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Transducer Variability Study

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16. Abstract

Phased array technology may provide a significant tool for improving ultrasonic inspections of rotating jet-engine components. Two studies were performed to explore the capability of commercial vendors to manufacture the phased array transducers needed for sensitive aerospace inspections. The first, the variability study, involved the purchase and characterization of a small number of nominally identical phased array transducers. The goals were (1) to develop a set of portable measurement protocols that could readily be applied to quantify key operating characteristics of phased array transducers, and (2) to use those protocols to document differences in transducer operating characteristics. Two 10-MHz transducer designs were examined. The simpler design contained 15 elements in a planar annular array configuration, with the center element being a conventional transducer that could be removed from the array. Three phased array transducers with this design were purchased from two vendors. The complex design contained 110 elements arranged in a curved, segmented annular array. Three transducers of this design were purchased from a single vendor. For each transducer, various operating characteristics that influence detection sensitivity were measured at three test sites. These included beam diameter near the focal depth, center frequency, and frequency bandwidth. For the operating characteristics studied, the measured transducer-to-transducer variability have been summarized in a series of graphs and tables presented in this report. The test protocols are also described in detail.

The second study, referred to as the design study, was undertaken to assess the ability of transducer vendors to design novel, versatile, phased array transducers. Two different commercial firms were asked to design phased array transducers that could be used to inspect the interiors of forgings through curved surfaces without the use of reflecting mirrors. Design criteria included (1) the surface curvature parameters taken from dimensions of existent forgings; (2) the beam diameter requirements for achieving #1/2 flat-bottom hole sensitivity over a depth range of interest; and (3) the preferred water path for all inspections. Both suppliers provided one transducer design to inspect through the concave surfaces and one design to inspect through convex surfaces. The overall dimensions of the transducers, approximately 1.6″ by 1.4″, were very similar for the designs of both suppliers. However, the designs differed significantly in the number of elements and rings. The competing designs are documented and discussed in this report.

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LIST OF ACRONYMS

3D	Three-dimensional
D	Effective diameter
ETC	Engine Titanium Consortium
F	Geometric focal length
FBH	Flat-bottom hole
FFT	Fast Fourier transform
FSH	Full screen height
HW	Honeywell Engines, Systems & Services
ISU	Iowa State University
Ti	Titanium
P&W	Pratt & Whitney
PAC	Phased array control
RCE	Removable center element
RF	Radio frequency
SNR	Signal-to-noise ratio
TOF	Time of flight
UT	Ultrasonic

EXECUTIVE SUMMARY

As the Engine Titanium Consortium Phase II (ETC Phase II) program was completing technical efforts in 2004, it was recognized that the use of phased array technology provided a significant tool for improving inspection sensitivity. Specifically, a sensitivity improvement to the #1/2 flat-bottom hole (FBH) level was demonstrated for inspection of Ti-6-4 forgings using an inspection system with a specially designed phased array transducer. This sensitivity improvement was enabled by phased array technology, but that technology currently has only minimal exposure in the field of aerospace inspection. Two limited studies were sponsored by the Federal Aviation Administration to explore the capability of commercial vendors to manufacture the phased array transducers needed for sensitive aerospace inspections. The first, referred to here as the variability study, involved the purchase and characterization of a small number of nominally identical phased array transducers to document any differences in their operating characteristics. The second, referred to as the design study, was undertaken to assess the ability of transducer vendors to design novel, versatile phased array transducers. The specific design problem involved forging inspections through curved surfaces without the use of reflecting mirrors.

The goals of the transducer variability study were two-fold: (1) to develop a set of portable measurement protocols that could readily be applied at different installations to quantify key operating characteristics of phased array transducers, and (2) to use those protocols to assess the differences in characteristics of nominally identical transducers. The variability study involved two distinct 10-MHz phased array transducer designs, one relatively simple and one quite complex. The simple design contained 15 elements in an annular array configuration with the center element being a conventional (stand alone) transducer that could be removed from the array. Three phased array transducers with this design were purchased from each of two vendors, denoted here as supplier A and supplier B. No special design activities were required for the 15-element transducers; in fact, the transducer was a catalog item for supplier B. The complex design contained 110 elements arranged in a segmented annular array, with differing radii of curvature used on three different portions of the transducer face. One such transducer had been used for the ETC-Phase II forging inspection development task, and two more transducers of the same design were ordered from the original supplier, supplier A.

To assess the operating characteristics of the 15-element and 110-element phased array transducers, a series of measurement protocols were developed, tested, and used. It was known from earlier ETC-Phase II studies that sonic pulse volume (as determined by focal spot size, center frequency, and frequency bandwidth) is the primary driver in achieving good sensitivity during forging inspections. The protocols were primarily aimed at measuring these three characteristics of the phased array transducers, although other properties were quantified as well. While less critical to overall performance, the relative positioning of the individual elements within a given phased array was also checked (via time-of-flight methods) as a measure of fabrication repeatability. A separate set of protocols was designed to characterize the removable center elements of the 15-element phased array transducers, concentrating on focusing characteristics and near-surface defect resolution.

The transducer characterization activities were performed at three facilities in a round-robin fashion (Iowa State Uuniversity, Honeywell, and Pratt & Whitney). The necessary tools, such as calibration standards and shaped reflecting surfaces, were transferred to each site along with the

transducers to help ensure uniformity in the measurements. All three sites used the same make of phased array instrument, although there were slight differences in the models. A large amount of data was gathered during the round-robin study, and the observed variability in transducer operating characteristics were documented in a series of graphs and tables.

One method of describing variability within a set of transducers is to compare the standard deviation to the mean value for some given characteristic. For most measured characteristics, the variability seen at any given testing facility was found to be less than 15% of the mean value, indicating both reasonable intra-facility measurement consistency and reasonable repeatability in the manufacture of the transducers. There was also some variability ±21% of the mean value in inter-facility results. This was true for both the 110-element complex transducers (produced by a single manufacturer) and the 15-element transducers (produced by two manufacturers). There were some characteristics, such as measured absolute amplitudes from reference reflectors at a fixed gain, which had a higher than 15% variability. However, in many circumstances, such absolute amplitude variations can be accommodated in practice by simply adjusting the gain level during the calibration step of an inspection. The removable center elements, which were characterized separately, also showed low variability with nearly all measured characteristics varying by less than 10% of the mean value, which is about the same variability measured in current fix-focused, removable element transducers. The bandwidth variability (about 14%) and near-surface resolution variability (about 50%) were notable exceptions.

No effort was made to estimate what might be termed an acceptable variability for any given transducer characteristic. This is because the acceptable range of a transducer parameter will generally depend on the details of the specific inspection one has in mind. Rather, it is hoped that interested readers can use the variability values documented in the report tables as a starting point for estimating how such variability might influence a particular inspection of interest. For example, the values cited could be used as inputs to model-based detection sensitivity calculations.

In an effort unrelated to the transducer variability evaluation, a transducer design study was accomplished by asking two different commercial vendors to design phased array transducers that could be used to inspect through curved surfaces without the use of reflecting mirrors. Specifically, the ETC team provided the following information: (1) the surface curvature parameters, taken from dimensions of forgings studied earlier by the ETC-Phase II team; (2) the beam diameter requirements for achieving #1/2 FBH sensitivity over a depth range of interest; and (3) the preferred water path for all inspections. The two vendors were designated supplier A, which provided some of the transducers used in the variability study, and supplier E, which had a track record in phased array transducer design.

Both suppliers came to the conclusion that a single phased array transducer could not be made to compensate for both concave and convex curvatures.

1. INTRODUCTION.

1.1 PURPOSE.

High-sensitivity forging inspections require transducers that perform with precision to form ultrasonic (UT) wave fields. The recently demonstrated #1/2 flat-bottom hole (FBH) sensitivity inspection [1] was accomplished with the application of a complex phased array transducer to generate the necessary UT wave field. The purpose of this study was a preliminary evaluation of the producibility and repeatability of nominally identical phased array transducers. For some imagined inspections, deviation from the designed wave field geometry can result in substantial reduction in detection sensitivity.

Another aspect of the study was to determine the industrial suppliers' ability to design complex phased array transducers. The ability to design and build special-purpose phased array transducers was demonstrated in one instance within the earlier Engine Titanium Consortium (ETC) Phase II program [1]. Using phased array technology for aerospace inspections will likely require that reliable designs be available for transducers that meet special needs.

1.2 BACKGROUND.

1.2.1 Transducer Variability.

The assessment of variability in the performance of phased array transducers is in most respects no different than conventional fixed-focused transducers. To understand this point of view, consider the physical mechanisms involved in detecting a flaw. A major accomplishment of the ETC program was the discovery that the signal-to-noise ratio (SNR) in the detection of a small internal flaw in titanium (Ti) depends upon the beam diameter and pulse duration at the site of the flaw [1-3]. The pulse duration, in turn, is determined by the pulse center frequency and bandwidth. These parameters (beam diameter, center frequency, and bandwidth) can therefore serve as the performance specifications that determine the effectiveness of the inspection. In turn, the effectiveness of a transducer design is determined by the beam diameter, center frequency, and bandwidth that the transducer provides. The motivation of the task at hand is the fact that variability in the beam diameter and pulse duration will directly result in variability in the inspection SNR and will consequently influence probability of detection.

A potential source of variability in the wave field geometry comes from variation in the fabrication of transducers, such as deviations from the nominal design of the radiating surface geometry and piezoelectric efficiency. A goal of the current study was to better understand the uniformity of transducer manufacture, and consequently of transducer performance, for multiple transducers fabricated by the same manufacturer and for nominally identical transducers fabricated by different manufacturers.

Note that ETC Phase I multizone billet transducers underwent similar acceptance testing. There, beam diameter, center frequency, and bandwidth are measured for each transducer, and variability in transducer manufacture was assessed by noting the variation in these key parameters. In the work at hand using phased arrays, the same underlying principles apply: the effectiveness of the phased array inspection will depend on how reliably the phased array UT

system can produce an UT pulse with the required beam diameter, center frequency, and bandwidth. It is in this respect that the assessment of variability is essentially the same for phased array and conventional transducers. In the case of the multizone billet inspection, each zone of the billet is inspected separately using a transducer designed for that zone. Thus, the variability in these key parameters had to be measured separately for each transducer (i.e., for each inspection zone). In the case of a phased array designed to inspect a large depth zone, it is sensible to measure the variability at more than one depth, i.e., with the transducer focused sequentially at multiple representative flaw depths.

One major difference between the multizone billet transducers and phased array transducers is that the former are each designed with a very specific inspection in mind (i.e., fixed billet curvature, water path, and focal depth), while the latter can accommodate many types of inspections. For their specific applications, experimental testing or model-based sensitivity calculations can be used to determine acceptable ranges for the operating characteristics of multizone transducers [4]. For the phased-array transducers, there may not be one particular inspection foremost in mind. Rather, measurements are made for fairly generic inspection setups using simple reflectors in water or FBH reflectors beneath flat surfaces in metal test blocks. Thus, it is not possible to a priori specify acceptable ranges for measured operating characteristics of the phased array transducers.

It is emphasized that it is the variability in the final beam generated by the phased array that is important. It is theoretically possible to have a substantial variability in the response of individual array elements, yet still obtain an acceptable focus when all the elements are fired in unison. If this is true, a meaningful determination of variability in phased array performance may be made by the measurement of the variability in the ultimate beam diameter, center frequency, and frequency bandwidth generated by the transducer when operating as intended for the inspection. Such tests were implemented as the primary measure of variability for the transducers studied in this report.

Should a phased array transducer not meet the performance specification, one could ask the question why not? Answers to this question might be found in examining the variability in the responses of individual elements of the phased array. This could be a useful thing to examine, since it is conceivable that variability in the individual elements of the phased array could be compensated for by making appropriate adjustments in the time delays and gains applied to individual elements. It is reiterated, however, that determining the variability among individual element responses is not necessarily an indicator of the variability in the ultimate performance of the transducer. It is for this reason that the determination of element-to-element variability can be viewed as having secondary importance as far as inspection performance is concerned. Nonetheless, in the present work, element-by-element variability in pulse amplitude and transit time were studied and compiled. Pulse transit time is the most important parameter in phased array operation, since this determines the coherency with which the individual element responses sum when focused at a particular position. From a transducer manufacturer's point of view, such variability may be the most important data to assess, as it gives an indication of how well the manufacturing processes are being controlled. The work reported here, however, primarily addresses the needs of those performing inspections, not those manufacturing transducers. Low variability in element-to-element responses would certainly seem to indicate a higher-quality

transducer. However, the variability in element-to-element responses is not always a direct indicator of the variability in ultimate transducer performance.

An analogous situation occurs regarding conventional fixed-focused transducers. If a particular transducer does not perform to specification when its beam diameter, center frequency, and bandwidth are examined, a regional evaluation of the transducer surface could be conducted to determine any variability about the nominal values of the surface geometry and piezoelectric response. This could be done, for example, by scanning a small ball target in water in close proximity to the transducer. There is little motivation for the end user to do this, however, because there is nothing the user could do about it (other than return the transducer to the manufacturer) even if the underlying causes of the substandard performance were determined. This information would be of considerable interest to the transducer manufacturer, however.

With this background in mind, a series of tests were identified to measure variability in phased array transducer performance using transducers specified to be nominally identical. Two different phased array transducer designs were studied. The first design was a commercially available off-the-shelf 10-MHz transducer containing 14 annular ring elements, plus a removable 3/8-inch-diameter center element designed to provide enhanced near-surface resolution. Three of these transducers were purchased from the original manufacturer, supplier B. Additionally, an order was placed with a second transducer manufacturer, supplier A, for three transducers having the same element geometry, for a total of six nominally identical transducers.

The second design studied was a 110-element transducer designed to maintain an F6 focus to a depth of 3.25 inches in Ti. One of these transducers had been previously manufactured for earlier work [1]. For the present study, two more of these transducers were ordered from the original manufacturer, supplier A.

For each phased array design, tests were performed to measure variability in beam diameter, signal amplitude, center frequency, and bandwidth. These tests served to assess the primary performance variability of the transducer as it impacted uniformity of inspection sensitivity. Tests were also performed to quantify the variability in pulse arrival time on an element-by-element basis, in which the measured arrival times for reflections from a test standard were compared to the theoretically intended value. Extensive evaluations were also performed for the removable center elements of the 15-element annular array transducers, leading to a comparative assessment of the properties of six conventional, 10-MHz, single-element, spherically focused transducers. The measurements of the operating characteristics of the phased array transducers and the removable center elements are discussed in section 2.

A relatively standard procurement process was used to obtain phased array transducers for study, although longer wait times for fabrication are required than for fixed-focus transducers. All nine of the tested phased array transducers could be operated in a nominal fashion without difficulty. The first 15-element transducer delivered by supplier A had a crack in the surface that was not noticed during the initial acceptance evaluations, but supplier A found the problem during manufacture of the second transducer of the same design. Both of these early transducers were replaced before characterization activity began.

1.2.2 Transducer Designs.

Some regions of forgings must be inspected with the sonic beam passing through a curved surface. The approach adopted during ETC Phase II [1] is to insert a curved mirror into the water path. The mirror predistorts the ultrasound beam in a fashion complementary to the distortion caused by refraction at the curved entry surface. When properly designed, the net effect of the mirror is to greatly reduce the distortion to the UT beam caused by surface curvature. Use of mirrors to correct for surface curvature is a long-established practice in conventional UT inspection. The challenge in high-sensitivity forging inspections is to implement the use of mirrors for large-aperture, highly focused beams and to operate the mirrors over a large range of focal depths. This can be a difficult task [1]. One can imagine an alternative approach in which mirrors are not used; rather, the predistortion of the sound beam is accomplished by suitably phasing the elements of a phased array transducer. In a study unrelated to the transducer variability work, phased array transducer design capability within the supplier base was evaluated, and designs were requested for phased array transducers that would compensate for surface curvature by phasing the elements. Two companies (denoted supplier A and supplier E) were selected based on experience in the field of phased array technology. They were asked to provide design solutions for transducers that could correct for typical concave and convex curvatures as present in the forgings evaluated in the ETC Phase II task [1]. The specific design criteria and resulting transducer designs are discussed in the Design Study portion of this report.

1.3 OBJECTIVES.

The work summarized in this report is essentially an extension of the original ETC Phase II [1]. The underlying goal was to explore the capability of commercial vendors to manufacture the phased array transducers needed for sensitive aerospace inspections, so as to enable informed planning for future implementation of the technology.

This report discusses two separate but related studies. The first, the variability study, involved the purchase and characterization of a small number of nominally identical phased array transducers to document any differences in their operating characteristics. The objective of the variability study was two-fold: (1) to develop a set of portable measurement protocols that could readily be applied at different installations to quantify key operating characteristics of phased array transducers and (2) to use those protocols to assess the differences in characteristics of nominally identical transducers. The second study, the design study, was undertaken to assess the ability of transducer vendors to design novel, versatile phased array transducers. The specific design problem addressed forging inspection through curved surfaces without the use of reflecting mirrors.

It must be noted that in the variability study, no effort was made to estimate what might be termed an acceptable variability for any given transducer characteristic. This is because the acceptable range of a transducer parameter will depend on the details of the specific inspection one has in mind. For example, if a transducer focuses shorter or longer than designed and one is inspecting through a flat surface, one can often largely compensate for the error in focal depth by suitably adjusting the water path. However, this ploy is less effective when inspecting though a curved surface, since a change in water path will then affect both the depth of focus and the

shape of the beam spot. For phased array transducers, one can, of course, adjust the firing patterns of the individual elements to compensate for some types of less-than-nominal focusing behaviors. Similarly, if two transducers differ in their efficiencies for conversion of electrical energy to sound, this difference will result in observed absolute amplitude differences for the responses from a given reference reflector. However, such absolute amplitude variations can be accommodated in practice by adjusting the gain level during the calibration step of an inspection. In this report, the variability of the measured transducer characteristics is summarized in a series of bar graphs and tables that largely speak for themselves. It is hoped that interested readers can use the documented variability values as a starting point for estimating how such variability might influence a particular inspection of interest. For example the values cited could be used as inputs to model-based calculations of detection sensitivity in the spirit of Chiou, et al. [4]. Although such calculations are feasible, given some particular straw man inspection scenario, they are beyond the planned scope of the present study.

