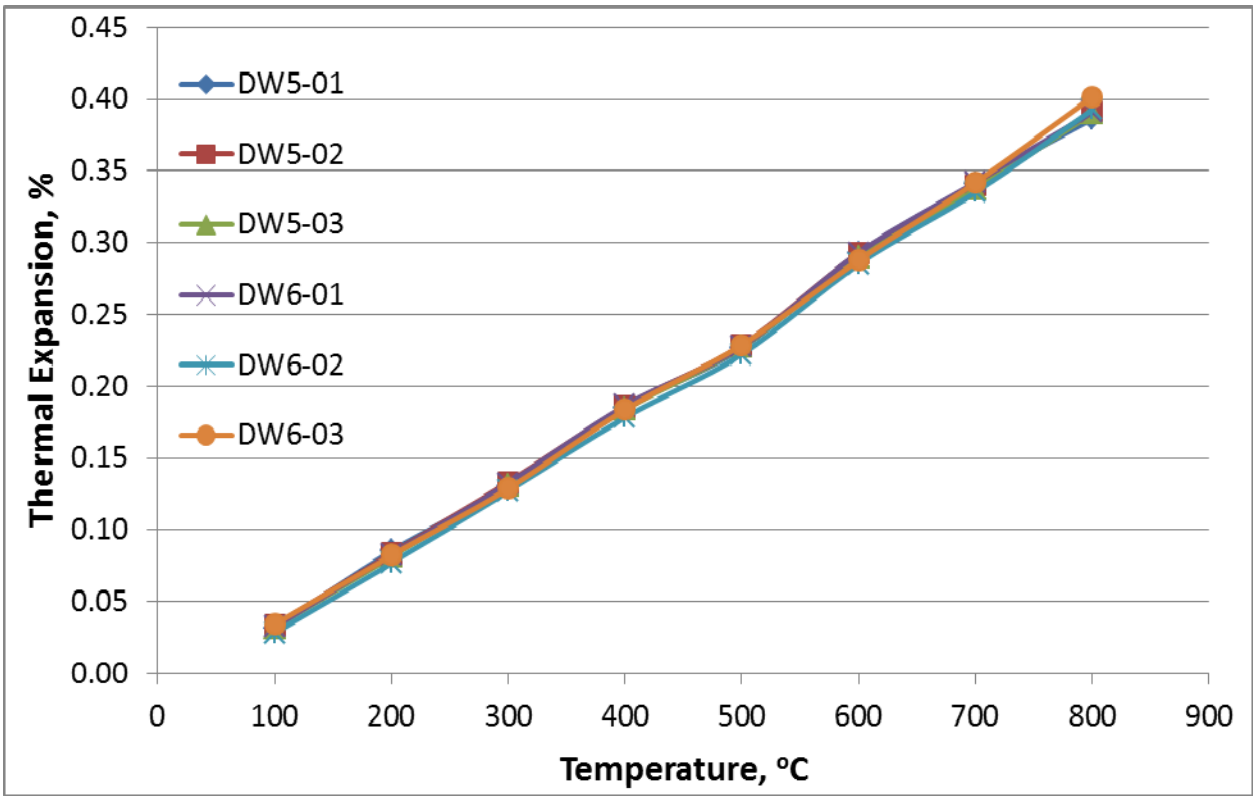

Fig. 181. The thermal expansion behavior of PCEA (WG) creep specimens

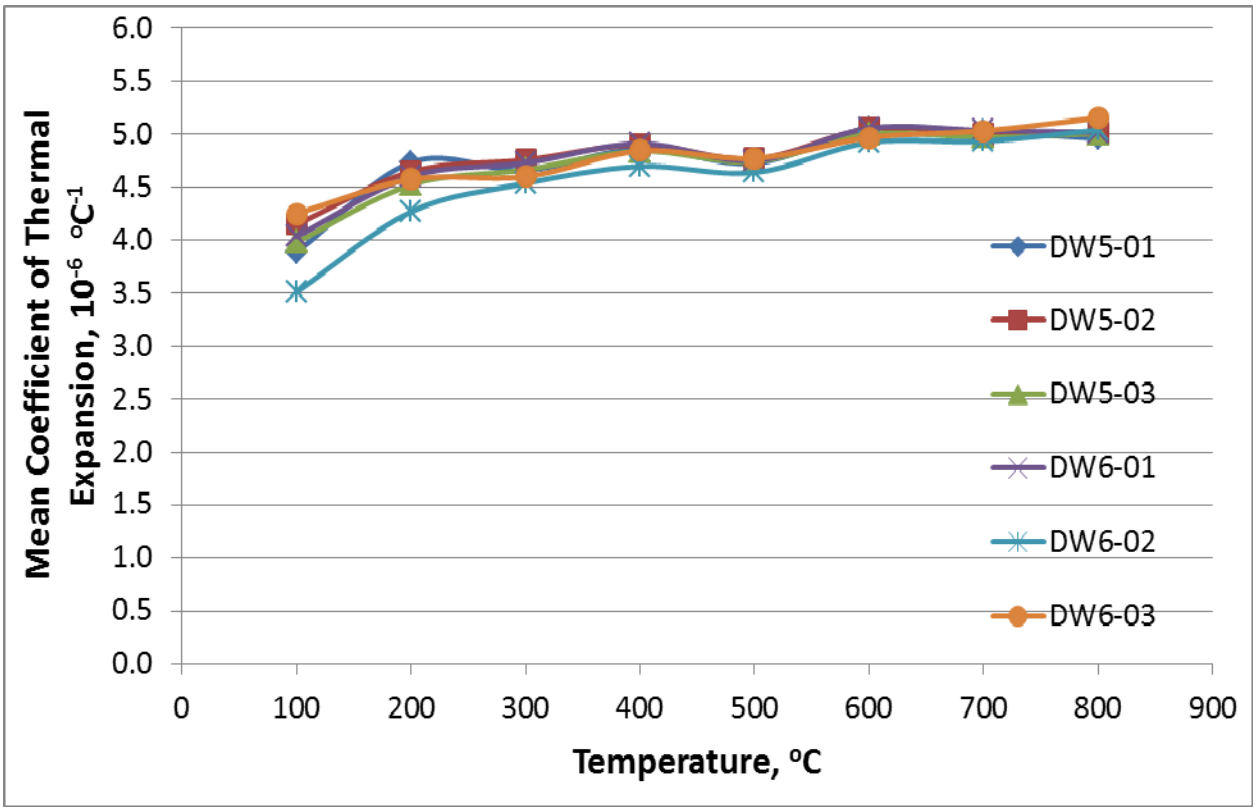

Fig. 182. The mean coefficient of thermal expansion for NBG-17 (WG) creep specimens

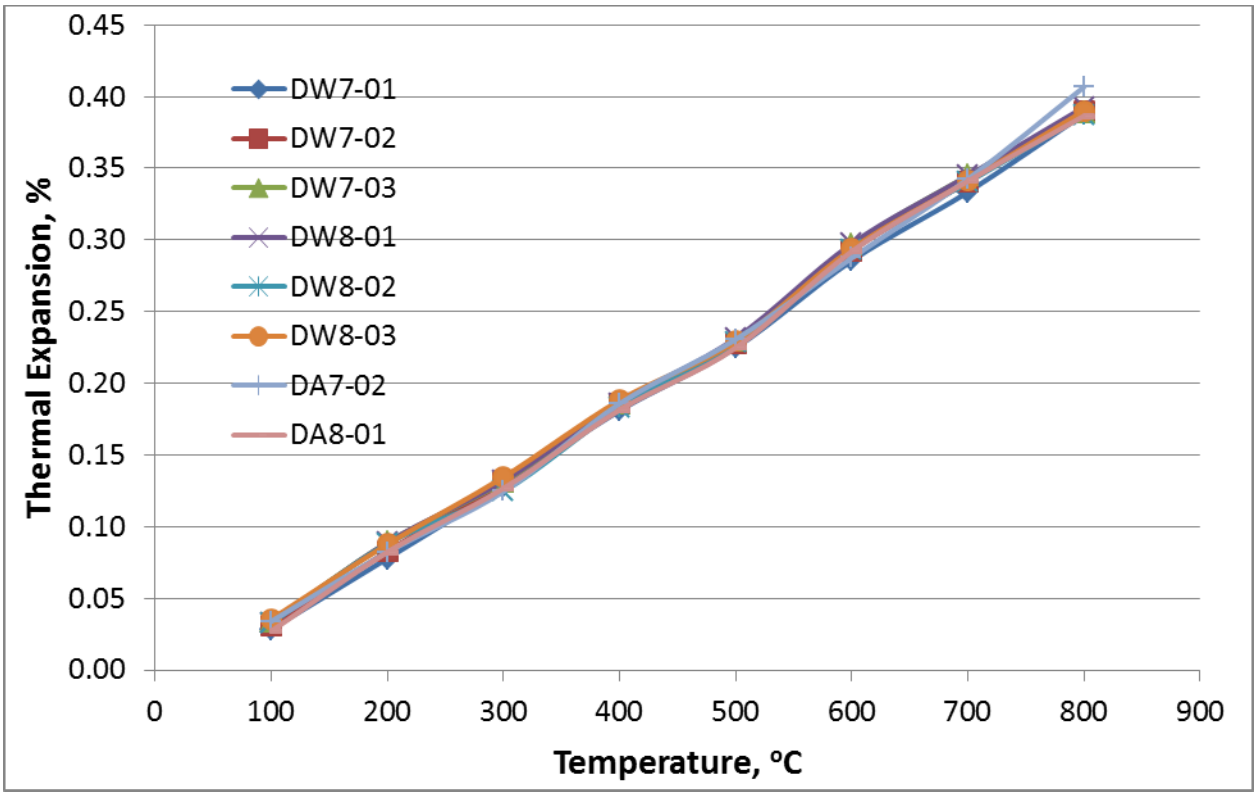

Fig. 183. The thermal expansion behavior of PCEA (WG) creep specimens including the two mislabeled samples (DA7-02 and DA8-01)

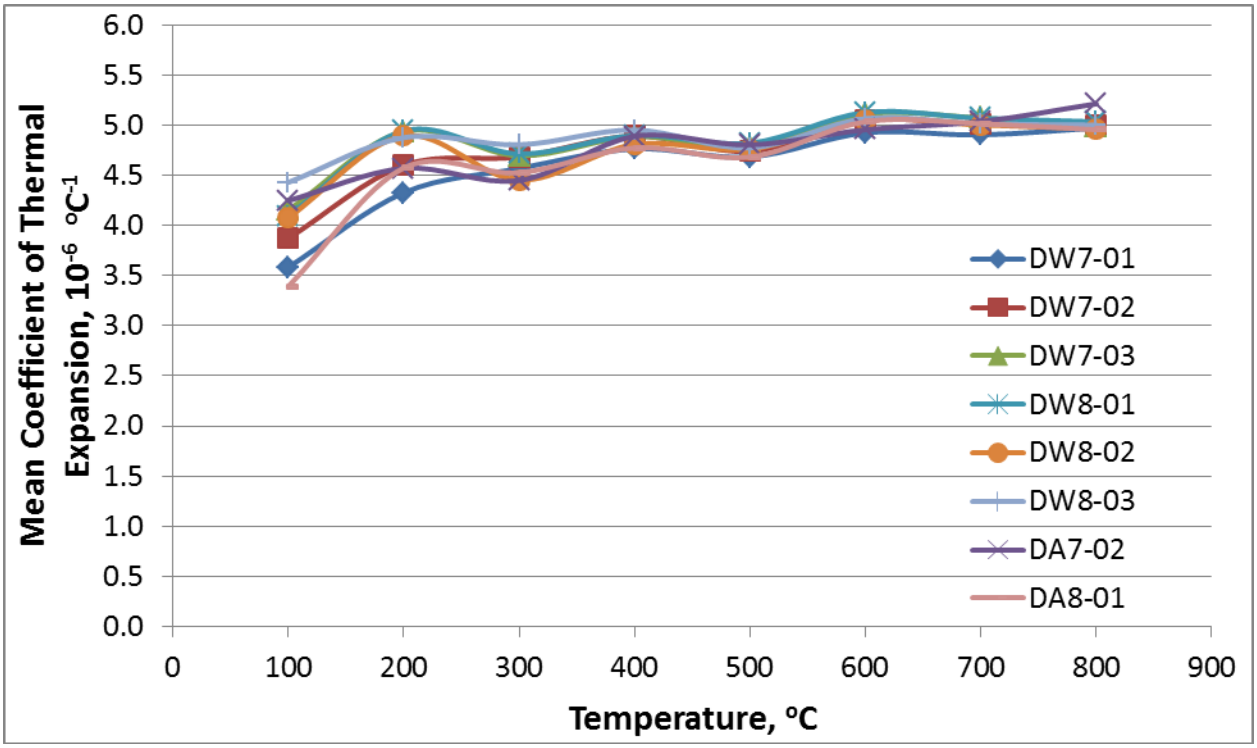

Fig. 184. The mean coefficient of thermal expansion for PCEA (WG) creep specimens including the two mislabeled samples (DA7-02 and DA8-01)

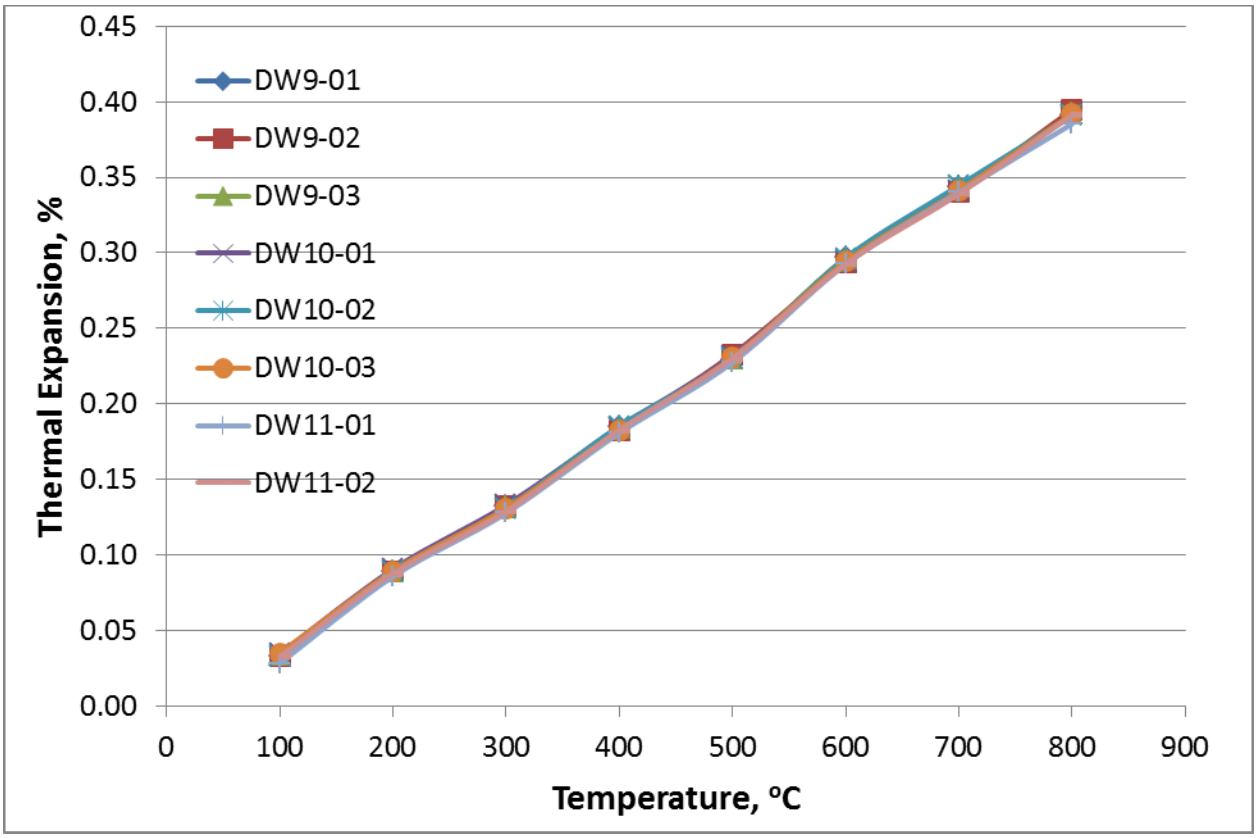

Fig. 185. The thermal expansion behavior of PCEA (WG) creep specimens

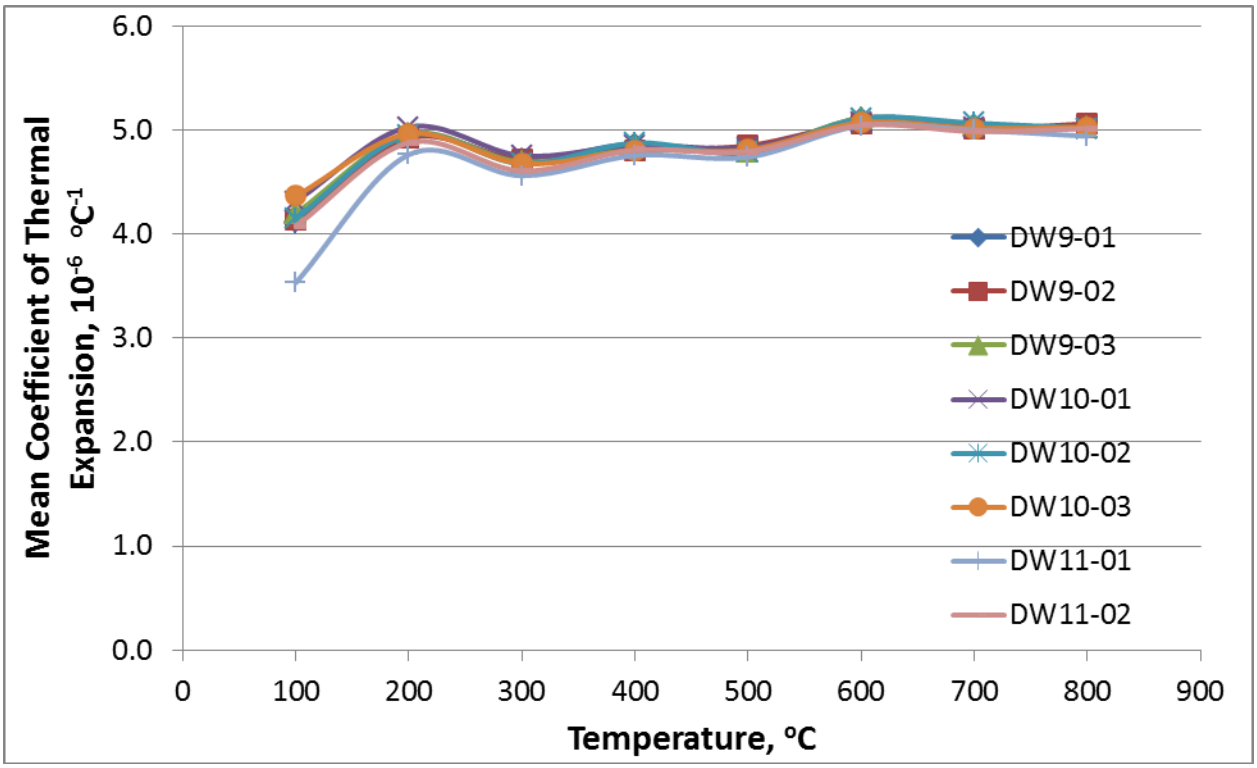

Fig. 186. The mean coefficient of thermal expansion for PCEA (WG) creep specimens

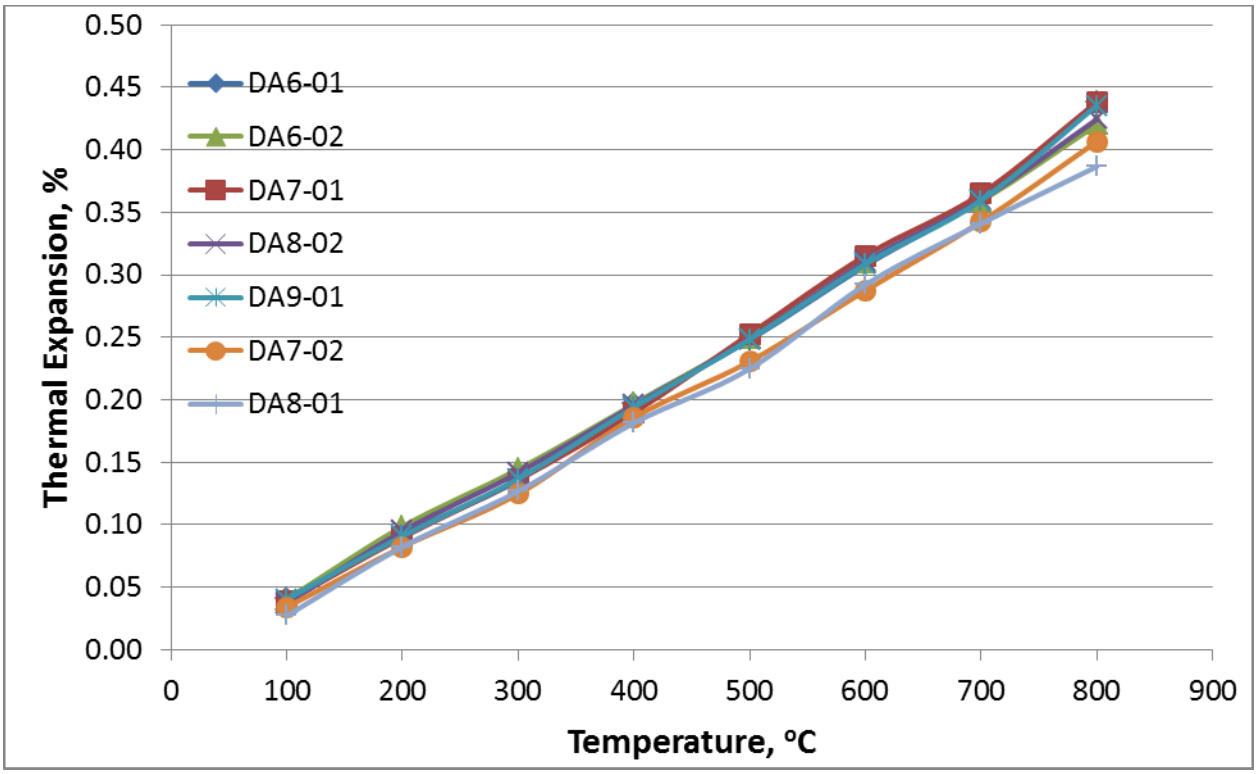

Fig. 187. The thermal expansion behavior of PCEA (AG) creep specimens including the two mislabeled samples (DA7-02 and DA8-01)

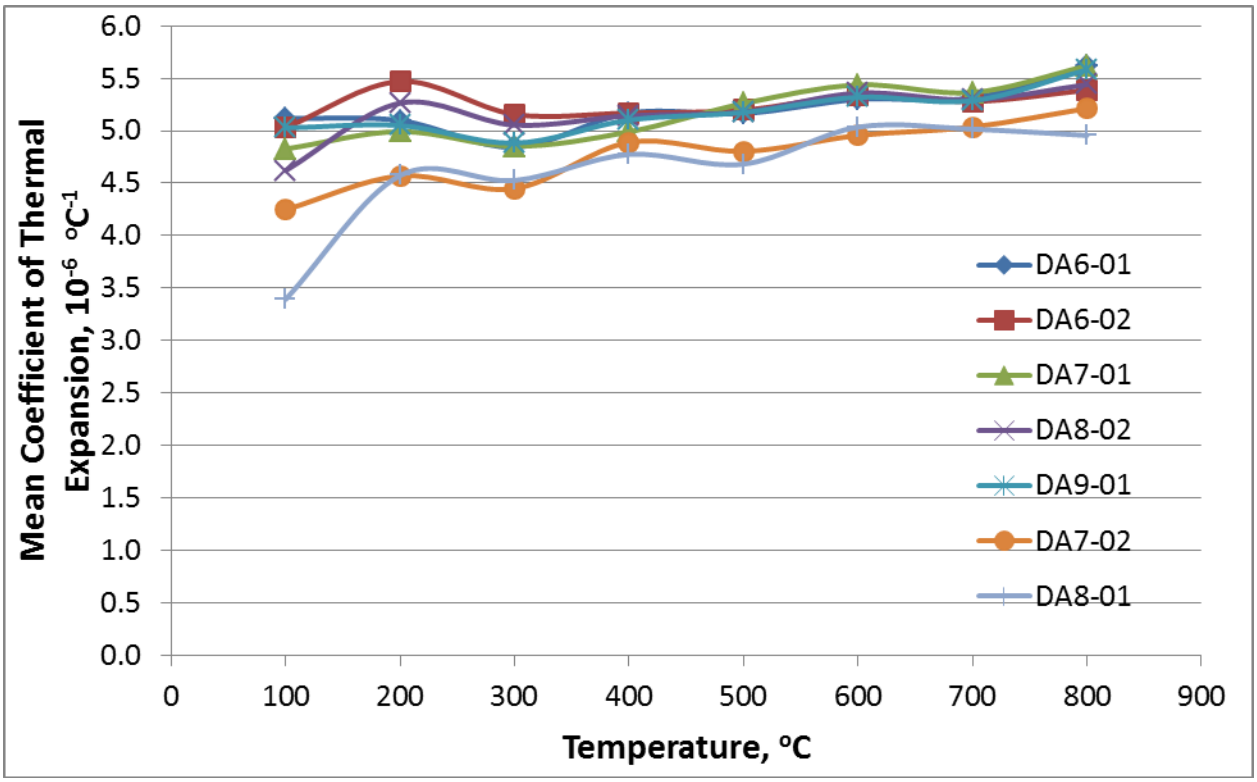

Fig. 188. The mean coefficient of thermal expansion for PCEA (WG) creep specimens including the two mislabeled samples (DA7-02 and DA8-01)

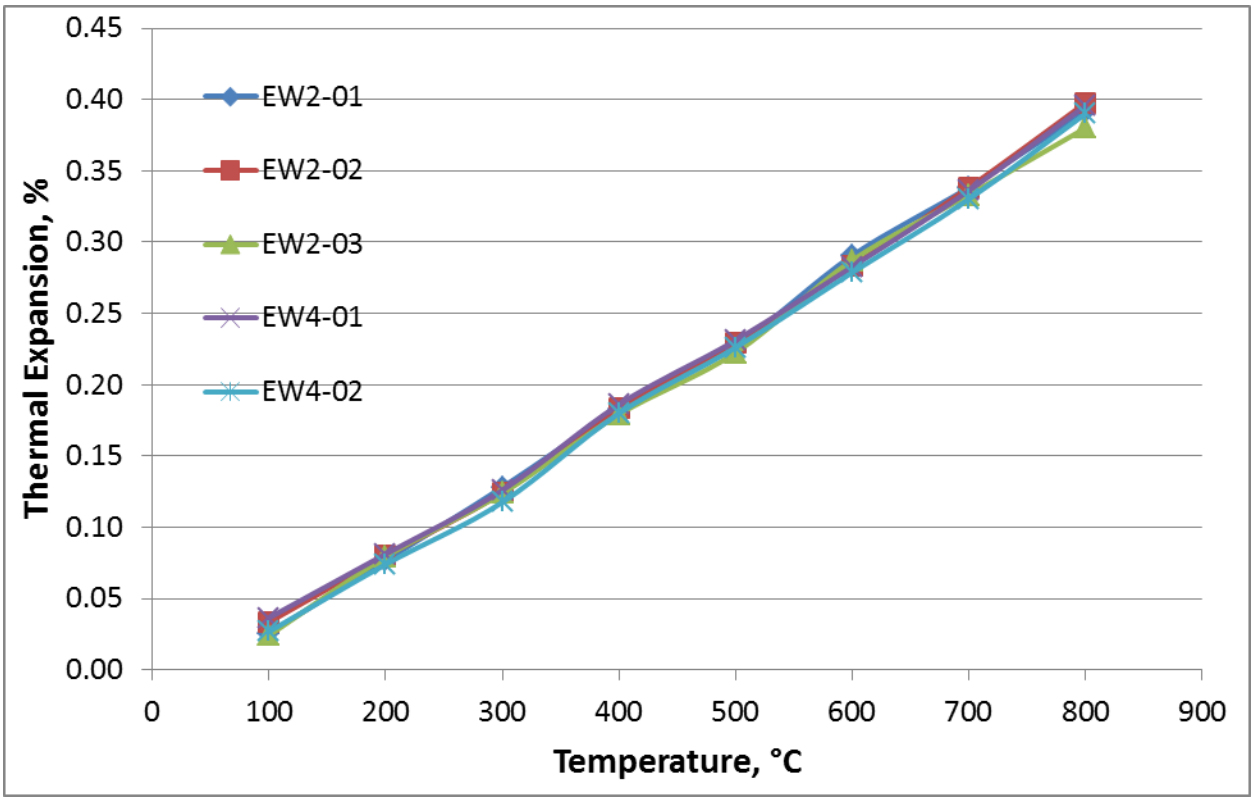

Fig. 189. The thermal expansion behavior of IG-110 creep specimens

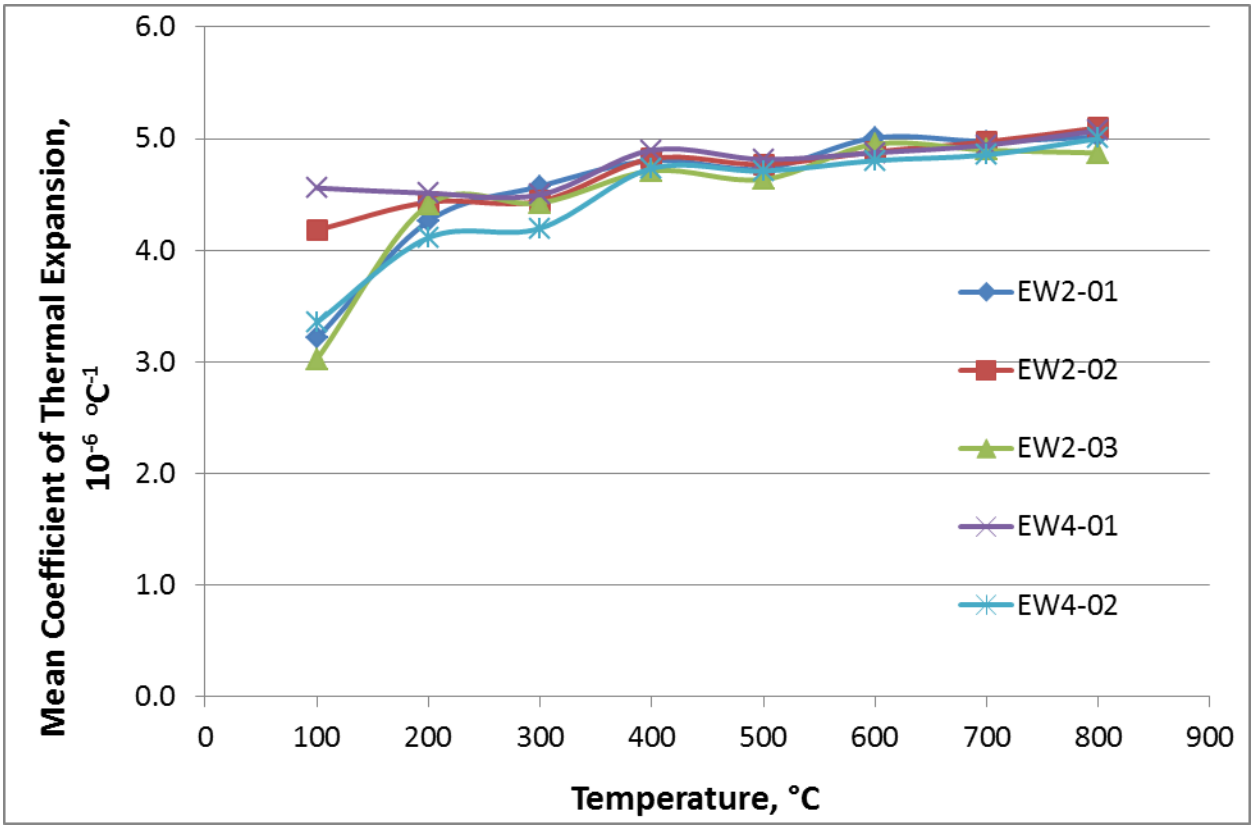

Fig. 190. The mean coefficient of thermal expansion for IG-110 creep specimens

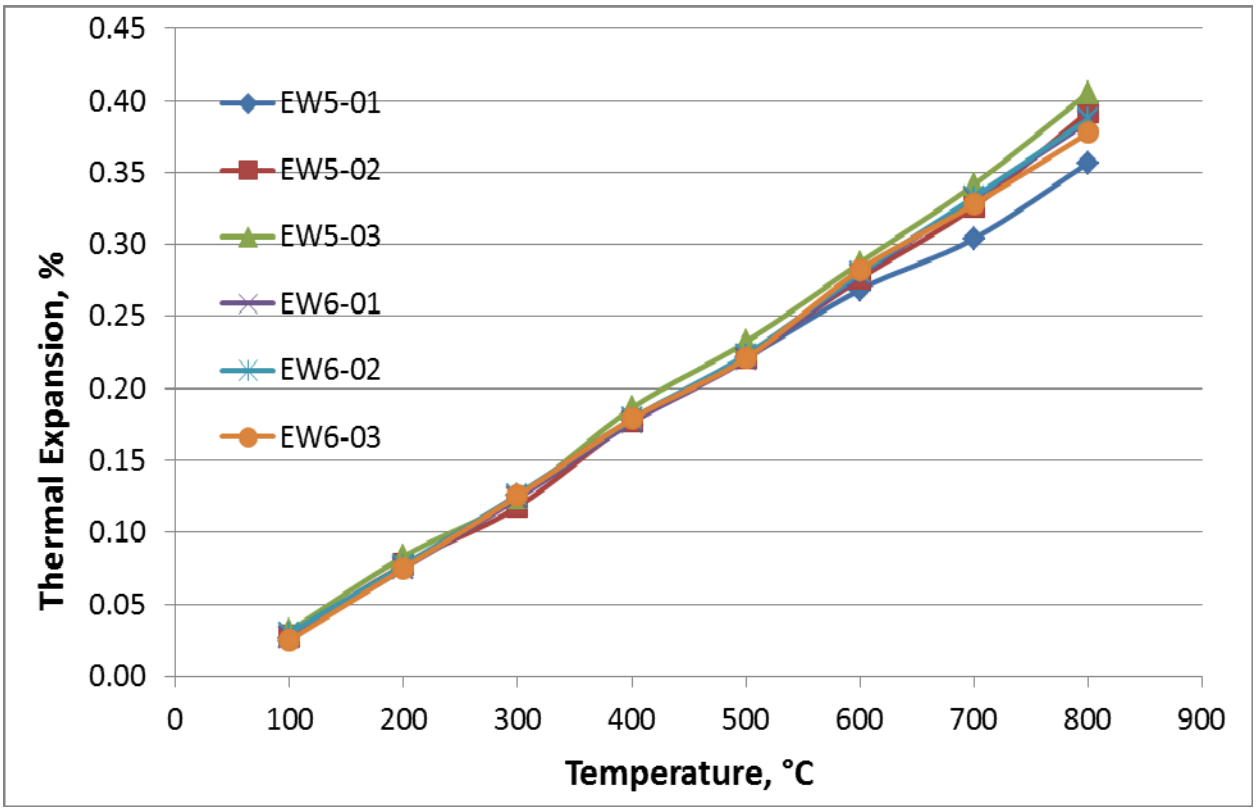

Fig. 191. The thermal expansion behavior of IG-110 creep specimens

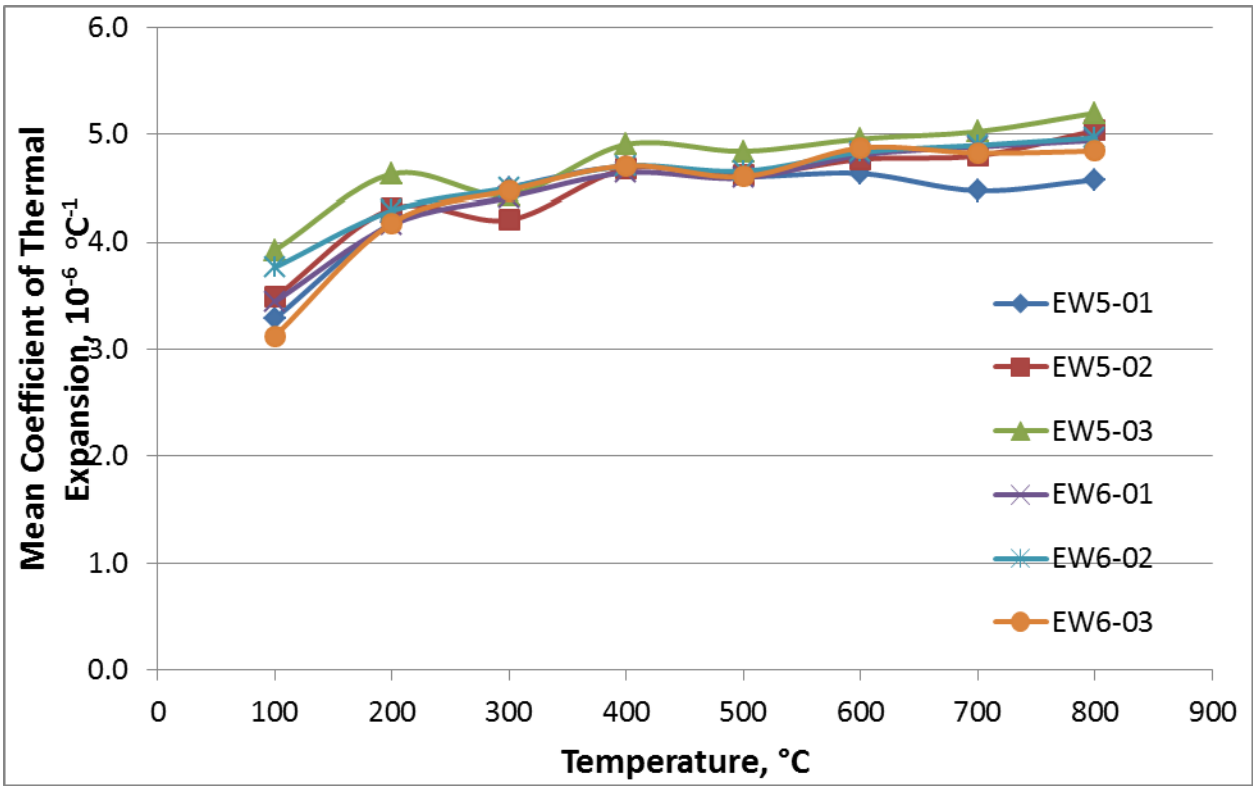

Fig. 192. The mean coefficient of thermal expansion for IG-110 creep specimens

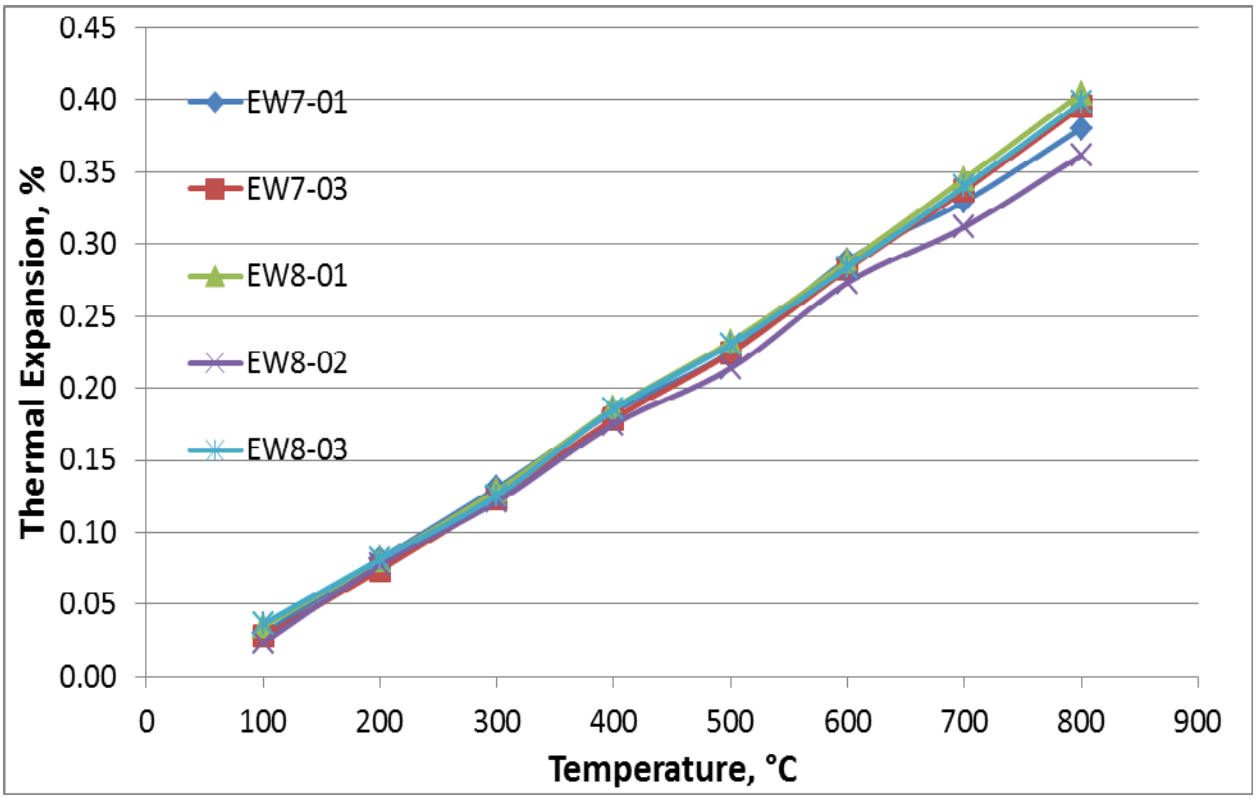

Fig. 193. The thermal expansion behavior of IG-110 creep specimens

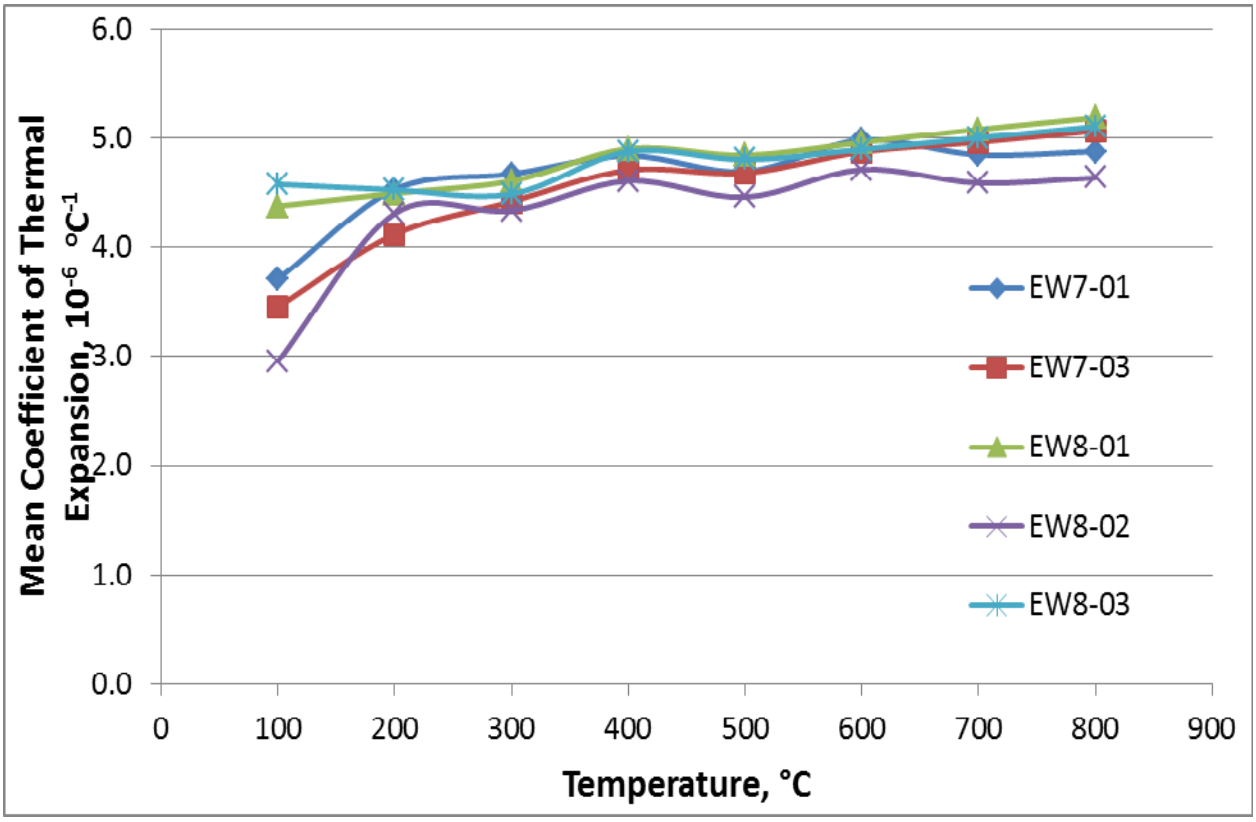

Fig. 194. The mean coefficient of thermal expansion for IG-110 creep specimens

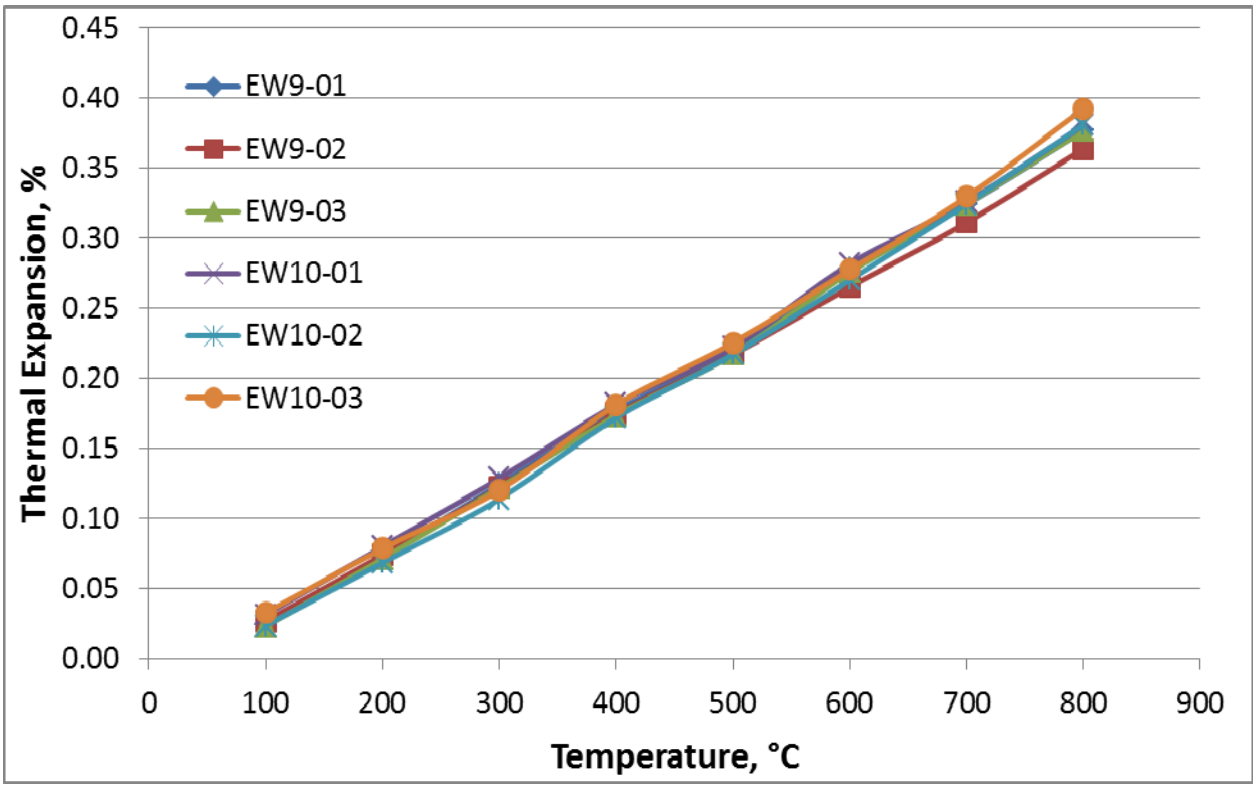

Fig. 195. The thermal expansion behavior of IG-110 creep specimens

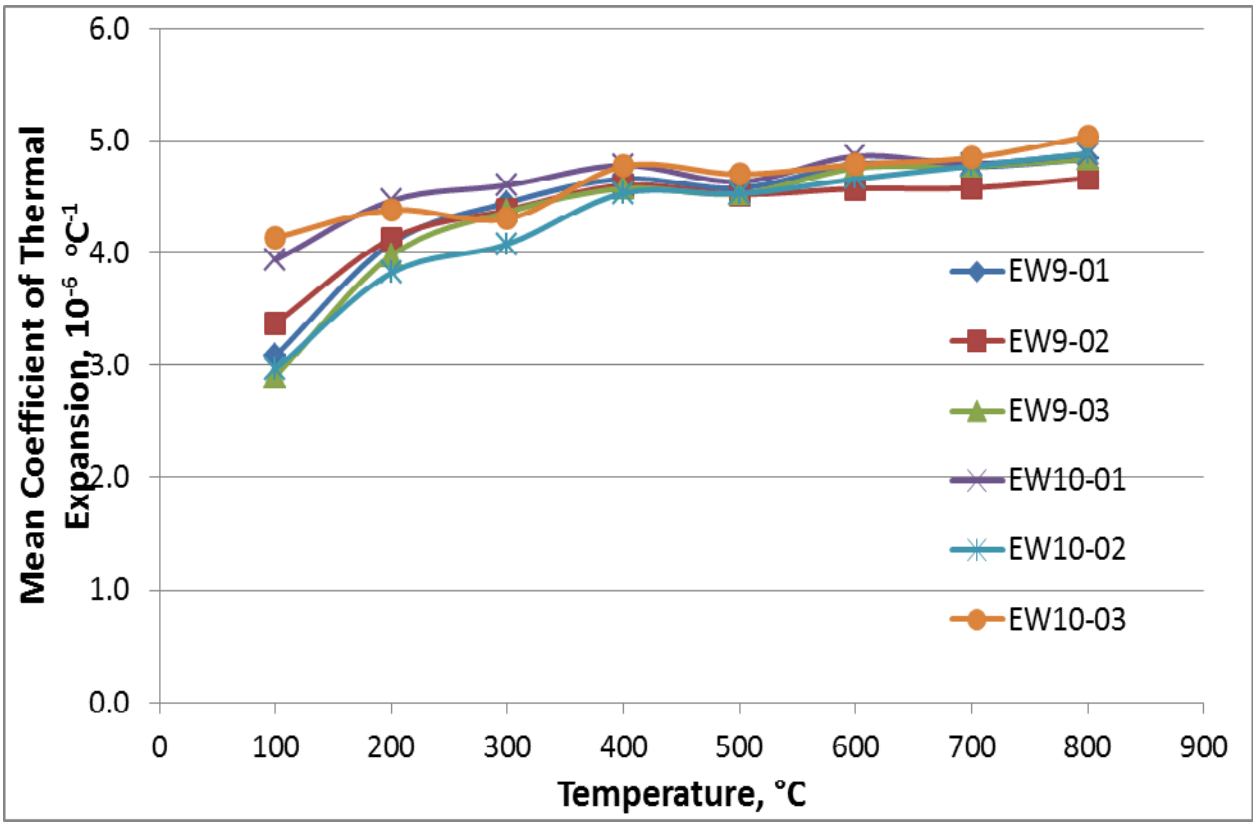

Fig. 196. The mean coefficient of thermal expansion for IG-110 creep specimens

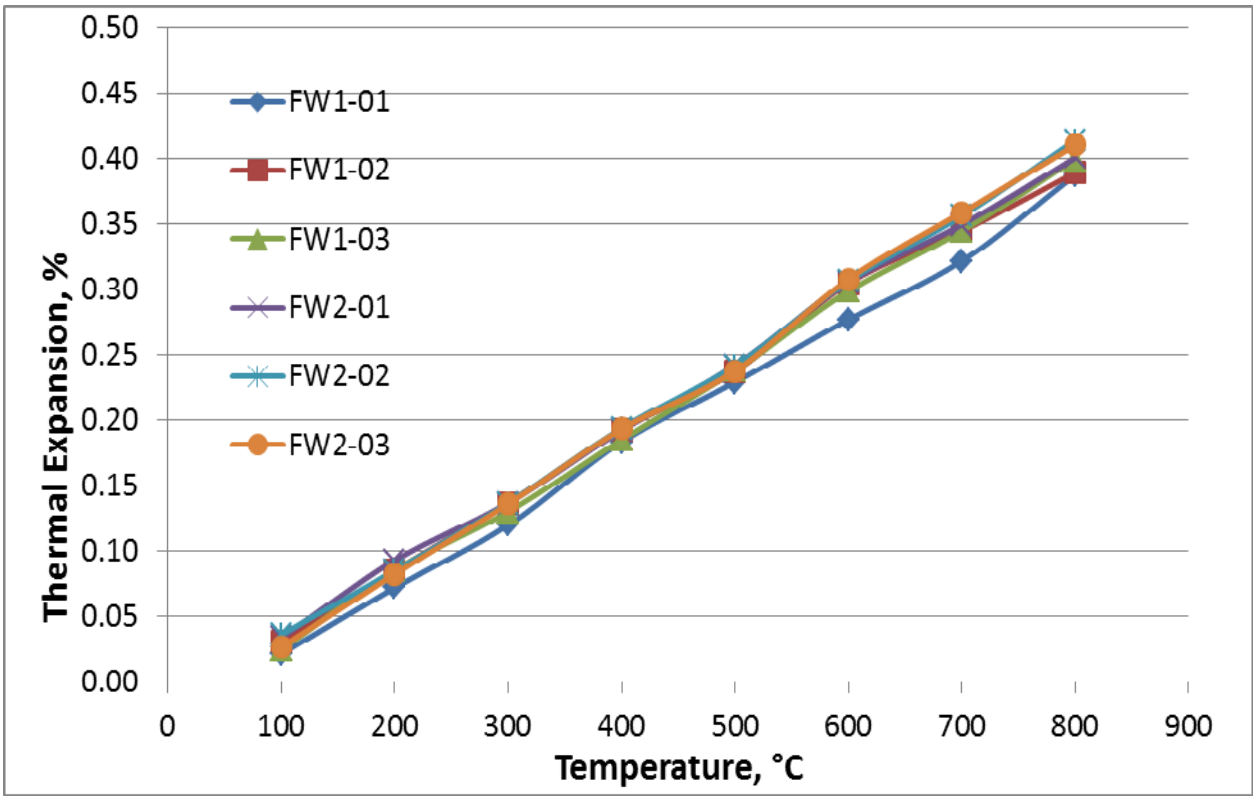

Fig. 197. The thermal expansion behavior of IG-430 creep specimens

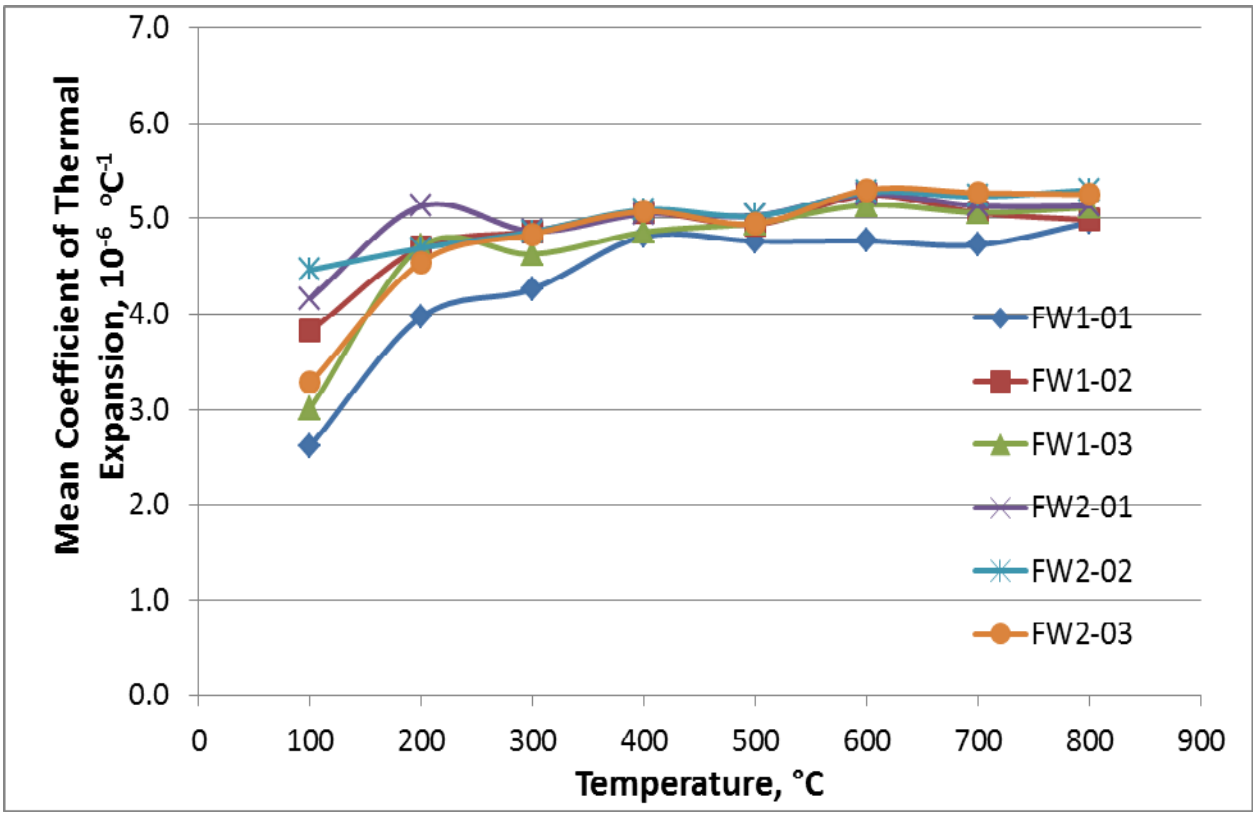

Fig. 198. The mean coefficient of thermal expansion for IG-430 creep specimens

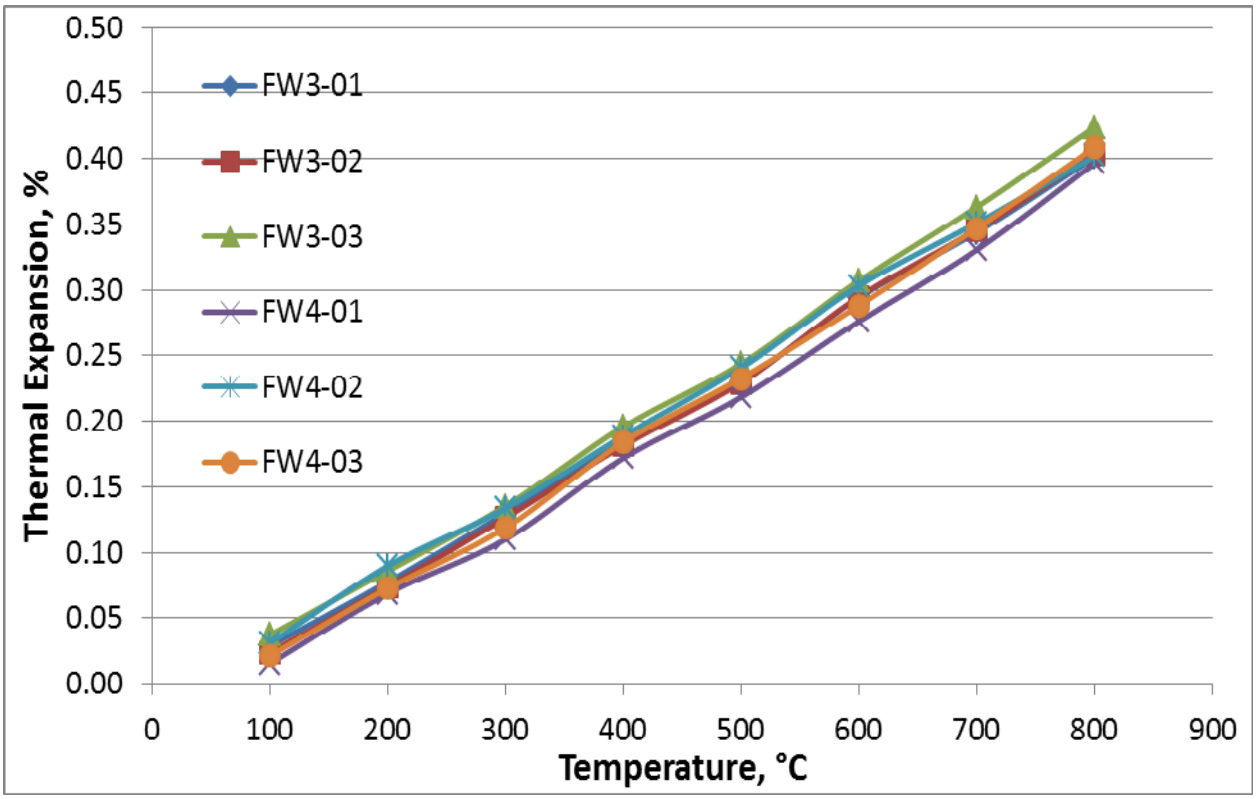

Fig. 199. The thermal expansion behavior of IG-430 creep specimens

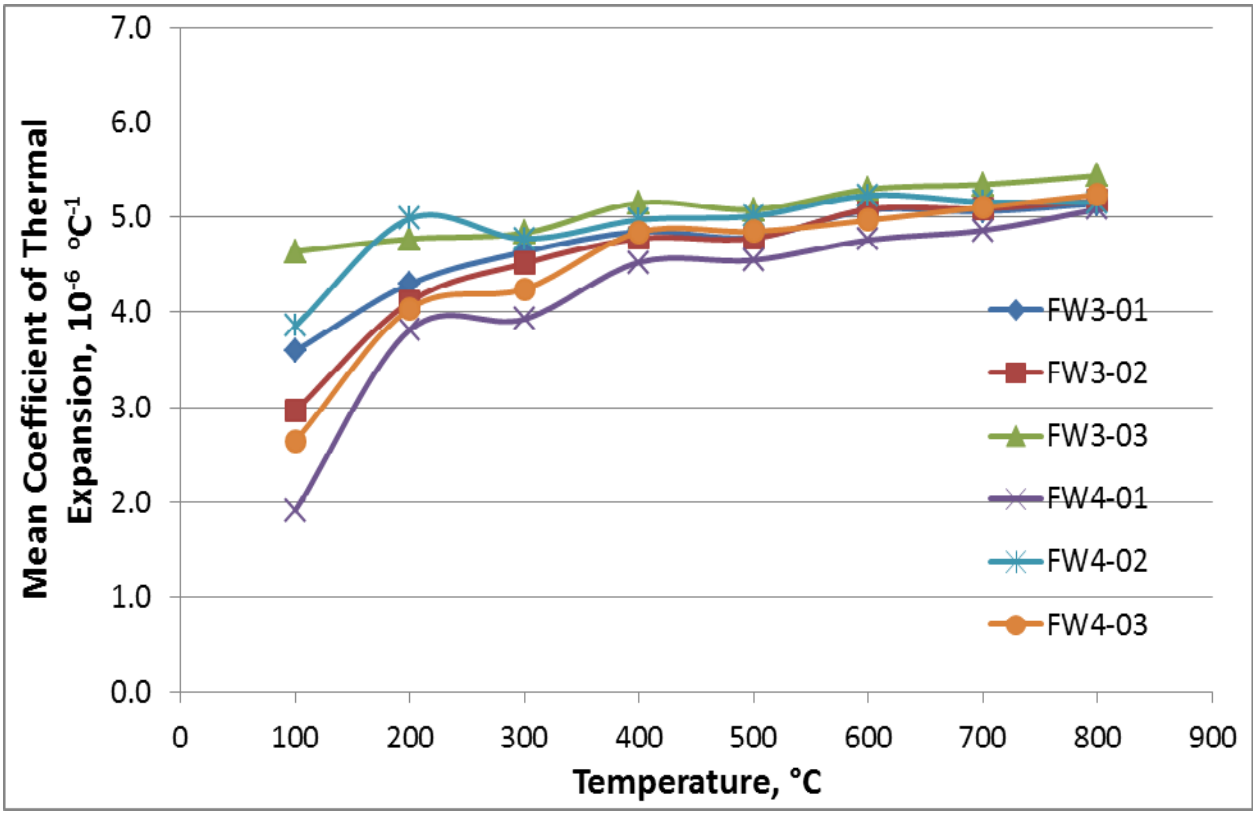

Fig. 200. The mean coefficient of thermal expansion for IG-430 creep specimens

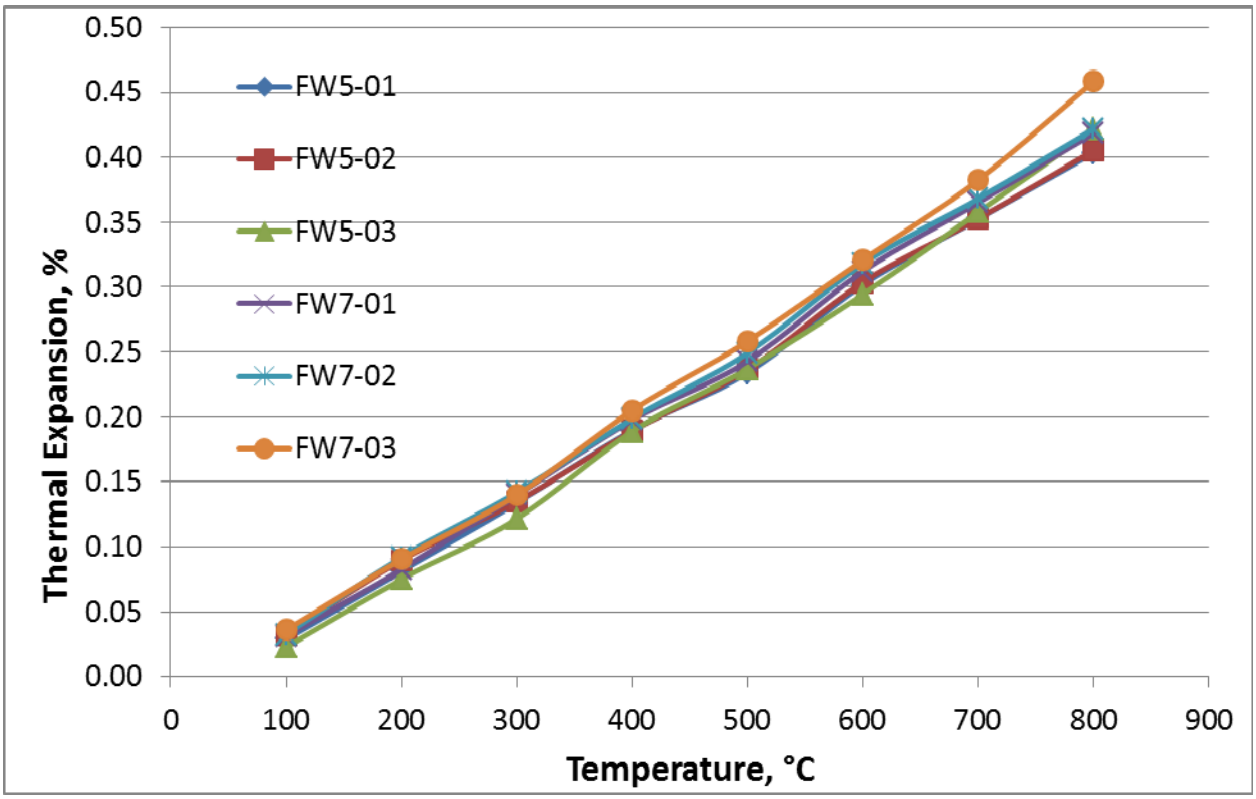

Fig. 201. The thermal expansion behavior of IG-430 creep specimens

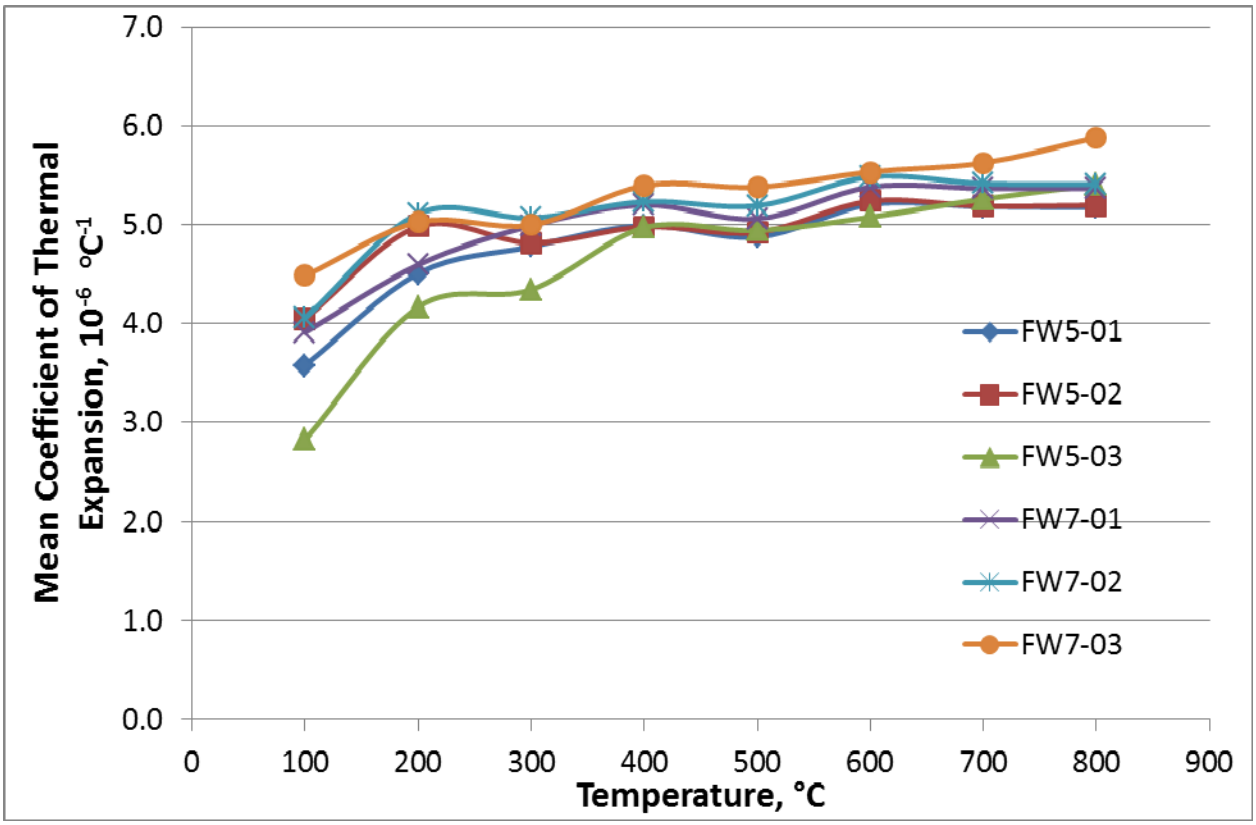

Fig. 202. The mean coefficient of thermal expansion for IG-430 creep specimens

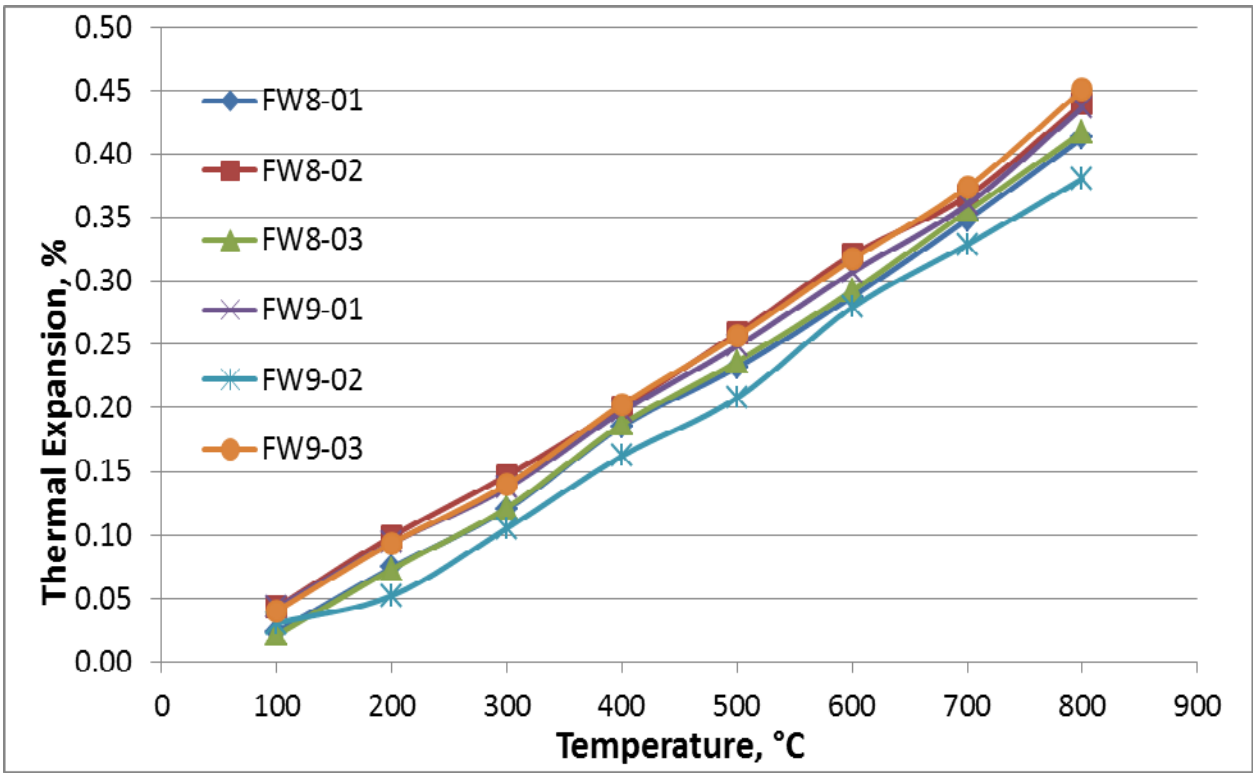

Fig. 203. The thermal expansion behavior of IG-430 creep specimens

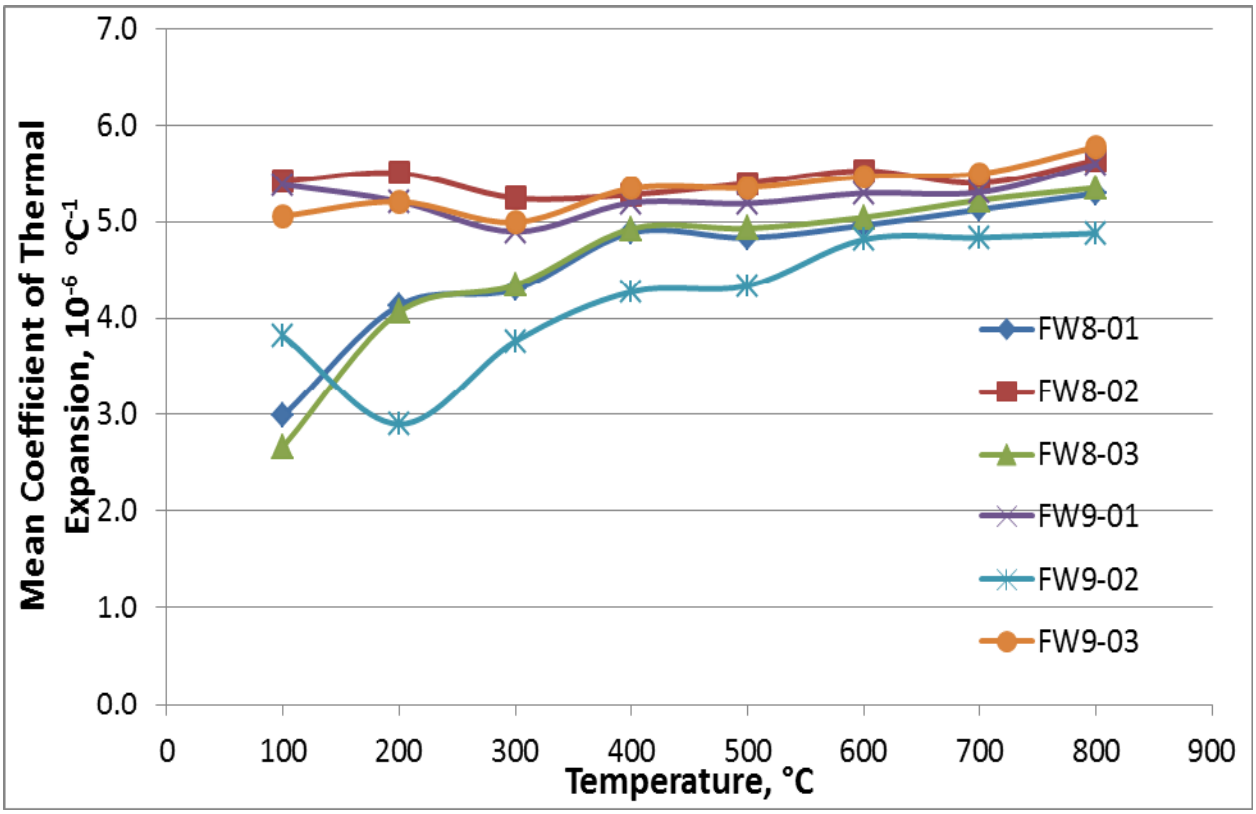

Fig. 204. The mean coefficient of thermal expansion for IG-430 creep specimens

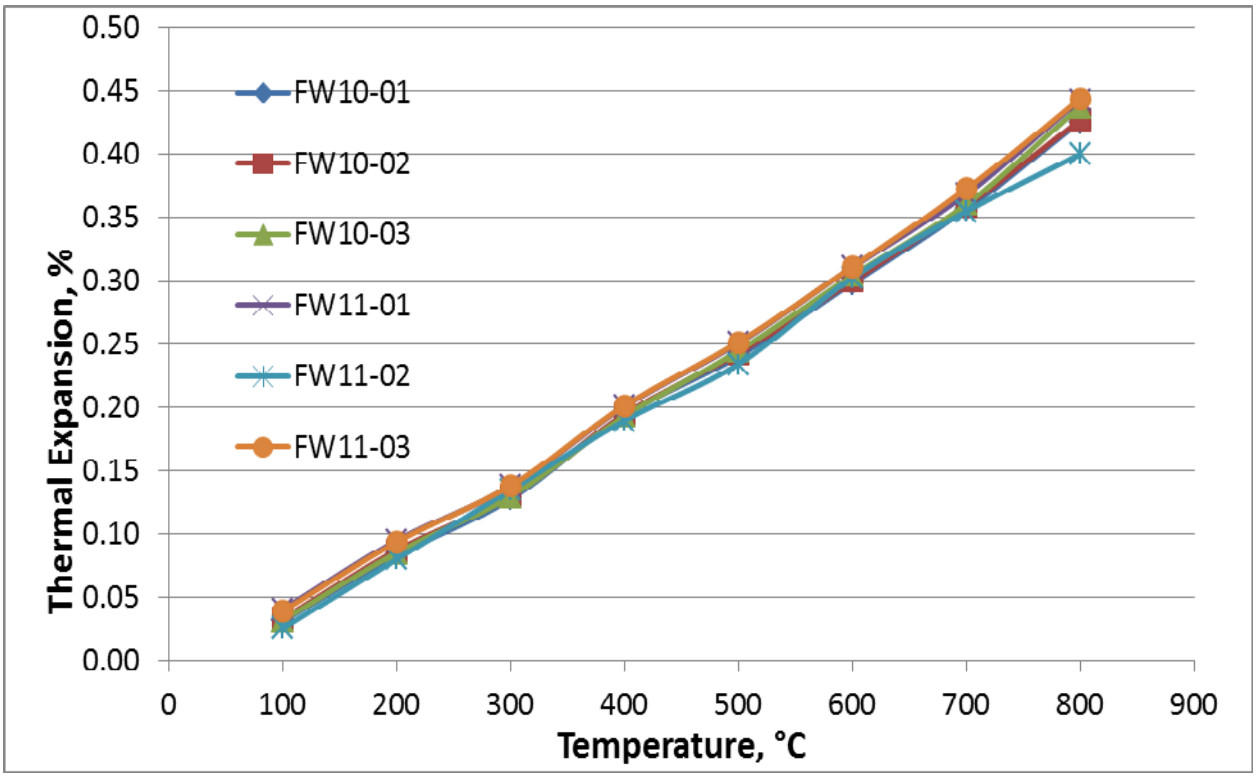

Fig. 205. The thermal expansion behavior of IG-430 creep specimens

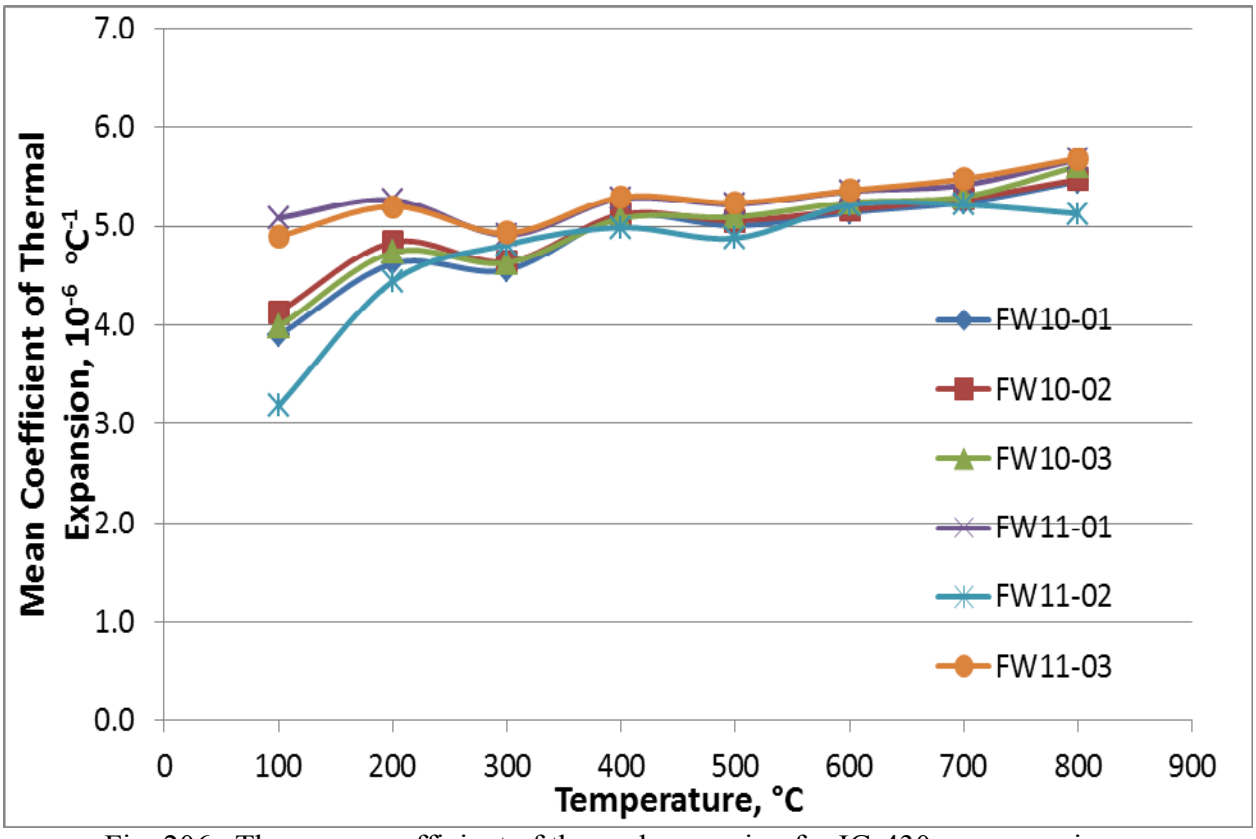

Fig. 206. The mean coefficient of thermal expansion for IG-430 creep specimens

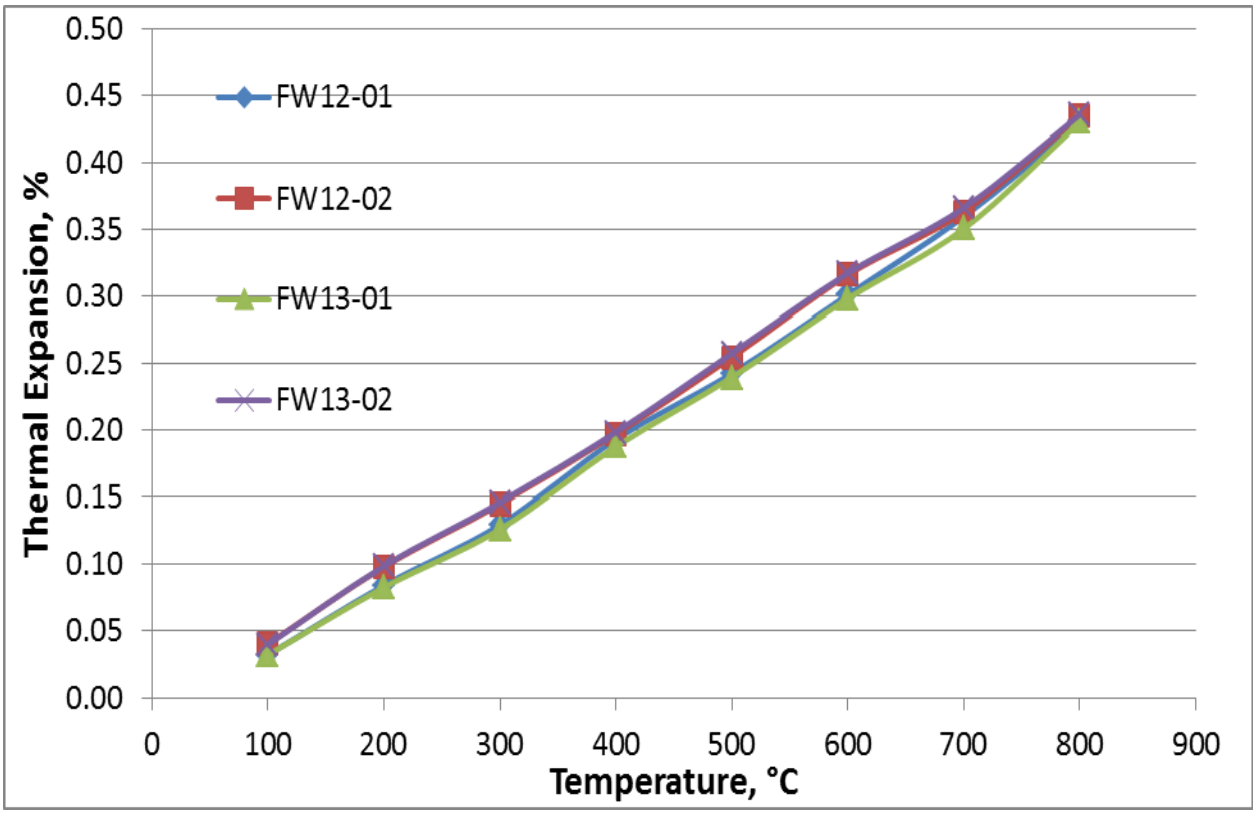

Fig. 207. The thermal expansion behavior of IG-430 creep specimens

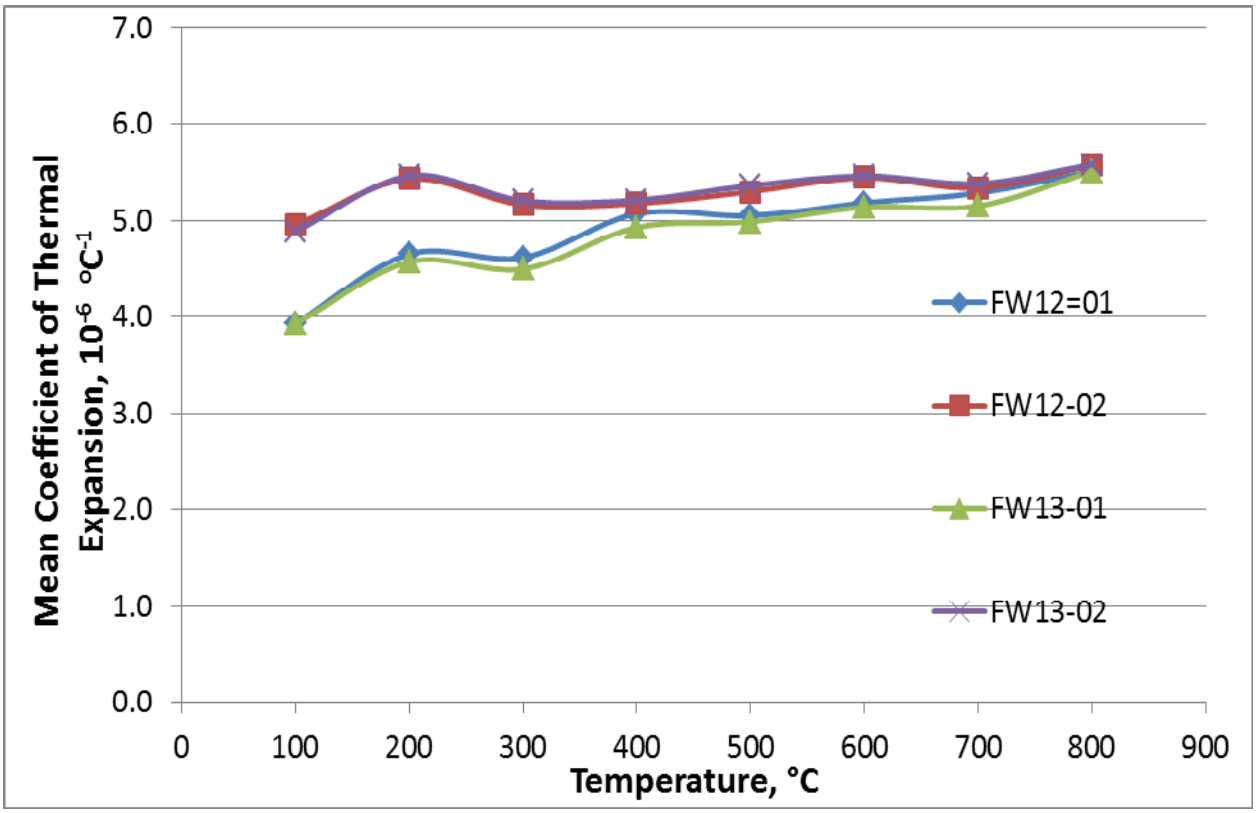

Fig. 208. The mean coefficient of thermal expansion for IG-430 creep specimens

Table 44. A summary of the mean CTE (25-500°C) for all the creep specimens by grade/orientation

Grade/Orientation	CTE $x10^{-6}$ °C^{-1} 25-500°C	
	Mean	St. Dev.
NBG-17 (AG)	5.53	0.086
NBG-17 (WG)	5.34	0.104
NBG-18 (AG)	5.40	0.176
NBG-18 (WG)	5.31	0.163
H-451 (WG)	3.75	0.096
PCEA (WG)	4.76	0.057
PCEA (AG)	5.20	0.038
IG-110	4.66	0.109
IG-1430	5.01	0.229

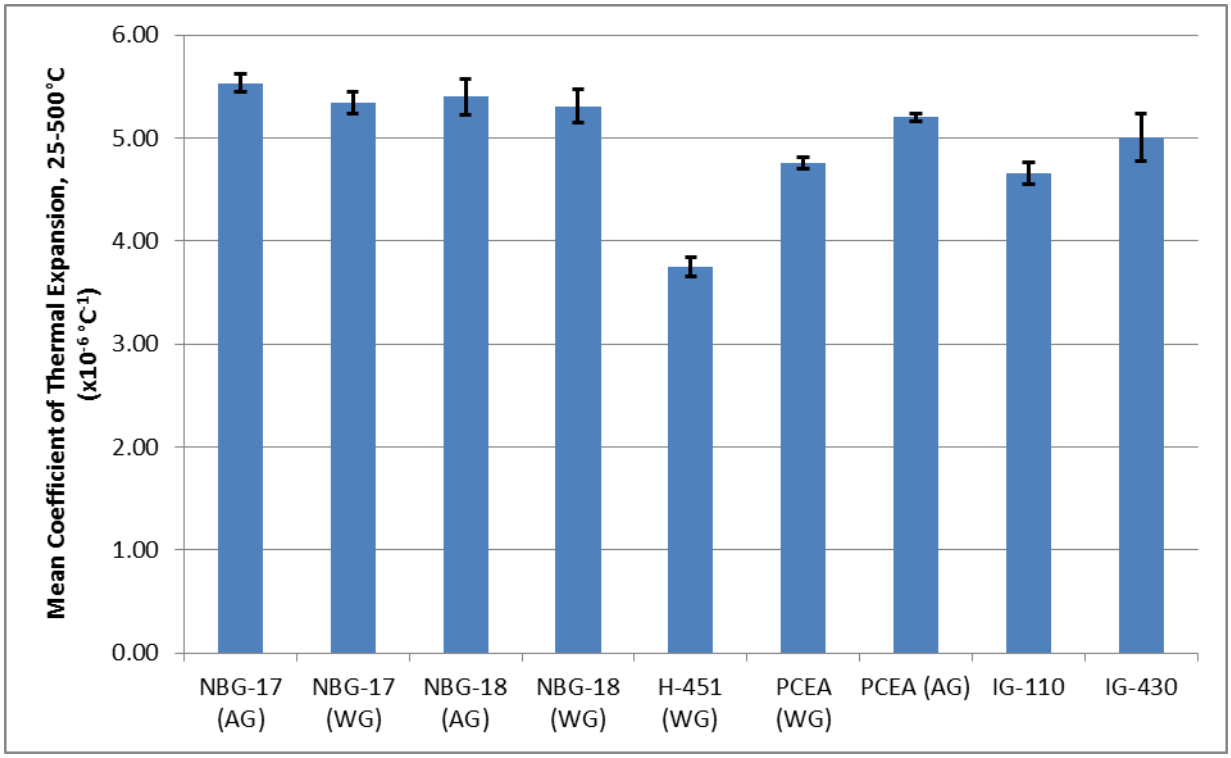

Fig. 209. A summary plot of the mean CTE (25-500°C) for all the creep specimens by grade/orientation (error bars represent ± 1 standard deviation)

3.6. Pre-Irradiation Examination, Electrical Resistivity

The electrical resistivity data are in Appendices 142-147. Corrected values are highlighted yellow with corrected raw data highlighted yellow with red type face. A few transcription errors were found in individual resistivity data. One error in dimensions was noted and corrected (these errors were noted in the previous sections and carried forward). Table 45 summarizes the errors found and corrected values of the electrical resistivity.

Table 45. List of errors detected and corrected values for the electrical resistivity data

Grade	Sample Number	Uncorrected R, μΩm	Error and Correction	Corrected R, μΩm
NBG-17	AL6-03	9.00	Voltage reading 3/3 entered as 0.000373 should be 0.00373	9.53
NBG-17	AW2-03	9.50	Voltage reading 3/3 entered as 0.002618 should be 0.003618	9.66
NBG-18	BW1-03	7.42	CSA entered as 97.4839 mm^2 should be 127.3367 mm^2	9.69
NBG-18	BW1-01	8.92	Voltage reading 2/3 entered as 0.002895 should be 0.003895	9.08
NBG-18	BL6-01	8.88	Voltage reading 3/2 entered as 0.002855 should be 0.003855	9.04
H-451	CW9-02	11.6	Voltage reading 4/3 entered as 0.030500 should be 0.003050	7.28
PCEA	DW5-03	8.21	Voltage reading 2/3 entered as 0.003661 should be 0.003361	8.17
IG-110	EW10-01	10.77	Voltage reading 2/4 entered as 0.00282 should be 0.00482	11.08

As discussed previously (3.1. Density) two of the PCEA specimens (DA7-02 and DA8-01) appear to be with-grain orientation rather than against-grain orientation. These two data points are highlighted in red in Fig. 216.

The corrected mean values for electrical resistivity and standard deviations are reported in Table 46 and plotted in Fig. 210. The majority of the graphites have a resistivity of between 8 and 10 μΩm. Grade H-451 has a notably lower resistivity and grade IG-110 has a notably higher electrical resistivity. The near-isotropic grades NBG-17, NBG-18, and PCEA all exhibited differences in their WG and AG resistivity's. In all cases the AG resistivity was greater than the

WG resistivity. This difference is expected and indicates the preferred orientation of the crystallographic basal planes in the filler particles, which tend to align during forming and are more electrically conductive.

Table 46. Summary of mean and standard deviation for electrical resistivity for each major grade

	Electrical Resistivity, μΩm			
Grade	No. of Samples	Mean	St. Dev	± 3SD
NBG-17-(AG)	30	10.22	0.221	0.663
NBG-17-(WG)	8	9.87	0.426	1.278
NBG-18-(AG)	30	9.48	0.202	0.606
NBG-18-(WG)	8	9.29	0.230	0.689
H-451	22	6.98	0.622	1.866
PCEA (WG)	33	8.04	0.082	0.246
PCEA (AG)	5	9.03	0.149	0.447
IG-110	22	12.22	0.592	1.776
IG-430	34	9.68	0.687	2.061

The electrical resistivity data is reported and plotted for each grade in Figs. 211-219. Corrected values are highlighted in yellow.

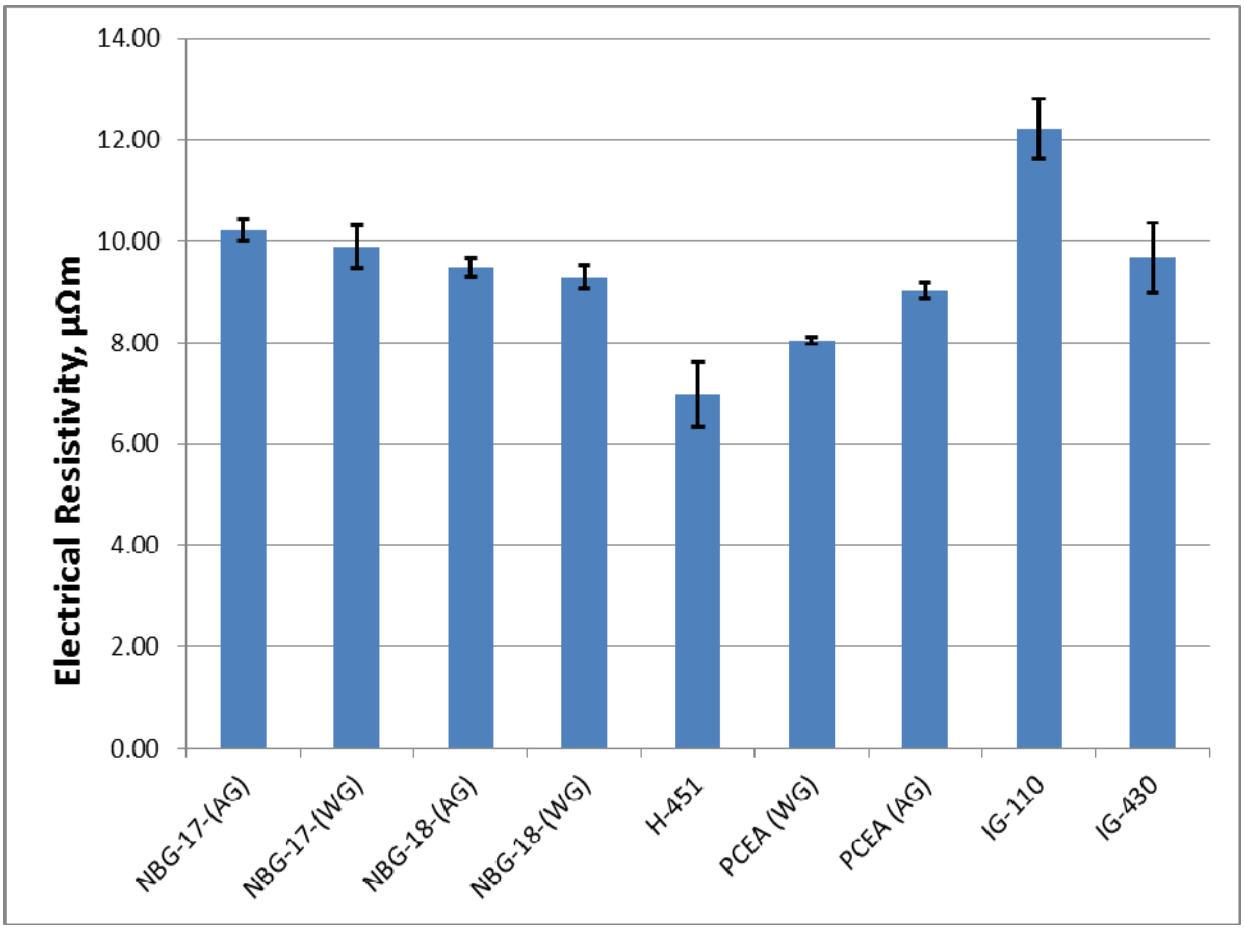

Fig. 210. Summary plot of the electrical resistivity for of the major grades (mean ± 1 standard deviation).

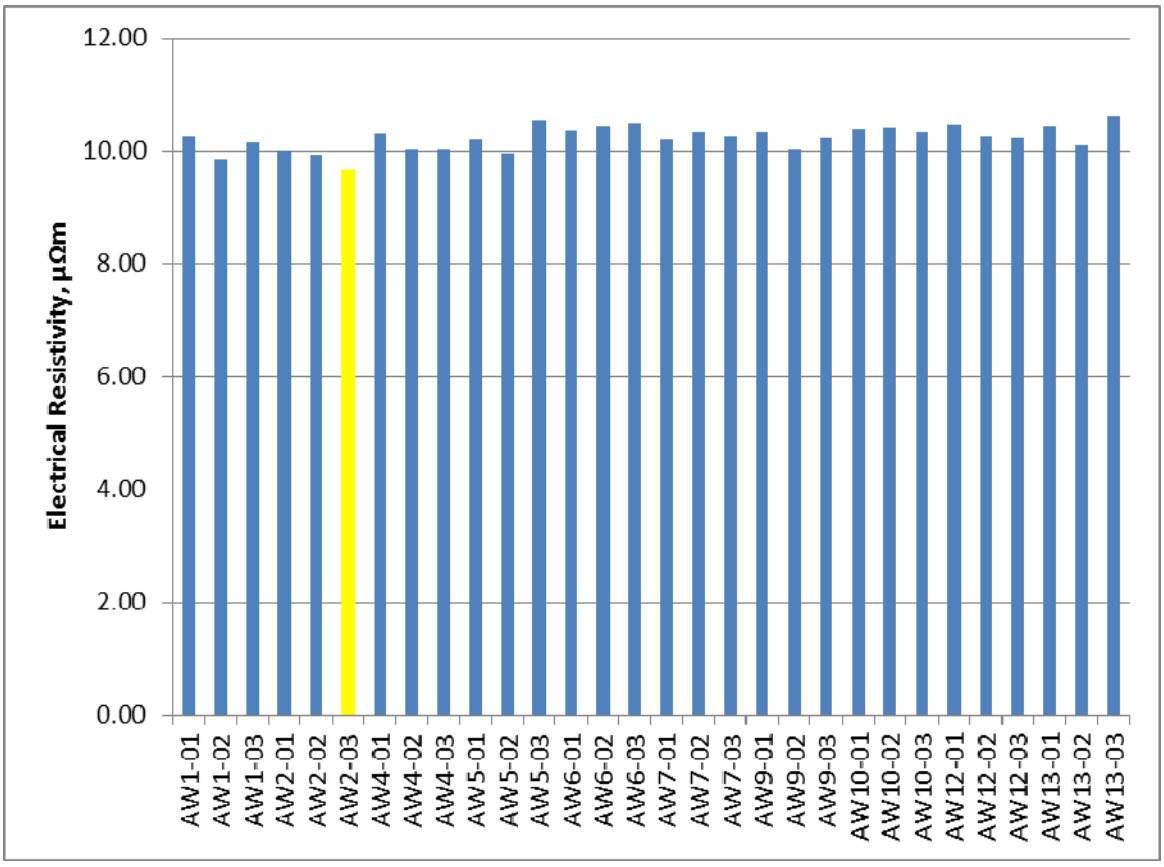

Fig. 211. Electrical resistivity for grade NBG-17 (against-grain) creep samples

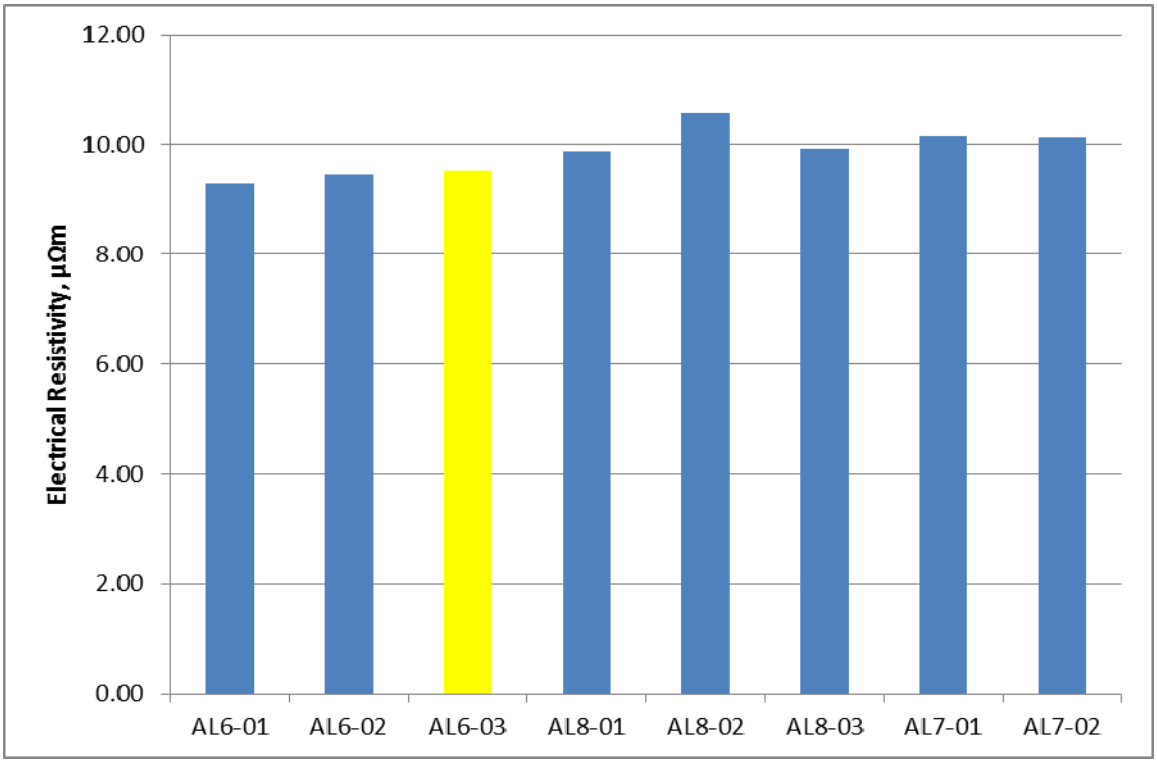

Fig. 212. Electrical resistivity for grade NBG-17 (with-grain) creep samples

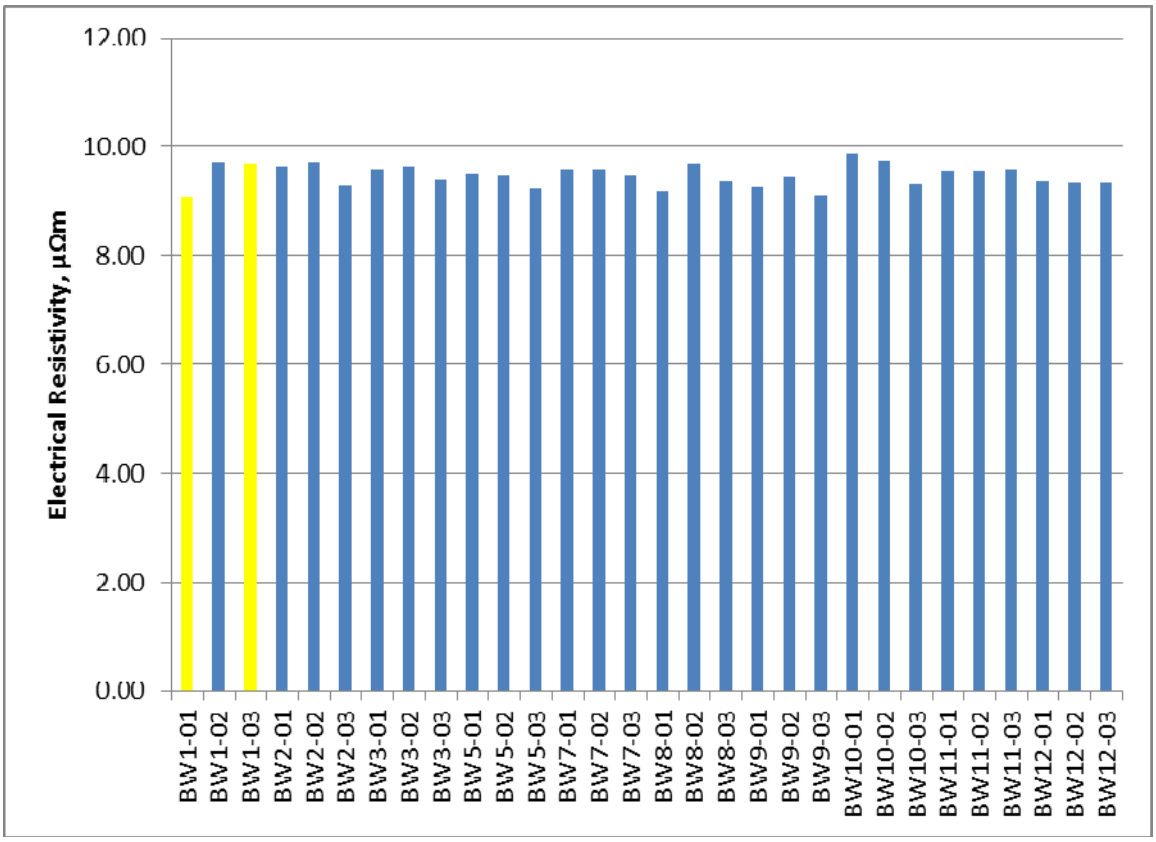

Fig. 213. Electrical resistivity for grade NBG-18(against-grain) creep samples

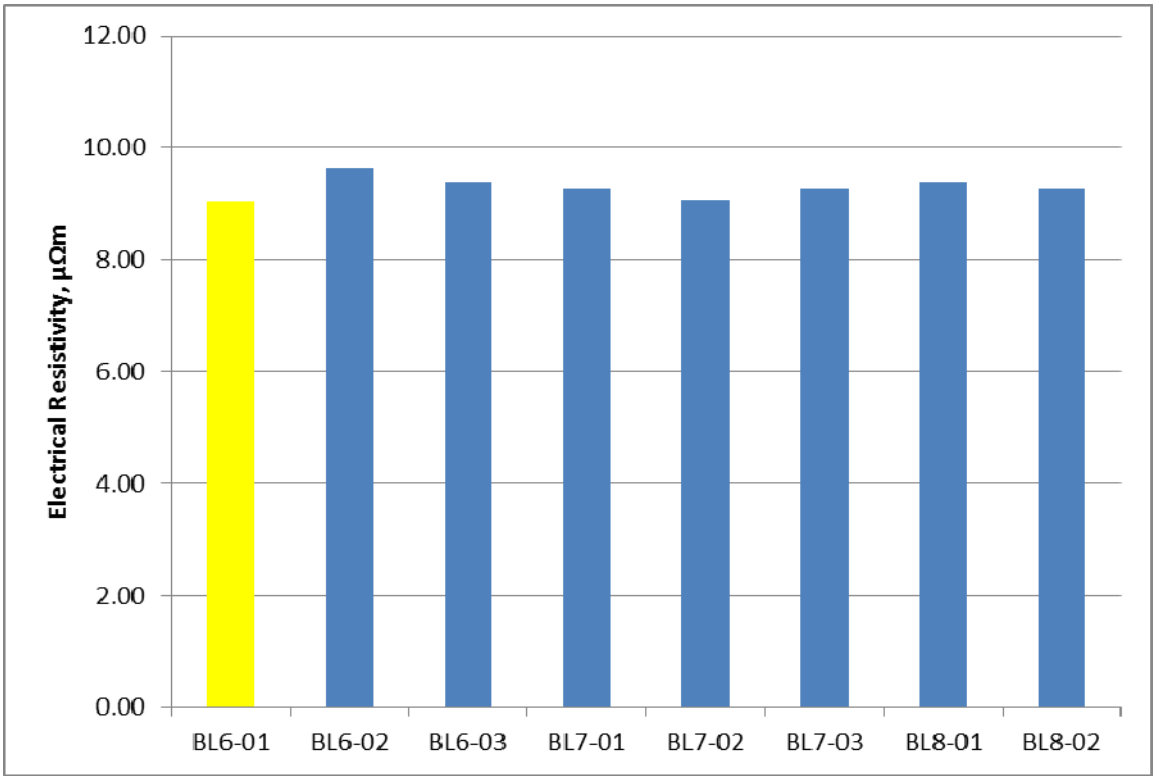

Fig. 214. Electrical resistivity for grade NBG-18 (against-grain) creep samples

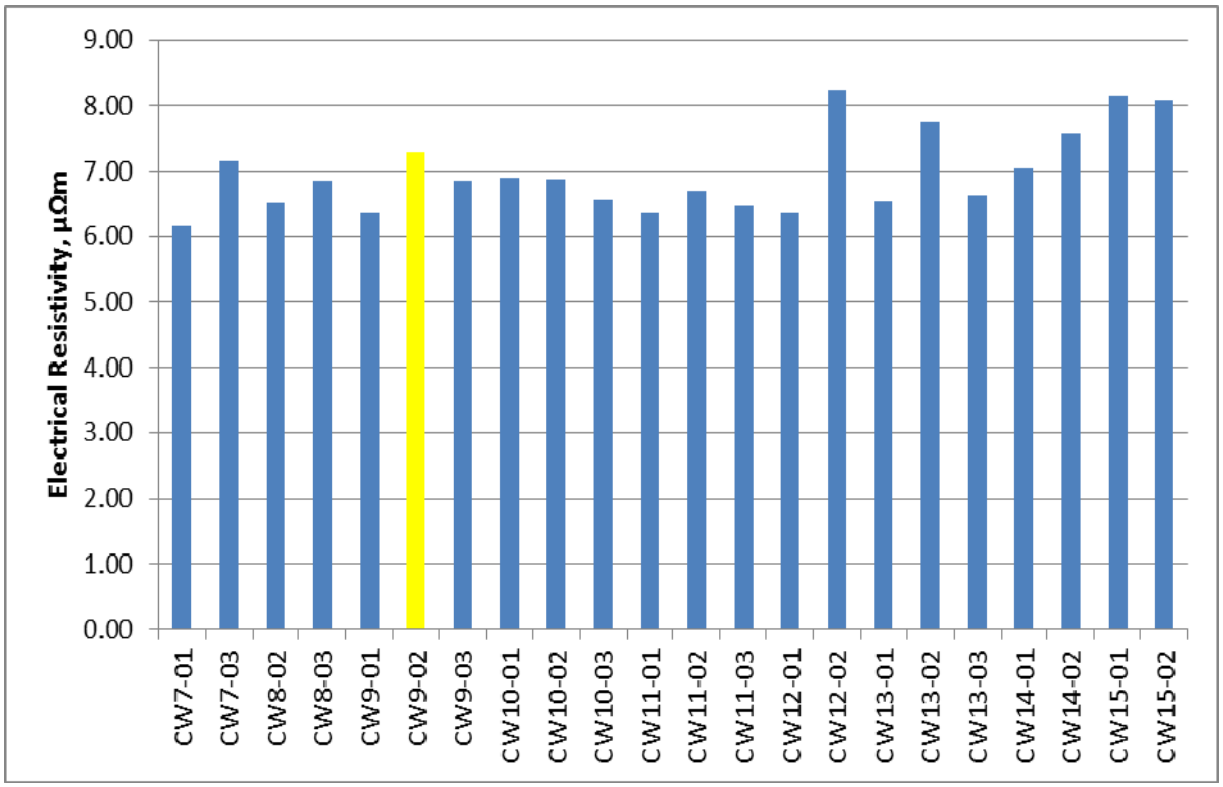

Fig. 215. Electrical resistivity for grade H-451 (with-grain) creep samples

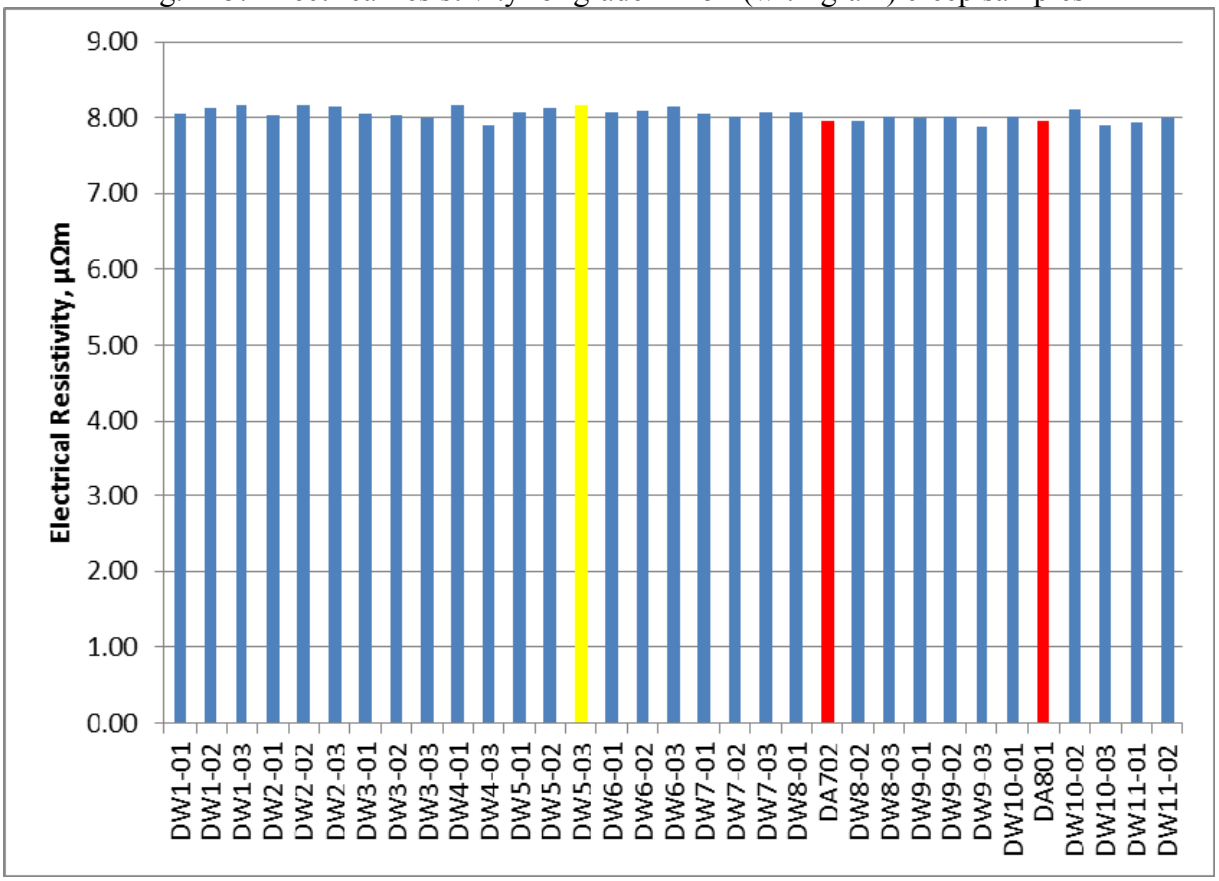

Fig. 216. Electrical resistivity for grade PCEA (with-grain) creep samples

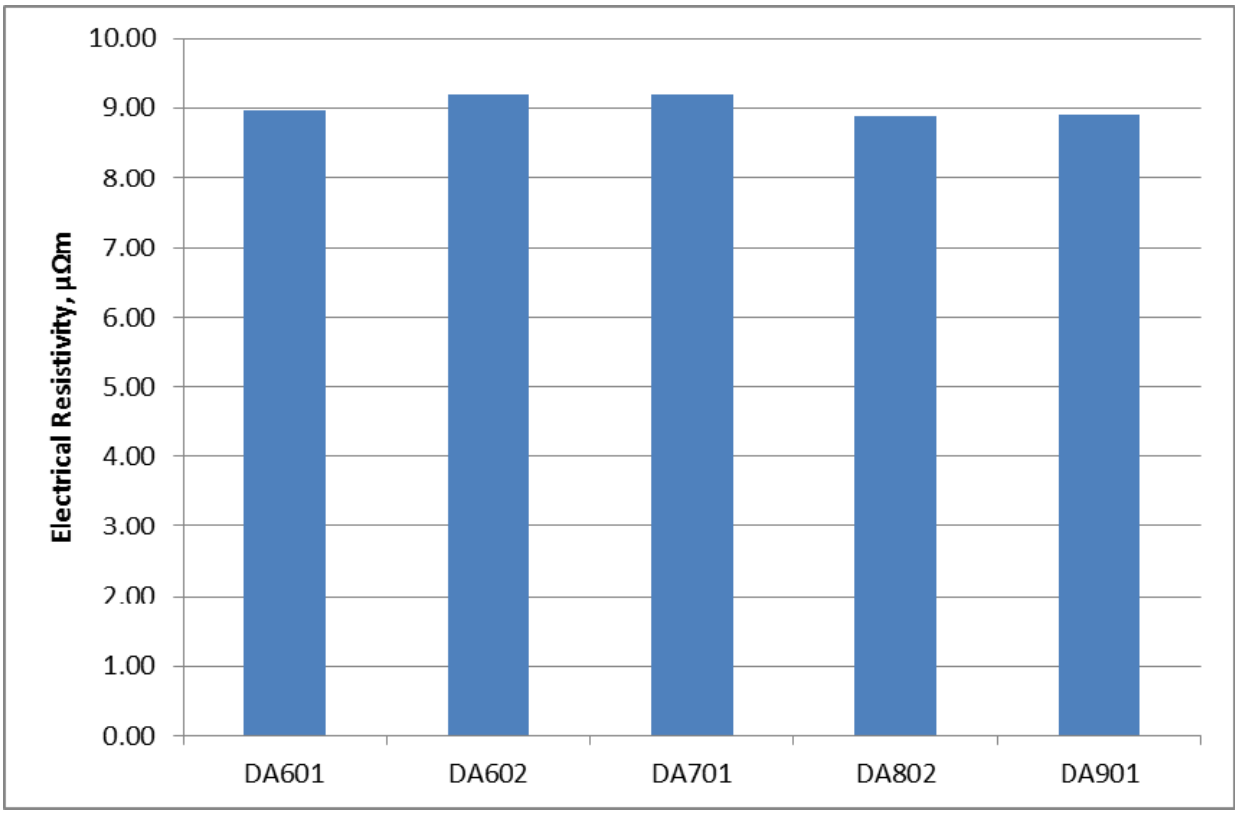

Fig. 217. Electrical resistivity for grade PCEA (against-grain) creep samples

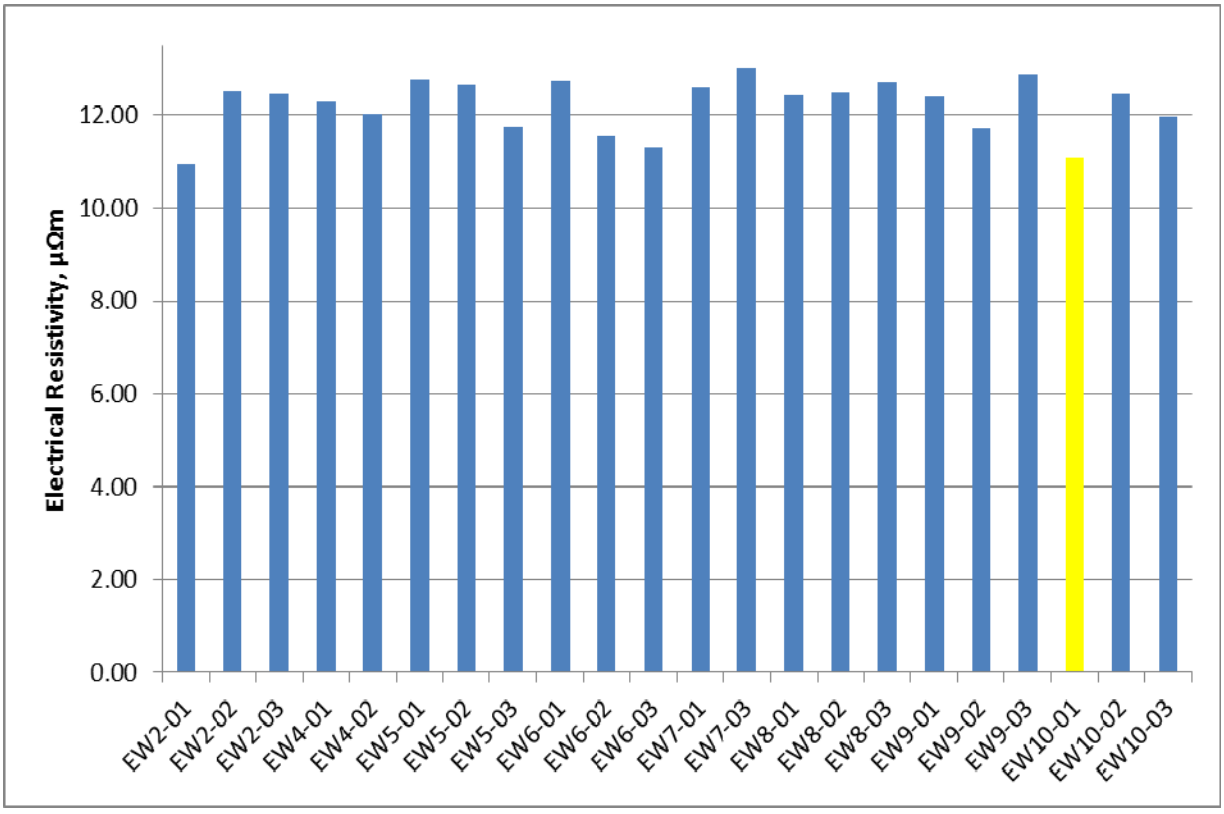

Fig. 218. Electrical resistivity for grade IG-110 creep samples

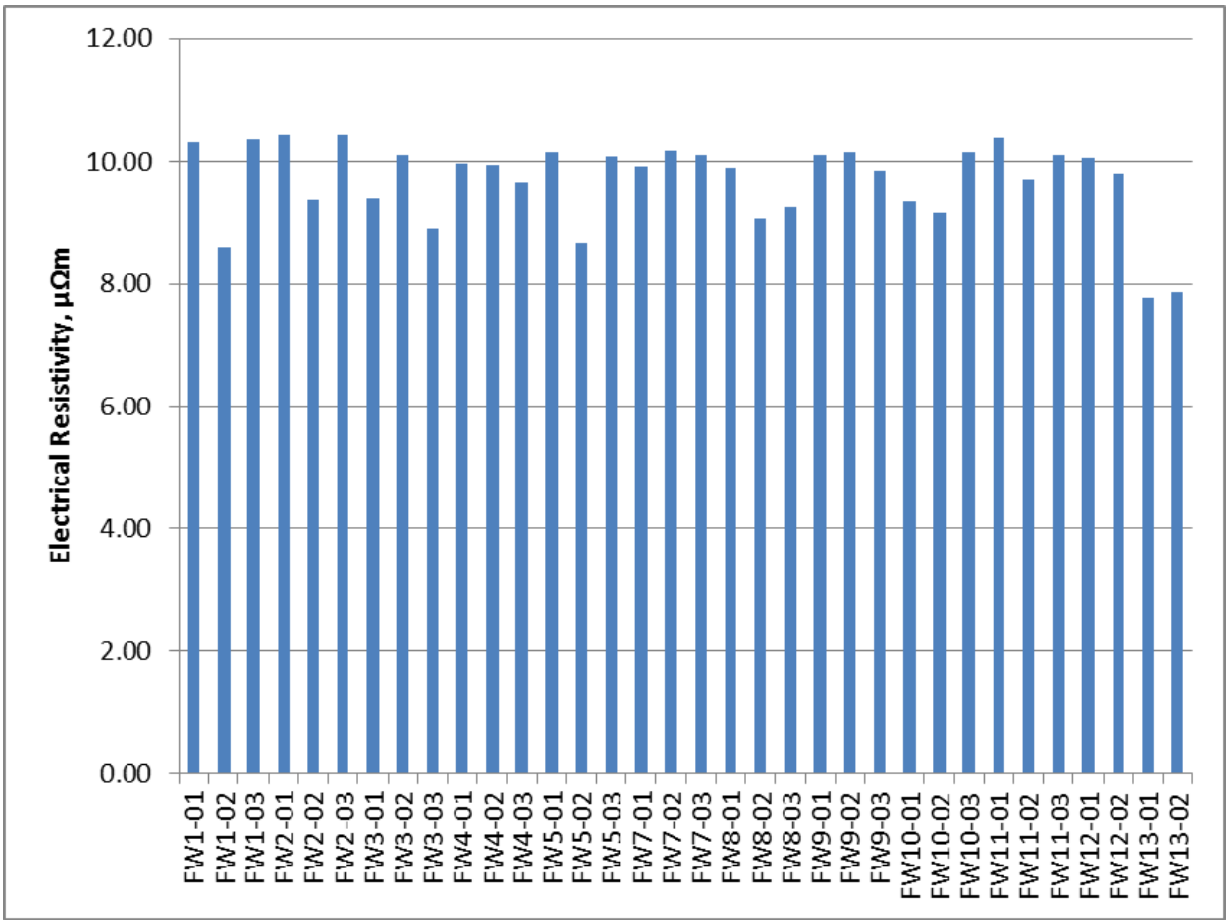

Fig. 219. Electrical resistivity for grade IG-430 creep samples

4 Conclusions

The characterization (non-destructively) of AGC-1 creep and piggy-back specimens is reported and evaluated for the various grades included in AGC-1. The properties measured were:

- Dimensions, Specimen Mass and Density (by mensuration)
- Elastic Constants
    - Flexural Dynamic Young's Modulus (fundamental frequency method)
    - Sonic elastic constants
        - Longitudinal Dynamic Young's Modulus
        - Longitudinal Dynamic Shear Modulus
        - Poisson's ratio
- Thermal Conductivity (ambient temperature)
- Thermal Expansion (elevated temperature)
- Electrical Resistivity

Some of the methods used for characterization are difficult to apply to the small specimens geometries adopted of necessity for AGC-1. However, within the scope of ASTM C 781 [11], these methods are modified to accommodate the smaller sample sizes specifically for irradiation experiments. Consequently, some of the data should not be considered representative of the absolute properties for the graphite, but should allow for relative effects (or fractional property changes) to be established post-irradiation.

Small, but significant, dimensional shrinkages are observed as a result of the thermal excursion associated with thermal expansion measurement. The dimensional change, predominantly shrinkage, was as large as > 0.0008 in. over the 1.000 in. length and > 0.0007 in. over the 0.500 in. diameter. Changes of this magnitude may be significant where the irradiation induced dimensional change will be small, < 0.5% over the 1.000 in. specimen length, or a < 0.005 in. change, as may be the case in low dose, 600°C irradiation experiments [14]. In such circumstances the error associated with not accounting for this thermally induced shrinkage could exceed 10%. Since the magnitude of the change varies from specimen to specimen the

resulting error from not using final dimensions (after CTE) is potentially significant when evaluating the creep strain. Consequently, it is recommended that all specimens be finally dimensionally measured AFTER thermal excursion associated with thermal expansion measurements.

Young's modulus was determined non-destructively by the fundamental frequency method (flexural dynamic Young's modulus) and sonically from the longitudinal wave velocity. There was reasonable agreement between the moduli determined from the two methods, although the flexural dynamic moduli Young's values were somewhat greater than the Young's Modulus from sonic velocity for all of the grades/orientations examined here. Based upon the non-destructive evaluations of Young's modulus all of the grades meet the ASTM D 7219 (2008) nuclear graphite specification requirement for Young's modulus. Other elastic constants were determined sonically, including shear dynamic modulus and Poisson's ratio. A large difference was observed in the Poisson's ratio between the isostatically pressed grades ($\mu \approx 0.17$-0.25) and the other grades ($\mu \approx 0.31$-0.33). Moreover, the measured value of Poisson's ratio was typically smaller when determined from the piggyback specimens.

The majority of the fully dense graphite grades exhibited a room temperature thermal conductivity in the range 100-210 W/m.K. Grade 2020 exhibited a particularly low conductivity (80.6 W/m.K). The A3-matrix samples exhibited a mean conductivity of 14.3 W/m.K, which can be attributed to the low final heat treatment temperature of A3-matrix (~1800°C) and the low bulk density of A3-matrix material (see discussion in Section 3.1). The graphite grades tending to exhibit the greatest room temperature thermal conductivities were the extruded (WG orientation) grades.

The six major grades were subject to thermal expansion measurement over the temperature range 100 to 800°C at 100°C intervals. Review of the data revealed only one data package error, namely that the data for NBG-17 specimen AL8-02 was incorrectly copied (a duplicate data set from AL8-03 specimen was erroneously reported). This error was corrected during this analysis and the revised data package is correct. The expansion and CTE data for PCEA specimens DA7-

02 and DA8-01 confirm that these specimens are in fact with-grain orientation rather than against-grain specimens as marked.

The thermal expansion data sets are remarkably consistent within grades. The mean CTE is somewhat more variable within grades, particularly at the lower measurements temperatures. However, at higher temperatures the within grades variability is markedly reduced. The ASTM specifications for nuclear graphite, D7219 [16] require the with-grain CTE (25-500°C) to be between 3.5 and 5.5 x 10^{-6} $°C^{-1}$. The CTE data reported here are summarized in Table 44 and Fig. 209 which reports the mean CTE (10-500°C) for all the primary grades. Grade NBG-17 (AG) mean CTE (25-500°C) was slightly above this range (5.54 x 10^{-6}). The NBG-17 used here was from a trial batch, not a production batch, and this may have caused the slightly higher CTE. Subsequent production batches of NBG-17 included in the AGC series and baseline program should be monitored closely to assure CTE compliance.

The majority of the graphite grades have an electrical resistivity between 8 and 10 μΩm. Grade H-451 has a notably lower resistivity and grade IG-110 has a notably higher electrical resistivity. The near-isotropic grades NBG-17, NBG-18, and PCEA all exhibited differences in their WG and AG resistivity's. In all cases the AG resistivity was greater than the WG resistivity. This difference is expected and indicates the preferred orientation of the crystallographic basal planes in the filler particles, which tend to align during forming, which are more electrically conductive.

Evaluation of the specimen data set indicated several anomalies that resulted from probable transposition errors, or improper machining/engraving of the sample orientation. The analysis and evaluation of the specimen data highlights several key facts:

(a) During pre-irradiation examination dimensions should be finally measured after any physical property determinations that require temperature excursions
(b) Errors occur during transposition of data. Consequently, direct electronic data recording (e.g., direct output from instruments) are recommended.
(c) Prompt evaluation of the data set is recommended such that if errors are found they can be rectified or mitigated prior to installing the specimens in the irradiation capsule.

4 References

1. AGC-1 Pre-Irradiation Examination Data Packages, submitted to INL (2008)
2. T. Burchell and R. Bratton. ORNL/TM-2005/505. Graphite Irradiation Creep Capsule AGC-1 Experimental Plan. May 2005.
3. T. D. Burchell, A Revised AGC-1 Creep Capsule Layout, ORNL/TM-2009/009 (January, 2009)
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6. Acknowledgments

The authors wish to thank Cliff Davisson for dimensional and Specimen Mass measurements and Ashli Clark for measurements of thermal expansion.

This work is sponsored by the U.S. Department of Energy, Office of Nuclear Energy Science and Technology under contract DE-AC05-00OR22725 with Oak Ridge National Laboratory, managed by UT-Battelle, LLC.

Appendix 1. Final dimensions, specimen mass and bulk density for NBG-17 Creep specimens (sheet 1)

	Specimen	Sample	Length Measurements, in.			
Type	Number	Location	Allowable: 0.998 - 1.000			
			T1	T2	T3	T4
Creep	AW1-01	1S3	0.99915	0.99910	0.99925	0.99915
Creep	AW1-02	1S11	0.99895	0.99900	0.99890	0.99890
Creep	AW1-03	1S12	0.99890	0.99890	0.99855	0.99875
Creep	AL6-01	1S13	0.99890	0.99865	0.99865	0.99880
Creep	AW2-01	1U3	0.99910	0.99915	0.99895	0.99895
Creep	AW2-02	1U11	0.99910	0.99910	0.99910	0.99900
Creep	AW2-03	1U12	0.99900	0.99910	0.99900	0.99895
Creep	AL6-02	2S4	0.99870	0.99875	0.99885	0.99875
Creep	AW4-01	2S6	0.99900	0.99895	0.99900	0.99900
Creep	AL6-03	2S10	0.99850	0.99845	0.99830	0.99835
Creep	AW4-02	2U4	0.99890	0.99890	0.99890	0.99895
Creep	AW4-03	2U6	0.99940	0.99940	0.99935	0.99940
Creep	AW5-01	2U10	0.99895	0.99900	0.99900	0.99895
Creep	AL8-01	3S8	0.99820	0.99830	0.99825	0.99825
Creep	AW5-02	3S13	0.99900	0.99885	0.99895	0.99925
Creep	AW5-03	3U8	0.99900	0.99915	0.99910	0.99900
Creep	AW6-01	3U12	0.99910	0.99925	0.99900	0.99905
Creep	AW6-02	4S8	0.99915	0.99905	0.99915	0.99915
Creep	AL8-02	4S11	0.99910	0.99910	0.99895	0.99930
Creep	AW6-03	4S12	0.99930	0.99925	0.99950	0.99930
Creep	AW7-01	4U8	0.99900	0.99900	0.99880	0.99880
Creep	AW7-02	4U11	0.99880	0.99900	0.99900	0.99895
Creep	AL8-03	5S3	0.99865	0.99850	0.99865	0.99875
Creep	AW7-03	5S6	0.99910	0.99910	0.99900	0.99905
Creep	AW9-01	5S14	0.99915	0.99910	0.99905	0.99920
Creep	AW9-02	5U3	0.99915	0.99895	0.99915	0.99910
Creep	AW9-03	5U6	0.99910	0.99905	0.99910	0.99900
Creep	AW10-01	5U13	0.99905	0.99930	0.99930	0.99915
Creep	AW10-02	6S1	0.99910	0.99905	0.99900	0.99905
Creep	AW10-03	6S8	0.99895	0.99890	0.99910	0.99900
Creep	AW12-01	6S15	0.99830	0.99815	0.99820	0.99825
Creep	AW12-02	6U1	0.99885	0.99880	0.99895	0.99885
Creep	AW12-03	6U8	0.99810	0.99810	0.99815	0.99810
Creep	AW13-01	6U14	0.99905	0.99890	0.99880	0.99885
Creep	AL7-01	Spare 1A	0.99875	0.99865	0.99865	0.99885
Creep	AL7-02	Spare 2A	0.99860	0.99860	0.99850	0.99845
Creep	AW13-02	Spare 1W	0.99860	0.99880	0.99865	0.99870
Creep	AW13-03	Spare 2W	0.99840	0.99840	0.99850	0.99850

Appendix 1. Final dimensions, specimen mass and bulk density for NBG-17 Creep specimens (sheet 2)

Outside Diameter Measurements								
Allowable: 0.500 - 0.502								
D1	D2	D3	D4		$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$
0.50125	0.50140	0.50130	0.50085		0.50130	0.50130	0.50125	0.50120
0.50140	0.50165	0.50165	0.50145		0.50145	0.50175	0.50165	0.50150
0.50185	0.50170	0.50155	0.50150		0.50170	0.50150	0.50155	0.50150
0.50150	0.50140	0.50120	0.50145		0.50150	0.50145	0.50115	0.50115
0.50165	0.50165	0.50140	0.50135		0.50165	0.50155	0.50150	0.50160
0.50150	0.50150	0.50135	0.50135		0.50150	0.50140	0.50130	0.50125
0.50090	0.50080	0.50105	0.50090		0.50095	0.50080	0.50085	0.50090
0.50155	0.50135	0.50110	0.50105		0.50140	0.50140	0.50120	0.50105
0.50160	0.50145	0.50150	0.50130		0.50150	0.50150	0.50165	0.50150
0.50135	0.50135	0.50130	0.50180		0.50125	0.50135	0.50160	0.50160
0.50140	0.50140	0.50145	0.50130		0.50165	0.50150	0.50150	0.50145
0.50185	0.50180	0.50165	0.50150		0.50180	0.50180	0.50175	0.50155
0.50155	0.50160	0.50160	0.50180		0.50155	0.50155	0.50145	0.50190
0.50145	0.50125	0.50095	0.50095		0.50145	0.50040	0.50095	0.50095
0.50100	0.50080	0.50100	0.50170		0.50095	0.50085	0.50115	0.50170
0.50125	0.50120	0.50140	0.50170		0.50125	0.50125	0.50145	0.50160
0.50145	0.50160	0.50160	0.50190		0.50145	0.50135	0.50155	0.50180
0.50120	0.50150	0.50135	0.50160		0.50120	0.50130	0.50145	0.50150
0.50130	0.50160	0.50150	0.50120		0.50150	0.50150	0.50145	0.50130
0.50090	0.50115	0.50120	0.50135		0.50110	0.50115	0.50115	0.50140
0.50170	0.50155	0.50145	0.50135		0.50175	0.50155	0.50145	0.50140
0.50165	0.50150	0.50145	0.50120		0.50165	0.50155	0.50155	0.50135
0.50160	0.50130	0.50110	0.50150		0.50165	0.50150	0.50125	0.50130
0.50175	0.50160	0.50150	0.50110		0.50155	0.50150	0.50140	0.50130
0.50100	0.50115	0.50120	0.50135		0.50110	0.50110	0.50130	0.50150
0.50115	0.50125	0.50135	0.50150		0.50115	0.50120	0.50130	0.50140
0.50130	0.50150	0.50155	0.50165		0.50120	0.50130	0.50145	0.50170
0.50095	0.50100	0.50110	0.50140		0.50105	0.50100	0.50120	0.50145
0.50135	0.50150	0.50150	0.50180		0.50150	0.50155	0.50155	0.50180
0.50140	0.50125	0.50130	0.50155		0.50130	0.50135	0.50135	0.50155
0.50170	0.50145	0.50145	0.50140		0.50180	0.50160	0.50160	0.50135
0.50130	0.50160	0.50130	0.50130		0.50125	0.50100	0.50115	0.50125
0.50130	0.50100	0.50100	0.50115		0.50130	0.50095	0.50090	0.50100
0.50160	0.50105	0.50120	0.50110		0.50160	0.50110	0.50105	0.50110
0.50130	0.50095	0.50075	0.50060		0.50110	0.50085	0.50065	0.50060
0.50150	0.50135	0.50100	0.50095		0.50135	0.50130	0.50130	0.50095
0.50135	0.50130	0.50150	0.50150		0.50120	0.50130	0.50145	0.50160
0.50125	0.50140	0.50140	0.50155		0.50125	0.50140	0.50150	0.50160

Appendix 1. Final dimensions, specimen mass and bulk density for NBG-17 Creep specimens (sheet 3)

Hole Diameter, in.				Measured by:	Date:
Allowable: 0.124 - 0.128					mm/dd/yr
H1	H2	H1'	H2'		
0.12440	0.12430	0.12500	0.12480	CCD	12/18/2007
0.12520	0.12520	0.12470	0.12450	CCD	12/18/2007
0.12480	0.12470	0.12490	0.12470	CCD	12/18/2007
0.12500	0.12490	0.12450	0.12450	CCD	12/18/2007
0.12480	0.12460	0.12500	0.12480	CCD	12/18/2007
0.12550	0.12540	0.12530	0.12520	CCD	12/18/2007
0.12480	0.12470	0.12600	0.12590	CCD	12/18/2007
0.12540	0.12530	0.12450	0.12460	CCD	12/18/2007
0.12500	0.12490	0.12520	0.12510	CCD	12/18/2007
0.12560	0.12560	0.12500	0.12490	CCD	12/18/2007
0.12510	0.12490	0.12520	0.12510	CCD	12/18/2007
0.12480	0.12460	0.12460	0.12460	CCD	12/18/2007
0.12480	0.12480	0.12470	0.12490	CCD	12/18/2007
0.12500	0.12480	0.12500	0.12480	CCD	12/18/2007
0.12500	0.12480	0.12500	0.12490	CCD	12/18/2007
0.12480	0.12480	0.12480	0.12450	CCD	12/18/2007
0.12510	0.12490	0.12540	0.12530	CCD	12/18/2007
0.12600	0.12590	0.12540	0.12530	CCD	12/18/2007
0.12450	0.12450	0.12470	0.12490	CCD	12/18/2007
0.12560	0.12540	0.12560	0.12560	CCD	12/18/2007
0.12480	0.12470	0.12530	0.12520	CCD	12/18/2007
0.12550	0.12540	0.12520	0.12510	CCD	12/18/2007
0.12470	0.12460	0.12640	0.12630	CCD	12/18/2007
0.12460	0.12450	0.12570	0.12580	CCD	12/18/2007
0.12450	0.12440	0.12490	0.12490	CCD	12/18/2007
0.12500	0.12490	0.12480	0.12490	CCD	12/18/2007
0.12480	0.12470	0.12540	0.12530	CCD	12/18/2007
0.12500	0.12500	0.12510	0.12500	CCD	12/18/2007
0.12570	0.12540	0.12470	0.12450	CCD	12/18/2007
0.12470	0.12460	0.12530	0.12520	CCD	12/18/2007
0.12460	0.12450	0.12530	0.12510	CCD	12/18/2007
0.12470	0.12460	0.12550	0.12530	CCD	12/18/2007
0.12460	0.12450	0.12470	0.12450	CCD	12/18/2007
0.12460	0.12460	0.12510	0.12500	CCD	12/18/2007
0.12550	0.12540	0.12560	0.12550	CCD	12/18/2007
0.12480	0.12460	0.12490	0.12470	CCD	12/18/2007
0.12550	0.12560	0.12590	0.12560	CCD	12/18/2007
0.12480	0.12470	0.12480	0.12470	CCD	12/18/2007

Appendix 1. Final dimensions, specimen mass and bulk density for NBG-17 Creep specimens (sheet 4)

Average * Length mm	Average * Diameter mm	Average * Cross sect Area, mm^2	Average * Length m	Average * Diameter m	2- hole volume m^3
25.3787	12.7313	127.3018	0.0254	0.0127	5.1973E-08
25.3730	12.7397	127.4701	0.0254	0.0127	5.2203E-08
25.3689	12.7408	127.4924	0.0254	0.0127	5.2098E-08
25.3683	12.7343	127.3621	0.0254	0.0127	5.2056E-08
25.3756	12.7392	127.4606	0.0254	0.0127	5.2119E-08
25.3765	12.7354	127.3844	0.0254	0.0127	5.2579E-08
25.3749	12.7227	127.1304	0.0254	0.0127	5.2580E-08
25.3686	12.7321	127.3177	0.0254	0.0127	5.2245E-08
25.3743	12.7381	127.4384	0.0254	0.0127	5.2328E-08
25.3594	12.7368	127.413	0.0254	0.0127	5.2517E-08
25.3724	12.7370	127.4161	0.0254	0.0127	5.2349E-08
25.3844	12.7435	127.5464	0.0254	0.0127	5.1994E-08
25.3740	12.7413	127.5019	0.0254	0.0127	5.2119E-08
25.3556	12.7265	127.2066	0.0254	0.0127	5.2202E-08
25.3749	12.7291	127.2574	0.0254	0.0127	5.2223E-08
25.3762	12.7352	127.3812	0.0254	0.0127	5.2056E-08
25.3771	12.7403	127.4828	0.0254	0.0127	5.2433E-08
25.3778	12.7352	127.3812	0.0254	0.0127	5.2831E-08
25.3775	12.7360	127.3971	0.0254	0.0127	5.1994E-08
25.3832	12.7298	127.2732	0.0254	0.0127	5.2747E-08
25.3721	12.7387	127.4511	0.0254	0.0127	5.2286E-08
25.3730	12.7378	127.432	0.0254	0.0127	5.2537E-08
25.3654	12.7356	127.3876	0.0254	0.0127	5.2708E-08
25.3762	12.7371	127.4193	0.0254	0.0127	5.2413E-08
25.3778	12.7308	127.2923	0.0254	0.0127	5.2015E-08
25.3768	12.7327	127.3304	0.0254	0.0127	5.2202E-08
25.3762	12.7370	127.4161	0.0254	0.0127	5.2328E-08
25.3797	12.7291	127.2574	0.0254	0.0127	5.2307E-08
25.3759	12.7398	127.4733	0.0254	0.0127	5.2349E-08
25.3743	12.7351	127.378	0.0254	0.0127	5.2244E-08
25.3549	12.7392	127.4606	0.0254	0.0127	5.2182E-08
25.3711	12.7322	127.3209	0.0254	0.0127	5.2307E-08
25.3521	12.7273	127.2225	0.0254	0.0127	5.1931E-08
25.3721	12.7311	127.2986	0.0254	0.0127	5.2140E-08
25.3676	12.7216	127.1082	0.0254	0.0127	5.2705E-08
25.3629	12.7308	127.2923	0.0254	0.0127	5.2077E-08
25.3667	12.7356	127.3876	0.0254	0.0127	5.2831E-08
25.3606	12.7360	127.3971	0.0254	0.0127	5.2077E-08

Appendix 1. Final dimensions, specimen mass and bulk density for NBG-17 Creep specimens (sheet 5)

Specimen Number	Specimen Mass, g	Weighed by:	Date: mm/dd/yr	Density kg/m^3	Density g/cm^3
AW1-01	5.8614	JPS	11/14/2007	1843.9120	1.8439
AW1-02	5.9043	JPS	11/14/2007	1855.4736	1.8555
AW1-03	5.9168	JPS	11/14/2007	1859.3184	1.8593
AL6-01	5.9342	JPS	11/14/2007	1866.7473	1.8667
AW2-01	5.9366	JPS	11/14/2007	1865.5269	1.8655
AW2-02	5.9269	JPS	11/14/2007	1863.8103	1.8638
AW2-03	5.9217	JPS	11/14/2007	1866.0756	1.8661
AL6-02	5.9218	JPS	11/14/2007	1863.5944	1.8636
AW4-01	5.9331	JPS	11/14/2007	1864.9751	1.8650
AL6-03	5.9401	JPS	11/14/2007	1868.7820	1.8688
AW4-02	5.9364	JPS	11/14/2007	1866.4981	1.8665
AW4-03	5.9319	JPS	11/14/2007	1862.0395	1.8620
AW5-01	5.9411	JPS	11/14/2007	1866.4450	1.8664
AL8-01	5.9178	JPS	11/14/2007	1864.9368	1.8649
AW5-02	5.9287	JPS	11/14/2007	1866.1773	1.8662
AW5-03	5.9198	JPS	11/14/2007	1861.3423	1.8613
AW6-01	5.9383	JPS	11/14/2007	1865.7956	1.8658
AW6-02	5.9258	JPS	11/14/2007	1863.5646	1.8636
AL8-02	5.9359	JPS	11/14/2007	1866.0365	1.8660
AW6-03	5.9126	JPS	11/14/2007	1860.5651	1.8606
AW7-01	5.9322	JPS	11/14/2007	1864.6449	1.8646
AW7-02	5.9339	JPS	11/14/2007	1865.5389	1.8655
AL8-03	5.9307	JPS	11/14/2007	1865.8639	1.8659
AW7-03	5.9369	JPS	11/14/2007	1866.3607	1.8664
AW9-01	5.9210	JPS	11/14/2007	1862.8984	1.8629
AW9-02	5.9283	JPS	11/14/2007	1864.8092	1.8648
AW9-03	5.9321	JPS	11/14/2007	1864.8494	1.8648
AW10-01	5.9287	JPS	11/14/2007	1865.8705	1.8659
AW10-02	5.9365	JPS	11/14/2007	1865.4180	1.8654
AW10-03	5.9260	JPS	11/14/2007	1863.5915	1.8636
AW12-01	5.9283	JPS	11/14/2007	1864.4968	1.8645
AW12-02	5.9355	JPS	11/14/2007	1867.7053	1.8677
AW12-03	5.9277	JPS	11/14/2007	1867.9216	1.8679
AW13-01	5.9277	JPS	11/14/2007	1865.4123	1.8654
AL7-01	5.9224	JPS	11/14/2007	1867.2474	1.8672
AL7-02	5.9248	JPS	11/14/2007	1865.2453	1.8652
AW13-02	5.9269	JPS	11/14/2007	1864.6460	1.8646
AW13-03	5.9357	JPS	11/14/2007	1867.2810	1.8673

Appendix 2. Final dimensions, specimen mass and bulk density for NBG-18 Creep specimens (sheet 1)

Sample Location	Specimen Type	Specimen Number	Length Measurements, in. Allowable: 0.998 - 1.000			
			T1	T2	T3	T4
1S1	Creep	BL6-01	0.99880	0.99890	0.99880	0.99885
1S4	Creep	BW1-01	0.99890	0.99885	0.99905	0.99905
1U1	Creep	BW1-02	0.99890	0.99860	0.99870	0.99890
1U4	Creep	BW1-03	0.99870	0.99875	0.99895	0.99870
2S2	Creep	BW2-01	0.99885	0.99860	0.99855	0.99855
2S11	Creep	BW2-02	0.99875	0.99875	0.99855	0.99865
2S12	Creep	BL6-02	0.99890	0.99870	0.99875	0.99885
2U2	Creep	BW2-03	0.99850	0.99880	0.99840	0.99860
2U11	Creep	BW3-01	0.99870	0.99860	0.99870	0.99865
3S2	Creep	BW3-02	0.99915	0.99905	0.99920	0.99925
3S11	Creep	BW3-03	0.99860	0.99885	0.99875	0.99875
3S12	Creep	BL6-03	0.99880	0.99900	0.99890	0.99895
3S14	Creep	BW5-01	0.99865	0.99855	0.99850	0.99860
3U2	Creep	BW5-02	0.99880	0.99875	0.99860	0.99890
3U11	Creep	BW5-03	0.99860	0.99850	0.99875	0.99870
3U13	Creep	BW7-01	0.99885	0.99880	0.99865	0.99880
4S5	Creep	BW7-02	0.99900	0.99900	0.99900	0.99895
4S7	Creep	BL7-01	0.99875	0.99875	0.99870	0.99865
4S14	Creep	BW7-03	0.99865	0.99865	0.99850	0.99860
4U5	Creep	BW8-01	0.99925	0.99920	0.99935	0.99940
4U7	Creep	BW8-02	0.99915	0.99890	0.99885	0.99905
4U13	Creep	BW8-03	0.99840	0.99840	0.99825	0.99855
5S5	Creep	BL7-02	0.99855	0.99860	0.99865	0.99875
5S8	Creep	BW9-01	0.99895	0.99920	0.99925	0.99920
5S15	Creep	BW9-02	0.99875	0.99845	0.99870	0.99890
5U5	Creep	BW9-03	0.99905	0.99910	0.99935	0.99925
5U8	Creep	BW10-01	0.99930	0.99905	0.99915	0.99930
5U14	Creep	BW10-02	0.99900	0.99895	0.99910	0.99910
6S3	Creep	BL7-03	0.99880	0.99855	0.99880	0.99900
6S6	Creep	BW10-03	0.99910	0.99895	0.99910	0.99910
6S13	Creep	BW11-01	0.99895	0.99885	0.99900	0.99895
6U3	Creep	BW11-02	0.99895	0.99880	0.99910	0.99905
6U6	Creep	BW11-03	0.99875	0.99895	0.99900	0.99890
6U12	Creep	BW12-01	0.99890	0.99875	0.99885	0.99890
Spare 1A	Creep	BL8-01	0.99905	0.99910	0.99905	0.99895
Spare 2A	Creep	BL8-02	0.99805	0.99840	0.99830	0.99815
Spare 1W	Creep	BW12-02	0.99910	0.99900	0.99910	0.99920
Spare 2W	Creep	BW12-03	0.99840	0.99835	0.99855	0.99860

Appendix 2. Final dimensions, specimen mass and bulk density for NBG-18 Creep specimens (sheet 2)

Outside Diameter Measurements							
Allowable: 0.500 - 0.502							
D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$
0.50160	0.50145	0.50130	0.50125	0.50160	0.50145	0.50130	0.50125
0.50160	0.50160	0.50150	0.50130	0.50145	0.50160	0.50150	0.50145
0.50145	0.50155	0.50175	0.50170	0.50165	0.50165	0.50180	0.50180
0.50110	0.50125	0.50135	0.50145	0.50115	0.50130	0.50145	0.50135
0.50165	0.50165	0.50160	0.50150	0.50170	0.50155	0.50165	0.50160
0.50180	0.50175	0.50175	0.50145	0.50175	0.50165	0.50170	0.50140
0.50160	0.50150	0.50145	0.50110	0.50170	0.50140	0.50140	0.50110
0.50120	0.50130	0.50135	0.50125	0.50120	0.50125	0.50140	0.50125
0.50180	0.50170	0.50160	0.50155	0.50170	0.50165	0.50160	0.50155
0.50110	0.50115	0.50120	0.50125	0.50105	0.50110	0.50115	0.50130
0.50135	0.50165	0.50160	0.50180	0.50130	0.50170	0.50165	0.50190
0.50160	0.50155	0.50155	0.50160	0.50160	0.50155	0.50150	0.50165
0.50150	0.50160	0.50155	0.50120	0.50155	0.50160	0.50165	0.50120
0.50175	0.50160	0.50160	0.50150	0.50160	0.50155	0.50145	0.50145
0.50155	0.50150	0.50160	0.50145	0.50155	0.50155	0.50150	0.50145
0.50155	0.50145	0.50150	0.50145	0.50155	0.50150	0.50150	0.50145
0.50150	0.50150	0.50160	0.50160	0.50155	0.50150	0.50155	0.50160
0.50170	0.50150	0.50150	0.50160	0.50170	0.50165	0.50155	0.50165
0.50125	0.50135	0.50105	0.50175	0.50120	0.50115	0.50105	0.50155
0.50165	0.50150	0.50140	0.50145	0.50155	0.50140	0.50140	0.50150
0.50140	0.50155	0.50145	0.50125	0.50140	0.50160	0.50150	0.50130
0.50150	0.50115	0.50135	0.50115	0.50135	0.50120	0.50125	0.50120
0.50135	0.50165	0.50160	0.50150	0.50150	0.50140	0.50160	0.50135
0.50150	0.50165	0.50115	0.50130	0.50155	0.50160	0.50105	0.50125
0.50100	0.50085	0.50115	0.50110	0.50120	0.50080	0.50120	0.50110
0.50100	0.50100	0.50120	0.50090	0.50090	0.50105	0.50105	0.50100
0.50165	0.50160	0.50160	0.50165	0.50160	0.50155	0.50150	0.50165
0.50145	0.50070	0.50105	0.50140	0.50145	0.50060	0.50105	0.50140
0.50140	0.50155	0.50155	0.50160	0.50135	0.50150	0.50155	0.50160
0.50145	0.50115	0.50135	0.50155	0.50130	0.50110	0.50135	0.50150
0.50155	0.50165	0.50150	0.50155	0.50150	0.50160	0.50150	0.50165
0.50140	0.50155	0.50175	0.50130	0.50140	0.50145	0.50180	0.50130
0.50140	0.50150	0.50165	0.50165	0.50125	0.50130	0.50160	0.50170
0.50145	0.50170	0.50165	0.50140	0.50150	0.50160	0.50160	0.50150
0.50150	0.50205	0.50180	0.50160	0.50165	0.50190	0.50170	0.50155
0.50230	0.50205	0.50260	0.50275	0.50230	0.50240	0.50245	0.50255
0.50150	0.50155	0.50165	0.50165	0.50155	0.50150	0.50165	0.50160
0.50190	0.50165	0.50180	0.50175	0.50200	0.50180	0.50185	0.50170

Appendix 2. Final dimensions, specimen mass and bulk density for NBG-18 Creep specimens (sheet 3)

Hole Diameter, in.				Measured by:	Date:
Allowable: 0.124 - 0.128					mm/dd/yr
H1	H2	H1'	H2'		
0.12670	0.12680	0.12770	0.12770	CCD	9/17/2007
0.12770	0.12760	0.12770	0.12770	CCD	9/17/2007
0.12710	0.12710	0.12730	0.12730	CCD	9/17/2007
0.12740	0.12730	0.12780	0.12790	CCD	9/17/2007
0.12750	0.12750	0.12750	0.12750	CCD	9/17/2007
0.12770	0.12770	0.12770	0.12780	CCD	9/17/2007
0.12760	0.12770	0.12750	0.12750	CCD	9/17/2007
0.12760	0.12770	0.12770	0.12760	CCD	9/17/2007
0.12770	0.12780	0.12760	0.12760	CCD	9/17/2007
0.12760	0.12780	0.12750	0.12760	CCD	9/17/2007
0.12800	0.12800	0.12760	0.12760	CCD	9/17/2007
0.12750	0.12760	0.12750	0.12750	CCD	9/17/2007
0.12780	0.12790	0.12780	0.12790	CCD	9/17/2007
0.12740	0.12740	0.12750	0.12750	CCD	9/17/2007
0.12760	0.12770	0.12750	0.12760	CCD	9/17/2007
0.12780	0.12780	0.12710	0.12710	CCD	9/17/2007
0.12780	0.12780	0.12730	0.12740	CCD	9/17/2007
0.12760	0.12780	0.12780	0.12790	CCD	9/17/2007
0.12770	0.12770	0.12770	0.12770	CCD	9/17/2007
0.12780	0.12780	0.12770	0.12780	CCD	9/17/2007
0.12770	0.12780	0.12770	0.12770	CCD	9/17/2007
0.12770	0.12780	0.12730	0.12740	CCD	9/17/2007
0.12770	0.12760	0.12780	0.12780	CCD	9/17/2007
0.12790	0.12800	0.12710	0.12710	CCD	9/17/2007
0.12760	0.12760	0.12760	0.12760	CCD	9/17/2007
0.12760	0.12760	0.12730	0.12740	CCD	9/17/2007
0.12770	0.12770	0.12770	0.12780	CCD	9/17/2007
0.12780	0.12780	0.12740	0.12740	CCD	9/17/2007
0.12790	0.12800	0.12760	0.12760	CCD	9/17/2007
0.12770	0.12770	0.12740	0.12740	CCD	9/17/2007
0.12780	0.12780	0.12750	0.12750	CCD	9/17/2007
0.12720	0.12700	0.12760	0.12760	CCD	9/17/2007
0.12760	0.12760	0.12730	0.12730	CCD	9/17/2007
0.12760	0.12760	0.12760	0.12760	CCD	9/17/2007
0.12760	0.12770	0.12770	0.12780	CCD	9/17/2007
0.12760	0.12760	0.12760	0.12770	CCD	9/17/2007
0.12780	0.12780	0.12740	0.12740	CCD	9/17/2007
0.12710	0.12710	0.12720	0.12720	CCD	9/17/2007

Appendix 2. Final dimensions, specimen mass and bulk density for NBG-18 Creep specimens (sheet 4)

Average * Length mm	Average * Diameter mm	Average * Cross-sectional Area. mm^2	Average * Length m	Average * Diameter m	2- hole volume m^3
25.3705	12.7356	127.3876	0.0254	0.0127	5.4165E-08
25.3736	12.7381	127.4384	0.0254	0.0127	5.4548E-08
25.3689	12.7424	127.5241	0.0254	0.0127	5.4143E-08
25.3689	12.7330	127.3367	0.0254	0.0127	5.4484E-08
25.3654	12.7410	127.4956	0.0254	0.0127	5.4398E-08
25.3663	12.7421	127.5178	0.0254	0.0127	5.4591E-08
25.3695	12.7357	127.3907	0.0254	0.0127	5.4462E-08
25.3638	12.7324	127.3240	0.0254	0.0127	5.4526E-08
25.3660	12.7418	127.5114	0.0254	0.0127	5.4548E-08
25.3787	12.7295	127.2669	0.0254	0.0127	5.4505E-08
25.3679	12.7411	127.4987	0.0254	0.0127	5.4655E-08
25.3724	12.7400	127.4765	0.0254	0.0127	5.4420E-08
25.3638	12.7376	127.4288	0.0254	0.0127	5.4697E-08
25.3686	12.7397	127.4701	0.0254	0.0127	5.4356E-08
25.3654	12.7386	127.4482	0.0254	0.0127	5.4484E-08
25.3689	12.7380	127.4354	0.0254	0.0127	5.4356E-08
25.3743	12.7394	127.4638	0.0254	0.0127	5.4463E-08
25.3673	12.7408	127.4924	0.0254	0.0127	5.4633E-08
25.3644	12.7329	127.3336	0.0254	0.0127	5.4569E-08
25.3822	12.7376	127.4288	0.0254	0.0127	5.4633E-08
25.3743	12.7364	127.4034	0.0254	0.0127	5.4591E-08
25.3594	12.7322	127.3209	0.0254	0.0127	5.4441E-08
25.3654	12.7379	127.4352	0.0254	0.0127	5.4591E-08
25.3784	12.7351	127.3780	0.0254	0.0127	5.4420E-08
25.3670	12.7267	127.2098	0.0254	0.0127	5.4484E-08
25.3794	12.7257	127.1907	0.0254	0.0127	5.4377E-08
25.3797	12.7406	127.4892	0.0254	0.0127	5.4591E-08
25.3756	12.7289	127.2542	0.0254	0.0127	5.4484E-08
25.3692	12.7384	127.4447	0.0254	0.0127	5.4633E-08
25.3762	12.7341	127.3590	0.0254	0.0127	5.4441E-08
25.3730	12.7397	127.4701	0.0254	0.0127	5.4527E-08
25.3740	12.7379	127.4352	0.0254	0.0127	5.4271E-08
25.3721	12.7383	127.4415	0.0254	0.0127	5.4356E-08
25.3708	12.7394	127.4638	0.0254	0.0127	5.4484E-08
25.3756	12.7437	127.5496	0.0254	0.0127	5.4569E-08
25.3549	12.7616	127.9089	0.0254	0.0128	5.4505E-08
25.3771	12.7402	127.4797	0.0254	0.0127	5.4484E-08
25.3613	12.7459	127.5941	0.0254	0.0127	5.4100E-08

Appendix 2. Final dimensions, specimen mass and bulk density for NBG-18 Creep specimens (sheet 5)