When discussing general trends in the transducer variability data, the study team occasionally uses terms such as small, moderate, and large to indicate relative levels of variability. Here, small is generally reserved for percentage variations about the mean of 10% or less, i.e., $\sigma/\langle A\rangle$ less than 0.10, where $\langle A\rangle$ denotes the average value of a set of measurements and σ denotes the standard deviation about that average. Similarly, moderate is used for variations of 10% to 25%, and large for variations of 25% or more. However, small (or moderate or large) in this general context does not imply that the variability would necessarily have a small (or moderate or large) effect on detection sensitivity or probability of detection. Thus, the reader is cautioned to use the data summarized in the ensuing figures and tables to directly form an opinion as to the ultimate effect of the performance variability on any particular inspection.

2. DISCUSSION OF APPROACHES AND RESULTS.

2.1 TRANSDUCER VARIABILITY STUDY.

2.1.1 Transducer Purchases.

The transducers chosen for this study were selected from a short list of phased array probes designed in the past for disk inspections. One such transducer was the 10-MHz, 110-element probe designed for Ti forging inspection development during ETC Phase II. There, the design criterion was to achieve #1/2 FBH sensitivity for depths up to 3.2″ in Ti alloy engine disks. A probe of that design was successfully manufactured by supplier A as a 110-element, annular-sectorial array with three discrete radii of curvature and an outer diameter of 2.75″. The probe was used to inspect test blocks and engine forgings at Iowa State University (ISU) and was determined to have met the design specifications. Key specifications for this probe are summarized below, and its design is described in detail in section 4.1 of DOT/FAA/AR-05/46, "Inspection Development for Titanium Forgings."

For the transducer variability study, it was decided that two additional probes of the same design should be ordered from supplier A. The original probe bears the serial number 3446A101 and the two new probes have serial numbers 3446B101 and 3446B102. These transducers will be referred as 110-element or Type-II probes in this report. The price of the original probe was $21,156, and the prices of two new probes were $11,562 each.

For the second probe used in the study, it was decided to use a simpler design so that any variability between probe manufacturers could be assessed as well. The transducer that was selected was a 10-MHz annular array with 15 elements, which is a catalog item for supplier B. The center element of this probe is removable, being a conventional, single-element, fixed-focused transducer intended to achieve good near-surface resolution. More specifically, the removable center element (RCE) is a 10-MHz, 0.375″ diameter, spherically focused transducer having a 3″ focus in water. The RCE is typical of one type of conventional transducer currently employed in jet engine forging inspections. The near-surface resolution requirement is often formulated in terms of the response from a 0.060″ deep #1 FBH in IN100 material, for which the SNR should be greater than 18 dB. IN100 is a powder-nickel material with essentially no UT grain noise. In addition to the RCE, there are 14 equal area rings, the outer diameter of the largest being 1.25″. Three probes of this type were ordered from supplier B and another three probes of the same design were ordered from supplier A. The objective was to study the variability in probe performance for a given manufacturer as well as manufacturer-to-manufacturer variability. Five of the six RCEs were manufactured by supplier C, and the sixth one was made by supplier D. Table 1 contains the serial numbers of the 14-element annular arrays and their RCEs. These transducers will be referred to as 15-element or Type-I probes in this report. The price of each supplier B probe was $6,500, and the price of each supplier A probe was $8,733. (These prices included the RCE.) For reference, the price of the RCE alone, which can be ordered separately, is approximately $1,250.

Table 1. Serial Numbers of 15-Element Annular Array Probes

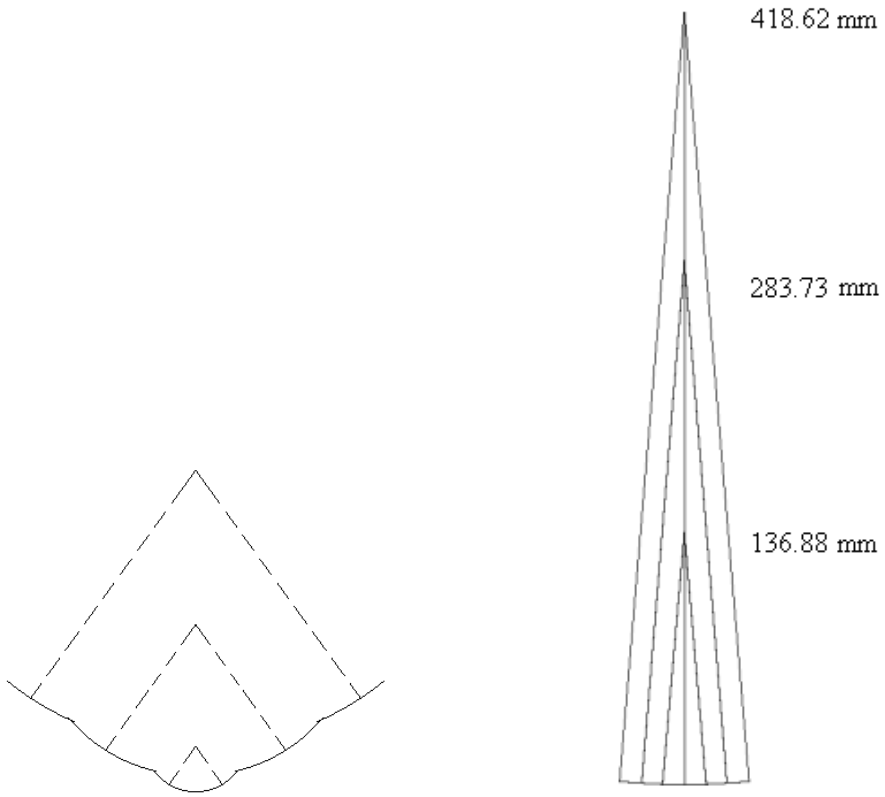
Annular Array		RCE	
Manufacturer	Serial Number	Manufacturer	Serial Number
Supplier A	4608A101	Supplier C	VA1602
Supplier A	4608A102	Supplier C	VA1601
Supplier A	4608A103	Supplier C	VA1501
Supplier B	403Y004	Supplier C	VA1502
Supplier B	403Y006	Supplier C	VA1503
Supplier B	403Y007	Supplier D	405051

The 110-element probes were ordered with specific element descriptions relating to the segmentation of the rings, the element sizes, and the wiring patterns. The compound surface geometry is depicted in figure 1, and the surface specifications are as follows:

- Inner surface
  - Aperture radius: 11.8358 mm
  - Curvature radius: 136.8820 mm
- Middle Surface
  - Aperture radius: 23.0791 mm
  - Curvature radius: 283.7308 mm

- Outer Surface

  - Aperture radius: 35.1398 mm
  - Curvature radius: 418.6163 mm



(a) Concept of compound spherical surface (not drawn to scale)

(b) Compound spherical surface elements (drawn to scale)

Figure 1. Surface Characteristics and Focusing Features of the 110-Element Transducers (a) Surface Concept and (b) Focal Characteristics of the Surface Curvatures

The element layout is depicted in figure 2, and figure 3 shows one of the 110-element transducers.

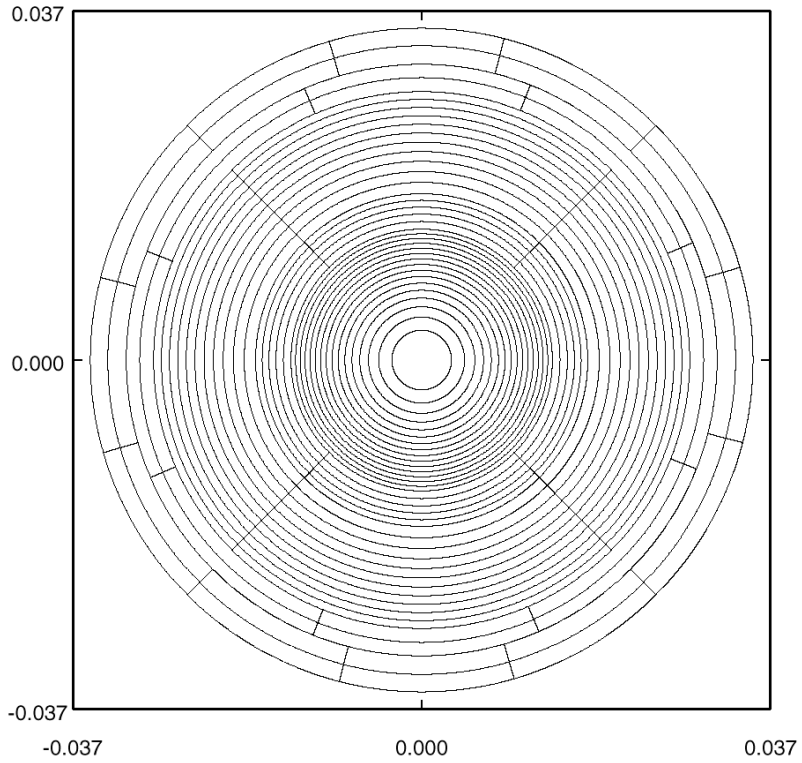


Figure 2. Layout of the 110 Elements of the Probe

Figure 3. Supplier A 110-Element Probe

The 110-element transducers were ordered with the following electrical and mechanical specifications:

- Center frequency: 10 $\pm$1 MHz (each element)
- 6-dB bandwidth: $\geq$60%
- Connector and pin wiring conforms to R/D Tech Focus standard
- Cable length: 3 m (9.8 ft)
- Element-machining precision requirement: 0.025 mm (λ/6 at 10 MHz)

    - The supplier had tried to prepare the surface to the 0.025-mm precision, but the intent of the order was to have the supplier maintain phase variation within λ/6 for neighboring elements.

The 15-element annular arrays were ordered from both suppliers with the same specifications. The acoustic characteristics that were required for acceptance are described as follows:

- Frequency (-6 dB): 10 MHz (±15%)

- Bandwidth (-6dB): >70%

- Acoustic matching with: water

- Impedance matching: 50 Ohms

- Number of elements: center element (3″ focus, radius 0.189″, meets near-surface resolution specification of SNR>18 dB on 0.060″ deep #1 FBH measured with R/D Tech Focus phased array unit) and 14-element annular array (see table 2)

- Number of channels: 15

Table 2. Element Configuration for the Annular Array

Ring No.	Interior Radius (mm)	Exterior Radius (mm)	Spacing Between Elements i-1 and i (mm)	Ring Width (mm)	Area (mm^2)
1*	0.00	4.80	0	4.80	72.38
2	6.99	7.68	2.19	0.69	31.80
3	7.88	8.49	0.2	0.61	31.37
4	8.69	9.26	0.2	0.57	32.14
5	9.46	9.97	0.2	0.51	31.13
6	10.17	10.66	0.2	0.49	32.07
7	10.86	11.31	0.2	0.45	31.34
8	11.51	11.94	0.2	0.43	31.68
9	12.14	12.55	0.2	0.41	31.80
10	12.75	13.14	0.2	0.39	31.72
11	13.34	13.72	0.2	0.38	32.30
12	13.92	14.27	0.2	0.35	31.00
13	14.47	14.82	0.2	0.35	32.21
14	15.02	15.35	0.2	0.33	31.49
15	15.55	15.87	0.2	0.32	31.59

*Removable center element

The mechanical characteristics for the transducers were specified as follows:

- Cable: multicoaxial with shielding wiring to the housing—length 5 m
- Cable way out: axial (on side)
- Connector: 1 Hypertronics + 1 Limo (standard R/D Tech Focus with PIM/06)
- Housing Material: Stainless steel with waterproof ultra high frequency on top for mechanical fixing

The layout of the elements is depicted in figure 4, and figures 5 and 6 show the transducers produced by the two suppliers.

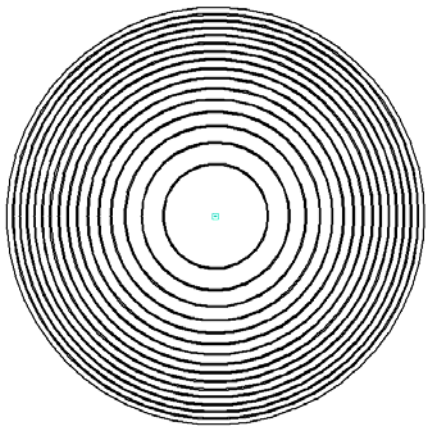


Figure 4. Layout of Rings for the 15-Element Transducers

Figure 5. Supplier A 15-Element Probe

Figure 6. Supplier B 15-Element Probe

Each set of probes was delivered in a 2- to 3-month time frame from the placement of the orders. Here, a set refers to either (1) the pair of newer 110-element transducers from supplier A, (2) three 15-element transducers from supplier B, or (3) three 15-element transducers from supplier A. The three 15-element transducers produced by supplier A required two fabrication runs. In the first set of three, the manufacturer noticed cracks on the surfaces of two of the transducers. One of the transducers containing a surface crack had already been delivered and appeared to be working correctly, but it was returned for repair at the manufacturer's request. All three transducers were refabricated without any further cracking.

All nine probes were delivered with all elements functioning correctly, i.e., there were no dead elements. There were also no problems with interfacing the transducers to the phased array pulser/receiver instruments. The next section of the report describes the characterization of these nine transducers.

2.1.2 Transducers Studied and Round-Robin Measurement Sites.

As indicated earlier, two types of 10-MHz phased array transducers were included in the study. These are shown in figures 7 and 8, respectively, which, for later reference, conveniently combine photographs, basic designs, and serial number information that were listed separately in earlier tables and figures.

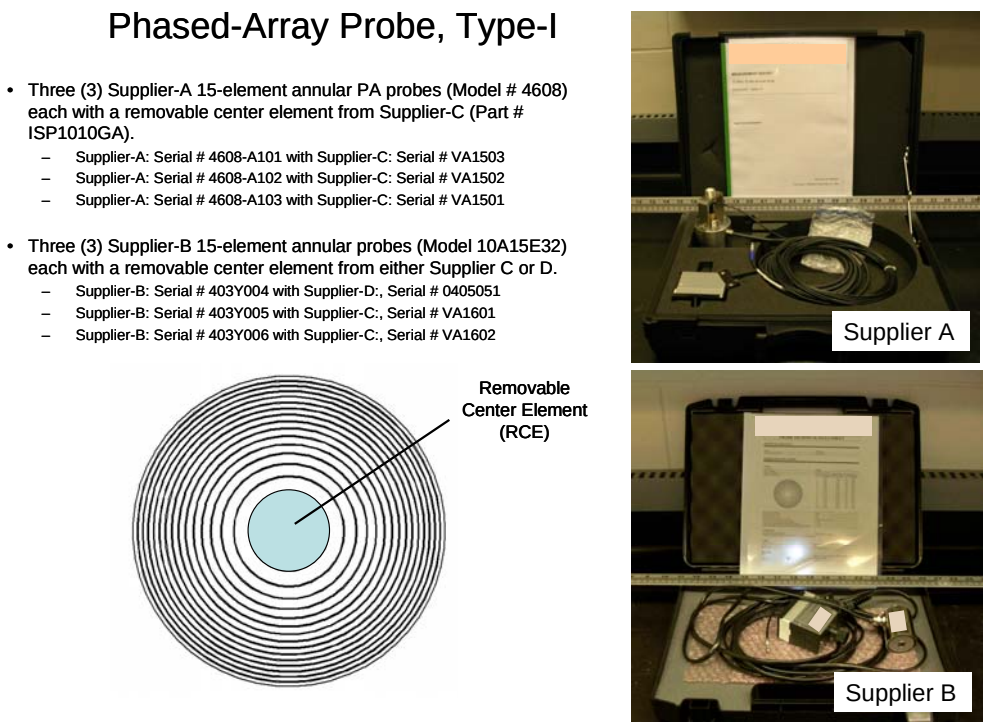


Figure 7. Type-I Phased Array Transducers

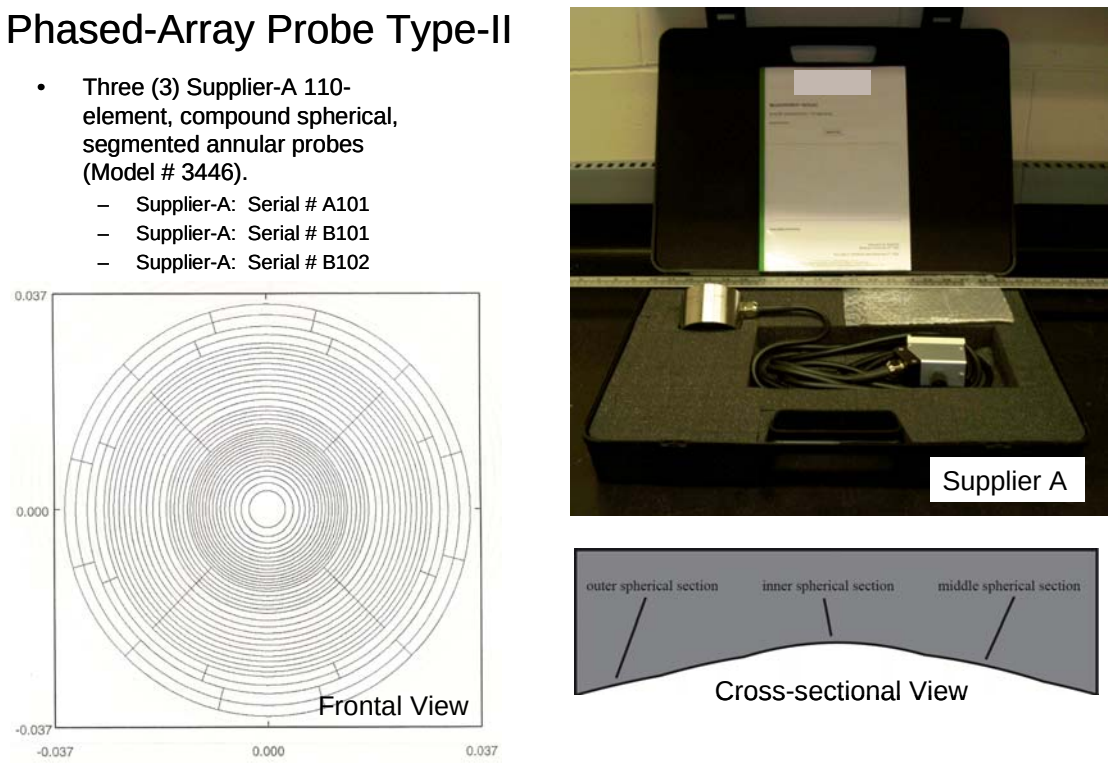


Figure 8. Type-II Phased Array Transducers

Briefly recapping, Type-I transducers each had 15 elements, including the circular RCE. The 14 outer elements were concentric annular rings of approximately equal area that all laid in a common plane. The RCE was a standard, circular element, spherically focused transducer having a nominal diameter of 3/8″ and a nominal focal length in water of 3.0″. A total of six Type-I transducers and their associated RCEs were studied, with the various manufacturers indicated in figure 7.