Specimen Number	Specimen Mass, g	Weighed by:	Date: mm/dd/yr	Density kg/m^3	Density g/cm^3
BL6-01	5.9514	CCD	9/12/2007	1872.8536	1.8729
BW1-01	5.9653	CCD	9/12/2007	1876.4538	1.8765
BW1-02	5.9715	CCD	9/12/2007	1877.2383	1.8772
BW1-03	5.9608	CCD	9/12/2007	1876.8810	1.8769
BW2-01	5.9707	CCD	9/12/2007	1877.8288	1.8778
BW2-02	5.9706	CCD	9/12/2007	1877.5060	1.8775
BL6-02	5.9668	CCD	9/12/2007	1877.8999	1.8779
BW2-03	5.9744	CCD	9/12/2007	1881.7626	1.8818
BW3-01	5.9657	CCD	9/12/2007	1876.0589	1.8761
BW3-02	5.9512	CCD	9/12/2007	1874.1771	1.8742
BW3-03	5.9714	CCD	9/12/2007	1877.9615	1.8780
BL6-03	5.9625	CCD	9/12/2007	1875.0225	1.8750
BW5-01	5.9693	CCD	9/12/2007	1878.6845	1.8787
BW5-02	5.9594	CCD	9/12/2007	1874.3912	1.8744
BW5-03	5.9704	CCD	9/12/2007	1878.4952	1.8785
BW7-01	5.9624	CCD	9/12/2007	1875.8303	1.8758
BW7-02	5.9578	CCD	9/12/2007	1873.6166	1.8736
BL7-01	5.9751	CCD	9/12/2007	1879.2556	1.8793
BW7-03	5.9619	CCD	9/12/2007	1877.6600	1.8777
BW8-01	5.9639	CCD	9/12/2007	1875.5620	1.8756
BW8-02	5.9649	CCD	9/12/2007	1876.8288	1.8768
BW8-03	5.9588	CCD	9/12/2007	1877.1808	1.8772
BL7-02	5.9591	CCD	9/12/2007	1875.1968	1.8752
BW9-01	5.9733	CCD	9/12/2007	1879.4415	1.8794
BW9-02	5.9530	CCD	9/12/2007	1876.4713	1.8765
BW9-03	5.9693	CCD	9/12/2007	1880.8987	1.8809
BW10-01	5.9741	CCD	9/12/2007	1878.0309	1.8780
BW10-02	5.9621	CCD	9/12/2007	1878.0268	1.8780
BL7-03	5.9632	CCD	9/12/2007	1876.0829	1.8761
BW10-03	5.9708	CCD	9/12/2007	1879.1204	1.8791
BW11-01	5.9612	CCD	9/12/2007	1874.7239	1.8747
BW11-02	5.9666	CCD	9/12/2007	1876.7228	1.8767
BW11-03	5.9674	CCD	9/12/2007	1877.0729	1.8771
BW12-01	5.9644	CCD	9/12/2007	1875.9673	1.8760
BL8-01	5.9728	CCD	9/12/2007	1877.0162	1.8770
BL8-02	5.9868	CCD	9/12/2007	1877.5552	1.8776
BW12-02	5.9721	CCD	9/12/2007	1877.6732	1.8777
BW12-03	5.9791	CCD	9/12/2007	1879.1289	1.8791

Appendix 3. Final dimensions, specimen mass and bulk density for H-451 Creep specimens (sheet 1)

Specimen Type	Specimen Number	Sample Location	Length Measurements, in. Allowable: 0.998 - 1.000			
			T1	T2	T3	T4
Creep	CW7-01	1S8	0.99795	0.99895	0.99845	0.99760
Creep	CW7-03	1S15	0.99845	0.99835	0.99855	0.99865
Creep	CW8-02	1U8	0.99845	0.99875	0.99765	0.99870
Creep	CW8-03	1U14	0.99780	0.99880	0.99855	0.99850
Creep	CW9-01	2S13	0.99875	0.99870	0.99875	0.99875
Creep	CW9-02	2U12	0.99860	0.99830	0.99865	0.99825
Creep	CW9-03	3S1	0.99820	0.99800	0.99820	0.99800
Creep	CW10-01	3S10	0.99865	0.99825	0.99890	0.99855
Creep	CW10-02	3U1	0.99870	0.99840	0.99835	0.99820
Creep	CW10-03	3U10	0.99815	0.99850	0.99835	0.99820
Creep	CW11-01	4S2	0.99830	0.99830	0.99830	0.99875
Creep	CW11-02	4S13	0.99860	0.99820	0.99850	0.99870
Creep	CW11-03	4U2	0.99830	0.99830	0.99855	0.99760
Creep	CW12-01	4U12	0.99820	0.99805	0.99860	0.99850
Creep	CW12-02	5S7	0.99810	0.99870	0.99840	0.99840
Creep	CW13-01	5U7	0.99840	0.99830	0.99735	0.99820
Creep	CW13-02	6S5	0.99855	0.99845	0.99810	0.99860
Creep	CW13-03	6S9	0.99820	0.99860	0.99855	0.99880
Creep	CW14-01	6U5	0.99810	0.99795	0.99790	0.99820
Creep	CW14-02	6U9	0.99815	0.99795	0.99800	0.99815
Creep	CW15-01	Spare 1	0.99850	0.99790	0.99810	0.99860
Creep	CW15-02	Spare 2	0.99805	0.99770	0.99825	0.99800

Appendix 3. Final dimensions, specimen mass and bulk density for H-451 Creep specimens (sheet 2)

Outside Diameter Measurements								
Allowable: 0.500 - 0.502								
D1	D2	D3	D4		$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$
0.50050	0.50035	0.50035	0.50045		0.50070	0.50065	0.50065	0.50050
0.50070	0.50100	0.50080	0.50070		0.50075	0.50105	0.50090	0.50100
0.50075	0.50100	0.50085	0.50045		0.50060	0.50095	0.50070	0.50085
0.50080	0.50100	0.50090	0.50090		0.50110	0.50110	0.50095	0.50080
0.50000	0.50065	0.50090	0.50105		0.50070	0.50080	0.50080	0.50085
0.49890	0.50045	0.50085	0.50090		0.50030	0.50080	0.50090	0.50110
0.50080	0.50125	0.50085	0.50100		0.50065	0.50120	0.50100	0.50080
0.50000	0.50020	0.50045	0.49995		0.50090	0.50075	0.50060	0.50025
0.50050	0.50080	0.50095	0.50080		0.50085	0.50090	0.50095	0.50040
0.50100	0.50095	0.50060	0.50050		0.50100	0.50095	0.50090	0.50040
0.50065	0.50075	0.50080	0.50085		0.50085	0.50060	0.50060	0.50035
0.50105	0.50130	0.50130	0.50115		0.50135	0.50120	0.50115	0.50095
0.50100	0.50105	0.50105	0.50090		0.50105	0.50090	0.50080	0.50070
0.50085	0.50100	0.50100	0.50090		0.50100	0.50090	0.50095	0.50055
0.50010	0.50050	0.50060	0.50060		0.49980	0.50020	0.50030	0.50030
0.50105	0.50100	0.50050	0.50090		0.50090	0.50090	0.50040	0.50070
0.50070	0.50100	0.50110	0.50110		0.50080	0.50115	0.50105	0.50105
0.50085	0.50085	0.50065	0.50060		0.50080	0.50060	0.50055	0.50015
0.50065	0.50090	0.50100	0.50115		0.50115	0.50125	0.50130	0.50140
0.50120	0.50105	0.50085	0.50050		0.50100	0.50100	0.50095	0.50090
0.50100	0.50115	0.50120	0.50125		0.50100	0.50095	0.50115	0.50090
0.50045	0.50085	0.50110	0.50070		0.50095	0.50090	0.50090	0.50050

Appendix 3. Final dimensions, specimen mass and bulk density for H-451 Creep specimens (sheet 3)

Hole Diameter, in.				Measured by:	Date:
Allowable: 0.124 - 0.128					mm/dd/yr
H1	H2	H1'	H2'		
0.1280	0.1280	0.1282	0.1283	CCD	9/11/2007
0.1277	0.1277	0.1274	0.1273	CCD	9/11/2007
0.1280	0.1279	0.1282	0.1281	CCD	9/11/2007
0.1280	0.1281	0.1278	0.1278	CCD	9/11/2007
0.1283	0.1284	0.1282	0.1280	CCD	9/11/2007
0.1284	0.1284	0.1280	0.1280	CCD	9/11/2007
0.1278	0.1278	0.1281	0.1281	CCD	9/11/2007
0.1281	0.1281	0.1282	0.1283	CCD	9/11/2007
0.1284	0.1284	0.1281	0.1281	CCD	9/11/2007
0.1284	0.1284	0.1283	0.1280	CCD	9/11/2007
0.1278	0.1278	0.1279	0.1281	CCD	9/11/2007
0.1279	0.1279	0.1281	0.1282	CCD	9/11/2007
0.1280	0.1281	0.1281	0.1282	CCD	9/11/2007
0.1277	0.1276	0.1284	0.1283	CCD	9/11/2007
0.1277	0.1278	0.1282	0.1282	CCD	9/11/2007
0.1283	0.1282	0.1280	0.1280	CCD	9/11/2007
0.1284	0.1284	0.1278	0.1277	CCD	9/11/2007
0.1278	0.1278	0.1279	0.1279	CCD	9/11/2007
0.1278	0.1278	0.1276	0.1276	CCD	9/11/2007
0.1276	0.1275	0.1280	0.1279	CCD	9/11/2007
0.1272	0.1271	0.1277	0.1277	CCD	9/11/2007
0.1277	0.1278	0.1283	0.1283	CCD	9/11/2007

Appendix 3. Final dimensions, specimen mass and bulk density for H-451 Creep specimens (sheet 4)

Average Length mm	Average Diameter mm	Average Cross-sect Area, mm^2	Average Length m	Average Diameter m	2- hole volume m^3
25.3552	12.7132	126.940157	0.0254	0.0127	5.4933E-08
25.3619	12.7219	127.1146	0.0254	0.0127	5.4420E-08
25.3590	12.7195	127.0670	0.0254	0.0127	5.4869E-08
25.3597	12.7240	127.1558	0.0254	0.0127	5.4762E-08
25.3679	12.7183	127.0416	0.0254	0.0127	5.5019E-08
25.3606	12.7133	126.9433	0.0254	0.0127	5.4997E-08
25.3517	12.7240	127.1558	0.0254	0.0127	5.4783E-08
25.3641	12.7098	126.8736	0.0254	0.0127	5.4976E-08
25.3597	12.7195	127.0670	0.0254	0.0127	5.5040E-08
25.3568	12.7200	127.0765	0.0254	0.0127	5.5062E-08
25.3597	12.7173	127.0226	0.0254	0.0127	5.4740E-08
25.3619	12.7300	127.2764	0.0254	0.0127	5.4847E-08
25.3540	12.7237	127.1495	0.0254	0.0127	5.4912E-08
25.3578	12.7227	127.1304	0.0254	0.0127	5.4826E-08
25.3594	12.7076	126.8292	0.0254	0.0127	5.4805E-08
25.3508	12.7202	127.0797	0.0254	0.0127	5.4933E-08
25.3600	12.7252	127.1812	0.0254	0.0127	5.4890E-08
25.3629	12.7160	126.9972	0.0254	0.0127	5.4697E-08
25.3502	12.7279	127.2352	0.0254	0.0127	5.4569E-08
25.3508	12.7237	127.1495	0.0254	0.0127	5.4612E-08
25.3562	12.7273	127.2225	0.0254	0.0127	5.4335E-08
25.3492	12.7202	127.0797	0.0253	0.0127	5.4848E-08

Appendix 3. Final dimensions, specimen mass and bulk density for H-451 Creep specimens (sheet 5)

Specimen Mass, g	Weighed by:	Date:	Density	Density
		mm/dd/yr		
			kg/m^3	g/cm^3
5.4271	CCD	9/4/2007	1715.4476	1.7154
5.4328	CCD	9/4/2007	1714.1158	1.7141
5.4300	CCD	9/4/2007	1714.3243	1.7143
5.4286	CCD	9/4/2007	1712.5629	1.7126
5.4090	CCD	9/4/2007	1707.5133	1.7075
5.4109	CCD	9/4/2007	1709.9484	1.7099
5.4137	CCD	9/4/2007	1708.4179	1.7084
5.4191	CCD	9/4/2007	1713.2456	1.7132
5.4214	CCD	9/4/2007	1711.6583	1.7117
5.4368	CCD	9/4/2007	1716.5980	1.7166
5.4335	CCD	9/4/2007	1715.9260	1.7159
5.4356	CCD	9/4/2007	1713.0118	1.7130
5.4380	CCD	9/4/2007	1716.0900	1.7161
5.4304	CCD	9/4/2007	1713.6446	1.7136
5.4069	CCD	9/4/2007	1710.2308	1.7102
5.4562	CCD	9/4/2007	1723.0267	1.7230
5.4695	CCD	9/4/2007	1725.1634	1.7252
5.4530	CCD	9/4/2007	1722.1916	1.7222
5.4557	CCD	9/4/2007	1720.5736	1.7206
5.4374	CCD	9/4/2007	1715.9570	1.7160
5.4467	CCD	9/4/2007	1717.3667	1.7174
5.4146	CCD	9/4/2007	1709.9524	1.7100

Appendix 4. Final dimensions, specimen mass and bulk density for PCEA Creep specimens (sheet 1)

Specimen	Specimen	Sample	Length Measurements, in.			
Type	Number	Location	Allowable: 0.998 - 1.000			
			T1	T2	T3	T4
Creep	DW1-01	1S2	0.99935	0.99935	0.99940	0.99945
Creep	DW1-02	1S6	0.99930	0.99930	0.99935	0.99925
Creep	DW1-03	1S14	0.99930	0.99935	0.99935	0.99935
Creep	DW2-01	1U2	0.99910	0.99910	0.99905	0.99905
Creep	DW2-02	1U6	0.99905	0.99900	0.99905	0.99910
Creep	DW2-03	1U13	0.99900	0.99905	0.99905	0.99900
Creep	DW3-01	2S1	0.99920	0.99920	0.99910	0.99915
Creep	DW3-02	2S8	0.99915	0.99915	0.99910	0.99925
Creep	DW3-03	2S14	0.99915	0.99915	0.99915	0.99910
Creep	DW4-01	2U8	0.99955	0.99960	0.99960	0.99965
Creep	DW4-03	2U1	0.99930	0.99935	0.99935	0.99935
Creep	DW5-01	2U13	0.99930	0.99930	0.99935	0.99930
Creep	DA601	3S6	0.99950	0.99965	0.99965	0.99955
Creep	DW5-02	3S15	0.99925	0.99925	0.99915	0.99930
Creep	DW5-03	3U6	0.99925	0.99920	0.99920	0.99930
Creep	DW6-01	3U14	0.99925	0.99920	0.99925	0.99925
Creep	DA602	4S1	0.99955	0.99960	0.99960	0.99940
Creep	DA701	4S6	0.99965	0.99960	0.99950	0.99955
Creep	DW6-02	4S15	0.99910	0.99910	0.99915	0.99915
Creep	DW6-03	4U1	0.99905	0.99910	0.99910	0.99915
Creep	DW7-01	4U6	0.99915	0.99925	0.99920	0.99910
Creep	DW7-02	4U14	0.99920	0.99915	0.99920	0.99920
Creep	DW7-03	5S4	0.99925	0.99925	0.99930	0.99930
Creep	DW8-01	5S9	0.99925	0.99930	0.99930	0.99930
Creep	DA702	5S11	0.99900	0.99890	0.99895	0.99900
Creep	DW8-02	5S12	0.99925	0.99930	0.99925	0.99930
Creep	DW8-03	5U4	0.99935	0.99930	0.99940	0.99935
Creep	DW9-01	5U9	0.99940	0.99940	0.99935	0.99940
Creep	DW9-02	5U11	0.99940	0.99925	0.99935	0.99940
Creep	DW9-03	6S4	0.99940	0.99940	0.99940	0.99940
Creep	DW10-01	6S11	0.99935	0.99940	0.99940	0.99935
Creep	DA801	6S12	0.99940	0.99940	0.99940	0.99945
Creep	DW10-02	6U11	0.99930	0.99940	0.99950	0.99930
Creep	DW10-03	6U4	0.99935	0.99945	0.99945	0.99945
Creep	DW11-01	Spare 1W	0.99935	0.99940	0.99935	0.99940
Creep	DW11-02	Spare 2W	0.99940	0.99940	0.99940	0.99935
Creep	DA802	Spare 1A	0.99950	0.99940	0.99940	0.99960
Creep	DA901	Spare 2A	0.99960	0.99960	0.99965	0.99960

Appendix 4. Final dimensions, specimen mass and bulk density for PCEA Creep specimens (sheet 2)

Outside Diameter Measurements								
Allowable: 0.500 - 0.502								
D1	D2	D3	D4		$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$
0.50075	0.50090	0.50115	0.50145		0.50075	0.50090	0.50110	0.50130
0.50075	0.50100	0.50115	0.50140		0.50075	0.50090	0.50120	0.50135
0.50060	0.50095	0.50120	0.50140		0.50075	0.50110	0.50110	0.50155
0.50075	0.50085	0.50105	0.50130		0.50075	0.50090	0.50115	0.50145
0.50090	0.50100	0.50105	0.50140		0.50070	0.50090	0.50120	0.50150
0.50145	0.50110	0.50105	0.50095		0.50145	0.50100	0.50085	0.50075
0.50075	0.50085	0.50120	0.50140		0.50065	0.50085	0.50105	0.50120
0.50155	0.50120	0.50090	0.50070		0.50165	0.50125	0.50095	0.50085
0.50065	0.50090	0.50110	0.50150		0.50075	0.50085	0.50115	0.50150
0.50075	0.50085	0.50120	0.50155		0.50075	0.50075	0.50100	0.50140
0.50070	0.50075	0.50100	0.50130		0.50060	0.50070	0.50080	0.50120
0.50050	0.50080	0.50090	0.50135		0.50080	0.50085	0.50110	0.50140
0.50085	0.50105	0.50115	0.50135		0.50100	0.50105	0.50120	0.50135
0.50070	0.50090	0.50090	0.50145		0.50090	0.50100	0.50115	0.50150
0.50085	0.50095	0.50120	0.50175		0.50085	0.50100	0.50115	0.50170
0.50080	0.50085	0.50110	0.50155		0.50095	0.50100	0.50135	0.50170
0.50125	0.50105	0.50105	0.50105		0.50140	0.50115	0.50110	0.50110
0.50100	0.50100	0.50110	0.50130		0.50110	0.50110	0.50120	0.50130
0.50160	0.50135	0.50105	0.50090		0.50170	0.50140	0.50110	0.50095
0.50180	0.50160	0.50130	0.50100		0.50180	0.50160	0.50130	0.50100
0.50090	0.50110	0.50130	0.50165		0.50095	0.50095	0.50135	0.50165
0.50095	0.50110	0.50125	0.50150		0.50095	0.50095	0.50120	0.50160
0.50090	0.50110	0.50125	0.50155		0.50095	0.50105	0.50125	0.50170
0.50085	0.50110	0.50130	0.50170		0.50095	0.50115	0.50130	0.50165
0.50200	0.50170	0.50135	0.50120		0.50200	0.50180	0.50140	0.50125
0.50085	0.50100	0.50135	0.50175		0.50100	0.50110	0.50140	0.50185
0.50165	0.50135	0.50100	0.50105		0.50165	0.50140	0.50125	0.50105
0.50110	0.50120	0.50135	0.50180		0.50110	0.50120	0.50135	0.50170
0.50090	0.50105	0.50135	0.50160		0.50110	0.50115	0.50125	0.50160
0.50100	0.50100	0.50095	0.50110		0.50100	0.50090	0.50100	0.50110
0.50070	0.50065	0.50065	0.50095		0.50060	0.50065	0.50060	0.50085
0.50075	0.50065	0.50075	0.50090		0.50075	0.50070	0.50085	0.50095
0.50065	0.50060	0.50070	0.50090		0.50065	0.50055	0.50065	0.50080
0.50055	0.50055	0.50065	0.50075		0.50065	0.50065	0.50055	0.50085
0.50095	0.50060	0.50065	0.50060		0.50095	0.50065	0.50065	0.50065
0.50100	0.50085	0.50070	0.50075		0.50090	0.50085	0.50070	0.50075
0.50145	0.50130	0.50105	0.50115		0.50145	0.50120	0.50110	0.50115
0.50120	0.50120	0.50120	0.50150		0.50115	0.50115	0.50120	0.50150

Appendix 4. Final dimensions, specimen mass and bulk density for PCEA Creep specimens (sheet 3)

Hole Diameter, in.				Measured by:	Date:
Allowable: 0.124 - 0.128					mm/dd/yr
H1	H2	H1'	H2'		
0.1261	0.1262	0.1260	0.1260	CCD	1/10/2008
0.1260	0.1259	0.1262	0.1259	CCD	1/10/2008
0.1262	0.1264	0.1260	0.1258	CCD	1/10/2008
0.1258	0.1258	0.1261	0.1259	CCD	1/10/2008
0.1260	0.1259	0.1261	0.1259	CCD	1/10/2008
0.1259	0.1260	0.1258	0.1258	CCD	1/10/2008
0.1271	0.1271	0.1273	0.1272	CCD	1/10/2008
0.1260	0.1258	0.1260	0.1260	CCD	1/10/2008
0.1262	0.1258	0.1262	0.1260	CCD	1/10/2008
0.1262	0.1259	0.1260	0.1260	CCD	1/10/2008
0.1262	0.1261	0.1262	0.1259	CCD	1/10/2008
0.1259	0.1261	0.1260	0.1258	CCD	1/10/2008
0.1258	0.1258	0.1258	0.1258	CCD	1/10/2008
0.1261	0.1260	0.1259	0.1259	CCD	1/10/2008
0.1260	0.1260	0.1260	0.1260	CCD	1/10/2008
0.1261	0.1259	0.1258	0.1260	CCD	1/10/2008
0.1260	0.1258	0.1259	0.1257	CCD	1/10/2008
0.1259	0.1258	0.1254	0.1254	CCD	1/10/2008
0.1260	0.1260	0.1262	0.1258	CCD	1/10/2008
0.1258	0.1259	0.1259	0.1258	CCD	1/10/2008
0.1262	0.1261	0.1260	0.1260	CCD	1/10/2008
0.1260	0.1259	0.1261	0.1258	CCD	1/10/2008
0.1259	0.1259	0.1261	0.1259	CCD	1/10/2008
0.1262	0.1261	0.1259	0.1257	CCD	1/10/2008
0.1275	0.1270	0.1258	0.1259	CCD	1/10/2008
0.1258	0.1259	0.1259	0.1258	CCD	1/10/2008
0.1261	0.1259	0.1262	0.1259	CCD	1/10/2008
0.1260	0.1260	0.1259	0.1259	CCD	1/10/2008
0.1258	0.1261	0.1260	0.1258	CCD	1/10/2008
0.1258	0.1262	0.1259	0.1258	CCD	1/10/2008
0.1257	0.1261	0.1260	0.1261	CCD	1/10/2008
0.1259	0.1258	0.1261	0.1260	CCD	1/10/2008
0.1260	0.1259	0.1260	0.1260	CCD	1/10/2008
0.1262	0.1261	0.1258	0.1260	CCD	1/10/2008
0.1258	0.1259	0.1258	0.1258	CCD	1/10/2008
0.1259	0.1259	0.1260	0.1260	CCD	1/10/2008
0.1254	0.1254	0.1260	0.1259	CCD	1/10/2008
0.1257	0.1259	0.1257	0.1256	CCD	1/10/2008

Appendix 4. Final dimensions, specimen mass and bulk density for PCEA Creep specimens (sheet 4)

Average *	Average *	Average *	Average *	Average *	2- hole
Length	Diameter	Cross-sec	Length	Diameter	volume
mm	mm	Area, mm^2	m	m	m^3
25.3844	12.7264	127.20342	0.0254	0.0127	5.3189E-08
25.3822	12.7270	127.21612	0.0254	0.0127	5.3126E-08
25.3832	12.7275	127.22564	0.0254	0.0127	5.3210E-08
25.3765	12.7260	127.19707	0.0254	0.0127	5.3042E-08
25.3759	12.7275	127.22564	0.0254	0.0127	5.3105E-08
25.3752	12.7273	127.22246	0.0254	0.0127	5.3021E-08
25.3787	12.7252	127.18121	0.0254	0.0127	5.4121E-08
25.3787	12.7287	127.25103	0.0254	0.0127	5.3084E-08
25.3781	12.7267	127.20977	0.0254	0.0127	5.3168E-08
25.3898	12.7262	127.20025	0.0254	0.0127	5.3147E-08
25.3832	12.7224	127.1241	0.0254	0.0127	5.3210E-08
25.3825	12.7244	127.16534	0.0254	0.0127	5.3084E-08
25.3895	12.7286	127.24785	0.0254	0.0127	5.2957E-08
25.3806	12.7270	127.21612	0.0254	0.0127	5.3105E-08
25.3806	12.7300	127.27642	0.0254	0.0127	5.3126E-08
25.3806	12.7295	127.2669	0.0254	0.0127	5.3084E-08
25.3883	12.7291	127.25738	0.0254	0.0127	5.2999E-08
25.3892	12.7289	127.2542	0.0254	0.0127	5.2810E-08
25.3778	12.7319	127.31452	0.0254	0.0127	5.3126E-08
25.3771	12.7362	127.40025	0.0254	0.0127	5.2999E-08
25.3790	12.7313	127.30182	0.0254	0.0127	5.3189E-08
25.3794	12.7302	127.2796	0.0254	0.0127	5.3084E-08
25.3816	12.7310	127.29547	0.0254	0.0127	5.3084E-08
25.3819	12.7318	127.31134	0.0254	0.0127	5.3105E-08
25.3736	12.7403	127.48284	0.0254	0.0127	5.3592E-08
25.3816	12.7327	127.33039	0.0254	0.0127	5.2999E-08
25.3835	12.7330	127.33674	0.0254	0.0127	5.3147E-08
25.3844	12.7343	127.36215	0.0254	0.0127	5.3084E-08
25.3835	12.7318	127.31134	0.0254	0.0127	5.3063E-08
25.3848	12.7256	127.18755	0.0254	0.0127	5.3063E-08
25.3841	12.7179	127.03528	0.0254	0.0127	5.3105E-08
25.3851	12.7200	127.07651	0.0254	0.0127	5.3084E-08
25.3841	12.7175	127.02577	0.0254	0.0127	5.3105E-08
25.3854	12.7165	127.00674	0.0254	0.0127	5.3147E-08
25.3841	12.7181	127.03845	0.0254	0.0127	5.2978E-08
25.3844	12.7206	127.0892	0.0254	0.0127	5.3084E-08
25.3867	12.7313	127.30182	0.0254	0.0127	5.2852E-08
25.3902	12.7321	127.31769	0.0254	0.0127	5.2894E-08

Appendix 4. Final dimensions, specimen mass and bulk density for PCEA Creep specimens (sheet 5)

Specimen Number	Specimen Mass, g	Weighed by:	Date: mm/dd/yr	Density kg/m^3	Density g/cm^3
DW1-01	5.7468	CCD	1/8/2008	1809.5605	1.8096
DW1-02	5.7516	CCD	1/8/2008	1811.0133	1.8110
DW1-03	5.7604	CCD	1/8/2008	1813.6252	1.8136
DW2-01	5.7565	CCD	1/8/2008	1813.1991	1.8132
DW2-02	5.7443	CCD	1/8/2008	1809.0253	1.8090
DW2-03	5.7447	CCD	1/8/2008	1809.1952	1.8092
DW3-01	5.7568	CCD	1/8/2008	1813.9791	1.8140
DW3-02	5.7597	CCD	1/8/2008	1813.2875	1.8133
DW3-03	5.7625	CCD	1/8/2008	1814.8616	1.8149
DW4-01	5.7407	CCD	1/8/2008	1807.2709	1.8073
DW4-03	5.7429	CCD	1/8/2008	1809.5839	1.8096
DW5-01	5.6963	CCD	1/8/2008	1794.2825	1.7943
DA601	5.6611	CCD	1/8/2008	1781.4499	1.7814
DW5-02	5.7316	CCD	1/8/2008	1804.8187	1.8048
DW5-03	5.7596	CCD	1/8/2008	1812.7739	1.8128
DW6-01	5.7612	CCD	1/8/2008	1813.3914	1.8134
DA602	5.6454	CCD	1/8/2008	1776.4881	1.7765
DA701	5.6448	CCD	1/8/2008	1776.1708	1.7762
DW6-02	5.7631	CCD	1/8/2008	1813.5312	1.8135
DW6-03	5.7397	CCD	1/8/2008	1804.9061	1.8049
DW7-01	5.7650	CCD	1/8/2008	1814.2570	1.8143
DW7-02	5.7628	CCD	1/8/2008	1813.8033	1.8138
DW7-03	5.7567	CCD	1/8/2008	1811.4924	1.8115
DW8-01	5.7662	CCD	1/8/2008	1814.2408	1.8142
DA702	5.7624	CCD	1/8/2008	1811.4418	1.8114
DW8-02	5.7745	CCD	1/8/2008	1816.5388	1.8165
DW8-03	5.7800	CCD	1/8/2008	1818.1223	1.8181
DW9-01	5.7479	CCD	1/8/2008	1807.5536	1.8076
DW9-02	5.7474	CCD	1/8/2008	1808.1866	1.8082
DW9-03	5.7734	CCD	1/8/2008	1818.0714	1.8181
DW10-01	5.7473	CCD	1/8/2008	1812.1282	1.8121
DA801	5.7665	CCD	1/8/2008	1817.5008	1.8175
DW10-02	5.7395	CCD	1/8/2008	1809.8067	1.8098
DW10-03	5.7473	CCD	1/8/2008	1812.4742	1.8125
DW11-01	5.7456	CCD	1/8/2008	1811.4741	1.8115
DW11-02	5.7520	CCD	1/8/2008	1812.7928	1.8128
DA802	5.6459	CCD	1/8/2008	1776.0456	1.7760
DA901	5.6473	CCD	1/8/2008	1776.0358	1.7760

Appendix 5. Final dimensions, specimen mass and bulk density for IG-110 Creep specimens (sheet 1)

Specimen Type	Specimen Number	Sample Location	Length Measurements, in. Allowable: 0.998 - 1.000			
			T1	T2	T3	T4
Creep	EW2-01	1S7	0.99925	0.99925	0.99845	0.99940
Creep	EW2-02	1S9	0.99950	0.99955	0.99935	0.99915
Creep	EW2-03	1U7	0.99945	0.99945	0.99935	0.99940
Creep	EW4-01	1U9	0.99880	0.99910	0.99835	0.99865
Creep	EW4-02	2S5	0.99885	0.99915	0.99880	0.99905
Creep	EW5-01	2S7	0.99880	0.99875	0.99875	0.99895
Creep	EW5-02	2U5	0.99910	0.99890	0.99840	0.99890
Creep	EW5-03	2U7	0.99930	0.99900	0.99895	0.99905
Creep	EW6-01	3S9	0.99875	0.99900	0.99915	0.99890
Creep	EW6-02	3U9	0.99930	0.99930	0.99905	0.99925
Creep	EW6-03	4S4	0.99895	0.99890	0.99905	0.99910
Creep	EW7-01	4S9	0.99875	0.99905	0.99915	0.99920
Creep	EW7-03	4U4	0.99920	0.99905	0.99900	0.99905
Creep	EW8-01	4U9	0.99920	0.99915	0.99915	0.99885
Creep	EW8-02	5S1	0.99895	0.99865	0.99880	0.99885
Creep	EW8-03	5S13	0.99895	0.99910	0.99905	0.99940
Creep	EW9-01	5U1	0.99860	0.99915	0.99925	0.99925
Creep	EW9-02	5U12	0.99875	0.99945	0.99945	0.99890
Creep	EW9-03	6S14	0.99900	0.99885	0.99910	0.99905
Creep	EW10-01	6U13	0.99925	0.99905	0.99905	0.99915
Creep	EW10-02	Spare 1	0.99910	0.99910	0.99910	0.99910
Creep	EW10-03	Spare 2	0.99900	0.99905	0.99905	0.99905

Appendix 5. Final dimensions, specimen mass and bulk density for IG-110 Creep specimens (sheet 2)

Outside Diameter Measurements								
Allowable: 0.500 - 0.502								
D1	D2	D3	D4		$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$
0.50100	0.50105	0.50120	0.50100		0.50085	0.50100	0.50110	0.50065
0.50070	0.50100	0.50120	0.50095		0.50080	0.50090	0.50105	0.50120
0.50120	0.50105	0.50100	0.50065		0.50100	0.50105	0.50095	0.50080
0.49980	0.50040	0.50070	0.50085		0.50030	0.50045	0.50025	0.50060
0.50095	0.50080	0.50070	0.50000		0.50090	0.50085	0.50060	0.50055
0.50050	0.50065	0.50080	0.50040		0.50060	0.50080	0.50085	0.50080
0.50070	0.50050	0.50040	0.50065		0.50005	0.50035	0.50050	0.49995
0.50025	0.50005	0.50025	0.50010		0.50080	0.50070	0.50070	0.50050
0.50025	0.50025	0.50025	0.50030		0.50010	0.50045	0.50035	0.50040
0.50060	0.50075	0.50070	0.50040		0.50070	0.50055	0.50060	0.50050
0.50005	0.50040	0.50045	0.50035		0.50025	0.50040	0.50050	0.50050
0.50060	0.50060	0.50060	0.50005		0.50005	0.50070	0.50080	0.50035
0.50040	0.50040	0.50015	0.49935		0.50005	0.49990	0.49990	0.49875
0.49950	0.50010	0.49990	0.50030		0.50005	0.50020	0.50020	0.50025
0.50050	0.50040	0.50030	0.50015		0.50040	0.50030	0.50030	0.49995
0.49980	0.49980	0.50005	0.50035		0.49865	0.50000	0.50010	0.50040
0.49625	0.50020	0.50010	0.50035		0.50035	0.50035	0.50010	0.50000
0.50040	0.50055	0.50020	0.50015		0.50045	0.50050	0.50040	0.50010
0.49915	0.50000	0.49990	0.50000		0.49995	0.50020	0.50035	0.50040
0.49965	0.49985	0.49970	0.49915		0.49985	0.50010	0.50045	0.50050
0.50010	0.50020	0.50010	0.49955		0.50000	0.50020	0.50045	0.50005
0.50050	0.50010	0.49995	0.49995		0.49965	0.50005	0.49990	0.50015

Appendix 5. Final dimensions, specimen mass and bulk density for IG-110 Creep specimens (sheet 3)

Hole Diameter, in.				Measured by:	Date:
Allowable: 0.124 - 0.128					mm/dd/yr
H1	H2	H1'	H2'		
0.1260	0.1266	0.1264	0.1265	CCD	8/28/2007
0.1262	0.1262	0.1262	0.1262	CCD	8/28/2007
0.1263	0.1264	0.1261	0.1262	CCD	8/28/2007
0.1262	0.1263	0.1263	0.1261	CCD	8/28/2007
0.1260	0.1262	0.1262	0.1263	CCD	8/28/2007
0.1261	0.1261	0.1261	0.1261	CCD	8/28/2007
0.1260	0.1262	0.1262	0.1262	CCD	8/28/2007
0.1262	0.1261	0.1261	0.1260	CCD	8/28/2007
0.1261	0.1260	0.1260	0.1259	CCD	8/28/2007
0.1259	0.1260	0.1260	0.1260	CCD	8/28/2007
0.1261	0.1260	0.1262	0.1261	CCD	8/28/2007
0.1263	0.1261	0.1262	0.1262	CCD	8/28/2007
0.1262	0.1261	0.1261	0.1259	CCD	8/28/2007
0.1262	0.1261	0.1261	0.1260	CCD	8/28/2007
0.1259	0.1259	0.1257	0.1257	CCD	8/28/2007
0.1259	0.1261	0.1263	0.1261	CCD	8/28/2007
0.1261	0.1259	0.1260	0.1259	CCD	8/28/2007
0.1261	0.1260	0.1261	0.1261	CCD	8/28/2007
0.1262	0.1261	0.1261	0.1261	CCD	8/28/2007
0.1262	0.1262	0.1260	0.1259	CCD	8/28/2007
0.1259	0.1260	0.1261	0.1263	CCD	8/28/2007
0.1261	0.1260	0.1261	0.1260	CCD	8/28/2007

Appendix 5. Final dimensions, specimen mass and bulk density for IG-110 Creep specimens (sheet 4)

Average * Length mm	Average * Diameter mm	Average * Cross-sec Area, mm^2	Average * Length m	Average * Diameter m	2- hole volume m^3
25.3768	12.7249	127.1749	0.0254	0.0127	5.3442E-08
25.3844	12.7248	127.1717	0.0254	0.0127	5.3295E-08
25.3851	12.7244	127.1653	0.0254	0.0127	5.3337E-08
25.3676	12.7106	126.8894	0.0254	0.0127	5.3316E-08
25.3736	12.7170	127.0163	0.0254	0.0127	5.3274E-08
25.3698	12.7171	127.0194	0.0254	0.0127	5.3210E-08
25.3702	12.7098	126.8736	0.0254	0.0127	5.3252E-08
25.3765	12.7106	126.8894	0.0254	0.0127	5.3210E-08
25.3733	12.7075	126.8261	0.0254	0.0127	5.3126E-08
25.3803	12.7152	126.9814	0.0254	0.0127	5.3105E-08
25.3746	12.7092	126.8609	0.0254	0.0127	5.3210E-08
25.3756	12.7119	126.9148	0.0254	0.0127	5.3295E-08
25.3765	12.6965	126.6075	0.0254	0.0127	5.3189E-08
25.3768	12.7016	126.7088	0.0254	0.0127	5.3210E-08
25.3698	12.7073	126.8229	0.0254	0.0127	5.2957E-08
25.3778	12.6973	126.6233	0.0254	0.0127	5.3210E-08
25.3762	12.6927	126.5315	0.0254	0.0127	5.3105E-08
25.3775	12.7087	126.8514	0.0254	0.0127	5.3189E-08
25.3746	12.6998	126.6740	0.0254	0.0127	5.3231E-08
25.3778	12.6976	126.6297	0.0254	0.0127	5.3189E-08
25.3771	12.7021	126.7183	0.0254	0.0127	5.3189E-08
25.3756	12.7008	126.6930	0.0254	0.0127	5.3168E-08

Appendix 5. Final dimensions, specimen mass and bulk density for IG-110 Creep specimens (sheet 5)

Specimen Mass, g	Weighed by:	Date:	Density	Density
		mm/dd/yr		
			kg/m^3	g/cm^3
5.5838	CCD	8/21/2007	1759.3137	1.7593
5.5901	CCD	8/21/2007	1760.7237	1.7607
5.5930	CCD	8/21/2007	1761.7051	1.7617
5.5908	CCD	8/21/2007	1766.1293	1.7661
5.5921	CCD	8/21/2007	1764.2965	1.7643
5.5756	CCD	8/21/2007	1759.2796	1.7593
5.5834	CCD	8/21/2007	1763.8010	1.7638
5.5845	CCD	8/21/2007	1763.4524	1.7635
5.5918	CCD	8/21/2007	1766.8321	1.7668
5.5979	CCD	8/21/2007	1766.0537	1.7661
5.6009	CCD	8/21/2007	1769.1701	1.7692
5.5902	CCD	8/21/2007	1765.0076	1.7650
5.5730	CCD	8/21/2007	1763.7939	1.7638
5.5829	CCD	8/21/2007	1765.4794	1.7655
5.5862	CCD	8/21/2007	1765.2606	1.7653
5.5817	CCD	8/21/2007	1766.2445	1.7662
5.5981	CCD	8/21/2007	1772.7961	1.7728
5.5911	CCD	8/21/2007	1765.9951	1.7660
5.5902	CCD	8/21/2007	1768.4518	1.7685
5.5822	CCD	8/21/2007	1766.3018	1.7663
5.5845	CCD	8/21/2007	1765.8165	1.7658
5.5923	CCD	8/21/2007	1768.7431	1.7687

Appendix 6. Final dimensions, specimen mass and bulk density for IG-430 Creep specimens (sheet 1)

Specimen	Specimen	Sample	Length Measurements, in.			
Type	Number	Location	Allowable: 0.998 - 1.000			
			T1	T2	T3	T4
Creep	FW1-01	1S5	0.99885	0.99890	0.99885	0.99880
Creep	FW1-02	1S10	0.99910	0.99925	0.99895	0.99915
Creep	FW1-03	1U5	0.99905	0.99875	0.99925	0.99900
Creep	FW2-01	1U10	0.99895	0.99905	0.99905	0.99900
Creep	FW2-02	2S3	0.99850	0.99855	0.99905	0.99900
Creep	FW2-03	2S9	0.99895	0.99920	0.99865	0.99920
Creep	FW3-01	2S15	0.99920	0.99915	0.99910	0.99885
Creep	FW3-02	2U3	0.99895	0.99900	0.99915	0.99910
Creep	FW3-03	2U9	0.99925	0.99880	0.99890	0.99915
Creep	FW4-01	2U14	0.99920	0.99925	0.99930	0.99920
Creep	FW4-02	3S3	0.99930	0.99895	0.99930	0.99910
Creep	FW4-03	3S4	0.99880	0.99895	0.99905	0.99830
Creep	FW5-01	3S5	0.99915	0.99925	0.99855	0.99865
Creep	FW5-02	3S7	0.99940	0.99940	0.99940	0.99940
Creep	FW5-03	3U3	0.99945	0.99920	0.99945	0.99935
Creep	FW7-01	3U4	0.99950	0.99930	0.99940	0.99945
Creep	FW7-02	3U5	0.99925	0.99920	0.99910	0.99910
Creep	FW7-03	3U7	0.99950	0.99945	0.99950	0.99930
Creep	FW8-01	4S3	0.99935	0.99910	0.99925	0.99910
Creep	FW8-02	4S10	0.99920	0.99935	0.99925	0.99935
Creep	FW8-03	4U3	0.99910	0.99920	0.99895	0.99925
Creep	FW9-01	4U10	0.99950	0.99970	0.99960	0.99945
Creep	FW9-02	5S2	0.99945	0.99955	0.99945	0.99950
Creep	FW9-03	5S10	0.99930	0.99920	0.99925	0.99925
Creep	FW10-01	5U2	0.99975	0.99975	0.99970	0.99970
Creep	FW10-02	5U10	0.99960	0.99960	0.99960	0.99950
Creep	FW10-03	6S2	0.99930	0.99930	0.99930	0.99935
Creep	FW11-01	6S7	0.99935	0.99935	0.99930	0.99935
Creep	FW11-02	6S10	0.99955	0.99935	0.99935	0.99940
Creep	FW11-03	6U2	0.99945	0.99945	0.99945	0.99940
Creep	FW12-01	6U7	0.99950	0.99955	0.99940	0.99955
Creep	FW12-02	6U10	0.99945	0.99950	0.99940	0.99950
Creep	FW13-01	Spare 1	0.99940	0.99925	0.99925	0.99935
Creep	FW13-02	Spare 2	0.99925	0.99925	0.99920	0.99925

Appendix 6. Final dimensions, specimen mass and bulk density for IG-430 Creep specimens (sheet 2)

Outside Diameter Measurements								
Allowable: 0.500 - 0.502								
D1	D2	D3	D4		$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$
0.50040	0.50065	0.50045	0.49970		0.50040	0.50020	0.50020	0.50005
0.50050	0.50050	0.50040	0.50055		0.50055	0.50045	0.50050	0.50010
0.50065	0.50055	0.50060	0.50060		0.50065	0.50060	0.50060	0.50050
0.50025	0.50010	0.49990	0.49990		0.49980	0.49980	0.50020	0.50025
0.50020	0.50035	0.50045	0.50040		0.49975	0.49980	0.50005	0.49985
0.50030	0.50020	0.50035	0.50045		0.49995	0.50020	0.50010	0.49995
0.49995	0.49980	0.49980	0.50000		0.50010	0.50010	0.50010	0.49985
0.50050	0.50055	0.50015	0.50000		0.50065	0.50060	0.50060	0.49835
0.50065	0.50050	0.50060	0.50025		0.50050	0.50055	0.50055	0.50025
0.50070	0.50050	0.50055	0.50040		0.50050	0.50040	0.50050	0.50035
0.50065	0.49995	0.49995	0.50040		0.50050	0.50055	0.50060	0.50045
0.50065	0.50065	0.50065	0.50035		0.50025	0.50050	0.50070	0.50070
0.50070	0.50080	0.50045	0.50065		0.50090	0.50075	0.50055	0.50050
0.50110	0.50105	0.50100	0.50110		0.50120	0.50125	0.50105	0.50115
0.50110	0.50110	0.50150	0.50130		0.50120	0.50115	0.50115	0.50135
0.50150	0.50130	0.50150	0.50150		0.50150	0.50125	0.50150	0.50140
0.50135	0.50135	0.50140	0.50150		0.50130	0.50125	0.50130	0.50145
0.50140	0.50130	0.50140	0.50135		0.50150	0.50135	0.50140	0.50140
0.50035	0.50030	0.50050	0.50070		0.50040	0.50040	0.50055	0.50065
0.50035	0.50030	0.50040	0.50065		0.50050	0.50050	0.50050	0.50080
0.50040	0.50060	0.50060	0.50060		0.50050	0.50050	0.50050	0.50050
0.50075	0.50070	0.50065	0.50065		0.50090	0.50070	0.50070	0.50070
0.50100	0.50065	0.50065	0.50070		0.50095	0.50060	0.50060	0.50050
0.50065	0.50055	0.50045	0.50070		0.50070	0.50070	0.50060	0.50075
0.50090	0.50090	0.50090	0.50090		0.50085	0.50075	0.50070	0.50085
0.50085	0.50090	0.50095	0.50090		0.50090	0.50100	0.50085	0.50080
0.50080	0.50075	0.50075	0.50085		0.50090	0.50090	0.50085	0.50095
0.50095	0.50070	0.50080	0.50085		0.50100	0.50080	0.50095	0.50095
0.50105	0.50090	0.50085	0.50090		0.50115	0.50100	0.50075	0.50115
0.50115	0.50085	0.50095	0.50115		0.50100	0.50075	0.50080	0.50100
0.50115	0.50110	0.50105	0.50100		0.50115	0.50100	0.50100	0.50095
0.50085	0.50105	0.50100	0.50100		0.50095	0.50100	0.50095	0.50105
0.50120	0.50110	0.50120	0.50120		0.50100	0.50095	0.50100	0.50105
0.50120	0.50120	0.50095	0.50105		0.50125	0.50110	0.50110	0.50110

Appendix 6. Final dimensions, specimen mass and bulk density for IG-430 Creep specimens (sheet 3)

Hole Diameter, in.				Measured by:	Date:
Allowable: 0.124 - 0.128					mm/dd/yr
H1	H2	H1'	H2'		
0.1263	0.1262	0.1263	0.1265	CCD	8/31/2007
0.1263	0.1262	0.1261	0.1263	CCD	8/31/2007
0.1263	0.1264	0.1263	0.1261	CCD	31-Aug
0.1264	0.1263	0.1264	0.1263	CCD	8/31/2007
0.1266	0.1263	0.1262	0.1264	CCD	8/31/2007
0.1264	0.1263	0.1265	0.1262	CCD	8/31/2007
0.1260	0.1262	0.1264	0.1264	CCD	8/31/2007
0.1262	0.1261	0.1260	0.1262	CCD	8/31/2007
0.1261	0.1262	0.1263	0.1263	CCD	8/31/2007
0.1261	0.1261	0.1261	0.1262	CCD	8/31/2007
0.1261	0.1263	0.1261	0.1260	CCD	8/31/2007
0.1261	0.1261	0.1261	0.1260	CCD	8/31/2007
0.1261	0.1260	0.1260	0.1262	CCD	8/31/2007
0.1262	0.1263	0.1260	0.1262	CCD	8/31/2007
0.1261	0.1262	0.1259	0.1260	CCD	8/31/2007
0.1262	0.1261	0.1261	0.1263	CCD	8/31/2007
0.1259	0.1260	0.1262	0.1261	CCD	8/31/2007
0.1261	0.1259	0.1260	0.1262	CCD	8/31/2007
0.1262	0.1261	0.1263	0.1262	CCD	8/31/2007
0.1262	0.1263	0.1263	0.1262	CCD	8/31/2007
0.1260	0.1261	0.1263	0.1262	CCD	8/31/2007
0.1264	0.1261	0.1262	0.1260	CCD	8/31/2007
0.1264	0.1263	0.1263	0.1263	CCD	8/31/2007
0.1261	0.1261	0.1261	0.1261	CCD	8/31/2007
0.1262	0.1262	0.1260	0.1262	CCD	8/31/2007
0.1263	0.1263	0.1263	0.1263	CCD	8/31/2007
0.1263	0.1263	0.1261	0.1263	CCD	8/31/2007
0.1261	0.1262	0.1262	0.1262	CCD	8/31/2007
0.1262	0.1261	0.1262	0.1261	CCD	8/31/2007
0.1262	0.1260	0.1260	0.1262	CCD	8/31/2007
0.1260	0.1259	0.1260	0.1261	CCD	8/31/2007
0.1259	0.1259	0.1262	0.1261	CCD	8/31/2007
0.1262	0.1263	0.1260	0.1262	CCD	8/31/2007
0.1260	0.1262	0.1264	0.1264	CCD	8/31/2007

Appendix 6. Final dimensions, specimen mass and bulk density for IG-430 Creep specimens (sheet 4)

Average * Length mm	Average * Diameter mm	Average * Cross-sec Area, mm^2	Average * Length m	Average * Diameter m	2- hole volume m^3
25.3708	12.7065	126.80704	0.0254	0.0127	5.3400E-08
25.3775	12.7113	126.90212	0.0254	0.0127	5.3316E-08
25.3749	12.7151	126.9782	0.0254	0.0127	5.3358E-08
25.3749	12.7006	126.68983	0.0254	0.0127	5.3421E-08
25.3689	12.7027	126.73101	0.0254	0.0127	5.3443E-08
25.3746	12.7048	126.77219	0.0254	0.0127	5.3421E-08
25.3765	12.6990	126.65817	0.0254	0.0127	5.3337E-08
25.3759	12.7044	126.76586	0.0254	0.0127	5.3231E-08
25.3752	12.7122	126.92114	0.0254	0.0127	5.3316E-08
25.3806	12.7124	126.92431	0.0254	0.0127	5.3231E-08
25.3787	12.7097	126.87042	0.0254	0.0127	5.3231E-08
25.3689	12.7141	126.95918	0.0254	0.0127	5.3189E-08
25.3721	12.7168	127.01308	0.0254	0.0127	5.3189E-08
25.3848	12.7283	127.24151	0.0254	0.0127	5.3274E-08
25.3838	12.7313	127.30182	0.0254	0.0127	5.3168E-08
25.3851	12.7364	127.40343	0.0254	0.0127	5.3274E-08
25.3787	12.7346	127.3685	0.0254	0.0127	5.3168E-08
25.3857	12.7352	127.3812	0.0254	0.0127	5.3168E-08
25.3797	12.7122	126.92114	0.0254	0.0127	5.3295E-08
25.3819	12.7127	126.93065	0.0254	0.0127	5.3337E-08
25.3778	12.7133	126.94333	0.0254	0.0127	5.3253E-08
25.3889	12.7183	127.04162	0.0254	0.0127	5.3274E-08
25.3870	12.7179	127.03528	0.0254	0.0127	5.3400E-08
25.3810	12.7162	127.0004	0.0254	0.0127	5.3210E-08
25.3930	12.7214	127.10506	0.0254	0.0127	5.3252E-08
25.3892	12.7227	127.13044	0.0254	0.0127	5.3379E-08
25.3825	12.7214	127.10506	0.0254	0.0127	5.3337E-08
25.3832	12.7222	127.12092	0.0254	0.0127	5.3274E-08
25.3851	12.7246	127.16852	0.0254	0.0127	5.3252E-08
25.3857	12.7243	127.16217	0.0254	0.0127	5.3210E-08
25.3873	12.7267	127.20977	0.0254	0.0127	5.3126E-08
25.3863	12.7249	127.17486	0.0254	0.0127	5.3147E-08
25.3825	12.7276	127.22881	0.0254	0.0127	5.3274E-08
25.3806	12.7284	127.24468	0.0254	0.0127	5.3337E-08

Appendix 6. Final dimensions, specimen mass and bulk density for IG-430 Creep specimens (sheet 5)

Specimen Mass, g	Weighed by:	Date:	Density	Density
		mm/dd/yr		
			kg/m^3	g/cm^3
5.7233	CCD	8/17/2007	1808.9987	1.8090
5.7574	CCD	8/17/2007	1817.8562	1.8179
5.7655	CCD	8/17/2007	1819.5140	1.8195
5.7255	CCD	8/17/2007	1811.1090	1.8111
5.7308	CCD	8/17/2007	1812.6374	1.8126
5.7428	CCD	8/17/2007	1815.4046	1.8154
5.7337	CCD	8/17/2007	1814.0002	1.8140
5.7257	CCD	8/17/2007	1809.8901	1.8099
5.7546	CCD	8/17/2007	1816.8570	1.8169
5.7339	CCD	8/17/2007	1809.8359	1.8098
5.7458	CCD	8/17/2007	1814.5138	1.8145
5.7692	CCD	8/17/2007	1821.3022	1.8213
5.7637	CCD	8/17/2007	1818.5493	1.8185
5.7849	CCD	8/17/2007	1821.0284	1.8210
5.7923	CCD	8/17/2007	1822.4885	1.8225
5.7641	CCD	8/17/2007	1812.1129	1.8121
5.7693	CCD	8/17/2007	1814.6549	1.8147
5.7559	CCD	8/17/2007	1809.7501	1.8098
5.7551	CCD	8/17/2007	1816.6792	1.8167
5.7571	CCD	8/17/2007	1817.0345	1.8170
5.7267	CCD	8/17/2007	1807.5069	1.8075
5.7732	CCD	8/17/2007	1819.9518	1.8200
5.7547	CCD	8/17/2007	1814.4229	1.8144
5.7710	CCD	8/17/2007	1820.4011	1.8204
5.7745	CCD	8/17/2007	1819.1251	1.8191
5.7841	CCD	8/17/2007	1822.1301	1.8221
5.7886	CCD	8/17/2007	1824.3809	1.8244
5.7770	CCD	8/17/2007	1820.4113	1.8204
5.7712	CCD	8/17/2007	1817.7408	1.8177
5.7713	CCD	8/17/2007	1817.7941	1.8178
5.7506	CCD	8/17/2007	1810.4219	1.8104
5.7608	CCD	8/17/2007	1814.2205	1.8142
5.7910	CCD	8/17/2007	1823.2959	1.8233
5.7909	CCD	8/17/2007	1823.2087	1.8232

Appendix 7. Dimensions, specimen mass and bulk density for NBG-17 Piggy-back specimens

Specimen Type	Specimen ID Number	Sample Number	Length Measurements, in.				Average *	Outside Diameter			
			Allowable: 0.248 - 0.250				Length	Measurements, in.		Hole Diameter, in.	
			T1	T2	T3	T4	m	D1	D2	H1	H2
								Allowable: 0.500 - 0.502		Allowable: 0.124 - 0.128	
C	AW14C01	1PB16	0.24985	0.24960	0.24915	0.24945	0.006338	0.50040	0.50040	0.12690	0.12700
C	AW14C02	2PB16	0.24915	0.24950	0.24950	0.24920	0.006333	0.50110	0.50110	0.12500	0.12490
C	AW14C04	3PB16	0.24910	0.24920	0.24940	0.24935	0.006331	0.50155	0.50155	0.12700	0.12680
C	AW15C02	4PB16	0.24925	0.24935	0.24965	0.24935	0.006335	0.50090	0.50095	0.12700	0.12700
C	AW15C03	Spare 1	0.24900	0.24895	0.24930	0.24930	0.006328	0.50150	0.50150	0.12700	0.12690
C	AW15C06	Spare 2	0.24945	0.24910	0.24920	0.24955	0.006333	0.50125	0.50130	0.12700	0.12680

Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:	Density	Density
	mm/dd/yr			mm/dd/yr		
					kg/m^3	g/cm^3
CCD	3/2/2007	1.4053	CCD	3/2/2007	1867.8514	1.8679
CCD	3/2/2007	1.4103	CCD	3/2/2007	1866.2154	1.8662
CCD	3/2/2007	1.4104	CCD	3/2/2007	1867.2257	1.8672
CCD	3/2/2007	1.4096	CCD	3/2/2007	1870.3166	1.8703
CCD	3/2/2007	1.4086	CCD	3/2/2007	1866.2765	1.8663
CCD	3/2/2007	1.4094	CCD	3/2/2007	1867.6216	1.8676

Measurements taken by Cliff Davisson; calculations made by Joe Strizak
Density determined by ASTM C 559 - 90 (Reapproved 2005)
Measuring instruments:
Mititoyo Blade Micrometer, 0-1", ID# M212229
Dyer Digital indicator ,0-1", for Dyer Small Hole Gage, ID# 212210
Mettler Balance, Model AT261, ID# X522314
* Average= arithmetic average = mean

Appendix 8. Dimensions, specimen mass and bulk density for NBG-18 Piggy-back specimens

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in. Allowable: 0.248 - 0.250 T1	T2	T3	T4	Average * Length m	Outside Diameter, in. Allowable: 0.500 - 0.502 D1	D2	Hole Diameter, in. Allowable:0.124 - 0.128 H1	H2
C	BW14C01	1PB18	0.24990	0.25000	0.24970	0.24960	0.00634492	0.50130	0.50125	0.12740	0.12710
C	BW14C02	1PB25	0.24880	0.24935	0.24920	0.24885	0.00632587	0.50130	0.50130	0.12730	0.12740
C	BW14C03	2PB18	0.24930	0.24905	0.24870	0.24890	0.00632428	0.50110	0.50105	0.12720	0.12690
C	BW14C04	2PB24	0.24930	0.24900	0.24910	0.24940	0.00632968	0.50165	0.50170	0.12730	0.12720
C	BW14C05	3PB18	0.24830	0.24840	0.24830	0.24820	0.00630682	0.50150	0.50145	0.12740	0.12700
C	BW15C02	4PB18	0.24875	0.24880	0.24900	0.24895	0.00632143	0.50160	0.50160	0.12730	0.12720
C	BW15C03	4PB23	0.24885	0.24915	0.24920	0.24895	0.00632555	0.50150	0.50145	0.12700	0.12690
C	BW15C04	4PB25	0.24940	0.24925	0.24850	0.24860	0.00632301	0.50150	0.50150	0.12690	0.12700
C	BW15C05	Spare 1	0.24845	0.24900	0.24945	0.24875	0.00632238	0.50150	0.50150	0.12690	0.12700
C	BW15C08	Spare 2	0.24880	0.24885	0.24900	0.24885	0.00632143	0.50145	0.50145	0.12690	0.12700

Measured by:	Date: mm/dd/yy	Specimen Mass, g	Weighed by:	Date: mm/dd/yy	Density kg/m^3	Density g/cm^3
CCD	3/1/2007	1.41840	CCD	3/2/2007	1876.6834	1.8767
CCD	3/1/2007	1.41540	CCD	3/2/2007	1878.3570	1.8784
CCD	3/1/2007	1.41260	CCD	3/2/2007	1876.3025	1.8763
CCD	3/1/2007	1.41970	CCD	3/2/2007	1879.7184	1.8797
CCD	3/1/2007	1.41360	CCD	3/2/2007	1879.9257	1.8799
CCD	3/1/2007	1.41870	CCD	3/2/2007	1881.4485	1.8814
CCD	3/1/2007	1.41800	CCD	3/2/2007	1879.6854	1.8797
CCD	3/1/2007	1.42090	CCD	3/2/2007	1884.0855	1.8841
CCD	3/1/2007	1.41900	CCD	3/2/2007	1881.7551	1.8818
CCD	3/1/2007	1.41790	CCD	3/2/2007	1880.9804	1.8810

Measurements taken by Cliff Davisson; calculations made by Joe Strizak
Density determined by ASTM C 559 - 90 (Reapproved 2005)
Measuring instruments:
Mititoyo Blade Micrometer, 0-1", ID# M212229
Dyer Digital indicator ,0-1", for Dyer Small Hole Gage, ID# 212210
Mettler Balance, Model AT261, ID# X522314
* Average= arithmetic average = mean

Appendix 9. Dimensions, specimen mass and bulk density for H-451 Piggy-back specimens

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in. Allowable: 0.248 - 0.250 T1	T2	T3	T4	Average * Length m	Outside Diameter, in. Allowable: 0.500 - 0.502 D1	D2	Hole Diameter, in. Allowable: 0.124 - 0.128 H1	H2
C	CW1C02	2PB20	0.24935	0.24965	0.24930	0.24910	0.00633349	0.50175	0.50175	0.12820	0.12830
C	CW1C03	3PB20	0.24910	0.24910	0.24885	0.24885	0.00632397	0.50155	0.50155	0.12830	0.12820
C	CW1C04	4PB20	0.24885	0.24875	0.24900	0.24920	0.00632333	0.50150	0.50140	0.12660	0.12650
C	CW2C01	6PB21	0.24910	0.24935	0.24950	0.24925	0.00633222	0.50160	0.50150	0.12810	0.12790
C	CW2C03	Spare 1	0.24960	0.2494	0.24945	0.24965	0.00633794	0.50160	0.50155	0.12810	0.12780
C	CW2C05	Spare 2	0.24960	0.24955	0.24925	0.24940	0.00633603	0.50145	0.50150	0.12660	0.12690

Measured by:	Date: mm/dd/yr	Specimen Mass, g	Weighed by:	Date: mm/dd/yr	Density kg/cm^3	Density g/cm^3
CCD	3/6/2007	1.31460	CCD	3/7/2007	1740.8488	1.7408
CCD	3/6/2007	1.30190	CCD	3/7/2007	1728.1013	1.7281
CCD	3/6/2007	1.30300	CCD	3/7/2007	1727.2896	1.7273
CCD	3/6/2007	1.30940	CCD	3/7/2007	1735.3179	1.7353
CCD	3/6/2007	1.31140	CCD	3/7/2007	1736.1217	1.7361
CCD	3/6/2007	1.30900	CCD	3/7/2007	1731.9534	1.7320

Measurements taken by Cliff Davisson; calculations made by Joe Strizak
Density determined by ASTM C 559 - 90 (Reapproved 2005)
Measuring instruments:
Mititoyo Blade Micrometer, 0-1", ID# M212229
Dyer Digital indicator ,0-1", for Dyer Small Hole Gage, ID# 212210
Mettler Balance, Model AT261, ID# X522314
* Average= arithmetic average = mean

Appendix 10. Dimensions, specimen mass and bulk density for PCEA Piggy-back specimens

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in. Allowable: 0.248 - 0.250				Average * Length	Outside Diameter, in. Allowable: 0.500 - 0.502		Hole Diameter, in. Allowable: 0.124 - 0.128	
			T1	T2	T3	T4	m	D1	D2	H1	H2
C	DW14C01	1PB17	0.25145	0.25140	0.25140	0.25135	0.00638556	0.50195	0.50185	0.12740	0.12770
C	DW14C02	1PB24	0.24945	0.24940	0.24945	0.24940	0.0063354	0.50095	0.50090	0.12770	0.12730
C	DW14C03	2PB17	0.24945	0.24945	0.24945	0.24945	0.00633603	0.50090	0.50080	0.12720	0.12770
C	DW14C04	3PB17	0.24945	0.24945	0.24935	0.24940	0.00633508	0.50085	0.50075	0.12720	0.12770
C	DW14C05	3PB23	0.24845	0.24950	0.24945	0.24945	0.00633	0.50090	0.50090	0.12720	0.12760
C	DW15C01	3PB25	0.24945	0.24945	0.24935	0.24935	0.00633476	0.50120	0.50110	0.12730	0.12750
C	DW15C02	4PB17	0.24945	0.24945	0.24945	0.24945	0.00633603	0.50120	0.50110	0.12730	0.12750
C	DW15C03	4PB24	0.24945	0.24945	0.24945	0.24940	0.00633571	0.50105	0.50110	0.12720	0.12770
C	DW15C04	Spare 1	0.24945	0.24940	0.24940	0.24950	0.00633571	0.50110	0.50120	0.12710	0.12760
C	DW15C05	Spare 2	0.24950	0.24950	0.24945	0.24950	0.00633698	0.50115	0.50120	0.12760	0.12730

Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:	Density	Density
	mm/dd/yr			mm/dd/yr		
					kg/m^3	g/cm^3
CCD	3/5/2007	1.3868	CCD	3/6/2007	1818.9359	1.8189
CCD	3/5/2007	1.3668	CCD	3/6/2007	1814.3289	1.8143
CCD	3/5/2007	1.3728	CCD	3/6/2007	1822.5952	1.8226
CCD	3/5/2007	1.3721	CCD	3/6/2007	1822.3288	1.8223
CCD	3/5/2007	1.3723	CCD	3/6/2007	1823.1796	1.8232
CCD	3/5/2007	1.3712	CCD	3/6/2007	1818.4077	1.8184
CCD	3/5/2007	1.3731	CCD	3/6/2007	1820.5624	1.8206
CCD	3/5/2007	1.3728	CCD	3/6/2007	1820.9368	1.8209
CCD	3/5/2007	1.3726	CCD	3/6/2007	1819.8916	1.8199
CCD	3/5/2007	1.3710	CCD	3/6/2007	1817.4094	1.8174

Measurements taken by Cliff Davisson; calculations made by Joe Strizak
Density determined by ASTM C 559 - 90 (Reapproved 2005)
Measuring instruments:
Mititoyo Blade Micrometer, 0-1", ID# M212229
Dyer Digital indicator ,0-1", for Dyer Small Hole Gage, ID# 212210
Mettler Balance, Model AT261, ID# X522314
* Average= arithmetic average = mean

Appendix 11. Dimensions, specimen mass and bulk density for IG-110 Piggy-back specimens

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in. Allowable: 0.248 - 0.250				Average * Length	Outside Diameter, in. Allowable: 0.500 - 0.502		Hole Diameter, in. Allowable: 0.124 - 0.128	
			T1	T2	T3	T4	m	D1	D2	H1	H2
C	EW13C01	1PB21	0.24915	0.24920	0.24920	0.24915	0.00632905	0.50025	0.50050	0.12740	0.12720
C	EW13C02	2PB21	0.24930	0.24925	0.24935	0.24930	0.00633222	0.50040	0.50040	0.12690	0.12770
C	EW13C03	2PB23	0.24935	0.24925	0.24930	0.24930	0.00633222	0.50050	0.50045	0.12710	0.12780
C	EW13C04	3PB21	0.24930	0.24930	0.24925	0.24925	0.00633159	0.50035	0.50020	0.12700	0.12790
C	EW14C01	4PB21	0.24940	0.24940	0.24940	0.24945	0.00633508	0.50020	0.50030	0.12740	0.12770
C	EW14C04	Spare 1	0.24940	0.24940	0.24935	0.24935	0.00633413	0.50020	0.50020	0.12720	0.12770
C	EW14C05	Spare 2	0.24945	0.24940	0.24950	0.24945	0.00633603	0.50040	0.50010	0.12730	0.12790

Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:	Density	Density
	mm/dd/yr			mm/dd/yr		
					kg/m^3	g/cm^3
CCD	3/13/2007	1.34200	CCD	3/13/2007	1787.0020	1.7870
CCD	3/13/2007	1.34140	CCD	3/13/2007	1785.1154	1.7851
CCD	3/13/2007	1.34030	CCD	3/13/2007	1783.3712	1.7834
CCD	3/13/2007	1.34030	CCD	3/13/2007	1785.0748	1.7851
CCD	3/13/2007	1.34220	CCD	3/13/2007	1787.0069	1.7870
CCD	3/13/2007	1.33710	CCD	3/13/2007	1780.6708	1.7807
CCD	3/13/2007	1.33940	CCD	3/13/2007	1783.1078	1.7831

Measurements taken by Cliff Davisson; calculations made by Joe Strizak
Density determined by ASTM C 559 - 90 (Reapproved 2005)
Measuring instruments:
Mititoyo Blade Micrometer, 0-1", ID# M212229
Dyer Digital indicator ,0-1", for Dyer Small Hole Gage, ID# 212210
Mettler Balance, Model AT261, ID# X522314
* Average= arithmetic average = mean

Appendix 12. Dimensions, specimen mass and bulk density for IG-430 Piggy-back specimens

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in. Allowable: 0.248 - 0.250				Average * Length	Outside Diameter, in. Allowable: 0.500 - 0.502		Hole Diameter, in. Allowable: 0.124 - 0.128	
			T1	T2	T3	T4	m	D1	D2	H1	H2
C	FW18C01	1PB19	0.24920	0.24920	0.24920	0.24920	0.00632968	0.50135	0.50130	0.12720	0.12750
C	FW18C02	1PB23	0.24935	0.24935	0.24930	0.24930	0.00633286	0.50140	0.50140	0.12720	0.12780
C	FW18C03	2PB19	0.24940	0.24940	0.24940	0.24940	0.00633476	0.50120	0.50130	0.12790	0.12700
C	FW18C04	2PB25	0.24910	0.24910	0.24910	0.24910	0.00632714	0.50115	0.50125	0.12720	0.12750
C	FW18C06	3PB19	0.24910	0.24910	0.24910	0.24910	0.00632714	0.50125	0.50125	0.12730	0.12770
C	FW19C01	3PB24	0.24915	0.24920	0.24920	0.24925	0.00632968	0.50135	0.50140	0.12730	0.12760
C	FW19C02	4PB19	0.24940	0.24935	0.24930	0.24925	0.00633286	0.50130	0.50135	0.12760	0.12710
C	FW19C04	Spare 1	0.24945	0.24950	0.24945	0.24940	0.00633603	0.50040	0.50030	0.12700	0.12770
C	FW19C05	Spare 2	0.24940	0.24940	0.24950	0.24945	0.00633571	0.50050	0.50040	0.12710	0.12740

Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:	Density	Density
	mm/dd/yr			mm/dd/yr		
					kg/m^3	g/cm^3
CCD	3/12/2007	1.37860	CCD	3/12/2007	1828.2239	1.8282
CCD	3/12/2007	1.36610	CCD	3/12/2007	1810.4536	1.8105
CCD	3/12/2007	1.37670	CCD	3/12/2007	1825.0203	1.8250
CCD	3/12/2007	1.38120	CCD	3/12/2007	1833.3844	1.8334
CCD	3/12/2007	1.37670	CCD	3/12/2007	1827.3186	1.8273
CCD	3/12/2007	1.37950	CCD	3/12/2007	1829.2256	1.8292
CCD	3/12/2007	1.37980	CCD	3/12/2007	1828.8976	1.8289
CCD	3/12/2007	1.37280	CCD	3/12/2007	1826.2933	1.8263
CCD	3/12/2007	1.37370	CCD	3/12/2007	1826.6036	1.8266

Measurements taken by Cliff Davisson; calculations made by Joe Strizak
Density determined by ASTM C 559 - 90 (Reapproved 2005)
Measuring instruments:
Mititoyo Blade Micrometer, 0-1", ID# M212229
Dyer Digital indicator ,0-1", for Dyer Small Hole Gage, ID# 212210
Mettler Balance, Model AT261, ID# X522314
* Average= arithmetic average = mean

Appendix 13. Dimensions, specimen mass and bulk density for A3-Matrix Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in. Allowable: 0.248 - 0.250 T1	T2	T3	T4	Average * Length m	Outside Diameter, in. Allowable: 0.500 - 0.502 D1	D2	Hole Diameter, in. H1	H2
A	H-3-1	CPB2	0.24850	0.24875	0.24845	0.24815	0.006311	0.50120	0.50100	X	X
A	H-3-2	CPB12	0.24885	0.24860	0.24720	0.24700	0.006297	0.50080	0.50080	X	X
A	H-4-1	CPB22	0.24660	0.24710	0.24805	0.24675	0.006277	0.50075	0.50085	X	X
A	H-4-2	CPB32	0.24560	0.24445	0.24465	0.24595	0.006227	0.50085	0.50080	X	X
A	H-5-1	CPB42	0.24825	0.24810	0.24805	0.24845	0.006305	0.50110	0.50110	X	X
A	H-5-2	CPB52	0.24795	0.24770	0.24865	0.24775	0.006300	0.50080	0.50080	X	X
A	H-7-1	CPB62	0.24860	0.24810	0.24830	0.24890	0.006311	0.50095	0.50090	X	X
A	H-7-2	CPB72	0.24770	0.24830	0.24740	0.24615	0.006284	0.50060	0.50050	X	X
A	H-8-1	CPB82	0.24775	0.24595	0.24705	0.24790	0.006278	0.50095	0.50085	X	X
A	H-8-2	CPB92	0.24890	0.24880	0.24880	0.24880	0.006320	0.50070	0.50060	X	X
A	H-9-1	CPB102	0.24935	0.24920	0.24680	0.24885	0.006313	0.50115	0.50120	X	X
A	H-9-2	CPB112	0.24865	0.24770	0.24770	0.24840	0.006302	0.50080	0.50080	X	X
A	H-10-1	CPB122	0.24895	0.24875	0.24790	0.24870	0.006314	0.50060	0.50065	X	X
A	H-10-2	CPB132	0.24795	0.24805	0.24730	0.24795	0.006294	0.50055	0.50060	X	X
A	H-12-1	CPB142	0.24885	0.24830	0.24820	0.24875	0.006313	0.50080	0.50100	X	X
A	H-12-2	CPB152	0.24835	0.24820	0.24800	0.24780	0.006301	0.50075	0.50080	X	X
A	H-13-1	CPB162	0.24750	0.24740	0.24750	0.24725	0.006284	0.50060	0.50070	X	X
A	H-13-2	CPB172	0.24865	0.24845	0.24850	0.24890	0.006315	0.50055	0.50050	X	X
A	H-14-1	CPB182	0.24845	0.24870	0.24875	0.24840	0.006314	0.50075	0.50065	X	X
A	H-14-2	CPB192	0.24900	0.24880	0.24895	0.24845	0.006320	0.50060	0.50050	X	X
A	H-15-1	Spare 1	0.24845	0.24895	0.24860	0.24825	0.006313	0.50070	0.50070	X	X
A	H-15-2	Spare 2	0.24880	0.24910	0.24890	0.24860	0.006321	0.50060	0.50060	X	X
								Allowable: 0.500 - 0.502		Allowable: 0.124 - 0.128	
C	H-16-1	5PB22	0.24835	0.24865	0.24820	0.24790	0.006306	0.50060	0.50065	0.12360	0.12400
C	H-16-2	6PB17	0.24805	0.24805	0.24850	0.24850	0.006306	0.50055	0.50060	0.12510	0.12480
C	H-17-1	6PB22	0.24860	0.24845	0.24860	0.24855	0.006313	0.50125	0.50125	0.12330	0.12380
C	H-18-1	Spare 1	0.24690	0.24775	0.24795	0.24660	0.006281	0.50005	0.50005	0.12380	0.12410
C	H-18-2	Spare 2	0.24900	0.24880	0.24850	0.24850	0.006317	0.49990	0.49980	0.12340	0.12390

See footnotes to Appendix 12.

Appendix 13. Dimensions, specimen mass and bulk density for A3-Matrix Piggy-back specimens (sheet 2)

					Density,	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:		
	mm/dd/yy			mm/dd/yy	kg/m^3	g/cm^3
CCD	2/20/2007	1.0903	CCD	2/22/2007	1357.8266	1.3578
CCD	2/20/2007	1.0599	CCD	2/22/2007	1324.4811	1.3245
CCD	2/20/2007	1.0262	CCD	2/22/2007	1286.4551	1.2865
CCD	2/20/2007	0.9832	CCD	2/22/2007	1242.2923	1.2423
CCD	2/20/2007	1.0966	CCD	2/22/2007	1367.0479	1.3670
CCD	2/20/2007	1.0695	CCD	2/22/2007	1335.9387	1.3359
CCD	2/20/2007	1.0961	CCD	2/22/2007	1365.9350	1.3659
CCD	2/20/2007	1.0682	CCD	2/22/2007	1339.0224	1.3390
CCD	2/20/2007	1.0864	CCD	2/22/2007	1361.1722	1.3612
CCD	2/20/2007	1.0657	CCD	2/22/2007	1327.6404	1.3276
CCD	2/21/2007	1.0930	CCD	2/22/2007	1360.3027	1.3603
CCD	2/21/2007	1.0654	CCD	2/22/2007	1330.2809	1.3303
CCD	2/21/2007	0.9940	CCD	2/22/2007	1239.6864	1.2397
CCD	2/21/2007	1.0278	CCD	2/22/2007	1286.0417	1.2860
CCD	2/21/2007	1.0904	CCD	2/22/2007	1358.6940	1.3587
CCD	2/21/2007	1.0628	CCD	2/22/2007	1327.3007	1.3273
CCD	2/21/2007	0.9995	CCD	2/22/2007	1252.2778	1.2523
CCD	2/21/2007	1.0385	CCD	2/22/2007	1295.4424	1.2954
CCD	2/21/2007	1.1962	CCD	2/22/2007	1491.4171	1.4914
CCD	2/21/2007	1.2250	CCD	2/22/2007	1526.8583	1.5269
CCD	2/21/2007	1.1986	CCD	2/22/2007	1494.4846	1.4945
CCD	2/21/2007	1.2295	CCD	2/22/2007	1531.8532	1.5319
CCD	2/21/2007	1.1896	CCD	2/22/2007	1582.1799	1.5822
CCD	2/21/2007	1.1705	CCD	2/22/2007	1559.0038	1.5590
CCD	2/21/2007	1.1911	CCD	2/22/2007	1577.8085	1.5778
CCD	2/21/2007	1.1815	CCD	2/22/2007	1581.7200	1.5817
CCD	2/21/2007	1.1660	CCD	2/22/2007	1553.0140	1.5530

See footnotes to appendix 12.

Appendix 14. Dimensions, specimen mass and bulk density for HLM Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in.				Average *	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250				Length	Allowable: 0.500 - 0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4	m	D1	D2	H1	H2
B	J1B03	CPB3	0.24945	0.24950	0.24950	0.24950	0.006337	0.50055	0.50050	0.08100	0.08140
B	J1B04	CPB13	0.24950	0.24945	0.24950	0.24945	0.006337	0.50050	0.50025	0.08100	0.08110
B	J1B05	CPB23	0.24945	0.24950	0.24940	0.24945	0.006336	0.50040	0.50040	0.08140	0.08110
B	J1B06	CPB33	0.24940	0.24940	0.24945	0.24945	0.006335	0.50040	0.50015	0.08140	0.08090
B	J1B07	CPB43	0.24945	0.24950	0.24950	0.24945	0.006337	0.50055	0.50060	0.08130	0.08150
B	J2B01	CPB53	0.24960	0.24945	0.24945	0.24935	0.006336	0.50045	0.50040	0.08120	0.08150
B	J2B03	CPB63	0.24950	0.24945	0.24935	0.24935	0.006335	0.50065	0.50065	0.08120	0.08150
B	J2B04	CPB73	0.24955	0.24935	0.24925	0.24945	0.006335	0.50050	0.50055	0.08120	0.08120
B	J2B05	CPB83	0.24925	0.24940	0.24950	0.24940	0.006334	0.50045	0.50055	0.08130	0.08150
B	J2B06	CPB93	0.24930	0.24940	0.24940	0.24925	0.006333	0.50035	0.50040	0.08130	0.08150
B	J5B01	CPB103	0.24940	0.24940	0.24935	0.24940	0.006334	0.50045	0.50040	0.08090	0.08140
B	J5B02	CPB113	0.24930	0.24955	0.24950	0.24945	0.006336	0.50045	0.50050	0.08120	0.08130
B	J5B04	CPB123	0.24935	0.24950	0.24945	0.24940	0.006335	0.50045	0.50035	0.08140	0.08100
B	J5B05	CPB133	0.24940	0.24945	0.24945	0.24935	0.006335	0.50045	0.50050	0.08140	0.08140
B	J5B06	CPB143	0.24940	0.24940	0.24945	0.24945	0.006335	0.50030	0.50050	0.08120	0.08130
B	J6B01	CPB153	0.24945	0.24950	0.24960	0.24955	0.006338	0.50060	0.50050	0.08100	0.08150
B	J6B02	CPB163	0.24945	0.24950	0.24945	0.24945	0.006336	0.50080	0.50070	0.08120	0.08160
B	J6B03	CPB173	0.24940	0.24945	0.24935	0.24930	0.006334	0.50060	0.50065	0.08140	0.08140
B	J6B05	CPB183	0.24945	0.24935	0.24940	0.24945	0.006335	0.50055	0.50065	0.08070	0.08140
B	J6B06	Spare 1	0.24945	0.24940	0.24960	0.24950	0.006337	0.50070	0.50070	0.08130	0.08100
B	J6B08	Spare 2	0.24935	0.24945	0.24945	0.24945	0.006335	0.50050	0.50050	0.08140	0.08120
								Allowable: 0.500 - 0.502		Allowable: 0.124 - 0.128	
C	J3C01	6PB18	0.24940	0.24940	0.24940	0.24935	0.006334	0.50065	0.50065	0.12590	0.12590
C	J3C04	6PB24	0.24935	0.24935	0.24930	0.24940	0.006333	0.50080	0.50100	0.12620	0.12630
C	J7C03	Spare 1	0.24930	0.24925	0.24930	0.24915	0.006331	0.49965	0.49970	0.12650	0.12670
C	J7C04	Spare 2	0.24930	0.24925	0.24930	0.24925	0.006332	0.49985	0.49980	0.12420	0.12450

See footnote to appendix 12.

Appendix 14. Dimensions, specimen mass and bulk density for HLM Piggy-back specimens (sheet 2)

					Density	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:		
	mm/dd/yy			mm/dd/yy	kg/m^3	g/cm^3
CCD	2/27/2007	1.3844	CCD	2/27/2007	1767.4706	1.7675
CCD	2/27/2007	1.3846	CCD	2/27/2007	1768.7270	1.7687
CCD	2/27/2007	1.3835	CCD	2/27/2007	1767.5527	1.7676
CCD	2/27/2007	1.3795	CCD	2/27/2007	1763.4060	1.7634
CCD	2/27/2007	1.3789	CCD	2/27/2007	1760.4106	1.7604
CCD	2/27/2007	1.3809	CCD	2/27/2007	1764.0791	1.7641
CCD	2/27/2007	1.3843	CCD	2/27/2007	1767.1445	1.7671
CCD	2/27/2007	1.3826	CCD	2/27/2007	1765.7921	1.7658
CCD	2/27/2007	1.3822	CCD	2/27/2007	1765.7862	1.7658
CCD	2/27/2007	1.3778	CCD	2/27/2007	1761.4217	1.7614
CCD	2/27/2007	1.3868	CCD	2/27/2007	1771.9126	1.7719
CCD	2/27/2007	1.3847	CCD	2/27/2007	1768.5414	1.7685
CCD	2/27/2007	1.3841	CCD	2/27/2007	1768.4374	1.7684
CCD	2/27/2007	1.3845	CCD	2/27/2007	1768.7288	1.7687
CCD	2/27/2007	1.3833	CCD	2/27/2007	1767.4745	1.7675
CCD	2/27/2007	1.3863	CCD	2/27/2007	1769.5076	1.7695
CCD	2/27/2007	1.3832	CCD	2/27/2007	1764.7210	1.7647
CCD	2/27/2007	1.3847	CCD	2/27/2007	1768.1615	1.7682
CCD	2/27/2007	1.3812	CCD	2/27/2007	1763.1962	1.7632
CCD	2/27/2007	1.3842	CCD	2/27/2007	1765.8882	1.7659
CCD	2/27/2007	1.3849	CCD	2/27/2007	1768.8515	1.7689
CCD	2/27/2007	1.3317	CCD	2/27/2007	1767.0234	1.7670
CCD	2/27/2007	1.3278	CCD	2/27/2007	1760.8976	1.7609
CCD	2/27/2007	1.3245	CCD	2/27/2007	1767.1097	1.7671
CCD	2/27/2007	1.3235	CCD	2/27/2007	1760.2151	1.7602

See footnote to appendix 12.

Appendix 15. Dimensions, specimen mass and bulk density for PGX Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in.				Average *	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250				Length	Allowable: 0.500 - 0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4	m	D1	D2	H1	H2
B	K2B01	CPB4	0.24870	0.24915	0.24920	0.24880	0.006324	0.50155	0.50150	0.0818	0.0818
B	K2B02	CPB14	0.24910	0.24925	0.24925	0.24915	0.006329	0.50130	0.50135	0.0817	0.0818
B	K2B03	CPB24	0.24960	0.24950	0.24950	0.24960	0.006339	0.50135	0.50135	0.0820	0.0819
B	K2B04	CPB34	0.24885	0.24860	0.24910	0.24935	0.006324	0.50135	0.50185	0.0814	0.0818
B	K2B05	CPB44	0.24925	0.24930	0.24910	0.24905	0.006329	0.50165	0.50145	0.0816	0.0815
B	K2B06	CPB54	0.24925	0.24910	0.24970	0.24965	0.006335	0.50165	0.50195	0.0815	0.0814
B	K2B07	CPB64	0.24865	0.24890	0.24920	0.24920	0.006324	0.50130	0.50145	0.0819	0.0818
B	K3B01	CPB74	0.24870	0.24885	0.24895	0.24870	0.006320	0.50135	0.50135	0.0818	0.0816
B	K3B02	CPB84	0.24920	0.24910	0.24935	0.24945	0.006332	0.50125	0.50130	0.0815	0.0817
B	K3B03	CPB94	0.24870	0.24900	0.24900	0.24865	0.006320	0.50125	0.50140	0.0816	0.0817
B	K3B04	CPB104	0.24940	0.24940	0.24940	0.24960	0.006336	0.50110	0.50105	0.0817	0.0815
B	K3B05	CPB114	0.24950	0.24930	0.24930	0.24935	0.006334	0.50100	0.50100	0.0817	0.0816
B	K3B06	CPB124	0.24890	0.24900	0.24960	0.24950	0.006331	0.50100	0.50090	0.0816	0.0817
B	K3B07	CPB134	0.24890	0.24930	0.24930	0.24890	0.006327	0.50165	0.50155	0.0814	0.0815
B	K6B01	CPB144	0.24940	0.24945	0.24930	0.24930	0.006334	0.50155	0.50165	0.0818	0.0818
B	K6B02	CPB154	0.24945	0.24965	0.24950	0.24925	0.006336	0.50135	0.50140	0.0818	0.0816
B	K6B03	CPB164	0.24975	0.24970	0.24915	0.24960	0.006339	0.50140	0.50135	0.0815	0.0813
B	K6B04	CPB174	0.24945	0.24980	0.24985	0.24980	0.006343	0.50160	0.50150	0.0818	0.0819
B	K6B05	CPB184	0.24930	0.24935	0.24955	0.24960	0.006336	0.50145	0.50135	0.0820	0.0817
B	K6B06	Spare 1	0.24930	0.24900	0.24930	0.24950	0.006332	0.50130	0.50130	0.0815	0.0816
B	K6B07	Spare 2	0.24920	0.24910	0.24915	0.24950	0.006331	0.50150	0.50160	0.0818	0.0817
								Allowable: 0.500 - 0.502		Allowable: 0.124 - 0.128	
C	K4C01	6PB19	0.24950	0.24930	0.24920	0.24935	0.006333	0.50170	0.50165	0.1277	0.1278
C	K4C02	Spare 1	0.24960	0.24945	0.24945	0.24965	0.006338	0.50130	0.50150	0.1281	0.1278
C	K5C01	Spare 2	0.24960	0.24965	0.24970	0.24960	0.006341	0.50170	0.50170	0.1280	0.1279

See footnote to appendix 12.

Appendix 15. Dimensions, specimen mass and bulk density for PGX Piggy-back specimens (sheet 2)

					Density	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:		
	mm/dd/yy			mm/dd/yy	kg/m^3	g/cm^3
CCD	03/14/07	1.3894	CCD	03/14/07	1771.0299	1.7710
CCD	03/14/07	1.3909	CCD	03/14/07	1772.7340	1.7727
CCD	03/14/07	1.3957	CCD	03/14/07	1776.3235	1.7763
CCD	03/14/07	1.3924	CCD	03/14/07	1773.9830	1.7740
CCD	03/14/07	1.3922	CCD	03/14/07	1772.6084	1.7726
CCD	03/14/07	1.3956	CCD	03/14/07	1773.2222	1.7732
CCD	03/14/07	1.3916	CCD	03/14/07	1774.8059	1.7748
CCD	03/14/07	1.3868	CCD	03/14/07	1770.0208	1.7700
CCD	03/14/07	1.3894	CCD	03/14/07	1770.3860	1.7704
CCD	03/14/07	1.3883	CCD	03/14/07	1771.7907	1.7718
CCD	03/14/07	1.3914	CCD	03/14/07	1773.1438	1.7731
CCD	03/14/07	1.3913	CCD	03/14/07	1774.2434	1.7742
CCD	03/14/07	1.3907	CCD	03/14/07	1774.6426	1.7746
CCD	03/14/07	1.3935	CCD	03/14/07	1774.3163	1.7743
CCD	03/14/07	1.3958	CCD	03/14/07	1775.7881	1.7758
CCD	03/14/07	1.3950	CCD	03/14/07	1775.5764	1.7756
CCD	03/14/07	1.3938	CCD	03/14/07	1773.0724	1.7731
CCD	03/14/07	1.3956	CCD	03/14/07	1773.3787	1.7734
CCD	03/14/07	1.3928	CCD	03/14/07	1772.8610	1.7729
CCD	03/14/07	1.3924	CCD	03/14/07	1773.9678	1.7740
CCD	03/14/07	1.3928	CCD	03/14/07	1773.1640	1.7732
CCD	03/14/07	1.3404	CCD	03/14/07	1774.7054	1.7747
CCD	03/14/07	1.3422	CCD	03/14/07	1778.1346	1.7781
CCD	03/14/07	1.3445	CCD	03/14/07	1778.1915	1.7782

See footnote to appendix 12.

Appendix 16. Dimensions, specimen mass and bulk density for PPEA Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in.				Average *	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250				Length	Allowable: 0.500 - 0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4	m	D1	D2	H1	H2
B	L2B02	CPB5	0.24930	0.24945	0.24910	0.24925	0.006332	0.50120	0.50120	0.0818	0.0818
B	L2B03	CPB15	0.24935	0.24955	0.24920	0.24915	0.006333	0.50115	0.50120	0.0817	0.0817
B	L2B04	CPB25	0.24900	0.24885	0.24920	0.24915	0.006326	0.50135	0.50135	0.0817	0.0818
B	L2B05	CPB35	0.24950	0.24920	0.24900	0.24925	0.006331	0.50110	0.50115	0.0815	0.0816
B	L2B06	CPB45	0.24925	0.24930	0.24925	0.24915	0.006331	0.50135	0.50135	0.0819	0.0818
B	L2B07	CPB55	0.24940	0.24925	0.24930	0.24940	0.006333	0.50145	0.50150	0.0819	0.0818
B	L2B08	CPB65	0.24945	0.24935	0.24910	0.24920	0.006332	0.50145	0.50135	0.0817	0.0817
B	L3B03	CPB75	0.24950	0.24950	0.24930	0.24935	0.006335	0.50040	0.50040	0.0819	0.0819
B	L3B04	CPB85	0.24940	0.24925	0.24900	0.24915	0.006330	0.50140	0.50130	0.0819	0.0817
B	L3B05	CPB95	0.24955	0.24925	0.24900	0.24935	0.006332	0.50120	0.50120	0.0819	0.0819
B	L3B06	CPB105	0.24920	0.24935	0.24970	0.24950	0.006336	0.50100	0.50110	0.0815	0.0817
B	L3B07	CPB115	0.24845	0.24860	0.24860	0.24850	0.006313	0.50130	0.50140	0.0816	0.0817
B	L3B08	CPB125	0.24940	0.24940	0.24915	0.24915	0.006332	0.50145	0.50140	0.0820	0.0819
B	L3B09	CPB135	0.24895	0.24920	0.24925	0.24895	0.006327	0.50135	0.50145	0.0815	0.0817
B	L6B01	CPB145	0.24910	0.24890	0.24910	0.24930	0.006327	0.50160	0.50160	0.0817	0.0818
B	L6B02	CPB155	0.24935	0.24940	0.24945	0.24940	0.006335	0.50135	0.50130	0.0817	0.0816
B	L6B03	CPB165	0.24905	0.24900	0.24895	0.24900	0.006325	0.50130	0.50130	0.0817	0.0818
B	L6B04	CPB175	0.24925	0.24900	0.24920	0.24935	0.006330	0.50135	0.50140	0.0817	0.0818
B	L6B05	CPB185	0.24960	0.24960	0.24945	0.24950	0.006338	0.50145	0.50145	0.0814	0.0816
B	L6B06	Spare 1	0.24960	0.24965	0.24955	0.24950	0.006339	0.50140	0.50140	0.0818	0.0819
B	L6B07	Spare 2	0.24935	0.24930	0.24930	0.24930	0.006333	0.50175	0.50175	0.0816	0.0816
								Allowable: 0.500 - 0.502		Allowable: 0.124 - 0.128	
C	L4C01	5PB25	0.24940	0.24940	0.24900	0.24900	0.006330	0.50115	0.50105	0.1278	0.1280
C	L4C02	6PB20	0.24905	0.24935	0.24975	0.24935	0.006334	0.50120	0.50115	0.1279	0.1280
C	L5C01	Spare 1	0.24890	0.24895	0.24865	0.24880	0.006320	0.50155	0.50150	0.1279	0.1281
C	L5C02	Spare 2	0.24900	0.24920	0.24940	0.24900	0.006328	0.50165	0.50165	0.1277	0.1278

See footnote to Appendix 12.

Appendix 16. Dimensions, specimen mass and bulk density for PPEA Piggy-back specimens (sheet 2)

					Density	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:		
				mm/dd/yy	kg/m^3	g/cm^3
CCD	2/28/2007	1.4432	CCD	2/28/2007	1839.7498	1.8397
CCD	2/28/2007	1.4436	CCD	2/28/2007	1840.0485	1.8400
CCD	2/28/2007	1.4423	CCD	2/28/2007	1839.0710	1.8391
CCD	2/28/2007	1.4430	CCD	2/28/2007	1840.0300	1.8400
CCD	2/28/2007	1.4451	CCD	2/28/2007	1841.3781	1.8414
CCD	2/28/2007	1.4446	CCD	2/28/2007	1839.0605	1.8391
CCD	2/28/2007	1.4453	CCD	2/28/2007	1840.7941	1.8408
CCD	2/28/2007	1.4365	CCD	2/28/2007	1836.3401	1.8363
CCD	2/28/2007	1.4408	CCD	2/28/2007	1836.1138	1.8361
CCD	2/28/2007	1.4395	CCD	2/28/2007	1835.0640	1.8351
CCD	2/28/2007	1.4417	CCD	2/28/2007	1837.5245	1.8375
CCD	2/28/2007	1.4369	CCD	2/28/2007	1835.8409	1.8358
CCD	2/28/2007	1.4405	CCD	2/28/2007	1834.7994	1.8348
CCD	2/28/2007	1.4416	CCD	2/28/2007	1837.3411	1.8373
CCD	2/28/2007	1.4443	CCD	2/28/2007	1839.3665	1.8394
CCD	2/28/2007	1.4470	CCD	2/28/2007	1842.5403	1.8425
CCD	2/28/2007	1.4449	CCD	2/28/2007	1843.1338	1.8431
CCD	2/28/2007	1.4467	CCD	2/28/2007	1843.3822	1.8434
CCD	2/28/2007	1.4450	CCD	2/28/2007	1837.8543	1.8379
CCD	2/28/2007	1.4468	CCD	2/28/2007	1840.6741	1.8407
CCD	2/28/2007	1.4466	CCD	2/28/2007	1839.4110	1.8394
CCD	2/28/2007	1.3826	CCD	2/28/2007	1836.3868	1.8364
CCD	2/28/2007	1.3874	CCD	2/28/2007	1840.9799	1.8410
CCD	2/28/2007	1.3858	CCD	2/28/2007	1840.2712	1.8403
CCD	2/28/2007	1.3895	CCD	2/28/2007	1841.2951	1.8413

See footnote to Appendix 12.

Appendix 17. Dimensions, specimen mass and bulk density for NBG-25 Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in.				Average *	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250				Length	Allowable: 0.500 0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4	m	D1	D2	H1	H2
B	M3B01	CPB6	0.24880	0.24905	0.24885	0.24855	0.006320	0.50150	0.50150	0.0816	0.0818
B	M3B02	CPB16	0.24915	0.24905	0.24885	0.24890	0.006324	0.50120	0.50130	0.0821	0.0823
B	M3B03	CPB26	0.24930	0.24970	0.24950	0.24910	0.006335	0.50110	0.50105	0.0818	0.0817
B	M3B04	CPB36	0.24960	0.24915	0.24920	0.24960	0.006334	0.50130	0.50135	0.0818	0.0818
B	M3B05	CPB46	0.24905	0.24945	0.24930	0.24880	0.006328	0.50130	0.50130	0.0823	0.0824
B	M4B01	CPB56	0.24885	0.24905	0.24965	0.24955	0.006332	0.50145	0.50140	0.0822	0.0822
B	M4B02	CPB66	0.24955	0.24910	0.24965	0.24990	0.006339	0.50125	0.50115	0.0822	0.0825
B	M4B03	CPB76	0.24920	0.24940	0.24950	0.24940	0.006334	0.50110	0.50110	0.0816	0.0818
B	M4B04	CPB86	0.24970	0.24940	0.24960	0.24985	0.006341	0.50130	0.50125	0.0817	0.0817
B	M4B06	CPB96	0.24975	0.24935	0.24900	0.24920	0.006333	0.50120	0.50130	0.0817	0.0820
B	M7B01	CPB106	0.24845	0.24865	0.24790	0.24800	0.006306	0.50145	0.50135	0.0824	0.0826
B	M7B02	CPB116	0.24820	0.24870	0.24810	0.24780	0.006304	0.50120	0.50125	0.0825	0.0825
B	M7B03	CPB126	0.24850	0.24890	0.24930	0.24880	0.006321	0.50140	0.50145	0.0818	0.0822
B	M7B04	CPB136	0.24875	0.24885	0.24820	0.24815	0.006312	0.50135	0.50140	0.0818	0.0818
B	M7B07	CPB146	0.24860	0.24845	0.24790	0.24795	0.006305	0.50125	0.50130	0.0821	0.0821
B	M8B01	CPB156	0.24875	0.24895	0.24915	0.24880	0.006322	0.50140	0.50140	0.0818	0.0817
B	M8B03	CPB166	0.24890	0.24855	0.24840	0.24885	0.006316	0.50105	0.50110	0.0827	0.0826
B	M8B04	CPB176	0.24905	0.24860	0.24860	0.24910	0.006320	0.50110	0.50105	0.0818	0.0818
B	M8B05	CPB186	0.24915	0.24915	0.24930	0.24930	0.006330	0.50095	0.50100	0.0818	0.0820
B	M8B06	Spare 1	0.24955	0.24945	0.24920	0.24925	0.006334	0.50075	0.50070	0.0817	0.0819
B	M8B09	Spare 2	0.24825	0.24855	0.24880	0.24860	0.006313	0.50130	0.50125	0.0818	0.0818
								Allowable: 0.500 0.502		Allowable: 0.124 - 0.128	
C	M2C01	5PB16	0.24930	0.24960	0.24880	0.24855	0.006326	0.50150	0.50140	0.1267	0.1268
C	M2C02	5PB24	0.24935	0.24925	0.24900	0.24900	0.006328	0.50135	0.50125	0.1267	0.1265
C	M2C04	Spare 1	0.24970	0.24940	0.24855	0.24870	0.006327	0.50120	0.50130	0.1266	0.1264
C	M2C05	Spare 2	0.24955	0.24910	0.24915	0.24950	0.006333	0.50145	0.50150	0.1265	0.1268

See footnote to appendix 12.

Appendix 17. Dimensions, specimen mass and bulk density for NBG-25 Piggy-back specimens (sheet 2)

					Density	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:		
	mm/dd/yy			mm/dd/yy	kg/m^3	g/cm^3
CCD	3/19/2007	1.4500	CCD	3/19/2007	1849.4551	1.8495
CCD	3/19/2007	1.4516	CCD	3/19/2007	1852.7118	1.8527
CCD	3/19/2007	1.4524	CCD	3/19/2007	1851.4365	1.8514
CCD	3/19/2007	1.4520	CCD	3/19/2007	1849.1851	1.8492
CCD	3/19/2007	1.4516	CCD	3/19/2007	1851.3108	1.8513
CCD	3/19/2007	1.4511	CCD	3/19/2007	1848.6109	1.8486
CCD	3/19/2007	1.4508	CCD	3/19/2007	1848.0823	1.8481
CCD	3/19/2007	1.4487	CCD	3/19/2007	1846.6539	1.8467
CCD	3/19/2007	1.4503	CCD	3/19/2007	1845.4252	1.8454
CCD	3/19/2007	1.4485	CCD	3/19/2007	1845.8190	1.8458
CCD	3/19/2007	1.4479	CCD	3/19/2007	1852.7141	1.8527
CCD	3/19/2007	1.4436	CCD	3/19/2007	1848.9104	1.8489
CCD	3/19/2007	1.4494	CCD	3/19/2007	1849.1644	1.8492
CCD	3/19/2007	1.4484	CCD	3/19/2007	1850.9020	1.8509
CCD	3/19/2007	1.4459	CCD	3/19/2007	1850.7915	1.8508
CCD	3/19/2007	1.4456	CCD	3/19/2007	1843.9191	1.8439
CCD	3/19/2007	1.4437	CCD	3/19/2007	1846.8297	1.8468
CCD	3/19/2007	1.4435	CCD	3/19/2007	1844.3125	1.8443
CCD	3/19/2007	1.4434	CCD	3/19/2007	1842.1961	1.8422
CCD	3/19/2007	1.4440	CCD	3/19/2007	1843.7122	1.8437
CCD	3/19/2007	1.4455	CCD	3/19/2007	1847.4887	1.8475
CCD	3/19/2007	1.3959	CCD	3/19/2007	1850.0024	1.8500
CCD	3/19/2007	1.3982	CCD	3/19/2007	1853.2848	1.8533
CCD	3/19/2007	1.3988	CCD	3/19/2007	1854.7410	1.8547
CCD	3/19/2007	1.4000	CCD	3/19/2007	1853.0856	1.8531

See footnote to Appendix 12.

Appendix 18. Dimensions, Specimen Mass and bulk density for 2020 Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in.				Average *	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250				Length	Allowable: 0.500 - 0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4	m	D1	D2	H1	H2
B	N1B03	CPB7	0.24895	0.24890	0.24940	0.24965	0.006330	0.50155	0.50160	0.08220	0.08220
B	N1B04	CPB17	0.24965	0.24950	0.24900	0.24920	0.006333	0.50165	0.50170	0.08220	0.08230
B	N1B05	CPB27	0.24920	0.24885	0.24930	0.24960	0.006331	0.50165	0.50170	0.08160	0.08160
B	N1B06	CPB37	0.24990	0.24960	0.24935	0.24980	0.006341	0.50155	0.50160	0.08180	0.08180
B	N1B08	CPB47	0.24930	0.24925	0.24950	0.24950	0.006334	0.50175	0.50180	0.08170	0.08190
B	N2B04	CPB57	0.24925	0.24955	0.24940	0.24910	0.006333	0.50155	0.50150	0.08200	0.08210
B	N2B05	CPB67	0.24955	0.24970	0.24960	0.24950	0.006340	0.50140	0.50140	0.08200	0.08180
B	N2B06	CPB77	0.24975	0.24960	0.24970	0.24990	0.006343	0.50135	0.50135	0.08190	0.08190
B	N2B07	CPB87	0.24910	0.24905	0.24880	0.24890	0.006324	0.50175	0.50170	0.08180	0.08190
B	N2B08	CPB97	0.24935	0.24920	0.24935	0.24955	0.006334	0.50150	0.50135	0.08220	0.08220
B	N5B01	CPB107	0.24915	0.24930	0.24925	0.24910	0.006330	0.50145	0.50155	0.08180	0.08170
B	N5B02	CPB117	0.24920	0.24935	0.24970	0.24975	0.006337	0.50135	0.50135	0.08180	0.08200
B	N5B03	CPB127	0.24935	0.24930	0.24955	0.24950	0.006335	0.50130	0.50130	0.08160	0.08180
B	N5B04	CPB137	0.24965	0.24955	0.24910	0.24900	0.006333	0.50145	0.50155	0.08180	0.08200
B	N5B05	CPB147	0.24905	0.24900	0.24915	0.24930	0.006328	0.50135	0.50135	0.08220	0.08210
B	N6B02	CPB157	0.24955	0.24925	0.24900	0.24930	0.006332	0.50140	0.50145	0.08190	0.08190
B	N6B03	CPB167	0.24965	0.24985	0.24980	0.24960	0.006343	0.50130	0.50130	0.08240	0.08230
B	N6B04	CPB177	0.24940	0.24930	0.24905	0.24940	0.006332	0.50130	0.50120	0.08150	0.08160
B	N6B05	CPB187	0.24910	0.24925	0.24960	0.24935	0.006333	0.50125	0.50130	0.08230	0.08250
B	N6B07	Spare 1	0.24880	0.24885	0.24910	0.24900	0.006323	0.50120	0.50125	0.08230	0.08230
B	N6B08	Spare 2	0.24980	0.24980	0.24965	0.24960	0.006343	0.50135	0.50130	0.08170	0.08170
								Allowable: 0.500 - 0.502		Allowable: 0.124 - 0.128	
C	N3C01	5PB17	0.24970	0.24965	0.24930	0.24950	0.006338	0.50150	0.50155	0.12690	0.12670
C	N3C02	6PB23	0.24960	0.24960	0.24920	0.24915	0.006334	0.50135	0.50130	0.12710	0.12690
C	N7C01	Spare 1	0.24915	0.24875	0.24875	0.24910	0.006323	0.50145	0.50145	0.12710	0.12700
C	N7C02	Spare 2	0.24915	0.24890	0.24900	0.24930	0.006327	0.50140	0.50140	0.12690	0.12690

See footnote to Appendix 12.

Appendix 18. Dimensions, Specimen Mass and bulk density for 2020 Piggy-back specimens (sheet 2)

					Density	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:		
	mm/dd/yy			mm/dd/yy	kg/m^3	g/cm^3
CCD	3/16/2007	1.3680	CCD	3/16/2007	1742.0251	1.7420
CCD	3/16/2007	1.3712	CCD	3/16/2007	1744.6559	1.7447
CCD	3/16/2007	1.3711	CCD	3/16/2007	1744.4700	1.7445
CCD	3/16/2007	1.3710	CCD	3/16/2007	1742.3191	1.7423
CCD	3/16/2007	1.3698	CCD	3/16/2007	1741.2868	1.7413
CCD	3/16/2007	1.3704	CCD	3/16/2007	1744.5632	1.7446
CCD	3/16/2007	1.3716	CCD	3/16/2007	1744.9727	1.7450
CCD	3/16/2007	1.3715	CCD	3/16/2007	1744.1549	1.7442
CCD	3/16/2007	1.3706	CCD	3/16/2007	1745.6937	1.7457
CCD	3/16/2007	1.3693	CCD	3/16/2007	1743.7907	1.7438
CCD	3/16/2007	1.3673	CCD	3/16/2007	1741.3188	1.7413
CCD	3/16/2007	1.3664	CCD	3/16/2007	1739.3232	1.7393
CCD	3/16/2007	1.3707	CCD	3/16/2007	1745.4457	1.7454
CCD	3/16/2007	1.3666	CCD	3/16/2007	1739.7291	1.7397
CCD	3/16/2007	1.3662	CCD	3/16/2007	1741.9785	1.7420
CCD	3/16/2007	1.3657	CCD	3/16/2007	1739.4666	1.7395
CCD	3/16/2007	1.3692	CCD	3/16/2007	1742.2005	1.7422
CCD	3/16/2007	1.3690	CCD	3/16/2007	1744.4253	1.7444
CCD	3/16/2007	1.3685	CCD	3/16/2007	1744.3410	1.7443
CCD	3/16/2007	1.3650	CCD	3/16/2007	1742.8280	1.7428
CCD	3/16/2007	1.3697	CCD	3/16/2007	1741.9857	1.7420
CCD	3/16/2007	1.3186	CCD	3/16/2007	1743.7659	1.7438
CCD	3/16/2007	1.3187	CCD	3/16/2007	1746.8117	1.7468
CCD	3/16/2007	1.3160	CCD	3/16/2007	1745.5504	1.7456
CCD	3/16/2007	1.3170	CCD	3/16/2007	1745.9143	1.7459

See footnote to Appendix 12.

Appendix 19. Dimensions, Specimen Mass and bulk density for PCIB Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Location	Length Measurements, in.				Average *	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250				Length	Allowable: 0.500-0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4	m	D1	D2	H1	H2
B	P1B02	CPB8	0.24985	0.24980	0.24990	0.25000	0.006347	0.50160	0.50165	0.08180	0.08200
B	P1B04	CPB18	0.24995	0.24965	0.24935	0.24945	0.006340	0.50165	0.50160	0.08180	0.08190
B	P1B05	CPB28	0.24965	0.24965	0.24960	0.24965	0.006341	0.50150	0.50150	0.08200	0.08210
B	P1B06	CPB38	0.24950	0.24945	0.24940	0.24940	0.006336	0.50140	0.50140	0.08190	0.08180
B	P1B07	CPB48	0.24945	0.24960	0.24960	0.24960	0.006339	0.50140	0.50140	0.08210	0.08210
B	P1B08	CPB58	0.24930	0.24925	0.24920	0.24940	0.006332	0.50130	0.50110	0.08160	0.08180
B	P1B10	CPB68	0.24945	0.24960	0.24960	0.24930	0.006337	0.50170	0.50170	0.08180	0.08180
B	P3B04	CPB78	0.24970	0.24940	0.24960	0.24975	0.006340	0.50095	0.50090	0.08190	0.08190
B	P3B05	CPB88	0.24955	0.24975	0.24960	0.24950	0.006340	0.50190	0.50190	0.08150	0.08170
B	P3B06	CPB98	0.24985	0.24970	0.24980	0.24975	0.006344	0.50165	0.50165	0.08180	0.08180
B	P3B07	CPB108	0.24945	0.24950	0.24925	0.24910	0.006333	0.50150	0.50150	0.08150	0.08150
B	P3B08	CPB118	0.24830	0.24880	0.24930	0.24875	0.006319	0.50175	0.50180	0.08150	0.08170
B	P3B09	CPB128	0.24970	0.24980	0.24980	0.24965	0.006343	0.50170	0.50170	0.08190	0.08180
B	P3B10	CPB138	0.24960	0.24965	0.24970	0.24965	0.006341	0.50150	0.50150	0.08190	0.08190
B	P4B01	CPB148	0.24915	0.24900	0.24920	0.24910	0.006327	0.50180	0.50150	0.08150	0.08170
B	P4B02	CPB158	0.24950	0.24950	0.24930	0.24930	0.006335	0.50140	0.50145	0.08190	0.08180
B	P4B03	CPB168	0.24915	0.24910	0.24935	0.24960	0.006332	0.50135	0.50145	0.08160	0.08180
B	P4B04	CPB178	0.24915	0.24940	0.24950	0.24940	0.006334	0.50150	0.50150	0.08180	0.08200
B	P4B05	CPB188	0.24980	0.24965	0.24920	0.24910	0.006336	0.50135	0.50135	0.08210	0.08210
B	P4B07	Spare 1	0.24960	0.24970	0.24960	0.24940	0.006339	0.50140	0.50150	0.08190	0.08180
B	P4B10	Spare 2	0.24920	0.24910	0.24915	0.24920	0.006329	0.50195	0.50195	0.08200	0.08210
								Allowable: 0.500-0.502		Allowable: 0.124 - 0.128	
C	P2C02	5PB18	0.24925	0.24940	0.24940	0.24935	0.006333	0.50130	0.50130	0.12790	0.12790
C	P2C03	6PB25	0.24970	0.24945	0.24920	0.24950	0.006336	0.50135	0.50130	0.12790	0.12810
C	P2C06	Spare 1	0.24880	0.24920	0.24930	0.24890	0.006326	0.50160	0.50170	0.12800	0.12800
C	P2C08	Spare 2	0.24885	0.24925	0.24920	0.24875	0.006325	0.50160	0.50165	0.12810	0.12790

See footnote to Appendix 12.

Appendix 19. Dimensions, Specimen Mass and bulk density for PCIB Piggy-back specimens (sheet 2)

					Density	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:		
	mm/dd/yy			mm/dd/yy	kg/m^3	g/cm^3
CCD	2/20/2007	1.4382	CCD	3/20/2007	1825.8218	1.8258
CCD	2/20/2007	1.4387	CCD	3/20/2007	1828.4993	1.8285
CCD	2/20/2007	1.4354	CCD	3/20/2007	1825.2098	1.8252
CCD	2/20/2007	1.4313	CCD	3/20/2007	1821.9582	1.8220
CCD	2/20/2007	1.4340	CCD	3/20/2007	1824.7865	1.8248
CCD	2/20/2007	1.4341	CCD	3/20/2007	1827.9355	1.8279
CCD	2/20/2007	1.4389	CCD	3/20/2007	1828.9551	1.8290
CCD	2/20/2007	1.4329	CCD	3/20/2007	1826.3306	1.8263
CCD	2/20/2007	1.4368	CCD	3/20/2007	1823.7253	1.8237
CCD	2/20/2007	1.4393	CCD	3/20/2007	1827.7320	1.8277
CCD	2/20/2007	1.4382	CCD	3/20/2007	1830.3897	1.8304
CCD	2/20/2007	1.4353	CCD	3/20/2007	1828.7066	1.8287
CCD	2/20/2007	1.4403	CCD	3/20/2007	1828.9630	1.8290
CCD	2/20/2007	1.4385	CCD	3/20/2007	1828.8764	1.8289
CCD	2/20/2007	1.4332	CCD	3/20/2007	1824.5826	1.8246
CCD	2/20/2007	1.4357	CCD	3/20/2007	1827.6467	1.8276
CCD	2/20/2007	1.4345	CCD	3/20/2007	1826.8555	1.8269
CCD	2/20/2007	1.4359	CCD	3/20/2007	1827.6755	1.8277
CCD	2/20/2007	1.4399	CCD	3/20/2007	1833.5883	1.8336
CCD	2/20/2007	1.4443	CCD	3/20/2007	1837.1171	1.8371
CCD	2/20/2007	1.4388	CCD	3/20/2007	1829.6456	1.8296
CCD	2/20/2007	1.3878	CCD	3/20/2007	1840.6128	1.8406
CCD	2/20/2007	1.3843	CCD	3/20/2007	1835.1469	1.8351
CCD	2/20/2007	1.3816	CCD	3/20/2007	1832.0594	1.8321
CCD	2/20/2007	1.3849	CCD	3/20/2007	1836.9076	1.8369

See footnote to Appendix 12.

Appendix 20. Dimensions, Specimen Mass and bulk density for BAN Piggy-back specimens (sheet 1)

Specimen Type	Sample Location	Specimen ID Number	Length Measurements, in.				Average *	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250				Length	Allowable: 0.500 0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4	m	D1	D2	H1	H2
B	CPB9	R2B01A	0.24960	0.2496	0.24940	0.24945	0.006338	0.50170	0.50170	0.08250	0.08250
B	CPB19	R2B03A	0.24910	0.24925	0.24950	0.24940	0.006333	0.50160	0.50160	0.08140	0.08130
B	CPB29	R2B06A	0.24895	0.24895	0.24905	0.24895	0.006324	0.50175	0.50180	0.08210	0.08250
B	CPB39	R2B07A	0.24930	0.24920	0.24925	0.24920	0.006331	0.50170	0.50170	0.08250	0.08230
B	CPB49	R2B08A	0.24920	0.24920	0.24915	0.24905	0.006328	0.50165	0.50170	0.08260	0.08240
B	CPB59	R2B09A	0.24885	0.24885	0.24945	0.24945	0.006328	0.50185	0.50180	0.08250	0.08260
B	CPB69	R2B10A	0.24910	0.24855	0.24850	0.24915	0.006320	0.50185	0.50190	0.08190	0.08220
B	CPB79	R3B01A	0.24945	0.24925	0.24950	0.24955	0.006336	0.50175	0.50170	0.08260	0.08280
B	CPB89	R3B02A	0.24900	0.24905	0.24910	0.24905	0.006326	0.50160	0.50165	0.08280	0.08270
B	CPB99	R3B03A	0.24870	0.24880	0.24865	0.24850	0.006316	0.50175	0.50175	0.08220	0.08220
B	CPB109	R3B04A	0.24860	0.24870	0.24905	0.24900	0.006320	0.50170	0.50175	0.08260	0.08260
B	CPB119	R3B06A	0.24925	0.24945	0.24925	0.24890	0.006330	0.50170	0.50175	0.08180	0.08170
B	CPB129	R3B07A	0.24805	0.24825	0.24835	0.24805	0.006304	0.50160	0.50165	0.08170	0.08170
B	CPB139	R3B08A	0.24910	0.24895	0.24915	0.24930	0.006328	0.50155	0.50155	0.08170	0.08180
B	CPB149	R6B01A	0.24915	0.24930	0.24945	0.24935	0.006333	0.50115	0.50115	0.08240	0.08220
B	CPB159	R6B02A	0.24925	0.24925	0.24960	0.24945	0.006334	0.50105	0.50100	0.08210	0.08220
B	CPB169	R6B04A	0.24900	0.24880	0.24865	0.24885	0.006320	0.50185	0.50185	0.08250	0.08250
B	CPB179	R6B06A	0.24890	0.24920	0.24900	0.24890	0.006325	0.50165	0.50170	0.08060	0.08080
B	CPB189	R6B08A	0.24915	0.24930	0.24960	0.24970	0.006336	0.50160	0.50165	0.08230	0.08250
B	Spare 1	R6B09A	0.24905	0.24900	0.24870	0.24880	0.006322	0.50135	0.50140	0.08240	0.08230
B	Spare 2	R6B10A	0.24875	0.24875	0.24885	0.24895	0.006320	0.50145	0.50145	0.08050	0.08060
								Allowable: 0.500 0.502		Allowable: 0.124 - 0.128	
C	1PB22	R4C01A	0.24935	0.24915	0.24935	0.24930	0.006332	0.50120	0.50115	0.12700	0.12730
C	2PB22	R4C04A	0.24905	0.24880	0.24945	0.24965	0.006331	0.50160	0.50155	0.12760	0.12750
C	3PB22	R4C07A	0.24965	0.24950	0.24945	0.24945	0.006338	0.50165	0.50170	0.12720	0.12690
C	4PB22	R4C08A	0.24930	0.24950	0.24935	0.24920	0.006333	0.50160	0.50155	0.12700	0.12710
C	5PB19	R5C01A	0.24925	0.24940	0.24940	0.24925	0.006333	0.50130	0.50135	0.12700	0.12680
C	5PB23	R5C02A	0.24975	0.24950	0.24955	0.24990	0.006342	0.50125	0.50120	0.12720	0.12690
C	Spare 1	R5C03A	0.24990	0.24980	0.24925	0.24960	0.006341	0.50130	0.50130	0.12770	0.12780
C	Spare 2	R5C05A	0.24930	0.24955	0.24930	0.24895	0.006332	0.50140	0.50140	0.12700	0.12710

See footnote to Appendix 12.

Appendix 20. Dimensions, Specimen Mass and bulk density for BAN Piggy-back specimens (sheet 2)

Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:	Density	Density
	mm/dd/yy			mm/dd/yy	kg/m^3	g/cm^3
CCD	4/18/2007	1.4458	CCD	4/19/2007	1838.4044	1.8384
CCD	4/18/2007	1.4454	CCD	4/19/2007	1838.7086	1.8387
CCD	4/18/2007	1.4388	CCD	4/19/2007	1832.6430	1.8326
CCD	4/18/2007	1.4435	CCD	4/19/2007	1837.3812	1.8374
CCD	4/18/2007	1.4435	CCD	4/19/2007	1838.3385	1.8383
CCD	4/18/2007	1.4461	CCD	4/19/2007	1840.5804	1.8406
CCD	4/18/2007	1.4436	CCD	4/19/2007	1838.8039	1.8388
CCD	4/18/2007	1.4505	CCD	4/19/2007	1844.9950	1.8450
CCD	4/18/2007	1.4475	CCD	4/19/2007	1844.8621	1.8449
CCD	4/18/2007	1.4472	CCD	4/19/2007	1845.7243	1.8457
CCD	4/18/2007	1.4477	CCD	4/19/2007	1845.7491	1.8457
CCD	4/18/2007	1.4500	CCD	4/19/2007	1844.8474	1.8448
CCD	4/18/2007	1.4421	CCD	4/19/2007	1843.1598	1.8432
CCD	4/18/2007	1.4490	CCD	4/19/2007	1845.5449	1.8455
CCD	4/18/2007	1.4418	CCD	4/19/2007	1838.6825	1.8387
CCD	4/18/2007	1.4415	CCD	4/19/2007	1838.5040	1.8385
CCD	4/18/2007	1.4431	CCD	4/19/2007	1838.9108	1.8389
CCD	4/18/2007	1.4415	CCD	4/19/2007	1834.6964	1.8347
CCD	4/18/2007	1.4431	CCD	4/19/2007	1835.9633	1.8360
CCD	4/18/2007	1.4425	CCD	4/19/2007	1841.0791	1.8411
CCD	4/18/2007	1.4398	CCD	4/19/2007	1835.3301	1.8353
CCD	4/18/2007	1.3871	CCD	4/19/2007	1839.6288	1.8396
CCD	4/18/2007	1.3847	CCD	4/19/2007	1834.4787	1.8345
CCD	4/18/2007	1.3905	CCD	4/19/2007	1838.3539	1.8384
CCD	4/18/2007	1.3875	CCD	4/19/2007	1836.4575	1.8365
CCD	4/18/2007	1.3964	CCD	4/19/2007	1850.0007	1.8500
CCD	4/18/2007	1.3971	CCD	4/19/2007	1849.4211	1.8494
CCD	4/18/2007	1.3968	CCD	4/19/2007	1850.1138	1.8501
CCD	4/18/2007	1.3956	CCD	4/19/2007	1849.0200	1.8490

See footnote to Appendix 12.

Appendix 21. Dimensions, Specimen Mass and bulk density for NBG-10 Piggy-back specimens (sheet 1)

Specimen Type	Specimen ID Number	Sample Number	Length Measurements, in.				Average * Length, m.	Outside Diameter, in.		Hole Diameter, in.	
			Allowable: 0.248 - 0.250					Allowable: 0.500 - 0.502		Allowable: 0.080 - 0.082	
			T1	T2	T3	T4		D1	D2	H1	H2
B	S1B01	CPB10	0.24930	0.24950	0.24960	0.24950	0.006337	0.50170	0.50165	0.08210	0.08220
B	S1B03	CPB20	0.24990	0.24965	0.24945	0.24960	0.006341	0.50165	0.50155	0.08130	0.08140
B	S1B04	CPB30	0.24990	0.24980	0.24945	0.24945	0.006341	0.49960	0.49955	0.08170	0.08160
B	S1B07	CPB40	0.24915	0.24915	0.24905	0.24910	0.006327	0.50145	0.50155	0.08220	0.08210
B	S1B08	CPB50	0.24930	0.24940	0.24980	0.24965	0.006338	0.50125	0.50130	0.08210	0.08200
B	S1B09	CPB60	0.24950	0.24965	0.24930	0.24935	0.006336	0.50150	0.50150	0.08130	0.08160
B	S1B10	CPB70	0.24940	0.24945	0.24955	0.24950	0.006337	0.50145	0.50155	0.08170	0.08190
B	S3B01	CPB80	0.24885	0.24875	0.24895	0.24890	0.006321	0.50095	0.50105	0.08150	0.08190
B	S3B03	CPB90	0.24890	0.24890	0.24910	0.24915	0.006325	0.50110	0.50090	0.08170	0.08180
B	S3B04	CPB100	0.24855	0.24890	0.24885	0.24845	0.006317	0.50120	0.50110	0.08210	0.08190
B	S3B07	CPB110	0.24830	0.24810	0.24830	0.24870	0.006308	0.50170	0.50180	0.08210	0.08200
B	S3B08	CPB120	0.24960	0.24975	0.24965	0.24990	0.006343	0.50095	0.50095	0.08200	0.08210
B	S3B09	CPB130	0.24990	0.24980	0.24955	0.24980	0.006344	0.50095	0.50095	0.08180	0.08180
B	S3B10	CPB140	0.24970	0.24970	0.24945	0.24945	0.006339	0.50095	0.50105	0.08170	0.08150
B	S4B01	CPB150	0.24960	0.24965	0.24960	0.24940	0.006339	0.50120	0.50125	0.08170	0.08150
B	S4B03	CPB160	0.24975	0.24955	0.24960	0.24980	0.006342	0.50140	0.50120	0.08170	0.08190
B	S4B04	CPB170	0.24920	0.24920	0.24925	0.24925	0.006330	0.50135	0.50130	0.08200	0.08190
B	S4B07	CPB180	0.24820	0.24795	0.24780	0.24810	0.006300	0.50090	0.50110	0.08160	0.08180
B	S4B08	CPB190	0.24930	0.24940	0.24890	0.24885	0.006327	0.50100	0.50095	0.08150	0.08170
B	S4B09	Spare 1	0.24915	0.24890	0.24875	0.24905	0.006324	0.50100	0.50120	0.08210	0.08200
B	S4B10	Spare 2	0.24920	0.24895	0.24900	0.24920	0.006327	0.50155	0.50145	0.08180	0.08200
								Allowable: 0.500 - 0.502		Allowable: 0.124 - 0.128	
C	S2C01	5PB20	0.24920	0.24930	0.24915	0.24900	0.006329	0.50135	0.50135	0.12730	0.12740
C	S2C02	Spare 1	0.24845	0.24845	0.24870	0.24865	0.006313	0.50170	0.50175	0.12770	0.12780
C	S2C03	Spare 2	0.24850	0.24855	0.24865	0.24875	0.006315	0.50150	0.50155	0.12750	0.12750

See footnote to Appendix 12.

Appendix 21. Dimensions, Specimen Mass and bulk density for NBG-10 Piggy-back specimens (sheet 2)

					Density	Density
Measured by:	Date:	Specimen Mass, g	Weighed by:	Date:	kg/m^3	g/cm^3
	mm/dd/yy			mm/dd/yy		
CCD	2/21/2007	1.4177	CCD	2/22/2007	1802.7053	1.8027
CCD	2/21/2007	1.4143	CCD	2/22/2007	1796.7138	1.7967
CCD	2/21/2007	1.4018	CCD	2/22/2007	1796.0557	1.7961
CCD	2/21/2007	1.4082	CCD	2/22/2007	1794.5172	1.7945
CCD	2/21/2007	1.4072	CCD	2/22/2007	1791.7202	1.7917
CCD	2/21/2007	1.4125	CCD	2/22/2007	1796.7207	1.7967
CCD	2/21/2007	1.4115	CCD	2/22/2007	1795.6879	1.7957
CCD	2/21/2007	1.4043	CCD	2/22/2007	1794.4793	1.7945
CCD	2/21/2007	1.4078	CCD	2/22/2007	1797.9285	1.7979
CCD	2/21/2007	1.4049	CCD	2/22/2007	1795.7656	1.7958
CCD	2/21/2007	1.4080	CCD	2/22/2007	1797.8083	1.7978
CCD	2/21/2007	1.4095	CCD	2/22/2007	1795.6930	1.7957
CCD	2/21/2007	1.4108	CCD	2/22/2007	1796.7780	1.7968
CCD	2/21/2007	1.4048	CCD	2/22/2007	1789.8740	1.7899
CCD	2/21/2007	1.4141	CCD	2/22/2007	1800.1521	1.8002
CCD	2/22/2007	1.4154	CCD	2/22/2007	1800.6822	1.8007
CCD	2/22/2007	1.4098	CCD	2/22/2007	1796.7926	1.7968
CCD	2/22/2007	1.4002	CCD	2/22/2007	1795.3725	1.7954
CCD	2/22/2007	1.4083	CCD	2/22/2007	1797.8490	1.7978
CCD	2/22/2007	1.4059	CCD	2/22/2007	1795.4873	1.7955
CCD	2/22/2007	1.4086	CCD	2/22/2007	1794.9063	1.7949
CCD	2/22/2007	1.3634	CCD	2/22/2007	1808.1460	1.8081
CCD	2/22/2007	1.3614	CCD	2/22/2007	1807.7444	1.8077
CCD	2/22/2007	1.3584	CCD	2/22/2007	1804.4470	1.8044

See footnote to Appendix 12.

Appendix 22. Dimensional change (length) after thermal excursion for NBG-17 specimens

Specimen ID Number	Initial Length Measurements					Final Length Measurements					Delta (Fin-Init)
	Length Measurements, in.				Mean	Length Measurements, in.				Mean	
	Allowable: 0.998 - 1.000				Length	Allowable: 0.998 - 1.000				Length	
	T1	T2	T3	T4	(ins)	T1	T2	T3	T4	(ins)	(ins)
AW1-01	0.99915	0.99930	0.99905	0.99925	0.99919	0.99915	0.99910	0.99925	0.99915	0.99916	-0.00003
AW1-02	0.99885	0.99895	0.99910	0.99890	0.99895	0.99895	0.99900	0.99890	0.99890	0.99894	-0.00001
AW1-03	0.99880	0.99875	0.99895	0.99890	0.99885	0.99890	0.99890	0.99855	0.99875	0.99878	-0.00008
AL6-01	0.99875	0.99885	0.99875	0.99875	0.99878	0.99890	0.99865	0.99865	0.99880	0.99875	-0.00002
AW2-01	0.99900	0.99925	0.99905	0.99895	0.99906	0.99910	0.99915	0.99895	0.99895	0.99904	-0.00002
AW2-02	0.99900	0.99915	0.99915	0.99910	0.99910	0.99910	0.99910	0.99910	0.99900	0.99908	-0.00002
AW2-03	0.99910	0.99915	0.99920	0.99915	0.99915	0.99900	0.99910	0.99900	0.99895	0.99901	-0.00014
AL6-02	0.99890	0.99890	0.99885	0.99885	0.99888	0.99870	0.99875	0.99885	0.99875	0.99876	-0.00011
AW4-01	0.99900	0.99910	0.99910	0.99910	0.99908	0.99900	0.99895	0.99900	0.99900	0.99899	-0.00009
AL6-03	0.99825	0.99845	0.99870	0.99840	0.99845	0.99850	0.99845	0.99830	0.99835	0.99840	-0.00005
AW4-02	0.99895	0.99905	0.99910	0.99910	0.99905	0.99890	0.99890	0.99890	0.99895	0.99891	-0.00014
AW4-03	0.99955	0.99960	0.99955	0.99945	0.99954	0.99940	0.99940	0.99935	0.99940	0.99939	-0.00015
AW5-01	0.99910	0.99900	0.99910	0.99915	0.99909	0.99895	0.99900	0.99900	0.99895	0.99898	-0.00011
AL8-01	0.99845	0.99840	0.99830	0.99835	0.99838	0.99820	0.99830	0.99825	0.99825	0.99825	-0.00012
AW5-02	0.99885	0.99895	0.99925	0.99900	0.99901	0.99900	0.99885	0.99895	0.99925	0.99901	0.00000
AW5-03	0.99910	0.99900	0.99900	0.99905	0.99904	0.99900	0.99915	0.99910	0.99900	0.99906	0.00002
AW6-01	0.99910	0.99920	0.99910	0.99920	0.99915	0.99910	0.99925	0.99900	0.99905	0.99910	-0.00005
AW6-02	0.99910	0.99910	0.99900	0.99925	0.99911	0.99915	0.99905	0.99915	0.99915	0.99913	0.00001
AL8-02	0.99910	0.99925	0.99920	0.99945	0.99925	0.99910	0.99910	0.99895	0.99930	0.99911	-0.00014
AW6-03	0.99920	0.99930	0.99930	0.99955	0.99934	0.99930	0.99925	0.99950	0.99930	0.99934	0.00000
AW7-01	0.99910	0.99895	0.99885	0.99910	0.99900	0.99900	0.99900	0.99880	0.99880	0.99890	-0.00010
AW7-02	0.99910	0.99900	0.99900	0.99910	0.99905	0.99880	0.99900	0.99900	0.99895	0.99894	-0.00011

AL8-03	0.99880	0.99880	0.99870	0.99880	0.99878	0.99865	0.99850	0.99865	0.99875	0.99864	-0.00014
AW7-03	0.99920	0.99935	0.99910	0.99910	0.99919	0.99910	0.99910	0.99900	0.99905	0.99906	-0.00012
AW9-01	0.99925	0.99930	0.99910	0.99910	0.99919	0.99915	0.99910	0.99905	0.99920	0.99913	-0.00006
AW9-02	0.99910	0.99935	0.99920	0.99925	0.99923	0.99915	0.99895	0.99915	0.99910	0.99909	-0.00014
AW9-03	0.99905	0.99905	0.99925	0.99930	0.99916	0.99910	0.99905	0.99910	0.99900	0.99906	-0.00010
AW10-01	0.99935	0.99950	0.99925	0.99920	0.99933	0.99905	0.99930	0.99930	0.99915	0.99920	-0.00013
AW10-02	0.99920	0.99915	0.99910	0.99915	0.99915	0.99910	0.99905	0.99900	0.99905	0.99905	-0.00010
AW10-03	0.99920	0.99910	0.99905	0.99910	0.99911	0.99895	0.99890	0.99910	0.99900	0.99899	-0.00012
AW12-01	0.99830	0.99825	0.99830	0.99830	0.99829	0.99830	0.99815	0.99820	0.99825	0.99823	-0.00006
AW12-02	0.99910	0.99905	0.99895	0.99900	0.99903	0.99885	0.99880	0.99895	0.99885	0.99886	-0.00016
AW12-03	0.99830	0.99840	0.99830	0.99830	0.99833	0.99810	0.99810	0.99815	0.99810	0.99811	-0.00021
AW13-01	0.99895	0.99890	0.99895	0.99885	0.99891	0.99905	0.99890	0.99880	0.99885	0.99890	-0.00001
AL7-01	0.99870	0.99875	0.99890	0.99870	0.99876	0.99875	0.99865	0.99865	0.99885	0.99873	-0.00004
AL7-02	0.99865	0.99865	0.99855	0.99855	0.99860	0.99860	0.99860	0.99850	0.99845	0.99854	-0.00006
AW13-02	0.99865	0.99875	0.99880	0.99865	0.99871	0.99860	0.99880	0.99865	0.99870	0.99869	-0.00002
AW13-03	0.99860	0.99850	0.99860	0.99860	0.99858	0.99840	0.99840	0.99850	0.99850	0.99845	-0.00013

Appendix 23. Dimensional change (length) after thermal excursion for NBG-18 specimens

Specimen ID Number	Initial Length Measurements					Final Length Measurements					Delta (Fin-Init)
	Length Measurements, in.				Mean	Length Measurements, in.				Mean	
	Allowable: 0.998 - 1.000				Length	Allowable: 0.998 - 1.000				Length	
	T1	T2	T3	T4	(ins)	T1	T2	T3	T4	(ins)	(ins)
BL6-01	0.99915	0.99900	0.99885	0.99900	0.99900	0.99880	0.99890	0.99880	0.99885	0.99884	-0.00016
BW1-01	0.99900	0.99905	0.99920	0.99925	0.99913	0.99890	0.99885	0.99905	0.99905	0.99896	-0.00016
BW1-02	0.99900	0.99890	0.99895	0.99920	0.99901	0.99890	0.99860	0.99870	0.99890	0.99878	-0.00024
BW1-03	0.99900	0.99895	0.99900	0.99910	0.99901	0.99870	0.99875	0.99895	0.99870	0.99878	-0.00024
BW2-01	0.99880	0.99870	0.99890	0.99895	0.99884	0.99885	0.99860	0.99855	0.99855	0.99864	-0.00020
BW2-02	0.99910	0.99895	0.99880	0.99895	0.99895	0.99875	0.99875	0.99855	0.99865	0.99868	-0.00027
BL6-02	0.99895	0.99890	0.99905	0.99890	0.99895	0.99890	0.99870	0.99875	0.99885	0.99880	-0.00015
BW2-03	0.99880	0.99870	0.99895	0.99905	0.99888	0.99850	0.99880	0.99840	0.99860	0.99858	-0.00030
BW3-01	0.99890	0.99875	0.99905	0.99890	0.99890	0.99870	0.99860	0.99870	0.99865	0.99866	-0.00024
BW3-02	0.99940	0.99950	0.99945	0.99935	0.99943	0.99915	0.99905	0.99920	0.99925	0.99916	-0.00026
BW3-03	0.99900	0.99885	0.99900	0.99900	0.99896	0.99860	0.99885	0.99875	0.99875	0.99874	-0.00023
BL6-03	0.99915	0.99915	0.99915	0.99910	0.99914	0.99880	0.99900	0.99890	0.99895	0.99891	-0.00022
BW5-01	0.99875	0.99870	0.99880	0.99890	0.99879	0.99865	0.99855	0.99850	0.99860	0.99858	-0.00021
BW5-02	0.99890	0.99900	0.99900	0.99880	0.99893	0.99880	0.99875	0.99860	0.99890	0.99876	-0.00016
BW5-03	0.99880	0.99880	0.99890	0.99895	0.99886	0.99860	0.99850	0.99875	0.99870	0.99864	-0.00023
BW7-01	0.99900	0.99900	0.99910	0.99910	0.99905	0.99885	0.99880	0.99865	0.99880	0.99878	-0.00027
BW7-02	0.99910	0.99915	0.99925	0.99930	0.99920	0.99900	0.99900	0.99900	0.99895	0.99899	-0.00021
BL7-01	0.99895	0.99890	0.99895	0.99905	0.99896	0.99875	0.99875	0.99870	0.99865	0.99871	-0.00025
BW7-03	0.99875	0.99885	0.99885	0.99885	0.99883	0.99865	0.99865	0.99850	0.99860	0.99860	-0.00023
BW8-01	0.99940	0.99930	0.99930	0.99960	0.99940	0.99925	0.99920	0.99935	0.99940	0.99930	-0.00010
BW8-02	0.99915	0.99930	0.99950	0.99925	0.99930	0.99915	0.99890	0.99885	0.99905	0.99899	-0.00031
BW8-03	0.99890	0.99895	0.99900	0.99890	0.99894	0.99840	0.99840	0.99825	0.99855	0.99840	-0.00054
BL7-02	0.99920	0.99910	0.99895	0.99900	0.99906	0.99855	0.99860	0.99865	0.99875	0.99864	-0.00043
BW9-01	0.99950	0.99935	0.99920	0.99940	0.99936	0.99895	0.99920	0.99925	0.99920	0.99915	-0.00021

BW9-02	0.99900	0.99905	0.99885	0.99890	0.99895	0.99875	0.99845	0.99870	0.99890	0.99870	-0.00025
BW9-03	0.99940	0.99950	0.99935	0.99930	0.99939	0.99905	0.99910	0.99935	0.99925	0.99919	-0.00020
BW10-01	0.99915	0.99935	0.99930	0.99920	0.99925	0.99930	0.99905	0.99915	0.99930	0.99920	-0.00005
BW10-02	0.99900	0.99910	0.99920	0.99905	0.99909	0.99900	0.99895	0.99910	0.99910	0.99904	-0.00005
BL7-03	0.99900	0.99870	0.99885	0.99910	0.99891	0.99880	0.99855	0.99880	0.99900	0.99879	-0.00012
BW10-03	0.99925	0.99925	0.99925	0.99920	0.99924	0.99910	0.99895	0.99910	0.99910	0.99906	-0.00018
BW11-01	0.99895	0.99905	0.99910	0.99905	0.99904	0.99895	0.99885	0.99900	0.99895	0.99894	-0.00010
BW11-02	0.99900	0.99910	0.99920	0.99910	0.99910	0.99895	0.99880	0.99910	0.99905	0.99898	-0.00013
BW11-03	0.99890	0.99915	0.99910	0.99890	0.99901	0.99875	0.99895	0.99900	0.99890	0.99890	-0.00011
BW12-01	0.99900	0.99895	0.99900	0.99885	0.99895	0.99890	0.99875	0.99885	0.99890	0.99885	-0.00010
BL8-01	0.99910	0.99910	0.99905	0.99895	0.99905	0.99905	0.99910	0.99905	0.99895	0.99904	-0.00001
BL8-02	0.99820	0.99845	0.99850	0.99810	0.99831	0.99805	0.99840	0.99830	0.99815	0.99823	-0.00009
BW12-02	0.99920	0.99920	0.99910	0.99925	0.99919	0.99910	0.99900	0.99910	0.99920	0.99910	-0.00009
BW12-03	0.99880	0.99860	0.99860	0.99870	0.99868	0.99840	0.99835	0.99855	0.99860	0.99848	-0.00020

Appendix 24. Dimensional change (length) after thermal excursion for H-451 specimens

Specimen ID Number	Initial Length Measurements					Final Length Measurements					Delta (Fin-Init)
	Length Measurements, in.				Mean	Length Measurements, in.				Mean	
	Allowable: 0.998 - 1.000				Length	Allowable: 0.998 - 1.000				Length	
	T1	T2	T3	T4	(ins)	T1	T2	T3	T4	(ins)	(ins)
CW7-01	0.99915	0.99920	0.99900	0.99910	0.99911	0.99795	0.99895	0.99845	0.99760	0.99824	-0.00087
CW7-03	0.99910	0.99900	0.99900	0.99900	0.99903	0.99845	0.99835	0.99855	0.99865	0.99850	-0.00052
CW8-02	0.99900	0.99895	0.99910	0.99905	0.99903	0.99845	0.99875	0.99765	0.99870	0.99839	-0.00064
CW8-03	0.99885	0.99895	0.99905	0.99890	0.99894	0.99780	0.99880	0.99855	0.99850	0.99841	-0.00053
CW9-01	0.99915	0.99925	0.99925	0.99920	0.99921	0.99875	0.99870	0.99875	0.99875	0.99874	-0.00048
CW9-02	0.99910	0.99925	0.99910	0.99910	0.99914	0.99860	0.99830	0.99865	0.99825	0.99845	-0.00069
CW9-03	0.99885	0.99885	0.99880	0.99895	0.99886	0.99820	0.99800	0.99820	0.99800	0.99810	-0.00076
CW10-01	0.99895	0.99895	0.99900	0.99895	0.99896	0.99865	0.99825	0.99890	0.99855	0.99859	-0.00038
CW10-02	0.99900	0.99895	0.99890	0.99895	0.99895	0.99870	0.99840	0.99835	0.99820	0.99841	-0.00054
CW10-03	0.99880	0.99865	0.99855	0.99885	0.99871	0.99815	0.99850	0.99835	0.99820	0.99830	-0.00041
CW11-01	0.99870	0.99890	0.99910	0.99875	0.99886	0.99830	0.99830	0.99830	0.99875	0.99841	-0.00045
CW11-02	0.99865	0.99870	0.99885	0.99885	0.99876	0.99860	0.99820	0.99850	0.99870	0.99850	-0.00026
CW11-03	0.99890	0.99880	0.99870	0.99880	0.99880	0.99830	0.99830	0.99855	0.99760	0.99819	-0.00061
CW12-01	0.99885	0.99895	0.99870	0.99880	0.99883	0.99820	0.99805	0.99860	0.99850	0.99834	-0.00049
CW12-02	0.99895	0.99915	0.99915	0.99885	0.99903	0.99810	0.99870	0.99840	0.99840	0.99840	-0.00063
CW13-01	0.99880	0.99900	0.99855	0.99855	0.99873	0.99840	0.99830	0.99735	0.99820	0.99806	-0.00066
CW13-02	0.99910	0.99910	0.99880	0.99895	0.99899	0.99855	0.99845	0.99810	0.99860	0.99843	-0.00056
CW13-03	0.99915	0.99910	0.99895	0.99905	0.99906	0.99820	0.99860	0.99855	0.99880	0.99854	-0.00052
CW14-01	0.99860	0.99865	0.99885	0.99890	0.99875	0.99810	0.99795	0.99790	0.99820	0.99804	-0.00071
CW14-02	0.99870	0.99870	0.99870	0.99880	0.99873	0.99815	0.99795	0.99800	0.99815	0.99806	-0.00066
CW15-01	0.99900	0.99890	0.99885	0.99880	0.99889	0.99850	0.99790	0.99810	0.99860	0.99828	-0.00061
CW15-02	0.99865	0.99865	0.99890	0.99900	0.99880	0.99805	0.99770	0.99825	0.99800	0.99800	-0.00080

Appendix 25. Dimensional change (length) after thermal excursion for PCEA specimens

Specimen ID Number	Initial Length Measurements					Final Length Measurements					Delta (Fin-Init)
	Length Measurements, in.				Mean	Length Measurements, in.				Mean	
	Allowable: 0.998 - 1.000				Length	Allowable: 0.998 - 1.000				Length	
	T1	T2	T3	T4	(ins)	T1	T2	T3	T4	(ins)	(ins)
DW1-01	0.99935	0.99935	0.99930	0.99930	0.99933	0.99935	0.99935	0.99940	0.99945	0.99939	0.00006
DW1-02	0.99930	0.99930	0.99930	0.99930	0.99930	0.99930	0.99930	0.99935	0.99925	0.99930	0.00000
DW1-03	0.99930	0.99925	0.99925	0.99925	0.99926	0.99930	0.99935	0.99935	0.99935	0.99934	0.00008
DW2-01	0.99910	0.99905	0.99910	0.99905	0.99908	0.99910	0.99910	0.99905	0.99905	0.99908	0.00000
DW2-02	0.99900	0.99905	0.99900	0.99895	0.99900	0.99905	0.99900	0.99905	0.99910	0.99905	0.00005
DW2-03	0.99910	0.99905	0.99905	0.99905	0.99906	0.99900	0.99905	0.99905	0.99900	0.99903	-0.00004
DW3-01	0.99905	0.99905	0.99905	0.99895	0.99903	0.99920	0.99920	0.99910	0.99915	0.99916	0.00014
DW3-02	0.99900	0.99910	0.99900	0.99900	0.99903	0.99915	0.99915	0.99910	0.99925	0.99916	0.00014
DW3-03	0.99910	0.99910	0.99915	0.99900	0.99909	0.99915	0.99915	0.99915	0.99910	0.99914	0.00005
DW4-01	0.99955	0.99960	0.99960	0.99960	0.99959	0.99955	0.99960	0.99960	0.99965	0.99960	0.00001
DW4-03	0.99935	0.99935	0.99935	0.99930	0.99934	0.99930	0.99935	0.99935	0.99935	0.99934	0.00000
DW5-01	0.99925	0.99930	0.99930	0.99925	0.99928	0.99930	0.99930	0.99935	0.99930	0.99931	0.00004
DA601	0.99960	0.99940	0.99970	0.99960	0.99958	0.99950	0.99965	0.99965	0.99955	0.99959	0.00001
DW5-02	0.99925	0.99925	0.99925	0.99925	0.99925	0.99925	0.99925	0.99915	0.99930	0.99924	-0.00001
DW5-03	0.99930	0.99930	0.99930	0.99930	0.99930	0.99925	0.99920	0.99920	0.99930	0.99924	-0.00006
DW6-01	0.99925	0.99930	0.99930	0.99930	0.99929	0.99925	0.99920	0.99925	0.99925	0.99924	-0.00005
DA602	0.99945	0.99945	0.99925	0.99945	0.99940	0.99955	0.99960	0.99960	0.99940	0.99954	0.00014
DA701	0.99965	0.99960	0.99960	0.99965	0.99963	0.99965	0.99960	0.99950	0.99955	0.99958	-0.00005
DW6-02	0.99920	0.99920	0.99915	0.99915	0.99918	0.99910	0.99910	0.99915	0.99915	0.99913	-0.00005
DW6-03	0.99910	0.99910	0.99910	0.99910	0.99910	0.99905	0.99910	0.99910	0.99915	0.99910	0.00000
DW7-01	0.99915	0.99920	0.99915	0.99915	0.99916	0.99915	0.99925	0.99920	0.99910	0.99918	0.00001
DW7-02	0.99925	0.99925	0.99915	0.99910	0.99919	0.99920	0.99915	0.99920	0.99920	0.99919	0.00000
DW7-03	0.99940	0.99930	0.99925	0.99920	0.99929	0.99925	0.99925	0.99930	0.99930	0.99928	-0.00001
DW8-01	0.99940	0.99930	0.99930	0.99930	0.99933	0.99925	0.99930	0.99930	0.99930	0.99929	-0.00004

DA702	0.99895	0.99900	0.99900	0.99900	0.99899	0.99900	0.99890	0.99895	0.99900	0.99896	-0.00002
DW8-02	0.99935	0.99940	0.99940	0.99935	0.99938	0.99925	0.99930	0.99925	0.99930	0.99928	-0.00010
DW8-03	0.99935	0.99935	0.99935	0.99935	0.99935	0.99935	0.99930	0.99940	0.99935	0.99935	0.00000
DW9-01	0.99950	0.99945	0.99950	0.99950	0.99949	0.99940	0.99940	0.99935	0.99940	0.99939	-0.00010
DW9-02	0.99945	0.99945	0.99945	0.99945	0.99945	0.99940	0.99925	0.99935	0.99940	0.99935	-0.00010
DW9-03	0.99960	0.99955	0.99960	0.99950	0.99956	0.99940	0.99940	0.99940	0.99940	0.99940	-0.00016
DW10-01	0.99950	0.99945	0.99960	0.99960	0.99954	0.99935	0.99940	0.99940	0.99935	0.99938	-0.00016
DA801	0.99955	0.99960	0.99955	0.99945	0.99954	0.99940	0.99940	0.99940	0.99945	0.99941	-0.00013
DW10-02	0.99930	0.99945	0.99950	0.99950	0.99944	0.99930	0.99940	0.99950	0.99930	0.99938	-0.00006
DW10-03	0.99945	0.99945	0.99945	0.99940	0.99944	0.99935	0.99945	0.99945	0.99945	0.99943	-0.00001
DW11-01	0.99940	0.99940	0.99945	0.99945	0.99943	0.99935	0.99940	0.99935	0.99940	0.99938	-0.00005
DW11-02	0.99940	0.99940	0.99940	0.99940	0.99940	0.99940	0.99940	0.99940	0.99935	0.99939	-0.00001
DA802	0.99950	0.99945	0.99955	0.99960	0.99953	0.99950	0.99940	0.99940	0.99960	0.99948	-0.00005
DA901	0.99955	0.99965	0.99960	0.99975	0.99964	0.99960	0.99960	0.99965	0.99960	0.99961	-0.00003

Appendix 26. Dimensional change (length) after thermal excursion for IG-110 specimens

Specimen ID Number	Initial Length Measurements					Final Length Measurements					Delta (Fin-Init)
	Length Measurements, in.				Mean	Length Measurements, in.				Mean	
	Allowable: 0.998 - 1.000				Length	Allowable: 0.998 - 1.000				Length	
	T1	T2	T3	T4	(ins)	T1	T2	T3	T4	(ins)	(ins)
EW2-01	0.99940	0.99945	0.99940	0.99940	0.99941	0.99925	0.99925	0.99845	0.99940	0.99909	-0.00033
EW2-02	0.99940	0.99935	0.99945	0.99950	0.99943	0.99950	0.99955	0.99935	0.99915	0.99939	-0.00004
EW2-03	0.99955	0.99950	0.99945	0.99955	0.99951	0.99945	0.99945	0.99935	0.99940	0.99941	-0.00010
EW4-01	0.99895	0.99910	0.99905	0.99900	0.99903	0.99880	0.99910	0.99835	0.99865	0.99873	-0.00030
EW4-02	0.99920	0.99925	0.99925	0.99920	0.99923	0.99885	0.99915	0.99880	0.99905	0.99896	-0.00026
EW5-01	0.99935	0.99935	0.99920	0.99920	0.99928	0.99880	0.99875	0.99875	0.99895	0.99881	-0.00046
EW5-02	0.99910	0.99900	0.99915	0.99910	0.99909	0.99910	0.99890	0.99840	0.99890	0.99883	-0.00026
EW5-03	0.99895	0.99925	0.99920	0.99895	0.99909	0.99930	0.99900	0.99895	0.99905	0.99908	-0.00001
EW6-01	0.99930	0.99930	0.99930	0.99925	0.99929	0.99875	0.99900	0.99915	0.99890	0.99895	-0.00034
EW6-02	0.99940	0.99945	0.99945	0.99945	0.99944	0.99930	0.99930	0.99905	0.99925	0.99923	-0.00021
EW6-03	0.99935	0.99925	0.99925	0.99925	0.99928	0.99895	0.99890	0.99905	0.99910	0.99900	-0.00027
EW7-01	0.99925	0.99930	0.99925	0.99935	0.99929	0.99875	0.99905	0.99915	0.99920	0.99904	-0.00025
EW7-03	0.99930	0.99930	0.99930	0.99930	0.99930	0.99920	0.99905	0.99900	0.99905	0.99908	-0.00022
EW8-01	0.99925	0.99930	0.99930	0.99930	0.99929	0.99920	0.99915	0.99915	0.99885	0.99909	-0.00020
EW8-02	0.99915	0.99930	0.99930	0.99930	0.99926	0.99895	0.99865	0.99880	0.99885	0.99881	-0.00045
EW8-03	0.99925	0.99935	0.99935	0.99935	0.99933	0.99895	0.99910	0.99905	0.99940	0.99913	-0.00020
EW9-01	0.99930	0.99930	0.99930	0.99935	0.99931	0.99860	0.99915	0.99925	0.99925	0.99906	-0.00025
EW9-02	0.99930	0.99930	0.99930	0.99930	0.99930	0.99875	0.99945	0.99945	0.99880	0.99911	-0.00019
EW9-03	0.99920	0.99930	0.99930	0.99930	0.99928	0.99900	0.99885	0.99910	0.99905	0.99900	-0.00027
EW10-01	0.99925	0.99940	0.99930	0.99930	0.99931	0.99925	0.99905	0.99905	0.99915	0.99913	-0.00019
EW10-02	0.99925	0.99935	0.99935	0.99935	0.99933	0.99910	0.99910	0.99910	0.99910	0.99910	-0.00023
EW10-03	0.99925	0.99940	0.99930	0.99935	0.99933	0.99900	0.99905	0.99905	0.99905	0.99904	-0.00029

Appendix 27. Dimensional change (length) after thermal excursion for IG-430 specimens

Specimen ID Number	Initial Length Measurements					Final Length Measurements					Delta (Fin-Init)
	Length Measurements, in. Allowable: 0.998 - 1.000				Mean Length (ins)	Length Measurements, in. Allowable: 0.998 - 1.000				Mean Length (ins)	(ins)
	T1	T2	T3	T4		T1	T2	T3	T4		
FW1-01	0.99925	0.99925	0.99920	0.99925	0.99924	0.99885	0.99890	0.99885	0.99880	0.99885	-0.00039
FW1-02	0.99925	0.99930	0.99930	0.99925	0.99928	0.99910	0.99925	0.99895	0.99915	0.99911	-0.00016
FW1-03	0.99930	0.99925	0.99930	0.99930	0.99929	0.99905	0.99875	0.99925	0.99900	0.99901	-0.00027
FW2-01	0.99910	0.99910	0.99920	0.99915	0.99914	0.99895	0.99905	0.99905	0.99900	0.99901	-0.00013
FW2-02	0.99915	0.99915	0.99915	0.99915	0.99915	0.99850	0.99855	0.99905	0.99900	0.99878	-0.00037
FW2-03	0.99925	0.99935	0.99930	0.99930	0.99930	0.99895	0.99920	0.99865	0.99920	0.99900	-0.00030
FW3-01	0.99935	0.99925	0.99935	0.99925	0.99930	0.99920	0.99915	0.99910	0.99885	0.99908	-0.00023
FW3-02	0.99925	0.99905	0.99910	0.99925	0.99916	0.99895	0.99900	0.99915	0.99910	0.99905	-0.00011
FW3-03	0.99925	0.99915	0.99920	0.99925	0.99921	0.99925	0.99880	0.99890	0.99915	0.99903	-0.00019
FW4-01	0.99935	0.99925	0.99930	0.99935	0.99931	0.99920	0.99925	0.99930	0.99920	0.99924	-0.00008
FW4-02	0.99930	0.99930	0.99925	0.99920	0.99926	0.99930	0.99895	0.99930	0.99910	0.99916	-0.00010
FW4-03	0.99900	0.99910	0.99915	0.99910	0.99909	0.99880	0.99895	0.99905	0.99830	0.99878	-0.00031
FW5-01	0.99910	0.99920	0.99925	0.99920	0.99919	0.99915	0.99925	0.99855	0.99865	0.99890	-0.00029
FW5-02	0.99940	0.99940	0.99950	0.99945	0.99944	0.99940	0.99940	0.99940	0.99940	0.99940	-0.00004
FW5-03	0.99950	0.99945	0.99945	0.99950	0.99948	0.99945	0.99920	0.99945	0.99935	0.99936	-0.00011
FW7-01	0.99950	0.99945	0.99955	0.99955	0.99951	0.99950	0.99930	0.99940	0.99945	0.99941	-0.00010
FW7-02	0.99930	0.99930	0.99930	0.99925	0.99929	0.99925	0.99920	0.99910	0.99910	0.99916	-0.00013
FW7-03	0.99950	0.99930	0.99950	0.99945	0.99944	0.99950	0.99945	0.99950	0.99930	0.99944	0.00000
FW8-01	0.99930	0.99930	0.99920	0.99915	0.99924	0.99935	0.99910	0.99925	0.99910	0.99920	-0.00004
FW8-02	0.99935	0.99930	0.99945	0.99935	0.99936	0.99920	0.99935	0.99925	0.99935	0.99929	-0.00008
FW8-03	0.99915	0.99930	0.99920	0.99930	0.99924	0.99910	0.99920	0.99895	0.99925	0.99913	-0.00011
FW9-01	0.99955	0.99950	0.99950	0.99950	0.99951	0.99950	0.99970	0.99960	0.99945	0.99956	0.00005
FW9-02	0.99950	0.99935	0.99950	0.99945	0.99945	0.99945	0.99955	0.99945	0.99950	0.99949	0.00004
FW9-03	0.99940	0.99940	0.99935	0.99930	0.99936	0.99930	0.99920	0.99925	0.99925	0.99925	-0.00011

FW10-01	0.99955	0.99965	0.99970	0.99960	0.99963	0.99975	0.99975	0.99970	0.99970	0.99973	0.00010
FW10-02	0.99960	0.99960	0.99960	0.99960	0.99960	0.99960	0.99960	0.99960	0.99950	0.99958	-0.00002
FW10-03	0.99940	0.99940	0.99940	0.99940	0.99940	0.99930	0.99930	0.99930	0.99935	0.99931	-0.00009
FW11-01	0.99940	0.99940	0.99940	0.99940	0.99940	0.99935	0.99935	0.99930	0.99935	0.99934	-0.00006
FW11-02	0.99930	0.99930	0.99930	0.99930	0.99930	0.99955	0.99935	0.99935	0.99940	0.99941	0.00011
FW11-03	0.99945	0.99940	0.99935	0.99945	0.99941	0.99945	0.99945	0.99945	0.99940	0.99944	0.00003
FW12-01	0.99950	0.99950	0.99955	0.99945	0.99950	0.99950	0.99955	0.99940	0.99955	0.99950	0.00000
FW12-02	0.99950	0.99950	0.99955	0.99950	0.99951	0.99945	0.99950	0.99940	0.99950	0.99946	-0.00005
FW13-01	0.99940	0.99930	0.99920	0.99925	0.99929	0.99940	0.99925	0.99925	0.99935	0.99931	0.00003
FW13-02	0.99930	0.99935	0.99930	0.99930	0.99931	0.99925	0.99925	0.99920	0.99925	0.99924	-0.00007

Appendix 28. Dimensional change (diameter) after thermal excursion for NBG-17 (sheet 1)

Specimen ID Number	Initial Outside Diameter Measurements								
	Allowable: 0.500 - 0.502 in.								Mean Dia, in.
	D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$	
AW1-01	0.50100	0.50100	0.50100	0.50090	0.50100	0.50105	0.50105	0.50090	0.50099
AW1-02	0.50130	0.50140	0.50135	0.50135	0.50135	0.50140	0.50150	0.50140	0.50138
AW1-03	0.50130	0.50135	0.50150	0.50150	0.50130	0.50150	0.50150	0.50160	0.50144
AL6-01	0.50125	0.50140	0.50130	0.50145	0.50115	0.50135	0.50130	0.50145	0.50133
AW2-01	0.50150	0.50150	0.50125	0.50120	0.50160	0.50145	0.50130	0.50135	0.50139
AW2-02	0.50120	0.50125	0.50130	0.50145	0.50120	0.50130	0.50130	0.50140	0.50130
AW2-03	0.50090	0.50090	0.50085	0.50095	0.50100	0.50080	0.50080	0.50095	0.50089
AL6-02	0.50105	0.50115	0.50130	0.50135	0.50110	0.50105	0.50125	0.50130	0.50119
AW4-01	0.50130	0.50120	0.50140	0.50145	0.50120	0.50135	0.50145	0.50150	0.50136
AL6-03	0.50130	0.50155	0.50155	0.50175	0.50135	0.50150	0.50145	0.50175	0.50153
AW4-02	0.50140	0.50140	0.50140	0.50150	0.50150	0.50150	0.50130	0.50135	0.50142
AW4-03	0.50155	0.50155	0.50175	0.50190	0.50150	0.50155	0.50165	0.50180	0.50166
AW5-01	0.50150	0.50150	0.50160	0.50170	0.50155	0.50165	0.50165	0.50180	0.50162
AL8-01	0.50130	0.50050	0.50095	0.50095	0.50130	0.50050	0.50100	0.50100	0.50094
AW5-02	0.50170	0.50135	0.50085	0.50095	0.50170	0.50105	0.50100	0.50095	0.50119
AW5-03	0.50175	0.50135	0.50125	0.50130	0.50165	0.50120	0.50140	0.50130	0.50140
AW6-01	0.50180	0.50155	0.50175	0.50135	0.50190	0.50165	0.50155	0.50150	0.50163
AW6-02	0.50125	0.50125	0.50140	0.50150	0.50125	0.50135	0.50130	0.50125	0.50132
AL8-02	0.50130	0.50130	0.50150	0.50140	0.50140	0.50130	0.50140	0.50130	0.50136
AW6-03	0.50115	0.50115	0.50115	0.50135	0.50115	0.50115	0.50120	0.50125	0.50119
AW7-01	0.50140	0.50150	0.50155	0.50180	0.50150	0.50150	0.50160	0.50175	0.50158
AW7-02	0.50135	0.50140	0.50165	0.50180	0.50135	0.50145	0.50155	0.50180	0.50154
AL8-03	0.50135	0.50135	0.50135	0.50170	0.50090	0.50135	0.50135	0.50180	0.50139
AW7-03	0.50130	0.50130	0.50145	0.50160	0.50130	0.50140	0.50140	0.50155	0.50141
AW9-01	0.50150	0.50125	0.50125	0.50120	0.50160	0.50120	0.50130	0.50120	0.50131
AW9-02	0.50145	0.50130	0.50140	0.50125	0.50160	0.50120	0.50145	0.50120	0.50136
AW9-03	0.50135	0.50135	0.50140	0.50155	0.50135	0.50140	0.50155	0.50165	0.50145
AW10-01	0.50130	0.50125	0.50100	0.50100	0.50130	0.50125	0.50095	0.50105	0.50114
AW10-02	0.50160	0.50155	0.50150	0.50140	0.50180	0.50160	0.50150	0.50140	0.50154
AW10-03	0.50130	0.50125	0.50130	0.50150	0.50130	0.50130	0.50135	0.50155	0.50136
AW12-01	0.50170	0.50155	0.50140	0.50120	0.50165	0.50150	0.50135	0.50140	0.50147
AW12-02	0.50120	0.50105	0.50100	0.50155	0.50120	0.50125	0.50120	0.50150	0.50124
AW12-03	0.50120	0.50095	0.50105	0.50135	0.50120	0.50115	0.50100	0.50125	0.50114
AW13-01	0.50105	0.50110	0.50110	0.50115	0.50105	0.50125	0.50125	0.50110	0.50113
AL7-01	0.50050	0.50065	0.50100	0.50160	0.50055	0.50065	0.50085	0.50160	0.50093
AL7-02	0.50110	0.50120	0.50130	0.50130	0.50110	0.50105	0.50130	0.50130	0.50121
AW13-02	0.50150	0.50130	0.50125	0.50125	0.50160	0.50155	0.50125	0.50125	0.50137
AW13-03	0.50160	0.50155	0.50150	0.50135	0.50170	0.50155	0.50130	0.50130	0.50148

Appendix 28. Dimensional change (diameter) after thermal excursion for NBG-17 (sheet 2)

Final Outside Diameter Measurements									Delta (Final-Init), in.
Allowable: 0.500 - 0.502 in.								Mean Dia, in.	
D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$		
0.50125	0.50140	0.50130	0.50085	0.50130	0.50130	0.50125	0.50120	0.50123	0.00024
0.50140	0.50165	0.50165	0.50145	0.50145	0.50175	0.50165	0.50150	0.50156	0.00018
0.50185	0.50170	0.50155	0.50150	0.50170	0.50150	0.50155	0.50150	0.50161	0.00016
0.50150	0.50140	0.50120	0.50145	0.50150	0.50145	0.50115	0.50115	0.50135	0.00002
0.50165	0.50165	0.50140	0.50135	0.50165	0.50155	0.50150	0.50160	0.50154	0.00015
0.50150	0.50150	0.50135	0.50135	0.50150	0.50140	0.50130	0.50125	0.50139	0.00009
0.50090	0.50080	0.50105	0.50090	0.50095	0.50080	0.50085	0.50090	0.50089	0.00000
0.50155	0.50135	0.50110	0.50105	0.50140	0.50140	0.50120	0.50105	0.50126	0.00007
0.50160	0.50145	0.50150	0.50130	0.50150	0.50150	0.50165	0.50150	0.50150	0.00014
0.50135	0.50135	0.50130	0.50180	0.50125	0.50135	0.50160	0.50160	0.50145	-0.00008
0.50140	0.50140	0.50145	0.50130	0.50165	0.50150	0.50150	0.50145	0.50146	0.00004
0.50185	0.50180	0.50165	0.50150	0.50180	0.50180	0.50175	0.50155	0.50171	0.00006
0.50155	0.50160	0.50160	0.50180	0.50155	0.50155	0.50145	0.50190	0.50163	0.00001
0.50145	0.50125	0.50095	0.50095	0.50145	0.50040	0.50095	0.50095	0.50104	0.00011
0.50100	0.50080	0.50100	0.50170	0.50095	0.50085	0.50115	0.50170	0.50114	-0.00005
0.50125	0.50120	0.50140	0.50170	0.50125	0.50125	0.50145	0.50160	0.50139	-0.00001
0.50145	0.50160	0.50160	0.50190	0.50145	0.50135	0.50155	0.50180	0.50159	-0.00004
0.50120	0.50150	0.50135	0.50160	0.50120	0.50130	0.50145	0.50150	0.50139	0.00007
0.50130	0.50160	0.50150	0.50120	0.50150	0.50150	0.50145	0.50130	0.50142	0.00006
0.50090	0.50115	0.50120	0.50135	0.50110	0.50115	0.50115	0.50140	0.50118	-0.00002
0.50170	0.50155	0.50145	0.50135	0.50175	0.50155	0.50145	0.50140	0.50153	-0.00005
0.50165	0.50150	0.50145	0.50120	0.50165	0.50155	0.50155	0.50135	0.50149	-0.00006
0.50160	0.50130	0.50110	0.50150	0.50165	0.50150	0.50125	0.50130	0.50140	0.00001
0.50175	0.50160	0.50150	0.50110	0.50155	0.50150	0.50140	0.50130	0.50146	0.00005
0.50100	0.50115	0.50120	0.50135	0.50110	0.50110	0.50130	0.50150	0.50121	-0.00010
0.50115	0.50125	0.50135	0.50150	0.50115	0.50120	0.50130	0.50140	0.50129	-0.00007
0.50130	0.50150	0.50155	0.50165	0.50120	0.50130	0.50145	0.50170	0.50146	0.00001
0.50095	0.50100	0.50110	0.50140	0.50105	0.50100	0.50120	0.50145	0.50114	0.00001
0.50135	0.50150	0.50150	0.50180	0.50150	0.50155	0.50155	0.50180	0.50157	0.00002
0.50140	0.50125	0.50130	0.50155	0.50130	0.50135	0.50135	0.50155	0.50138	0.00002
0.50170	0.50145	0.50145	0.50140	0.50180	0.50160	0.50160	0.50135	0.50154	0.00007
0.50130	0.50160	0.50130	0.50130	0.50125	0.50100	0.50115	0.50125	0.50127	0.00003
0.50130	0.50100	0.50100	0.50115	0.50130	0.50095	0.50090	0.50100	0.50108	-0.00007
0.50160	0.50105	0.50120	0.50110	0.50160	0.50110	0.50105	0.50110	0.50123	0.00009
0.50130	0.50095	0.50075	0.50060	0.50110	0.50085	0.50065	0.50060	0.50085	-0.00007
0.50150	0.50135	0.50100	0.50095	0.50135	0.50130	0.50130	0.50095	0.50121	0.00001
0.50135	0.50130	0.50150	0.50150	0.50120	0.50130	0.50145	0.50160	0.50140	0.00003
0.50125	0.50140	0.50140	0.50155	0.50125	0.50140	0.50150	0.50160	0.50142	-0.00006

Appendix 29. Dimensional change (diameter) after thermal excursion for NBG-18 (sheet 1)