Type-II transducers were more complex, containing 110 elements placed upon a curved surface to promote focusing. Three such transducers, all manufactured by Supplier A, were used in the study.

A series of measurements was designed to document the operational capabilities of the transducers when powered by R/D Tech Tomoscan hardware and controlled by an R/D Tech TomoView™ operating system. The measurements were carried out at three separate sites following a common set of inspection protocols (included in appendix D). These sites were (in the order that measurements were performed):

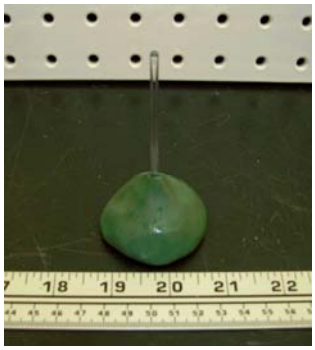
- ISU, Ames, Iowa
- United Technologies Pratt & Whitney (P&W), East Hartford, Connecticut
- Honeywell Engines, Systems & Services (HW), Phoenix, Arizona

Some differences existed between facilities in the hardware and software used to carry out the measurements. All pulser/receiver hardware was supplied by R/D Tech: ISU and HW used Tomoscan Focus instruments (also referred to as Tomoscan II), while P&W used a newer Tomoscan III instrument. The software used to control the instruments was also supplied by R/D Tech, with all three facilities employing the TomoView 2.2 software package. HW had purchased an add-on to this software known as Motionview to directly control scanning operations. ISU and P&W each used UTEX Winspect software to control scanning operations, with auxiliary-positioning signals being supplied to TomoView so that the latter software could monitor scanning operations. It was the consensus of the team that the various hardware and software differences, in and of themselves, should have no effect on the planned transducer characterization measurements. Of course, even if two facilities have nominally identical hardware and software, some differences in operating characteristics are always expected, and that was the case here as well.

2.1.3 Ultrasonic Specimens.

The round-robin study made use of several specimens that served as UT targets for pulse-echo measurements. These specimens are displayed and described in figures 9 through 11.

- Small glass rod with rounded tip with green clay base.
- Approximate length = 3 inches
- Approximate diameter of tip = 1/8 inch



- IN100 step block with white plastic support.
- Approx. dimensions of 10” x 2.6” x 1.2”
- #1 FBHs located at depths of 0.05”, 0.10”, 0.15”, 0.50”, 1.0”, 1.5”, 2.0”, 2.5”
- Longitudinal wave speed = 6138 m/s = 0.2417 in/us

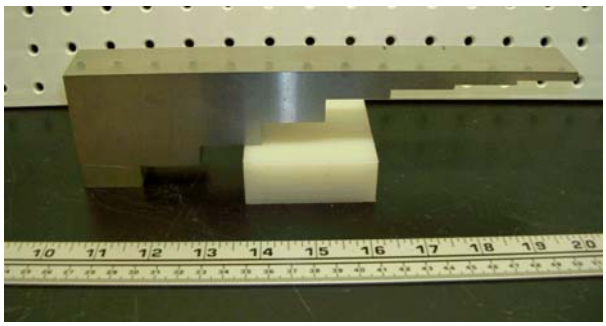


Figure 9. Ultrasonic Targets Used for Characterizing the Removable Center Elements of Type-I Transducers

- One plano-convex glass reflector for use with inner section of 110-element probe.
  - Dimensions: diameter = 30 mm and radius of curvature = 62.02 mm
  - use 2.947-inch water path (as measured relative to rings in inner section of probe)
- One plano-convex glass reflector for use with middle section of 110-element probe.
  - Dimensions: diameter = 40 mm and radius of curvature = 206.72 mm
  - use 3.031-inch water path (as measured relative to rings in middle section of probe)
- One plano-convex glass reflector for use with outer section of 110-element probe.
  - Dimensions: diameter = 50 mm and radius of curvature = 258.40 mm
  - use 6.308-inch water path (as measured relative to rings in outer section of probe)
- One plano-concave glass reflector for use with 15-element probe.
  - diameter = 50 mm
  - use planar side with 15-element probe at a water path of 3.000 inches

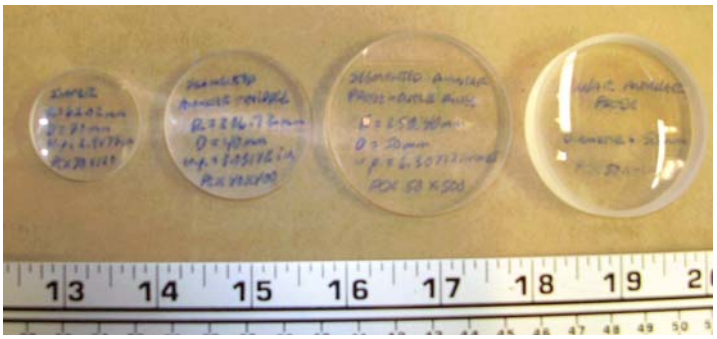


Figure 10. Curved Glass Reflectors Used in the Characterization of Type-I and Type-II Phased Array Transducers

- Three blocks from a set of P&W-supplied, forged Ti 6-4 calibration blocks, each containing one #1/2 FBH. Each block had a 2” x 2” flat sound-entry surface:
  - PW block #4, containing one FBH at a depth of 0.7 inches.
  - PW block #8 , containing one FBH at a depth of 1.6 inches.
  - PW block #12 , containing one FBH at a depth of 2.5 inches.

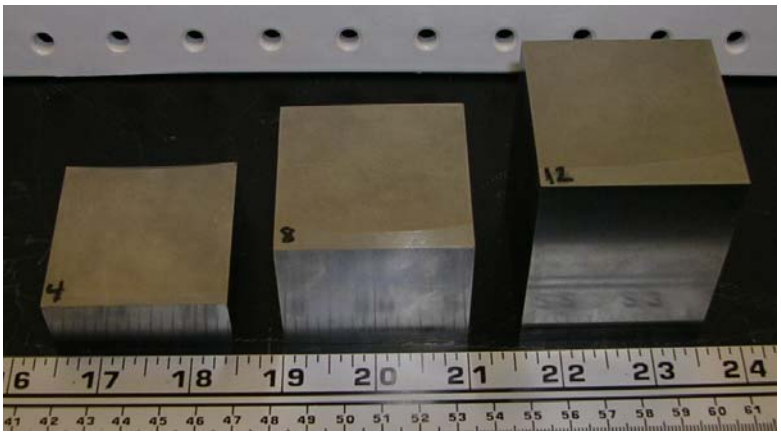


Figure 11. The FBH Blocks Used in the Characterization of Type-I and Type-II Phased Array Transducers

Figure 9 shows the two types of specimens that were used in the characterizations of the RCEs of the Type-I transducers. A glass rod with a rounded tip served as a ball-like target in water. The rounded rod was preferred over a spherical target (such as a ball bearing) because there was no back-wall echo, thus simplifying the appearance of time-domain waveforms (A-scans). A step block containing #1 FBHs at a series of depths was also used for RCE characterization. This was fabricated from IN100 so that backscattered grain noise would be negligible. These two types of targets were essentially used to measure UT responses for the RCE as a function of depth, either in water (for a variable water path) or in metal (for a fixed water path).

Figures 10 and 11 show additional specimens that played a role in the characterization of the other (non-RCE) elements of the phased array transducers.

2.1.4 General Ground Rules.

To guide the measurements, the following general ground rules were adopted, which all users in the round-robin study followed.

- During testing, the center element should neither be removed from the array nor should its orientation within the array be altered in any manner.

- The phased array transducer, including the RCE, should not be energized when it is out of the water. After the transducer has been energized, one must wait at least 10 minutes for the system to stabilize before any data is taken.

- TomoView Version 2.2 software should be used for all data acquisition, including the RCE. ISU provided the appropriate setup files, incorporating the necessary phased array control (PAC) files and UT settings. (PAC files describe which elements will be fired and their relative time delays.)

- One should not load a setup file that energizes fewer rings than the previous setup file without restarting the TomoView software and Tomoscan hardware.

- When a pulse-echo amplitude is measured, this specifically indicates the peak-to-peak amplitude of the unrectified signal, unless stated otherwise.

- If electronic noise is present so that the instantaneous signal jitters noticeably, care must be taken in the determination of a peak-to-peak amplitude. In particular, the peak positive and peak negative amplitude values should each be visually averaged before they are recorded. In other words, the jittering positive peak amplitude should be above the recorded positive peak value 50% of the time and below it 50% of the time; similarly, for the recorded negative peak amplitude.

- In the course of the measurements, it will occasionally be necessary to set the water path to some particular value between the transducer and a target. To simplify this procedure (and to use common industrial practice), all water paths will be set via time of flight (TOF), ignoring any time delay between the electronic "main bang" and the emission of a

sound pulse by the transducer. However, the time difference between the Tomoscan trigger pulse (i.e., the leftmost point displayed on the system A-scan) and the start of the main bang cannot be ignored; it will be measured and used when setting the water path.

Table 3 lists the various TomoView setup files that were supplied to participants in the round-robin study. Several additional computer files that were used to record and analyze data are listed in table 4.

Table 3. TomoView Setup Files Used During Round-Robin Testing

File Name	Sample Used	Purpose
RCE-Y-zero-plus.acq	Glass rod	For Y+0 determine and optional C-scan for spot size.
TVoffsetValue.acq	None	For determination of t0 offset time (big bang start).
RCE-SpotSize.acq	Glass rod	For optional C-scan for spot size.
RCE-FBH-Ref_Ascan.acq	IN100 step block with #1 FBHs	For A-scan (ref signal) and six FBH amplitudes.
RCE-NearSR.acq	IN100 step block with #1 FBHs	For determining near surface resolution signal-to-noise.
015E-Delays.acq	Plano-concave reflector, 50 mm D	For determining TOF variation over all array elements
RDT-015E-FBH-block08.acq	PW block #8 of set of 13 blocks	For determining spot size via C-scan of mid-zone FBH using 15-element probes manufactured by R/D Tech.
Ima-015E-FBH-block08.acq	PW block #8 of set of 13 blocks	For determining spot size via C-scan of mid-zone FBH using 15-element probes manufactured by Imasonic.
110E-Delays.acq	Plano-convex reflector, 30 mm D Plano-convex reflector, 40 mm D Plano-convex reflector, 50 mm D	TOF variation over all array elements in inner, middle, and outer section of 110-element probe.
110E-FBH-block04.acq	PW block #4 of set of 13 blocks	For determining spot size of mid-zone FBH, zone 2.

Table 4. Additional Files Used During Round-Robin Testing

File Name	Purpose
PA_char_plans_RCE_88.xls	Contains various spreadsheets for recording raw data and displaying results of data analysis (for removable center element only).
NMF5.exe	Software for analyzing data from removable center element to determine an effective diameter and focal length.
NMF5_ref_signal.txt	Prototype file for reference signal A-scan data, as input to NMF5.exe
NMF5_input.txt	Prototype file for input of additional data to NMF5.exe.
PA_performance_015E_Delays-OUTFIT.xls	Contains various spreadsheets for recording raw data and displaying results of data analysis (for 15-element probe only).
PA_performance_110E_Delays-OUTFIT.xls	Contains various spreadsheets for recording raw data and displaying results of data analysis (for 110-element probe only).

The specific method used to set inspection water paths requires further explanation. The first step is the measurement of an instrumentation time offset, denoted t_0. That measurement is illustrated in figure 12 using the R/D Tech instrumentation and software residing at ISU. A

TomoView setup file (TVoffsetValue.acq) was loaded, which was designed to fire (with a user-specified time delay of zero) only the RCE of a Type-I transducer. The early time portion of the resulting A-scan signal is shown in figure 12. The time offset, t_0, is defined as the time delay between the beginning of the A-scan trace (internal t=0 point for instrumentation displays) and the onset of the main bang. For the case shown, the time offset is 1.08 µsec, as indicated by the vertical red line, which serves as a cursor. Roughly half-way between the t=0 point and the main bang onset, an additional small signal can be seen; this is believed to be associated with an internal timing pulse used by the Tomoscan hardware. The time offset, t_0, is believed to be a property of the R/D Tech hardware alone and, hence, independent of the transducer to which the hardware is attached. At each of the facilities participating in the round-robin study, the time offset for their specific hardware was measured. The results are listed in table 5.

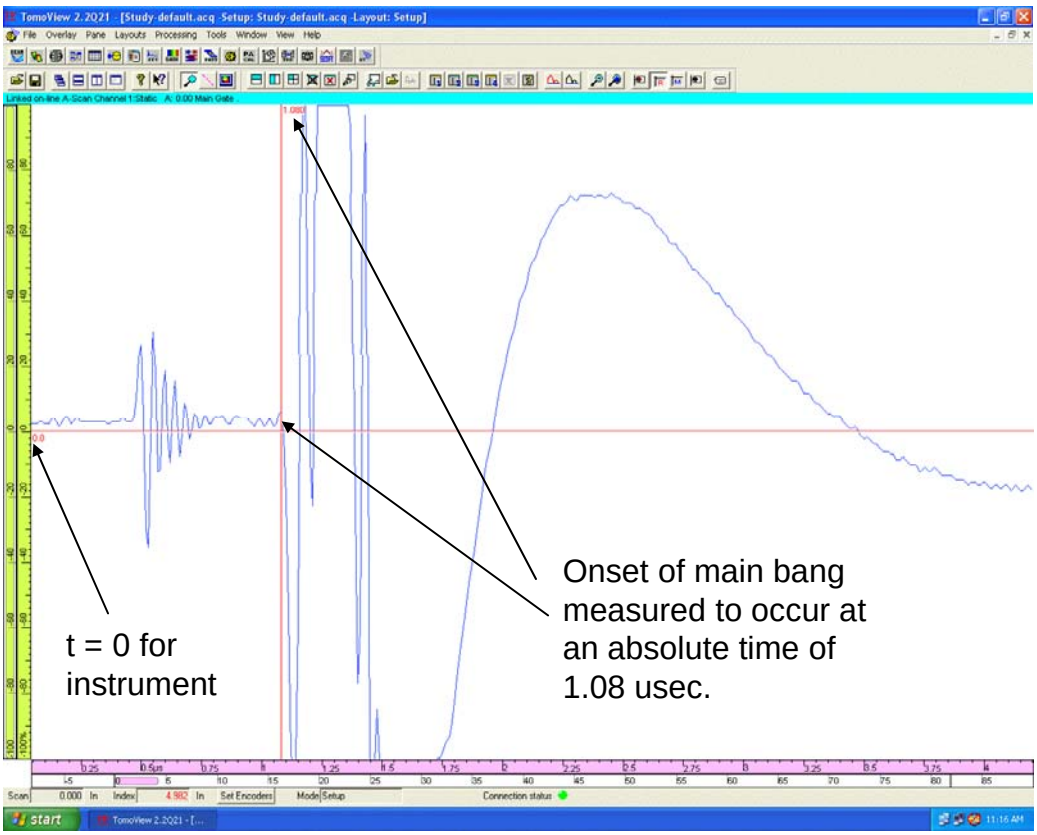


Figure 12. Measurement of the Instrumentation Time Offset, t_0

Table 5. Measured Instrumentation Time Offset Values

Facility	Time Offset (usec)	R/D Tech Hardware
ISU	1.08	Tomoscan II (FOCUS)
Pratt & Whitney	1.41	Tomoscan III
Honeywell	1.07	Tomoscan II (FOCUS)

Once the time offset had been determined, it was straightforward to set the one-way water path to a reflector to any desired distance Z. The specific method used was to adjust the water path until the arrival time of the front-wall echo (i.e., the arrival time of the dominant peak in the A-scan signal) occurred at time

$$t = \frac{2z}{v} + t_0 \tag{1}$$

where t_0 denotes the measured time offset and v denotes the speed of sound in water. Temperature-dependent sound speeds for pure water, as summarized by Bilaniuk and Wong [5] were used in equation 1. The water temperature was measured prior to each experimental trial, and the corresponding sound speed was obtained from either a look-up table or a simple calculator inserted into a spreadsheet data table. The manner in which the sound speed in pure water varies with temperature is shown in figure 13.