Specimen ID Number	Initial Outside Diameter Measurements								
	Allowable: 0.500 - 0.502 in.								Mean Dia, in.
	D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$	
BL6-01	0.50155	0.50145	0.50125	0.50130	0.50155	0.50145	0.50130	0.50130	0.50139
BW1-01	0.50160	0.50155	0.50145	0.50150	0.50155	0.50145	0.50145	0.50145	0.50150
BW1-02	0.50180	0.50175	0.50150	0.50155	0.50180	0.50180	0.50160	0.50145	0.50166
BW1-03	0.50120	0.50130	0.50130	0.50140	0.50115	0.50125	0.50140	0.50155	0.50132
BW2-01	0.50175	0.50170	0.50170	0.50170	0.50175	0.50165	0.50170	0.50165	0.50170
BW2-02	0.50135	0.50155	0.50165	0.50185	0.50150	0.50165	0.50155	0.50190	0.50163
BL6-02	0.50175	0.50155	0.50150	0.50120	0.50175	0.50155	0.50160	0.50120	0.50151
BW2-03	0.50115	0.50120	0.50145	0.50130	0.50120	0.50140	0.50135	0.50130	0.50129
BW3-01	0.50175	0.50155	0.50165	0.50175	0.50175	0.50160	0.50155	0.50175	0.50167
BW3-02	0.50115	0.50120	0.50120	0.50130	0.50115	0.50120	0.50120	0.50130	0.50121
BW3-03	0.50120	0.50150	0.50165	0.50190	0.50120	0.50150	0.50165	0.50190	0.50156
BL6-03	0.50165	0.50160	0.50145	0.50170	0.50175	0.50170	0.50140	0.50170	0.50162
BW5-01	0.50115	0.50145	0.50145	0.50150	0.50115	0.50135	0.50150	0.50135	0.50136
BW5-02	0.50150	0.50145	0.50140	0.50145	0.50145	0.50145	0.50145	0.50145	0.50145
BW5-03	0.50145	0.50135	0.50140	0.50160	0.50140	0.50140	0.50145	0.50160	0.50146
BW7-01	0.50160	0.50145	0.50155	0.50150	0.50155	0.50140	0.50150	0.50145	0.50150
BW7-02	0.50150	0.50150	0.50150	0.50150	0.50150	0.50155	0.50150	0.50160	0.50152
BL7-01	0.50155	0.50145	0.50155	0.50140	0.50175	0.50155	0.50150	0.50160	0.50154
BW7-03	0.50120	0.50120	0.50100	0.50140	0.50120	0.50130	0.50090	0.50135	0.50119
BW8-01	0.50150	0.50145	0.50130	0.50140	0.50145	0.50145	0.50135	0.50135	0.50141
BW8-02	0.50135	0.50155	0.50155	0.50130	0.50135	0.50140	0.50145	0.50125	0.50140
BW8-03	0.50160	0.50125	0.50145	0.50135	0.50165	0.50120	0.50145	0.50125	0.50140
BL7-02	0.50170	0.50170	0.50165	0.50160	0.50165	0.50175	0.50170	0.50160	0.50167
BW9-01	0.50135	0.50155	0.50150	0.50145	0.50130	0.50135	0.50155	0.50155	0.50145
BW9-02	0.50105	0.50115	0.50080	0.50110	0.50110	0.50115	0.50090	0.50110	0.50104
BW9-03	0.50095	0.50100	0.50110	0.50095	0.50100	0.50100	0.50110	0.50095	0.50101
BW10-01	0.50160	0.50150	0.50150	0.50150	0.50160	0.50145	0.50150	0.50150	0.50152
BW10-02	0.50135	0.50100	0.50080	0.50145	0.50135	0.50100	0.50065	0.50140	0.50113
BL7-03	0.50160	0.50145	0.50140	0.50135	0.50160	0.50145	0.50140	0.50135	0.50145
BW10-03	0.50150	0.50130	0.50130	0.50145	0.50140	0.50130	0.50130	0.50145	0.50138
BW11-01	0.50150	0.50160	0.50155	0.50160	0.50150	0.50155	0.50155	0.50160	0.50156
BW11-02	0.50135	0.50150	0.50135	0.50140	0.50100	0.50150	0.50135	0.50140	0.50136
BW11-03	0.50130	0.50120	0.50140	0.50160	0.50130	0.50120	0.50150	0.50155	0.50138
BW12-01	0.50130	0.50130	0.50150	0.50125	0.50135	0.50145	0.50150	0.50130	0.50137
BL8-01	0.50145	0.50180	0.50170	0.50150	0.50145	0.50180	0.50175	0.50150	0.50162
BL8-02	0.50210	0.50230	0.50240	0.50250	0.50220	0.50210	0.50240	0.50250	0.50231
BW12-02	0.50145	0.50140	0.50140	0.50160	0.50140	0.50140	0.50145	0.50160	0.50146
BW12-03	0.50170	0.50165	0.50180	0.50190	0.50165	0.50165	0.50175	0.50195	0.50176

Appendix 29. Dimensional change (diameter) after thermal excursion for NBG-18 (sheet 2)

Final Outside Diameter Measurements									Delta (Final-Init), in.
Allowable: 0.500 - 0.502 in.								Mean Dia, in.	
D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$		
0.50160	0.50145	0.50130	0.50125	0.50160	0.50145	0.50130	0.50125	0.50140	0.00001
0.50160	0.50160	0.50150	0.50130	0.50145	0.50160	0.50150	0.50145	0.50150	0.00000
0.50145	0.50155	0.50175	0.50170	0.50165	0.50165	0.50180	0.50180	0.50167	0.00001
0.50110	0.50125	0.50135	0.50145	0.50115	0.50130	0.50145	0.50135	0.50130	-0.00002
0.50165	0.50165	0.50160	0.50150	0.50170	0.50155	0.50165	0.50160	0.50161	-0.00009
0.50180	0.50175	0.50175	0.50145	0.50175	0.50165	0.50170	0.50140	0.50166	0.00003
0.50160	0.50150	0.50145	0.50110	0.50170	0.50140	0.50140	0.50110	0.50141	-0.00011
0.50120	0.50130	0.50135	0.50125	0.50120	0.50125	0.50140	0.50125	0.50128	-0.00002
0.50180	0.50170	0.50160	0.50155	0.50170	0.50165	0.50160	0.50155	0.50164	-0.00002
0.50110	0.50115	0.50120	0.50125	0.50105	0.50110	0.50115	0.50130	0.50116	-0.00005
0.50135	0.50165	0.50160	0.50180	0.50130	0.50170	0.50165	0.50190	0.50162	0.00006
0.50160	0.50155	0.50155	0.50160	0.50160	0.50155	0.50150	0.50165	0.50158	-0.00004
0.50150	0.50160	0.50155	0.50120	0.50155	0.50160	0.50165	0.50120	0.50148	0.00012
0.50175	0.50160	0.50160	0.50150	0.50160	0.50155	0.50145	0.50145	0.50156	0.00011
0.50155	0.50150	0.50160	0.50145	0.50155	0.50155	0.50150	0.50145	0.50152	0.00006
0.50155	0.50145	0.50150	0.50145	0.50155	0.50150	0.50150	0.50145	0.50149	-0.00001
0.50150	0.50150	0.50160	0.50160	0.50155	0.50150	0.50155	0.50160	0.50155	0.00003
0.50170	0.50150	0.50150	0.50160	0.50170	0.50165	0.50155	0.50165	0.50161	0.00006
0.50125	0.50135	0.50105	0.50175	0.50120	0.50115	0.50105	0.50155	0.50129	0.00010
0.50165	0.50150	0.50140	0.50145	0.50155	0.50140	0.50140	0.50150	0.50148	0.00008
0.50140	0.50155	0.50145	0.50125	0.50140	0.50160	0.50150	0.50130	0.50143	0.00003
0.50150	0.50115	0.50135	0.50115	0.50135	0.50120	0.50125	0.50120	0.50127	-0.00013
0.50135	0.50165	0.50160	0.50150	0.50150	0.50140	0.50160	0.50135	0.50149	-0.00018
0.50150	0.50165	0.50115	0.50130	0.50155	0.50160	0.50105	0.50125	0.50138	-0.00007
0.50100	0.50085	0.50115	0.50110	0.50120	0.50080	0.50120	0.50110	0.50105	0.00001
0.50100	0.50100	0.50120	0.50090	0.50090	0.50105	0.50105	0.50100	0.50101	0.00001
0.50165	0.50160	0.50160	0.50165	0.50160	0.50155	0.50150	0.50165	0.50160	0.00008
0.50145	0.50070	0.50105	0.50140	0.50145	0.50060	0.50105	0.50140	0.50114	0.00001
0.50140	0.50155	0.50155	0.50160	0.50135	0.50150	0.50155	0.50160	0.50151	0.00006
0.50145	0.50115	0.50135	0.50155	0.50130	0.50110	0.50135	0.50150	0.50134	-0.00003
0.50155	0.50165	0.50150	0.50155	0.50150	0.50160	0.50150	0.50165	0.50156	0.00001
0.50140	0.50155	0.50175	0.50130	0.50140	0.50145	0.50180	0.50130	0.50149	0.00014
0.50140	0.50150	0.50165	0.50165	0.50125	0.50130	0.50160	0.50170	0.50151	0.00013
0.50145	0.50170	0.50165	0.50140	0.50150	0.50160	0.50160	0.50150	0.50155	0.00018
0.50150	0.50205	0.50180	0.50160	0.50165	0.50190	0.50170	0.50155	0.50172	0.00010
0.50230	0.50205	0.50260	0.50275	0.50230	0.50240	0.50245	0.50255	0.50243	0.00011
0.50150	0.50155	0.50165	0.50165	0.50155	0.50150	0.50165	0.50160	0.50158	0.00012
0.50190	0.50165	0.50180	0.50175	0.50200	0.50180	0.50185	0.50170	0.50181	0.00005

Appendix 30. Dimensional change (diameter) after thermal excursion for H-451 (sheet 1)

Specimen ID Number	Initial Outside Diameter Measurements								
	Allowable: 0.500 - 0.502 in.								Mean Dia, in.
	D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$	
CW7-01	0.50120	0.50125	0.50120	0.50135	0.50105	0.50100	0.50125	0.50125	0.50119
CW7-03	0.50160	0.50150	0.50140	0.50140	0.50160	0.50145	0.50140	0.50135	0.50146
CW8-02	0.50180	0.50160	0.50150	0.50155	0.50180	0.50160	0.50150	0.50145	0.50160
CW8-03	0.50170	0.50155	0.50140	0.50120	0.50175	0.50150	0.50135	0.50135	0.50148
CW9-01	0.50155	0.50115	0.50130	0.50125	0.50155	0.50130	0.50115	0.50130	0.50132
CW9-02	0.50165	0.50145	0.50140	0.50120	0.50165	0.50135	0.50130	0.50120	0.50140
CW9-03	0.50130	0.50130	0.50160	0.50140	0.50145	0.50130	0.50150	0.50145	0.50141
CW10-01	0.50120	0.50115	0.50120	0.50140	0.50115	0.50115	0.50125	0.50130	0.50123
CW10-02	0.50140	0.50130	0.50145	0.50145	0.50125	0.50135	0.50135	0.50160	0.50139
CW10-03	0.50120	0.50145	0.50120	0.50115	0.50115	0.50140	0.50120	0.50120	0.50124
CW11-01	0.50155	0.50150	0.50145	0.50130	0.50155	0.50135	0.50130	0.50130	0.50141
CW11-02	0.50175	0.50160	0.50160	0.50175	0.50165	0.50165	0.50170	0.50175	0.50168
CW11-03	0.50150	0.50150	0.50155	0.50170	0.50155	0.50155	0.50160	0.50175	0.50159
CW12-01	0.50150	0.50150	0.50150	0.50160	0.50160	0.50150	0.50150	0.50160	0.50154
CW12-02	0.50125	0.50115	0.50115	0.50110	0.50130	0.50115	0.50105	0.50100	0.50114
CW13-01	0.50135	0.50090	0.50120	0.50130	0.50120	0.50095	0.50115	0.50120	0.50116
CW13-02	0.50155	0.50150	0.50135	0.50150	0.50170	0.50155	0.50145	0.50155	0.50152
CW13-03	0.50135	0.50135	0.50130	0.50120	0.50150	0.50140	0.50120	0.50120	0.50131
CW14-01	0.50170	0.50165	0.50155	0.50175	0.50160	0.50160	0.50170	0.50190	0.50168
CW14-02	0.50155	0.50160	0.50150	0.50165	0.50155	0.50145	0.50145	0.50165	0.50155
CW15-01	0.50170	0.50150	0.50160	0.50180	0.50155	0.50155	0.50160	0.50155	0.50161
CW15-02	0.50145	0.50135	0.50140	0.50150	0.50150	0.50120	0.50140	0.50155	0.50142

Appendix 30. Dimensional change (diameter) after thermal excursion for H-451 (sheet 2)

Final Outside Diameter Measurements									Delta (Final-Init), in.
Allowable: 0.500 - 0.502 in.								Mean Dia, in.	
D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$		
0.50050	0.50035	0.50035	0.50045	0.50070	0.50065	0.50065	0.50050	0.50052	-0.00067
0.50070	0.50100	0.50080	0.50070	0.50075	0.50105	0.50090	0.50100	0.50086	-0.00060
0.50075	0.50100	0.50085	0.50045	0.50060	0.50095	0.50070	0.50085	0.50077	-0.00083
0.50080	0.50100	0.50090	0.50090	0.50110	0.50110	0.50095	0.50080	0.50094	-0.00053
0.50000	0.50065	0.50090	0.50105	0.50070	0.50080	0.50080	0.50085	0.50072	-0.00060
0.49890	0.50045	0.50085	0.50090	0.50030	0.50080	0.50090	0.50110	0.50053	-0.00087
0.50080	0.50125	0.50085	0.50100	0.50065	0.50120	0.50100	0.50080	0.50094	-0.00047
0.50000	0.50020	0.50045	0.49995	0.50090	0.50075	0.50060	0.50025	0.50039	-0.00084
0.50050	0.50080	0.50095	0.50080	0.50085	0.50090	0.50095	0.50040	0.50077	-0.00062
0.50100	0.50095	0.50060	0.50050	0.50100	0.50095	0.50090	0.50040	0.50079	-0.00046
0.50065	0.50075	0.50080	0.50085	0.50085	0.50060	0.50060	0.50035	0.50068	-0.00073
0.50105	0.50130	0.50130	0.50115	0.50135	0.50120	0.50115	0.50095	0.50118	-0.00050
0.50100	0.50105	0.50105	0.50090	0.50105	0.50090	0.50080	0.50070	0.50093	-0.00066
0.50085	0.50100	0.50100	0.50090	0.50100	0.50090	0.50095	0.50055	0.50089	-0.00064
0.50010	0.50050	0.50060	0.50060	0.49980	0.50020	0.50030	0.50030	0.50030	-0.00084
0.50105	0.50100	0.50050	0.50090	0.50090	0.50090	0.50040	0.50070	0.50079	-0.00036
0.50070	0.50100	0.50110	0.50110	0.50080	0.50115	0.50105	0.50105	0.50099	-0.00052
0.50085	0.50085	0.50065	0.50060	0.50080	0.50060	0.50055	0.50015	0.50063	-0.00068
0.50065	0.50090	0.50100	0.50115	0.50115	0.50125	0.50130	0.50140	0.50110	-0.00058
0.50120	0.50105	0.50085	0.50050	0.50100	0.50100	0.50095	0.50090	0.50093	-0.00062
0.50100	0.50115	0.50120	0.50125	0.50100	0.50095	0.50115	0.50090	0.50108	-0.00053
0.50045	0.50085	0.50110	0.50070	0.50095	0.50090	0.50090	0.50050	0.50079	-0.00062

Appendix 31. Dimensional change (diameter) after thermal excursion for PCEA (sheet 1)

Specimen ID Number	Initial Outside Diameter Measurements								
	Allowable: 0.500 - 0.502 in.								Mean Dia, in.
	D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$	
DW1-01	0.50150	0.50125	0.50110	0.50095	0.50140	0.50120	0.50095	0.50085	0.50115
DW1-02	0.50085	0.50085	0.50120	0.50140	0.50080	0.50100	0.50130	0.50145	0.50111
DW1-03	0.50090	0.50100	0.50120	0.50150	0.50090	0.50090	0.50110	0.50145	0.50112
DW2-01	0.50075	0.50090	0.50100	0.50145	0.50080	0.50095	0.50120	0.50145	0.50106
DW2-02	0.50085	0.50090	0.50110	0.50135	0.50085	0.50095	0.50115	0.50145	0.50108
DW2-03	0.50085	0.50095	0.50120	0.50130	0.50075	0.50085	0.50110	0.50145	0.50106
DW3-01	0.50140	0.50115	0.50100	0.50080	0.50165	0.50120	0.50110	0.50095	0.50116
DW3-02	0.50095	0.50105	0.50125	0.50145	0.50085	0.50095	0.50115	0.50135	0.50113
DW3-03	0.50075	0.50090	0.50105	0.50145	0.50080	0.50095	0.50120	0.50135	0.50106
DW4-01	0.50145	0.50125	0.50110	0.50090	0.50145	0.50120	0.50105	0.50085	0.50116
DW4-03	0.50060	0.50070	0.50090	0.50120	0.50080	0.50090	0.50100	0.50120	0.50091
DW5-01	0.50145	0.50110	0.50095	0.50080	0.50140	0.50065	0.50085	0.50070	0.50099
DA601	0.50090	0.50090	0.50095	0.50120	0.50090	0.50095	0.50100	0.50125	0.50101
DW5-02	0.50080	0.50090	0.50120	0.50150	0.50070	0.50085	0.50100	0.50135	0.50104
DW5-03	0.50070	0.50085	0.50110	0.50130	0.50095	0.50100	0.50110	0.50135	0.50104
DW6-01	0.50140	0.50110	0.50090	0.50080	0.50160	0.50130	0.50090	0.50090	0.50111
DA602	0.50115	0.50095	0.50095	0.50095	0.50115	0.50115	0.50110	0.50100	0.50105
DA701	0.50125	0.50110	0.50105	0.50095	0.50130	0.50115	0.50110	0.50105	0.50112
DW6-02	0.50080	0.50095	0.50125	0.50160	0.50085	0.50095	0.50115	0.50150	0.50113
DW6-03	0.50140	0.50135	0.50115	0.50100	0.50170	0.50140	0.50115	0.50105	0.50128
DW7-01	0.50075	0.50100	0.50115	0.50125	0.50100	0.50100	0.50130	0.50150	0.50112
DW7-02	0.50145	0.50120	0.50105	0.50080	0.50135	0.50120	0.50100	0.50085	0.50111
DW7-03	0.50100	0.50105	0.50120	0.50155	0.50090	0.50085	0.50120	0.50145	0.50115
DW8-01	0.50090	0.50085	0.50115	0.50160	0.50095	0.50105	0.50135	0.50155	0.50118
DA702	0.50130	0.50140	0.50160	0.50185	0.50125	0.50140	0.50160	0.50190	0.50154
DW8-02	0.50155	0.50130	0.50110	0.50095	0.50165	0.50140	0.50110	0.50105	0.50126
DW8-03	0.50160	0.50135	0.50115	0.50090	0.50170	0.50145	0.50125	0.50105	0.50131
DW9-01	0.50165	0.50130	0.50115	0.50100	0.50175	0.50135	0.50130	0.50105	0.50132
DW9-02	0.50145	0.50130	0.50110	0.50105	0.50150	0.50135	0.50100	0.50100	0.50122
DW9-03	0.50110	0.50090	0.50090	0.50075	0.50115	0.50100	0.50095	0.50100	0.50097
DW10-01	0.50055	0.50055	0.50060	0.50060	0.50065	0.50055	0.50065	0.50085	0.50063
DA801	0.50075	0.50065	0.50065	0.50075	0.50070	0.50080	0.50070	0.50080	0.50073
DW10-02	0.50065	0.50065	0.50060	0.50065	0.50080	0.50060	0.50045	0.50060	0.50063
DW10-03	0.50050	0.50065	0.50065	0.50065	0.50060	0.50050	0.50060	0.50075	0.50061
DW11-01	0.50060	0.50045	0.50055	0.50070	0.50085	0.50065	0.50040	0.50055	0.50059
DW11-02	0.50070	0.50060	0.50075	0.50080	0.50065	0.50065	0.50065	0.50080	0.50070
DA802	0.50100	0.50100	0.50120	0.50140	0.50115	0.50100	0.50120	0.50130	0.50116
DA901	0.50115	0.50110	0.50120	0.50145	0.50110	0.50105	0.50115	0.50130	0.50119

Appendix 31. Dimensional change (diameter) after thermal excursion for PCEA (sheet 2)

Final Outside Diameter Measurements									Delta (Final-Init), in.
Allowable: 0.500 - 0.502 in.								Mean Dia, in.	
D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$		
0.50075	0.50090	0.50115	0.50145	0.50075	0.50090	0.50110	0.50130	0.50104	-0.00011
0.50075	0.50100	0.50115	0.50140	0.50075	0.50090	0.50120	0.50135	0.50106	-0.00004
0.50060	0.50095	0.50120	0.50140	0.50075	0.50110	0.50110	0.50155	0.50108	-0.00004
0.50075	0.50085	0.50105	0.50130	0.50075	0.50090	0.50115	0.50145	0.50103	-0.00004
0.50090	0.50100	0.50105	0.50140	0.50070	0.50090	0.50120	0.50150	0.50108	0.00001
0.50145	0.50110	0.50105	0.50095	0.50145	0.50100	0.50085	0.50075	0.50108	0.00002
0.50075	0.50085	0.50120	0.50140	0.50065	0.50085	0.50105	0.50120	0.50099	-0.00016
0.50155	0.50120	0.50090	0.50070	0.50165	0.50125	0.50095	0.50085	0.50113	0.00001
0.50065	0.50090	0.50110	0.50150	0.50075	0.50085	0.50115	0.50150	0.50105	-0.00001
0.50075	0.50085	0.50120	0.50155	0.50075	0.50075	0.50100	0.50140	0.50103	-0.00012
0.50070	0.50075	0.50100	0.50130	0.50060	0.50070	0.50080	0.50120	0.50088	-0.00003
0.50050	0.50080	0.50090	0.50135	0.50080	0.50085	0.50110	0.50140	0.50096	-0.00002
0.50085	0.50105	0.50115	0.50135	0.50100	0.50105	0.50120	0.50135	0.50113	0.00012
0.50070	0.50090	0.50090	0.50145	0.50090	0.50100	0.50115	0.50150	0.50106	0.00002
0.50085	0.50095	0.50120	0.50175	0.50085	0.50100	0.50115	0.50170	0.50118	0.00014
0.50080	0.50085	0.50110	0.50155	0.50095	0.50100	0.50135	0.50170	0.50116	0.00005
0.50125	0.50105	0.50105	0.50105	0.50140	0.50115	0.50110	0.50110	0.50114	0.00009
0.50100	0.50100	0.50110	0.50130	0.50110	0.50110	0.50120	0.50130	0.50114	0.00002
0.50160	0.50135	0.50105	0.50090	0.50170	0.50140	0.50110	0.50095	0.50126	0.00013
0.50180	0.50160	0.50130	0.50100	0.50180	0.50160	0.50130	0.50100	0.50143	0.00015
0.50090	0.50110	0.50130	0.50165	0.50095	0.50095	0.50135	0.50165	0.50123	0.00011
0.50095	0.50110	0.50125	0.50150	0.50095	0.50095	0.50120	0.50160	0.50119	0.00008
0.50090	0.50110	0.50125	0.50155	0.50095	0.50105	0.50125	0.50170	0.50122	0.00007
0.50085	0.50110	0.50130	0.50170	0.50095	0.50115	0.50130	0.50165	0.50125	0.00007
0.50200	0.50170	0.50135	0.50120	0.50200	0.50180	0.50140	0.50125	0.50159	0.00005
0.50085	0.50100	0.50135	0.50175	0.50100	0.50110	0.50140	0.50185	0.50129	0.00002
0.50165	0.50135	0.50100	0.50105	0.50165	0.50140	0.50125	0.50105	0.50130	-0.00001
0.50110	0.50120	0.50135	0.50180	0.50110	0.50120	0.50135	0.50170	0.50135	0.00003
0.50090	0.50105	0.50135	0.50160	0.50110	0.50115	0.50125	0.50160	0.50125	0.00003
0.50100	0.50100	0.50095	0.50110	0.50100	0.50090	0.50100	0.50110	0.50101	0.00004
0.50070	0.50065	0.50065	0.50095	0.50060	0.50065	0.50060	0.50085	0.50071	0.00008
0.50075	0.50065	0.50075	0.50090	0.50075	0.50070	0.50085	0.50095	0.50079	0.00006
0.50065	0.50060	0.50070	0.50090	0.50065	0.50055	0.50065	0.50080	0.50069	0.00006
0.50055	0.50055	0.50065	0.50075	0.50065	0.50065	0.50055	0.50085	0.50065	0.00004
0.50095	0.50060	0.50065	0.50060	0.50095	0.50065	0.50065	0.50065	0.50071	0.00012
0.50100	0.50085	0.50070	0.50075	0.50090	0.50085	0.50070	0.50075	0.50081	0.00011
0.50145	0.50130	0.50105	0.50115	0.50145	0.50120	0.50110	0.50115	0.50123	0.00008
0.50120	0.50120	0.50120	0.50150	0.50115	0.50115	0.50120	0.50150	0.50126	0.00007

Appendix 32. Dimensional change (diameter) after thermal excursion for IG-110 (sheet 1)

Specimen ID Number	Initial Outside Diameter Measurements								
	Allowable: 0.500 - 0.502 in.								Mean Dia, in.
	D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$	
EW2-01	0.50140	0.50135	0.50130	0.50135	0.50140	0.50125	0.50125	0.50135	0.50133
EW2-02	0.50150	0.50140	0.50140	0.50155	0.50145	0.50135	0.50130	0.50145	0.50143
EW2-03	0.50135	0.50130	0.50130	0.50140	0.50135	0.50125	0.50125	0.50130	0.50131
EW4-01	0.50115	0.50105	0.50110	0.50125	0.50110	0.50105	0.50105	0.50125	0.50113
EW4-02	0.50135	0.50120	0.50115	0.50115	0.50130	0.50115	0.50110	0.50110	0.50119
EW5-01	0.50115	0.50110	0.50115	0.50120	0.50115	0.50115	0.50120	0.50115	0.50116
EW5-02	0.50100	0.50085	0.50105	0.50110	0.50095	0.50060	0.50085	0.50110	0.50094
EW5-03	0.50105	0.50105	0.50100	0.50110	0.50105	0.50090	0.50095	0.50110	0.50103
EW6-01	0.50070	0.50065	0.50070	0.50095	0.50080	0.50060	0.50075	0.50090	0.50076
EW6-02	0.50080	0.50090	0.50095	0.50105	0.50075	0.50090	0.50090	0.50095	0.50090
EW6-03	0.50090	0.50090	0.50090	0.50085	0.50095	0.50100	0.50100	0.50095	0.50093
EW7-01	0.50100	0.50105	0.50100	0.50090	0.50100	0.50110	0.50100	0.50095	0.50100
EW7-03	0.50060	0.50060	0.50075	0.50075	0.50055	0.50065	0.50070	0.50090	0.50069
EW8-01	0.50060	0.50065	0.50065	0.50085	0.50065	0.50060	0.50065	0.50080	0.50068
EW8-02	0.50090	0.50080	0.50070	0.50070	0.50090	0.50075	0.50070	0.50070	0.50077
EW8-03	0.50055	0.50065	0.50065	0.50090	0.50055	0.50055	0.50060	0.50080	0.50066
EW9-01	0.50050	0.50050	0.50035	0.50085	0.50065	0.50065	0.50065	0.50085	0.50063
EW9-02	0.50065	0.50060	0.50065	0.50085	0.50060	0.50060	0.50065	0.50080	0.50068
EW9-03	0.50055	0.50065	0.50070	0.50080	0.50055	0.50065	0.50060	0.50075	0.50066
EW10-01	0.50065	0.50065	0.50070	0.50085	0.50065	0.50075	0.50075	0.50090	0.50074
EW10-02	0.50050	0.50060	0.50060	0.50085	0.50075	0.50075	0.50085	0.50085	0.50072
EW10-03	0.50085	0.50085	0.50080	0.50075	0.50080	0.50055	0.50045	0.50060	0.50071

Appendix 32. Dimensional change (diameter) after thermal excursion for IG-110 (sheet 2)

Final Outside Diameter Measurements									Delta (Final-Init), in.
Allowable: 0.500 - 0.502 in.								Mean Dia, in.	
D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$		
0.50100	0.50105	0.50120	0.50100	0.50085	0.50100	0.50110	0.50065	0.50098	-0.00035
0.50070	0.50100	0.50120	0.50095	0.50080	0.50090	0.50105	0.50120	0.50098	-0.00045
0.50120	0.50105	0.50100	0.50065	0.50100	0.50105	0.50095	0.50080	0.50096	-0.00035
0.49980	0.50040	0.50070	0.50085	0.50030	0.50045	0.50025	0.50060	0.50042	-0.00071
0.50095	0.50080	0.50070	0.50000	0.50090	0.50085	0.50060	0.50055	0.50067	-0.00052
0.50050	0.50065	0.50080	0.50040	0.50060	0.50080	0.50085	0.50080	0.50068	-0.00048
0.50070	0.50050	0.50040	0.50065	0.50005	0.50035	0.50050	0.49995	0.50039	-0.00055
0.50025	0.50005	0.50025	0.50010	0.50080	0.50070	0.50070	0.50050	0.50042	-0.00061
0.50025	0.50025	0.50025	0.50030	0.50010	0.50045	0.50035	0.50040	0.50029	-0.00046
0.50060	0.50075	0.50070	0.50040	0.50070	0.50055	0.50060	0.50050	0.50060	-0.00030
0.50005	0.50040	0.50045	0.50035	0.50025	0.50040	0.50050	0.50050	0.50036	-0.00057
0.50060	0.50060	0.50060	0.50005	0.50005	0.50070	0.50080	0.50035	0.50047	-0.00053
0.50040	0.50040	0.50015	0.49935	0.50005	0.49990	0.49990	0.49875	0.49986	-0.00082
0.49950	0.50010	0.49990	0.50030	0.50005	0.50020	0.50020	0.50025	0.50006	-0.00062
0.50050	0.50040	0.50030	0.50015	0.50040	0.50030	0.50030	0.49995	0.50029	-0.00048
0.49980	0.49980	0.50005	0.50035	0.49865	0.50000	0.50010	0.50040	0.49989	-0.00076
0.49625	0.50020	0.50010	0.50035	0.50035	0.50035	0.50010	0.50000	0.49971	-0.00091
0.50040	0.50055	0.50020	0.50015	0.50045	0.50050	0.50040	0.50010	0.50034	-0.00033
0.49915	0.50000	0.49990	0.50000	0.49995	0.50020	0.50035	0.50040	0.49999	-0.00066
0.49965	0.49985	0.49970	0.49915	0.49985	0.50010	0.50045	0.50050	0.49991	-0.00083
0.50010	0.50020	0.50010	0.49955	0.50000	0.50020	0.50045	0.50005	0.50008	-0.00064
0.50050	0.50010	0.49995	0.49995	0.49965	0.50005	0.49990	0.50015	0.50003	-0.00068

Appendix 33. Dimensional change (diameter) after thermal excursion for IG-430 (sheet 1)

Specimen ID Number	Initial Outside Diameter Measurements								Mean Dia, in.
	Allowable: 0.500 - 0.502 in.								
	D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$	
FW1-01	0.50105	0.50090	0.50095	0.50100	0.50090	0.50085	0.50095	0.50090	0.50094
FW1-02	0.50090	0.50090	0.50085	0.50085	0.50095	0.50085	0.50090	0.50095	0.50089
FW1-03	0.50095	0.50095	0.50090	0.50095	0.50100	0.50100	0.50095	0.50100	0.50096
FW2-01	0.50065	0.50045	0.50045	0.50055	0.50065	0.50060	0.50055	0.50065	0.50057
FW2-02	0.50065	0.50060	0.50060	0.50065	0.50075	0.50065	0.50065	0.50070	0.50066
FW2-03	0.50065	0.50070	0.50080	0.50080	0.50060	0.50045	0.50060	0.50065	0.50066
FW3-01	0.50075	0.50080	0.50080	0.50080	0.50075	0.50070	0.50070	0.50075	0.50076
FW3-02	0.50085	0.50085	0.50075	0.50085	0.50080	0.50080	0.50075	0.50075	0.50080
FW3-03	0.50085	0.50080	0.50075	0.50075	0.50080	0.50090	0.50080	0.50085	0.50081
FW4-01	0.50100	0.50085	0.50080	0.50085	0.50100	0.50080	0.50085	0.50085	0.50088
FW4-02	0.50105	0.50090	0.50090	0.50090	0.50090	0.50085	0.50090	0.50085	0.50091
FW4-03	0.50095	0.50090	0.50095	0.50110	0.50100	0.50095	0.50095	0.50110	0.50099
FW5-01	0.50115	0.50100	0.50100	0.50100	0.50130	0.50120	0.50110	0.50110	0.50111
FW5-02	0.50120	0.50105	0.50100	0.50110	0.50130	0.50125	0.50105	0.50120	0.50114
FW5-03	0.50120	0.50110	0.50110	0.50105	0.50130	0.50115	0.50115	0.50105	0.50114
FW7-01	0.50160	0.50150	0.50135	0.50140	0.50145	0.50145	0.50130	0.50130	0.50142
FW7-02	0.50135	0.50120	0.50140	0.50150	0.50130	0.50130	0.50135	0.50150	0.50136
FW7-03	0.50130	0.50125	0.50120	0.50135	0.50140	0.50140	0.50140	0.50150	0.50135
FW8-01	0.50040	0.50040	0.50065	0.50080	0.50040	0.50040	0.50050	0.50065	0.50053
FW8-02	0.50040	0.50035	0.50040	0.50055	0.50045	0.50040	0.50050	0.50065	0.50046
FW8-03	0.50060	0.50070	0.50040	0.50050	0.50065	0.50065	0.50050	0.50050	0.50056
FW9-01	0.50055	0.50050	0.50060	0.50085	0.50065	0.50065	0.50075	0.50090	0.50068
FW9-02	0.50060	0.50050	0.50040	0.50100	0.50055	0.50035	0.50040	0.50085	0.50058
FW9-03	0.50065	0.50070	0.50070	0.50075	0.50055	0.50050	0.50050	0.50055	0.50061
FW10-01	0.50085	0.50080	0.50075	0.50095	0.50070	0.50070	0.50060	0.50080	0.50077
FW10-02	0.50085	0.50090	0.50070	0.50070	0.50080	0.50090	0.50080	0.50080	0.50081
FW10-03	0.50090	0.50080	0.50065	0.50085	0.50080	0.50065	0.50070	0.50080	0.50077
FW11-01	0.50090	0.50075	0.50075	0.50090	0.50090	0.50070	0.50070	0.50090	0.50081
FW11-02	0.50090	0.50095	0.50075	0.50095	0.50100	0.50090	0.50080	0.50095	0.50090
FW11-03	0.50095	0.50075	0.50075	0.50090	0.50110	0.50085	0.50070	0.50100	0.50088
FW12-01	0.50085	0.50090	0.50090	0.50085	0.50100	0.50090	0.50100	0.50090	0.50091
FW12-02	0.50100	0.50085	0.50095	0.50085	0.50090	0.50090	0.50100	0.50085	0.50091
FW13-01	0.50110	0.50120	0.50095	0.50110	0.50105	0.50100	0.50090	0.50095	0.50103
FW13-02	0.50100	0.50095	0.50100	0.50105	0.50090	0.50105	0.50085	0.50085	0.50096

Appendix 33. Dimensional change (diameter) after thermal excursion for IG-430 (sheet 2)

Final Outside Diameter Measurements									Delta (Final-Init), in.
Allowable: 0.500 - 0.502 in.								Mean Dia, in.	
D1	D2	D3	D4	$D1^{90}$	$D2^{90}$	$D3^{90}$	$D4^{90}$		
0.50040	0.50065	0.50045	0.49970	0.50040	0.50020	0.50020	0.50005	0.50026	-0.00068
0.50050	0.50050	0.50040	0.50055	0.50055	0.50045	0.50050	0.50010	0.50044	-0.00045
0.50065	0.50055	0.50060	0.50060	0.50065	0.50060	0.50060	0.50050	0.50059	-0.00037
0.50025	0.50010	0.49990	0.49990	0.49980	0.49980	0.50020	0.50025	0.50003	-0.00054
0.50020	0.50035	0.50045	0.50040	0.49975	0.49980	0.50005	0.49985	0.50011	-0.00055
0.50030	0.50020	0.50035	0.50045	0.49995	0.50020	0.50010	0.49995	0.50019	-0.00047
0.49995	0.49980	0.49980	0.50000	0.50010	0.50010	0.50010	0.49985	0.49996	-0.00079
0.50050	0.50055	0.50015	0.50000	0.50065	0.50060	0.50060	0.49835	0.50018	-0.00062
0.50065	0.50050	0.50060	0.50025	0.50050	0.50055	0.50055	0.50025	0.50048	-0.00033
0.50070	0.50050	0.50055	0.50040	0.50050	0.50040	0.50050	0.50035	0.50049	-0.00039
0.50065	0.49995	0.49995	0.50040	0.50050	0.50055	0.50060	0.50045	0.50038	-0.00053
0.50065	0.50065	0.50065	0.50035	0.50025	0.50050	0.50070	0.50070	0.50056	-0.00043
0.50070	0.50080	0.50045	0.50065	0.50090	0.50075	0.50055	0.50050	0.50066	-0.00044
0.50110	0.50105	0.50100	0.50110	0.50120	0.50125	0.50105	0.50115	0.50111	-0.00003
0.50110	0.50110	0.50150	0.50130	0.50120	0.50115	0.50115	0.50135	0.50123	0.00009
0.50150	0.50130	0.50150	0.50150	0.50150	0.50125	0.50150	0.50140	0.50143	0.00001
0.50135	0.50135	0.50140	0.50150	0.50130	0.50125	0.50130	0.50145	0.50136	0.00000
0.50140	0.50130	0.50140	0.50135	0.50150	0.50135	0.50140	0.50140	0.50139	0.00004
0.50035	0.50030	0.50050	0.50070	0.50040	0.50040	0.50055	0.50065	0.50048	-0.00004
0.50035	0.50030	0.50040	0.50065	0.50050	0.50050	0.50050	0.50080	0.50050	0.00004
0.50040	0.50060	0.50060	0.50060	0.50050	0.50050	0.50050	0.50050	0.50053	-0.00004
0.50075	0.50070	0.50065	0.50065	0.50090	0.50070	0.50070	0.50070	0.50072	0.00004
0.50100	0.50065	0.50065	0.50070	0.50095	0.50060	0.50060	0.50050	0.50071	0.00013
0.50065	0.50055	0.50045	0.50070	0.50070	0.50070	0.50060	0.50075	0.50064	0.00003
0.50090	0.50090	0.50090	0.50090	0.50085	0.50075	0.50070	0.50085	0.50084	0.00007
0.50085	0.50090	0.50095	0.50090	0.50090	0.50100	0.50085	0.50080	0.50089	0.00009
0.50080	0.50075	0.50075	0.50085	0.50090	0.50090	0.50085	0.50095	0.50084	0.00008
0.50095	0.50070	0.50080	0.50085	0.50100	0.50080	0.50095	0.50095	0.50088	0.00006
0.50105	0.50090	0.50085	0.50090	0.50115	0.50100	0.50075	0.50115	0.50097	0.00007
0.50115	0.50085	0.50095	0.50115	0.50100	0.50075	0.50080	0.50100	0.50096	0.00008
0.50115	0.50110	0.50105	0.50100	0.50115	0.50100	0.50100	0.50095	0.50105	0.00014
0.50085	0.50105	0.50100	0.50100	0.50095	0.50100	0.50095	0.50105	0.50098	0.00007
0.50120	0.50110	0.50120	0.50120	0.50100	0.50095	0.50100	0.50105	0.50109	0.00006
0.50120	0.50120	0.50095	0.50105	0.50125	0.50110	0.50110	0.50110	0.50112	0.00016

Appendix 34. NBG-17 fundamental frequency and flexural dynamic Young's modulus data (sheet 1)

Modulus by Resonant Frequency

Specimen ID Number				AW1-01	AW1-02	AW1-03	AL6-01	AW2-01	AW2-02	AW2-03	AL6-02
Sample location				**1S3**	**1S11**	**1S12**	**1S13**	**1U3**	**1U11**	**1U12**	**2S4**
Specimen Mass of bar	m	[g]		5.8614	5.9043	5.9168	5.9342	5.9366	5.9269	5.9217	5.9218
length of bar	L	[mm]		25.37936	25.37333	25.37079	25.36889	25.37619	25.37714	25.37841	25.37143
diameter of bar	D	[mm]		12.73127	12.73969	12.74080	12.73429	12.73921	12.73540	12.72270	12.73207
Poisson's ratio	m			0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
average resonant frequency	f_{avg}	[Hz]		29655	29779	29749	30515	29880	29894	30001	30569
frequency data	f_i		1	29662	29777	29800	30549	29420	29927	29975	30573
(specimen ID number			2	29650	29783	29807	30520	29918	29956	30017	30572
oriented up in fixture)			3	29662	29669	29800	30519	29934	29924	30030	30578
			4	29670	29780	29793	30522	29922	29598	30030	30568
			5	29666	29786	29539	30517	29924	29924	30023	30571
			6	29658	29771	29794	30507	29920	29934	29971	30566
			7	29647	29828	29795	30515	29984	29915	29984	30566
			8	29654	29776	29794	30504	29933	29920	29990	30560
			9	29648	29815	29575	30500	29925	29923	29995	30567
			10	29634	29804	29794	30498	29921	29917	29990	30565
correction factor for rod		$T_{1'}$		2.11268	2.114512	2.114895	2.114005	2.114206	2.113519	2.111384	2.113445
flexural dynamic Young's modulus **		E		1.09E+10	1.10E+10	1.10E+10	1.17E+10	1.12E+10	1.12E+10	1.13E+10	1.17E+10
$T_{1'}$ correction factor				2.28643	2.288743	2.289226	2.288103	2.288357	2.28749	2.284795	2.287396
calculation of individual				0.030921	0.031032	0.031055	0.031001	0.031014	0.030972	0.030842	0.030967
terms				0.324996	0.326166	0.326411	0.325842	0.32597	0.325532	0.32417	0.325484
				2.275419	2.277713	2.278192	2.277078	2.27733	2.27647	2.273798	2.276377
resultant $T_{1'}$		$T_{1'}$		2.11268	2.114512	2.114895	2.114005	2.114206	2.113519	2.111384	2.113445
flexural dynamic Young's modulus *	E	[Pa]		1.09E+10	1.10E+10	1.10E+10	1.17E+10	1.12E+10	1.12E+10	1.13E+10	1.17E+10

Average Modulus for specimen group	1.13E+10
Standard deviation	1.93E+08

Appendix 34. NBG-17 fundamental frequency and flexural dynamic Young's modulus data (sheet 2)

AW4-01	AL6-03	AW4-02	AW4-03	AW5-01	AL8-01	AW5-02	AW5-03	AW6-01	AW6-02	AL8-02	AW6-03	AW7-01
2S6	**2S10**	**2U4**	**2U6**	**2U10**	**3S8**	**3S13**	**3U8**	**3U12**	**4S8**	**4S11**	**4S12**	**4U8**
5.9331	5.9401	5.9364	5.9319	5.9411	5.9178	5.9287	5.9198	5.9383	5.9258	5.9359	5.9126	5.9322
25.37651	25.36063	25.37587	25.38825	25.37682	25.35873	25.37492	25.37555	25.37841	25.37746	25.38095	25.38317	25.37460
12.73810	12.73683	12.73699	12.74350	12.74128	12.72651	12.72905	12.73524	12.74032	12.73524	12.73604	12.72985	12.73874
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
29949	30509	30012	29877	30020	30360	30009	29937	30019	29914	29882	29846	29919
29932	30536	30007	29876	30052	30362	30010	29941	30043	29914	29884	29846	29915
29937	30512	30009	29907	29773	30265	30009	29932	30018	29924	29883	29841	29918
29926	30508	30022	29883	30048	30368	30012	29936	30040	29906	29888	29845	29911
29944	30504	30009	29886	30048	30368	30009	29932	30017	29916	29882	29845	29908
29962	30512	30013	29863	30039	30371	30010	29938	30036	29914	29885	29836	29919
29961	30509	30015	29883	30044	30383	30003	29943	30020	29930	29879	29843	29917
29930	30504	30012	29886	30050	30371	30007	29942	30029	29921	29876	29845	29915
29958	30504	30008	29876	30047	30367	30000	29932	29993	29901	29875	29855	29917
29962	30503	30013	29861	30049	30370	30009	29941	29992	29913	29880	29849	29924
29974	30501	30008	29852	30049	30374	30018	29931	29997	29904	29890	29854	29941
2.114003	2.115077	2.113876	2.113923	2.114486	2.113576	2.112681	2.113622	2.114205	2.113468	2.113315	2.112145	2.114258
1.12E+10	1.16E+10	1.13E+10	1.12E+10	1.13E+10	1.15E+10	1.13E+10	1.12E+10	1.13E+10	1.12E+10	1.12E+10	1.11E+10	1.12E+10
2.2881	2.289456	2.28794	2.287999	2.28871	2.287561	2.286431	2.287619	2.288356	2.287425	2.287232	2.285755	2.288422
0.031001	0.031066	0.030993	0.030996	0.031031	0.030975	0.030921	0.030978	0.031013	0.030969	0.030959	0.030888	0.031017
0.32584	0.326527	0.325759	0.325789	0.326149	0.325568	0.324997	0.325597	0.32597	0.325499	0.325401	0.324655	0.326003
2.277075	2.278419	2.276916	2.276975	2.27768	2.276541	2.275421	2.276598	2.277329	2.276406	2.276214	2.27475	2.277394
2.114003	2.115077	2.113876	2.113923	2.114486	2.113576	2.112681	2.113622	2.114205	2.113468	2.113315	2.112145	2.114258
1.12E+10	1.16E+10	1.13E+10	1.12E+10	1.13E+10	1.15E+10	1.13E+10	1.12E+10	1.13E+10	1.12E+10	1.12E+10	1.11E+10	1.12E+10

Appendix 34. NBG-17 fundamental frequency and flexural dynamic Young's modulus data (sheet 3)

AW7-02	AL8-03	AW7-03	AW9-01	AW9-02	AW9-03	AW10-01	AW10-02	AW10-03	AW12-01	AW12-02	AW12-03	AW13-01
4U11	**5S3**	**5S6**	**5S14**	**5U3**	**5U6**	**5U13**	**6S1**	**6S8**	**6S15**	**6U1**	**6U8**	**6U14**
5.9339	5.9307	5.9369	5.9210	5.9283	5.9321	5.9287	5.9365	5.9260	5.9283	5.9355	5.9277	5.9277
25.37587	25.36889	25.37936	25.37936	25.38032	25.37873	25.38286	25.37841	25.37746	25.35650	25.37524	25.35746	25.37238
12.73778	12.73556	12.73715	12.73080	12.73270	12.73699	12.72905	12.73985	12.73508	12.73921	12.73223	12.72731	12.73112
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
30009	30475	30061	29730	29972	29953	29934	29893	29818	29980	29893	29958	29877
30008	30483	30055	29731	29983	29952	29948	29879	29760	29953	29997	29954	29882
30013	30474	30071	29733	29971	29949	29941	29879	29747	29978	29974	29961	29874
30013	30476	30062	29732	29969	29945	29938	29877	29748	29989	30002	29960	29886
30009	30475	30058	29735	29963	29948	29932	29895	29745	29980	30007	29963	29884
30013	30474	30061	29732	29976	29954	29936	29894	29741	29978	29913	29954	29879
30015	30472	30062	29727	29975	29952	29938	29896	29955	29989	30003	29958	29878
30005	30475	30058	29724	29959	29952	29934	29902	29907	29977	29904	29956	29876
30007	30470	30061	29734	29982	29961	29920	29884	29806	29987	30019	29955	29881
30001	30474	30062	29724	29975	29957	29931	29909	29880	29982	29840	29964	29867
30003	30476	30056	29731	29968	29958	29920	29912	29892	29983	29270	29959	29867
2.114003	2.114209	2.11362	2.112604	2.112832	2.113646	2.112044	2.114129	2.113443	2.115791	2.113164	2.113805	2.113216
1.13E+10	1.16E+10	1.13E+10	1.11E+10	1.12E+10	1.12E+10	1.12E+10	1.12E+10	1.11E+10	1.12E+10	1.12E+10	1.12E+10	1.12E+10
2.2881	2.28836	2.287617	2.286334	2.286622	2.28765	2.285627	2.28826	2.287393	2.290358	2.287041	2.28785	2.287106
0.031001	0.031014	0.030978	0.030916	0.03093	0.03098	0.030882	0.031009	0.030967	0.03111	0.03095	0.030989	0.030953
0.325841	0.325972	0.325596	0.324948	0.325093	0.325613	0.324591	0.325921	0.325483	0.326984	0.325305	0.325714	0.325338
2.277075	2.277333	2.276596	2.275324	2.27561	2.276629	2.274623	2.277233	2.276374	2.279314	2.276025	2.276828	2.27609
2.114003	2.114209	2.11362	2.112604	2.112832	2.113646	2.112044	2.114129	2.113443	2.115791	2.113164	2.113805	2.113216
1.13E+10	1.16E+10	1.13E+10	1.11E+10	1.12E+10	1.12E+10	1.12E+10	1.12E+10	1.11E+10	1.12E+10	1.12E+10	1.12E+10	1.12E+10

Appendix 34. NBG-17 fundamental frequency and flexural dynamic Young's modulus data (sheet 4)

AL7-01	AL7-02	AW13-02	AW13-03
		Spare	**Spare**
Spare 1A	**Spare 2A**	**1W**	**2W**
5.9224	5.9248	5.9269	5.9357
25.36857	25.36444	25.36730	25.36381
12.72159	12.73080	12.73556	12.73604
0.1667	0.1667	0.1667	0.1667
30551	30558	29980	30013
30601	30616	29976	30018
30600	30597	29977	30008
30604	30595	30061	30006
30611	30561	29976	30009
30605	30497	29986	30015
30626	30505	29954	30010
30578	30694	29991	30015
30604	30529	29966	30021
30097	30453	29961	30014
30581	30531	29954	30014
2.111996	2.113803	2.114336	2.114694
1.17E+10	1.17E+10	1.12E+10	1.13E+10
2.285567	2.287848	2.288521	2.288972
0.030879	0.030989	0.031021	0.031043
0.32456	0.325713	0.326054	0.326282
2.274564	2.276825	2.277493	2.27794
2.111996	2.113803	2.114336	2.114694
1.17E+10	1.17E+10	1.12E+10	1.13E+10

Appendix 35. NBG-18 fundamental frequency and flexural dynamic Young's modulus data (sheet 1)

Modulus by Resonant Frequency

Specimen ID Number				BL6-01	BW1-01	BW1-02	BW1-03	BW2-01	BW2-02	BL6-02
Sample location				**1S1**	**1S4**	**1U1**	**1U4**	**2S2**	**2S11**	**2S12**
Specimen Mass of bar	m	[g]		5.9514	5.9653	5.9715	5.9608	5.9707	5.9706	5.9668
length of bar	L	[mm]		25.3705	25.3736	25.3689	25.3689	25.3654	25.3663	25.3695
diameter of bar	D	[mm]		12.7356	12.7381	12.7424	12.7330	12.7410	12.7421	12.7357
Poisson's ratio	m			0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
average resonant frequency	f_{avg}	[Hz]		31596	31028	31153	31071	31109	31256	31001
frequency data	f_i		1	31592	31029	31154	31067	31106	31283	31002
(specimen ID number			2	31603	31026	31156	31119	31111	31314	31003
oriented up in fixture)			3	31600	31065	31158	31098	31116	31306	31002
			4	31591	31019	31154	31042	31099	31110	31000
			5	31600	31034	31150	31102	31119	31207	31000
			6	31597	31018	31154	31092	31104	31224	31001
			7	31595	31006	31147	31010	31114	31271	31001
			8	31601	31033	31154	31006	31107	31274	30997
			9	31587	31024	31150	31093	31102	31281	30999
			10	31596	31027	31153	31085	31109	31292	31004
correction factor for rod		$T_{1'}$		2.114081	2.114232	2.115303	2.113798	2.115355	2.115456	2.114183
flexural dynamic Young's modulus **		E		1.25E+10	1.21E+10	1.22E+10	1.21E+10	1.22E+10	1.23E+10	1.21E+10
$T_{1'}$ correction factor				2.288199	2.288390	2.289741	2.287842	2.289807	2.289935	2.288327
calculation of individual				0.031006	0.031015	0.031080	0.030989	0.031083	0.031090	0.031012
terms				0.325890	0.325987	0.326671	0.325710	0.326705	0.326770	0.325956
				2.277173	2.277363	2.278702	2.276819	2.278768	2.278895	2.277301
resultant $T_{1'}$		$T_{1'}$		2.114081	2.114232	2.115303	2.113798	2.115355	2.115456	2.114183
flexural dynamic Young's modulus *	E	[Pa]		1.25E+10	1.21E+10	1.22E+10	1.21E+10	1.22E+10	1.23E+10	1.21E+10
Average Modulus for specimen group			1.22E+10							
Standard deviation			1.66E+08							

Appendix 35. NBG-18 fundamental frequency and flexural dynamic Young's modulus data (sheet 2)

BW2-03	BW3-01	BW3-02	BW3-03	BL6-03	BW5-01	BW5-02	BW5-03	BW7-01	BW7-02	BL7-01
2U2	**2U11**	**3S2**	**3S11**	**3S12**	**3S14**	**3U2**	**3U11**	**3U13**	**4S5**	**4S7**
5.9744	5.9657	5.9512	5.9714	5.9625	5.9693	5.9594	5.9704	5.9624	5.9578	5.9751
25.3638	25.3660	25.3787	25.3679	25.3724	25.3638	25.3686	25.3654	25.3689	25.3743	25.3673
12.7324	12.7418	12.7295	12.7411	12.7400	12.7376	12.7397	12.7386	12.7380	12.7394	12.7408
0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
31258	31078	31086	31146	31088	31086	31204	31238	30893	31187	31767
31261	31100	31084	31141	31084	31094	31189	31239	30889	31151	31766
31247	31042	31094	31138	31090	31122	31143	31244	30890	31173	31765
31258	31081	31082	31172	31082	31136	31190	31229	30900	31176	31766
31249	31084	31088	31132	31085	31053	31203	31240	30898	31177	31761
31261	31071	31090	31142	31080	31056	31191	31236	30891	31208	31764
31261	31080	31073	31191	31088	31051	31226	31239	30884	31139	31765
31259	31093	31089	31146	31084	31056	31234	31237	30894	31271	31767
31267	31077	31086	31133	31095	31120	31261	31242	30896	31192	31768
31259	31072	31084	31136	31102	31121	31219	31238	30894	31204	31769
31261	31076	31091	31129	31086	31051	31186	31238	30894	31180	31774
2.114108	2.115431	2.112451	2.115176	2.114640	2.114948	2.114896	2.114975	2.114592	2.114385	2.115176
1.23E+10	1.21E+10	1.22E+10	1.22E+10	1.21E+10	1.22E+10	1.22E+10	1.23E+10	1.20E+10	1.22E+10	1.27E+10
2.288233	2.289903	2.286141	2.289581	2.288904	2.289294	2.289227	2.289328	2.288844	2.288582	2.289581
0.031008	0.031088	0.030907	0.031073	0.031040	0.031059	0.031055	0.031060	0.031037	0.031024	0.031073
0.325908	0.326754	0.324850	0.326590	0.326248	0.326445	0.326411	0.326462	0.326217	0.326085	0.326590
2.277207	2.278863	2.275133	2.278544	2.277873	2.278259	2.278193	2.278292	2.277813	2.277553	2.278544
2.114108	2.115431	2.112451	2.115176	2.114640	2.114948	2.114896	2.114975	2.114592	2.114385	2.115176
1.23E+10	1.21E+10	1.22E+10	1.22E+10	1.21E+10	1.22E+10	1.22E+10	1.23E+10	1.20E+10	1.22E+10	1.27E+10

Appendix 35. NBG-18 fundamental frequency and flexural dynamic Young's modulus data (sheet 3)

BW7-03	BW8-01	BW8-02	BW8-03	BL7-02	BW9-01	BW9-02	BW9-03	BW10-01	BW10-02	BL7-03
4S14	**4U5**	**4U7**	**4U13**	**5S5**	**5S8**	**5S15**	**5U5**	**5U8**	**5U14**	**6S3**
5.9619	5.9639	5.9649	5.9588	5.9591	5.9733	5.9530	5.9693	5.9741	5.9621	5.9632
25.3644	25.3822	25.3743	25.3594	25.3654	25.3784	25.3670	25.3794	25.3797	25.3756	25.3692
12.7329	12.7376	12.7364	12.7322	12.7379	12.7351	12.7267	12.7257	12.7406	12.7289	12.7384
0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
31228	31061	31087	30973	31471	31019	31176	31199	31011	31114	31642
31234	31055	31085	30985	31462	31010	31156	31201	31015	31118	31675
31229	31064	31085	30985	31466	31023	31164	31201	31013	31121	31672
31225	31062	31082	30981	31461	31014	31161	31196	31006	31113	31675
31229	31062	31087	30970	31469	31017	31185	31198	31016	31117	31678
31225	31056	31084	30983	31513	31011	31164	31191	31003	31120	31667
31232	31065	31095	30975	31466	31021	31216	31182	31014	31118	31675
31226	31069	31088	30898	31470	31015	31158	31198	31006	31092	31371
31223	31057	31087	30990	31465	31042	31180	31199	31005	31118	31669
31222	31056	31088	30970	31464	31016	31196	31233	31027	31112	31671
31232	31062	31093	30988	31471	31018	31183	31192	31009	31109	31669
2.114134	2.113467	2.113902	2.114441	2.114871	2.113366	2.112938	2.111791	2.114154	2.112605	2.114641
1.23E+10	1.21E+10	1.22E+10	1.21E+10	1.24E+10	1.21E+10	1.22E+10	1.23E+10	1.21E+10	1.22E+10	1.26E+10
2.288265	2.287424	2.287972	2.288653	2.289197	2.287297	2.286755	2.285307	2.288291	2.286335	2.288906
0.031009	0.030969	0.030995	0.031028	0.031054	0.030963	0.030936	0.030867	0.031010	0.030916	0.031040
0.325924	0.325498	0.325776	0.326120	0.326396	0.325434	0.325160	0.324429	0.325937	0.324948	0.326248
2.277239	2.276404	2.276949	2.277623	2.278162	2.276279	2.275742	2.274306	2.277265	2.275325	2.277874
2.114134	2.113467	2.113902	2.114441	2.114871	2.113366	2.112938	2.111791	2.114154	2.112605	2.114641
1.23E+10	1.21E+10	1.22E+10	1.21E+10	1.24E+10	1.21E+10	1.22E+10	1.23E+10	1.21E+10	1.22E+10	1.26E+10

Appendix 35. NBG-18 fundamental frequency and flexural dynamic Young's modulus data (sheet 4)

BW10-03	BW11-01	BW11-02	BW11-03	BW12-01	BL8-01	BL8-02	BW12-02	BW12-03
6S6	**6S13**	**6U3**	**6U6**	**6U12**	**Spare 1A**	**Spare 2A**	**Spare 1W**	**Spare 2W**
5.9708	5.9612	5.9666	5.9674	5.9644	5.9728	5.9868	5.9721	5.9791
25.3762	25.3730	25.3740	25.3721	25.3708	25.3756	25.3549	25.3771	25.3613
12.7341	12.7397	12.7379	12.7383	12.7394	12.7437	12.7616	12.7402	12.7459
0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
31104	31090	31205	31079	31018	31747	31658	31093	31058
31094	31125	31210	31076	31017	31787	31619	31093	31039
31103	31043	31205	31074	31003	31750	31661	31093	31059
31115	31079	31206	31080	31016	31745	31638	31093	31054
31097	31099	31201	31079	31018	31747	31688	31093	31053
31107	31085	31213	31084	31017	31748	31645	31091	31058
31104	31111	31185	31077	31016	31737	31682	31088	31071
31113	31090	31224	31078	31012	31751	31695	31090	31067
31103	31082	31208	31088	31005	31737	31658	31097	31055
31105	31075	31176	31080	31012	31739	31679	31089	31076
31097	31110	31223	31078	31059	31733	31613	31098	31050
2.113393	2.114538	2.114181	2.114386	2.114666	2.114969	2.119512	2.114282	2.116477
1.22E+10	1.21E+10	1.22E+10	1.21E+10	1.21E+10	1.27E+10	1.26E+10	1.22E+10	1.21E+10
2.287330	2.288776	2.288326	2.288583	2.288937	2.289321	2.295059	2.288453	2.291224
0.030964	0.031034	0.031012	0.031024	0.031041	0.031060	0.031337	0.031018	0.031152
0.325451	0.326182	0.325955	0.326085	0.326264	0.326458	0.329371	0.326019	0.327423
2.276311	2.277745	2.277299	2.277554	2.277905	2.278285	2.283974	2.277425	2.280172
2.113393	2.114538	2.114181	2.114386	2.114666	2.114969	2.119512	2.114282	2.116477
1.22E+10	1.21E+10	1.22E+10	1.21E+10	1.21E+10	1.27E+10	1.26E+10	1.22E+10	1.21E+10

Appendix 36. H-451 fundamental frequency and flexural dynamic Young's modulus data (sheet 1)

Modulus by Resonant Frequency

Specimen ID Number				CW7-01	CW7-03	CW8-02	CW8-03	CW9-01	CW9-02	CW9-03
Sample location				**1S8**	**1S15**	**1U8**	**1U14**	**2S13**	**2U12**	**3S1**
Specimen Mass of bar	m	[g]		5.4271	5.4328	5.4300	5.4286	5.4090	5.4109	5.4137
length of bar	L	[mm]		25.3552	25.3619	25.3590	25.3597	25.3679	25.3606	25.3517
diameter of bar	D	[mm]		12.7132	12.7219	12.7195	12.7240	12.7183	12.7133	12.7240
Poisson's ratio	m			0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
average resonant frequency	f_{avg}	[Hz]		27698	27057	27260	27038	27261	27136	27215
frequency data	f_i		1	27693	27065	27265	27047	27271	27152	27200
(specimen ID number			2	27700	27049	27262	27040	27264	27142	27281
oriented up in fixture)			3	27700	27055	27256	27040	27257	27133	27193
			4	27705	27059	27254	27038	27253	27128	27211
			5	27697	27061	27259	27050	27270	27126	27185
			6	27700	27055	27266	27035	27272	27131	27203
			7	27700	27062	27260	27023	27254	27128	27198
			8	27693	27058	27256	27031	27270	27143	27177
			9	27695	27048	27262	27050	27247	27132	27242
			10	27692	27056	27264	27029	27252	27145	27264
correction factor for rod		$T_{1'}$		2.111720	2.112583	2.112431	2.113092	2.111514	2.111312	2.113730
flexural dynamic Young's modulus **		E		8.81E+09	8.41E+09	8.53E+09	8.38E+09	8.51E+09	8.44E+09	8.47E+09
$T_{1'}$ correction factor				2.285218	2.286307	2.286116	2.286950	2.284958	2.284703	2.287756
calculation of individual				0.030863	0.030915	0.030906	0.030946	0.030850	0.030838	0.030985
terms				0.324384	0.324934	0.324837	0.325259	0.324253	0.324124	0.325667
				2.274218	2.275298	2.275108	2.275935	2.273960	2.273707	2.276734
resultant $T_{1'}$		$T_{1'}$		2.111720	2.112583	2.112431	2.113092	2.111514	2.111312	2.113730
flexural dynamic Young's modulus *	E	[Pa]		8.81E+09	8.41E+09	8.53E+09	8.38E+09	8.51E+09	8.44E+09	8.47E+09

Average Modulus for specimen group	8.84E+09
Standard deviation	3.70E+08

Appendix 36. H-451 fundamental frequency and flexural dynamic Young's modulus data (sheet 2)

CW10-01	CW10-02	CW10-03	CW11-01	CW11-02	CW11-03	CW12-01	CW12-02	CW13-01	CW13-02	CW13-03
3S10	**3U1**	**3U10**	**4S2**	**4S13**	**4U2**	**4U12**	**5S7**	**5U7**	**6S5**	**6S9**
5.4191	5.4214	5.4368	5.4335	5.4356	5.4380	5.4304	5.4069	5.4562	5.4695	5.4530
25.3641	25.3597	25.3568	25.3597	25.3619	25.3540	25.3578	25.3594	25.3508	25.3600	25.3629
12.7098	12.7195	12.7200	12.7173	12.7300	12.7237	12.7227	12.7076	12.7202	12.7252	12.7160
0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
27998	27725	27486	27934	27572	27305	28834	27447	28840	28585	27452
27998	27745	27499	27935	27582	27293	28831	27403	28806	28655	27458
27992	27758	27486	27935	27571	27344	28833	27431	28839	28572	27461
27998	27757	27493	27941	27574	27291	28834	27433	28878	28570	27452
28004	27762	27496	27931	27572	27308	28840	27474	28843	28575	27444
28092	27756	27482	27931	27572	27306	28831	27484	28836	28616	27456
27948	27754	27481	27929	27577	27300	28826	27456	28864	28560	27441
27966	27760	27481	27948	27568	27295	28836	27440	28833	28581	27455
27988	27751	27484	27937	27570	27309	28831	27447	28838	28555	27459
27996	27460	27476	27922	27560	27305	28848	27435	28833	28586	27459
28002	27744	27479	27926	27577	27303	28831	27462	28834	28575	27439
2.110473	2.112380	2.112686	2.112024	2.113880	2.113501	2.113042	2.110499	2.113196	2.113270	2.111566
9.01E+09	8.81E+09	8.68E+09	8.97E+09	8.72E+09	8.56E+09	9.54E+09	8.64E+09	9.59E+09	9.44E+09	8.70E+09
2.283644	2.286051	2.286437	2.285602	2.287945	2.287466	2.286887	2.283677	2.287082	2.287175	2.285023
0.030787	0.030903	0.030921	0.030881	0.030994	0.030971	0.030943	0.030789	0.030952	0.030957	0.030853
0.323590	0.324805	0.325000	0.324578	0.325762	0.325520	0.325227	0.323607	0.325326	0.325373	0.324286
2.272657	2.275044	2.275427	2.274598	2.276921	2.276447	2.275872	2.272690	2.276066	2.276158	2.274025
2.110473	2.112380	2.112686	2.112024	2.113880	2.113501	2.113042	2.110499	2.113196	2.113270	2.111566
9.01E+09	8.81E+09	8.68E+09	8.97E+09	8.72E+09	8.56E+09	9.54E+09	8.64E+09	9.59E+09	9.44E+09	8.70E+09

Appendix 36. H-451 fundamental frequency and flexural dynamic Young's modulus data (sheet 3)

CW14-01	CW14-02	CW15-01	CW15-02
6U5	**6U9**	**Spare 1**	**Spare 2**
5.4557	5.4374	5.4467	5.4146
25.3502	25.3508	25.3562	25.3492
12.7279	12.7237	12.7273	12.7202
0.16667	0.16667	0.16667	0.16667
28365	28220	28355	27451
28372	28217	28344	27453
28362	28227	28347	27447
28360	28223	28391	27478
28365	28214	28351	27427
28355	28219	28350	27440
28366	28212	28344	27482
28369	28224	28354	27460
28372	28230	28352	27447
28364	28216	28364	27444
28365	28214	28352	27430
2.114495	2.113756	2.113907	2.113324
9.26E+09	9.14E+09	9.24E+09	8.62E+09
2.288721	2.287789	2.287979	2.287243
0.031031	0.030986	0.030995	0.030960
0.326155	0.325683	0.325780	0.325407
2.277691	2.276766	2.276956	2.276225
2.114495	2.113756	2.113907	2.113324
9.26E+09	9.14E+09	9.24E+09	8.62E+09

Appendix 37. PCEA fundamental frequency and flexural dynamic Young's modulus data (sheet 1)

Modulus by Resonant Frequency

Specimen ID Number				DW1-01	DW1-02	DW1-03	DW2-01	DW2-02	DW2-03	DW3-01	DW3-02
Sample location				**1S2**	**1S6**	**1S14**	**1U2**	**1U6**	**1U13**	**2S1**	**2S8**
Specimen Mass of bar	m	[g]		5.7468	5.7516	5.7604	5.7565	5.7443	5.7447	5.7568	5.7597
length of bar	L	[mm]		25.3844	25.3822	25.3832	25.3765	25.3759	25.3752	25.3787	25.3787
diameter of bar	D	[mm]		12.7264	12.7270	12.7275	12.7260	12.7275	12.7273	12.7252	12.7287
Poisson's ratio	m			0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
average resonant frequency	f_{avg}	[Hz]		30053	30052	30230	30052	29999	30078	30087	29843
frequency data	f_i		1	30059	29770	30231	30086	30691	30137	30086	29973
(specimen ID number			2	30058	30090	30245	30091	29969	30129	30086	29925
oriented up in fixture)			3	30050	30090	30230	30093	29530	30129	30137	29955
			4	30049	30085	30225	30091	29595	30127	30074	29922
			5	30072	30072	30231	30090	29968	30127	30139	29950
			6	30054	30071	30222	30084	30001	30114	30077	29949
			7	30038	30089	30229	30089	30063	30133	30076	29019
			8	30052	30088	30237	30063	30002	29614	30077	29938
			9	30039	30086	30226	29745	30198	30137	30068	29849
			10	30056	30082	30228	30088	29972	30128	30053	29952
correction factor for rod		$T_{1'}$		2.111485	2.111765	2.111764	2.112071	2.112351	2.112376	2.111765	2.112324
flexural dynamic Young's modulus **		E		1.10E+10	1.10E+10	1.11E+10	1.10E+10	1.09E+10	1.10E+10	1.10E+10	1.08E+10
$T_{1'}$ correction factor				2.284921	2.285274	2.285274	2.285661	2.286014	2.286046	2.285275	2.285981
calculation of individual				0.030848	0.030865	0.030865	0.030884	0.030901	0.030902	0.030865	0.030899
terms				0.324234	0.324413	0.324412	0.324608	0.324786	0.324802	0.324413	0.324769
				2.273923	2.274274	2.274273	2.274657	2.275007	2.275039	2.274275	2.274974
resultant $T_{1'}$		$T_{1'}$		2.111485	2.111765	2.111764	2.112071	2.112351	2.112376	2.111765	2.112324
flexural dynamic Young's modulus *	E	[Pa]		1.10E+10	1.10E+10	1.11E+10	1.10E+10	1.09E+10	1.10E+10	1.10E+10	1.08E+10
Average Modulus for specimen group				1.07E+10							
Standard deviation				6.91E+08							

Appendix 37. PCEA fundamental frequency and flexural dynamic Young's modulus data (sheet 2)

DW3-03	DW4-01	DW4-03	DW5-01	DA601	DW5-02	DW5-03	DW6-01	DA602	DA701	DW6-02	DW6-03	DW7-01
2S14	**2U8**	**2U1**	**2U13**	**3S6**	**3S15**	**3U6**	**3U14**	**4S1**	**4S6**	**4S15**	**4U1**	**4U6**
5.7625	5.7407	5.7429	5.6963	5.6611	5.7316	5.7596	5.7612	5.6454	5.6448	5.7631	5.7397	5.7650
25.3781	25.3898	25.3832	25.3825	25.3895	25.3806	25.3806	25.3806	25.3883	25.3892	25.3778	25.3771	25.3790
12.7267	12.7262	12.7224	12.7244	12.7286	12.7270	12.7300	12.7295	12.7291	12.7289	12.7319	12.7362	12.7313
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
30049	29871	29923	29483	27359	29775	30098	30151	27441	27491	30273	30091	30042
30163	29878	29988	29492	27422	29851	30047	30129	27447	27454	30268	30172	30124
30135	29877	29969	29497	27390	29828	30120	30193	27459	27542	30267	29787	29752
30123	29863	29381	29443	27380	29212	30115	30190	27430	27522	30306	30163	30093
29293	29879	29987	29469	27003	29798	30122	29809	27446	27444	30265	30152	30117
30126	29868	29989	29492	27381	29824	30085	30191	27442	27513	30257	30141	30103
30126	29864	29981	29491	27416	29839	30082	30200	27443	27467	30272	30275	29660
30139	29866	29980	29488	27392	29840	30091	30224	27449	27452	30266	30177	30235
30131	29867	29980	29482	27397	29871	30068	30189	27412	27529	30270	29761	30136
30129	29875	29982	29485	27406	29815	30104	30181	27449	27521	30312	30153	30116
30125	29873	29995	29492	27400	29867	30145	30203	27431	27461	30245	30131	30082
2.112045	2.111027	2.110952	2.111333	2.111433	2.111892	2.112375	2.112299	2.111611	2.111509	2.112909	2.113647	2.112705
1.10E+10	1.08E+10	1.09E+10	1.05E+10	8.96E+09	1.07E+10	1.10E+10	1.11E+10	8.99E+09	9.02E+09	1.12E+10	1.10E+10	1.10E+10
2.285628	2.284343	2.284248	2.284729	2.284856	2.285435	2.286045	2.285948	2.285080	2.284952	2.286719	2.287650	2.286462
0.030882	0.030821	0.030816	0.030839	0.030845	0.030873	0.030902	0.030898	0.030856	0.030850	0.030935	0.030980	0.030922
0.324591	0.323942	0.323895	0.324137	0.324201	0.324494	0.324801	0.324753	0.324315	0.324250	0.325142	0.325613	0.325012
2.274625	2.273350	2.273256	2.273733	2.273859	2.274433	2.275037	2.274942	2.274081	2.273954	2.275706	2.276629	2.275451
2.112045	2.111027	2.110952	2.111333	2.111433	2.111892	2.112375	2.112299	2.111611	2.111509	2.112909	2.113647	2.112705
1.10E+10	1.08E+10	1.09E+10	1.05E+10	8.96E+09	1.07E+10	1.10E+10	1.11E+10	8.99E+09	9.02E+09	1.12E+10	1.10E+10	1.10E+10

Appendix 37. PCEA fundamental frequency and flexural dynamic Young's modulus data (sheet 3)

DW7-02	DW7-03	DW8-01	DA702	DW8-02	DW8-03	DW9-01	DW9-02	DW9-03	DW10-01	DA801	DW10-02	DW10-03
4U14	**5S4**	**5S9**	**5S11**	**5S12**	**5U4**	**5U9**	**5U11**	**6S4**	**6S11**	**6S12**	**6U11**	**6U4**
5.7628	5.7567	5.7662	5.7624	5.7745	5.7800	5.7479	5.7474	5.7734	5.7473	5.7665	5.7395	5.7473
25.3794	25.3816	25.3819	25.3736	25.3816	25.3835	25.3844	25.3835	25.3848	25.3841	25.3851	25.3841	25.3854
12.7302	12.7310	12.7318	12.7403	12.7327	12.7330	12.7343	12.7318	12.7256	12.7179	12.7200	12.7175	12.7165
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
30044	30210	29975	29970	30182	30225	29930	30071	30276	29958	30445	29851	30029
29808	30209	30105	29946	30206	29832	29975	30087	30284	29732	30443	29677	30053
29858	30220	29449	29962	30205	30275	29513	30057	30277	29226	30446	30139	30034
30171	30227	30075	29979	30177	30269	29949	30066	30258	30089	30440	29243	30027
30184	30220	30114	30003	30198	30271	30071	30086	30075	30063	30454	30111	30021
30168	30227	29396	29965	30220	30211	29924	30076	30530	30065	30449	29257	30020
30165	30153	30030	29919	30178	30276	29942	30043	30265	30101	30441	30114	30016
30192	30205	30087	29946	30256	30265	29961	30066	30253	30061	30444	30109	30015
30166	30207	30119	30000	30221	30283	29943	30081	30260	30101	30452	30105	30043
29521	30211	30041	30002	30319	30293	30008	30063	30255	30080	30444	29660	30014
30211	30222	30332	29979	29840	30272	30012	30085	30302	30060	30432	30094	30043
2.112502	2.112451	2.112552	2.114589	2.112730	2.112628	2.112755	2.112425	2.111332	2.110165	2.110418	2.110088	2.109834
1.10E+10	1.11E+10	1.09E+10	1.09E+10	1.11E+10	1.12E+10	1.09E+10	1.10E+10	1.12E+10	1.09E+10	1.13E+10	1.08E+10	1.10E+10
2.286205	2.286141	2.286269	2.288840	2.286493	2.286364	2.286525	2.286108	2.284729	2.283255	2.283575	2.283159	2.282838
0.030910	0.030907	0.030913	0.031037	0.030924	0.030918	0.030925	0.030905	0.030839	0.030768	0.030784	0.030764	0.030748
0.324883	0.324850	0.324915	0.326215	0.325028	0.324963	0.325044	0.324833	0.324137	0.323394	0.323555	0.323345	0.323184
2.275197	2.275132	2.275259	2.277808	2.275482	2.275354	2.275513	2.275100	2.273733	2.272271	2.272589	2.272176	2.271858
2.112502	2.112451	2.112552	2.114589	2.112730	2.112628	2.112755	2.112425	2.111332	2.110165	2.110418	2.110088	2.109834
1.10E+10	1.11E+10	1.09E+10	1.09E+10	1.11E+10	1.12E+10	1.09E+10	1.10E+10	1.12E+10	1.09E+10	1.13E+10	1.08E+10	1.10E+10

Appendix 37. PCEA fundamental frequency and flexural dynamic Young's modulus data (sheet 4)

DW11-01 **Spare 1W**	DW11-02 **Spare 2W**	DA802 **Spare 1A**	DA901 **Spare 2A**
5.7456	5.7520	5.6459	5.6473
25.3841	25.3844	25.3867	25.3902
12.7181	12.7206	12.7313	12.7321
0.1667	0.1667	0.1667	0.1667
30154	30162	27486	27334
29023	29994	27486	27165
30960	29983	27483	27305
30367	30371	27488	27357
30457	30325	27484	27368
30558	29716	27489	27362
29273	30371	27481	27473
30454	30404	27491	27369
30981	30370	27486	27290
29073	29750	27485	27310
30391	30333	27491	27345
2.110190	2.110571	2.112094	2.111941
1.11E+10	1.11E+10	9.01E+09	8.92E+09
2.283287	2.283767	2.285690	2.285497
0.030770	0.030793	0.030885	0.030876
0.323410	0.323652	0.324622	0.324525
2.272303	2.272780	2.274686	2.274494
2.110190	2.110571	2.112094	2.111941
1.11E+10	1.11E+10	9.01E+09	8.92E+09

Appendix 38. IG-110 fundamental frequency and flexural dynamic Young's modulus data (sheet 1)

Modulus by Resonant Frequency

Specimen ID Number				EW2-01	EW2-02	EW2-03	EW4-01	EW4-02	EW5-01	EW5-02
Sample location				**1S7**	**1S9**	**1U7**	**1U9**	**2S5**	**2S7**	**2U5**
Specimen Mass of bar	m	[g]		5.5838	5.5901	5.5930	5.5908	5.5921	5.5756	5.5834
length of bar	L	[mm]		25.3768	25.3844	25.3851	25.3676	25.3736	25.3698	25.3702
diameter of bar	D	[mm]		12.7249	12.7248	12.7244	12.7106	12.7170	12.7171	12.7098
Poisson's ratio	m			0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
average resonant frequency	f_{avg}	[Hz]		26712	27114	27042	27496	26863	27161	27481
frequency data	f_i		1	26795	27115	27051	27498	26859	27161	27480
(specimen ID number			2	26703	27114	27038	27497	26859	27165	27464
oriented up in fixture)			3	26698	27119	27049	27498	26870	27163	27476
			4	26705	27094	27046	27499	26863	27147	27498
			5	26705	27118	27035	27498	26852	27164	27467
			6	26712	27117	27048	27494	26869	27173	27492
			7	26701	27108	27034	27488	26870	27172	27491
			8	26711	27121	27046	27500	26852	27152	27486
			9	26690	27118	27043	27495	26858	27156	27477
			10	26704	27112	27033	27492	26873	27160	27480
correction factor for rod		$T_{1'}$		2.111868	2.111231	2.111129	2.110320	2.110852	2.111183	2.109989
flexural dynamic Young's modulus **		E		8.43E+09	8.70E+09	8.66E+09	8.96E+09	8.55E+09	8.71E+09	8.95E+09
$T_{1'}$ correction factor				2.285404	2.284601	2.284472	2.283451	2.284122	2.284540	2.283033
calculation of individual				0.030872	0.030833	0.030827	0.030778	0.030810	0.030830	0.030758
terms				0.324478	0.324073	0.324008	0.323493	0.323831	0.324042	0.323282
				2.274402	2.273606	2.273478	2.272465	2.273132	2.273546	2.272052
resultant $T_{1'}$		$T_{1'}$		2.111868	2.111231	2.111129	2.110320	2.110852	2.111183	2.109989
flexural dynamic Young's modulus *	E	[Pa]		8.43E+09	8.70E+09	8.66E+09	8.96E+09	8.55E+09	8.71E+09	8.95E+09
Average Modulus for specimen group		8.88E+09								
Standard deviation		2.13E+08								

Appendix 38. IG-110 fundamental frequency and flexural dynamic Young's modulus data (sheet 2)

EW5-03	EW6-01	EW6-02	EW6-03	EW7-01	EW7-03	EW8-01	EW8-02	EW8-03	EW9-01	EW9-02
2U7	**3S9**	**3U9**	**4S4**	**4S9**	**4U4**	**4U9**	**5S1**	**5S13**	**5U1**	**5U12**
5.5845	5.5918	5.5979	5.6009	5.5902	5.5730	5.5829	5.5862	5.5817	5.5981	5.5911
25.3765	25.3733	25.3803	25.3746	25.3756	25.3765	25.3768	25.3698	25.3778	25.3762	25.3775
12.7106	12.7075	12.7152	12.7092	12.7119	12.6965	12.7016	12.7073	12.6973	12.6927	12.7087
0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
27047	27492	27384	27507	27571	27239	26967	27465	27449	27657	27860
27052	27491	27351	27575	27533	27236	26971	27465	27442	27676	27818
27051	27497	27391	27558	27578	27233	26973	27460	27452	27651	27820
27050	27493	27394	27587	27582	27329	26970	27457	27447	27651	27809
27044	27489	27388	27475	27584	27229	26969	27467	27449	27654	27839
27047	27493	27386	27488	27567	27226	26964	27458	27447	27653	27845
27041	27493	27380	27472	27580	27230	26969	27471	27442	27661	27902
27045	27491	27394	27480	27566	27230	26955	27469	27450	27656	27898
27051	27496	27391	27483	27562	27227	26970	27460	27456	27650	27867
27045	27490	27390	27476	27571	27217	26959	27472	27451	27669	27902
27040	27484	27378	27476	27586	27236	26970	27467	27449	27650	27902
2.109607	2.109354	2.110038	2.109531	2.109887	2.107349	2.108135	2.109608	2.107374	2.106766	2.109223
8.67E+09	8.97E+09	8.90E+09	8.99E+09	9.01E+09	8.80E+09	8.63E+09	8.94E+09	8.95E+09	9.13E+09	9.21E+09
2.282552	2.282232	2.283095	2.282456	2.282904	2.279702	2.280694	2.282553	2.279734	2.278966	2.282067
0.030735	0.030719	0.030761	0.030730	0.030752	0.030598	0.030646	0.030735	0.030600	0.030563	0.030711
0.323039	0.322878	0.323314	0.322991	0.323217	0.321606	0.322104	0.323040	0.321622	0.321236	0.322795
2.271574	2.271257	2.272113	2.271479	2.271924	2.268749	2.269732	2.271575	2.268780	2.268019	2.271093
2.109607	2.109354	2.110038	2.109531	2.109887	2.107349	2.108135	2.109608	2.107374	2.106766	2.109223
8.67E+09	8.97E+09	8.90E+09	8.99E+09	9.01E+09	8.80E+09	8.63E+09	8.94E+09	8.95E+09	9.13E+09	9.21E+09

Appendix 38. IG-110 fundamental frequency and flexural dynamic Young's modulus data (sheet 3)

EW9-03	EW10-01	EW10-02	EW10-03
6S14	**6U13**	**Spare 1**	**Spare 2**
5.5902	5.5822	5.5845	5.5923
25.3746	25.3778	25.3771	25.3756
12.6998	12.6976	12.7021	12.7008
0.16667	0.16667	0.16667	0.16667
27558	27253	27571	27972
27566	27244	27495	27988
27565	27247	27498	27987
27571	27251	27596	27941
27556	27258	27588	27959
27548	27254	27598	27943
27563	27250	27601	27992
27545	27255	27634	27973
27566	27248	27329	27976
27547	27247	27685	27980
27550	27272	27685	27984
2.108034	2.107425	2.108186	2.108110
9.03E+09	8.83E+09	9.03E+09	9.31E+09
2.280566	2.279798	2.280758	2.280662
0.030640	0.030603	0.030649	0.030644
0.322040	0.321654	0.322137	0.322088
2.269606	2.268844	2.269796	2.269701
2.108034	2.107425	2.108186	2.108110
9.03E+09	8.83E+09	9.03E+09	9.31E+09

Appendix 39. IG-430 fundamental frequency and flexural dynamic Young's modulus data (sheet 1)

Modulus by Resonant Frequency

Specimen ID Number				FW1-01	FW1-02	FW1-03	FW2-01	FW2-02	FW2-03	FW3-01	FW3-02
Sample location				**1S5**	**1S10**	**1U5**	**1U10**	**2S3**	**2S9**	**2S15**	**2U3**
Specimen Mass of bar	m	[g]		5.7233	5.7574	5.7655	5.7255	5.7308	5.7428	5.7337	5.7257
length of bar	L	[mm]		25.37079	25.37746	25.37492	25.37492	25.36889	25.3746	25.37651	25.37587
diameter of bar	D	[mm]		12.70651	12.71127	12.71508	12.70064	12.7027	12.70476	12.69905	12.70445
Poisson's ratio	m			0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
average resonant frequency	f_{avg}	[Hz]		27490	27466	27713	27715	27426	27461	28596	27747
frequency data	f_i		1	27512	27460	27682	27694	27421	27462	28602	27757
(specimen ID number			2	27514	27467	27687	27693	27430	27459	28596	27740
oriented up in fixture)			3	27496	27469	27688	27696	27428	27455	28595	27748
			4	27488	27470	27680	27699	27427	27452	28600	27748
			5	27501	27471	27686	27699	27425	27464	28595	27718
			6	27479	27468	27838	27900	27427	27464	28589	27743
			7	27479	27469	27631	27691	27428	27467	28593	27749
			8	27475	27469	27867	27698	27424	27462	28600	27744
			9	27478	27462	27685	27688	27422	27454	28595	27773
			10	27473	27456	27681	27695	27425	27466	28596	27754
correction factor for rod		$T_{1'}$		2.109405	2.109633	2.110445	2.108136	2.108948	2.108821	2.107755	2.108668
flexural dynamic Young's modulus **		E		9.18E+09	9.22E+09	9.39E+09	9.35E+09	9.16E+09	9.20E+09	9.98E+09	9.37E+09
$T_{1'}$ correction factor				2.282296	2.282583	2.283609	2.280694	2.28172	2.281559	2.280214	2.281367
calculation of individual				0.030722	0.030736	0.030785	0.030646	0.030695	0.030687	0.030623	0.030678
terms				0.322911	0.323055	0.323573	0.322105	0.322621	0.32254	0.321863	0.322443
				2.271321	2.271606	2.272623	2.269733	2.270749	2.27059	2.269256	2.270399
resultant $T_{1'}$		$T_{1'}$		2.109405	2.109633	2.110445	2.108136	2.108948	2.108821	2.107755	2.108668
flexural dynamic Young's modulus *	E	[Pa]		9.18E+09	9.22E+09	9.39E+09	9.35E+09	9.16E+09	9.20E+09	9.98E+09	9.37E+09

Average Modulus for specimen group	9.48E+09
Standard deviation	2.58E+08

Appendix 39. IG-430 fundamental frequency and flexural dynamic Young's modulus data (sheet 2)

FW3-03	FW4-01	FW4-02	FW4-03	FW5-01	FW5-02	FW5-03	FW7-01	FW7-02	FW7-03	FW8-01	FW8-02	FW8-03
2U9	**2U14**	**3S3**	**3S4**	**3S5**	**3S7**	**3U3**	**3U4**	**3U5**	**3U7**	**4S3**	**4S10**	**4U3**
5.7546	5.7339	5.7458	5.7692	5.7637	5.7849	5.7923	5.7641	5.7693	5.7559	5.7551	5.7571	5.7267
25.37524	25.38063	25.37873	25.36889	25.37206	25.38476	25.38381	25.38508	25.37873	25.38571	25.37968	25.3819	25.37778
12.71222	12.71238	12.70968	12.71413	12.71683	12.72826	12.73127	12.73635	12.73461	12.73524	12.71222	12.7127	12.71334
0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
27754	28127	28034	27836	28028	28487	28007	27443	27656	27399	28108	27658	27585
27655	28131	28013	27829	28030	28489	28017	27446	27688	27397	28119	27670	27617
27698	28131	28048	27836	28028	28486	28006	27447	27683	27399	28109	27654	27616
27752	28130	28017	27840	28030	28483	28005	27444	27689	27399	28114	27652	27609
27729	28124	28020	27832	28027	28485	28009	27437	27681	27398	28116	27658	27319
27938	28123	28057	27840	28029	28484	28015	27441	27688	27397	28105	27660	27614
27753	28129	28044	27842	28024	28487	28000	27444	27676	27402	28106	27656	27613
27943	28121	28035	27836	28026	28487	28005	27444	27686	27402	28106	27652	27617
27753	28128	27962	27837	28033	28491	28003	27444	27696	27402	28095	27659	27617
27617	28131	28047	27840	28026	28491	28000	27439	27679	27395	28107	27660	27612
27697	28125	28097	27832	28028	28486	28012	27442	27389	27402	28106	27663	27615
2.109963	2.109556	2.109277	2.110777	2.110954	2.111764	2.112323	2.113034	2.113265	2.112805	2.109607	2.109505	2.109937
9.40E+09	9.63E+09	9.59E+09	9.47E+09	9.59E+09	9.93E+09	9.60E+09	9.16E+09	9.31E+09	9.12E+09	9.65E+09	9.35E+09	9.24E+09
2.283	2.282487	2.282135	2.284027	2.284251	2.285274	2.285979	2.286877	2.287168	2.286588	2.282551	2.282422	2.282968
0.030756	0.030732	0.030715	0.030805	0.030816	0.030865	0.030899	0.030942	0.030956	0.030928	0.030735	0.030728	0.030755
0.323266	0.323007	0.32283	0.323783	0.323896	0.324412	0.324769	0.325222	0.325369	0.325076	0.323039	0.322974	0.323249
2.272019	2.27151	2.271161	2.273037	2.273259	2.274273	2.274973	2.275863	2.276151	2.275576	2.271574	2.271446	2.271987
2.109963	2.109556	2.109277	2.110777	2.110954	2.111764	2.112323	2.113034	2.113265	2.112805	2.109607	2.109505	2.109937
9.40E+09	9.63E+09	9.59E+09	9.47E+09	9.59E+09	9.93E+09	9.60E+09	9.16E+09	9.31E+09	9.12E+09	9.65E+09	9.35E+09	9.24E+09

Appendix 39. IG-430 fundamental frequency and flexural dynamic Young's modulus data (sheet 3)

FW9-01	FW9-02	FW9-03	FW10-01	FW10-02	FW10-03	FW11-01	FW11-02	FW11-03	FW12-01	FW12-02	FW13-01	FW13-02
4U10	**5S2**	**5S10**	**5U2**	**5U10**	**6S2**	**6S7**	**6S10**	**6U2**	**6U7**	**6U10**	**Spare 1**	**Spare 2**
5.7732	5.7547	5.7710	5.7745	5.7841	5.7886	5.7770	5.7712	5.7713	5.7506	5.7608	5.7910	5.7909
25.38889	25.38698	25.38095	25.39302	25.38921	25.38254	25.38317	25.38508	25.38571	25.3873	25.38635	25.38254	25.38063
12.71826	12.71794	12.71619	12.72143	12.7227	12.72143	12.72223	12.72461	12.72429	12.72667	12.72492	12.72762	12.72842
0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667	0.16667
28302	27641	27755	28578	28504	28040	27494	28104	27654	27514	27829	28340	28179
28165	27650	27756	28569	28513	28024	27497	28103	27656	27518	27833	28337	28177
28348	27644	27744	28582	28502	28072	27503	28097	27642	27520	27827	28339	28179
28153	27639	27765	28571	28500	28028	27500	28096	27635	27511	27828	28316	28182
28388	27635	27749	28555	28507	28028	27490	28108	27636	27518	27822	28291	28180
28337	27636	27761	28583	28506	28036	27495	28118	27636	27515	27833	28334	28177
28326	27651	27760	28576	28486	28036	27491	28105	27643	27516	27822	28380	28179
28324	27646	27750	28587	28507	28022	27489	28106	27684	27512	27831	28375	28178
28315	27645	27751	28586	28511	28071	27490	28106	27664	27505	27834	28318	28175
28332	27636	27755	28579	28506	28038	27498	28102	27670	27514	27830	28317	28184
28333	27627	27757	28590	28504	28041	27488	28103	27672	27512	27831	28393	28178
2.109834	2.109936	2.11014	2.110011	2.110519	2.11085	2.110926	2.111155	2.111053	2.111306	2.111104	2.111841	2.112121
9.81E+09	9.32E+09	9.42E+09	1.00E+10	9.95E+09	9.64E+09	9.25E+09	9.65E+09	9.34E+09	9.21E+09	9.44E+09	9.83E+09	9.72E+09
2.282838	2.282966	2.283223	2.283061	2.283702	2.28412	2.284216	2.284504	2.284376	2.284696	2.28444	2.285371	2.285724
0.030748	0.030755	0.030767	0.030759	0.03079	0.03081	0.030815	0.030828	0.030822	0.030838	0.030825	0.03087	0.030887
0.323184	0.323248	0.323378	0.323296	0.323619	0.32383	0.323879	0.324024	0.323959	0.324121	0.323991	0.324461	0.324639
2.271858	2.271985	2.27224	2.272079	2.272715	2.273129	2.273225	2.27351	2.273383	2.2737	2.273446	2.274369	2.274719
2.109834	2.109936	2.11014	2.110011	2.110519	2.11085	2.110926	2.111155	2.111053	2.111306	2.111104	2.111841	2.112121
9.81E+09	9.32E+09	9.42E+09	1.00E+10	9.95E+09	9.64E+09	9.25E+09	9.65E+09	9.34E+09	9.21E+09	9.44E+09	9.83E+09	9.72E+09

Appendix 40. NBG-17 (AG) elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho v_l^2$	Shear Modulus, [Pa] $G=\rho v_s^2$	Poisson's Ratio $\mu=(1-[2(v_s/v_l)^2])/(2-[2(v_s/v_l)^2])$	Elastic Modulus, [Pa] $E=\rho v_l^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
AW1-01	**1S3**	1843.91	2.766E+03	1.416E+03	1.420E+03	1.418E+03	1.41028E+10	3.709E+09	3.216E-01	9.803E+09
AW1-02	**1S11**	1855.47	2.797E+03	1.400E+03	1.400E+03	1.400E+03	1.45206E+10	3.636E+09	3.330E-01	9.694E+09
AW1-03	**1S12**	1859.32	2.788E+03	1.408E+03	1.402E+03	1.405E+03	1.44502E+10	3.669E+09	3.299E-01	9.758E+09
AW2-01	**1U3**	1865.53	2.786E+03	1.418E+03	1.422E+03	1.420E+03	1.44753E+10	3.764E+09	3.243E-01	9.969E+09
AW2-02	**1U11**	1863.81	2.786E+03	1.422E+03	1.414E+03	1.418E+03	1.44620E+10	3.748E+09	3.251E-01	9.933E+09
AW2-03	**1U12**	1866.08	2.795E+03	1.406E+03	1.403E+03	1.405E+03	1.45736E+10	3.682E+09	3.310E-01	9.801E+09
AW4-01	**2S6**	1864.98	2.779E+03	1.414E+03	1.410E+03	1.412E+03	1.44052E+10	3.721E+09	3.259E-01	9.866E+09
AW4-02	**2U4**	1866.50	2.776E+03	1.421E+03	1.417E+03	1.419E+03	1.43833E+10	3.756E+09	3.233E-01	9.941E+09
AW4-03	**2U6**	1862.04	2.777E+03	1.425E+03	1.412E+03	1.419E+03	1.43625E+10	3.747E+09	3.235E-01	9.918E+09
AW5-01	**2U10**	1866.45	2.776E+03	1.423E+03	1.432E+03	1.428E+03	1.43847E+10	3.803E+09	3.203E-01	1.004E+10
AW5-02	**3S13**	1866.18	2.792E+03	1.415E+03	1.411E+03	1.413E+03	1.45423E+10	3.725E+09	3.278E-01	9.893E+09
AW5-03	**3U8**	1861.34	2.789E+03	1.431E+03	1.423E+03	1.427E+03	1.44743E+10	3.792E+09	3.225E-01	1.003E+10
AW6-01	**3U12**	1865.80	2.789E+03	1.418E+03	1.435E+03	1.427E+03	1.45099E+10	3.797E+09	3.228E-01	1.005E+10
AW6-02	**4S8**	1863.56	2.777E+03	1.431E+03	1.424E+03	1.427E+03	1.43668E+10	3.797E+09	3.204E-01	1.003E+10
AW6-03	**4S12**	1860.57	2.777E+03	1.421E+03	1.413E+03	1.417E+03	1.43498E+10	3.735E+09	3.241E-01	9.891E+09
AW7-01	**4U8**	1864.64	2.779E+03	1.429E+03	1.428E+03	1.428E+03	1.44002E+10	3.803E+09	3.205E-01	1.005E+10
AW7-02	**4U11**	1865.54	2.791E+03	1.426E+03	1.429E+03	1.428E+03	1.45352E+10	3.803E+09	3.228E-01	1.006E+10
AW7-03	**5S6**	1866.36	2.801E+03	1.418E+03	1.417E+03	1.418E+03	1.46417E+10	3.751E+09	3.278E-01	9.961E+09
AW9-01	**5S14**	1862.90	2.789E+03	1.418E+03	1.413E+03	1.415E+03	1.44882E+10	3.732E+09	3.265E-01	9.901E+09
AW9-02	**5U3**	1864.81	2.817E+03	1.423E+03	1.416E+03	1.420E+03	1.47931E+10	3.759E+09	3.297E-01	9.995E+09
AW9-03	**5U6**	1864.85	2.813E+03	1.425E+03	1.428E+03	1.426E+03	1.47599E+10	3.794E+09	3.270E-01	1.007E+10
AW10-01	**5U13**	1865.87	2.780E+03	1.422E+03	1.405E+03	1.414E+03	1.44183E+10	3.728E+09	3.256E-01	9.885E+09
AW10-02	**6S1**	1865.42	2.798E+03	1.427E+03	1.411E+03	1.419E+03	1.46011E+10	3.758E+09	3.267E-01	9.971E+09
AW10-03	**6S8**	1863.59	2.810E+03	1.408E+03	1.404E+03	1.406E+03	1.47151E+10	3.685E+09	3.330E-01	9.824E+09
AW12-01	**6S15**	1864.50	2.795E+03	1.429E+03	1.421E+03	1.425E+03	1.45704E+10	3.787E+09	3.244E-01	1.003E+10

AW12-02	**6U1**	1867.71	2.797E+03	1.424E+03	1.425E+03	1.425E+03	1.46141E+10	3.790E+09	3.249E-01	1.004E+10
AW12-03	**6U8**	1867.92	2.798E+03	1.423E+03	1.432E+03	1.427E+03	1.46262E+10	3.804E+09	3.242E-01	1.008E+10
AW13-01	**6U14**	1865.41	2.779E+03	1.427E+03	1.416E+03	1.421E+03	1.44061E+10	3.769E+09	3.228E-01	9.972E+09
AW13-02	**Spare 1W**	1864.65	2.800E+03	1.415E+03	1.405E+03	1.410E+03	1.46174E+10	3.705E+09	3.302E-01	9.858E+09
AW13-03	**Spare 2W**	1867.28	2.824E+03	1.415E+03	1.405E+03	1.410E+03	1.48928E+10	3.713E+09	3.340E-01	9.905E+09
AW14C01	**1PB16**	1867.85	2.768E+03	1.450E+03	1.450E+03	1.450E+03	1.43079E+10	3.929E+09	3.107E-01	1.030E+10
AW14C02	**2PB16**	1866.2	2.777E+03	1.462E+03	1.442E+03	1.452E+03	1.43916E+10	3.935E+09	3.119E-01	1.032E+10
AW14C04	**3PB16**	1867.23	2.765E+03	1.459E+03	1.479E+03	1.469E+03	1.42754E+10	4.029E+09	3.034E-01	1.050E+10
AW15C02	**4PB16**	1870.32	2.766E+03	1.463E+03	1.424E+03	1.443E+03	1.43132E+10	3.896E+09	3.130E-01	1.023E+10
AW15C03	**Spare 1**	1866.28	2.775E+03	1.445E+03	1.455E+03	1.450E+03	1.43760E+10	3.922E+09	3.124E-01	1.030E+10
AW15C06	**Spare 2**	1867.62	2.778E+03	1.473E+03	1.469E+03	1.471E+03	1.44091E+10	4.042E+09	3.051E-01	1.055E+10

Appendix 41. NBG-17 (WG) elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (WG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
AL6-01	**1S13**	1866.75	2.863E+03	1.437E+03	1.429E+03	1.433E+03	1.53039E+10	3.835E+09	3.328E-01	1.022E+10
AL6-02	**2S4**	1863.59	2.831E+03	1.421E+03	1.429E+03	1.425E+03	1.49360E+10	3.785E+09	3.303E-01	1.007E+10
AL6-03	**2S10**	1868.78	2.849E+03	1.438E+03	1.457E+03	1.447E+03	1.51725E+10	3.916E+09	3.261E-01	1.038E+10
AL8-01	**3S8**	1864.94	2.846E+03	1.454E+03	1.439E+03	1.446E+03	1.51028E+10	3.902E+09	3.258E-01	1.035E+10
AL8-02	**4S11**	1866.04	2.777E+03	1.422E+03	1.424E+03	1.423E+03	1.43855E+10	3.778E+09	3.219E-01	9.989E+09
AL8-03	**5S3**	1865.86	2.828E+03	1.451E+03	1.438E+03	1.445E+03	1.49203E+10	3.894E+09	3.234E-01	1.031E+10
AL7-01	**Spare 1A**	1867.25	2.879E+03	1.413E+03	1.436E+03	1.424E+03	1.54756E+10	3.789E+09	3.379E-01	1.014E+10
AL7-02	**Spare 2A**	1865.25	2.844E+03	1.442E+03	1.416E+03	1.429E+03	1.50857E+10	3.810E+09	3.310E-01	1.014E+10

Appendix 42. NBG-18 (AG) elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
BW1-01	**1S4**	1876.45	2.829E+03	1.453E+03	1.45E+03	1.450E+03	1.50177E+10	3.945E+09	3.218E-01	1.043E+10
BW1-02	**1U1**	1877.24	2.874E+03	1.452E+03	1.467E+03	1.460E+03	1.55058E+10	3.999E+09	3.262E-01	1.061E+10
BW1-03	**1U4**	1876.88	2.880E+03	1.472E+03	1.453E+03	1.463E+03	1.55676E+10	4.014E+09	3.263E-01	1.065E+10
BW2-01	**2S2**	1877.83	2.870E+03	1.451E+03	1.453E+03	1.452E+03	1.54675E+10	3.959E+09	3.280E-01	1.052E+10
BW2-02	**2S11**	1877.51	2.880E+03	1.473E+03	1.454E+03	1.464E+03	1.55728E+10	4.021E+09	3.259E-01	1.066E+10
BW2-03	**2U2**	1881.76	2.880E+03	1.461E+03	1.466E+03	1.464E+03	1.56081E+10	4.030E+09	3.259E-01	1.069E+10
BW3-01	**2U11**	1876.06	2.870E+03	1.456E+03	1.462E+03	1.459E+03	1.54529E+10	3.994E+09	3.258E-01	1.059E+10
BW3-02	**3S2**	1874.18	2.875E+03	1.478E+03	1.475E+03	1.477E+03	1.54912E+10	4.086E+09	3.209E-01	1.079E+10
BW3-03	**3S11**	1877.96	2.883E+03	1.465E+03	1.453E+03	1.459E+03	1.56090E+10	3.998E+09	3.279E-01	1.062E+10
BW5-01	**3S14**	1878.68	2.860E+03	1.456E+03	1.465E+03	1.461E+03	1.53669E+10	4.007E+09	3.236E-01	1.061E+10
BW5-02	**3U2**	1874.39	2.877E+03	1.472E+03	1.462E+03	1.467E+03	1.55146E+10	4.034E+09	3.243E-01	1.068E+10
BW5-03	**3U11**	1878.50	2.893E+03	1.467E+03	1.479E+03	1.473E+03	1.57220E+10	4.076E+09	3.250E-01	1.080E+10
BW7-01	**3U13**	1875.83	2.884E+03	1.459E+03	1.469E+03	1.464E+03	1.56021E+10	4.020E+09	3.264E-01	1.067E+10
BW7-02	**4S5**	1873.62	2.865E+03	1.464E+03	1.465E+03	1.465E+03	1.53791E+10	4.018E+09	3.231E-01	1.063E+10
BW7-03	**4S14**	1877.66	2.873E+03	1.462E+03	1.472E+03	1.467E+03	1.54984E+10	4.041E+09	3.237E-01	1.070E+10
BW8-01	**4U5**	1875.56	2.859E+03	1.477E+03	1.471E+03	1.474E+03	1.53306E+10	4.075E+09	3.190E-01	1.075E+10
BW8-02	**4U7**	1876.83	2.862E+03	1.459E+03	1.484E+03	1.472E+03	1.53732E+10	4.064E+09	3.203E-01	1.073E+10
BW8-03	**4U13**	1877.18	2.870E+03	1.471E+03	1.472E+03	1.472E+03	1.54622E+10	4.065E+09	3.217E-01	1.074E+10
BW9-01	**5S8**	1879.44	2.852E+03	1.462E+03	1.444E+03	1.453E+03	1.52872E+10	3.968E+09	3.247E-01	1.051E+10
BW9-02	**5S15**	1876.47	2.867E+03	1.461E+03	1.461E+03	1.461E+03	1.54240E+10	4.005E+09	3.246E-01	1.061E+10
BW9-03	**5U5**	1880.90	2.872E+03	1.466E+03	1.475E+03	1.471E+03	1.55144E+10	4.067E+09	3.223E-01	1.076E+10
BW10-01	**5U8**	1878.03	2.858E+03	1.457E+03	1.477E+03	1.467E+03	1.53401E+10	4.042E+09	3.211E-01	1.068E+10
BW10-02	**5U14**	1878.03	2.855E+03	1.485E+03	1.477E+03	1.481E+03	1.53078E+10	4.119E+09	3.159E-01	1.084E+10
BW10-03	**6S6**	1879.12	2.865E+03	1.472E+03	1.483E+03	1.478E+03	1.54242E+10	4.102E+09	3.188E-01	1.082E+10
BW11-01	**6S13**	1874.72	2.864E+03	1.470E+03	1.460E+03	1.465E+03	1.53774E+10	4.024E+09	3.228E-01	1.064E+10

BW11-02	**6U3**	1876.72	2.855E+03	1.446E+03	1.461E+03	1.454E+03	1.52972E+10	3.965E+09	3.251E-01	1.051E+10
BW11-03	**6U6**	1877.07	2.848E+03	1.451E+03	1.472E+03	1.462E+03	1.52251E+10	4.009E+09	3.213E-01	1.059E+10
BW12-01	**6U12**	1875.97	2.864E+03	1.459E+03	1.459E+03	1.459E+03	1.53876E+10	3.993E+09	3.248E-01	1.058E+10
BW12-02	**Spare 1W**	1877.67	2.866E+03	1.479E+03	1.464E+03	1.471E+03	1.54197E+10	4.064E+09	3.211E-01	1.074E+10
BW12-03	**Spare 2W**	1879.13	2.862E+03	1.452E+03	1.453E+03	1.452E+03	1.53969E+10	3.962E+09	3.267E-01	1.051E+10
BW14C01	1PB18	1876.6834	2.845E+03	1.525E+03	1.479E+03	1.502E+03	1.51930E+10	4.235E+09	3.068E-01	1.107E+10
BW14C02	1PB25	1878.3570	2.837E+03	1.485E+03	1.471E+03	1.478E+03	1.51156E+10	4.104E+09	3.137E-01	1.078E+10
BW14C03	2PB18	1876.3025	2.848E+03	1.491E+03	1.509E+03	1.500E+03	1.52189E+10	4.222E+09	3.081E-01	1.104E+10
BW14C04	2PB24	1879.7184	2.851E+03	1.493E+03	1.500E+03	1.496E+03	1.52825E+10	4.209E+09	3.099E-01	1.103E+10
BW14C05	3PB18	1879.9257	2.866E+03	1.494E+03	1.491E+03	1.493E+03	1.54416E+10	4.188E+09	3.139E-01	1.100E+10
BW15C02	4PB18	1881.4485	2.860E+03	1.498E+03	1.473E+03	1.486E+03	1.53914E+10	4.153E+09	3.153E-01	1.092E+10
BW15C03	4PB23	1879.6854	2.823E+03	1.495E+03	1.524E+03	1.510E+03	1.49798E+10	4.283E+09	2.998E-01	1.113E+10
BW15C04	4PB25	1884.0855	2.848E+03	1.502E+03	1.495E+03	1.498E+03	1.52841E+10	4.230E+09	3.087E-01	1.107E+10
BW15C05	Spare 1	1881.7551	2.874E+03	1.495E+03	1.509E+03	1.502E+03	1.55391E+10	4.244E+09	3.122E-01	1.114E+10
BW15C08	Spare 2	1880.9804	2.860E+03	1.516E+03	1.477E+03	1.496E+03	1.53876E+10	4.212E+09	3.116E-01	1.105E+10

Appendix 43. NBG-18 (WG) elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (WG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
BL6-01	**1S1**	1872.85	2.903E+03	1.474E+03	1.588E+03	1.531E+03	1.57833E+10	4.390E+09	3.073E-01	1.148E+10
BL6-02	**2S12**	1877.90	2.860E+03	1.459E+03	1.457E+03	1.458E+03	1.53605E+10	3.992E+09	3.244E-01	1.057E+10
BL6-03	**3S12**	1875.02	2.871E+03	1.465E+03	1.443E+03	1.454E+03	1.54551E+10	3.964E+09	3.275E-01	1.052E+10
BL7-01	**4S7**	1879.26	2.930E+03	1.479E+03	1.503E+03	1.491E+03	1.61332E+10	4.178E+09	3.253E-01	1.107E+10
BL7-02	**5S5**	1875.20	2.890E+03	1.476E+03	1.473E+03	1.475E+03	1.56618E+10	4.077E+09	3.240E-01	1.080E+10
BL7-03	**6S3**	1876.08	2.930E+03	1.462E+03	1.472E+03	1.467E+03	1.61060E+10	4.037E+09	3.327E-01	1.076E+10
BL8-01	**Spare 1A**	1877.02	2.897E+03	1.434E+03	1.470E+03	1.452E+03	1.57504E+10	3.959E+09	3.321E-01	1.055E+10
BL8-02	**Spare 2A**	1877.56	2.865E+03	1.473E+03	1.461E+03	1.467E+03	1.54110E+10	4.042E+09	3.222E-01	1.069E+10

Appendix 44. H-451 elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
CW7-01	**1S8**	1715.45	2.593E+03	1.318E+03	1.331E+03	1.325E+03	1.15341E+10	3.009E+09	3.235E-01	7.966E+09
CW7-03	**1S15**	1714.12	2.519E+03	1.318E+03	1.321E+03	1.320E+03	1.08767E+10	2.984E+09	3.109E-01	7.825E+09
CW8-02	**1U8**	1714.32	2.521E+03	1.315E+03	1.327E+03	1.321E+03	1.08953E+10	2.992E+09	3.107E-01	7.842E+09
CW8-03	**1U14**	1712.56	2.524E+03	1.311E+03	1.326E+03	1.319E+03	1.09100E+10	2.977E+09	3.123E-01	7.814E+09
CW9-01	**2S13**	1707.51	2.547E+03	1.332E+03	1.324E+03	1.328E+03	1.10770E+10	3.011E+09	3.133E-01	7.910E+09
CW9-02	**2U12**	1709.95	2.508E+03	1.326E+03	1.314E+03	1.320E+03	1.07557E+10	2.979E+09	3.084E-01	7.797E+09
CW9-03	**3S1**	1708.42	2.513E+03	1.320E+03	1.313E+03	1.317E+03	1.07889E+10	2.961E+09	3.109E-01	7.763E+09
CW10-01	**3S10**	1713.25	2.557E+03	1.317E+03	1.318E+03	1.318E+03	1.12016E+10	2.974E+09	3.193E-01	7.847E+09
CW10-02	**3U1**	1711.66	2.554E+03	1.328E+03	1.336E+03	1.332E+03	1.11650E+10	3.037E+09	3.132E-01	7.976E+09
CW10-03	**3U10**	1716.60	2.546E+03	1.330E+03	1.318E+03	1.324E+03	1.11272E+10	3.009E+09	3.147E-01	7.912E+09
CW11-01	**4S2**	1715.93	2.577E+03	1.340E+03	1.335E+03	1.338E+03	1.13953E+10	3.070E+09	3.157E-01	8.077E+09
CW11-02	**4S13**	1713.01	2.536E+03	1.315E+03	1.309E+03	1.312E+03	1.10169E+10	2.949E+09	3.173E-01	7.768E+09
CW11-03	**4U2**	1716.09	2.523E+03	1.314E+03	1.314E+03	1.314E+03	1.09238E+10	2.963E+09	3.139E-01	7.786E+09
CW12-01	**4U12**	1713.64	2.528E+03	1.328E+03	1.341E+03	1.335E+03	1.09515E+10	3.052E+09	3.068E-01	7.976E+09
CW12-02	**5S7**	1710.23	2.536E+03	1.339E+03	1.335E+03	1.337E+03	1.09990E+10	3.057E+09	3.075E-01	7.995E+09
CW13-01	**5U7**	1723.03	2.587E+03	1.338E+03	1.345E+03	1.342E+03	1.15315E+10	3.101E+09	3.161E-01	8.162E+09
CW13-02	**6S5**	1725.16	2.593E+03	1.366E+03	1.373E+03	1.370E+03	1.15994E+10	3.236E+09	3.066E-01	8.455E+09
CW13-03	**6S9**	1722.19	2.572E+03	1.361E+03	1.345E+03	1.353E+03	1.13926E+10	3.153E+09	3.087E-01	8.252E+09
CW14-01	**6U5**	1720.57	2.600E+03	1.338E+03	1.357E+03	1.348E+03	1.16311E+10	3.124E+09	3.164E-01	8.225E+09
CW14-02	**6U9**	1715.96	2.561E+03	1.344E+03	1.359E+03	1.352E+03	1.12545E+10	3.134E+09	3.070E-01	8.193E+09
CW15-01	**Spare 1**	1717.37	2.546E+03	1.319E+03	1.317E+03	1.318E+03	1.11304E+10	2.984E+09	3.168E-01	7.860E+09
CW15-02	**Spare 2**	1709.95	2.605E+03	1.336E+03	1.315E+03	1.325E+03	1.16061E+10	3.004E+09	3.254E-01	7.962E+09
CW1C02	2PB20	1740.849	2.574E+03	1.362E+03	1.410E+03	1.386E+03	1.15374E+10	3.345E+09	2.958E-01	8.669E+09
CW1C03	3PB20	1728.101	2.649E+03	1.374E+03	1.330E+03	1.352E+03	1.21298E+10	3.158E+09	3.240E-01	8.363E+09
CW1C04	4PB20	1727.29	2.570E+03	1.418E+03	1.450E+03	1.434E+03	1.14115E+10	3.552E+09	2.741E-01	9.050E+09

CW2C01	6PB21	1735.318	2.661E+03	1.413E+03	1.433E+03	1.423E+03	1.22831E+10	3.514E+09	2.997E-01	9.133E+09
CW2C03	Spare 1	1736.122	2.663E+03	1.318E+03	1.387E+03	1.352E+03	1.23121E+10	3.175E+09	3.263E-01	8.421E+09
CW2C05	Spare 2	1731.953	2.662E+03	1.405E+03	1.417E+03	1.411E+03	1.22747E+10	3.449E+09	3.046E-01	8.999E+09

Appendix 45. PCEA (WG) elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
DW1-01	**1S2**	1809.56	2.695E+03	1.402E+03	1.397E+03	1.400E+03	1.31429E+10	3.544E+09	3.154E-01	9.324E+09
DW1-02	**1S6**	1811.01	2.683E+03	1.410E+03	1.410E+03	1.410E+03	1.30366E+10	3.600E+09	3.092E-01	9.428E+09
DW1-03	**1S14**	1813.63	2.686E+03	1.418E+03	1.415E+03	1.417E+03	1.30846E+10	3.639E+09	3.074E-01	9.515E+09
DW2-01	**1U2**	1813.20	2.682E+03	1.411E+03	1.418E+03	1.415E+03	1.30426E+10	3.628E+09	3.073E-01	9.486E+09
DW2-02	**1U6**	1809.03	2.697E+03	1.387E+03	1.406E+03	1.397E+03	1.31585E+10	3.528E+09	3.168E-01	9.292E+09
DW2-03	**1U13**	1809.20	2.668E+03	1.416E+03	1.417E+03	1.417E+03	1.28783E+10	3.630E+09	3.037E-01	9.465E+09
DW3-01	**2S1**	1813.98	2.697E+03	1.402E+03	1.415E+03	1.409E+03	1.31945E+10	3.599E+09	3.125E-01	9.446E+09
DW3-02	**2S8**	1813.29	2.680E+03	1.404E+03	1.415E+03	1.410E+03	1.30238E+10	3.602E+09	3.088E-01	9.430E+09
DW3-03	**2S14**	1814.86	2.691E+03	1.405E+03	1.397E+03	1.401E+03	1.31423E+10	3.562E+09	3.141E-01	9.362E+09
DW4-01	**2U8**	1807.27	2.664E+03	1.397E+03	1.386E+03	1.392E+03	1.28260E+10	3.499E+09	3.124E-01	9.185E+09
DW4-03	**2U1**	1809.58	2.700E+03	1.413E+03	1.409E+03	1.411E+03	1.31919E+10	3.603E+09	3.121E-01	9.455E+09
DW5-01	**2U13**	1794.28	2.663E+03	1.395E+03	1.371E+03	1.383E+03	1.27243E+10	3.432E+09	3.153E-01	9.028E+09
DW5-02	**3S15**	1804.82	2.647E+03	1.408E+03	1.394E+03	1.401E+03	1.26457E+10	3.543E+09	3.054E-01	9.249E+09
DW5-03	**3U6**	1812.77	2.666E+03	1.423E+03	1.401E+03	1.412E+03	1.28844E+10	3.614E+09	3.051E-01	9.434E+09
DW6-01	**3U14**	1813.39	2.691E+03	1.423E+03	1.422E+03	1.423E+03	1.31316E+10	3.669E+09	3.061E-01	9.585E+09
DW6-02	**4S15**	1813.53	2.691E+03	1.411E+03	1.412E+03	1.412E+03	1.31327E+10	3.613E+09	3.102E-01	9.468E+09
DW6-03	**4U1**	1804.91	2.685E+03	1.419E+03	1.435E+03	1.427E+03	1.30120E+10	3.675E+09	3.032E-01	9.579E+09
DW7-01	**4U6**	1814.26	2.691E+03	1.415E+03	1.415E+03	1.415E+03	1.31379E+10	3.633E+09	3.089E-01	9.509E+09
DW7-02	**4U14**	1813.80	2.688E+03	1.429E+03	1.414E+03	1.422E+03	1.31054E+10	3.665E+09	3.059E-01	9.572E+09
DW7-03	**5S4**	1811.49	2.675E+03	1.429E+03	1.410E+03	1.420E+03	1.29624E+10	3.650E+09	3.040E-01	9.520E+09
DW8-01	**5S9**	1814.24	2.683E+03	1.402E+03	1.412E+03	1.407E+03	1.30598E+10	3.592E+09	3.103E-01	9.412E+09
DA702	**5S11**	1811.44	2.688E+03	1.410E+03	1.434E+03	1.422E+03	1.30883E+10	3.663E+09	3.057E-01	9.565E+09
DW8-02	**5S12**	1816.54	2.689E+03	1.409E+03	1.415E+03	1.412E+03	1.31349E+10	3.622E+09	3.096E-01	9.486E+09
DW8-03	**5U4**	1818.12	2.698E+03	1.416E+03	1.427E+03	1.422E+03	1.32345E+10	3.674E+09	3.079E-01	9.610E+09
DW9-01	**5U9**	1807.55	2.678E+03	1.428E+03	1.413E+03	1.421E+03	1.29632E+10	3.647E+09	3.042E-01	9.514E+09

DW9-02	**5U11**	1808.19	2.692E+03	1.403E+03	1.413E+03	1.408E+03	1.31037E+10	3.585E+09	3.117E-01	9.404E+09
DW9-03	**6S4**	1818.07	2.683E+03	1.415E+03	1.433E+03	1.424E+03	1.30874E+10	3.687E+09	3.039E-01	9.614E+09
DW10-01	**6S11**	1812.13	2.678E+03	1.389E+03	1.399E+03	1.394E+03	1.29960E+10	3.521E+09	3.142E-01	9.255E+09
DA801	**6S12**	1817.50	2.698E+03	1.415E+03	1.403E+03	1.409E+03	1.32300E+10	3.608E+09	3.125E-01	9.472E+09
DW10-02	**6U11**	1809.81	2.669E+03	1.382E+03	1.386E+03	1.384E+03	1.28923E+10	3.467E+09	3.161E-01	9.125E+09
DW10-03	**6U4**	1812.47	2.692E+03	1.382E+03	1.373E+03	1.378E+03	1.31348E+10	3.439E+09	3.226E-01	9.098E+09
DW11-01	**Spare 1W**	1811.47	2.686E+03	1.418E+03	1.414E+03	1.416E+03	1.30705E+10	3.633E+09	3.075E-01	9.500E+09
DW11-02	**Spare 2W**	1812.79	2.698E+03	1.402E+03	1.416E+03	1.409E+03	1.31918E+10	3.599E+09	3.124E-01	9.448E+09
DW14C01	1PB17	1818.936	2.661E+03	1.475E+03	1.442E+03	1.458E+03	1.28781E+10	3.868E+09	2.854E-01	9.943E+09
DW14C02	1PB24	1814.329	2.586E+03	1.484E+03	1.494E+03	1.489E+03	1.21305E+10	4.022E+09	2.520E-01	1.007E+10
DW14C03	2PB17	1822.595	2.618E+03	1.498E+03	1.484E+03	1.491E+03	1.24937E+10	4.051E+09	2.601E-01	1.021E+10
DW14C04	3PB17	1822.329	2.640E+03	1.519E+03	1.477E+03	1.498E+03	1.26969E+10	4.089E+09	2.625E-01	1.032E+10
DW14C05	3PB23	1823.18	2.627E+03	1.482E+03	1.493E+03	1.488E+03	1.25777E+10	4.035E+09	2.638E-01	1.020E+10
DW15C01	3PB25	1818.408	2.575E+03	1.501E+03	1.487E+03	1.494E+03	1.20591E+10	4.059E+09	2.463E-01	1.012E+10
DW15C02	4PB17	1820.562	2.618E+03	1.487E+03	1.487E+03	1.487E+03	1.24797E+10	4.027E+09	2.618E-01	1.016E+10
DW15C03	4PB24	1820.937	2.597E+03	1.455E+03	1.505E+03	1.480E+03	1.22785E+10	3.988E+09	2.595E-01	1.005E+10
DW15C04	Spare 1	1819.892	2.651E+03	1.467E+03	1.473E+03	1.470E+03	1.27903E+10	3.933E+09	2.780E-01	1.005E+10
DW15C05	Spare 2	1817.409	2.663E+03	1.488E+03	1.484E+03	1.486E+03	1.28845E+10	4.012E+09	2.739E-01	1.022E+10

Appendix 46. PCEA (AG) elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (WG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
DA601	**3S6**	1781.45	2.484E+03	1.352E+03	1.338E+03	1.345E+03	1.09920E+10	3.223E+09	2.926E-01	8.331E+09
DA602	**4S1**	1776.49	2.474E+03	1.338E+03	1.360E+03	1.349E+03	1.08733E+10	3.233E+09	2.884E-01	8.331E+09
DA701	**4S6**	1776.17	2.494E+03	1.415E+03	1.34E+03	1.380E+03	1.10478E+10	3.380E+09	2.796E-01	8.650E+09
DA802	**Spare 1A**	1776.05	2.395E+03	1.346E+03	1.330E+03	1.338E+03	1.01872E+10	3.179E+09	2.732E-01	8.095E+09
DA901	**Spare 2A**	1776.04	2.373E+03	1.314E+03	1.317E+03	1.315E+03	1.00004E+10	3.072E+09	2.783E-01	7.854E+09

Appendix 47. IG-110 elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho v l^2$	Shear Modulus, [Pa] $G=\rho v s^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
EW2-01	**1S7**	1759.31	2.307E+03	1.334E+03	1.327E+03	1.331E+03	9.36351E+09	3.114E+09	0.2508	7.791E+09
EW2-02	**1S9**	1760.72	2.333E+03	1.345E+03	1.352E+03	1.349E+03	9.58342E+09	3.202E+09	0.2491	7.999E+09
EW2-03	**1U7**	1761.71	2.329E+03	1.352E+03	1.333E+03	1.343E+03	9.55591E+09	3.175E+09	0.2512	7.945E+09
EW4-01	**1U9**	1766.13	2.347E+03	1.346E+03	1.368E+03	1.357E+03	9.72856E+09	3.252E+09	0.2489	8.124E+09
EW4-02	**2S5**	1764.30	2.326E+03	1.340E+03	1.336E+03	1.338E+03	9.54533E+09	3.159E+09	0.2527	7.914E+09
EW5-01	**2S7**	1759.28	2.325E+03	1.357E+03	1.352E+03	1.355E+03	9.51001E+09	3.228E+09	0.2431	8.025E+09
EW5-02	**2U5**	1763.80	2.360E+03	1.359E+03	1.359E+03	1.359E+03	9.82367E+09	3.258E+09	0.2519	8.156E+09
EW5-03	**2U7**	1763.45	2.317E+03	1.341E+03	1.343E+03	1.342E+03	9.46707E+09	3.176E+09	0.2476	7.924E+09
EW6-01	**3S9**	1766.83	2.358E+03	1.343E+03	1.358E+03	1.351E+03	9.82388E+09	3.222E+09	0.2559	8.094E+09
EW6-02	**3U9**	1766.05	2.346E+03	1.344E+03	1.362E+03	1.353E+03	9.71986E+09	3.233E+09	0.2508	8.088E+09
EW6-03	**4S4**	1769.17	2.374E+03	1.344E+03	1.350E+03	1.347E+03	9.97082E+09	3.210E+09	0.2626	8.106E+09
EW7-01	**4S9**	1765.01	2.367E+03	1.344E+03	1.362E+03	1.353E+03	9.88879E+09	3.231E+09	0.2573	8.125E+09
EW7-03	**4U4**	1763.79	2.326E+03	1.343E+03	1.353E+03	1.348E+03	9.54261E+09	3.205E+09	0.2471	7.994E+09
EW8-01	**4U9**	1765.48	2.318E+03	1.336E+03	1.348E+03	1.342E+03	9.48614E+09	3.180E+09	0.2479	7.936E+09
EW8-02	**5S1**	1765.30	2.345E+03	1.330E+03	1.360E+03	1.345E+03	9.70743E+09	3.193E+09	0.2549	8.015E+09
EW8-03	**5S13**	1766.24	2.354E+03	1.364E+03	1.351E+03	1.358E+03	9.78732E+09	3.255E+09	0.2509	8.143E+09
EW9-01	**5U1**	1772.80	2.365E+03	1.375E+03	1.354E+03	1.365E+03	9.91565E+09	3.301E+09	0.2505	8.255E+09
EW9-02	**5U12**	1766.00	2.388E+03	1.346E+03	1.364E+03	1.355E+03	1.00707E+10	3.242E+09	0.2626	8.188E+09
EW9-03	**6S14**	1768.45	2.341E+03	1.366E+03	1.336E+03	1.351E+03	9.69161E+09	3.228E+09	0.2503	8.072E+09
EW10-01	**6U13**	1766.30	2.361E+03	1.346E+03	1.345E+03	1.346E+03	9.84593E+09	3.198E+09	0.2595	8.055E+09
EW10-02	**Spare 1**	1765.82	2.372E+03	1.314E+03	1.346E+03	1.330E+03	9.93257E+09	3.123E+09	0.2707	7.937E+09
EW10-03	**Spare 2**	1768.74	2.361E+03	1.345E+03	1.348E+03	1.347E+03	9.85553E+09	3.209E+09	0.2586	8.077E+09
EW13C01	1PB21	1787.00	2.388E+03	1.438E+03	1.426E+03	1.432E+03	1.01930E+10	3.665E+09	0.2192	8.938E+09
EW13C02	2PB21	1785.12	2.408E+03	1.455E+03	1.433E+03	1.444E+03	1.03475E+10	3.721E+09	0.2192	9.074E+09
EW13C03	2PB23	1783.37	2.408E+03	1.392E+03	1.449E+03	1.420E+03	1.03374E+10	3.598E+09	0.2331	8.872E+09

EW13C04	3PB21	1785.07	2.408E+03	1.426E+03	1.446E+03	1.436E+03	1.03473E+10	3.680E+09	0.2240	9.010E+09
EW14C01	4PB21	1787.01	2.391E+03	1.456E+03	1.417E+03	1.437E+03	1.02124E+10	3.689E+09	0.2173	8.981E+09
EW14C04	Spare 1	1780.67	2.390E+03	1.422E+03	1.400E+03	1.411E+03	1.01730E+10	3.547E+09	0.2323	8.743E+09
EW14C05	Spare 2	1783.11	2.391E+03	1.417E+03	1.417E+03	1.417E+03	1.01933E+10	3.583E+09	0.2290	8.806E+09

Appendix 48. IG-430 elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
FW1-01	**1S5**	1809.00	2.369E+03	1.489E+03	1.522E+03	1.506E+03	1.015E+10	4.100E+09	1.613E-01	9.523E+09
FW1-02	**1S10**	1817.86	2.352E+03	1.516E+03	1.508E+03	1.512E+03	1.006E+10	4.156E+09	1.478E-01	9.540E+09
FW1-03	**1U5**	1819.51	2.365E+03	1.498E+03	1.519E+03	1.509E+03	1.018E+10	4.140E+09	1.571E-01	9.581E+09
FW2-01	**1U10**	1811.11	2.371E+03	1.541E+03	1.488E+03	1.515E+03	1.018E+10	4.154E+09	1.554E-01	9.599E+09
FW2-02	**2S3**	1812.64	2.353E+03	1.518E+03	1.494E+03	1.506E+03	1.004E+10	4.111E+09	1.531E-01	9.481E+09
FW2-03	**2S9**	1815.40	2.354E+03	1.526E+03	1.492E+03	1.509E+03	1.006E+10	4.134E+09	1.512E-01	9.518E+09
FW3-01	**2S15**	1814.00	2.440E+03	1.536E+03	1.548E+03	1.542E+03	1.080E+10	4.313E+09	1.675E-01	1.007E+10
FW3-02	**2U3**	1809.89	2.389E+03	1.507E+03	1.515E+03	1.511E+03	1.033E+10	4.132E+09	1.666E-01	9.641E+09
FW3-03	**2U9**	1816.86	2.372E+03	1.505E+03	1.525E+03	1.515E+03	1.022E+10	4.170E+09	1.555E-01	9.637E+09
FW4-01	**2U14**	1809.84	2.390E+03	1.524E+03	1.497E+03	1.511E+03	1.034E+10	4.129E+09	1.675E-01	9.642E+09
FW4-02	**3S3**	1814.51	2.387E+03	1.522E+03	1.516E+03	1.519E+03	1.034E+10	4.187E+09	1.597E-01	9.711E+09
FW4-03	**3S4**	1821.30	2.382E+03	1.516E+03	1.498E+03	1.507E+03	1.033E+10	4.136E+09	1.663E-01	9.648E+09
FW5-01	**3S5**	1818.55	2.389E+03	1.524E+03	1.492E+03	1.508E+03	1.038E+10	4.135E+09	1.688E-01	9.667E+09
FW5-02	**3S7**	1821.03	2.418E+03	1.516E+03	1.538E+03	1.527E+03	1.065E+10	4.246E+09	1.683E-01	9.922E+09
FW5-03	**3U3**	1822.49	2.404E+03	1.516E+03	1.512E+03	1.514E+03	1.053E+10	4.178E+09	1.713E-01	9.786E+09
FW7-01	**3U4**	1812.11	2.370E+03	1.507E+03	1.485E+03	1.496E+03	1.018E+10	4.056E+09	1.688E-01	9.480E+09
FW7-02	**3U5**	1814.65	2.343E+03	1.486E+03	1.514E+03	1.500E+03	9.962E+09	4.083E+09	1.527E-01	9.413E+09
FW7-03	**3U7**	1809.75	2.348E+03	1.508E+03	1.502E+03	1.505E+03	9.977E+09	4.099E+09	1.513E-01	9.439E+09
FW8-01	**4S3**	1816.68	2.408E+03	1.508E+03	1.515E+03	1.512E+03	1.053E+10	4.150E+09	1.749E-01	9.753E+09
FW8-02	**4S10**	1817.03	2.372E+03	1.492E+03	1.510E+03	1.501E+03	1.022E+10	4.094E+09	1.661E-01	9.547E+09
FW8-03	**4U3**	1807.51	2.348E+03	1.512E+03	1.503E+03	1.508E+03	9.965E+09	4.108E+09	1.494E-01	9.442E+09
FW9-01	**4U10**	1819.95	2.451E+03	1.530E+03	1.525E+03	1.528E+03	1.093E+10	4.246E+09	1.825E-01	1.004E+10
FW9-02	**5S2**	1814.42	2.390E+03	1.517E+03	1.492E+03	1.505E+03	1.036E+10	4.107E+09	1.718E-01	9.625E+09
FW9-03	**5S10**	1820.40	2.379E+03	1.520E+03	1.513E+03	1.517E+03	1.030E+10	4.187E+09	1.578E-01	9.694E+09
FW10-01	**5U2**	1819.13	2.439E+03	1.511E+03	1.516E+03	1.514E+03	1.082E+10	4.167E+09	1.869E-01	9.892E+09

FW10-02	**5U10**	1822.13	2.432E+03	1.509E+03	1.532E+03	1.521E+03	1.078E+10	4.213E+09	1.791E-01	9.935E+09
FW10-03	**6S2**	1824.38	2.413E+03	1.521E+03	1.505E+03	1.513E+03	1.062E+10	4.176E+09	1.761E-01	9.823E+09
FW11-01	**6S7**	1820.41	2.372E+03	1.506E+03	1.519E+03	1.513E+03	1.024E+10	4.164E+09	1.574E-01	9.640E+09
FW11-02	**6S10**	1817.74	2.397E+03	1.516E+03	1.538E+03	1.527E+03	1.044E+10	4.238E+09	1.585E-01	9.820E+09
FW11-03	**6U2**	1817.79	2.355E+03	1.511E+03	1.490E+03	1.501E+03	1.008E+10	4.093E+09	1.583E-01	9.481E+09
FW12-01	**6U7**	1810.42	2.359E+03	1.517E+03	1.492E+03	1.505E+03	1.007E+10	4.098E+09	1.572E-01	9.484E+09
FW12-02	**6U10**	1814.22	2.379E+03	1.484E+03	1.489E+03	1.487E+03	1.027E+10	4.009E+09	1.798E-01	9.459E+09
FW13-01	**Spare 1**	1823.30	2.404E+03	1.485E+03	1.480E+03	1.483E+03	1.053E+10	4.008E+09	1.929E-01	9.562E+09
FW13-02	**Spare 2**	1823.21	2.372E+03	1.493E+03	1.490E+03	1.492E+03	1.026E+10	4.057E+09	1.729E-01	9.516E+09
FW18C01	1PB19	1828.22	2.380E+03	1.388E+03	1.422E+03	1.405E+03	1.035E+10	3.611E+09	2.323E-01	8.898E+09
FW18C02	1PB23	1810.45	2.381E+03	1.436E+03	1.436E+03	1.436E+03	1.026E+10	3.734E+09	2.141E-01	9.066E+09
FW18C03	2PB19	1825.02	2.338E+03	1.420E+03	1.383E+03	1.402E+03	9.973E+09	3.586E+09	2.192E-01	8.745E+09
FW18C04	2PB25	1833.38	2.397E+03	1.492E+03	1.461E+03	1.477E+03	1.053E+10	3.998E+09	1.940E-01	9.547E+09
FW18C06	3PB19	1827.32	2.318E+03	1.419E+03	1.435E+03	1.427E+03	9.815E+09	3.719E+09	1.949E-01	8.888E+09
FW19C01	3PB24	1829.23	2.407E+03	1.445E+03	1.479E+03	1.462E+03	1.060E+10	3.910E+09	2.076E-01	9.444E+09
FW19C02	4PB19	1828.90	2.408E+03	1.446E+03	1.469E+03	1.458E+03	1.060E+10	3.886E+09	2.108E-01	9.410E+09
FW19C04	Spare 1	1826.29	2.382E+03	1.450E+03	1.477E+03	1.463E+03	1.036E+10	3.911E+09	1.968E-01	9.362E+09
FW19C05	Spare 2	1826.60	2.321E+03	1.414E+03	1.433E+03	1.424E+03	9.839E+09	3.703E+09	1.982E-01	8.875E+09

Appendix 49. A3-Matrix elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
H-3-1	CPB2	1.358E+03	1.233E+03	9.533E+02	9.448E+02	9.490E+02	2.06301E+09	1.223E+09	-2.279E-01	1.888E+09
H-3-2	CPB12	1.324E+03	1.195E+03	9.087E+02	8.957E+02	9.022E+02	1.89100E+09	1.078E+09	-1.631E-01	1.805E+09
H-4-1	CPB22	1.286E+03	1.219E+03	8.336E+02	8.587E+02	8.461E+02	1.91110E+09	9.210E+08	3.485E-02	1.906E+09
H-4-2	CPB32	1.242E+03	1.039E+03	8.529E+02	8.314E+02	8.421E+02	1.34170E+09	8.810E+08	-4.562E-01	9.583E+08
H-5-1	CPB42	1.367E+03	1.194E+03	7.698E+02	7.891E+02	7.795E+02	1.94933E+09	8.306E+08	1.288E-01	1.875E+09
H-5-2	CPB52	1.336E+03	1.332E+03	8.618E+02	8.119E+02	8.368E+02	2.36998E+09	9.356E+08	1.739E-01	2.196E+09
H-7-1	CPB62	1.366E+03	1.250E+03	8.460E+02	8.304E+02	8.382E+02	2.13427E+09	9.596E+08	9.151E-02	2.095E+09
H-7-2	CPB72	1.339E+03	1.349E+03	8.182E+02	7.924E+02	8.053E+02	2.43496E+09	8.684E+08	2.228E-01	2.124E+09
H-8-1	CPB82	1.361E+03	1.214E+03	7.403E+02	7.492E+02	7.447E+02	2.00712E+09	7.550E+08	1.985E-01	1.810E+09
H-8-2	CPB92	1.328E+03	1.222E+03	7.323E+02	8.495E+02	7.909E+02	1.98396E+09	8.305E+08	1.400E-01	1.893E+09
H-9-1	CPB102	1.360E+03	1.173E+03	7.852E+02	7.671E+02	7.761E+02	1.87302E+09	8.194E+08	1.111E-01	1.821E+09
H-9-2	CPB112	1.330E+03	1.217E+03	7.657E+02	8.448E+02	8.053E+02	1.96898E+09	8.626E+08	1.102E-01	1.915E+09
H-10-1	CPB122	1.240E+03	1.068E+03	7.345E+02	6.831E+02	7.088E+02	1.41496E+09	6.228E+08	1.069E-01	1.379E+09
H-10-2	CPB132	1.286E+03	1.213E+03	7.422E+02	7.957E+02	7.690E+02	1.89136E+09	7.604E+08	1.638E-01	1.770E+09
H-12-1	CPB142	1.359E+03	1.156E+03	8.384E+02	8.114E+02	8.249E+02	1.81638E+09	9.246E+08	-1.835E-02	1.815E+09
H-12-2	CPB152	1.327E+03	1.256E+03	8.506E+02	8.658E+02	8.582E+02	2.09245E+09	9.776E+08	6.158E-02	2.076E+09
H-13-1	CPB162	1.252E+03	1.192E+03	8.515E+02	8.343E+02	8.429E+02	1.78054E+09	8.897E+08	6.079E-04	1.781E+09
H-13-2	CPB172	1.295E+03	1.299E+03	8.364E+02	8.808E+02	8.586E+02	2.18722E+09	9.550E+08	1.125E-01	2.125E+09
H-14-1	CPB182	1.491E+03	1.551E+03	9.789E+02	1.023E+03	1.001E+03	3.58938E+09	1.495E+09	1.432E-01	3.418E+09
H-14-2	CPB192	1.527E+03	1.676E+03	1.053E+03	1.028E+03	1.040E+03	4.29091E+09	1.653E+09	1.867E-01	3.923E+09
H-15-1	Spare 1	1.494E+03	1.555E+03	1.040E+03	1.012E+03	1.026E+03	3.61336E+09	1.573E+09	1.146E-01	3.506E+09
H-15-2	Spare 2	1.532E+03	1.650E+03	1.036E+03	1.052E+03	1.044E+03	4.17245E+09	1.670E+09	1.665E-01	3.895E+09
H-16-1	5PB22	1.582E+03	1.646E+03	1.053E+03	1.044E+03	1.048E+03	4.28910E+09	1.739E+09	1.590E-01	4.031E+09
H-16-2	6PB17	1.559E+03	1.642E+03	1.049E+03	1.051E+03	1.050E+03	4.20429E+09	1.719E+09	1.541E-01	3.968E+09
H-17-1	6PB22	1.578E+03	1.644E+03	1.042E+03	1.075E+03	1.059E+03	4.26445E+09	1.768E+09	1.458E-01	4.052E+09

H-18-1	Spare 1	1.582E+03	1.730E+03	1.026E+03	1.020E+03	1.023E+03	4.73559E+09	1.655E+09	2.313E-01	4.076E+09
H-18-2	Spare 2	1.553E+03	1.667E+03	9.764E+02	9.840E+02	9.802E+02	4.31438E+09	1.492E+09	2.357E-01	3.687E+09

Appendix 50. HLM elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
J1B03	CPB3	1767.4706	2.829E+03	1.440E+03	1.378E+03	1.409E+03	1.41457E+10	3.509E+09	3.351E-01	9.368E+09
J1B04	CPB13	1768.7270	2.907E+03	1.502E+03	1.415E+03	1.458E+03	1.49457E+10	3.760E+09	3.319E-01	1.002E+10
J1B05	CPB23	1767.5527	2.893E+03	1.430E+03	1.380E+03	1.405E+03	1.47950E+10	3.491E+09	3.456E-01	9.394E+09
J1B06	CPB33	1763.4060	2.933E+03	1.456E+03	1.424E+03	1.440E+03	1.51731E+10	3.656E+09	3.413E-01	9.808E+09
J1B07	CPB43	1760.4106	2.934E+03	1.450E+03	1.488E+03	1.469E+03	1.51521E+10	3.798E+09	3.327E-01	1.012E+10
J2B01	CPB53	1764.0791	2.906E+03	1.487E+03	1.463E+03	1.475E+03	1.49017E+10	3.840E+09	3.265E-01	1.019E+10
J2B03	CPB63	1767.1445	2.960E+03	1.354E+03	1.334E+03	1.344E+03	1.54859E+10	3.190E+09	3.703E-01	8.743E+09
J2B04	CPB73	1765.7921	2.933E+03	1.446E+03	1.463E+03	1.455E+03	1.51889E+10	3.737E+09	3.369E-01	9.991E+09
J2B05	CPB83	1765.7862	2.932E+03	1.453E+03	1.420E+03	1.436E+03	1.51840E+10	3.644E+09	3.421E-01	9.780E+09
J2B06	CPB93	1761.4217	2.932E+03	1.401E+03	1.446E+03	1.423E+03	1.51417E+10	3.569E+09	3.458E-01	9.607E+09
J5B01	CPB103	1771.9126	2.932E+03	1.446E+03	1.470E+03	1.458E+03	1.52367E+10	3.766E+09	3.358E-01	1.006E+10
J5B02	CPB113	1768.5414	2.933E+03	1.411E+03	1.487E+03	1.449E+03	1.52173E+10	3.714E+09	3.385E-01	9.944E+09
J5B04	CPB123	1768.4374	2.893E+03	1.443E+03	1.443E+03	1.443E+03	1.47977E+10	3.683E+09	3.343E-01	9.828E+09
J5B05	CPB133	1768.7288	2.960E+03	1.405E+03	1.392E+03	1.398E+03	1.54998E+10	3.459E+09	3.564E-01	9.384E+09
J5B06	CPB143	1767.4745	3.075E+03	1.453E+03	1.386E+03	1.420E+03	1.67152E+10	3.562E+09	3.646E-01	9.721E+09
J6B01	CPB153	1769.5076	2.965E+03	1.444E+03	1.418E+03	1.431E+03	1.55528E+10	3.623E+09	3.482E-01	9.768E+09
J6B02	CPB163	1764.7210	2.961E+03	1.417E+03	1.421E+03	1.419E+03	1.54696E+10	3.554E+09	3.509E-01	9.601E+09
J6B03	CPB173	1768.1615	2.960E+03	1.365E+03	1.446E+03	1.406E+03	1.54900E+10	3.493E+09	3.544E-01	9.463E+09
J6B05	CPB183	1763.1962	2.816E+03	1.398E+03	1.446E+03	1.422E+03	1.39775E+10	3.567E+09	3.287E-01	9.480E+09
J6B06	Spare 1	1765.8882	2.920E+03	1.440E+03	1.477E+03	1.459E+03	1.50595E+10	3.758E+09	3.337E-01	1.002E+10
J6B08	Spare 2	1768.8515	2.919E+03	1.417E+03	1.402E+03	1.409E+03	1.50753E+10	3.514E+09	3.480E-01	9.473E+09
J3C01	6PB18	1767.0234	2.988E+03	1.433E+03	1.404E+03	1.419E+03	1.57734E+10	3.557E+09	3.544E-01	9.635E+09
J3C04	6PB24	1760.8976	2.987E+03	1.433E+03	1.526E+03	1.479E+03	1.57138E+10	3.854E+09	3.375E-01	1.031E+10
J7C03	Spare 1	1767.1097	2.986E+03	1.410E+03	1.407E+03	1.408E+03	1.57593E+10	3.505E+09	3.570E-01	9.514E+09
J7C04	Spare 2	1760.2151	3.030E+03	1.483E+03	1.423E+03	1.453E+03	1.61568E+10	3.716E+09	3.507E-01	1.004E+10

Appendix 51. PGX elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] E=ρvl^2	Shear Modulus, [Pa] G=ρvs^2	Poisson's Ratio μ=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])	Elastic Modulus, [Pa] E=ρvl^2[(1+μ)(1-2μ)/(1-μ)]
			Longitudinal	Shear 0°	Shear 90°					
K2B01	CPB4	1771.0299	2.414E+03	1.384E+03	1.315E+03	1.349E+03	1.03183E+10	3.224E+09	2.727E-01	8.207E+09
K2B02	CPB14	1772.7340	2.463E+03	1.284E+03	1.241E+03	1.262E+03	1.07510E+10	2.825E+09	3.218E-01	7.468E+09
K2B03	CPB24	1776.3000	2.365E+03	1.326E+03	1.329E+03	1.328E+03	9.93775E+09	3.130E+09	2.701E-01	7.952E+09
K2B04	CPB34	1773.9830	2.405E+03	1.343E+03	1.252E+03	1.297E+03	1.02570E+10	2.986E+09	2.946E-01	7.733E+09
K2B05	CPB44	1772.6084	2.397E+03	1.310E+03	1.361E+03	1.336E+03	1.01877E+10	3.163E+09	2.749E-01	8.064E+09
K2B06	CPB54	1773.2222	2.399E+03	1.204E+03	1.158E+03	1.181E+03	1.02053E+10	2.473E+09	3.401E-01	6.629E+09
K2B07	CPB64	1774.8059	2.432E+03	1.351E+03	1.346E+03	1.348E+03	1.05000E+10	3.227E+09	2.782E-01	8.249E+09
K3B01	CPB74	1770.0208	2.450E+03	1.256E+03	1.362E+03	1.309E+03	1.06245E+10	3.033E+09	3.002E-01	7.887E+09
K3B02	CPB84	1770.3860	2.435E+03	1.284E+03	1.322E+03	1.303E+03	1.05003E+10	3.006E+09	2.994E-01	7.813E+09
K3B03	CPB94	1771.7907	2.441E+03	1.167E+03	1.323E+03	1.245E+03	1.05572E+10	2.746E+09	3.242E-01	7.273E+09
K3B04	CPB104	1773.1438	2.409E+03	1.296E+03	1.360E+03	1.328E+03	1.02901E+10	3.127E+09	2.817E-01	8.016E+09
K3B05	CPB114	1774.2434	2.544E+03	1.348E+03	1.401E+03	1.375E+03	1.14828E+10	3.352E+09	2.939E-01	8.674E+09
K3B06	CPB124	1774.6426	2.344E+03	1.316E+03	1.361E+03	1.339E+03	9.75048E+09	3.179E+09	2.581E-01	8.000E+09
K3B07	CPB134	1774.3163	2.491E+03	1.335E+03	1.361E+03	1.348E+03	1.10098E+10	3.224E+09	2.929E-01	8.337E+09
K6B01	CPB144	1775.7881	2.474E+03	1.359E+03	1.249E+03	1.304E+03	1.08690E+10	3.020E+09	3.077E-01	7.897E+09
K6B02	CPB154	1775.5764	2.475E+03	1.317E+03	1.362E+03	1.340E+03	1.08765E+10	3.186E+09	2.929E-01	8.238E+09
K6B03	CPB164	1773.0724	2.418E+03	1.306E+03	1.230E+03	1.268E+03	1.03667E+10	2.851E+09	3.103E-01	7.471E+09
K6B04	CPB174	1773.3787	2.366E+03	1.268E+03	1.376E+03	1.322E+03	9.92730E+09	3.099E+09	2.730E-01	7.891E+09
K6B05	CPB184	1772.8610	2.465E+03	1.162E+03	1.380E+03	1.271E+03	1.07723E+10	2.864E+09	3.189E-01	7.555E+09
K6B06	Spare 1	1773.9678	2.398E+03	1.336E+03	1.350E+03	1.343E+03	1.02051E+10	3.200E+09	2.716E-01	8.137E+09
K6B07	Spare 2	1773.1640	2.454E+03	1.356E+03	1.303E+03	1.329E+03	1.06771E+10	3.133E+09	2.924E-01	8.097E+09
K4C01	6PB19	1774.7054	2.455E+03	1.303E+03	1.287E+03	1.295E+03	1.06932E+10	2.977E+09	3.071E-01	7.782E+09
K4C02	Spare 1	1778.1346	2.410E+03	1.283E+03	1.180E+03	1.232E+03	1.03266E+10	2.697E+09	3.232E-01	7.138E+09
K5C01	Spare 2	1778.1915	2.536E+03	1.335E+03	1.349E+03	1.342E+03	1.14397E+10	3.203E+09	3.056E-01	8.363E+09

Appendix 52. PPEA elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] E=ρvl^2	Shear Modulus, [Pa] G=ρvs^2	Poisson's Ratio μ=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])	Elastic Modulus, [Pa] E=ρvl^2[(1+μ)(1-2μ)/(1-μ)]
			Longitudinal	Shear 0°	Shear 90°					
L2B02	CPB5	1839.75	2.827E+03	1.449E+03	1.429E+03	1.439E+03	1.47009E+10	3.810E+09	3.251E-01	1.010E+10
L2B03	CPB15	1840.05	2.766E+03	1.501E+03	1.456E+03	1.478E+03	1.40727E+10	4.021E+09	3.000E-01	1.045E+10
L2B04	CPB25	1839.07	2.762E+03	1.481E+03	1.468E+03	1.475E+03	1.40341E+10	3.999E+09	3.007E-01	1.040E+10
L2B05	CPB35	1840.03	2.765E+03	1.486E+03	1.476E+03	1.481E+03	1.40637E+10	4.036E+09	2.988E-01	1.048E+10
L2B06	CPB45	1841.38	2.765E+03	1.504E+03	1.416E+03	1.460E+03	1.40740E+10	3.925E+09	3.066E-01	1.026E+10
L2B07	CPB55	1839.06	2.790E+03	1.439E+03	1.501E+03	1.470E+03	1.43141E+10	3.974E+09	3.078E-01	1.039E+10
L2B08	CPB65	1840.79	2.784E+03	1.436E+03	1.436E+03	1.436E+03	1.42717E+10	3.795E+09	3.189E-01	1.001E+10
L3B03	CPB75	1836.34	2.779E+03	1.420E+03	1.466E+03	1.443E+03	1.41767E+10	3.826E+09	3.152E-01	1.006E+10
L3B04	CPB85	1836.11	2.764E+03	1.522E+03	1.429E+03	1.475E+03	1.40293E+10	3.996E+09	3.009E-01	1.040E+10
L3B05	CPB95	1835.06	2.765E+03	1.452E+03	1.494E+03	1.473E+03	1.40301E+10	3.981E+09	3.019E-01	1.037E+10
L3B06	CPB105	1837.52	2.804E+03	1.467E+03	1.430E+03	1.448E+03	1.44426E+10	3.855E+09	3.179E-01	1.016E+10
L3B07	CPB115	1835.84	2.769E+03	1.425E+03	1.428E+03	1.427E+03	1.40746E+10	3.737E+09	3.193E-01	9.859E+09
L3B08	CPB125	1834.80	2.752E+03	1.456E+03	1.413E+03	1.435E+03	1.38976E+10	3.776E+09	3.135E-01	9.919E+09
L3B09	CPB135	1837.34	2.739E+03	1.439E+03	1.476E+03	1.458E+03	1.37836E+10	3.903E+09	3.025E-01	1.017E+10
L6B01	CPB145	1839.37	2.812E+03	1.458E+03	1.499E+03	1.479E+03	1.45445E+10	4.021E+09	3.089E-01	1.053E+10
L6B02	CPB155	1842.54	2.841E+03	1.420E+03	1.430E+03	1.425E+03	1.48696E+10	3.743E+09	3.318E-01	9.969E+09
L6B03	CPB165	1843.13	2.762E+03	1.457E+03	1.457E+03	1.457E+03	1.40607E+10	3.915E+09	3.071E-01	1.023E+10
L6B04	CPB175	1843.38	2.752E+03	1.429E+03	1.435E+03	1.432E+03	1.39626E+10	3.781E+09	3.143E-01	9.938E+09
L6B05	CPB185	1837.85	2.842E+03	1.450E+03	1.424E+03	1.437E+03	1.48459E+10	3.797E+09	3.282E-01	1.009E+10
L6B06	Spare 1	1840.67	2.721E+03	1.421E+03	1.421E+03	1.421E+03	1.36241E+10	3.718E+09	3.123E-01	9.759E+09
L6B07	Spare 2	1839.41	2.778E+03	1.420E+03	1.426E+03	1.423E+03	1.41915E+10	3.725E+09	3.220E-01	9.850E+09
L4C01	5PB25	1836.39	2.764E+03	1.486E+03	1.442E+03	1.464E+03	1.40314E+10	3.935E+09	3.051E-01	1.027E+10
L4C02	6PB20	1840.98	2.778E+03	1.433E+03	1.453E+03	1.443E+03	1.42081E+10	3.833E+09	3.153E-01	1.008E+10
L5C01	Spare 1	1840.27	2.724E+03	1.450E+03	1.436E+03	1.443E+03	1.36565E+10	3.832E+09	3.050E-01	1.000E+10
L5C02	Spare 2	1841.30	2.788E+03	1.458E+03	1.403E+03	1.431E+03	1.43088E+10	3.768E+09	3.212E-01	9.958E+09

Appendix 53. NBG-25 elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho v_l^2$	Shear Modulus, [Pa] $G=\rho v_s^2$	Poisson's Ratio $\mu=(1-[2(v_s/v_l)^2])/(2-[2(v_s/v_l)^2])$	Elastic Modulus, [Pa] $E=\rho v_l^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
M3B01	CPB6	1849.4551	2.518E+03	1.530E+03	1.450E+03	1.490E+03	1.17255E+10	4.105E+09	2.306E-01	1.010E+10
M3B02	CPB16	1852.7118	2.520E+03	1.513E+03	1.457E+03	1.485E+03	1.17610E+10	4.086E+09	2.338E-01	1.008E+10
M3B03	CPB26	1851.4365	2.504E+03	1.516E+03	1.473E+03	1.494E+03	1.16081E+10	4.135E+09	2.234E-01	1.012E+10
M3B04	CPB36	1849.1851	2.513E+03	1.497E+03	1.508E+03	1.503E+03	1.16825E+10	4.176E+09	2.218E-01	1.020E+10
M3B05	CPB46	1851.3108	2.511E+03	1.482E+03	1.496E+03	1.489E+03	1.16738E+10	4.104E+09	2.289E-01	1.009E+10
M4B01	CPB56	1848.6109	2.503E+03	1.511E+03	1.504E+03	1.508E+03	1.15794E+10	4.202E+09	2.152E-01	1.021E+10
M4B02	CPB66	1848.0823	2.506E+03	1.485E+03	1.437E+03	1.461E+03	1.16017E+10	3.945E+09	2.424E-01	9.802E+09
M4B03	CPB76	1846.6539	2.494E+03	1.466E+03	1.494E+03	1.480E+03	1.14835E+10	4.045E+09	2.281E-01	9.936E+09
M4B04	CPB86	1845.4252	2.496E+03	1.503E+03	1.499E+03	1.501E+03	1.15012E+10	4.157E+09	2.170E-01	1.012E+10
M4B06	CPB96	1845.8190	2.493E+03	1.480E+03	1.459E+03	1.469E+03	1.14747E+10	3.986E+09	2.339E-01	9.836E+09
M7B01	CPB106	1852.7141	2.512E+03	1.512E+03	1.501E+03	1.507E+03	1.16942E+10	4.207E+09	2.191E-01	1.026E+10
M7B02	CPB116	1848.9104	2.512E+03	1.483E+03	1.487E+03	1.485E+03	1.16627E+10	4.077E+09	2.312E-01	1.004E+10
M7B03	CPB126	1849.1644	2.518E+03	1.480E+03	1.494E+03	1.487E+03	1.17273E+10	4.091E+09	2.322E-01	1.008E+10
M7B04	CPB136	1850.9020	2.515E+03	1.521E+03	1.532E+03	1.527E+03	1.17050E+10	4.313E+09	2.083E-01	1.042E+10
M7B07	CPB146	1850.7915	2.512E+03	1.470E+03	1.505E+03	1.487E+03	1.16783E+10	4.094E+09	2.301E-01	1.007E+10
M8B01	CPB156	1843.9191	2.519E+03	1.502E+03	1.495E+03	1.498E+03	1.16978E+10	4.138E+09	2.263E-01	1.015E+10
M8B03	CPB166	1846.8297	2.516E+03	1.518E+03	1.493E+03	1.506E+03	1.16940E+10	4.187E+09	2.211E-01	1.023E+10
M8B04	CPB176	1844.3125	2.518E+03	1.508E+03	1.518E+03	1.513E+03	1.16929E+10	4.222E+09	2.174E-01	1.028E+10
M8B05	CPB186	1842.1961	2.522E+03	1.489E+03	1.500E+03	1.495E+03	1.17164E+10	4.116E+09	2.293E-01	1.012E+10
M8B06	Spare 1	1843.7122	2.504E+03	1.519E+03	1.497E+03	1.508E+03	1.15560E+10	4.194E+09	2.152E-01	1.019E+10
M8B09	Spare 2	1847.4887	2.515E+03	1.488E+03	1.468E+03	1.478E+03	1.16871E+10	4.035E+09	2.363E-01	9.977E+09
M2C01	5PB16	1850.0024	2.520E+03	1.485E+03	1.513E+03	1.499E+03	1.17512E+10	4.158E+09	2.262E-01	1.020E+10
M2C02	5PB24	1853.2848	2.521E+03	1.489E+03	1.529E+03	1.509E+03	1.17795E+10	4.219E+09	2.210E-01	1.030E+10
M2C04	Spare 1	1854.7410	2.521E+03	1.492E+03	1.536E+03	1.514E+03	1.17851E+10	4.251E+09	2.179E-01	1.035E+10
M2C05	Spare 2	1853.0856	2.503E+03	1.456E+03	1.463E+03	1.459E+03	1.16111E+10	3.946E+09	2.426E-01	9.806E+09

Appendix 54. 2020 elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
N1B03	CPB7	1742.0251	2.512E+03	1.529E+03	1.504E+03	1.517E+03	1.09924E+10	4.006E+09	2.133E-01	9.721E+09
N1B04	CPB17	1744.6559	2.575E+03	1.584E+03	1.552E+03	1.568E+03	1.15682E+10	4.289E+09	2.053E-01	1.034E+10
N1B05	CPB27	1744.4700	2.572E+03	1.510E+03	1.485E+03	1.498E+03	1.15400E+10	3.912E+09	2.436E-01	9.730E+09
N1B06	CPB37	1742.3191	2.567E+03	1.521E+03	1.543E+03	1.532E+03	1.14828E+10	4.088E+09	2.236E-01	1.000E+10
N1B08	CPB47	1741.2868	2.563E+03	1.544E+03	1.575E+03	1.560E+03	1.14385E+10	4.235E+09	2.061E-01	1.022E+10
N2B04	CPB57	1744.5632	2.595E+03	1.556E+03	1.548E+03	1.552E+03	1.17524E+10	4.203E+09	2.216E-01	1.027E+10
N2B05	CPB67	1744.9727	2.514E+03	1.557E+03	1.527E+03	1.542E+03	1.10286E+10	4.149E+09	1.984E-01	9.945E+09
N2B06	CPB77	1744.1549	2.610E+03	1.558E+03	1.594E+03	1.576E+03	1.18840E+10	4.333E+09	2.131E-01	1.051E+10
N2B07	CPB87	1745.6937	2.601E+03	1.557E+03	1.553E+03	1.555E+03	1.18100E+10	4.221E+09	2.219E-01	1.032E+10
N2B08	CPB97	1743.7907	2.563E+03	1.518E+03	1.591E+03	1.555E+03	1.14549E+10	4.214E+09	2.090E-01	1.019E+10
N5B01	CPB107	1741.3188	2.627E+03	1.476E+03	1.540E+03	1.508E+03	1.20130E+10	3.959E+09	2.542E-01	9.931E+09
N5B02	CPB117	1739.3232	2.524E+03	1.523E+03	1.534E+03	1.529E+03	1.10805E+10	4.064E+09	2.104E-01	9.838E+09
N5B03	CPB127	1745.4457	2.534E+03	1.552E+03	1.584E+03	1.568E+03	1.12078E+10	4.291E+09	1.898E-01	1.021E+10
N5B04	CPB137	1739.7291	2.553E+03	1.544E+03	1.518E+03	1.531E+03	1.13392E+10	4.078E+09	2.192E-01	9.944E+09
N5B05	CPB147	1741.9785	2.592E+03	1.539E+03	1.558E+03	1.549E+03	1.17034E+10	4.177E+09	2.225E-01	1.021E+10
N6B02	CPB157	1739.4666	2.541E+03	1.521E+03	1.507E+03	1.514E+03	1.12312E+10	3.987E+09	2.248E-01	9.767E+09
N6B03	CPB167	1742.2005	2.527E+03	1.547E+03	1.539E+03	1.543E+03	1.11252E+10	4.148E+09	2.028E-01	9.978E+09
N6B04	CPB177	1744.4253	2.568E+03	1.537E+03	1.560E+03	1.548E+03	1.15053E+10	4.182E+09	2.145E-01	1.016E+10
N6B05	CPB187	1744.3410	2.574E+03	1.537E+03	1.544E+03	1.541E+03	1.15571E+10	4.140E+09	2.210E-01	1.011E+10
N6B07	Spare 1	1742.8280	2.602E+03	1.527E+03	1.538E+03	1.533E+03	1.18002E+10	4.095E+09	2.343E-01	1.011E+10
N6B08	Spare 2	1741.9857	2.621E+03	1.562E+03	1.540E+03	1.551E+03	1.19675E+10	4.190E+09	2.306E-01	1.031E+10
N3C01	5PB17	1743.7659	2.608E+03	1.553E+03	1.516E+03	1.535E+03	1.18605E+10	4.106E+09	2.352E-01	1.014E+10
N3C02	6PB23	1746.8117	2.513E+03	1.526E+03	1.522E+03	1.524E+03	1.10314E+10	4.057E+09	2.091E-01	9.811E+09
N7C01	Spare 1	1745.5504	2.519E+03	1.513E+03	1.524E+03	1.518E+03	1.10772E+10	4.023E+09	2.148E-01	9.775E+09
N7C02	Spare 2	1745.9143	2.531E+03	1.514E+03	1.525E+03	1.519E+03	1.11825E+10	4.029E+09	2.184E-01	9.818E+09

Appendix 55. PCIB elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho v_l^2$	Shear Modulus, [Pa] $G=\rho v_s^2$	Poisson's Ratio $\mu=(1-[2(v_s/v_l)^2])/(2-[2(v_s/v_l)^2])$	Elastic Modulus, [Pa] $E=\rho v_l^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
P1B02	CPB8	1825.8218	2.468E+03	1.442E+03	1.485E+03	1.464E+03	1.11211E+10	3.911E+09	2.288E-01	9.611E+09
P1B04	CPB18	1828.4993	2.446E+03	1.417E+03	1.433E+03	1.425E+03	1.09398E+10	3.713E+09	2.431E-01	9.231E+09
P1B05	CPB28	1825.2098	2.467E+03	1.431E+03	1.506E+03	1.469E+03	1.11084E+10	3.936E+09	2.256E-01	9.648E+09
P1B06	CPB38	1821.9582	2.437E+03	1.473E+03	1.447E+03	1.460E+03	1.08199E+10	3.884E+09	2.200E-01	9.477E+09
P1B07	CPB48	1824.7865	2.426E+03	1.429E+03	1.391E+03	1.410E+03	1.07397E+10	3.628E+09	2.449E-01	9.033E+09
P1B08	CPB58	1827.9355	2.473E+03	1.476E+03	1.479E+03	1.478E+03	1.11831E+10	3.992E+09	2.225E-01	9.759E+09
P1B10	CPB68	1828.9551	2.464E+03	1.395E+03	1.446E+03	1.421E+03	1.11041E+10	3.691E+09	2.511E-01	9.234E+09
P3B04	CPB78	1826.3306	2.448E+03	1.444E+03	1.425E+03	1.434E+03	1.09436E+10	3.758E+09	2.385E-01	9.309E+09
P3B05	CPB88	1823.7253	2.457E+03	1.444E+03	1.474E+03	1.459E+03	1.10096E+10	3.882E+09	2.277E-01	9.532E+09
P3B06	CPB98	1827.732	2.440E+03	1.455E+03	1.397E+03	1.426E+03	1.08816E+10	3.717E+09	2.406E-01	9.222E+09
P3B07	CPB108	1830.3897	2.436E+03	1.443E+03	1.436E+03	1.439E+03	1.08596E+10	3.792E+09	2.317E-01	9.341E+09
P3B08	CPB118	1828.7066	2.449E+03	1.429E+03	1.379E+03	1.404E+03	1.09679E+10	3.605E+09	2.552E-01	9.050E+09
P3B09	CPB128	1828.963	2.467E+03	1.488E+03	1.425E+03	1.457E+03	1.11312E+10	3.880E+09	2.325E-01	9.564E+09
P3B10	CPB138	1828.8764	2.437E+03	1.427E+03	1.360E+03	1.394E+03	1.08616E+10	3.551E+09	2.571E-01	8.929E+09
P4B01	CPB148	1824.5826	2.460E+03	1.467E+03	1.399E+03	1.433E+03	1.10416E+10	3.747E+09	2.432E-01	9.316E+09
P4B02	CPB158	1827.6467	2.435E+03	1.436E+03	1.417E+03	1.427E+03	1.08365E+10	3.719E+09	2.387E-01	9.214E+09
P4B03	CPB168	1826.8555	2.434E+03	1.465E+03	1.465E+03	1.465E+03	1.08229E+10	3.921E+09	2.160E-01	9.535E+09
P4B04	CPB178	1827.6755	2.455E+03	1.436E+03	1.434E+03	1.435E+03	1.10158E+10	3.763E+09	2.406E-01	9.337E+09
P4B05	CPB188	1833.5883	2.465E+03	1.430E+03	1.443E+03	1.437E+03	1.11413E+10	3.784E+09	2.429E-01	9.405E+09
P4B07	Spare 1	1837.1171	2.486E+03	1.464E+03	1.464E+03	1.464E+03	1.13527E+10	3.937E+09	2.345E-01	9.721E+09
P4B10	Spare 2	1829.6456	2.463E+03	1.465E+03	1.455E+03	1.460E+03	1.10961E+10	3.900E+09	2.290E-01	9.586E+09
P2C02	5PB18	1840.6128	2.473E+03	1.479E+03	1.473E+03	1.476E+03	1.12567E+10	4.010E+09	2.233E-01	9.811E+09
P2C03	6PB25	1835.1469	2.504E+03	1.453E+03	1.487E+03	1.470E+03	1.15064E+10	3.966E+09	2.371E-01	9.811E+09
P2C06	Spare 1	1832.0594	2.452E+03	1.441E+03	1.428E+03	1.434E+03	1.10143E+10	3.770E+09	2.398E-01	9.348E+09
P2C08	Spare 2	1836.9076	2.452E+03	1.474E+03	1.461E+03	1.468E+03	1.10400E+10	3.956E+09	2.208E-01	9.659E+09