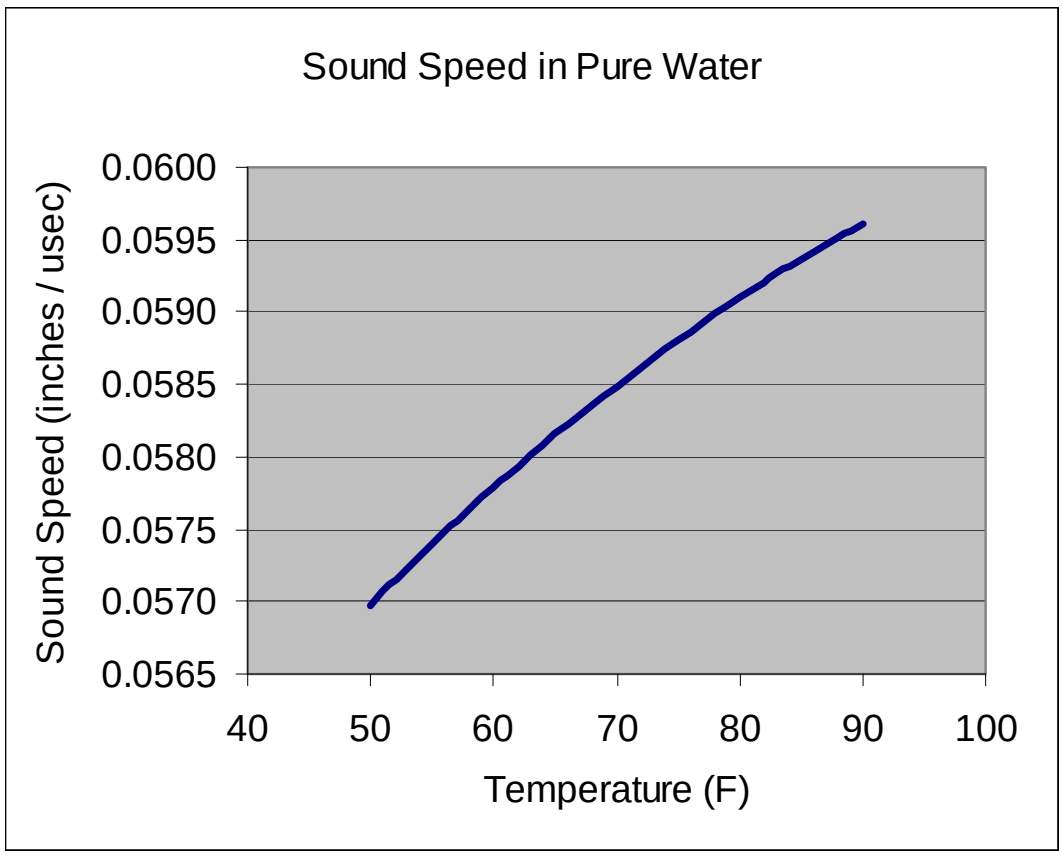


Figure 13. Assumed Sound Speed in Water for all Measurements and Analyses

2.1.5 Characterization of the RCEs.

Recall that each of the six Type-I phased array transducers contained an RCE. Each RCE was a 10-MHz, broadband, circular-element, spherically focused transducer having a nominal diameter of 3/8″ and a nominal focal length in water of 3.0″. Five of the six RCE transducers were manufactured by supplier C; the sixth was manufactured by supplier D.

Several experiments were carried out to document the performance of each RCE transducer. The goals of the experiments were to measure quantities related to (1) the focusing characteristics; (2) the hotness or coolness of the transducer, i.e., its efficiency for converting electrical energy to and from sound; and (3) the ability to resolve a near-surface defect in the presence of the noise due to the front-wall ring down.

2.1.5.1 Removable Center Element: Types of Measurements.

In all, five types of pulse-echo measurements were performed on the RCEs. These are briefly outlined below:

- Peaked Amplitude Versus Depth for a Ball Target in Water. Using a hemispherical glass rod tip in water as a target, the peak-to-peak response was measured as a function of water path. This was used to determine the so-called Y+0 distance, i.e., the water path at which the echo from a small target is maximized. In addition, the data served (1) to document the shape of the axial beam profile in water for later comparison to model predictions for ideal focused transducers and (2) to document the absolute amplitude of ball target responses given a fixed electrical input pulse to the transducer.

- C-scan of a Ball Target in Water Located at the Y+0 point. This optional measurement was used to determine the beam diameter at the focus (at the -6 dB level).

- Acquisition and Analysis of an A-scan Reference Signal From a Specific FBH Reflector. #1 FBH reflector, located 0.5″ deep in a IN100 step block was used. The water path was 3.0″, placing the FBH target a bit beyond the beam focus, and the transducer was scanned laterally to maximize the peak-to-peak response. The resulting FBH A-scan radio frequency (RF) waveform was used to determine a center frequency and bandwidth for the transducer. The A-scan also served as an input reference signal in a subsequent model-based analysis.

- Peaked Amplitude Versus Depth for Six #1 FBH Targets. In this measurement, the targets were #1 FBHs located at six different depths in the same IN100 step block. The water path was again 3.0″, and the transducer was moved laterally to maximize each signal in turn. Only peak-to-peak amplitude data was recorded and served to document the absolute amplitudes of FBH responses given a fixed electrical input pulse to the transducer. In addition, the amplitude-versus-depth data (together with the measured Y+0 point taken from the FBH reference signal A-scan) were used to deduce two model parameters describing the transducer focal characteristics, namely, the effective diameter and geometric focal length in water.

- Near-Surface Resolution Measurement. In this measurement, the response from the shallowest FBH in the IN100 step block was studied. The water path was varied to maximize the response from the #1 FBH at a 0.050″ depth. An A-scan of the peaked FBH signal was acquired for a time gate containing both the FBH signal itself and the ringdown of the front-wall echo. The transducer was then moved laterally away from the

FBH so that only the front-wall ringdown noise was seen. The object was to determine an approximate SNR for a small near-surface defect.

Each RCE measurement is now discussed in turn, and the results of the round-robin study are summarized. Although the discussion is currently directed at the characterization of the RCE transducers, the methods and analyses used are, in many cases, the same as those employed later when the phased elements of Type-I or Type-II transducers are fired in unison to form a focused beam. Thus, these methods and analyses will be discussed in detail here.

2.1.5.2 Removable Center Element: Peaked Response Amplitude for a Ball Target in Water.

Figure 14 shows the basic measurement arrangement used to acquire and quantify echoes from the submerged glass rod target. A typical A-scan response, at it appears in a TomoView display window, is also shown. For all measurements at all three facilities, the RCE was pulsed in the same nominal manner, i.e., with the same nominal values of pulse height and pulse duration, and without filtering. By adjusting two orientation angles, the transducer beam was first made normal to the flat surface supporting the glass rod and its clay base. The three spatial degrees of freedom of the transducer relative to the target (X, Y, and Z) were then adjusted to approximately maximize the response from the glass rod tip. This determined an initial water path for the measurements. The water path was subsequently increased or decreased in steps of about 0.2″ until the on-axis response dropped by roughly 6 dB from its global maximum. Data were typically acquired at about 12 water paths, ranging from roughly 2.3 to 4.6 inches. At each water path, the lateral coordinates (X and Y) were carefully adjusted to maximize the peak-to-peak response. As indicated in figure 14, the maximized response was then recorded together with the absolute arrival time (TOF) of the dominant negative peak. The absolute gain setting of the R/D Tech instrument was typically changed for each water path, so that the maximized response occupied roughly 75%-90% of the full screen height (FSH).

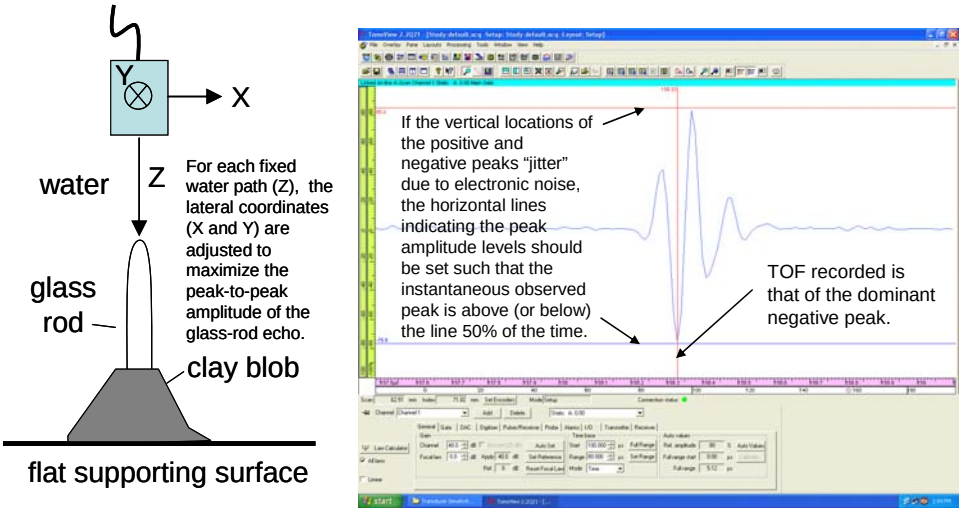


Figure 14. Measurement of Peak-to-Peak Amplitude and TOF for a Typical Pulse-Echo Response From the Glass Rod in Water

The peak response, TOF, and inspection gain data were entered into the upper portion of a Microsoft® Excel® spreadsheet, as shown in figure 15. Using the recorded values of the time offset and water temperature, the spreadsheet calculated the water path for each measurement from the TOF value. The spreadsheet was also used to graph the peak amplitude versus water path (or versus TOF) data as it would have appeared if the inspection gain were fixed. An example is shown in figure 16, where the assumed fixed gain is 27 dB. This same fixed dB has been used in this report when comparing glass rod in water data from the three test facilities. In the upper portion of figure 16, the plotted points represent the measured data, and the solid curve is a model prediction showing the expected shape of the amplitude versus depth data (i.e., the on-axis profile) for an ideal focused piston transducer. The generation of such model curves will be discussed later in this report. Similar comparisons of measured and predicted on-axis profiles for all cases can be found in appendix A.

Worksheet for glass-rod target in water (including determination of Y+0 point)
(Fill in only the cells that are highlighted in Yellow)

Date =	17-Feb-05		
User / outfit	Jon Friedl/ISU		
Probe ID number =	Supplier A 4608-A101		
Water temperature (F) =	68.54	(see C-to-F conversion below, if needed)	
Water temperature (C) =	20.30		(calculated)
Big bang start (t0 offset) =	1.08	usec	
sound speed in water =	0.058397	in/usec	(calculated)
fixed gain for graphs =	27	dB	

Absolute time of dominant negative peak (measured)	Gain setting (measured)	Peak positive amplitude (measured)	Peak negative amplitude (measured)	Water path (calculated)	Peak amplitude at the fixed gain specified in cell D11 (calculated)
time(usec)	gain (dB)	%FSH	%FSH	Z (in)	%FSH
81.99	44.0	82.0	-87.5	2.362	23.94
88.94	40.5	85.2	-85.9	2.565	36.16
95.91	38.0	90.6	-85.9	2.769	49.74
102.89	36.0	88.3	-80.5	2.973	59.89
109.94	35.0	87.5	-77.3	3.179	65.61
116.85	35.0	87.5	-77.3	3.380	65.61
123.92	35.5	92.2	-75.0	3.587	62.84
130.93	36.0	93.0	-71.9	3.791	58.51
137.99	37.0	94.5	-73.4	3.998	53.09
144.92	37.5	90.6	-70.3	4.200	48.03
151.93	38.5	90.6	-68.7	4.405	42.39
158.87	40.0	91.4	-69.5	4.607	36.02
165.96	41.0	91.4	-69.5	4.814	32.10

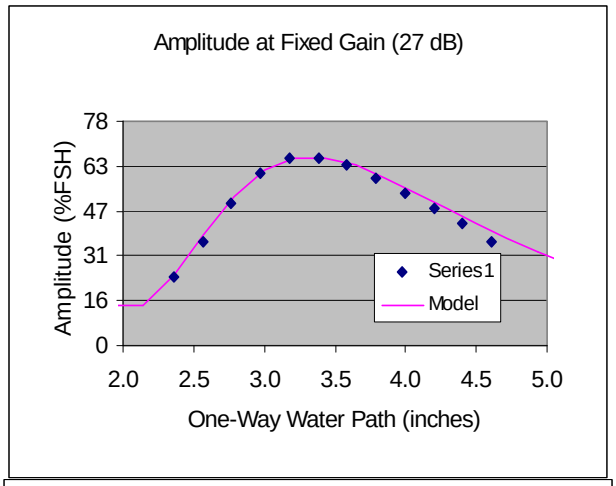
- The user enters data into the yellow highlighted spreadsheet cells:
  - Date
  - Name / test facility
  - Probe #
  - Water Temperature (F)
  - Time offset, t0
  - Fixed gain level for graphing
- For each water path enter:
  - TOF (dominant neg. peak)
  - gain setting
  - maximum peak amplitude
  - minimum peak amplitude

The peak-to-peak amplitudes, recalculated for a fixed gain level (27 dB), are tabulated here and plotted.

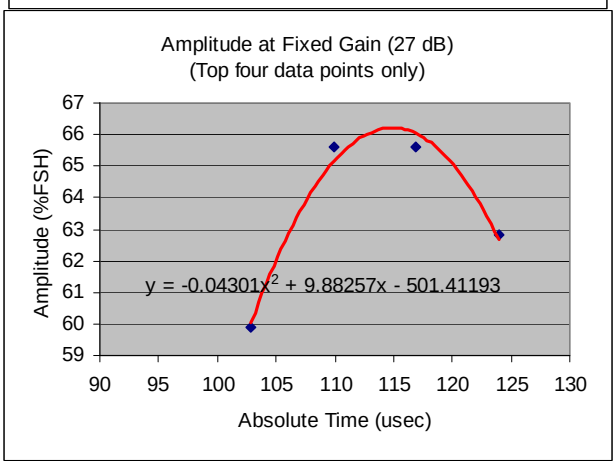
TOF and amplitude data in increasing TOF order

Figure 15. Example of a Microsoft Excel Spreadsheet Used to Record and Analyze the Ball Target in Water Data for the RCE

(a)



(b)



C-to-F conversion:		Calculator for Determination of Y+0		
Temp (C) =	20.30			
Temp (F) =	68.54	Parabola is Y = Ax^2 + Bx +C		
		From graph at right, enter:		
		A =	-0.06076	
		B =	13.9595	
		(peak is at X = -B/2A)		
		Y-Plus-Zero =	114.87	microseconds
		Y-Plus-Zero =	3.323	inches

Figure 16. (a) Typical Graph of Peak Response Versus Water Path for an RCE Using the Glass Rod Target and (b) Parabolic fit to the High-Amplitude Portion of the Data Used to Determine the Y+0 Point

Recall that Y+0, as defined here, refers to the water path at which the peak-to-peak response is greatest. The spreadsheet was designed to determine the Y+0 point from the plotted data. This was done by fitting a parabola through the four highest-amplitude data points, and then locating the peak of the parabola. An example is shown in the lower portion of figure 16, where the resulting value of Y+0 = 3.32 inches was determined with the aid of a built-in spreadsheet calculator that translates between TOF and water path.

The Y+0 point is one commonly used measure of the actual focal length of a transducer. The measured Y+0 values for the RCEs of the six Type-I transducers are summarized in figure 17. The results are shown for the measurements conducted at all three round-robin facilities.

The format used in figure 17 is common to many figures used in this report to summarize data for Type-I transducers. The lower bar graph always displays results for the six transducers using the standard ordering of figure 7: the three supplier A transducers are listed first; and the three supplier B transducers are listed last. In the upper bar graph, the same data is displayed, but the transducer order has been altered so that the results of the ISU measurements increase monotonically from left to right. This allows the viewer to readily observe whether or not the ordering trend seen at ISU was also seen at the other facilities. In cases where the same general trend is observed at all three facilities, one can be somewhat confident that there are systematic and reproducible differences between the performances of the six transducers. Conversely, if different ordering trends are seen at different facilities, it is likely that measurement uncertainties are too large to readily detect inherent differences in transducer properties. Such measurement uncertainties arise from differences in the hardware at the three facilities as well as from differences in operator performance. Note that the ISU results are used to order the data in the upper bar graphs solely because ISU was the first facility to complete the measurements.

In figure 17 and similar figures, the results of all measurements are tabulated below the two bar graphs. In addition, certain statistical information is listed in the right-hand margin of the lower graph. This includes an average value for a set of N measurements, denoted by

$$< A > \;=\; \frac{1}{N} \sum_{i=1}^{N} A_i \tag{2}$$

and the corresponding standard deviation of the measurements about their mean, denoted by

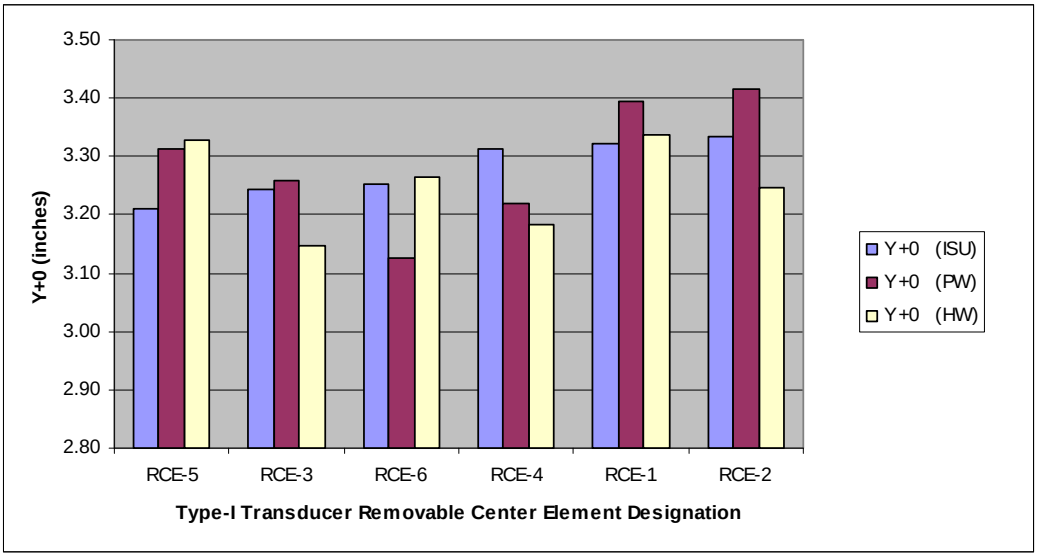
$$\sigma \;=\; \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (A_i - < A >)^2}. \tag{3}$$

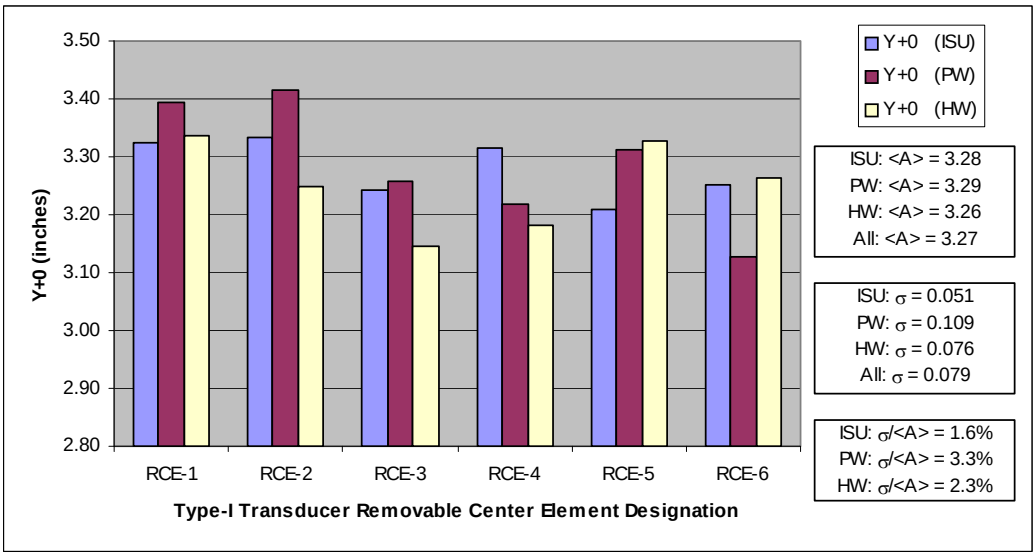
$<A>$ and σ are listed separately for the measurements performed at a given facility ($N = 6$), and also for the combined set of all measurements ($N = 18$). The "fluctuation level," or percentage fluctuation about the mean value, is defined as

$$Fluctuation\ Level = \left[\frac{\sigma}{< A >} \right] \bullet 100\% \tag{4}$$

and is also listed for each facility.