Appendix 56. BAN elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity (AG)										
			Sonic Velocities, v [m/s]							
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Longitudinal	Shear 0°	Shear 90°	Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
R2B01A	CPB9	1838.4044	2.545E+03	1.418E+03	1.418E+03	1.418E+03	1.19110E+10	3.696E+09	2.750E-01	9.425E+09
R2B03A	CPB19	1838.7086	2.543E+03	1.446E+03	1.417E+03	1.431E+03	1.18941E+10	3.767E+09	2.682E-01	9.555E+09
R2B06A	CPB29	1832.6430	2.540E+03	1.444E+03	1.461E+03	1.452E+03	1.18212E+10	3.865E+09	2.571E-01	9.717E+09
R2B07A	CPB39	1837.3812	2.543E+03	1.450E+03	1.452E+03	1.451E+03	1.18780E+10	3.870E+09	2.584E-01	9.739E+09
R2B08A	CPB49	1838.3385	2.541E+03	1.451E+03	1.432E+03	1.442E+03	1.18730E+10	3.820E+09	2.628E-01	9.648E+09
R2B09A	CPB59	1840.5804	2.562E+03	1.432E+03	1.432E+03	1.432E+03	1.20807E+10	3.773E+09	2.730E-01	9.605E+09
R2B10A	CPB69	1838.8039	2.559E+03	1.417E+03	1.430E+03	1.423E+03	1.20386E+10	3.726E+09	2.759E-01	9.508E+09
R3B01A	CPB79	1844.9950	2.565E+03	1.450E+03	1.411E+03	1.431E+03	1.21404E+10	3.776E+09	2.743E-01	9.622E+09
R3B02A	CPB89	1844.8621	2.561E+03	1.438E+03	1.438E+03	1.438E+03	1.21012E+10	3.813E+09	2.699E-01	9.686E+09
R3B03A	CPB99	1845.7243	2.557E+03	1.439E+03	1.400E+03	1.420E+03	1.20686E+10	3.720E+09	2.772E-01	9.502E+09
R3B04A	CPB109	1845.7491	2.559E+03	1.417E+03	1.446E+03	1.432E+03	1.20841E+10	3.783E+09	2.721E-01	9.625E+09
R3B06A	CPB119	1844.8474	2.563E+03	1.449E+03	1.432E+03	1.440E+03	1.21164E+10	3.827E+09	2.691E-01	9.714E+09
R3B07A	CPB129	1843.1598	2.552E+03	1.446E+03	1.446E+03	1.446E+03	1.20061E+10	3.853E+09	2.637E-01	9.739E+09
R3B08A	CPB139	1845.5449	2.562E+03	1.413E+03	1.438E+03	1.425E+03	1.21133E+10	3.750E+09	2.758E-01	9.569E+09
R6B01A	CPB149	1838.6825	2.543E+03	1.430E+03	1.430E+03	1.430E+03	1.18940E+10	3.758E+09	2.691E-01	9.538E+09
R6B02A	CPB159	1838.5040	2.544E+03	1.404E+03	1.427E+03	1.416E+03	1.18966E+10	3.684E+09	2.757E-01	9.399E+09
R6B04A	CPB169	1838.9108	2.538E+03	1.446E+03	1.421E+03	1.433E+03	1.18467E+10	3.779E+09	2.658E-01	9.566E+09
R6B06A	CPB179	1834.6964	2.540E+03	1.412E+03	1.402E+03	1.407E+03	1.18382E+10	3.633E+09	2.786E-01	9.290E+09
R6B08A	CPB189	1835.9633	2.545E+03	1.414E+03	1.421E+03	1.417E+03	1.18876E+10	3.687E+09	2.752E-01	9.404E+09
R6B09A	Spare 1	1841.0791	2.529E+03	1.393E+03	1.427E+03	1.410E+03	1.17734E+10	3.659E+09	2.745E-01	9.327E+09
R6B10A	Spare 2	1835.3301	2.528E+03	1.456E+03	1.436E+03	1.446E+03	1.17292E+10	5.36083E+09	2.567E-01	9.649E+09
R4C01A	1PB22	1839.6288	2.533E+03	1.459E+03	1.401E+03	1.430E+03	1.18014E+10	5.39142E+09	2.661E-01	9.525E+09
R4C04A	2PB22	1834.4787	2.532E+03	1.420E+03	1.445E+03	1.432E+03	1.17646E+10	5.10278E+09	2.647E-01	9.522E+09
R4C07A	3PB22	1838.3539	2.535E+03	1.431E+03	1.408E+03	1.420E+03	1.18155E+10	5.18930E+09	2.716E-01	9.422E+09

R4C08A	4PB22	1836.4575	2.533E+03	1.449E+03	1.386E+03	1.417E+03	1.17847E+10	5.32017E+09	2.721E-01	9.388E+09
R5C01A	5PB19	1850.0007	2.533E+03	1.410E+03	1.436E+03	1.423E+03	1.18716E+10	5.03958E+09	2.694E-01	9.514E+09
R5C02A	5PB23	1849.4211	2.537E+03	1.438E+03	1.438E+03	1.438E+03	1.19017E+10	5.24640E+09	2.632E-01	9.663E+09
R5C03A	Spare 1	1850.1138	2.536E+03	1.425E+03	1.425E+03	1.425E+03	1.19024E+10	5.15007E+09	2.694E-01	9.537E+09
R5C05A	Spare 2	1849.0200	2.533E+03	1.423E+03	1.401E+03	1.412E+03	1.18616E+10	5.12817E+09	2.746E-01	9.396E+09

Appendix 57. NBG-10 elastic constants data from sonic velocity

Dynamic Young's and Shear Modulus and Poisson's Ratio by Sonic Velocity										
Specimen ID Number	Specimen Location	Density, ρ kg/m^3	Sonic Velocities, v [m/s]			Average Shear Velocity	Elastic Modulus, [Pa] $E=\rho vl^2$	Shear Modulus, [Pa] $G=\rho vs^2$	Poisson's Ratio $\mu=(1-[2(vs/vl)^2])/(2-[2(vs/vl)^2])$	Elastic Modulus, [Pa] $E=\rho vl^2[(1+\mu)(1-2\mu)/(1-\mu)]$
			Longitudinal	Shear 0°	Shear 90°					
S1B01	CPB10	1802.7053	2.697E+03	1.453E+03	1.450E+03	1.452E+03	1.31086E+10	3.799E+09	2.959E-01	9.847E+09
S1B03	CPB20	1796.7138	2.698E+03	1.451E+03	1.412E+03	1.432E+03	1.30815E+10	3.683E+09	3.041E-01	9.605E+09
S1B04	CPB30	1796.0557	2.687E+03	1.441E+03	1.441E+03	1.441E+03	1.29662E+10	3.730E+09	2.981E-01	9.684E+09
S1B07	CPB40	1794.5172	2.647E+03	1.440E+03	1.461E+03	1.450E+03	1.25761E+10	3.775E+09	2.855E-01	9.706E+09
S1B08	CPB50	1791.7202	2.652E+03	1.464E+03	1.421E+03	1.442E+03	1.26002E+10	3.728E+09	2.899E-01	9.617E+09
S1B09	CPB60	1796.7207	2.651E+03	1.467E+03	1.457E+03	1.462E+03	1.26274E+10	3.838E+09	2.816E-01	9.839E+09
S1B10	CPB70	1795.6879	2.651E+03	1.437E+03	1.372E+03	1.404E+03	1.26242E+10	3.541E+09	3.051E-01	9.243E+09
S3B01	CPB80	1794.4793	2.690E+03	1.446E+03	1.446E+03	1.446E+03	1.29830E+10	3.754E+09	2.966E-01	9.736E+09
S3B03	CPB90	1797.9285	2.691E+03	1.468E+03	1.451E+03	1.459E+03	1.30244E+10	3.828E+09	2.919E-01	9.890E+09
S3B04	CPB100	1795.7656	2.688E+03	1.449E+03	1.449E+03	1.449E+03	1.29758E+10	3.770E+09	2.953E-01	9.765E+09
S3B07	CPB110	1797.8083	2.684E+03	1.450E+03	1.437E+03	1.444E+03	1.29536E+10	3.746E+09	2.966E-01	9.714E+09
S3B08	CPB120	1795.6930	2.643E+03	1.425E+03	1.429E+03	1.427E+03	1.25429E+10	3.657E+09	2.943E-01	9.465E+09
S3B09	CPB130	1796.7780	2.666E+03	1.429E+03	1.462E+03	1.445E+03	1.27664E+10	3.753E+09	2.918E-01	9.697E+09
S3B10	CPB140	1789.8740	2.668E+03	1.444E+03	1.418E+03	1.431E+03	1.27450E+10	3.665E+09	2.981E-01	9.517E+09
S4B01	CPB150	1800.1521	2.686E+03	1.418E+03	1.434E+03	1.426E+03	1.29875E+10	3.661E+09	3.037E-01	9.547E+09
S4B03	CPB160	1800.6822	2.682E+03	1.435E+03	1.435E+03	1.435E+03	1.29545E+10	3.707E+09	2.996E-01	9.635E+09
S4B04	CPB170	1796.7926	2.682E+03	1.412E+03	1.407E+03	1.410E+03	1.29265E+10	3.570E+09	3.092E-01	9.348E+09
S4B07	CPB180	1795.3725	2.669E+03	1.479E+03	1.445E+03	1.462E+03	1.27942E+10	3.837E+09	2.858E-01	9.867E+09
S4B08	CPB190	1797.8490	2.681E+03	1.422E+03	1.422E+03	1.422E+03	1.29218E+10	3.634E+09	3.043E-01	9.481E+09
S4B09	Spare 1	1795.4873	2.680E+03	1.444E+03	1.399E+03	1.421E+03	1.28926E+10	3.628E+09	3.042E-01	9.463E+09
S4B10	Spare 2	1794.9063	2.681E+03	1.441E+03	1.454E+03	1.448E+03	1.29007E+10	3.763E+09	2.941E-01	9.739E+09
S2C01	5PB20	1808.1460	2.682E+03	1.465E+03	1.479E+03	1.472E+03	1.30041E+10	3.917E+09	2.845E-01	1.006E+10
S2C02	Spare 1	1807.7444	2.675E+03	1.445E+03	1.461E+03	1.453E+03	1.29355E+10	3.816E+09	2.907E-01	9.852E+09
S2C03	Spare 2	1804.4470	2.676E+03	1.462E+03	1.469E+03	1.465E+03	1.29201E+10	3.874E+09	2.859E-01	9.963E+09

Appendix 58. Ambient temperature thermal diffusivity and thermal conductivity data for NBG-17 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
AW14C01	1PB16	A	21	721.3	1.1422	1.1371	1.1452	1.1415	1867.9	153.79
AW14C02	2PB16	A	21	721.3	1.1248		1.1230	1.1239	1866.2	151.29
AW14C04	3PB16	A	21	721.3	1.1310	1.1379		1.1345	1867.2	152.79
AW15C02	4PB16	A	21	721.3	1.1721			1.1721	1870.3	158.12
AW15C03	Spare 1	A	21	721.3	1.1611		1.1583	1.1597	1866.3	156.11
AW15C06	Spare 2	A	21	721.3	1.1164	1.1197	1.1214	1.1192	1867.6	150.76

Appendix 59. Ambient temperature thermal diffusivity and thermal conductivity data for NBG-18 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
BW14C01	1PB18	A	21	721.3	1.1573		1.1513	1.1543	1876.7	156.25
BW14C02	1PB25	A	21	721.3	1.1442	1.1445	1.1474	1.1454	1878.4	155.18
BW14C03	2PB18	A	21	721.3		1.1636	1.1693	1.1665	1876.3	157.86
BW14C04	2PB24	A	21	721.3	1.1690	1.1588	1.1614	1.1631	1879.7	157.69
BW14C05	3PB18	A	21	721.3	1.1359	1.1354	1.1391	1.1368	1879.9	154.15
BW15C02	4PB18	A	21	721.3	1.1646	1.1551	1.1535	1.1577	1881.4	157.11
BW15C03	4PB23	A	21	721.3	1.1628	1.1615	1.1638	1.1627	1879.7	157.64
BW15C04	4PB25	A	21	721.3	1.1573	1.1565	1.1537	1.1558	1884.1	157.08
BW15C05	Spare 1	A	21	721.3	1.1741	1.1845		1.1793	1881.8	160.07
BW15C08	Spare 2	A	21	721.3	1.1647	1.1638	1.1749	1.1678	1881.0	158.44

Appendix 60. Ambient temperature thermal diffusivity and thermal conductivity data for H-451 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
CW1C02	2PB20	A	21	721.3	1.5152	1.5062	1.5125	1.5113	1740.8	189.77
CW1C03	3PB20	A	21	721.3	1.5080	1.5028	1.5056	1.5055	1728.1	187.65
CW1C04	4PB20	A	23	726.9	1.5761	1.5671	1.5731	1.5721	1727.3	197.39
CW2C01	6PB21	A	23	726.9	1.5185	1.5023	1.5200	1.5136	1735.3	190.93
CW2C03	Spare 1	A	22	724.1	1.5153	1.5151	1.5138	1.5147	1736.1	190.42
CW2C05	Spare 2	A	22	724.1	1.4527	1.4533	1.4530	1.4530	1732.0	182.22

Appendix 61. Ambient temperature thermal diffusivity and thermal conductivity data for PCEA (WG) piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
DW14C01	1PB17	A	21	721.3	1.5089	1.5101	1.4721	1.4970	1818.9	196.41
DW14C02	1PB24	A	21	721.3	1.4839	1.4881	1.4793	1.4838	1814.3	194.18
DW14C03	2PB17	A	21	721.3	1.5154	1.5184	1.5212	1.5183	1822.6	199.61
DW14C04	3PB17	A	21	721.3	1.5312	1.5348	1.5375	1.5345	1822.3	201.70
DW14C05	3PB23	A	21	721.3	1.5151	1.5065	1.5031	1.5082	1823.2	198.34
DW15C01	3PB25	A	21	721.3		1.5183	1.5134	1.5159	1818.4	198.82
DW15C02	4PB17	A	21	721.3	1.5232	1.5255	1.5163	1.5217	1820.6	199.82
DW15C03	4PB24	A	21	721.3	1.5501	1.5584		1.5543	1820.9	204.14
DW15C04	Spare 1	A	21	721.3	1.5827	1.5860	1.5777	1.5821	1819.9	207.68
DW15C05	Spare 2	A	21	721.3	1.5386	1.5314		1.5350	1817.4	201.22

Appendix 62. Ambient temperature thermal diffusivity and thermal conductivity data for IG-110 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
EW13C01	1PB21	A	21	721.3	1.0100	1.0083	1.0061	1.0081	1787.0	129.94
EW13C02	2PB21	A	21	721.3	1.0522	1.0495	1.0493	1.0503	1785.1	135.24
EW13C03	2PB23	A	21	721.3	1.0330		1.0340	1.0335	1783.4	132.94
EW13C04	3PB21	A	21	721.3	1.0624		1.0572	1.0598	1785.1	136.46
EW14C01	4PB21	A	21	721.3	1.0624		1.0572	1.0598	1787.0	136.60
EW14C04	Spare 1	A	21	721.3	1.0604	1.0626		1.0615	1780.7	136.34
EW14C05	Spare 2	A	21	721.3	1.0349	1.0234	1.0264	1.0282	1783.1	132.25

Appendix 63. Ambient temperature thermal diffusivity and thermal conductivity data for IG-430 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
FW18C01	1PB19	A	21	721.3	1.1757	1.1833		1.1795	1828.2	155.54
FW18C02	1PB23	A	21	721.3	1.1312	1.1285	1.1265	1.1287	1810.5	147.40
FW18C03	2PB19	A	21	721.3	1.0918	1.0909	1.0863	1.0897	1825.0	143.44
FW18C04	2PB25	A	21	721.3	1.2012	1.2090	1.2024	1.2042	1833.4	159.25
FW18C06	3PB19	A	21	721.3	1.1765	1.1742	1.1607	1.1705	1827.3	154.27
FW19C01	3PB24	A	21	721.3	1.2141	1.2099	1.2093	1.2111	1829.2	159.80
FW19C02	4PB19	A	21	721.3	1.2891	1.2799	1.2813	1.2834	1828.9	169.31
FW19C04	Spare 1	A	21	721.3	1.2283	1.2372		1.2328	1826.3	162.39
FW19C05	Spare 2	A	21	721.3	1.2283	1.2372		1.2328	1826.6	162.42

Appendix 64. Ambient temperature thermal diffusivity and thermal conductivity data for A3-Matrix piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
H-3-1	CPB2	A	21	721.3	0.1331	0.1333	0.1335	0.1333	1357.8	13.06
H-3-2	CPB12	A	21	721.3		0.1110	0.1124	0.1117	1324.5	10.67
H-4-1	CPB22	A	21	721.3	0.1131	0.1130	0.1122	0.1128	1286.5	10.46
H-4-2	CPB32	A	21	721.3	0.1080	0.1071	0.1078	0.1076	1242.3	9.64
H-5-1	CPB42	A	21	721.3	0.1306	0.1312	0.1311	0.1310	1367.0	12.91
H-5-2	CPB52	A	21	721.3	0.1348	0.1342	0.1349	0.1346	1335.9	12.97
H-7-1	CPB62	A	21	721.3	0.1416	0.1418	0.1418	0.1417	1365.9	13.96
H-7-2	CPB72	A	21	721.3	0.1193	0.1190	0.1198	0.1194	1339.0	11.53
H-8-1	CPB82	A	21	721.3	0.1430	0.1433		0.1432	1361.2	14.05
H-8-2	CPB92	A	21	721.3	0.1242	0.1249	0.1254	0.1248	1327.6	11.95
H-9-1	CPB102	A	21	721.3	0.1436	0.1440	0.1431	0.1436	1360.3	14.09
H-9-2	CPB112	A	21	721.3	0.1215	0.1222		0.1219	1330.3	11.69
H-10-1	CPB122	A	21	721.3	0.1094	0.1090	0.1087	0.1090	1239.7	9.75
H-10-2	CPB132	A	21	721.3	0.1151	0.1150	0.1153	0.1151	1286.0	10.68
H-12-1	CPB142	A	21	721.3	0.1404	0.1396	0.1399	0.1400	1358.7	13.72
H-12-2	CPB152	A	21	721.3	0.1270	0.1270	0.1269	0.1270	1327.3	12.16
H-13-1	CPB162	A	21	721.3	0.1005	0.1008	0.1004	0.1006	1252.3	9.08
H-13-2	CPB172	A	21	721.3	0.1082	0.1085	0.1082	0.1083	1295.4	10.12
H-14-1	CPB182	A	21	721.3	0.1435	0.1441		0.1438	1491.4	15.47
H-14-2	CPB192	A	21	721.3	0.1652	0.1654	0.1652	0.1653	1526.9	18.20
H-15-1	Spare 1	A	21	721.3	0.1447	0.1450	0.1445	0.1447	1494.5	15.60
H-15-2	Spare 2	A	21	721.3	0.1820	0.1815	0.1814	0.1816	1531.9	20.07
H-16-1	5PB22	A	21	721.3	0.1818	0.1811	0.1824	0.1818	1582.2	20.74
H-16-2	6PB17	A	21	721.3	0.1634	0.1638	0.1645	0.1639	1559.0	18.43
H-17-1	6PB22	A	21	721.3	0.1863	0.1863	0.1875	0.1867	1577.8	21.25

H-18-1	Spare 1	A	21	721.3	0.1922	0.1929	0.1920	0.1924	1581.7	21.95
H-18-2	Spare 2	A	21	721.3	0.1872	0.1876		0.1874	1553.0	20.99

Appendix 65. Ambient temperature thermal diffusivity and thermal conductivity data for HLM piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
J1B03	CPB3	A	21	721.3	1.6404	1.6192	1.6313	1.6303	1767.5	207.84
J1B04	CPB13	A	21	721.3		1.7589	1.7403	1.7496	1768.7	223.21
J1B05	CPB23	A	21	721.3	1.6565	1.6469	1.6542	1.6525	1767.6	210.69
J1B06	CPB33	A	21	721.3	1.6595	1.6542	1.6568	1.6568	1763.4	210.74
J1B07	CPB43	A	21	721.3	1.6285	1.6168	1.6242	1.6232	1760.4	206.11
J2B01	CPB53	A	21	721.3	1.6327	1.6407	1.6476	1.6403	1764.1	208.72
J2B03	CPB63	A	21	721.3	1.6254	1.6337	1.6402	1.6331	1767.1	208.16
J2B04	CPB73	A	21	721.3	1.7337	1.7308	1.7481	1.7375	1765.8	221.30
J2B05	CPB83	A	21	721.3	1.6834	1.6791	1.6741	1.6789	1765.8	213.83
J2B06	CPB93	A	21	721.3	1.6911	1.6779	1.6721	1.6804	1761.4	213.49
J5B01	CPB103	A	21	721.3	1.7476	1.7491	1.7628	1.7532	1771.9	224.07
J5B02	CPB113	A	21	721.3	1.6554		1.6552	1.6553	1768.5	211.16
J5B04	CPB123	A	21	721.3	1.6887	1.6830	1.6831	1.6849	1768.4	214.93
J5B05	CPB133	A	21	721.3	1.7423	1.7395	1.7388	1.7402	1768.7	222.01
J5B06	CPB143	A	21	721.3	1.6984	1.6941	1.6922	1.6949	1767.5	216.08
J6B01	CPB153	A	21	721.3	1.7346	1.7359		1.7353	1769.5	221.48
J6B02	CPB163	A	21	721.3	1.7687	1.7620	1.7518	1.7608	1764.7	224.14
J6B03	CPB173	A	21	721.3	1.7180	1.7195	1.7187	1.7187	1768.2	219.20
J6B05	CPB183	A	22	724.1	1.6903	1.6835	1.6898	1.6879	1763.2	215.50
J6B06	Spare 1	A	21	721.3	1.6150	1.6065	1.5972	1.6062	1765.9	204.59
J6B08	Spare 2	A	21	724.1	1.6542	1.6575	1.6587	1.6568	1768.9	212.21
J3C01	6PB18	A	21	721.3	1.6589	1.6601		1.6595	1767.0	211.51
J3C04	6PB24	A	22	724.1	1.7752	1.7676	1.7683	1.7704	1760.9	225.73
J7C03	Spare 1	A	21	721.3	1.6542	1.6575	1.6587	1.6568	1767.1	211.18
J7C04	Spare 2	A	22	724.1	1.7534	1.7543	1.7507	1.7528	1760.2	223.41

Appendix 66. Ambient temperature thermal diffusivity and thermal conductivity data for PGX piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
K2B01	CPB4	A	21	721.3	1.0847	1.0856	1.0799	1.0834	1771.0	138.40
K2B02	CPB14	A	21	721.3	1.0787	1.0756	1.0805	1.0783	1772.7	137.88
K2B03	CPB24	A	21	721.3			1.0830	1.0830	1776.3	138.76
K2B04	CPB34	A	21	721.3	1.0788	1.0790	1.0756	1.0778	1774.0	137.91
K2B05	CPB44	A	21	721.3	1.0590	1.0568	1.0610	1.0589	1772.6	135.39
K2B06	CPB54	A	21	721.3	1.1009			1.1009	1773.2	140.81
K2B07	CPB64	A	20	718.5	1.1073	1.1027	1.1009	1.1036	1774.8	140.74
K3B01	CPB74	A	21	721.3	1.0843	1.0925	1.0902	1.0890	1770.0	139.03
K3B02	CPB84	A	21	721.3	1.1039	1.1032	1.1073	1.1048	1770.4	141.08
K3B03	CPB94	A	21	721.3		1.0814	1.0847	1.0831	1771.8	138.41
K3B04	CPB104	A	21	721.3	1.0940	1.0850	1.0849	1.0880	1773.1	139.15
K3B05	CPB114	A	21	721.3	1.0982		1.0970	1.0976	1774.2	140.47
K3B06	CPB124	A	21	721.3	1.1084	1.1007	1.1074	1.1055	1774.6	141.51
K3B07	CPB134	A	21	721.3	1.1084	1.1104		1.1094	1774.3	141.98
K6B01	CPB144	A	21	721.3	1.1143	1.1149	1.1178	1.1157	1775.8	142.90
K6B02	CPB154	A	21	721.3		1.0583	1.0539	1.0561	1775.6	135.26
K6B03	CPB164	A	21	721.3	1.1005		1.0896	1.0951	1773.1	140.05
K6B04	CPB174	A	21	721.3	1.0673	1.0677	1.0665	1.0672	1773.4	136.51
K6B05	CPB184	A	21	721.3	1.0983	1.1002	1.0961	1.0982	1772.9	140.43
K6B06	Spare 1	A	21	721.3	1.1086	1.0984	1.0956	1.1009	1774.0	140.86
K6B07	Spare 2	A	21	721.3	1.1041	1.1048	1.0967	1.1019	1773.2	140.93
K4C01	6PB19	A	21	721.3	1.0699	1.0681	1.0687	1.0689	1774.7	136.83
K4C02	Spare 1	A	21	721.3	1.0604	1.0623	1.0660	1.0629	1778.1	136.32
K5C01	Spare 2	A	20	718.5	1.0782	1.0803	1.0782	1.0789	1778.2	137.84

Appendix 67. Ambient temperature thermal diffusivity and thermal conductivity data for PPEA piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
L2B02	CPB5	A	21	721.3	1.2378	1.2381	1.2384	1.2381	1839.7	164.30
L2B03	CPB15	A	21	721.3	1.2419	1.2408	1.2412	1.2413	1840.0	164.75
L2B04	CPB25	A	21	721.3	1.2236	1.2281		1.2259	1839.1	162.61
L2B05	CPB35	A	21	721.3	1.2344	1.2346	1.2278	1.2323	1840.0	163.55
L2B06	CPB45	A	21	721.3	1.2238	1.2443	1.2419	1.2367	1841.4	164.25
L2B07	CPB55	A	21	721.3	1.2278	1.2198	1.2219	1.2232	1839.1	162.25
L2B08	CPB65	A	21	721.3	1.2046	1.2046	1.2021	1.2038	1840.8	159.83
L3B03	CPB75	A	21	721.3	1.2267	1.2247	1.2220	1.2245	1836.3	162.19
L3B04	CPB85	A	21	721.3	1.2064	1.2131	1.2112	1.2102	1836.1	160.28
L3B05	CPB95	A	21	721.3	1.2130		1.2122	1.2126	1835.1	160.50
L3B06	CPB105	A	21	721.3	1.2147	1.2145	1.2094	1.2129	1837.5	160.75
L3B07	CPB115	A	21	721.3	1.1997	1.1989	1.2025	1.2004	1835.8	158.95
L3B08	CPB125	A	21	721.3	1.2088	1.2044	1.2058	1.2063	1834.8	159.65
L3B09	CPB135	A	21	721.3	1.2185	1.2218	1.2187	1.2197	1837.3	161.64
L6B01	CPB145	A	21	721.3	1.2273	1.2200	1.2252	1.2242	1839.4	162.41
L6B02	CPB155	A	21	721.3	1.2136	1.2187	1.2188	1.2170	1842.5	161.75
L6B03	CPB165	A	21	721.3	1.2261	1.2262	1.2281	1.2268	1843.1	163.10
L6B04	CPB175	A	21	721.3	1.2362	1.2375	1.2332	1.2356	1843.4	164.29
L6B05	CPB185	A	21	721.3	1.2260	1.2261	1.2354	1.2292	1837.9	162.94
L6B06	Spare 1	A	21	721.3	1.2272	1.2188	1.2290	1.2250	1840.7	162.64
L6B07	Spare 2	A	21	721.3	1.2330	1.2338	1.2317	1.2328	1839.4	163.57
L4C01	5PB25	A	21	721.3	1.2208	1.2111		1.2160	1836.4	161.06
L4C02	6PB20	A	21	721.3	1.2132	1.2084	1.2128	1.2115	1841.0	160.87
L5C01	Spare 1	A	21	721.3	1.2144	1.2083	1.2132	1.2120	1840.3	160.87
L5C02	Spare 2	A	21	721.3	1.2273	1.2200	1.2252	1.2242	1841.3	162.58

Appendix 68. Ambient temperature thermal diffusivity and thermal conductivity data for NBG-25 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
M3B01	CPB6	A	21	721.3	0.9613	0.9577	0.9572	0.9587	1849.5	127.90
M3B02	CPB16	A	21	721.3	0.9589	0.9606	0.9611	0.9602	1852.7	128.32
M3B03	CPB26	A	21	721.3	0.9570	0.9586	0.9582	0.9579	1851.4	127.93
M3B04	CPB36	A	21	721.3	0.9601	0.9624	0.9594	0.9606	1849.2	128.13
M3B05	CPB46	A	21	721.3	0.9614	0.9592	0.9635	0.9614	1851.3	128.38
M4B01	CPB56	A	21	721.3	0.9675	0.9648	0.9665	0.9663	1848.6	128.84
M4B02	CPB66	A	21	721.3	0.9613	0.9617	0.9630	0.9620	1848.1	128.24
M4B03	CPB76	A	21	721.3	0.9551	0.9550	0.9555	0.9552	1846.7	127.23
M4B04	CPB86	A	21	721.3	0.9482	0.9470	0.9446	0.9466	1845.4	126.00
M4B06	CPB96	A	21	721.3	0.9492	0.9480	0.9551	0.9508	1845.8	126.58
M7B01	CPB106	A	21	721.3	0.9629	0.9637	0.9627	0.9631	1852.7	128.71
M7B02	CPB116	A	21	721.3	0.9511	0.9548	0.9540	0.9533	1848.9	127.13
M7B03	CPB126	A	21	721.3	0.9562	0.9570	0.9578	0.9570	1849.2	127.64
M7B04	CPB136	A	21	721.3	0.9549	0.9541	0.9574	0.9555	1850.9	127.56
M7B07	CPB146	A	29	743.6	0.9091	0.9134	0.9136	0.9120	1850.8	125.52
M8B01	CPB156	A	25	732.5	0.9458	0.9362	0.9305	0.9375	1843.9	126.63
M8B03	CPB166	A	25	732.5	0.9428	0.9427	0.9428	0.9428	1846.8	127.54
M8B04	CPB176	A	25	732.5	0.9263	0.9296	0.9337	0.9299	1844.3	125.62
M8B05	CPB186	A	24	729.7	0.9315	0.9328	0.9305	0.9316	1842.2	125.23
M8B06	Spare 1	A	19	715.7	0.9430	0.9410	0.9468	0.9436	1843.7	124.51
M8B09	Spare 2	A	19	715.7	0.9429	0.9440	0.9459	0.9443	1847.5	124.86
M2C01	5PB16	A	19	715.7	0.9659	0.9663	0.9700	0.9674	1850.0	128.09
M2C02	5PB24	A	19	715.7	0.9843	0.9843	0.9752	0.9813	1853.3	130.15
M2C04	Spare 1	A	20	718.5	0.9600	0.9538	0.9588	0.9575	1854.7	127.60
M2C05	Spare 2	A	20	718.5	0.9339	0.9391	0.9432	0.9387	1853.1	124.99

Appendix 69. Ambient temperature thermal diffusivity and thermal conductivity data for 2020 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
N1B03	CPB7	A	21	721.3	0.6467		0.6434	0.6451	1742.0	81.05
N1B04	CPB17	A	21	721.3	0.6467		0.6468	0.6468	1744.7	81.39
N1B05	CPB27			721.3	No data				1744.5	
N1B06	CPB37	A	21	721.3	0.6248	0.6248	0.6256	0.6251	1742.3	78.55
N1B08	CPB47	A	21	721.3	0.6667		0.6630	0.6649	1741.3	83.50
N2B04	CPB57	A	21	721.3	0.6486	0.6458	0.6491	0.6478	1744.6	81.52
N2B05	CPB67	A	21	721.3	0.6522	0.6554		0.6538	1745.0	82.29
N2B06	CPB77	A	21	721.3	0.6729	0.6741	0.6698	0.6723	1744.2	84.58
N2B07	CPB87	A	21	721.3	0.6474	0.6424	0.6423	0.6440	1745.7	81.09
N2B08	CPB97	A	21	721.3		0.6179	0.6212	0.6196	1743.8	77.93
N5B01	CPB107	A	21	721.3	0.6325	0.6323	0.6329	0.6326	1741.3	79.45
N5B02	CPB117	A	21	721.3	0.6320	0.6329	0.6395	0.6348	1739.3	79.64
N5B03	CPB127	A	21	721.3	0.6189	0.6165	0.6172	0.6175	1745.4	77.75
N5B04	CPB137	A	21	721.3	0.6499	0.6516	0.6520	0.6512	1739.7	81.71
N5B05	CPB147	A	21	721.3	0.6663	0.6651		0.6657	1742.0	83.64
N6B02	CPB157	A	21	721.3	0.6235	0.6225	0.6231	0.6230	1739.5	78.17
N6B03	CPB167	A	21	721.3	0.6269		0.6267	0.6268	1742.2	78.77
N6B04	CPB177	A	21	721.3	0.6391	0.6380		0.6386	1744.4	80.35
N6B05	CPB187	A	21	721.3		0.6554	0.6552	0.6553	1744.3	82.45
N6B07	Spare 1	A	21	721.3	0.6556	0.6553	0.6564	0.6558	1742.8	82.44
N6B08	Spare 2	A	21	721.3	0.6583	0.6606	0.6629	0.6606	1742.0	83.00
N3C01	5PB17	A	21	721.3	0.6395	0.6393	0.6397	0.6395	1743.8	80.43
N3C02	6PB23	A	21	721.3	0.6190	0.6185	0.6185	0.6187	1746.8	77.81
N7C01	Spare 1	A	21	721.3	0.6320	0.6329	0.6346	0.6332	1745.6	79.78
N7C02	Spare 2	A	21	721.3	0.6109	0.6096	0.6096	0.6100	1745.9	76.81

Appendix 70. Ambient temperature thermal diffusivity and thermal conductivity data for PCIB piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
P1B02	CPB8	A	21	721.3	1.0677	1.0655	1.0684	1.0672	1825.8	140.55
P1B04	CPB18	A	21	721.3	1.0918	1.0982	1.0954	1.0951	1828.5	144.44
P1B05	CPB28	A	21	721.3		1.0586	1.0543	1.0565	1825.2	139.08
P1B06	CPB38	A	21	721.3	1.0672	1.0690	1.0661	1.0674	1822.0	140.28
P1B07	CPB48	A	21	721.3	1.0573	1.0598		1.0586	1824.8	139.33
P1B08	CPB58	A	21	721.3		1.0608	1.0645	1.0627	1827.9	140.11
P1B10	CPB68	A	19	715.7	1.0953	1.0977	1.0995	1.0975	1829.0	143.66
P3B04	CPB78	A	21	721.3	1.0730	1.0647	1.0675	1.0684	1826.3	140.74
P3B05	CPB88	A	21	721.3	1.0748	1.0712		1.0730	1823.7	141.15
P3B06	CPB98	A	21	721.3	1.0482	1.0489	1.0470	1.0480	1827.7	138.17
P3B07	CPB108	A	21	721.3	1.2149	1.2162		1.2156	1830.4	160.48
P3B08	CPB118	A	21	721.3	1.0631	1.0663	1.0660	1.0651	1828.7	140.50
P3B09	CPB128	A	21	721.3	1.0616	1.0609	1.0647	1.0624	1829.0	140.16
P3B10	CPB138	A	21	721.3	1.0707	1.0693	1.0705	1.0702	1828.9	141.17
P4B01	CPB148	A	21	721.3	1.0585	1.0574		1.0580	1824.6	139.23
P4B02	CPB158	A	21	721.3	1.0369	1.0408	1.0376	1.0384	1827.6	136.89
P4B03	CPB168	A	21	721.3	1.0645	1.0619	1.0624	1.0629	1826.9	140.06
P4B04	CPB178	A	21	721.3	1.0616	1.0603		1.0610	1827.7	139.87
P4B05	CPB188	A	21	721.3	1.0588	1.0569	1.0575	1.0577	1833.6	139.89
P4B07	Spare 1	A	21	721.3		1.1030	1.0942	1.0986	1837.1	145.58
P4B10	Spare 2	A	21	721.3	1.0537	1.0547	1.0490	1.0525	1829.6	138.90
P2C02	5PB18	A	21	721.3	1.0877	1.0834	1.0865	1.0859	1840.6	144.16
P2C03	6PB25	A	21	721.3	1.0750	1.0714	1.0722	1.0729	1835.1	142.01
P2C06	Spare 1	A	21	721.3	1.0830	1.0881	1.0823	1.0845	1832.1	143.31
P2C08	Spare 2	A	21	721.3	1.0669	1.0664	1.0712	1.0682	1836.9	141.53

Appendix 71. Ambient temperature thermal diffusivity and thermal conductivity data for BAN piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
R2B01A	CPB9	A	20	718.5	1.5521	1.5421	1.5484	1.5475	1838.4	204.41
R2B03A	CPB19	A	20	718.5		1.5687	1.5698	1.5693	1838.7	207.32
R2B06A	CPB29	A	20	718.5	1.5574	1.5472	1.5473	1.5506	1832.6	204.18
R2B07A	CPB39	A	20	718.5		1.5355	1.5325	1.5340	1837.4	202.51
R2B08A	CPB49	A	20	718.5	1.5465	1.5489	1.5457	1.5470	1838.3	204.34
R2B09A	CPB59	A	20	718.5		1.5615	1.5628	1.5622	1840.6	206.59
R2B10A	CPB69	A	20	718.5	1.5300	1.5208	1.5190	1.5233	1838.8	201.25
R3B01A	CPB79	A	20	718.5	1.5484	1.5540	1.5465	1.5496	1845.0	205.42
R3B02A	CPB89	A	20	718.5	1.5523	1.5384	1.5539	1.5482	1844.9	205.22
R3B03A	CPB99	A	20	718.5	1.5641	1.5689	1.5634	1.5655	1845.7	207.60
R3B04A	CPB109	A	20	718.5	1.5716	1.5767	1.5802	1.5762	1845.7	209.03
R3B06A	CPB119	A	20	718.5	1.5552	1.5536	1.5597	1.5562	1844.8	206.27
R3B07A	CPB129	A	20	718.5	1.5645	1.5169	1.5628	1.5481	1843.2	205.01
R3B08A	CPB139	A	20	718.5	1.5716	1.5749	1.5703	1.5723	1845.5	208.49
R6B01A	CPB149	A	20	718.5	1.5409	1.5362	1.5425	1.5399	1838.7	203.43
R6B02A	CPB159	A	20	718.5	1.5600	1.5566	1.5544	1.5570	1838.5	205.67
R6B04A	CPB169	A	20	718.5	1.5157	1.5160	1.5199	1.5172	1838.9	200.46
R6B06A	CPB179	A	20	718.5	1.5459	1.5457	1.5470	1.5462	1834.7	203.82
R6B08A	CPB189	A	20	718.5	1.5215	1.5232	1.5235	1.5227	1836.0	200.87
R6B09A	Spare 1	A	20	718.5	1.5385	1.5366	1.5039	1.5263	1841.1	201.91
R6B10A	Spare 2	A	20	718.5	1.5380		1.5375	1.5378	1835.3	202.78
R4C01A	1PB22	A	20	718.5	1.5533	1.5491	1.5511	1.5512	1839.6	205.03
R4C04A	2PB22	A	20	718.5	1.6199	1.6306	1.6154	1.6220	1834.5	213.79
R4C07A	3PB22	A	20	718.5	1.5462	1.5436		1.5449	1838.4	204.06
R4C08A	4PB22	A	20	718.5	1.5538		1.5521	1.5530	1836.5	204.91

R5C01A	5PB19	A	20	718.5	1.5654		1.5652	1.5653	1850.0	208.06
R5C02A	5PB23	A	20	718.5	1.5729	1.5710	1.5752	1.5730	1849.4	209.03
R5C03A	Spare 1	A	20	718.5	1.5824	1.5922	1.5955	1.5900	1850.1	211.36
R5C05A	Spare 2	A	20	718.5	1.5755	1.5709	1.5699	1.5721	1849.0	208.86

Appendix 72. Ambient temperature thermal diffusivity and thermal conductivity data for NBG-10 piggy-back specimens

Specimen ID Number	Sample Number	Seg	Temp, °C	Specific Heat (21°C) J/Kg.K	Clark & Taylor, cm^2/s				Density, kg/m^3	Thermal Conductivity, W/mK
					Shots			Average		
S1B01	CPB10	A	19	715.7	1.2221	1.2138	1.2149	1.2169	1802.7	157.01
S1B03	CPB20	A	19	715.7	1.2142	1.2129	1.2134	1.2135	1796.7	156.04
S1B04	CPB30	A	20	718.5	1.1935		1.1984	1.1960	1796.1	154.33
S1B07	CPB40	A	20	718.5	1.2094	1.2115	1.2076	1.2095	1794.5	155.95
S1B08	CPB50	A	20	718.5	1.2031	1.2076	1.2064	1.2057	1791.7	155.22
S1B09	CPB60	A	20	718.5	1.2344	1.2331	1.2337	1.2337	1796.7	159.27
S1B10	CPB70	A	20	718.5	1.2305	1.2239	1.2306	1.2283	1795.7	158.48
S3B01	CPB80	A	20	718.5	1.2016	1.2000	1.1954	1.1990	1794.5	154.59
S3B03	CPB90	A	20	718.5	1.2094	1.2032	1.2118	1.2081	1797.9	156.07
S3B04	CPB100	A	20	718.5	1.2180	1.2122	1.2137	1.2146	1795.8	156.72
S3B07	CPB110	A	20	718.5	1.2217	1.2181	1.2247	1.2215	1797.8	157.78
S3B08	CPB120	A	20	718.5	1.2014		1.2047	1.2031	1795.7	155.22
S3B09	CPB130	A	20	718.5	1.2121	1.2130	1.2047	1.2099	1796.8	156.20
S3B10	CPB140	A	19	715.7	1.2068	1.2010	1.2039	1.2039	1789.9	154.22
S4B01	CPB150	A	19	715.7	1.2331	1.2341	1.2341	1.2338	1800.2	158.95
S4B03	CPB160	A	19	715.7	1.2387	1.2369	1.2384	1.2380	1800.7	159.55
S4B04	CPB170	A	19	715.7	1.2111	1.2162	1.2145	1.2139	1796.8	156.11
S4B07	CPB180	A	19	715.7	1.2191		1.2182	1.2187	1795.4	156.59
S4B08	CPB190	A	19	715.7	1.1937	1.1919		1.1928	1797.8	153.48
S4B09	Spare 1	A	19	715.7	1.1885	1.1838		1.1862	1795.5	152.42
S4B10	Spare 2	A	19	715.7	1.2288	1.2280	1.2301	1.2290	1794.9	157.87
S2C01	5PB20	A	20	718.5		1.2088	1.2107	1.2098	1808.1	157.17
S2C02	Spare 1	A	20	718.5	1.2104	1.2024	1.2083	1.2070	1807.7	156.78
S2C03	Spare 2	A	20	718.5	1.2687	1.2623	1.2716	1.2675	1804.4	164.34

Appendix 73. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW1-01			AW1-02			AW1-03		
	1S3			**1S11**			**1S12**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03540	6.8130	4.4250	0.03640	6.6500	4.5500	0.03139	6.7460	3.9240
200	0.09529	5.8550	5.2940	0.09190	4.5130	5.1060	0.08883	4.6090	4.9350
300	0.15057	5.3450	5.3770	0.13748	5.7500	4.9100	0.13505	5.5800	4.8230
400	0.20900	5.5460	5.5000	0.20751	6.1920	5.4610	0.20394	6.7910	5.3670
500	0.26287	6.4650	5.4760	0.25991	5.1550	5.4150	0.25811	5.2250	5.3770
600	0.33437	6.1480	5.7650	0.31864	6.7650	5.4940	0.31985	6.6020	5.5150
700	0.38580	5.5290	5.6730	0.38445	6.0350	5.6540	0.38627	6.1770	5.6800
800	0.44750	0.0000	5.7370	0.45513	0.0000	5.8350	0.45556	0.0000	5.8400

Appendix 74. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW2-01			AW2-02			AW2-03		
	1U3			**1U11**			**1U12**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03387	7.7270	4.2330	0.03553	7.0070	4.4410	0.03471	6.9270	4.3390
200	0.09088	4.6410	5.0490	0.09636	5.6460	5.3530	0.08757	4.7980	4.8650
300	0.14557	6.1400	5.1990	0.14987	5.3360	5.3530	0.14546	6.0470	5.1950
400	0.21026	5.9760	5.5330	0.21062	5.8150	5.5430	0.20532	6.0290	5.4030
500	0.26230	5.3520	5.4650	0.26470	6.2620	5.5150	0.25672	5.1060	5.3480
600	0.33306	7.1270	5.7420	0.33366	6.3400	5.7530	0.32870	6.9410	5.6670
700	0.38994	5.8890	5.7340	0.38780	5.6160	5.7030	0.38388	5.7320	5.6450
800	0.45346	0.0000	5.8140	0.45243	0.0000	5.8000	0.44459	0.0000	5.7000

Appendix 75. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW4-01			AW4-02			AW4-03		
	2S6			**2U4**			**2U6**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.04031	6.7300	5.0390	0.03919	6.5920	4.8980	0.04018	6.7100	5.0230
200	0.09703	5.5680	5.3900	0.09201	4.7440	5.1120	0.09938	5.6770	5.5210
300	0.15648	5.3970	5.5880	0.14727	5.9920	5.2590	0.15205	5.3920	5.4310
400	0.21877	6.0430	5.7570	0.20890	6.1520	5.4970	0.21314	5.7810	5.6090
500	0.26913	6.3000	5.6070	0.25989	5.2240	5.4140	0.26920	6.3510	5.6080
600	0.34340	6.3170	5.9210	0.33218	6.8980	5.7270	0.33684	6.1980	5.8080
700	0.39881	5.9750	5.8650	0.38778	5.7510	5.7030	0.39285	5.8110	5.7770
800	0.46033	0.0000	5.9020	0.44981	0.0000	5.7670	0.46075	0.0000	5.9070

Appendix 76. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW5-01			AW5-02			AW5-03		
	2U10			**3S13**			**3U8**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03867	7.0760	4.8330	0.04243	6.6580	5.3040	0.03599	6.7340	4.4980
200	0.09749	5.5850	5.4160	0.09708	4.8210	5.3930	0.09194	5.0040	5.1080
300	0.15741	5.6300	5.6220	0.15214	5.9510	5.4340	0.14826	6.1160	5.2950
400	0.21856	5.9660	5.7520	0.21315	6.2210	5.6090	0.20958	6.0500	5.5150
500	0.27032	6.3970	5.6320	0.26564	5.2470	5.5340	0.26366	5.4480	5.4930
600	0.34545	6.4100	5.9560	0.33749	6.7780	5.8190	0.33557	6.7800	5.7860
700	0.39949	5.7160	5.8750	0.39265	5.7760	5.7740	0.39233	5.7610	5.7700
800	0.46049	0.0000	5.9040	0.45519	0.0000	5.8360	0.45276	0.0000	5.8050

Appendix 77. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW6-01			AW6-02			AW6-03		
	3U12			**4S8**			**4S12**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
°C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.04176	6.4580	5.2200	0.02893	7.7370	3.6170	0.03304	7.2440	4.1300
200	0.09694	5.1780	5.3860	0.08567	4.7400	4.7590	0.09382	5.5530	5.2120
300	0.15455	5.9530	5.5200	0.13873	5.9730	4.9550	0.14937	5.4540	5.3350
400	0.21622	5.8590	5.6900	0.20723	6.0210	5.4530	0.20988	5.8470	5.5230
500	0.26696	5.7190	5.5620	0.25970	5.4470	5.4100	0.26358	6.2760	5.4910
600	0.33984	6.5050	5.8590	0.32579	6.9410	5.6170	0.33342	6.3940	5.7490
700	0.39602	5.9110	5.8240	0.38405	5.9940	5.6480	0.38792	5.6520	5.7050
800	0.45626	0.0000	5.8490	0.45150	0.0000	5.7880	0.45229	0.0000	5.7990

Appendix 78. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW7-01			AW7-02			AW7-03		
	4U8			**4U11**			**5S6**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
°C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.03379	6.9530	4.2230	0.04372	6.5750	5.4650	0.03925	6.3740	4.9060
200	0.09131	4.9730	5.0730	0.09857	5.0290	5.4760	0.09279	5.0330	5.1550
300	0.14542	6.2590	5.1940	0.15583	6.2140	5.5650	0.14944	5.8430	5.3370
400	0.20979	6.1410	5.5210	0.21707	5.9670	5.7120	0.21099	5.9440	5.5520
500	0.26310	5.3450	5.4810	0.26953	5.3490	5.6150	0.26269	5.6020	5.4730
600	0.33496	7.0310	5.7750	0.34155	6.7600	5.8890	0.33568	6.6240	5.7880
700	0.39366	5.8530	5.7890	0.39890	5.6950	5.8660	0.39179	5.9830	5.7620
800	0.45705	0.0000	5.8600	0.45681	0.0000	5.8570	0.45221	0.0000	5.7980

Appendix 79. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW9-01			AW9-02			AW9-03		
	5S14			**5U3**			**5U6**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03910	7.0980	4.8870	0.03575	6.9540	4.4680	0.03609	7.1760	4.5110
200	0.09635	5.3160	5.3530	0.09460	5.8620	5.2560	0.09534	5.5270	5.2970
300	0.15477	5.5430	5.5270	0.14938	5.4140	5.3350	0.15360	5.2650	5.4860
400	0.21734	6.1370	5.7190	0.21117	5.6810	5.5570	0.21516	6.1160	5.6620
500	0.26788	6.0190	5.5810	0.26823	6.3640	5.5880	0.26543	6.1490	5.5300
600	0.34217	6.5510	5.8990	0.33525	6.1890	5.7800	0.33795	6.4280	5.8270
700	0.39682	5.8810	5.8360	0.38983	5.9370	5.7330	0.39185	5.7450	5.7630
800	0.45909	0.0000	5.8860	0.45914	0.0000	5.8860	0.45383	0.0000	5.8180

Appendix 80. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW10-01			AW10-02			AW10-03		
	5U13			**6S1**			**6S8**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.04136	7.4250	5.1700	0.03997	6.6610	4.9960	0.03639	7.2200	4.5480
200	0.10469	5.4010	5.8160	0.09561	5.4580	5.3120	0.09412	5.3920	5.2290
300	0.15480	5.5450	5.5280	0.15505	5.4740	5.5380	0.15294	5.3500	5.4620
400	0.21491	5.6860	5.6550	0.21612	5.9130	5.6870	0.21304	6.0740	5.6060
500	0.27411	6.4280	5.7110	0.26514	5.8930	5.5240	0.26410	6.1180	5.5020
600	0.34112	6.1110	5.8810	0.33808	6.1620	5.8290	0.33700	6.3640	5.8100
700	0.39536	6.1960	5.8140	0.39215	5.8230	5.7670	0.39036	5.7000	5.7410
800	0.46821	0.0000	6.0030	0.44987	0.0000	5.7680	0.45175	0.0000	5.7920

Appendix 81. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW12-01			AW12-02			AW12-03		
	6S15			**6U1**			**6U8**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
°C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.03102	8.0680	3.8780	0.04265	6.3400	5.3320	0.03797	7.7890	4.7460
200	0.09433	5.1440	5.2400	0.09525	4.9050	5.2920	0.09619	4.7840	5.3440
300	0.14925	5.3670	5.3300	0.15248	6.1700	5.4460	0.14656	5.1440	5.2340
400	0.20950	6.5180	5.5130	0.21451	6.0520	5.6450	0.20838	6.6860	5.4840
500	0.27007	5.7320	5.6270	0.26736	5.4180	5.5700	0.26620	5.5740	5.5460
600	0.33479	6.1010	5.7720	0.34081	6.8520	5.8760	0.32966	5.8180	5.6840
700	0.38709	6.5250	5.6930	0.39703	5.7870	5.8390	0.38862	6.8870	5.7150
800	0.46324	0.0000	5.9390	0.45867	0.0000	5.8800	0.46623	0.0000	5.9770

Appendix 82. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (AG) creep specimens

	AW13-01			AW13-02			AW13-03		
	6U14			**Spare 1W**			**Spare 2W**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
°C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.04348	6.3080	5.4350	0.04330	6.4740	5.4130	0.03853	7.2450	4.8160
200	0.09763	5.2700	5.4240	0.10192	4.9310	5.6620	0.09681	4.5980	5.3780
300	0.15703	5.9130	5.6080	0.14917	5.7230	5.3280	0.14485	5.9480	5.1730
400	0.21805	6.0230	5.7380	0.21757	6.3920	5.7250	0.21203	5.9720	5.5800
500	0.27011	5.8780	5.6270	0.27070	5.3610	5.6400	0.26605	5.1730	5.5430
600	0.34520	6.4390	5.9520	0.33379	6.7470	5.7550	0.32629	6.8710	5.6260
700	0.40146	5.9820	5.9040	0.39815	5.9070	5.8550	0.38876	5.7840	5.7170
800	0.46037	0.0000	5.9020	0.46596	0.0000	5.9740	0.45599	0.0000	5.8460

Appendix 83. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (WG) creep specimens

	AL6-01			AL6-02			AL6-03		
	1S13			**2S4**			**2S10**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03107	7.26500	3.884	0.03617	7.1690	4.5210	0.04365	6.9940	5.4560
200	0.08487	4.16700	4.715	0.09011	4.4300	5.0060	0.09739	4.6170	5.4110
300	0.13079	5.82000	4.671	0.13925	5.6330	4.9730	0.14421	4.8100	5.1500
400	0.20069	5.76000	5.281	0.20433	5.7510	5.3770	0.20384	6.3930	5.3640
500	0.24926	5.09800	5.193	0.25421	5.3110	5.2960	0.25933	5.2310	5.4030
600	0.30851	6.78300	5.319	0.31667	6.6090	5.4600	0.32117	5.8460	5.5370
700	0.37299	5.66000	5.485	0.37657	5.8080	5.5380	0.37576	6.4870	5.5260
800	0.43816	0.00000	5.617	0.44183	0.0000	5.6640	0.45421	0.0000	5.8230

Appendix 84. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (WG) creep specimens

	AL7-01			AL7-02		
	Spare 1A			**Spare 2A**		
Temp.	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
^{o}C	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03983	6.5720	4.9790	0.03708	6.4280	4.6350
200	0.09429	4.7470	5.2380	0.09339	4.7000	5.1890
300	0.14659	6.0280	5.2360	0.13896	5.2770	4.9630
400	0.20764	5.7890	5.4640	0.20356	6.3340	5.3570
500	0.25779	5.0270	5.3710	0.25480	5.1510	5.3080
600	0.32673	6.8260	5.6330	0.31557	6.1700	5.4410
700	0.38035	5.5000	5.5930	0.37577	5.9080	5.5260
800	0.44182	0.0000	5.6640	0.44254	0.0000	5.6740

Appendix 85. Thermal expansion, instantaneous CTE, and mean CTE for NBG-17 (WG) creep specimens

Temp.	AL8-01			AL8-02			AL8-03		
	3S8			**4S11**			**5S3**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
°C	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.03703	7.3880	4.6290	0.03902	6.3410	4.8770	0.03305	6.4770	4.1310
200	0.09655	4.5510	5.3640	0.09408	5.2610	5.2260	0.08600	4.5080	4.7780
300	0.14667	5.2480	5.2380	0.15199	5.7560	5.4280	0.13934	6.1280	4.9760
400	0.20142	6.0960	5.3010	0.21197	5.9250	5.5780	0.19920	5.8620	5.2420
500	0.25779	5.4240	5.3710	0.26443	5.6840	5.5090	0.24707	4.7420	5.1470
600	0.32170	5.7250	5.5460	0.33673	6.5850	5.8060	0.31181	6.2160	5.3760
700	0.36983	5.9440	5.4390	0.39278	5.9480	5.7760	0.36208	5.4540	5.3250
800	0.44065	0.0000	5.6490	0.45210	0.0000	5.7960	0.42535	0.0000	5.4530

Appendix 86. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW1-01			BW1-02			BW1-03		
	1S4			**1U1**			**1U4**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.03671	5.910	4.589	0.03926	5.925	4.908	0.04171	6.087	5.214
200	0.08418	4.326	4.676	0.09200	5.125	5.111	0.09455	4.913	5.253
300	0.13282	4.966	4.743	0.14767	5.863	5.274	0.15238	6.158	5.442
400	0.19155	5.894	5.041	0.20866	5.751	5.491	0.21263	5.774	5.596
500	0.23994	5.865	4.999	0.25834	5.274	5.382	0.25992	5.336	5.415
600	0.31632	6.527	5.454	0.32902	6.782	5.673	0.33547	6.869	5.784
700	0.36930	5.865	5.431	0.38444	5.520	5.654	0.39028	5.538	5.739
800	0.42957	0.000	5.507	0.44220	0.000	5.669	0.44783	0.000	5.741

Appendix 87. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW2-01			BW2-02			BW2-03		
	2S2			**2S11**			**2U2**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03947	7.131	4.934	0.03814	6.391	4.767	0.03764	6.736	4.705
200	0.09365	4.494	5.203	0.09201	5.158	5.112	0.08974	4.480	4.985
300	0.14581	6.276	5.207	0.15069	5.817	5.382	0.14444	6.250	5.159
400	0.21335	5.987	5.615	0.21120	5.604	5.558	0.20724	5.945	5.454
500	0.26327	5.086	5.485	0.25856	5.774	5.387	0.25643	4.915	5.342
600	0.33203	7.329	5.725	0.33270	6.504	5.736	0.32630	7.223	5.626
700	0.39179	5.810	5.762	0.38804	5.754	5.706	0.38445	5.638	5.654
800	0.45815	0.000	5.874	0.44429	0.000	5.696	0.44609	0.000	5.719

Appendix 88. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW3-01			BW3-02			BW3-03		
	2U11			**3S2**			**3S11**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03751	7.144	4.688	0.04075	7.657	5.094	0.04033	6.524	5.041
200	0.09300	4.606	5.166	0.10250	5.043	5.694	0.09566	5.198	5.314
300	0.15011	6.487	5.361	0.15212	5.005	5.433	0.15539	5.963	5.550
400	0.21272	6.002	5.598	0.21034	6.761	5.535	0.21657	5.769	5.699
500	0.26248	5.037	5.468	0.27337	5.586	5.695	0.26381	5.785	5.496
600	0.33596	7.278	5.792	0.33593	5.946	5.792	0.34133	6.563	5.885
700	0.39315	5.689	5.782	0.39253	6.963	5.772	0.39471	5.663	5.805
800	0.45312	0.000	5.809	0.47525	0.000	6.093	0.44920	0.000	5.759

Appendix 89. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW5-01			BW5-02			BW5-03		
	3S14			**3U2**			**3U11**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03609	7.257	4.511	0.03503	6.443	4.379	0.03649	6.514	4.562
200	0.09019	4.485	5.011	0.08934	5.351	4.963	0.08710	4.328	4.839
300	0.14015	5.902	5.005	0.15003	5.906	5.358	0.13836	5.834	4.941
400	0.21018	5.916	5.531	0.21127	5.689	5.560	0.20199	5.932	5.315
500	0.25940	5.323	5.404	0.25934	5.769	5.403	0.25088	5.002	5.227
600	0.32195	6.960	5.551	0.33490	6.724	5.774	0.31512	7.068	5.433
700	0.38735	5.929	5.696	0.39064	5.726	5.745	0.37730	6.544	5.548
800	0.45203	0.000	5.795	0.44559	0.000	5.713	0.45628	0.000	5.850

Appendix 90. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW7-01			BW7-02			BW7-03		
	3U13			**4S5**			**4S14**		
	Expansion	Instantaneous	mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02799	5.957	3.498	0.03321	6.522	4.151	0.03536	7.637	4.420
200	0.08047	4.794	4.471	0.08742	5.110	4.857	0.09309	4.643	5.171
300	0.13757	6.398	4.913	0.14862	5.874	5.308	0.14578	6.448	5.207
400	0.19757	5.865	5.199	0.20862	5.821	5.490	0.21325	5.809	5.612
500	0.24872	5.138	5.182	0.25568	5.747	5.327	0.26273	5.324	5.474
600	0.32179	7.092	5.548	0.33208	6.597	5.725	0.33170	7.015	5.719
700	0.37787	5.522	5.557	0.38582	5.955	5.674	0.39070	5.689	5.746
800	0.43582	0.000	5.587	0.45192	0.000	5.794	0.45387	0.000	5.819

Appendix 91. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW8-01			BW8-02			BW8-03		
	4U5			**4U7**			**4U13**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03977	7.431	4.971	0.03021	6.897	3.776	0.03184	7.001	3.979
200	0.10443	5.195	5.801	0.08536	5.278	4.742	0.08404	4.138	4.669
300	0.15469	5.024	5.525	0.14349	5.043	5.125	0.13187	5.662	4.710
400	0.21686	7.198	5.707	0.20292	5.702	5.340	0.19979	6.041	5.258
500	0.28101	5.980	5.854	0.24760	5.829	5.158	0.24932	4.972	5.194
600	0.34614	6.067	5.968	0.32191	6.230	5.550	0.30647	6.297	5.284
700	0.40048	6.989	5.889	0.37329	5.595	5.490	0.36557	5.458	5.376
800	0.48638	0.000	6.236	0.42789	0.000	5.486	0.42983	0.000	5.511

Appendix 92. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW9-01			BW9-02			BW9-03		
	5S8			**5S15**			**5U5**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02502	6.640	3.128	0.04296	6.404	5.370	0.03513	7.597	4.391
200	0.07794	4.344	4.330	0.09589	4.826	5.327	0.10042	5.736	5.579
300	0.12959	6.326	4.628	0.15263	6.351	5.451	0.15002	5.147	5.358
400	0.19490	5.901	5.129	0.21468	5.841	5.649	0.20884	5.566	5.496
500	0.24287	5.016	5.060	0.26499	5.223	5.521	0.26861	6.556	5.596
600	0.31090	7.084	5.360	0.33835	7.182	5.834	0.33510	5.960	5.778
700	0.36939	5.611	5.432	0.39575	5.544	5.820	0.38746	6.061	5.698
800	0.42831	0.000	5.491	0.45425	0.000	5.824	0.45758	0.000	5.866

Appendix 93. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW10-01			BW10-02			BW10-03		
	5U8			**5U14**			**6S6**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03542	6.795	4.428	0.03733	6.892	4.666	0.03361	6.819	4.201
200	0.09266	5.701	5.148	0.09304	5.357	5.169	0.09421	5.846	5.234
300	0.15315	5.462	5.469	0.15374	5.574	5.491	0.14861	5.181	5.307
400	0.21379	5.788	5.626	0.21375	5.845	5.625	0.20736	5.612	5.457
500	0.26323	6.248	5.484	0.26293	6.143	5.478	0.25944	6.401	5.405
600	0.33865	6.385	5.839	0.33916	6.441	5.848	0.33086	6.212	5.704
700	0.39124	5.654	5.754	0.39172	5.746	5.761	0.38319	5.451	5.635
800	0.44867	0.000	5.752	0.45038	0.000	5.774	0.44407	0.000	5.693

Appendix 94. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW11-01			BW11-02			BW11-03		
	6S13			**6U3**			**6U6**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03511	6.459	4.389	0.03172	7.631	3.965	0.03146	7.589	3.933
200	0.08613	4.666	4.785	0.08789	4.461	4.883	0.08708	4.537	4.838
300	0.14244	6.427	5.087	0.14110	6.264	5.039	0.13943	6.168	4.980
400	0.20664	6.011	5.438	0.20910	6.158	5.503	0.20831	5.991	5.482
500	0.25761	5.140	5.367	0.25993	5.191	5.415	0.25835	5.197	5.382
600	0.33027	7.294	5.694	0.32934	7.312	5.678	0.32483	7.097	5.600
700	0.38871	5.562	5.716	0.38833	5.771	5.711	0.38507	5.940	5.663
800	0.44897	0.000	5.756	0.45225	0.000	5.798	0.45062	0.000	5.777

Appendix 95. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (AG) creep specimens

Temp. (°C)	BW12-01			BW12-02			BW12-03		
	6U12			**Spare 1W**			**Spare 2W**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03971	7.099	4.963	0.03655	7.046	4.569	0.03167	7.088	3.958
200	0.09617	5.389	5.343	0.09799	5.938	5.444	0.09041	4.283	5.023
300	0.15785	5.573	5.637	0.15336	5.348	5.477	0.13822	6.453	4.936
400	0.21874	5.862	5.756	0.21266	5.700	5.596	0.20962	6.172	5.516
500	0.26657	6.209	5.553	0.26647	6.392	5.551	0.26054	5.182	5.428
600	0.34433	6.440	5.937	0.33756	6.220	5.820	0.32307	6.913	5.570
700	0.39729	5.800	5.843	0.38921	5.521	5.724	0.38626	6.202	5.680
800	0.45446	0.000	5.826	0.45326	0.000	5.811	0.45719	0.000	5.861

Appendix 96. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (WG) creep specimens

Temp. (°C)	BL6-01			BL6-02			BL6-03		
	1S1			**2S12**			**3S12**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03446	6.769	4.308	0.03970	6.644	4.963	0.03634	5.991	4.542
200	0.08788	5.055	4.882	0.09495	4.909	5.275	0.09010	5.373	5.006
300	0.14874	5.765	5.312	0.14900	6.549	5.321	0.14972	5.933	5.347
400	0.20894	5.526	5.498	0.21560	5.884	5.674	0.20976	5.817	5.520
500	0.25547	5.898	5.322	0.26722	5.250	5.567	0.25810	5.535	5.377
600	0.32840	6.459	5.662	0.33910	7.147	5.847	0.33242	6.730	5.731
700	0.38400	5.808	5.647	0.39803	5.666	5.853	0.38933	5.451	5.725
800	0.43921	0.000	5.631	0.45968	0.000	5.893	0.44035	0.000	5.646

Appendix 97. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (WG) creep specimens

Temp. (°C)	BL7-01			BL7-02			BL7-03		
	4S7			**5S5**			**6S3**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03740	6.967	4.675	0.03035	6.790	3.794	0.03125	6.108	3.906
200	0.09028	4.492	5.015	0.08099	4.113	4.499	0.08465	5.430	4.703
300	0.14451	6.298	5.161	0.12764	5.584	4.558	0.14345	5.681	5.123
400	0.20826	5.879	5.481	0.19464	5.759	5.122	0.20329	5.702	5.350
500	0.25788	4.933	5.373	0.24197	4.863	5.041	0.25093	5.466	5.228
600	0.32616	7.161	5.623	0.29915	6.204	5.158	0.32418	6.638	5.589
700	0.38407	5.666	5.648	0.36051	5.574	5.302	0.37938	5.436	5.579
800	0.44727	0.000	5.734	0.42195	0.000	5.410	0.43096	0.000	5.525

Appendix 98. Thermal expansion, instantaneous CTE, and mean CTE for NBG-18 (WG) creep specimens

Temp. (°C)	BL8-01			BL8-02		
	Spare 1A			**Spare 2A**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03252	6.488	4.065	0.03878	6.231	4.847
200	0.08526	5.047	4.736	0.09367	4.635	5.204
300	0.14015	5.310	5.005	0.13931	5.385	4.975
400	0.20069	5.614	5.281	0.20653	6.569	5.435
500	0.24752	5.817	5.157	0.25929	5.186	5.402
600	0.32166	6.376	5.546	0.31947	6.320	5.508
700	0.37487	5.589	5.513	0.38381	6.195	5.644
800	0.42735	0.000	5.479	0.45535	0.000	5.838

Appendix 99. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW7-01			CW7-03		
	1S8			**1S15**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.02935	5.173	3.668	0.02795	5.232	3.494
200	0.06718	2.868	3.732	0.06439	2.602	3.577
300	0.09903	3.561	3.537	0.09550	3.512	3.411
400	0.14649	5.161	3.855	0.14099	4.963	3.710
500	0.18726	3.706	3.901	0.18058	3.498	3.762
600	0.23545	4.362	4.060	0.22273	4.099	3.840
700	0.26933	3.960	3.961	0.25613	0.000	3.767
800	0.32130	0.000	4.119	0.29384	0.000	3.767

Appendix 100. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW8-02			CW8-03		
	1U8			**1U14**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}		$x10^{-6}$ °C^{-1}	$x10^{-6}$ °C^{-1}
100	0.01820	5.343	2.275	0.02731	4.718	3.414
200	0.05594	2.680	3.108	0.06479	3.353	3.599
300	0.08726	3.598	3.117	0.09695	3.182	3.463
400	0.13533	5.107	3.561	0.13795	4.311	3.630
500	0.17481	3.563	3.642	0.17834	4.616	3.715
600	0.21922	4.178	3.780	0.22945	4.064	3.956
700	0.24959	3.673	3.670	0.26588	3.891	3.910
800	0.30131	0.000	3.863	0.30802	0.000	3.949

Appendix 101. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW9-01			CW9-02			CW9-03		
	2S13			**2U12**			**3S1**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02079	5.456	2.599	0.02392	5.476	2.990	0.02406	4.854	3.007
200	0.06020	2.899	3.344	0.06347	2.685	3.526	0.06177	3.385	3.432
300	0.09281	3.629	3.315	0.09314	3.609	3.326	0.09478	3.097	3.385
400	0.14068	5.216	3.702	0.14072	5.126	3.703	0.13582	4.348	3.574
500	0.18171	3.690	3.786	0.18327	3.854	3.818	0.17582	4.432	3.663
600	0.22997	4.332	3.965	0.23129	4.615	3.988	0.22539	3.989	3.886
700	0.26238	3.950	3.859	0.26594	3.946	3.911	0.26201	4.065	3.853
800	0.31512	0.000	4.040	0.31970	0.000	4.099	0.30299	0.000	3.884

Appendix 102. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW10-01			CW10-02			CW10-03		
	3S10			**3U1**			**3U10**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02328	4.864	2.910	0.01893	4.879	2.366	0.02522	5.047	3.152
200	0.05990	3.035	3.328	0.05775	3.141	3.208	0.06385	3.382	3.547
300	0.09278	3.857	3.313	0.09125	4.022	3.259	0.09821	3.327	3.507
400	0.14452	5.220	3.803	0.14088	4.648	3.707	0.14166	4.546	3.728
500	0.18151	3.664	3.781	0.17437	3.900	3.633	0.18202	4.562	3.792
600	0.22971	3.864	3.960	0.22166	3.851	3.822	0.23314	4.214	4.020
700	0.26232	4.544	3.858	0.25644	4.439	3.771	0.27233	4.076	4.005
800	0.32481	0.000	4.164	0.31612	0.000	4.053	0.31543	0.000	4.044

Appendix 103. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW11-01			CW11-02			CW11-03		
	4S2			**4S13**			**4U2**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.01584	5.048	1.980	0.02371	4.875	2.963	0.02884	5.500	3.605
200	0.05714	3.563	3.174	0.05986	2.956	3.325	0.06809	2.676	3.783
300	0.08850	3.188	3.161	0.09267	3.726	3.309	0.09948	3.661	3.553
400	0.13139	4.519	3.458	0.14125	5.126	3.717	0.14581	5.000	3.837
500	0.17255	4.460	3.595	0.17914	3.521	3.732	0.18548	3.617	3.864
600	0.22010	4.156	3.795	0.22773	4.120	3.926	0.23146	4.243	3.991
700	0.25872	3.857	3.805	0.26041	4.015	3.830	0.26084	3.476	3.836
800	0.30165	0.000	3.867	0.31326	0.000	4.016	0.30967	0.000	3.970

Appendix 104. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW12-01			CW12-02		
	4U12			**5S7**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02648	5.580	3.310	0.02339	5.273	2.923
200	0.06844	3.013	3.802	0.06013	2.753	3.340
300	0.09776	3.475	3.491	0.09294	3.636	3.319
400	0.14424	4.973	3.796	0.14086	5.086	3.707
500	0.18721	3.975	3.900	0.18137	3.731	3.779
600	0.23403	4.594	4.035	0.23050	4.417	3.974
700	0.26926	3.803	3.960	0.26219	3.972	3.856
800	0.31865	0.000	4.085	0.31602	0.000	4.052

Appendix 105. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW13-01			CW13-02			CW13-03		
	5U7			**6S5**			**6S9**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02569	5.151	3.211	0.01630	5.031	2.037	0.02823	5.309	3.529
200	0.06374	3.185	3.541	0.05660	3.515	3.144	0.06707	2.823	3.726
300	0.10057	3.556	3.592	0.08888	3.282	3.174	0.09838	3.590	3.514
400	0.14139	4.291	3.721	0.13183	4.401	3.469	0.14685	5.199	3.864
500	0.18034	4.545	3.757	0.17281	4.541	3.600	0.18733	3.682	3.903
600	0.23225	3.908	4.004	0.22114	4.160	3.813	0.23504	4.271	4.052
700	0.26503	4.073	3.897	0.25873	3.905	3.805	0.26573	3.747	3.908
800	0.30808	0.000	3.950	0.30262	0.000	3.880	0.31735	0.000	4.069

Appendix 106. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW14-01			CW14-02		
	6U5			**6U9**		
	Expansion	Instantaneous	Mean	Expansion	Instantaneous	Mean
	%	CTE	CTE	%	CTE	CTE
		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$		$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.01944	4.727	2.430	0.02448	4.873	3.060
200	0.06021	3.648	3.345	0.06385	3.484	3.547
300	0.09207	3.184	3.288	0.09688	3.318	3.460
400	0.13464	4.624	3.543	0.14005	4.424	3.686
500	0.17747	4.535	3.697	0.18015	4.632	3.753
600	0.22573	4.309	3.892	0.23028	4.102	3.970
700	0.26381	3.783	3.880	0.26653	3.857	3.920
800	0.30766	0.000	3.944	0.31033	0.000	3.979

Appendix 107. Thermal expansion, instantaneous CTE, and mean CTE for H-451 (WG) creep specimens

Temp. (°C)	CW15-01 Spare 1 Expansion %	CW15-01 Spare 1 Instantaneous CTE $x10^{-6}$ $°C^{-1}$	CW15-01 Spare 1 Mean CTE $x10^{-6}$ $°C^{-1}$	CW15-02 Spare 2 Expansion %	CW15-02 Spare 2 Instantaneous CTE $x10^{-6}$ $°C^{-1}$	CW15-02 Spare 2 Mean CTE $x10^{-6}$ $°C^{-1}$
100	0.01842	4.854	2.303	0.02692	4.902	3.365
200	0.05634	3.193	3.130	0.06551	3.442	3.640
300	0.09250	3.603	3.304	0.09998	3.253	3.571
400	0.13357	4.369	3.515	0.14117	4.287	3.715
500	0.17323	4.588	3.609	0.18070	4.614	3.765
600	0.22532	4.051	3.885	0.23074	3.871	3.978
700	0.26182	4.167	3.850	0.26477	3.758	3.894
800	0.30500	0.000	3.910	0.30466	0.000	3.906

Appendix 108. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW1-01 1S2 Expansion %	DW1-01 1S2 Instantaneous CTE $x10^{-6}$ $°C^{-1}$	DW1-01 1S2 Mean CTE $x10^{-6}$ $°C^{-1}$	DW1-02 1S6 Expansion %	DW1-02 1S6 Instantaneous CTE $x10^{-6}$ $°C^{-1}$	DW1-02 1S6 Mean CTE $x10^{-6}$ $°C^{-1}$	DW1-03 1S14 Expansion %	DW1-03 1S14 Instantaneous CTE $x10^{-6}$ $°C^{-1}$	DW1-03 1S14 Mean CTE $x10^{-6}$ $°C^{-1}$
100	0.03561	6.066	4.451	0.03397	6.283	4.246	0.03334	6.646	4.168
200	0.08746	4.731	4.859	0.08719	4.756	4.844	0.08846	4.685	4.915
300	0.13303	4.310	4.751	0.13341	4.422	4.765	0.13230	4.482	4.725
400	0.18707	5.254	4.923	0.18771	5.183	4.940	0.18651	5.096	4.908
500	0.22874	4.960	4.765	0.22899	5.044	4.771	0.22888	5.265	4.768
600	0.29357	5.957	5.062	0.29377	5.881	5.065	0.29547	5.512	5.094
700	0.34179	5.066	5.026	0.34181	5.079	5.027	0.34345	4.951	5.051
800	0.39161	0.000	5.021	0.39038	0.000	5.005	0.38952	0.000	4.994

Appendix 109. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW2-01 1U2			DW2-02 1U6			DW2-03 1U13		
	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}
100	0.02779	5.568	3.474	0.03326	6.229	4.158	0.03275	6.184	4.093
200	0.07433	4.177	4.129	0.08146	4.277	4.525	0.08097	3.982	4.498
300	0.12076	5.285	4.313	0.13158	5.280	4.699	0.12864	5.413	4.594
400	0.17641	5.244	4.642	0.18496	5.270	4.867	0.18244	5.304	4.801
500	0.22106	4.437	4.605	0.22917	4.465	4.774	0.22741	4.485	4.738
600	0.27776	5.992	4.789	0.28957	6.254	4.993	0.28759	6.068	4.958
700	0.33253	5.015	4.890	0.34238	5.169	5.035	0.34050	5.174	5.007
800	0.38926	0.000	4.991	0.40054	0.000	5.135	0.39847	0.000	5.109

Appendix 110. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW3-01 2S1			DW3-02 2S8			DW3-03 2S14		
	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}
100	0.02917	6.214	3.646	0.03518	5.839	4.397	0.03318	5.846	4.147
200	0.07819	4.522	4.344	0.08298	4.391	4.610	0.08105	4.083	4.503
300	0.12709	4.893	4.539	0.13210	5.312	4.718	0.12772	5.415	4.562
400	0.17968	5.310	4.729	0.18637	5.377	4.904	0.18255	5.290	4.804
500	0.22356	4.407	4.657	0.23143	4.374	4.821	0.22853	4.650	4.761
600	0.28708	6.235	4.950	0.29105	6.150	5.018	0.28792	6.068	4.964
700	0.33545	5.239	4.933	0.34539	5.418	5.079	0.34307	5.135	5.045
800	0.39203	0.000	5.026	0.40501	0.000	5.192	0.40143	0.000	5.146

Appendix 111. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW4-01 2U8			DW4-03 2U1		
	Expansion %	Instantaneous CTE $x10^{-6}\ ^oC^{-1}$	Mean CTE $x10^{-6}\ ^oC^{-1}$	Expansion %	Instantaneous CTE $x10^{-6}\ ^oC^{-1}$	Mean CTE $x10^{-6}\ ^oC^{-1}$
100	0.03283	6.727	4.104	0.03218	6.1710	4.0220
200	0.08818	4.178	4.899	0.08399	4.7880	4.6660
300	0.12862	4.830	4.594	0.13108	4.3760	4.6810
400	0.18051	5.037	4.750	0.18471	5.1080	4.8610
500	0.22956	5.490	4.783	0.22453	4.8730	4.6780
600	0.29069	5.420	5.012	0.28973	5.8240	4.9950
700	0.33741	4.787	4.962	0.33600	5.1530	4.9410
800	0.38852	0.000	4.981	0.38589	0.0000	4.9470

Appendix 112. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW5-01 2U13			DW5-02 3S15			DW5-03 3U6		
	Expansion %	Instantaneous CTE $x10^{-6}\ ^oC^{-1}$	Mean CTE $x10^{-6}\ ^oC^{-1}$	Expansion %	Instantaneous CTE $x10^{-6}\ ^oC^{-1}$	Mean CTE $x10^{-6}\ ^oC^{-1}$	Expansion %	Instantaneous CTE $x10^{-6}\ ^oC^{-1}$	Mean CTE $x10^{-6}\ ^oC^{-1}$
100	0.03103	6.4060	3.8790	0.03315	5.972	4.144	0.03182	6.043	3.977
200	0.08512	4.4970	4.7290	0.08356	4.812	4.642	0.08133	4.621	4.518
300	0.13035	4.7530	4.6550	0.13306	4.470	4.752	0.13049	4.715	4.660
400	0.18466	5.1700	4.8590	0.18601	5.347	4.895	0.18374	5.267	4.835
500	0.22663	5.1360	4.7210	0.22860	4.752	4.762	0.22733	4.600	4.736
600	0.29265	5.6580	5.0460	0.29263	6.154	5.045	0.28972	6.274	4.995
700	0.34139	4.9700	5.0200	0.33992	5.064	4.999	0.33765	5.081	4.965
800	0.38633	0.0000	4.9530	0.39107	0.000	5.014	0.39012	0.000	5.002

Appendix 113. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW6-01 3U14			DW6-02 4S15			DW6-03 4U1		
	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}
100	0.03224	5.952	4.030	0.02803	6.229	3.504	0.03397	6.065	4.246
200	0.08274	4.832	4.597	0.07675	4.470	4.264	0.08225	4.051	4.569
300	0.13224	4.600	4.723	0.12683	5.000	4.530	0.12864	5.413	4.594
400	0.18648	5.168	4.907	0.17829	5.312	4.692	0.18380	5.295	4.837
500	0.22773	4.979	4.744	0.22237	4.457	4.633	0.22881	4.508	4.767
600	0.29302	6.082	5.052	0.28522	6.076	4.918	0.28784	6.077	4.963
700	0.34214	4.969	5.031	0.33510	5.284	4.928	0.34185	5.206	5.027
800	0.39092	0.000	5.012	0.39276	0.000	5.035	0.40173	0.000	5.150

Appendix 114. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW7-01 4U6			DW7-02 4U14			DW7-03 5S4		
	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}
100	0.02867	6.116	3.583	0.03097	6.165	3.872	0.03322	6.775	4.153
200	0.07788	4.171	4.327	0.08280	4.810	4.600	0.08889	4.654	4.938
300	0.12793	5.190	4.569	0.13114	4.565	4.684	0.13148	4.518	4.696
400	0.18102	5.314	4.764	0.18594	5.206	4.893	0.18572	5.116	4.887
500	0.22486	4.489	4.685	0.22752	4.906	4.740	0.22961	5.332	4.784
600	0.28566	6.149	4.925	0.29264	6.002	5.046	0.29642	5.460	5.111
700	0.33348	5.093	4.904	0.34067	5.117	5.010	0.34481	5.002	5.071
800	0.38788	0.000	4.973	0.39018	0.000	5.002	0.38911	0.000	4.989

Appendix 115. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW8-01 5S9			DW8-02 5S12			DW8-03 5U4		
	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}
100	0.03277	6.947	4.096	0.03262	6.954	4.077	0.03544	6.188	4.430
200	0.08898	4.746	4.943	0.08810	4.569	4.894	0.08778	4.828	4.877
300	0.13202	4.700	4.715	0.12472	4.663	4.454	0.13458	4.370	4.806
400	0.18614	4.991	4.898	0.18274	4.893	4.809	0.18821	5.066	4.953
500	0.23146	5.157	4.822	0.22852	5.269	4.761	0.22918	5.074	4.775
600	0.29736	5.571	5.127	0.29321	5.324	5.055	0.29387	5.831	5.067
700	0.34475	5.067	5.070	0.34027	4.948	5.004	0.34111	5.017	5.016
800	0.39263	0.000	5.034	0.38723	0.000	4.964	0.39018	0.000	5.002

Appendix 116. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens which were incorrectly labeled as (AG) specimens