In figure 17 specifically, one sees that measured Y+0 values fall within a fairly narrow band of 3.27″ ±0.15″, and that the orderings of the values are somewhat different at the three facilities. The only obvious conclusion that can be drawn is that the Y+0 values of the six RCE transducers are all reasonably similar, i.e., all within 4.5% of the full-sample mean (3.27″).



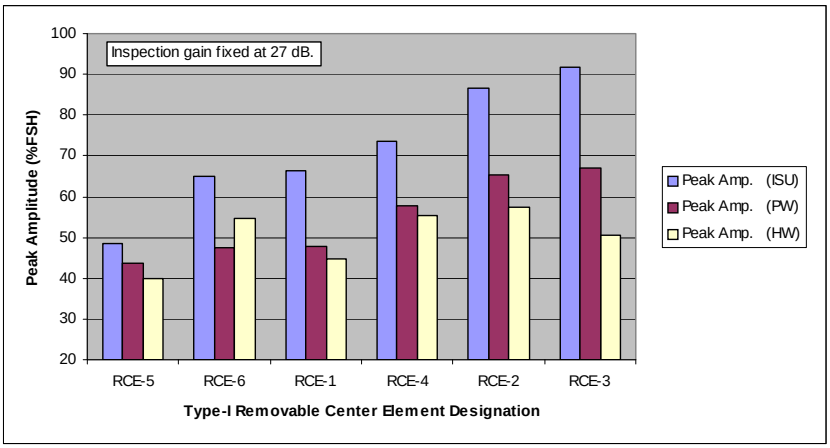


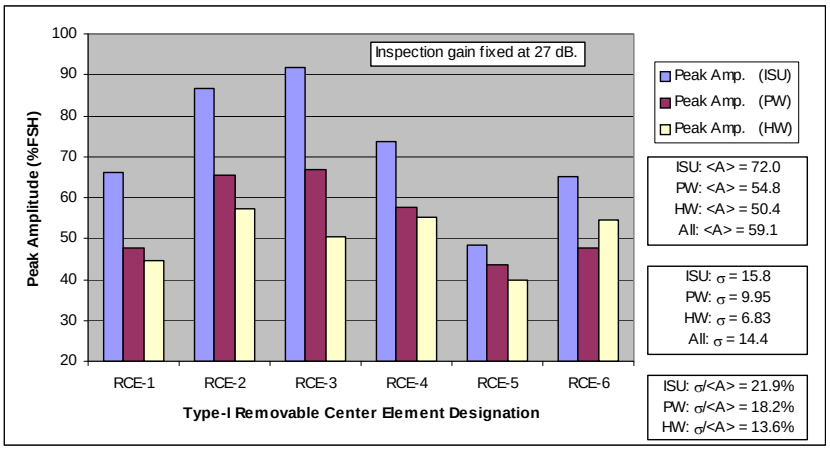
Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
Y+0 (ISU)	3.32	3.33	3.24	3.31	3.21	3.25
Y+0 (PW)	3.39	3.42	3.26	3.22	3.31	3.13
Y+0 (HW)	3.34	3.25	3.15	3.18	3.33	3.26
Average	3.35	3.33	3.22	3.24	3.28	3.21
Std. Deviation	0.037	0.085	0.061	0.068	0.064	0.077

All values are in inches.

Figure 17. Measured Y+0 Values for RCEs of Type-I Transducers

The relative hotness or coldness of the RCE transducers can be gauged by examining the strengths of the glass rod echoes when the inspection gain is held fixed. Such a comparison is made in figure 18, where the peak on-axis response is shown for a fixed gain setting of 27 dB. Each plotted amplitude value shown in the figure was inferred from the parabolic fit to high-amplitude data; it is the amplitude of the fitted parabola at its highest point, i.e., at the Y+0 distance. Such maximum amplitudes are expected to be somewhat dependent on the hardware used, including the cabling from the pulsing unit to the transducer. One sees that the average amplitude measured at ISU (72% FSH) was about 40% higher than those obtained at P&W or HW. All parties reported significant variations in the peak responses of the six probes, with the fluctuation level $\sigma/\langle A\rangle$ being about 20% at each facility. In addition, the ordering of the peak responses was the same at ISU and P&W.





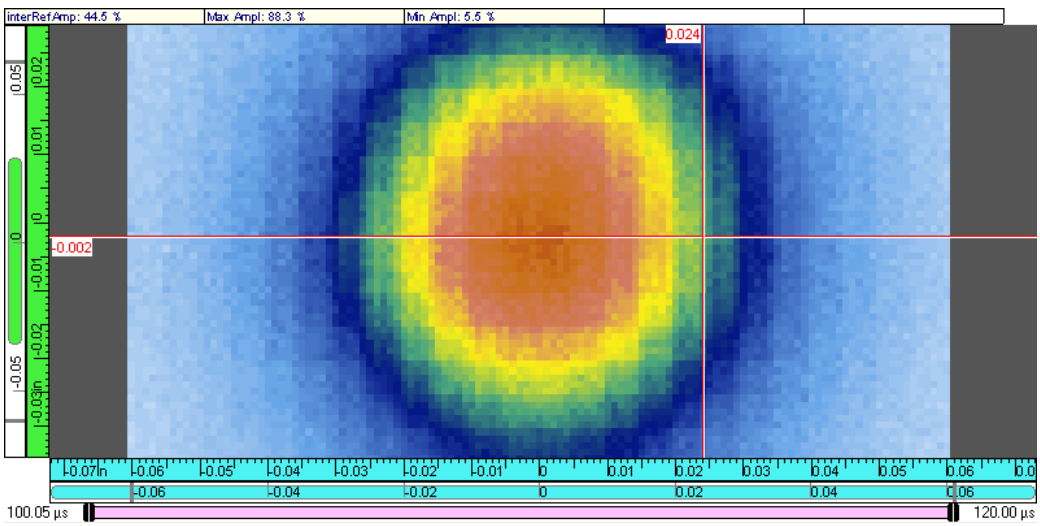
Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
Peak Amp. (ISU)	66.2	86.6	91.9	73.6	48.5	65.0
Peak Amp. (PW)	47.8	65.4	66.9	57.8	43.5	47.6
Peak Amp. (HW)	44.6	57.4	50.5	55.2	39.9	54.6
Average	52.9	69.8	69.8	62.2	44.0	55.7
Std. Deviation	11.7	15.1	20.9	10.0	4.3	8.8

All values are in percent full screen height.

Figure 18. Measured Peak Response From a Glass Rod Target in Water Located at the Y+0 Point, Using the RCE of Each Type-I Transducer

2.1.5.3 Removable Center Element: Beam Diameter.

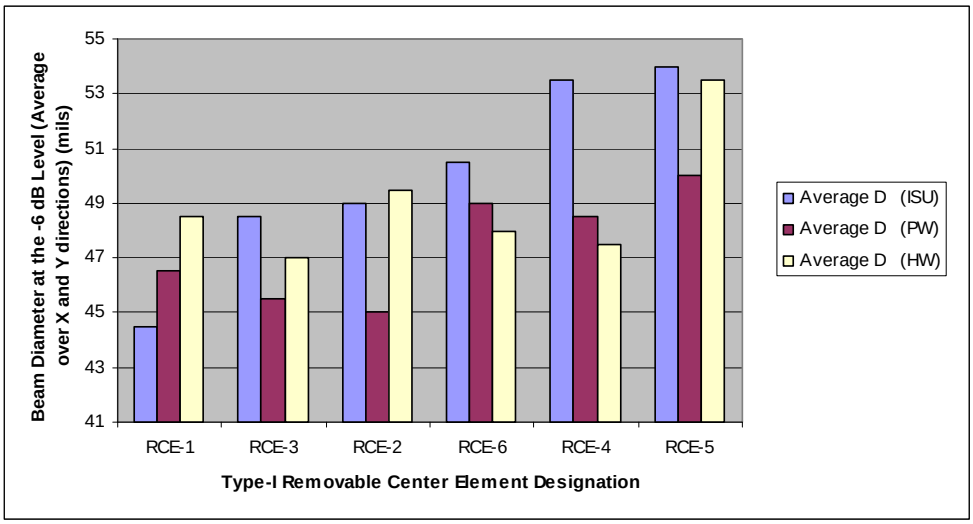
One way of assessing the focusing power of a transducer is to measure the lateral beam diameter at the focal distance. This was done for each RCE transducer using the glass rod tip as a target. The water path was set to the measured Y+0 distance, and the transducer was scanned laterally (in the X and Y directions, see figure 14) to produce a C-scan image of the peak-to-peak response from the rod tip. An example is shown in figure 19. The beam radius was defined as the distance one had to move from the center of the C-scan until the peak-to-peak response fell by 6 dB. This distance could be readily measured by using the TomoView display and associated pointers. For example, the intersection of the two red lines in figure 19 locates a point where the response is 6 dB below the maximum response (which occurs near the center of the C-scan). The measured beam diameters in the X and Y directions were then recorded in a Microsoft Excel spreadsheet, as indicated in the figure.

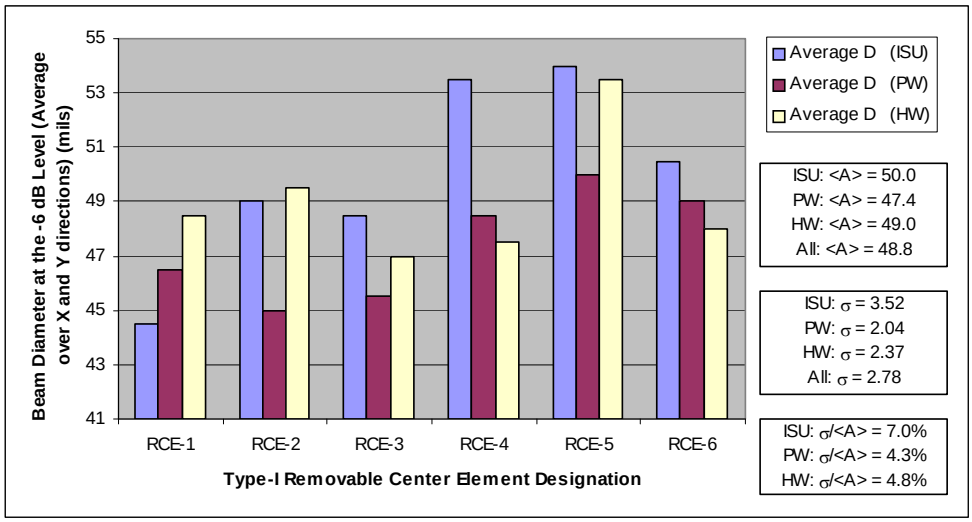


Measured beam widths from C-scan at Y+0 point:		
Full width at half max (X):	0.049	inches
Full width at half max (Y):	0.047	inches

Figure 19. Example C-Scan of the Glass Rod Target in Water Used to Measure the Beam Diameter at the Focus for an RCE Transducer

As before, a common TomoView setup file was used at all sites in the round-robin study so that the basic equipment settings used to acquire the C-scans were nominally identical. The measured beam diameters are tabulated and graphed in figure 20. They range from 44 to 54 mil, or by about 10% on either side of the full-sample mean value (48.8 mil). The ordering of the beam diameters varied somewhat from facility to facility, but all three facilities agreed that probe RCE-5 had the largest focal spot among the six probes.





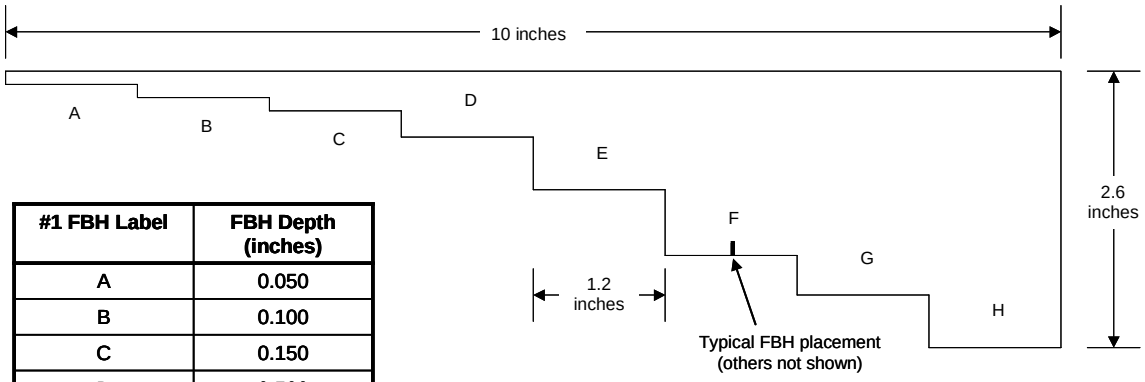
Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
Dx, Dy (ISU)	45, 44	49, 49	50, 47	52, 55	55, 53	51, 50
Dx, Dy (PW)	46, 47	45, 45	45, 46	49, 48	50, 50	49, 49
Dx, Dy (HW)	50, 47	50, 49	48, 46	49, 46	53, 54	48, 48
Average	46.5	47.8	47.0	49.8	52.5	49.2
Std. Deviation	2.00	2.47	1.50	3.21	2.18	1.26

All values are in mils.

Figure 20. Measured Beam Diameters at the Y+0 Point, Using the RCE of Each Type-I Transducer

2.1.5.4 Removable Center Element: Center Frequency and Bandwidth.

Two types of data were acquired using the FBH step block shown in figure 9, with a cross section view shown in figure 21. The first involved acquiring A-scan data for a specific #1 FBH within the block and analyzing that A-scan to deduce a center frequency and bandwidth. The second involved measuring peaked responses for a series of #1 FBHs at six different depths.



#1 FBH Label	FBH Depth (inches)
A	0.050
B	0.100
C	0.150
D	0.500
E	1.000
F	1.500
G	2.000
H	2.500

(Specimen measures 1.2" in the out-of-page dimension.)

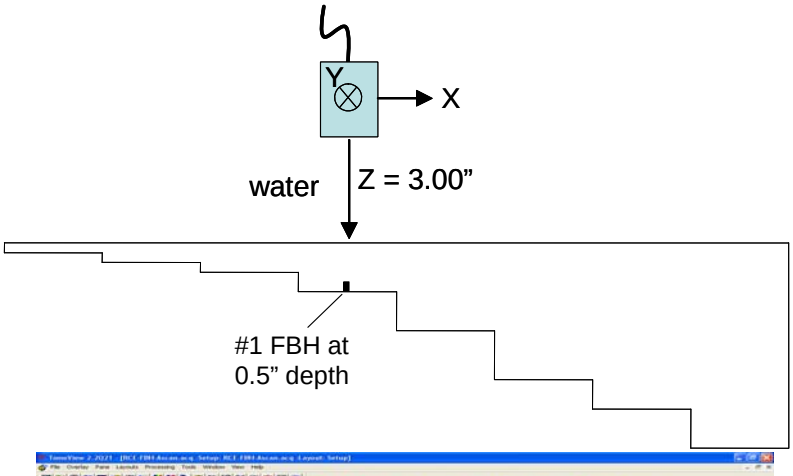
Figure 21. Schematic Diagram of the IN100 Step Block Containing #1 FBH Targets

Setups for both types of measurements were very similar. A particular TomoView setup file (RCE-FBH-Ref_Ascan.acq) was loaded, which caused only the RCE to be fired. The large upper surface of the FBH block was made level relative to the lateral scanning axes (X and Y) of the bridge holding the transducer. This was done by making small adjustments in the orientation of the step block until the TOF of the front-wall echo was stationary with respect to lateral movements of the transducer. Next, the sonic beam was made normal to the top surface of the step block. This was done by adjusting the two probe tilt angles to maximize the front-wall echo amplitude, using a water path of about 3″. The one-way water path was then set to 3.00″ via the TOF method.

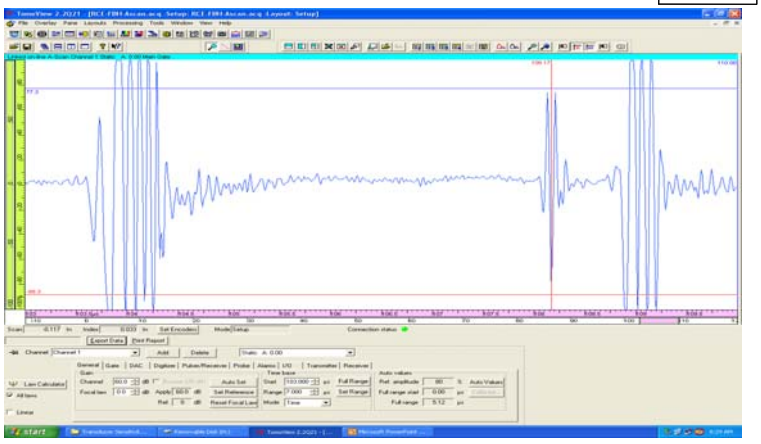
To acquire the reference A-scan, the transducer was approximately positioned over the #1 FBH located 0.5″ deep in the step block. The pulse-echo response from that FBH was maximized by making small adjustments to the lateral position of the transducer (i.e., to the X and Y transducer coordinates). Figure 22 displays the measurement setup and typical A-scans as they appeared in the TomoView display window. The central panel of figure 22 shows the A-scan within an extended time window: the front-wall, back-wall, and FBH echoes can all be seen. Note also that the TOF used to precisely set the water path was measured using the dominant negative peak of the FBH echo. The lower panel in figure 22 displays a magnified view of the FBH echo alone, using a time gate of 2.55 μsec duration. At the 100-MHz sampling rate, this displayed waveform contains 256 discrete points. The TomoView system was used to compute the fast Fourier transform (FFT) of the FBH echo, as illustrated in the lower left-hand portion of the

bottommost panel of figure 22. The peak frequency (10.94 MHz in this case) and bandwidth at the -6 dB level (8.2 MHz to 16.6 MHz) were noted. The 256-point A-scan itself was also output as an ASCII text file for later use in the determination of the transducer's effective diameter and geometric focal length. An example of such an exported text file is shown in figure 23. The last portion of the text file contains the 256 signal amplitudes (i.e., voltages) using a scale that extends from -128 to +127.

(a)



(b)



(c)

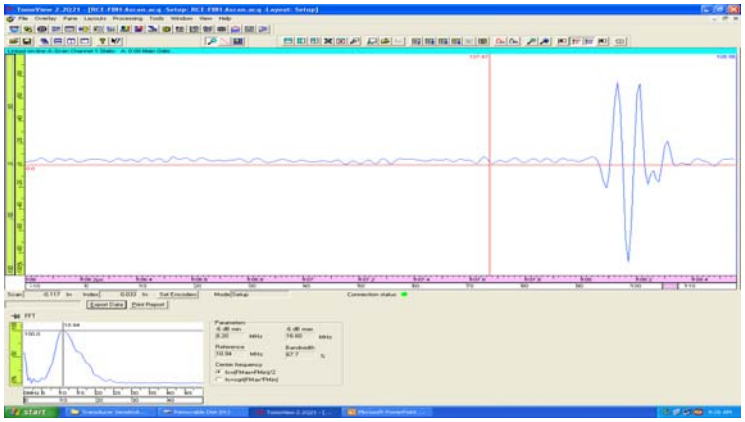


Figure 22. (a) Measurement Setup Using the RCE of a Type-I Transducer and the 0.5″ Deep FBH in the IN100 Step Block and (b and c) Typical A-Scans Acquired Using Two Different Time Scales

FBH-500mils.txt

```
Channel = Channel 1
Focal Law = Static   A: 0.00
Type = A-Scan
ScanStart (in) = 0.0000
ScanQty (sample) = 1.0
ScanResol (in) = 0.0010
IndexStart (in) = 0.0000
IndexQty (sample) = 1.0
IndexResol (in) = 0.0010
USoundStart (in) = 13.1603
USoundQty (sample) = 256.0
USoundResol (in) = 0.0012
AmplMin (sample) = -128.0
AmplMax (sample) = 127.0
AmplStart (%) = 0.00
AmplResol (%) = 0.78
3.1     3.9     7.0     9.3     8.5     6.2     4.6     6.2     7.0     7.8     6.2     4.6     3.9     5.4
7.8     8.5     5.4     3.9     4.6     6.2     6.2     4.6     3.9     5.4     7.0     6.2     3.9     2.3
3.1     3.9     3.9     3.1     3.9     5.4     6.2     5.4     3.9     2.3     2.3     3.9     4.6     4.6
3.9     3.1     3.1     3.9     4.6     3.9     1.5     1.5     3.1     4.6     6.2     6.2     4.6     2.3
0.7     2.3     4.6     4.6     3.1     1.5     3.1     5.4     4.6     3.1     1.5     3.1     4.6     4.6
3.9     3.1     4.6     7.0     7.0     4.6     1.5     0.7     2.3     3.9     4.6     3.9     3.9     3.9
4.6     5.4     4.6     3.9     3.1     4.6     6.2     4.6     1.5     1.5     4.6     7.8     7.0     3.9
2.3     3.9     6.2     5.4     3.9     3.1     3.9     5.4     6.2     4.6     3.9     3.9     4.6     4.6
3.9     4.6     6.2     7.0     5.4     3.9     3.9     4.6     5.4     5.4     3.9     3.1     3.9     6.2
7.0     6.2     4.6     4.6     5.4     6.2     5.4     4.6     4.6     5.4     6.2     6.2     6.2     5.4
5.4     5.4     5.4     4.6     3.9     4.6     5.4     7.0     6.2     4.6     3.1     3.1     3.9     6.2
7.8     7.8     6.2     5.4     4.6     4.6     5.4     5.4     3.9     3.9     4.6     6.2     6.2     5.4
5.4     5.4     6.2     5.4     5.4     6.2     7.8     7.0     3.9     2.3     2.3     3.9     3.9     4.6
4.6     5.4     5.4     3.9     3.1     3.9     5.4     5.4     3.9     3.1     4.6     8.5     8.5     3.1
-9.3    -20.3   -20.3   -3.1    28.9    60.1    71.0    41.4    -20.3   -73.4   -86.7   -46.0   21.0    67.9
67.9    26.5    -10.1   -17.1   -7.8    -6.2    -14.8   -14.0   0.7     15.6    17.1    7.0     -2.3    -5.4
-3.9    -2.3    -0.7    -0.7    0.7     3.1     5.4     5.4     3.1     1.5     0.0     0.0     -0.7    -0.7
0.7     3.9     6.2     4.6     1.5     0.7     3.1     4.6     3.9     0.7     0.0     2.3     4.6     5.4
5.4     5.4     7.0     7.8
```

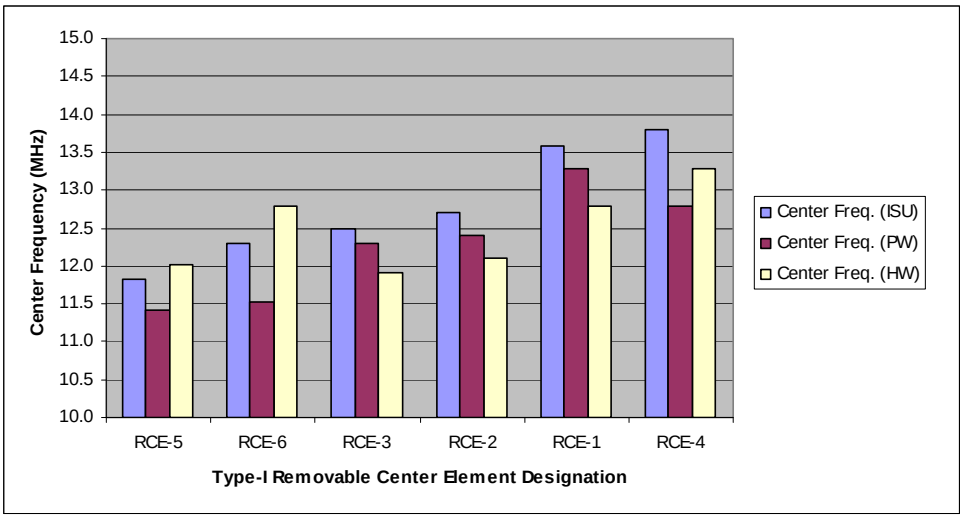
Figure 23. Example of an Exported Text File for an FBH A-Scan

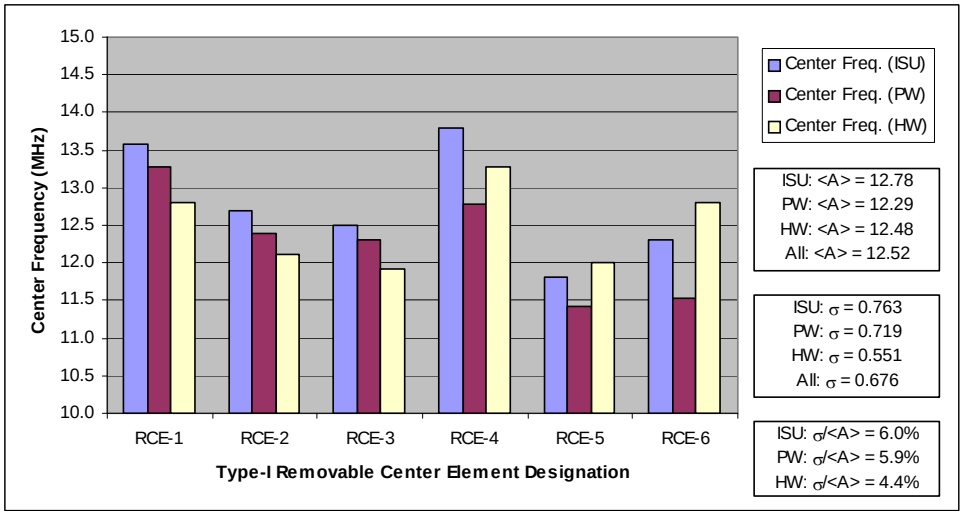
When acquiring FBH data, it was preferred that TomoView filters not be used. However, when no filtering is used, the ringdown of the front-surface echo will persist for a longer time and may interfere with the ability to acquire useable data from the shallowest FBHs in the specimen. Thus, users were given the option of using one set of filters (5 MHz high pass; 15 MHz low pass) if they deemed it necessary. When filtering was used, it was recommended that it be used for all FBH data, not just for the shallowest holes. In the end, P&W chose to implement the filtering for their FBH data, while ISU and HW did not.

The measured center frequencies and bandwidths for the RCE transducers are summarized in figures 24 and 25, respectively. The particular measures used in the figures are defined as follows:

$$\textit{Center frequency} = 0.5\,(f_{\max}+f_{\min}) \tag{5}$$

$$\%\ \textit{Bandwidth} = (100\%)(f_{\max} - f_{\min})\ /\ [\textit{center frequency}] \tag{6}$$

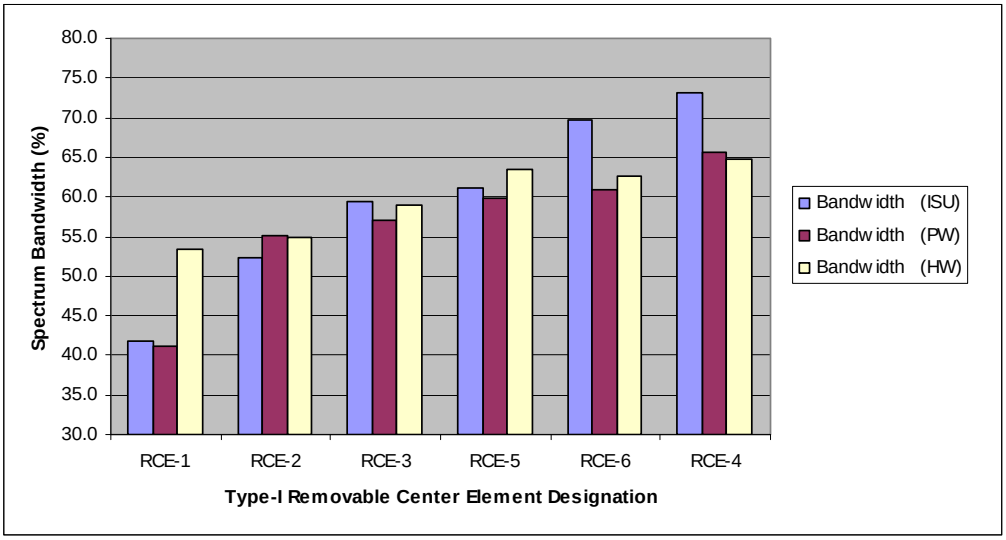


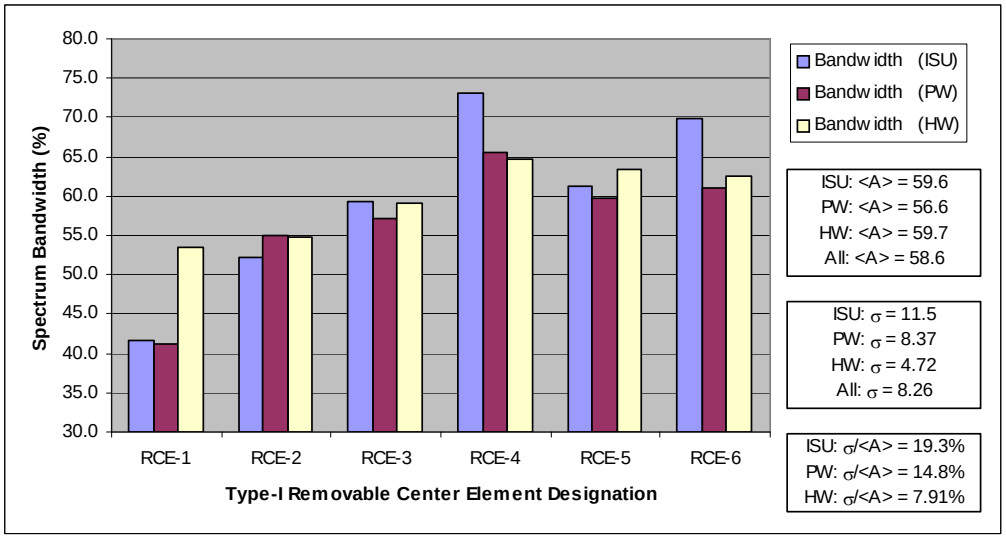


Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
Center Freq. (ISU)	13.6	12.7	12.5	13.8	11.8	12.3
Center Freq. (PW)	13.3	12.4	12.3	12.8	11.4	11.5
Center Freq. (HW)	12.8	12.1	11.9	13.3	12.0	12.8
Average	13.2	12.4	12.2	13.3	11.8	12.2
Std. Deviation	0.39	0.30	0.30	0.51	0.30	0.64

All values are in MHz.

Figure 24. Measured Center Frequencies for RCEs of Type-I Transducers, Using a #1 FBH at 0.5″ Depth





Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
Bandwidth (ISU)	41.7	52.3	59.4	73.1	61.2	69.8
Bandwidth (PW)	41.2	55.1	57.1	65.6	59.8	61.0
Bandwidth (HW)	53.4	54.8	59.0	64.7	63.4	62.6
Average	45.4	54.1	58.5	67.8	61.5	64.5
Std. Deviation	6.90	1.54	1.23	4.61	1.81	4.69

All values are in MHz.

Figure 25. Measured Spectrum Bandwidths for RCEs of Type-I Transducers, Using a #1 FBH at 0.5″ Depth

Here f_{min} and f_{max} denote the frequencies where the spectral amplitude has fallen by 6 dB from its peak value.

The center frequencies and bandwidths will depend in part on the transducers themselves, on the manner in which the transducers are pulsed, and if the responses are filtered. As shown in

figures 24 and 25, the spectral characteristics measured at the three facilities were very similar. The average values of center frequency and bandwidth for the suite of six transducers were nearly the same for the ISU, P&W, and HW data. In addition, the ordering of the measured bandwidths was the same at all three sites, and the ordering of the center frequencies was very similar. Thus, the decision by P&W to use filtering seems to have had little effect, although the average bandwidth was slightly lower (by 3%) at P&W compared to the other two facilities.

In figure 24, the measured center frequencies are all above the nominal value of 10 MHz. This is due in part to the use of an FBH target that tends to reflect the higher frequencies in the spectrum better than the lower frequencies. To test the dependence of the measured center frequency and bandwidth on the target, spot checks were made using the glass rod target located at Y+0. Center frequencies measured using the glass rod tended to be about 10% lower than those measured using the FBH target. In addition, the measured bandwidths tended to be about 15% higher, with most of this increase simply reflecting the lowering of the center frequency, which serves as the denominator in the bandwidth definition.

2.1.5.5 Removable Center Element: Peaked Response Amplitude for FBH Targets.

Peaked amplitudes were measured for the six #1 FBHs in the step block labeled B-G in figure 21, using a constant 3.00″ water path for all. The depths of these holes ranged from 0.1″ to 2.0″. Except for the hole at 0.5″ depth, A-scan data was not recorded. There were two goals for this portion of the study: (1) to document the absolute amplitudes of FBH responses given a fixed electrical input pulse to the transducer; and (2) to acquire the amplitude-versus-depth data needed for the model-based determination of the transducer's effective diameter and geometric focal length.

For each FBH target, the lateral transducer coordinates (X and Y in figure 22) were carefully adjusted to maximize the peak-to-peak response. As indicated in figure 26, that maximized response was recorded in a Microsoft Excel spreadsheet together with the absolute arrival time (TOF) of the dominant negative peak. The absolute gain setting of the R/D Tech instrument was also recorded. The gain was typically changed for each FBH depth so that the maximized response occupied roughly 75%-90% of the FSH.