Temp. (°C)	DA702 5S11			DA801 6S12		
	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}	Expansion %	Instantaneous CTE x10^{-6} °C^{-1}	Mean CTE x10^{-6} °C^{-1}
100	0.03398	6.583	4.248	0.02714	6.692	3.392
200	0.08225	3.932	4.570	0.08233	4.803	4.574
300	0.12458	4.796	4.449	0.12677	4.599	4.527
400	0.18581	5.545	4.890	0.18145	5.059	4.775
500	0.23065	4.786	4.805	0.22476	5.304	4.683
600	0.28748	5.570	4.956	0.29210	5.634	5.036
700	0.34249	5.785	5.037	0.34106	5.054	5.016
800	0.40673	0.000	5.214	0.38656	0.000	4.956

Appendix 117. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW9-01 5U9			DW9-02 5U11			DW9-03 6S4		
	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$
100	0.03287	6.925	4.109	0.03308	7.142	4.134	0.03358	6.775	4.197
200	0.08881	4.703	4.934	0.08861	4.199	4.923	0.08928	4.708	4.960
300	0.13193	4.572	4.712	0.13193	4.749	4.712	0.13140	4.592	4.693
400	0.18498	5.004	4.868	0.18243	4.965	4.801	0.18427	4.980	4.849
500	0.22946	5.220	4.781	0.23280	5.754	4.850	0.23010	5.417	4.794
600	0.29662	5.556	5.114	0.29354	5.489	5.061	0.29647	5.393	5.112
700	0.34355	5.149	5.052	0.34068	4.815	5.010	0.34326	5.063	5.048
800	0.39139	0.000	5.018	0.39473	0.000	5.061	0.39168	0.000	5.022

Appendix 118. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW10-01 6S11			DW10-02 6U11			DW10-03 6U4		
	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$
100	0.03452	6.945	4.315	0.03318	6.997	4.147	0.03492	6.708	4.365
200	0.09051	4.392	5.028	0.08910	4.613	4.950	0.08931	4.304	4.962
300	0.13306	4.648	4.752	0.13096	4.631	4.677	0.13096	4.734	4.677
400	0.18447	4.987	4.854	0.18525	4.899	4.875	0.18257	5.019	4.805
500	0.23195	5.521	4.832	0.22971	5.380	4.786	0.23086	5.552	4.810
600	0.29423	5.648	5.073	0.29632	5.533	5.109	0.29417	5.581	5.072
700	0.34142	4.795	5.021	0.34455	5.030	5.067	0.34115	4.826	5.017
800	0.39125	0.000	5.016	0.39102	0.000	5.013	0.39188	0.000	5.024

Appendix 119. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (WG) creep specimens

Temp. (°C)	DW11-01 Spare 1W			DW11-02 Spare 2W		
	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$
100	0.02824	7.159	3.530	0.03260	6.914	4.075
200	0.08573	4.611	4.763	0.08780	4.257	4.878
300	0.12767	4.743	4.560	0.12898	4.762	4.607
400	0.18069	4.929	4.755	0.18270	5.042	4.808
500	0.22750	5.399	4.740	0.23005	5.510	4.793
600	0.29237	5.466	5.041	0.29265	5.551	5.046
700	0.33992	4.938	4.999	0.33902	4.884	4.986
800	0.38532	0.000	4.940	0.39115	0.000	5.015

Appendix 120. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (AG) creep specimens

Temp. (°C)	DA601 3S6			DA602 4S1		
	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}$ $°C^{-1}$	Mean CTE $x10^{-6}$ $°C^{-1}$
100	0.04095	6.166	5.119	0.04025	7.3950	5.0310
200	0.09177	4.517	5.098	0.09849	4.3890	5.4710
300	0.13563	4.699	4.844	0.14438	4.8390	5.1570
400	0.19646	6.370	5.170	0.19648	5.3430	5.1710
500	0.24790	5.101	5.165	0.24951	5.8370	5.1980
600	0.30741	5.515	5.300	0.30966	5.6830	5.3390
700	0.36145	6.373	5.315	0.35901	4.9520	5.2800
800	0.43811	0.000	5.617	0.42024	0.0000	5.3880

Appendix 121. Thermal expansion, instantaneous CTE, and mean CTE for PCEA (AG) creep specimens

Temp. (°C)	DA701 4S6			DA802 Spare 1A			DA901 Spare 2A		
	Linear Expansion %	Instantaneous CTE $x10^{-6}$ °C^{-1}	Mean CTE $x10^{-6}$ °C^{-1}	Linear Expansion %	Instantaneous CTE $x10^{-6}$ °C^{-1}	Mean CTE $x10^{-6}$ °C^{-1}	Linear Expansion %	Instantaneous CTE $x10^{-6}$ °C^{-1}	Mean CTE $x10^{-6}$ °C^{-1}
100	0.03861	6.706	4.827	0.03696	7.341	4.621	0.04021	6.396	5.027
200	0.08987	4.208	4.993	0.09475	4.332	5.264	0.09092	4.649	5.051
300	0.13587	4.677	4.853	0.14155	4.919	5.055	0.13672	4.575	4.883
400	0.18968	5.740	4.991	0.19549	5.620	5.145	0.19393	6.209	5.103
500	0.25251	6.237	5.261	0.24859	5.696	5.179	0.24838	5.127	5.175
600	0.31541	5.868	5.438	0.31087	5.662	5.360	0.30863	5.639	5.321
700	0.36489	6.112	5.366	0.36015	5.538	5.296	0.35960	6.091	5.288
800	0.43825	0.000	5.619	0.42443	0.000	5.441	0.43549	0.000	5.583

Appendix 122. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW2-01 1S7			EW2-02 1S9			EW2-03 1U7		
	Linear Expansion %	Instantaneous CTE $x10^{-6}$ °C^{-1}	Mean CTE $x10^{-6}$ °C^{-1}	Linear Expansion %	Instantaneous CTE $x10^{-6}$ °C^{-1}	Mean CTE $x10^{-6}$ °C^{-1}	Linear Expansion %	Instantaneous CTE $x10^{-6}$ °C^{-1}	Mean CTE $x10^{-6}$ °C^{-1}
100	0.02569	6.32	3.211	0.03344	5.717	4.18	0.02419	6.634	3.023
200	0.07669	4.626	4.261	0.07975	3.98	4.431	0.07936	4.786	4.409
300	0.12808	4.886	4.574	0.12433	5.216	4.44	0.12388	4.616	4.424
400	0.18256	5.454	4.804	0.18323	5.323	4.822	0.17907	5.047	4.712
500	0.22707	4.75	4.731	0.22892	4.73	4.769	0.22247	5.343	4.635
600	0.29049	6.305	5.008	0.28321	5.593	4.883	0.28714	5.236	4.951
700	0.33844	5.061	4.977	0.33819	5.264	4.973	0.33308	4.819	4.898
800	0.39142	0	5.018	0.39765	0	5.098	0.38004	0	4.872

Appendix 123. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW4-01 1U9 Linear Expansion %	EW4-01 1U9 Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	EW4-01 1U9 Mean CTE $x10^{-6}\,^{o}C^{-1}$	EW4-02 2S5 Linear Expansion %	EW4-02 2S5 Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	EW4-02 2S5 Mean CTE $x10^{-6}\,^{o}C^{-1}$
100	0.03647	5.771	4.558	0.02683	6.36	3.354
200	0.0812	3.858	4.511	0.07403	3.859	4.113
300	0.12594	5.291	4.498	0.1175	5.204	4.197
400	0.18609	5.033	4.897	0.17989	5.449	4.734
500	0.23108	4.718	4.814	0.22609	4.73	4.71
600	0.2827	5.426	4.874	0.27864	5.255	4.804
700	0.33605	5.449	4.942	0.33014	5.538	4.855
800	0.39576	0	5.074	0.39009	0	5.001

Appendix 124. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW5-01 2S7 Linear Expansion %	EW5-01 2S7 Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	EW5-01 2S7 Mean CTE $x10^{-6}\,^{o}C^{-1}$	EW5-02 2U5 Linear Expansion %	EW5-02 2U5 Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	EW5-02 2U5 Mean CTE $x10^{-6}\,^{o}C^{-1}$	EW5-03 2U7 Linear Expansion %	EW5-03 2U7 Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	EW5-03 2U7 Mean CTE $x10^{-6}\,^{o}C^{-1}$
100	0.02631	6.226	3.289	0.02789	6.601	3.486	0.03141	6.783	3.927
200	0.07527	4.514	4.182	0.07762	3.754	4.312	0.08332	3.786	4.629
300	0.12599	5.022	4.5	0.11786	4.753	4.209	0.12421	5.113	4.436
400	0.17864	5.389	4.701	0.17771	5.765	4.677	0.18635	5.777	4.904
500	0.22108	4.058	4.606	0.22154	4.689	4.616	0.23234	4.84	4.84
600	0.26873	3.718	4.633	0.27638	4.884	4.765	0.28742	5.162	4.956
700	0.30407	4.379	4.472	0.3263	5.876	4.799	0.34164	5.966	5.024
800	0.3568	0	4.574	0.39259	0	5.033	0.40542	0	5.198

Appendix 125. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW6-01 3S9			EW6-02 3U9			EW6-03 4S4		
	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$
100	0.02757	5.899	3.446	0.03013	5.8	3.766	0.02499	6.041	3.124
200	0.07496	4.14	4.165	0.07731	4.302	4.295	0.07524	4.596	4.18
300	0.12366	5.325	4.416	0.12606	5.212	4.502	0.1254	4.804	4.478
400	0.17636	5.256	4.641	0.17873	5.34	4.703	0.1788	5.368	4.705
500	0.22034	4.389	4.59	0.22346	4.264	4.655	0.22098	4.465	4.604
600	0.2787	5.976	4.805	0.28021	5.895	4.831	0.28253	6.171	4.871
700	0.33185	4.882	4.88	0.33292	4.791	4.896	0.32793	4.653	4.823
800	0.38539	0	4.941	0.38738	0	4.966	0.37769	0	4.842

Appendix 126. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW7-01 4S9			EW7-03 4U4		
	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$
100	0.02967	6.075	3.709	0.02766	5.465	3.458
200	0.08148	4.77	4.527	0.07411	4.294	4.117
300	0.13077	4.508	4.67	0.12365	5.466	4.416
400	0.18379	5.349	4.836	0.17874	5.367	4.704
500	0.2252	4.798	4.692	0.22464	4.542	4.68
600	0.28885	5.763	4.98	0.28263	6.05	4.873
700	0.32949	4.685	4.845	0.33734	5.142	4.961
800	0.38029	0	4.876	0.39502	0	5.064

Appendix 127. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW8-01 4U9			EW8-02 5S1			EW8-03 5S13		
	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$
100	0.03501	5.487	4.376	0.02367	6.224	2.959	0.03659	5.538	4.574
200	0.08086	4.096	4.492	0.07758	4.699	4.31	0.08141	3.933	4.523
300	0.12893	5.494	4.605	0.12139	4.315	4.335	0.12559	5.218	4.485
400	0.1862	5.337	4.9	0.17498	5.024	4.605	0.18526	5.182	4.875
500	0.23238	4.593	4.841	0.21388	4.746	4.456	0.23048	4.666	4.802
600	0.28762	6.04	4.959	0.27324	5.243	4.711	0.28392	5.649	4.895
700	0.34536	5.206	5.079	0.31184	4.442	4.586	0.33997	5.411	5
800	0.40457	0	5.187	0.36154	0	4.635	0.39823	0	5.105

Appendix 128. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW9-01 5U1			EW9-02 5U12			EW9-03 6S14		
	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\,^{o}C^{-1}$	Mean CTE $x10^{-6}\,^{o}C^{-1}$
100	0.02469	5.981	3.087	0.02702	6.035	3.377	0.02321	6.069	2.902
200	0.07358	4.555	4.088	0.0743	4.093	4.128	0.07163	4.452	3.98
300	0.12457	4.772	4.449	0.12274	5.187	4.384	0.12224	4.969	4.366
400	0.1771	5.373	4.661	0.17487	5.242	4.602	0.17385	5.279	4.575
500	0.21968	4.402	4.577	0.21714	3.97	4.524	0.21734	4.335	4.528
600	0.27797	5.883	4.793	0.2653	4.521	4.574	0.27585	5.972	4.756
700	0.32411	4.768	4.766	0.31137	4.789	4.579	0.3245	4.754	4.772
800	0.37716	0	4.835	0.36412	0	4.668	0.37721	0	4.836

Appendix 129. Thermal expansion, instantaneous CTE, and mean CTE for IG-110 creep specimens

Temp. (°C)	EW10-01 6U13			EW10-02 Spare 1			EW10-03 Spare 2		
	Linear Expansion %	Instantaneous CTE $x10^{-6}\ ^{o}C^{-1}$	Mean CTE $x10^{-6}\ ^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\ ^{o}C^{-1}$	Mean CTE $x10^{-6}\ ^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\ ^{o}C^{-1}$	Mean CTE $x10^{-6}\ ^{o}C^{-1}$
100	0.03151	5.742	3.939	0.02375	5.424	2.969	0.0331	6.11	4.137
200	0.08037	4.627	4.465	0.06881	3.77	3.823	0.0789	3.802	4.384
300	0.12892	4.477	4.604	0.11428	5.589	4.081	0.1205	4.875	4.304
400	0.18164	5.321	4.78	0.17225	5.164	4.533	0.18138	5.43	4.773
500	0.22244	4.494	4.634	0.21733	4.583	4.528	0.22567	4.665	4.702
600	0.28192	5.753	4.861	0.27032	5.553	4.661	0.27771	4.912	4.788
700	0.32602	4.932	4.794	0.32473	5.218	4.775	0.32964	5.911	4.848
800	0.38082	0	4.882	0.38104	0	4.885	0.39295	0	5.038

Appendix 130. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW1-01 **1S5**			FW1-02 **1S10**			FW1-03 **1U5**		
	Linear Expansion %	Instantaneous CTE $x10^{-6}\ ^{o}C^{-1}$	Mean CTE $x10^{-6}\ ^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\ ^{o}C^{-1}$	Mean CTE $x10^{-6}\ ^{o}C^{-1}$	Linear Expansion %	Instantaneous CTE $x10^{-6}\ ^{o}C^{-1}$	Mean CTE $x10^{-6}\ ^{o}C^{-1}$
100	0.02096	6.457	2.620	0.03058	6.219	3.822	0.02413	7.225	3.016
200	0.07148	4.188	3.971	0.08460	5.148	4.700	0.08479	4.796	4.711
300	0.11943	5.659	4.265	0.13628	4.844	4.867	0.12958	5.016	4.628
400	0.18301	5.611	4.816	0.19240	5.525	5.063	0.18470	5.308	4.861
500	0.22869	4.448	4.764	0.23700	5.337	4.937	0.23774	5.956	4.953
600	0.27655	4.340	4.768	0.30442	5.337	5.249	0.29831	5.401	5.143
700	0.32140	5.598	4.726	0.34413	4.459	5.061	0.34433	4.729	5.064
800	0.38705	0.000	4.962	0.38892	0.000	4.986	0.39923	0.000	5.118

Appendix 131. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW2-01 **1U10**			FW2-02 **2S3**			FW2-03 **2S9**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03333	6.784	4.167	0.03571	5.637	4.463	0.02624	6.454	3.280
200	0.09238	5.121	5.132	0.08445	4.485	4.692	0.08185	5.021	4.547
300	0.13633	4.815	4.869	0.13623	5.811	4.865	0.13550	5.115	4.839
400	0.19183	5.133	5.048	0.19352	5.671	5.093	0.19284	5.536	5.075
500	0.24156	5.770	5.032	0.24137	4.686	5.029	0.23740	5.707	4.946
600	0.30513	4.915	5.261	0.30608	6.511	5.277	0.30762	5.906	5.304
700	0.34917	4.931	5.135	0.35593	4.995	5.234	0.35852	5.258	5.272

Appendix 132. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW3-01 **2S15**			FW3-02 **2U3**			FW3-03 **2U9**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02875	5.778	3.594	0.02373	5.781	2.966	0.03711	5.826	4.639
200	0.07738	4.611	4.299	0.07400	4.467	4.111	0.08594	4.266	4.774
300	0.12980	5.441	4.636	0.12641	5.777	4.515	0.13539	5.846	4.835
400	0.18419	5.512	4.847	0.18152	5.613	4.777	0.19582	5.749	5.153
500	0.22989	4.593	4.789	0.22946	4.684	4.780	0.24382	4.863	5.080
600	0.29428	6.317	5.074	0.29481	6.627	5.083	0.30713	6.612	5.295
700	0.34405	5.271	5.060	0.34607	5.383	5.089	0.36333	5.404	5.343
800	0.40108	0.000	5.142	0.40347	0.000	5.173	0.42402	0.000	5.436

Appendix 133. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW4-01 **2U14**			FW4-02 **3S3**			FW4-03 **3S4**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.01531	6.470	1.913	0.03082	7.024	3.853	0.02116	6.945	2.645
200	0.06866	4.162	3.815	0.08974	4.950	4.986	0.07270	4.088	4.039
300	0.11005	4.794	3.930	0.13368	4.910	4.774	0.11886	5.566	4.245
400	0.17197	6.282	4.526	0.18892	5.144	4.972	0.18408	5.535	4.844
500	0.21837	4.889	4.549	0.24064	5.803	5.013	0.23282	4.980	4.850
600	0.27621	5.251	4.762	0.30331	5.428	5.230	0.28812	6.089	4.968
700	0.33060	6.199	4.862	0.35116	4.833	5.164	0.34711	5.529	5.105
800	0.39659	0.000	5.084	0.40207	0.000	5.155	0.40874	0.000	5.240

Appendix 134. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW5-01 **3S5**			FW5-02 **3S7**			FW5-03 **3U3**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.02863	6.299	3.579	0.03239	6.560	4.049	0.02261	7.087	2.826
200	0.08114	4.856	4.508	0.08967	5.090	4.982	0.07505	4.187	4.169
300	0.13384	4.953	4.780	0.13486	4.715	4.816	0.12167	5.554	4.345
400	0.18972	5.501	4.993	0.18922	5.201	4.979	0.18893	5.797	4.972
500	0.23400	5.120	4.875	0.23630	5.557	4.923	0.23718	4.979	4.941
600	0.30189	6.309	5.205	0.30382	5.692	5.238	0.29455	6.329	5.079
700	0.35243	5.128	5.183	0.35270	5.259	5.187	0.35765	5.836	5.260
800	0.40351	0.000	5.173	0.40539	0.000	5.197	0.42167	0.000	5.406

Appendix 135. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW7-01			FW7-02			FW7-03		
	3U4			**3U5**			**3U7**		
	Linear Expansion	Instantaneous CTE	mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^oC^{-1}$	$x10^{-6}\ ^oC^{-1}$	%	$x10^{-6}\ ^oC^{-1}$	$x10^{-6}\ ^oC^{-1}$	%	$x10^{-6}\ ^oC^{-1}$	$x10^{-6}\ ^oC^{-1}$
100	0.03130	6.152	3.912	0.03244	6.747	4.055	0.03587	6.651	4.484
200	0.08271	5.087	4.595	0.09202	5.575	5.112	0.09051	4.767	5.028
300	0.13974	5.517	4.991	0.14193	5.059	5.069	0.13992	5.217	4.997
400	0.19751	5.634	5.198	0.19881	5.368	5.232	0.20505	6.887	5.396
500	0.24294	4.924	5.061	0.24924	5.989	5.192	0.25830	5.160	5.381
600	0.31223	6.660	5.383	0.31799	5.950	5.483	0.32095	5.935	5.534
700	0.36506	5.318	5.368	0.36824	5.218	5.415	0.38249	6.687	5.625
800	0.41856	0.000	5.366	0.42195	0.000	5.410	0.45861	0.000	5.880

Appendix 136. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW8-01			FW8-02			FW8-03		
	4S3			**4S10**			**4U3**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^oC^{-1}$	$x10^{-6}\ ^oC^{-1}$	%	$x10^{-6}\ ^oC^{-1}$	$x10^{-6}\ ^oC^{-1}$	%	$x10^{-6}\ ^oC^{-1}$	$x10^{-6}\ ^oC^{-1}$
100	0.02389	6.749	2.986	0.04332	7.291	5.415	0.02136	7.278	2.670
200	0.07433	4.018	4.129	0.09906	4.418	5.503	0.07310	4.133	4.061
300	0.12034	5.541	4.298	0.14678	4.730	5.242	0.12161	5.683	4.343
400	0.18565	5.621	4.886	0.20057	6.233	5.278	0.18718	5.603	4.926
500	0.23200	4.767	4.833	0.25897	5.219	5.395	0.23659	4.961	4.929
600	0.28772	6.066	4.961	0.32065	5.619	5.528	0.29243	6.385	5.042
700	0.34844	5.731	5.124	0.36715	6.216	5.399	0.35505	5.629	5.221
800	0.41262	0.000	5.290	0.43976	0.000	5.638	0.41715	0.000	5.348

Appendix 137. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW9-01			FW9-02			FW9-03		
	4U10			**5S2**			**5S10**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.04305	6.080	5.382	0.03053	2.798	3.817	0.04045	6.892	5.056
200	0.09373	4.645	5.207	0.05226	4.036	2.903	0.09366	4.741	5.204
300	0.13710	4.461	4.896	0.10534	4.833	3.762	0.13977	4.743	4.992
400	0.19731	6.423	5.192	0.16230	5.457	4.271	0.20297	6.578	5.341
500	0.24894	5.023	5.186	0.20808	5.690	4.335	0.25686	5.169	5.351
600	0.30700	5.326	5.293	0.27935	5.942	4.816	0.31708	5.555	5.467
700	0.36053	6.235	5.302	0.32882	5.357	4.836	0.37390	6.562	5.499
800	0.43655	0.000	5.597	0.38061	0.000	4.880	0.45064	0.000	5.777

Appendix 138. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW10-01			FW10-02			FW10-03		
	5U2			**5U10**			**6S2**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03115	7.032	3.893	0.03306	6.689	4.132	0.03187	6.547	3.984
200	0.08313	4.037	4.618	0.08703	4.185	4.835	0.08520	4.693	4.733
300	0.12761	5.244	4.557	0.12989	5.233	4.639	0.12961	4.739	4.629
400	0.19373	5.967	5.098	0.19439	6.088	5.115	0.19292	6.554	5.077
500	0.24019	4.815	5.004	0.24266	4.864	5.055	0.24442	5.228	5.092
600	0.29799	5.867	5.138	0.29951	5.729	5.164	0.30382	5.307	5.238
700	0.35629	5.976	5.240	0.35875	6.123	5.276	0.36016	6.554	5.297
800	0.42529	0.000	5.452	0.42668	0.000	5.470	0.43726	0.000	5.606

Appendix 139. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW11-01			FW11-02			FW11-03		
	6S7			**6S10**			**6U2**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.04065	6.070	5.081	0.02546	6.789	3.183	0.03916	6.249	4.895
200	0.09475	4.781	5.264	0.07994	5.140	4.441	0.09357	4.430	5.198
300	0.13752	4.661	4.911	0.13475	4.874	4.813	0.13803	5.270	4.930
400	0.20064	6.661	5.280	0.18947	5.288	4.986	0.20114	6.384	5.293
500	0.25055	5.065	5.220	0.23407	5.495	4.877	0.25132	5.105	5.236
600	0.31044	5.371	5.352	0.30231	6.030	5.212	0.31088	5.614	5.360
700	0.36822	6.553	5.415	0.35464	5.200	5.215	0.37235	6.528	5.476
800	0.44259	0.000	5.674	0.39972	0.000	5.125	0.44323	0.000	5.682

Appendix 140. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW12-01			FW12-02		
	6U7			**6U10**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03148	6.403	3.936	0.03965	7.258	4.956
200	0.08372	4.383	4.651	0.09777	4.345	5.432
300	0.12925	5.103	4.616	0.14460	4.863	5.164
400	0.19269	6.387	5.071	0.19676	5.981	5.178
500	0.24239	4.932	5.050	0.25443	5.491	5.301
600	0.30069	5.533	5.184	0.31573	5.609	5.444
700	0.35939	6.259	5.285	0.36308	5.843	5.339
800	0.42977	0.000	5.510	0.43463	0.000	5.572

Appendix 141. Thermal expansion, instantaneous CTE, and mean CTE for IG-430 creep specimens

Temp. (°C)	FW13-01 **Spare 1**			FW13-02 **Spare 2**		
	Linear Expansion	Instantaneous CTE	Mean CTE	Linear Expansion	Instantaneous CTE	Mean CTE
	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$	%	$x10^{-6}\ ^{o}C^{-1}$	$x10^{-6}\ ^{o}C^{-1}$
100	0.03145	6.342	3.931	0.03909	7.269	4.887
200	0.08228	4.596	4.571	0.09836	4.699	5.464
300	0.12590	4.527	4.497	0.14576	4.742	5.206
400	0.18730	6.462	4.929	0.19806	5.919	5.212
500	0.23939	5.049	4.987	0.25743	5.578	5.363
600	0.29800	5.279	5.138	0.31686	5.645	5.463
700	0.35032	6.437	5.152	0.36608	5.856	5.384
800	0.42977	0.000	5.510	0.43529	0.000	5.581

Appendix 142. Current, voltage and electrical resistivity data for NBG-17 – sheet 1

Resistivity

Specimen ID Number			AW1-01	AW1-02	AW1-03	AL6-01	AW2-01
Sample Location			**1S3**	**1S11**	**1S12**	**1S13**	**1U3**
Applied current, I	mA		4.0000	4.0000	4.0000	4.0000	4.0000
Compl. Voltage	V		2.5000	2.5000	2.5000	2.5000	2.5000
ID Orientation:							
Forward current:							
Measured Potential, mV		1	0.003864	0.003908	0.004064	0.003767	0.004004
		2	0.004122	0.003635	0.004031	0.003731	0.004043
		3	0.004248	0.004104	0.004085	0.003808	0.00422
		4	0.004104	0.003997	0.004152	0.003745	0.003986
Reverse current:							
Measured Potential, mV		1	0.004074	0.004427	0.004161	0.004025	0.004068
		2	0.004145	0.003989	0.003923	0.004048	0.004181
		3	0.003820	0.004128	0.003936	0.003833	0.004038
		4	0.004039	0.003264	0.004037	0.003451	0.004005
End-for-end orientation:							
Reverse current:							
Measured Potential, mV		1	0.003981	0.004041	0.004031	0.003667	0.003618
		2	0.004363	0.004057	0.003973	0.003742	0.004212
		3	0.003435	0.003615	0.003839	0.003118	0.003612
		4	0.004285	0.003843	0.004061	0.003587	0.004046
Forward current:		1	0.004140	0.003997	0.003974	0.003899	0.003597
Measured Potential, mV		2	0.003965	0.004109	0.003767	0.00355	0.003941
		3	0.004142	0.00352	0.004071	0.003191	0.003992
		4	0.004294	0.003721	0.004094	0.003727	0.003801
		0					
Average Potential, V	mV		0.00406	0.00390	0.00401	0.00368	0.00396
Resistance, R=V/I	mΩ		1.01595	0.97430	1.00311	0.92014	0.99006
Potential Contact Distance, L	mm		12.6139	12.6139	12.6139	12.6139	12.6139
Average area, A mm^2 *	mm^2		127.3018	127.4701	127.4924	127.3621	127.4606
Resistivity, p=(R*A)/L	μΩm		10.25	9.85	10.14	9.29	10.00

Measurements and calculations made by Joe Strizak

ASTM Standard C 611 - 98 (Reapproved 2005)

Employed Method 2 using a current source and a precision voltmeter:
Keithley 2400 Source Meter, S/N 0987875,US DOE # 0060835, Calibrated 8/07/2007, Cal. Due 8/07/2008

Keithley 2182 Nanovoltmeter, S/N 0985274,US DOE # 000620809, Calibrated 8/07/2007, Cal. Due 8/07/2008

Current contacts were on the end faces of the specimen (nominally 1.000 inch apart), and the probe location for voltage readings was fixed at .49661 in.

Specimens were dried in a lab oven for a minimum of 2 h at 110 deg. C, cooled to room temperature in a desiccator, and stored in the desiccator until tested.

Room temperature: 20 to 21.1 °C

* Cross-sectional area from "Final Dimensions" worksheet.

Appendix 142. Current, voltage and electrical resistivity data for NBG-17 – sheet 2

AW2-02 **1U11**	AW2-03 **1U12**	AL6-02 **2S4**	AW4-01 **2S6**	AL6-03 **2S10**	AW4-02 **2U4**	AW4-03 **2U6**	AW5-01 **2U10**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.00362	0.004086	0.003559	0.004241	0.004001	0.004203	0.004126	0.003359
0.003999	0.004219	0.003807	0.004014	0.003874	0.004104	0.004297	0.004192
0.004059	0.004009	0.003203	0.004144	0.003319	0.004243	0.004058	0.003492
0.004075	0.003857	0.0038	0.004289	0.00371	0.003841	0.003784	0.00367
0.004006	0.004139	0.003889	0.004105	0.004308	0.004086	0.004091	0.00429
0.004259	0.004117	0.003869	0.004256	0.003949	0.003953	0.004071	0.004069
0.004203	0.003746	0.003966	0.004148	0.003512	0.004165	0.004216	0.004294
0.004151	0.003314	0.004013	0.004174	0.003429	0.004142	0.003718	0.003695
0.003637	0.003553	0.003521	0.004078	0.003814	0.004162	0.004076	0.004108
0.003976	0.00392	0.003703	0.003751	0.00371	0.003376	0.004031	0.004296
0.003244	0.003618	0.004014	0.004179	0.00373	0.003679	0.002901	0.004034
0.003905	0.004103	0.003988	0.003867	0.003841	0.003988	0.003772	0.003965
0.004207	0.003668	0.003892	0.003979	0.003872	0.003777	0.004075	0.004321
0.003832	0.003762	0.003366	0.003861	0.003826	0.004222	0.004124	0.004215
0.003716	0.00364	0.003761	0.004043	0.003891	0.004042	0.00415	0.004414
0.004032	0.003582	0.003591	0.004028	0.003573	0.003549	0.003913	0.004136
0.00393	0.00383	0.00375	0.00407	0.00377	0.00397	0.00396	0.00403
0.98314	0.95833	0.93659	1.01808	0.94311	0.99269	0.99067	1.00859
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.3844	127.1304	127.3177	127.4384	127.4130	127.4161	127.5464	127.5019
9.93	9.66	9.45	10.29	9.53	10.03	10.02	10.19

Appendix 142. Current, voltage and electrical resistivity data for NBG-17 – sheet 3

AL8-01 **3S8**	AW5-02 **3S13**	AW5-03 **3U8**	AW6-01 **3U12**	AW6-02 **4S8**	AL8-02 **4S11**	AW6-03 **4S12**	AW7-01 **4U8**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.004154	0.003912	0.004055	0.004283	0.004264	0.004362	0.003911	0.003959
0.003211	0.00392	0.004338	0.003949	0.003919	0.004195	0.004141	0.003961
0.004169	0.004134	0.004149	0.004177	0.004142	0.004115	0.004378	0.004256
0.003807	0.004124	0.004379	0.004101	0.004246	0.003781	0.004034	0.004276
0.004006	0.003795	0.003896	0.004184	0.003869	0.004105	0.004409	0.004088
0.003877	0.003532	0.004339	0.004412	0.00425	0.00436	0.004212	0.004017
0.003938	0.004267	0.004509	0.00414	0.004089	0.004243	0.00401	0.004045
0.004212	0.004168	0.003955	0.004254	0.004304	0.003992	0.004091	0.004129
0.004018	0.003451	0.004535	0.004296	0.004255	0.004417	0.003716	0.004094
0.004029	0.003807	0.003999	0.004177	0.004209	0.004335	0.0041	0.003956
0.003906	0.003949	0.004141	0.003467	0.004189	0.003876	0.004373	0.003844
0.003965	0.003754	0.004328	0.004247	0.004244	0.004234	0.004257	0.004329
0.003741	0.004071	0.004006	0.004007	0.004105	0.004298	0.004278	0.003702
0.003829	0.00438	0.00396	0.003563	0.003951	0.004261	0.004155	0.004248
0.004041	0.003707	0.004063	0.004166	0.004071	0.003958	0.004151	0.003649
0.003852	0.004139	0.004099	0.004173	0.004033	0.004409	0.004261	0.003989
0.00392	0.00394	0.00417	0.00410	0.00413	0.00418	0.00415	0.00403
0.98055	0.98609	1.04298	1.02494	1.03344	1.04595	1.03870	1.00847
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.2066	127.2574	127.3812	127.4828	127.3812	127.3971	127.2732	127.4511
9.89	9.95	10.53	10.36	10.44	10.56	10.48	10.19

Appendix 142. Current, voltage and electrical resistivity data for NBG-17 – sheet 4

AW7-02 **4U11**	AL8-03 **5S3**	AW7-03 **5S6**	AW9-01 **5S14**	AW9-02 **5U3**	AW9-03 **5U6**	AW10-01 **5U13**	AW10-02 **6S1**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.004247	0.004093	0.003986	0.004193	0.003987	0.003903	0.004093	0.004334
0.004196	0.003957	0.00366	0.004304	0.004227	0.003722	0.004151	0.004012
0.004105	0.003965	0.004197	0.004039	0.004195	0.004086	0.00423	0.004142
0.004197	0.0040113	0.004138	0.004149	0.004323	0.003979	0.003911	0.004241
0.004141	0.004104	0.003955	0.004087	0.004375	0.004197	0.004376	0.004011
0.003637	0.004014	0.003834	0.003936	0.003876	0.004116	0.004199	0.004129
0.003485	0.00394	0.00444	0.00418	0.004027	0.004199	0.004045	0.004194
0.004179	0.003806	0.004048	0.004245	0.004224	0.004173	0.004051	0.004118
0.004011	0.003744	0.003892	0.004278	0.003971	0.003921	0.004176	0.003928
0.003799	0.003782	0.004271	0.004351	0.003314	0.004151	0.004126	0.004076
0.004405	0.004023	0.004143	0.004172	0.002983	0.003456	0.004169	0.004246
0.004281	0.003887	0.004122	0.003559	0.003782	0.004294	0.004353	0.004233
0.004257	0.004096	0.004182	0.004031	0.004113	0.004276	0.003845	0.003867
0.004327	0.003752	0.003838	0.003591	0.004297	0.004133	0.003992	0.00412
0.004056	0.003866	0.004108	0.004342	0.003714	0.003917	0.004027	0.004119
0.004067	0.00387	0.004149	0.004219	0.004119	0.004291	0.00422	0.004239
0.00409	0.00393	0.00406	0.00410	0.00397	0.00405	0.00412	0.00413
1.02172	0.98297	1.01505	1.02619	0.99261	1.01272	1.03069	1.03139
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.4320	127.3876	127.4193	127.2923	127.3304	127.4161	127.2574	127.4733
10.32	9.93	10.25	10.36	10.02	10.23	10.40	10.42

Appendix 142. Current, voltage and electrical resistivity data for NBG-17 – sheet 5

AW10-03 **6S8**	AW12-01 **6S15**	AW12-02 **6U1**	AW12-03 **6U8**	AW13-01 **6U14**	AL7-01 **Spare 1A**	AL7-02 **Spare 2A**	AW13-02 **Spare 1W**	AW13-03 **Spare 2W**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.004007	0.004316	0.003926	0.004096	0.004199	0.003731	0.003968	0.003889	0.004222
0.004244	0.004039	0.004206	0.004309	0.004334	0.004245	0.004104	0.004174	0.004281
0.004118	0.00394	0.004201	0.004077	0.004191	0.003727	0.0039	0.004157	0.004216
0.004148	0.004137	0.004341	0.003687	0.004396	0.004087	0.003874	0.004299	0.003989
0.004067	0.004292	0.003894	0.004301	0.004259	0.003952	0.004209	0.004327	0.004328
0.004167	0.003992	0.004232	0.004077	0.004267	0.004129	0.003989	0.003686	0.004288
0.004172	0.004274	0.004106	0.004102	0.004029	0.004229	0.003987	0.003881	0.00437
0.004361	0.003956	0.004361	0.003969	0.004232	0.00428	0.003852	0.003539	0.003836
0.003584	0.004231	0.003997	0.004316	0.004147	0.004048	0.004024	0.003161	0.004263
0.004237	0.004335	0.004225	0.004134	0.003876	0.00422	0.003864	0.004249	0.003876
0.004305	0.004209	0.003533	0.003987	0.00425	0.00413	0.004264	0.004312	0.004451
0.004393	0.004229	0.003955	0.004089	0.003887	0.00417	0.003911	0.004089	0.003823
0.003776	0.003749	0.003967	0.003603	0.004121	0.003792	0.004209	0.003792	0.00458
0.004433	0.004215	0.003607	0.003727	0.003837	0.004197	0.003839	0.004039	0.004327
0.004387	0.004074	0.004275	0.003793	0.004045	0.003562	0.004239	0.004399	0.004234
0.003219	0.004257	0.004091	0.004531	0.004092	0.004071	0.004036	0.003981	0.004186
0.00410	0.00414	0.00406	0.00405	0.00414	0.00404	0.00402	0.00400	0.00420
1.02528	1.03508	1.01433	1.01247	1.03378	1.00891	1.00420	0.99959	1.05109
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.3780	127.4606	127.3209	127.2225	127.2986	127.1082	127.2923	127.3876	127.3971
10.35	10.46	10.24	10.21	10.43	10.17	10.13	10.09	10.62

Appendix 143. Current, voltage and electrical resistivity data for NBG-18 – sheet 1

Resistivity

Specimen ID Number			BL6-01	BW1-01	BW1-02	BW1-03
Sample Location			**1S1**	**1S4**	**1U1**	**1U4**
Applied current, I	mA		4.0000	4.0000	4.0000	4.0000
Compl. Voltage	V		2.5000	2.5000	2.5000	2.5000
ID Orientation:						
Forward current:						
Measured Potential, mV		1	0.003648	0.003967	0.003759	0.003982
		2	0.003714	0.003539	0.003840	0.003974
		3	0.003346	0.003072	0.003847	0.003699
		4	0.003684	0.003751	0.003805	0.003784
Reverse current:						
Measured Potential, mV		1	0.003623	0.003321	0.003879	0.003971
		2	0.003027	0.003745	0.003658	0.003786
		3	0.003738	0.003895	0.003675	0.003933
		4	0.003712	0.003780	0.003673	0.003651
End-for-end orientation:						
Reverse current:						
Measured Potential, mV		1	0.003694	0.003635	0.003792	0.003834
		2	0.003855	0.003737	0.003982	0.003669
		3	0.003229	0.003158	0.003823	0.003907
		4	0.003768	0.003794	0.003846	0.003589
Forward current:		1	0.003630	0.003857	0.003958	0.003844
Measured Potential, mV		2	0.003146	0.003500	0.004030	0.003941
		3	0.003678	0.003629	0.003947	0.003906
		4	0.003811	0.003144	0.004036	0.003967
Average Potential, V	mV		0.00358	0.00360	0.00385	0.00384
Resistance, R=V/I	mΩ		0.89536	0.89881	0.96172	0.95995
Potential Contact Distance, L	mm		12.6139	12.6139	12.6139	12.6139
Average area, A mm^2 *	mm^2		127.3876	127.4384	127.5241	127.3367
Resistivity, p=(R*A)/L	μΩm		9.04	9.08	9.72	9.69

*see footnote Appendix 142

Appendix 143. Current, voltage and electrical resistivity data for NBG-18 – sheet 2

BW2-01 **2S2**	BW2-02 **2S11**	BL6-02 **2S12**	BW2-03 **2U2**	BW3-01 **2U11**	BW3-02 **3S2**	BW3-03 **3S11**	BL6-03 **3S12**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003837	0.003907	0.003754	0.003846	0.003880	0.003791	0.003799	0.003657
0.004017	0.003904	0.003786	0.003680	0.003767	0.003838	0.003764	0.003561
0.003798	0.003843	0.003753	0.003415	0.003841	0.003922	0.003852	0.003673
0.003843	0.003995	0.003771	0.003703	0.003536	0.003735	0.003792	0.003874
0.004010	0.003697	0.003869	0.003717	0.003929	0.003911	0.003689	0.003605
0.003809	0.003896	0.003866	0.003634	0.003887	0.003731	0.003191	0.003588
0.003774	0.003852	0.004002	0.003620	0.003722	0.004009	0.003704	0.003850
0.003369	0.003639	0.003994	0.003731	0.003622	0.003961	0.003885	0.003643
0.003755	0.004004	0.003698	0.003737	0.003955	0.003882	0.003660	0.003840
0.003661	0.003874	0.003765	0.003549	0.003706	0.003569	0.003873	0.003705
0.003790	0.003827	0.003895	0.003457	0.003817	0.003883	0.003728	0.003573
0.003983	0.003892	0.003717	0.003823	0.003885	0.003712	0.003672	0.003866
0.003876	0.003811	0.003747	0.003657	0.003813	0.003782	0.003653	0.003673
0.003929	0.003780	0.003811	0.003658	0.003681	0.003801	0.003763	0.003707
0.003885	0.003778	0.003812	0.003891	0.003837	0.003861	0.003626	0.003698
0.003765	0.003827	0.003951	0.003709	0.003814	0.003848	0.003803	0.003864
0.00382	0.00385	0.00382	0.00368	0.00379	0.00383	0.00372	0.00371
0.95470	0.96134	0.95611	0.91917	0.94831	0.95681	0.92897	0.92777
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.4956	127.5178	127.3907	127.3240	127.5114	127.2669	127.4987	127.4765
9.65	9.72	9.66	9.28	9.59	9.65	9.39	9.38

Appendix 143. Current, voltage and electrical resistivity data for NBG-18 – sheet 3

BW5-01 **3S14**	BW5-02 **3U2**	BW5-03 **3U11**	BW7-01 **3U13**	BW7-02 **4S5**	BL7-01 **4S7**	BW7-03 **4S14**	BW8-01 **4U5**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003677	0.003258	0.003668	0.003850	0.003906	0.003717	0.003700	0.003810
0.003818	0.003876	0.003638	0.003568	0.003878	0.003576	0.003711	0.003743
0.003864	0.003736	0.003622	0.003844	0.003862	0.003657	0.003924	0.003805
0.003567	0.003931	0.003669	0.003835	0.003882	0.003773	0.003733	0.003485
0.003711	0.003789	0.003734	0.003856	0.003724	0.003501	0.003689	0.003656
0.003764	0.003832	0.003025	0.003942	0.003831	0.003460	0.003757	0.003828
0.003809	0.003857	0.003748	0.003719	0.004002	0.003462	0.003831	0.003557
0.003793	0.004074	0.003621	0.003848	0.003866	0.003844	0.003807	0.003534
0.003774	0.003844	0.003785	0.003794	0.003487	0.003712	0.003529	0.003616
0.003840	0.003986	0.003776	0.003762	0.003877	0.003809	0.003847	0.003581
0.003712	0.003841	0.003692	0.003904	0.003617	0.003826	0.003856	0.003532
0.003753	0.003206	0.003570	0.003829	0.003812	0.003675	0.003828	0.003562
0.003726	0.003839	0.003766	0.003827	0.003991	0.003608	0.003667	0.003522
0.003787	0.003659	0.003729	0.003473	0.003723	0.003686	0.003753	0.003737
0.003794	0.003584	0.003731	0.003950	0.003722	0.003730	0.003702	0.003605
0.003806	0.003656	0.003697	0.003724	0.003600	0.003582	0.003713	0.003616
0.00376	0.00375	0.00365	0.00380	0.00380	0.00366	0.00375	0.00364
0.94055	0.93700	0.91361	0.94883	0.94969	0.91591	0.93823	0.90920
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.4288	127.4701	127.4482	127.4354	127.4638	127.4924	127.3336	127.4288
9.50	9.47	9.23	9.59	9.60	9.26	9.47	9.19

Appendix 143. Current, voltage and electrical resistivity data for NBG-18 – sheet 4

BW8-02 **4U7**	BW8-03 **4U13**	BL7-02 **5S5**	BW9-01 **5S8**	BW9-02 **5S15**	BW9-03 **5U5**	BW10-01 **5U8**	BW10-02 **5U14**	BL7-03 **6S3**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003942	0.003974	0.003611	0.003765	0.003780	0.003663	0.003827	0.003878	0.003640
0.003912	0.003836	0.003615	0.003882	0.003372	0.003600	0.003792	0.004215	0.003759
0.003948	0.003782	0.003707	0.003555	0.003780	0.003709	0.004082	0.003831	0.003851
0.004110	0.003836	0.003709	0.003756	0.003579	0.003711	0.004007	0.003766	0.003575
0.003827	0.003891	0.003741	0.003685	0.003805	0.003222	0.003935	0.003836	0.003394
0.003849	0.003603	0.003522	0.003717	0.003688	0.003290	0.003676	0.004026	0.003656
0.003924	0.003550	0.003316	0.003650	0.003859	0.003402	0.003973	0.003832	0.003575
0.003922	0.003801	0.003556	0.003638	0.003839	0.003603	0.003882	0.004018	0.003458
0.003502	0.003729	0.003695	0.003712	0.003848	0.003545	0.003839	0.003842	0.003710
0.003879	0.003571	0.003814	0.003655	0.003776	0.003562	0.003935	0.003751	0.003690
0.003770	0.003545	0.003314	0.003659	0.003768	0.003836	0.003655	0.003724	0.003743
0.003820	0.003816	0.003704	0.003508	0.003673	0.003727	0.004186	0.003830	0.004006
0.003825	0.003654	0.003431	0.003621	0.003817	0.003665	0.003931	0.003689	0.003582
0.003487	0.003447	0.003738	0.003596	0.003755	0.003651	0.003820	0.003739	0.003640
0.003841	0.003565	0.003430	0.003590	0.003787	0.003882	0.003875	0.003834	0.003859
0.003855	0.003730	0.003412	0.003778	0.003726	0.003696	0.004033	0.003961	0.003619
0.00384	0.00371	0.00358	0.00367	0.00374	0.00361	0.00390	0.00386	0.00367
0.95958	0.92703	0.89555	0.91823	0.93519	0.90256	0.97575	0.96519	0.91808
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.4034	127.3209	127.4352	127.3780	127.2098	127.1907	127.4892	127.2542	127.4447
9.69	9.36	9.05	9.27	9.43	9.10	9.86	9.74	9.28

Appendix 143. Current, voltage and electrical resistivity data for NBG-18 – sheet 5

BW10-03 **6S6**	BW11-01 **6S13**	BW11-02 **6U3**	BW11-03 **6U6**	BW12-01 **6U12**	BL8-01 **Spare 1A**	BL8-02 **Spare 2A**	BW12-02 **Spare 1W**	BW12-03 **Spare 2W**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003755	0.003904	0.004045	0.003928	0.003777	0.003868	0.004004	0.003770	0.003793
0.003690	0.003921	0.003958	0.003857	0.003552	0.003543	0.003820	0.003440	0.003816
0.003602	0.003761	0.003923	0.003637	0.003728	0.003876	0.003793	0.003581	0.003724
0.003627	0.003870	0.003886	0.003786	0.003664	0.003826	0.003726	0.003971	0.003612
0.003782	0.003931	0.003681	0.003901	0.003802	0.003519	0.003522	0.003829	0.003869
0.003608	0.003903	0.003475	0.003972	0.003585	0.003706	0.003401	0.003525	0.003448
0.003696	0.003955	0.004036	0.003905	0.004115	0.003805	0.003510	0.003891	0.003616
0.003604	0.003976	0.003743	0.003765	0.003616	0.003657	0.003643	0.003572	0.003572
0.003653	0.003565	0.003926	0.003766	0.003729	0.003781	0.004213	0.003838	0.003732
0.003791	0.003652	0.003812	0.003646	0.003556	0.003580	0.003807	0.003642	0.003689
0.003944	0.003850	0.003710	0.003797	0.003715	0.003635	0.003618	0.003668	0.003728
0.003709	0.003650	0.003633	0.003636	0.003814	0.003636	0.003647	0.003641	0.003474
0.003717	0.003611	0.003748	0.003920	0.003212	0.003709	0.003407	0.003819	0.003656
0.003646	0.003676	0.003692	0.003515	0.003723	0.003755	0.003453	0.003594	0.003984
0.003732	0.003611	0.003609	0.003856	0.003827	0.003779	0.003493	0.003587	0.003842
0.003519	0.003775	0.003767	0.003846	0.003839	0.003792	0.003492	0.003827	0.003565
0.00369	0.00379	0.00379	0.00380	0.00370	0.00372	0.00366	0.00370	0.00370
0.92305	0.94705	0.94756	0.94895	0.92584	0.92917	0.91483	0.92492	0.92375
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.3590	127.4701	127.4352	127.4415	127.4638	127.5496	127.9089	127.4797	127.5941
9.32	9.57	9.57	9.59	9.36	9.40	9.28	9.35	9.34

Appendix 144. Current, voltage and electrical resistivity data for H-451 – sheet 1

Resistivity

Specimen ID Number			CW7-01	CW7-03	CW8-02	CW8-03	CW9-01
Sample Location			**1S8**	**1S15**	**1U8**	**1U14**	**2S13**
Applied current, I	mA		4.0000	4.0000	4.0000	4.0000	4.0000
Compl. Voltage	V		2.5000	2.5000	2.5000	2.5000	2.5000
ID Orientation:							
Forward current:							
Measured Potential, mV		1	0.002290	0.003210	0.002700	0.003120	0.002510
		2	0.002430	0.003240	0.002590	0.002520	0.002510
		3	0.002420	0.003290	0.002560	0.002690	0.002570
		4	0.002390	0.003110	0.002490	0.002720	0.002520
Reverse current:							
Measured Potential, mV		1	0.002400	0.003230	0.002570	0.002670	0.002550
		2	0.002460	0.002590	0.002200	0.002540	0.002530
		3	0.002420	0.003170	0.002690	0.002540	0.002510
		4	0.002370	0.003190	0.002520	0.002570	0.002490
End-for-end orientation:							
Reverse current:							
Measured Potential, mV		1	0.002420	0.002580	0.003240	0.002570	0.002480
		2	0.002350	0.002310	0.002550	0.002510	0.002490
		3	0.002370	0.002620	0.002570	0.003100	0.002510
		4	0.002310	0.002590	0.002500	0.002580	0.002520
Forward current:		1	0.002390	0.002600	0.002510	0.002570	0.002570
Measured Potential, mV		2	0.002380	0.002440	0.002640	0.002510	0.002580
		3	0.002680	0.002550	0.002480	0.003250	0.002550
		4	0.003150	0.002680	0.002550	0.003090	0.002580
Average Potential, V	mV		0.00245	0.00284	0.00259	0.00272	0.00253
Resistance, R=V/I	mΩ		0.61297	0.70938	0.64625	0.68047	0.63234
Potential Contact Distance, L	mm		12.6139	12.6139	12.6139	12.6139	12.6139
Average area, A mm^2 *	mm^2		126.9402	127.1146	127.067	127.1558	127.0416
Resistivity, p=(R*A)/L	μΩm		6.17	7.15	6.51	6.86	6.37

*see footnote Appendix 142

Appendix 144. Current, voltage and electrical resistivity data for H-451 – sheet 2

CW9-02 **2U12**	CW9-03 **3S1**	CW10-01 **3S10**	CW10-02 **3U1**	CW10-03 **3U10**	CW11-01 **4S2**	CW11-02 **4S13**	CW11-03 **4U2**	CW12-01 **4U12**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.002980	0.003320	0.003160	0.002490	0.002470	0.002320	0.002450	0.003030	0.002700
0.002580	0.002530	0.003130	0.002480	0.002450	0.002490	0.002760	0.003140	0.002840
0.003020	0.002520	0.003290	0.002530	0.002440	0.002390	0.002440	0.002200	0.002430
0.002710	0.002570	0.003300	0.002490	0.002590	0.002380	0.002530	0.002470	0.002460
0.002960	0.002520	0.002650	0.002560	0.002430	0.002380	0.002580	0.002490	0.002440
0.002450	0.002560	0.002480	0.002540	0.002440	0.002670	0.002530	0.002840	0.002500
0.003200	0.002590	0.002530	0.002550	0.002510	0.002400	0.002510	0.002580	0.002430
0.003060	0.002920	0.002430	0.002540	0.002400	0.002450	0.002490	0.002580	0.002470
0.003160	0.003360	0.002430	0.002610	0.002900	0.002970	0.003110	0.002490	0.003070
0.002500	0.002470	0.002460	0.002830	0.002640	0.003020	0.002670	0.002460	0.002410
0.002760	0.002490	0.002490	0.003140	0.002400	0.002570	0.002680	0.002370	0.002420
0.002980	0.003070	0.002960	0.003150	0.002580	0.002380	0.002510	0.002600	0.002460
0.002500	0.003100	0.002620	0.003120	0.002420	0.002390	0.002480	0.002490	0.002460
0.003290	0.002510	0.002890	0.003200	0.002990	0.002430	0.002930	0.002470	0.002410
0.003050	0.002510	0.002390	0.002440	0.003030	0.002910	0.002990	0.002460	0.002450
0.003120	0.002460	0.002670	0.003090	0.003000	0.002330	0.002870	0.002450	0.002420
0.00290	0.00272	0.00274	0.00274	0.00261	0.00253	0.00266	0.00257	0.00252
0.72375	0.67969	0.68563	0.68375	0.65141	0.63250	0.66453	0.64250	0.63078
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
126.9433	127.1558	126.8736	127.067	127.0765	127.0226	127.2764	127.1495	127.1304
7.28	6.85	6.90	6.89	6.56	6.37	6.71	6.48	6.36

Appendix 144. Current, voltage and electrical resistivity data for H-451 – sheet 3

CW12-02 **5S7**	CW13-01 **5U7**	CW13-02 **6S5**	CW13-03 **6S9**	CW14-01 **6U5**	CW14-02 **6U9**	CW15-01 **Spare 1**	CW15-02 **Spare 2**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003210	0.002880	0.002950	0.002590	0.003080	0.003150	0.003090	0.003230
0.003150	0.002320	0.003040	0.002440	0.003100	0.002780	0.003210	0.003220
0.003090	0.002330	0.003080	0.002630	0.002870	0.002460	0.003120	0.003210
0.003110	0.002420	0.003050	0.002840	0.003130	0.003080	0.003210	0.003200
0.003100	0.002390	0.003080	0.002820	0.003150	0.003090	0.003180	0.003250
0.003310	0.002710	0.003060	0.002440	0.002850	0.003030	0.003110	0.003300
0.003270	0.002330	0.003110	0.002400	0.002910	0.003060	0.003120	0.003310
0.003210	0.002550	0.003090	0.002480	0.002950	0.003080	0.003210	0.003270
0.003360	0.002950	0.003250	0.002870	0.002900	0.002490	0.003250	0.003190
0.003460	0.002890	0.003230	0.002840	0.002920	0.002920	0.003450	0.003120
0.003420	0.002780	0.003010	0.002420	0.002780	0.003080	0.003420	0.003150
0.003310	0.002910	0.003090	0.002760	0.002580	0.002960	0.003210	0.003170
0.003530	0.002940	0.003020	0.002850	0.002300	0.003200	0.003440	0.003220
0.003290	0.002330	0.002840	0.002450	0.002420	0.003240	0.003160	0.003140
0.003250	0.002290	0.003120	0.002940	0.002350	0.003190	0.003200	0.003190
0.003450	0.002550	0.003150	0.002420	0.002360	0.003310	0.003310	0.003180
0.00328	0.00260	0.00307	0.00264	0.00279	0.00301	0.00323	0.00321
0.82063	0.64953	0.76828	0.65922	0.69766	0.75188	0.80766	0.80234
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
126.8292	127.0797	127.1812	126.9972	127.2352	127.14948	127.2225	127.0797
8.25	6.54	7.75	6.64	7.04	7.58	8.15	8.08

Appendix 145. Current, voltage and electrical resistivity data for PCEA – sheet 1

Resistivity

Specimen ID							
Number			**Trial**	DW1-01	DW1-02	DW1-03	DW2-01
Sample Location				**1S2**	**1S6**	**1S14**	**1U2**
Applied current, I	mA		4.0000	4.0000	4.0000	4.0000	4.0000
Compl. Voltage	V		2.5000	2.5000	2.5000	2.5000	2.5000
ID Orientation:							
Forward current:							
Measured Potential, mV		1	0.00517	0.003290	0.003271	0.00316	0.003191
		2	0.00496	0.003261	0.003292	0.003286	0.003324
		3	0.00495	0.003308	0.003253	0.003224	0.003183
		4	0.00478	0.003170	0.003151	0.003305	0.003233
Reverse current:							
Measured Potential, mV		1	0.00498	0.003004	0.003294	0.003273	0.003252
		2	0.00515	0.003112	0.003351	0.003246	0.003141
		3	0.00420	0.003358	0.003227	0.003321	0.003173
		4	0.00420	0.003189	0.003151	0.003281	0.003232
End-for-end orientation:							
Reverse current:							
Measured Potential, mV		1	0.00473	0.003062	0.003259	0.003228	0.003226
		2	0.00490	0.003062	0.003267	0.003118	0.003165
		3	0.00510	0.003154	0.003001	0.003291	0.003214
		4	0.00485	0.003179	0.003273	0.00325	0.003095
Forward current:		1	0.00514	0.003317	0.00311	0.003239	0.003302
Measured Potential, mV		2	0.00515	0.003228	0.003174	0.003074	0.002999
		3	0.00448	0.003190	0.003277	0.003231	0.003217
		4	0.00438	0.003200	0.003278	0.003265	0.003092
Average Potential	mV		0.00482	0.00319	0.00323	0.00324	0.00319
Resistance, R=V/I	mΩ		1.20500	0.79819	0.80670	0.80925	0.79748
Potential Contact Distance, L	mm		12.6139	12.6139	12.6139	12.6139	12.6139
Average area, A mm^2 *	mm^2		127.5	127.2034	127.2161	127.2256	127.1971
Resistivity, p=(R*A)/L	μΩm		12.18	8.05	8.14	8.16	8.04

*see footnote Appendix 142

Appendix 145. Current, voltage and electrical resistivity data for PCEA – sheet 2

DW2-02 **1U6**	DW2-03 **1U13**	DW3-01 **2S1**	DW3-02 **2S8**	DW3-03 **2S14**	DW4-01 **2U8**	DW4-03 **2U1**	DW5-01 **2U13**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003159	0.003181	0.003126	0.003013	0.003092	0.003338	0.003347	0.003248
0.003302	0.003141	0.003168	0.002997	0.003149	0.00322	0.003268	0.003306
0.003179	0.003056	0.003147	0.003312	0.003149	0.00334	0.003274	0.003253
0.003353	0.003234	0.003221	0.003186	0.003173	0.003206	0.003146	0.003146
0.003274	0.003305	0.003064	0.003327	0.003231	0.003347	0.003455	0.003151
0.003402	0.003232	0.003364	0.003244	0.003145	0.003026	0.00324	0.003027
0.003302	0.003263	0.003139	0.003211	0.003167	0.003299	0.003021	0.003261
0.003364	0.003031	0.003167	0.003218	0.00319	0.003196	0.00312	0.003161
0.00317	0.003354	0.003144	0.003271	0.003114	0.003299	0.002882	0.003136
0.003264	0.003289	0.003208	0.003204	0.003331	0.003291	0.003026	0.00318
0.003392	0.003369	0.003204	0.003204	0.003221	0.003305	0.00292	0.003155
0.003064	0.003136	0.003281	0.003216	0.003168	0.00324	0.003002	0.003178
0.003144	0.003277	0.003221	0.003069	0.0031	0.003137	0.003289	0.003062
0.00317	0.003335	0.003305	0.003233	0.003096	0.003329	0.00296	0.003269
0.003169	0.003239	0.003179	0.003118	0.003179	0.003057	0.003169	0.003452
0.003068	0.003263	0.003215	0.003188	0.003171	0.003175	0.003081	0.003194
0.00324	0.00323	0.00320	0.00319	0.00317	0.00324	0.00314	0.00320
0.80900	0.80789	0.79927	0.79705	0.79181	0.80945	0.78438	0.79967
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.2256	127.2225	127.1812	127.2510	127.2098	127.2002	127.1241	127.1653
8.16	8.15	8.06	8.04	7.99	8.16	7.91	8.06

Appendix 145. Current, voltage and electrical resistivity data for PCEA – sheet 3

DA601 **3S6**	DW5-02 **3S15**	DW5-03 **3U6**	DW6-01 **3U14**	DA602 **4S1**	DA701 **4S6**	DW6-02 **4S15**	DW6-03 **4U1**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003424	0.003354	0.003285	0.003281	0.003566	0.003478	0.002905	0.003028
0.003664	0.00303	0.003209	0.003266	0.00348	0.003804	0.003117	0.003239
0.003676	0.003257	0.003328	0.003	0.003525	0.00369	0.003216	0.003219
0.003529	0.003306	0.003294	0.002993	0.003598	0.00356	0.003272	0.003239
0.00356	0.003243	0.00328	0.003343	0.003672	0.003542	0.003234	0.003307
0.003421	0.003215	0.003233	0.003254	0.003529	0.003822	0.00328	0.003272
0.003662	0.003207	0.003361	0.003184	0.003814	0.003573	0.003128	0.003046
0.003564	0.003284	0.003302	0.002981	0.003595	0.003627	0.003284	0.003275
0.003487	0.003211	0.003284	0.003208	0.003666	0.003638	0.003248	0.003463
0.003594	0.003287	0.003318	0.003139	0.003609	0.003689	0.00329	0.003227
0.003699	0.003251	0.003201	0.003241	0.003734	0.003707	0.003216	0.003315
0.003684	0.003111	0.003233	0.003244	0.003651	0.003607	0.003153	0.003128
0.003521	0.003105	0.003077	0.00326	0.003837	0.003581	0.003331	0.003317
0.003226	0.003197	0.00315	0.003367	0.003668	0.003631	0.003199	0.003211
0.003508	0.003286	0.00307	0.003244	0.003709	0.003719	0.00314	0.003222
0.003696	0.003205	0.003179	0.003216	0.00364	0.00356	0.003253	0.003151
0.00356	0.00322	0.00324	0.00320	0.00364	0.00364	0.00320	0.00323
0.88930	0.80545	0.80944	0.80033	0.91083	0.90981	0.80103	0.80717
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.2479	127.2161	127.2764	127.2669	127.2574	127.2542	127.3145	127.4003
8.97	8.12	8.17	8.07	9.19	9.18	8.08	8.15

Appendix 145. Current, voltage and electrical resistivity data for PCEA – sheet 4

DW7-01 **4U6**	DW7-02 **4U14**	DW7-03 **5S4**	DW8-01 **5S9**	DA702 **5S11**	DW8-02 **5S12**	DW8-03 **5U4**	DW9-01 **5U9**	DW9-02 **5U11**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.003184	0.003203	0.003198	0.003208	0.003094	0.003178	0.003194	0.003245	0.003085
0.003227	0.003243	0.003297	0.00328	0.00309	0.003311	0.002861	0.003268	0.002993
0.003251	0.003295	0.003147	0.003246	0.003227	0.003268	0.003185	0.003124	0.003414
0.003317	0.002969	0.003134	0.003256	0.003162	0.002978	0.003308	0.003102	0.003263
0.003106	0.002952	0.003247	0.003077	0.003051	0.003304	0.003399	0.003106	0.003209
0.003351	0.003316	0.003177	0.00336	0.003146	0.003136	0.003149	0.003169	0.003247
0.003341	0.003352	0.003303	0.002994	0.002991	0.003061	0.003169	0.003106	0.003231
0.003308	0.003024	0.003136	0.003274	0.003156	0.002908	0.003312	0.003086	0.003212
0.002934	0.003223	0.003268	0.003202	0.003281	0.003204	0.003246	0.00301	0.003274
0.002989	0.003176	0.003229	0.003107	0.003091	0.003221	0.003037	0.003321	0.003192
0.002987	0.003179	0.003333	0.003341	0.003274	0.003111	0.003199	0.002993	0.003172
0.003247	0.003278	0.003106	0.003195	0.003216	0.003208	0.003342	0.00314	0.003131
0.003226	0.003123	0.003083	0.003327	0.003241	0.003083	0.003119	0.003213	0.003191
0.003204	0.003136	0.003078	0.003023	0.003236	0.00307	0.003291	0.003296	0.002933
0.003149	0.003118	0.003219	0.003134	0.002931	0.003161	0.002678	0.003319	0.003075
0.003246	0.003268	0.003235	0.003205	0.003242	0.003206	0.003303	0.003182	0.00317
0.00319	0.00318	0.00320	0.00320	0.00315	0.00315	0.00317	0.00317	0.00317
0.79792	0.79461	0.79984	0.80045	0.78795	0.78763	0.79363	0.79188	0.79363
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.3018	127.2796	127.2955	127.3113	127.4828	127.3304	127.3367	127.3621	127.3113
8.05	8.02	8.07	8.08	7.96	7.95	8.01	8.00	8.01

Appendix 145. Current, voltage and electrical resistivity data for PCEA – sheet 5

DW9-03 **6S4**	DW10-01 **6S11**	DA801 **6S12**	DW10-02 **6U11**	DW10-03 **6U4**	DW11-01 **Spare 1W**	DW11-02 **Spare 2W**	DA802 **Spare 1A**	DA901 **Spare 2A**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.00294	0.003308	0.003342	0.002946	0.003208	0.002951	0.003308	0.00356	0.003512
0.003205	0.003269	0.003311	0.003191	0.003139	0.00319	0.003207	0.003689	0.003567
0.003174	0.003171	0.0034	0.003382	0.003333	0.003042	0.003273	0.003631	0.003509
0.002691	0.003294	0.003211	0.003148	0.003143	0.002911	0.003189	0.003474	0.003445
0.003177	0.002785	0.003123	0.003287	0.003259	0.003115	0.00327	0.003484	0.003427
0.003222	0.003218	0.003366	0.003202	0.00298	0.003252	0.003267	0.003695	0.003631
0.003216	0.003292	0.002822	0.003278	0.003132	0.003137	0.003184	0.003521	0.003493
0.002733	0.003257	0.00317	0.003139	0.003177	0.002968	0.003202	0.003479	0.003419
0.003211	0.003397	0.003085	0.003251	0.003184	0.003203	0.003237	0.003416	0.003525
0.003295	0.002963	0.003044	0.003334	0.00293	0.003224	0.003072	0.003582	0.003472
0.003319	0.003106	0.003028	0.003224	0.003187	0.003049	0.003171	0.003368	0.003557
0.003073	0.00319	0.003144	0.003311	0.003238	0.003383	0.00296	0.003539	0.003583
0.003193	0.003232	0.002985	0.003202	0.003003	0.003234	0.003161	0.003392	0.003698
0.003305	0.003128	0.003172	0.003284	0.002916	0.003208	0.003077	0.003373	0.003509
0.003204	0.003091	0.00318	0.002962	0.003147	0.003155	0.003184	0.003594	0.003538
0.003104	0.003208	0.003173	0.003352	0.003273	0.003392	0.003002	0.003516	0.003594
0.00313	0.00318	0.00316	0.00322	0.00314	0.00315	0.00317	0.00352	0.00353
0.78222	0.79546	0.78994	0.80458	0.78514	0.78772	0.79319	0.87989	0.88248
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.1876	127.0353	127.0765	127.0258	127.0067	127.0385	127.0892	127.3018	127.3177
7.89	8.01	7.96	8.10	7.91	7.93	7.99	8.88	8.91

Appendix 146. Current, voltage and electrical resistivity data for IG-110 – sheet 1

Resistivity

Specimen ID							
Number			**EW2-01**	**EW2-02**	**EW2-03**	**EW4-01**	**EW4-02**
Sample Location			**1S7**	**1S9**	**1U7**	**1U9**	**2S5**
Applied current, I	mA		4.0000	4.0000	4.0000	4.0000	4.0000
Compl. Voltage	V		2.5000	2.5000	2.5000	2.5000	2.5000
ID Orientation:							
Forward current:							
Measured Potential, mV		1	0.00417	0.00539	0.00528	0.00501	0.00550
		2	0.00511	0.00518	0.00537	0.00538	0.00531
		3	0.00423	0.00392	0.00539	0.00510	0.00536
		4	0.00513	0.00524	0.00480	0.00503	0.00499
Reverse current:							
Measured Potential, mV		1	0.00430	0.00501	0.00482	0.00501	0.00522
		2	0.00416	0.00542	0.00477	0.00511	0.00531
		3	0.00427	0.00477	0.00504	0.00494	0.00510
		4	0.00428	0.00484	0.00463	0.00491	0.00512
End-for-end orientation:							
Reverse current:							
Measured Potential, mV		1	0.00419	0.00487	0.00504	0.00487	0.00517
		2	0.00425	0.00476	0.00439	0.00497	0.00402
		3	0.00441	0.00520	0.00476	0.00436	0.00505
		4	0.00409	0.00508	0.00498	0.00440	0.00406
Forward current:		1	0.00413	0.00466	0.00493	0.00470	0.00405
Measured Potential, mV		2	0.00420	0.00506	0.00520	0.00484	0.00415
		3	0.00425	0.00522	0.00476	0.00491	0.00403
		4	0.00424	0.00481	0.00491	0.00471	0.00404
Average Potential,	mV		0.00434	0.00496	0.00494	0.00489	0.00478
Resistance, R=V/I	mΩ		1.08453	1.24109	1.23547	1.22266	1.19500
Potential Contact Distance, L	mm		12.6139	12.6139	12.6139	12.6139	12.6139
Average area, A mm^2 *	mm^2		127.1749	127.1717	127.1653	126.8894	127.0163
Resistivity, p=(R*A)/L	μΩm		10.93	12.51	12.46	12.30	12.03

*see footnote Appendix 142

Appendix 146. Current, voltage and electrical resistivity data for IG-110 – sheet 2

EW5-01 2S7	EW5-02 2U5	EW5-03 2U7	EW6-01 3S9	EW6-02 3U9	EW6-03 4S4	EW7-01 4S9	EW7-03 4U4
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.00492	0.00489	0.00543	0.00522	0.00501	0.00480	0.00529	0.00457
0.00448	0.00532	0.00517	0.00509	0.00481	0.00478	0.00480	0.00528
0.00488	0.00525	0.00501	0.00504	0.00483	0.00429	0.00511	0.00526
0.00505	0.00502	0.00522	0.00517	0.00482	0.00485	0.00517	0.00519
0.00502	0.00510	0.00536	0.00519	0.00508	0.00490	0.00491	0.00517
0.00555	0.00517	0.00511	0.00528	0.00479	0.00448	0.00506	0.00530
0.00528	0.00504	0.00499	0.00518	0.00435	0.00479	0.00516	0.00556
0.00520	0.00512	0.00489	0.00470	0.00385	0.00391	0.00528	0.00517
0.00535	0.00492	0.00397	0.00508	0.00511	0.00464	0.00526	0.00527
0.00419	0.00508	0.00441	0.00492	0.00399	0.00402	0.00490	0.00476
0.00509	0.00471	0.00465	0.00495	0.00438	0.00485	0.00492	0.00493
0.00510	0.00505	0.00434	0.00507	0.00337	0.00439	0.00515	0.00536
0.00517	0.00510	0.00398	0.00512	0.00452	0.00436	0.00495	0.00531
0.00553	0.00516	0.00410	0.00486	0.00515	0.00396	0.00510	0.00538
0.00515	0.00465	0.00405	0.00511	0.00481	0.00488	0.00504	0.00511
0.00513	0.00498	0.00399	0.00509	0.00464	0.00403	0.00419	0.00535
0.00507	0.00504	0.00467	0.00507	0.00459	0.00450	0.00502	0.00519
1.26703	1.25875	1.16672	1.26672	1.14859	1.12391	1.25453	1.29641
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.0194	126.8736	126.8894	126.8261	126.9814	126.8609	126.9148	126.6075
12.76	12.66	11.74	12.74	11.56	11.30	12.62	13.01

Appendix 146. Current, voltage and electrical resistivity data for IG-110 – sheet 3

EW8-01 4U9	EW8-02 5S1	EW8-03 5S13	EW9-01 5U1	EW9-02 5U12	EW9-03 6S14	EW10-01 6U13	EW10-02 Spare 1	EW10-03 Spare 2
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.00476	0.00505	0.00470	0.00505	0.00486	0.00529	0.00481	0.00507	0.00490
0.00506	0.00455	0.00441	0.00491	0.00477	0.00501	0.00391	0.00508	0.00478
0.00524	0.00508	0.00519	0.00500	0.00511	0.00506	0.00394	0.00503	0.00501
0.00527	0.00513	0.00494	0.00489	0.00498	0.00505	0.00399	0.00510	0.00489
0.00526	0.00517	0.00493	0.00492	0.00451	0.00502	0.00399	0.00504	0.00470
0.00520	0.00493	0.00512	0.00470	0.00428	0.00529	0.00388	0.00459	0.00465
0.00450	0.00496	0.00509	0.00384	0.00465	0.00512	0.00448	0.00471	0.00471
0.00422	0.00487	0.00491	0.00502	0.00444	0.00515	0.00482	0.00498	0.00491
0.00465	0.00508	0.00531	0.00510	0.00451	0.00520	0.00431	0.00501	0.00478
0.00494	0.00494	0.00549	0.00526	0.00433	0.00505	0.00492	0.00498	0.00481
0.00529	0.00507	0.00455	0.00495	0.00446	0.00490	0.00434	0.00511	0.00469
0.00456	0.00501	0.00523	0.00496	0.00471	0.00538	0.00401	0.00487	0.00487
0.00515	0.00502	0.00525	0.00498	0.00481	0.00539	0.00427	0.00499	0.00468
0.00510	0.00493	0.00530	0.00525	0.00462	0.00524	0.00506	0.00506	0.00460
0.00495	0.00472	0.00534	0.00504	0.00471	0.00500	0.00496	0.00487	0.00459
0.00501	0.00505	0.00521	0.00529	0.00480	0.00486	0.00494	0.00492	0.00472
0.00495	0.00497	0.00506	0.00495	0.00466	0.00513	0.00441	0.00496	0.00477
1.23688	1.24313	1.26516	1.23688	1.16484	1.28141	1.10359	1.24078	1.19203
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
126.7088	126.8229	126.6233	126.5315	126.8514	126.6740	126.6297	126.7183	126.6930
12.42	12.50	12.70	12.41	11.71	12.87	11.08	12.46	11.97

Appendix 147. Current, voltage and electrical resistivity data for IG-430 – sheet 1

Resistivity

Specimen ID Number			FW1-01	FW1-02	FW1-03	FW2-01	FW2-02
Sample Location			**1S5**	**1S10**	**1U5**	**1U10**	**2S3**
Applied current, I	mA		4.0000	4.0000	4.0000	4.0000	4.0000
Compl. Voltage,	V		2.5000	2.5000	2.5000	2.5000	2.5000
ID Orientation:							
Forward current:							
Measured Potential, mV		1	0.00423	0.00333	0.00424	0.00428	0.00419
		2	0.00418	0.00328	0.00432	0.00403	0.00435
		3	0.00414	0.00325	0.00430	0.00408	0.00398
		4	0.00417	0.00329	0.00410	0.00411	0.00436
Reverse current:							
Measured Potential, mV		1	0.00414	0.00324	0.00408	0.00412	0.00439
		2	0.00421	0.00352	0.00415	0.00415	0.00376
		3	0.00409	0.00362	0.00398	0.00414	0.00407
		4	0.00412	0.00344	0.00407	0.00411	0.00398
End-for-end orientation:							
Reverse current:							
Measured Potential, mV		1	0.00400	0.00361	0.00425	0.00416	0.00339
		2	0.00418	0.00358	0.00394	0.00417	0.00334
		3	0.00410	0.00369	0.00400	0.00429	0.00329
		4	0.00405	0.00360	0.00414	0.00413	0.00334
Forward current:		1	0.00417	0.00334	0.00405	0.00424	0.00338
Measured Potential, mV		2	0.00378	0.00330	0.00417	0.00423	0.00328
		3	0.00405	0.00328	0.00407	0.00409	0.00335
		4	0.00410	0.00331	0.00396	0.00415	0.00325
Average Potential, V	mV		0.00411	0.00342	0.00411	0.00416	0.00373
Resistance, R=V/I	mΩ		1.02672	0.85438	1.02844	1.03875	0.93281
Potential Contact Distance, L	mm		12.6139	12.6139	12.6139	12.6139	12.6139
Average area, A mm^2 *	mm^2		126.807	126.9021	126.9782	126.6898	126.731
Resistivity, p=(R*A)/L	μΩm		10.32	8.60	10.35	10.43	9.37

*see footnote Appendix 142

Appendix 147. Current, voltage and electrical resistivity data for IG-430 – sheet 2

FW2-03	FW3-01	FW3-02	FW3-03	FW4-01	FW4-02	FW4-03	FW5-01	FW5-02
2S9	**2S15**	**2U3**	**2U9**	**2U14**	**3S3**	**3S4**	**3S5**	**3S7**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.00422	0.00369	0.00409	0.00382	0.00404	0.00416	0.00401	0.00402	0.00351
0.00408	0.00385	0.00401	0.00393	0.00405	0.00405	0.00406	0.00419	0.00313
0.00401	0.00363	0.00403	0.00360	0.00402	0.00406	0.00411	0.00407	0.00298
0.00416	0.00372	0.00385	0.00394	0.00401	0.00408	0.00406	0.00411	0.00305
0.00407	0.00373	0.00368	0.00393	0.00401	0.00399	0.00317	0.00419	0.00306
0.00413	0.00338	0.00420	0.00378	0.00405	0.00381	0.00376	0.00396	0.00314
0.00405	0.00378	0.00412	0.00386	0.00393	0.00395	0.00318	0.00399	0.00316
0.00409	0.00370	0.00402	0.00400	0.00386	0.00398	0.00414	0.00404	0.00298
0.00414	0.00389	0.00400	0.00330	0.00390	0.00317	0.00390	0.00400	0.00390
0.00423	0.00366	0.00384	0.00328	0.00381	0.00395	0.00378	0.00398	0.00395
0.00419	0.00371	0.00408	0.00329	0.00400	0.00388	0.00374	0.00402	0.00348
0.00413	0.00356	0.00412	0.00331	0.00396	0.00390	0.00379	0.00401	0.00373
0.00425	0.00391	0.00421	0.00270	0.00397	0.00392	0.00383	0.00401	0.00389
0.00418	0.00390	0.00398	0.00333	0.00404	0.00421	0.00402	0.00403	0.00355
0.00421	0.00387	0.00406	0.00341	0.00379	0.00405	0.00391	0.00392	0.00365
0.00424	0.00380	0.00409	0.00321	0.00401	0.00411	0.00388	0.00399	0.00379
0.00415	0.00374	0.00402	0.00354	0.00397	0.00395	0.00383	0.00403	0.00343
1.03719	0.93406	1.00594	0.88578	0.99141	0.98859	0.95844	1.00828	0.85859
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
126.7722	126.6582	126.7659	126.9211	126.9243	126.8704	126.9592	127.0131	127.2415
10.42	9.38	10.11	8.91	9.98	9.94	9.65	10.15	8.66

Appendix 147. Current, voltage and electrical resistivity data for IG-430 – sheet 3

FW5-03 **3U3**	FW7-01 **3U4**	FW7-02 **3U5**	FW7-03 **3U7**	FW8-01 **4S3**	FW8-02 **4S10**	FW8-03 **4U3**	FW9-01 **4U10**	FW9-02 **5S2**	FW9-03 **5S10**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.00412	0.00417	0.00392	0.00419	0.00349	0.00329	0.00353	0.00401	0.00414	0.00401
0.00388	0.00407	0.00417	0.00398	0.00382	0.00330	0.00350	0.00411	0.00399	0.00411
0.00396	0.00414	0.00405	0.00410	0.00387	0.00328	0.00361	0.00402	0.00401	0.00347
0.00401	0.00409	0.00411	0.00407	0.00358	0.00331	0.00377	0.00405	0.00404	0.00394
0.00411	0.00412	0.00416	0.00408	0.00391	0.00322	0.00347	0.00404	0.00403	0.00396
0.00397	0.00420	0.00378	0.00389	0.00394	0.00321	0.00351	0.00406	0.00397	0.00398
0.00399	0.00416	0.00380	0.00381	0.00396	0.00334	0.00339	0.00399	0.00399	0.00389
0.00410	0.00429	0.00385	0.00414	0.00414	0.00352	0.00356	0.00420	0.00405	0.00401
0.00378	0.00388	0.00396	0.00394	0.00403	0.00408	0.00422	0.00396	0.00417	0.00392
0.00398	0.00400	0.00409	0.00373	0.00422	0.00373	0.00394	0.00402	0.00396	0.00382
0.00379	0.00360	0.00405	0.00388	0.00402	0.00398	0.00370	0.00404	0.00406	0.00391
0.00408	0.00338	0.00400	0.00395	0.00413	0.00349	0.00379	0.00405	0.00409	0.00401
0.00399	0.00332	0.00408	0.00376	0.00411	0.00391	0.00380	0.00402	0.00398	0.00384
0.00407	0.00323	0.00420	0.00412	0.00398	0.00381	0.00360	0.00374	0.00405	0.00394
0.00413	0.00402	0.00416	0.00426	0.00388	0.00413	0.00377	0.00384	0.00401	0.00389
0.00402	0.00417	0.00410	0.00419	0.00385	0.00405	0.00361	0.00402	0.00399	0.00390
0.00400	0.00393	0.00403	0.00401	0.00393	0.00360	0.00367	0.00401	0.00403	0.00391
0.99969	0.98188	1.00750	1.00141	0.98328	0.90078	0.91828	1.00266	1.00828	0.97813
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.302	127.403	127.3685	127.3812	126.9211	126.931	126.9433	127.0416	127.035	127.0004
10.09	9.92	10.17	10.11	9.89	9.06	9.24	10.10	10.15	9.85

Appendix 147. Current, voltage and electrical resistivity data for IG-430 – sheet 4

FW10-01 **5U2**	FW10-02 **5U10**	FW10-03 **6S2**	FW11-01 **6S7**	FW11-02 **6S10**	FW11-03 **6U2**	FW12-01 **6U7**	FW12-02 **6U10**	FW13-01 **Spare 1**	FW13-02 **Spare 2**
4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000	2.5000
0.00346	0.00344	0.00401	0.00399	0.00391	0.00402	0.00367	0.00365	0.00375	0.00313
0.00363	0.00371	0.00408	0.00397	0.00361	0.00395	0.00404	0.00323	0.00304	0.00311
0.00325	0.00326	0.00417	0.00409	0.00385	0.00391	0.00405	0.00425	0.00299	0.00310
0.00336	0.00356	0.00412	0.00402	0.00378	0.00393	0.00396	0.00390	0.00304	0.00314
0.00374	0.00360	0.00417	0.00407	0.00377	0.00393	0.00395	0.00396	0.00306	0.00309
0.00378	0.00374	0.00404	0.00401	0.00384	0.00435	0.00386	0.00339	0.00305	0.00317
0.00368	0.00370	0.00364	0.00410	0.00385	0.00409	0.00383	0.00372	0.00299	0.00315
0.00392	0.00369	0.00392	0.00402	0.00379	0.00401	0.00375	0.00388	0.00298	0.00303
0.00385	0.00385	0.00415	0.00425	0.00380	0.00403	0.00404	0.00391	0.00321	0.00312
0.00386	0.00357	0.00399	0.00437	0.00388	0.00400	0.00412	0.00404	0.00298	0.00314
0.00366	0.00378	0.00415	0.00424	0.00378	0.00398	0.00409	0.00401	0.00300	0.00316
0.00377	0.00391	0.00397	0.00421	0.00391	0.00401	0.00399	0.00399	0.00308	0.00309
0.00380	0.00363	0.00403	0.00424	0.00390	0.00408	0.00412	0.00411	0.00301	0.00316
0.00389	0.00375	0.00408	0.00413	0.00388	0.00378	0.00408	0.00413	0.00303	0.00313
0.00378	0.00354	0.00397	0.00410	0.00400	0.00405	0.00410	0.00405	0.00299	0.00317
0.00388	0.00345	0.00401	0.00411	0.00398	0.00399	0.00413	0.00401	0.00309	0.00306
0.00371	0.00364	0.00403	0.00412	0.00385	0.00401	0.00399	0.00389	0.00308	0.00312
0.92672	0.90906	1.00781	1.03000	0.96141	1.00172	0.99656	0.97234	0.77016	0.78047
12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139	12.6139
127.1051	127.1304	127.1051	127.1209	127.1685	127.1622	127.2098	127.1749	127.2288	127.2447
9.34	9.16	10.16	10.38	9.69	10.10	10.05	9.80	7.77	7.87

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