	Worksheet for all FBHs-in-step-block data									
	(Fill in only the cells that are highlighted in Yellow)									
	Date =		27-Feb-01				Ref. signal A-scan file name:			
	User / outfit		Andrei Degtyar/PW					4608A101_refAscan-01.rdt		
	Probe ID number =		Supplier A 4608A101				Near surface resolution file names:			
	Water temperature (F) =		67.6				With FBH:	4608A101_NSR_wFBH-01.txt		
	Water temperature (C) =		19.78		(calculated)		Without FBH:	4608A101_NSR_woFBH-01.txt		
	Big bang start (t0 offset) =		1.41	usec						
	sound speed in water =		0.058334	in/usec	(calculated)	0.148167344	cm/usec			
	sound speed in IN100		0.241600	in/usec	(measured at ISU)					
	fixed gain for graphs =		56	dB	(should be same as used when 0.5"-deep FBH A-scan was exported)					
	Entries in table below are for 3.00" water path									
Nominal depth to FBH in step block (inches)	Absolute time of dominant negative peak (measured)	Absolute time of dominant negative peak (calculated) (expected)	Gain setting (measured)	Peak positive amplitude (measured) (0 to 100 scale)	Peak negative amplitude (measured) (100 to 0 scale)	Peak-to-peak amplitude at the measurement gain (calculated)	Peak-to-peak amplitude at the fixed gain specified in cell D12 (calculated)		Nominal depth to FBH in step block (cm)	Peak-to-peak amplitude at the fixed gain (model prediction)
depth (inches)	time (usec)	Z (in)	gain (dB)	%FSH	%FSH	%FSH	Experiment		depth (cm)	Theory
0.100	105.08	105.094	52.00	71.90	-71.90	143.80	227.91		0.254	237.94
0.150	105.54	105.508	52.00	80.50	-70.30	150.80	239.00		0.381	246.00
0.500	108.49	108.406	56.00	84.40	-78.90	163.30	163.30		1.270	166.23
1.000	112.66	112.545	62.00	69.50	-70.30	139.80	70.07		2.540	66.54
1.500	116.83	116.684	70.00	74.20	-80.50	154.70	30.87		3.810	29.93
2.000	121.04	120.823	70.00	35.90	-36.70	72.60	14.49		5.080	15.55

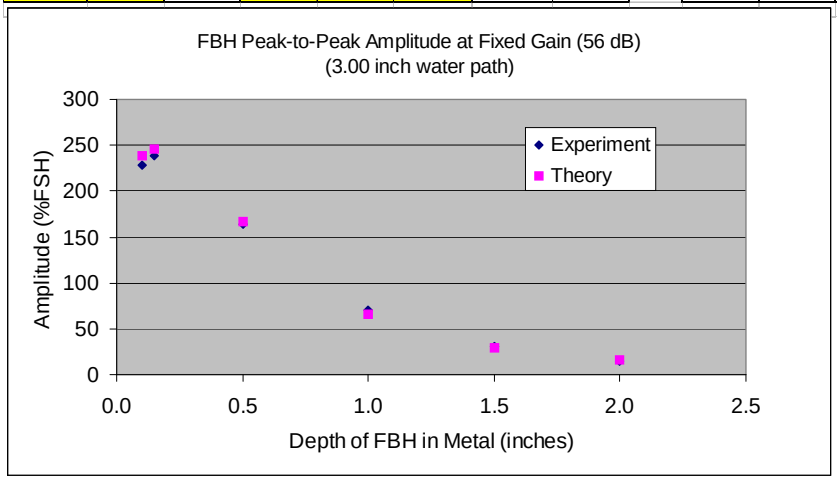
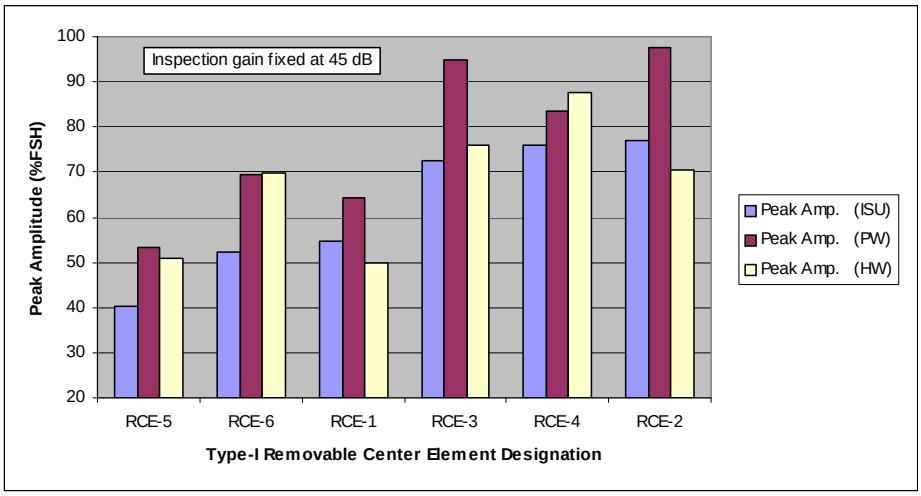
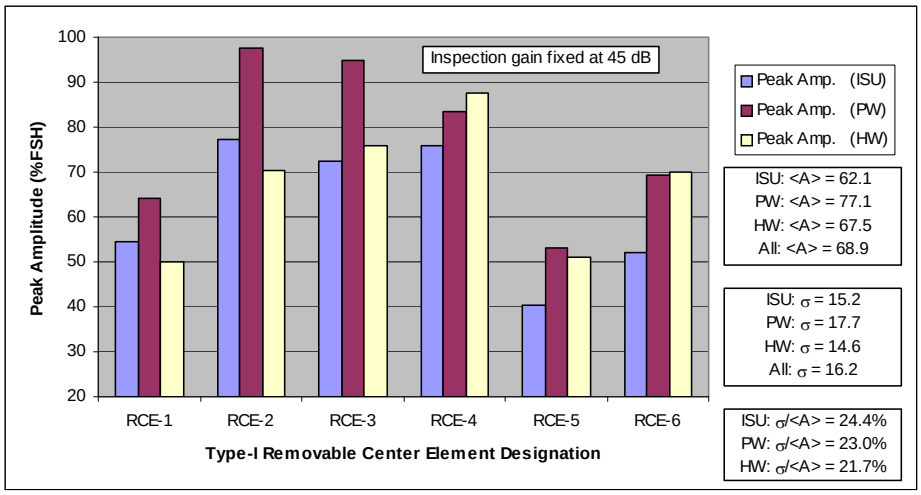


Figure 26. Portion of a Typical Spreadsheet Used to Record FBH Amplitude Versus Depth Data for an RCE Transducer and the Associated Graph of the Data at Fixed Gain

The spreadsheet was also used to calculate and graph the peak amplitude versus depth data as it would have appeared if the inspection gain were fixed. Examples of a typical spreadsheet table and its associated graph are shown in figure 26. There, the assumed fixed gain is 56 dB. On the graph in figure 26, two sets of plotted points are shown: one set arising from the measured data, and the other arising from model predictions for an ideal piston transducer. Similar comparisons of measured and predicted FBH amplitudes for all cases can be found in appendix B.

For selected FBH targets, the measured peak amplitudes using the six RCE transducers are compared in figures 27 and 28. Figure 27 shows the results for the 0.100″ deep FBH, which is typically located very near the actual beam focus. Figure 28 shows a similar comparison for the 0.500″ deep FBH, which was used to acquire the reference A-scan for the model-based analysis. Recall that the same nominal equipment settings (other than the inspection gain) were used at all three facilities, and the amplitudes have all been rescaled to a common gain setting (45 dB for figure 27; 49 dB for figure 28).

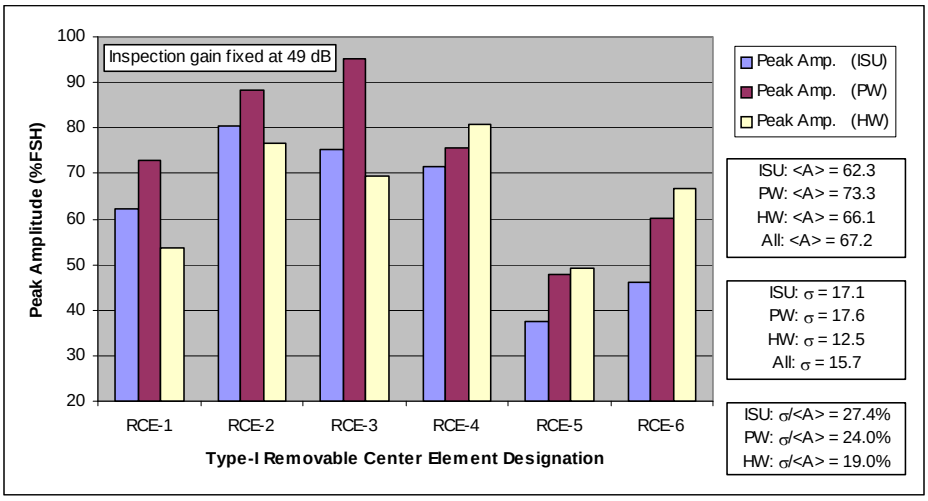


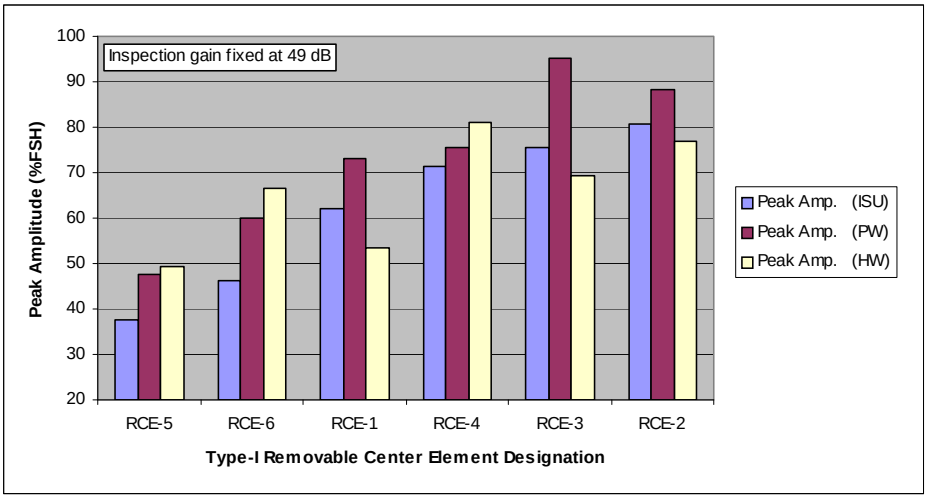


Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
Peak Amp. (ISU)	54.6	77.1	72.6	75.9	40.4	52.1
Peak Amp. (PW)	64.2	97.5	94.9	83.5	53.2	69.4
Peak Amp. (HW)	49.9	70.5	76.0	87.5	51.0	69.8
Average	56.2	81.7	81.1	82.3	48.2	63.8
Std. Deviation	7.3	14.1	12.0	5.9	6.9	10.1

All values are in percent full screen height.

Figure 27. Measured Peak Response From a #1 FBH Located 0.1″ Deep in IN100, Using the RCE of Each Type-I Transducer





Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
Peak Amp. (ISU)	62.2	80.6	75.4	71.5	37.6	46.2
Peak Amp. (PW)	72.9	88.3	95.3	75.6	47.7	60.1
Peak Amp. (HW)	53.5	76.8	69.5	80.9	49.4	66.6
Average	62.9	81.9	80.1	76.0	44.9	57.7
Std. Deviation	9.7	5.9	13.5	4.7	6.4	10.4

All values are in percent full screen height.

Figure 28. Measured Peak Response for a #1 FBH Located 0.5″ Deep in IN100, Using the RCE of Each Type-I Transducer

The measured peak responses from a given FBH will depend in part on the specific instrumentation used and on the operator's ability to normalize and center the narrow sonic beam on the reflector to maximize the measured response. Differences in average response (across the set of six transducers) are apparent in figures 27 and 28, with the P&W values tending to be highest and the ISU values tending to be lower. This may be due to instrumentation differences. The ordering of the peak responses for the six transducers was roughly the same at the three facilities, with the peak amplitudes tending to rise from left to right in the upper panel of either

figures 27 or 28. However, no two facilities had precisely the same ordering. One would expect to find a high degree of correspondence between figure 27 (peak responses for a FBH reflector) and figure 18 (peak responses for a glass rod target). Indeed, the probe-to-probe ordering of the responses at a given facility is approximately the same for the two experiments. It was also expected that the ratios of the relative average amplitudes as measured at the three facilities would be similar for such peak response experiments. For example, if the ISU instrumentation was running colder than at the other locations, one would expect the average ISU amplitude to be lowest for both glass rod and FBH targets. This was not the case. For the glass rod target, the average ISU response was significantly higher than either P&W or HW. However, for the FBH target, the average ISU response was lower than at the other two facilities. The reason for this reversal is not known. However, for both types of reflectors, the ratio of the average values reported by P&W and HW was approximately the same, with the P&W value being about 10%-15% higher throughout figures 18, 27, and 28.

2.1.5.6 Removable Center Element: Determination of Effective Diameter and Geometric Focal Length.

The model values shown in figures 26 and 16 for the ball target in water data are based on a treatment of the transducer as a so-called ideal spherically focused piston probe [6 and 7]. Such an ideal probe is described by the following two geometrical parameters that control the degree of focusing.

- An effective radius, a, (or effective diameter (D), D = 2a) describing the size of the vibrating piezoelectric element

- A geometric focal length (F), which describes the focal length in water in the absence of beam diffraction

The wavefronts leaving the face of the ideal transducer are initially converging toward the geometric focus. However, the tendency of sonic waves to spread (i.e., beam diffraction) prevents the sound field from focusing to a beam of zero cross section at the geometric focus. Rather, an actual focus (region of highest sound intensity) is formed somewhat short of the geometric focus. The separation between the actual and geometric focal points tends to shrink as the frequency increases. Certain models developed at ISU treat the transducer as an ideal piston probe, and use the D and F values as model inputs. Such models can predict the radiated sonic fields in the water and metal media and can also predict the echoes (A-scans) for embedded scatterers such as a ball target in water or an FBH in metal.

For each of the RCE transducers, a subset of the measured data was used to determine D and F values for the ideal piston transducer whose sound field best approximates that of the real transducer under study. The determination of these best fit D and F values was accomplished using a computer program written by Tim Gray at ISU. Inputs to this program consisted of

- the measured Y+0 point in water.

- The A-scan of the reference signal (i.e., the RF waveform from the #1 FBH at 0.5″ depth).

- The measured FBH amplitude versus depth values for the six FBHs in the IN100 step block.

- Basic ultrasonic properties of water and IN100 (i.e., sound speeds and attenuations). (Values for pure water were used.)

- Certain parameters that control the starting point, scope, and convergence of the search procedure used to locate the best fit values of D and F.

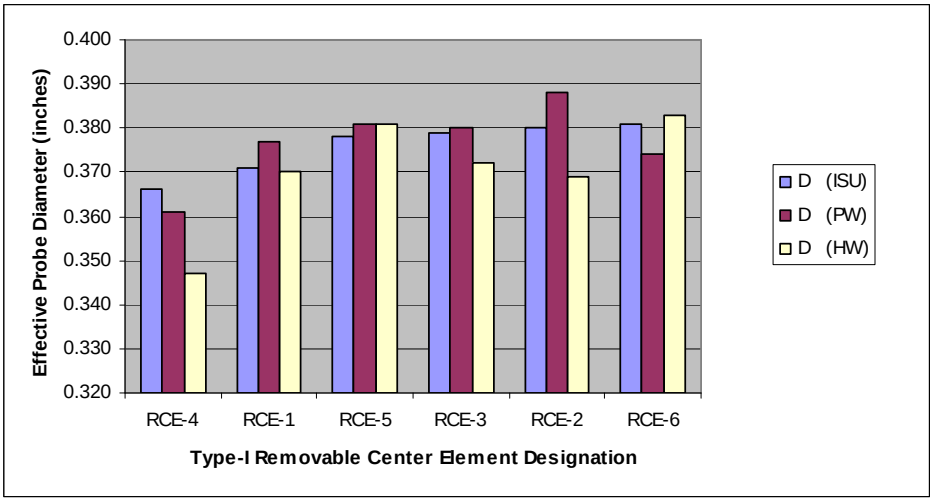
In its effort to reproduce the experimental data, the computer program varies D, F, and a third frequency-dependent quantity (the transducer efficiency factor), which describes the ability of the transducer to convert electrical energy to and from sound. The program seeks to reproduce the Y+0 point exactly (to within a user-supplied tolerance) and to reproduce the measured FBH amplitude versus depth data approximately (i.e., in the best possible least squares sense). After the optimization has been completed, program outputs include:

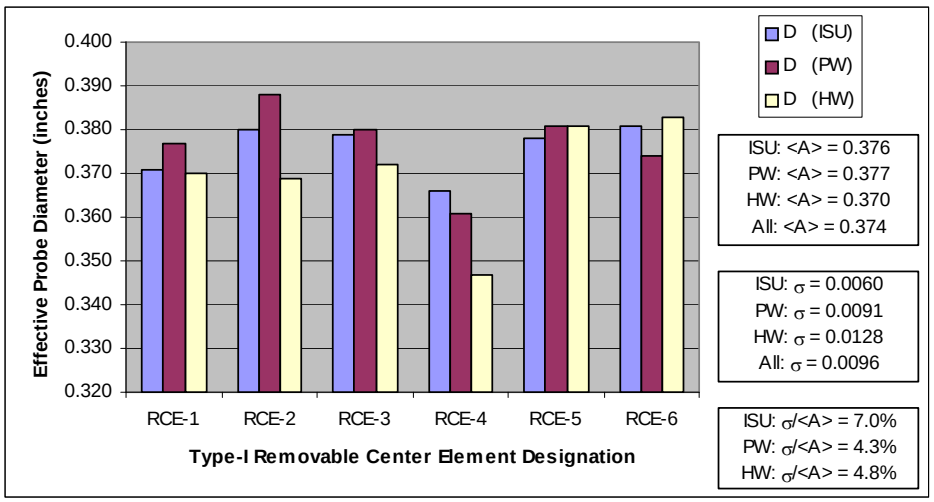
- The best-fit D and F
- Predicted FBH amplitude versus depth values for the ideal transducer
- A predicted ball target response versus water path curve for the ideal transducer

The predicted ball target and FBH responses can then be compared to the measured data, as was done in figures 16 and 26, respectively. Such comparisons are also shown for all cases in appendices A and B.

The best-fit piston probe parameters deduced from the measured data are compared in figure 29. Ideally, for a given transducer, these parameters should be independent of the facility where the measurements were made since they describe the transducer's inherent properties. In practice, measurement uncertainties will cause the FBH amplitude versus depth curves to have slightly different shapes at different facilities, leading to differences in deduced {D, F} values. The model predicted curves will never pass exactly through the measured data, and often one can find a family of nearby {D, F} pairs which reproduce the measured data with similar fidelity.

As shown in figure 29, all deduced {D, F} values fall within fairly narrow ranges. For the 18 measurements, all but one of the deduced effective diameters are within 4% of the nominal diameter of 0.375″. All 18 geometric focal lengths are within 5% of the full-sample average value of 4.78″. Within these narrow ranges, some clear probe-to-probe differences can be seen, as better illustrated in figure 30. There, the deduced geometric focal length has been plotted versus the deduced diameter, and results for a given transducer have been grouped together. For example, the probe RCE-4 (supplier D's only transducer) has a higher than average focal length, and a lower than average effective diameter. On the other hand, probes RCE-3 and RCE-6 have higher than average D and lower than average F values.





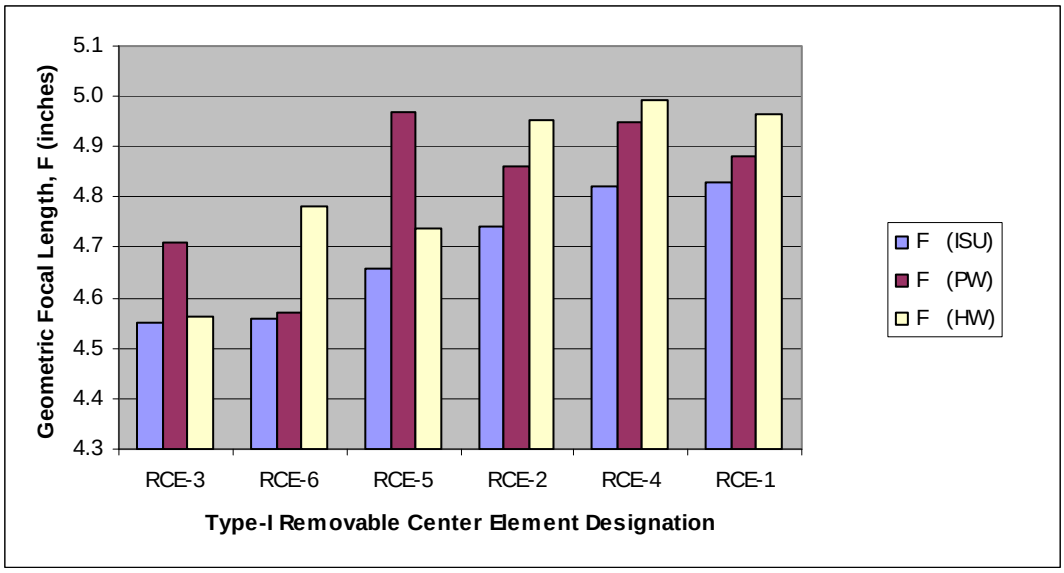
Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RCE-6
D, F (ISU)	0.371, 4.83	0.380, 4.74	0.379, 4.55	0.366, 4.82	0.378, 4.66	0.381, 4.56
D, F (PW)	0.377, 4.88	0.388, 4.86	0.380, 4.71	0.361, 4.95	0.381, 4.97	0.374, 4.57
D, F (HW)	0.370, 4.96	0.369, 4.95	0.372, 4.56	0.347, 4.99	0.381, 4.74	0.383, 4.78
Average	0.373, 4.89	0.379, 4.85	0.377, 4.61	0.358, 4.92	0.380, 4.79	0.379, 4.64
Std. Deviation	0.004, 0.07	0.010, 0.11	0.004, 0.09	0.010, 0.09	0.002, 0.16	0.005, 0.12

All values are in inches.

Figure 29. Deduced Effective Diameter and Geometric Focal Length for the RCE of Each Type-I Transducer

Recall that earlier (as summarized in figure 20) the beam diameter at the actual focal distance was measured using the ball target in water. For a spherically focused transducer, the beam diameter can also be estimated from knowledge of the effective diameter and focal length. A commonly used estimate is provided by

$$\textit{Beam diameter at focus}\ (\text{-6 } dB \textit{ level}) = 1.03\ (\lambda\, F_{act})/\, D = 1.03\ (v\, F_{act})\ /\ (f_o\, D) \qquad (7)$$



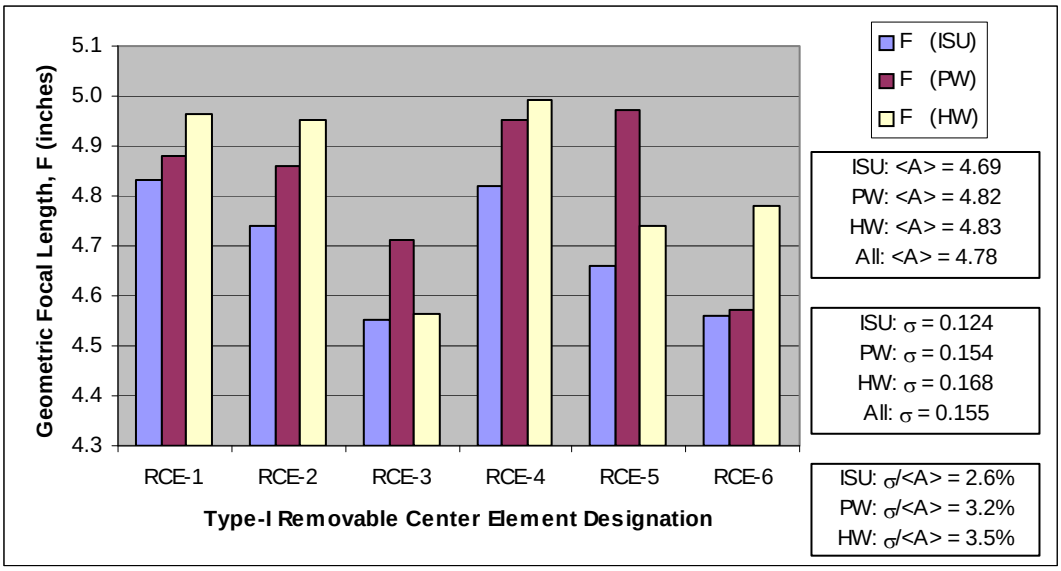
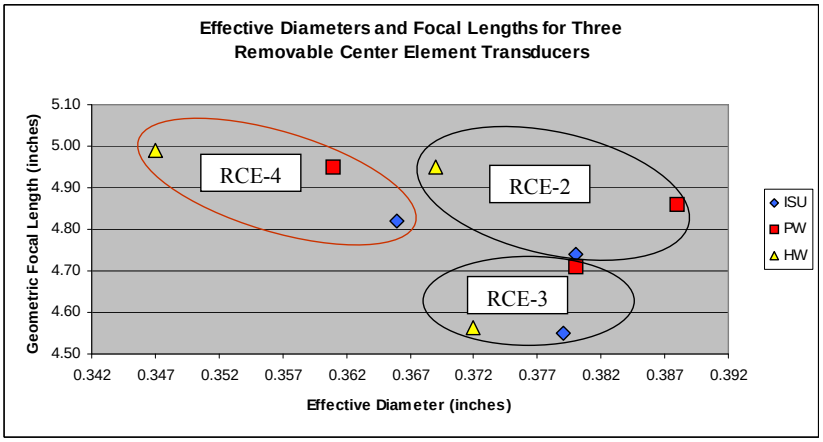
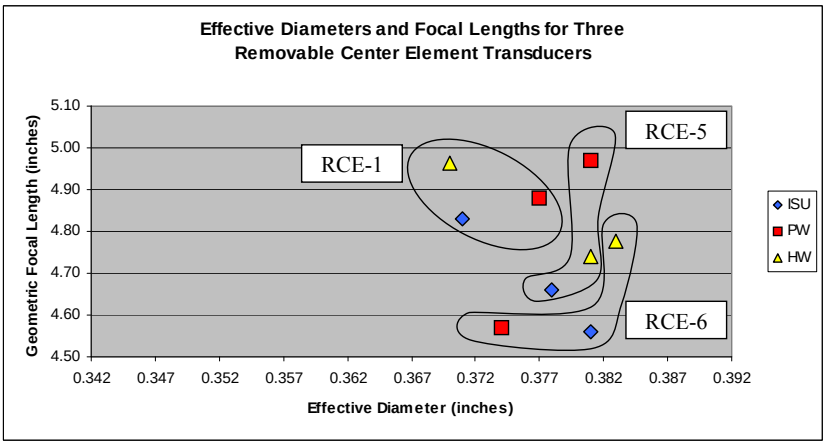


Figure 29. Deduced Effective Diameter and Geometric Focal Length for the RCE of Each Type-I Transducer (Continued)



(a)



(b)

Figure 30. (a) Relationship Between Deduced Effective Diameter Geometric Focal Length for the RCE of Type-I Transducer (RCE-2, RCE-3, and RCE-4 Only) and (b) Relationship Between Deduced Effective Diameter Geometric Focal Length for the RCE of Type-I Transducer (RCE-1, RCE-5, and RCE-6 Only)

Here λ and v denote the wavelength and sound speed in water, respectively, and f_o is the center frequency. D and F_{act} denote the effective diameter and actual focal length of the transducer, respectively. In figure 31, the measured beam diameters are compared with those estimated using equation 6. The estimates use the deduced D values of figure 29, the measured center frequencies of figure 24, and (for F_{act}) the measured Y+0 values of figure 17 If there were no measurement errors and equation 7 were exact, then the plotted points in figure 31 would lie along a straight, diagonal line. This is not the case, of course, and noticeable scatter about the trendline is seen. However, the typical separation of a plotted point from the trendline is similar to the average separation between beam diameters for a given transducer, as measured at the three facilities. On average for this suite of transducers, equation 7 was found to overestimate the mean beam diameter by about 6%, compared to the measured value. If the geometric focal length is used in equation 7 in place of the actual focal length, then the overestimation increases to about 60%.

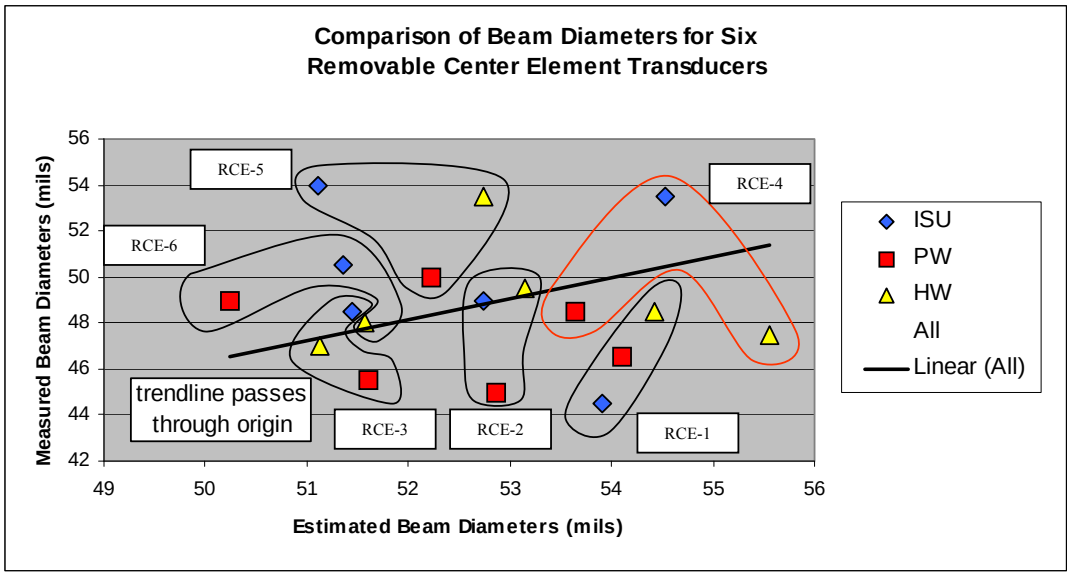


Figure 31. Relationship Between Measured and Estimated Beam Diameters at the Focus for the RCE of Each Type-I Transducer

2.1.5.7 Removable Center Element: Near-Surface Resolution Measurement.

The final measurement performed using each RCE transducer sought to determine an approximate SNR for a small near-surface defect under optimal focusing conditions. The target used was the #1 FBH at 0.050″ depth in the IN100 step block. Beginning with the transducer approximately centered over the FBH at the 3″ water path used for the earlier measurements, minor adjustments to the water path (Z) and the lateral probe coordinates (X and Y) were made to maximize the peak-to-peak FBH response. This corresponded to centering the defect within the beam's focal zone. An A-scan signal containing the FBH echo together with saturated front- and back-wall signals was captured and exported. An example is shown in figure 32(a). Without altering the water path, the transducer was moved laterally away from the FBH so that the FBH signal vanished completely, leaving only the front-wall ringdown in its place. An A-scan of this ringdown noise signal was acquired and exported. One example is shown in figure 32(b).

The gated peak-to-peak voltage of the maximized FBH signal was compared to the ringdown noise. Two narrow time gates were used, having durations of 0.2 and 0.3 μsec, respectively. As indicated in figure 32, each gate was centered at the arrival time of the dominant negative peak of the FBH signal. The gated peak-to-peak voltage of the FBH signal itself was the same for each gate, but the ringdown noise amplitude was gate-dependent. A near-surface SNR was defined as

$$SNR = \frac{Peak-to-peak\ FBH\ amplitude\ within\ the\ gate}{Peak-to-peak\ ring-down\ noise\ amplitude\ within\ the\ gate} \tag{8}$$

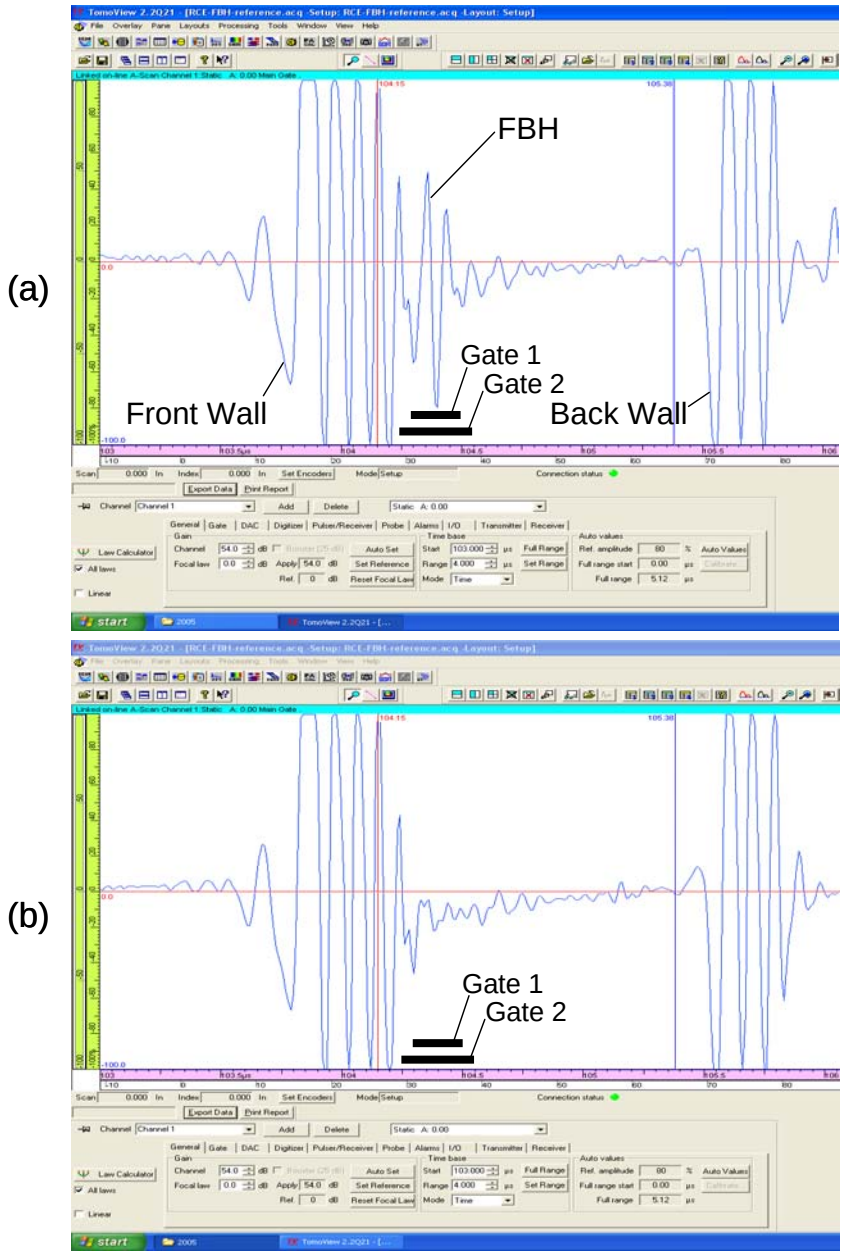
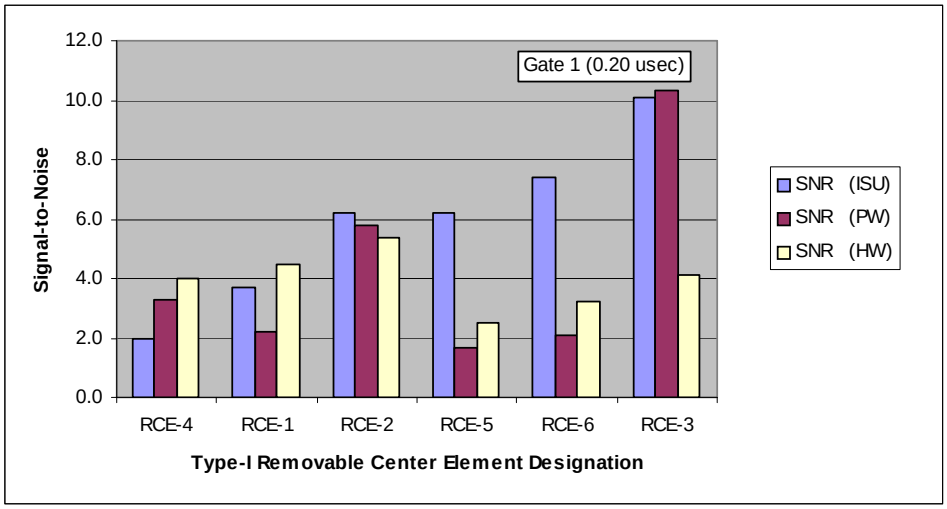
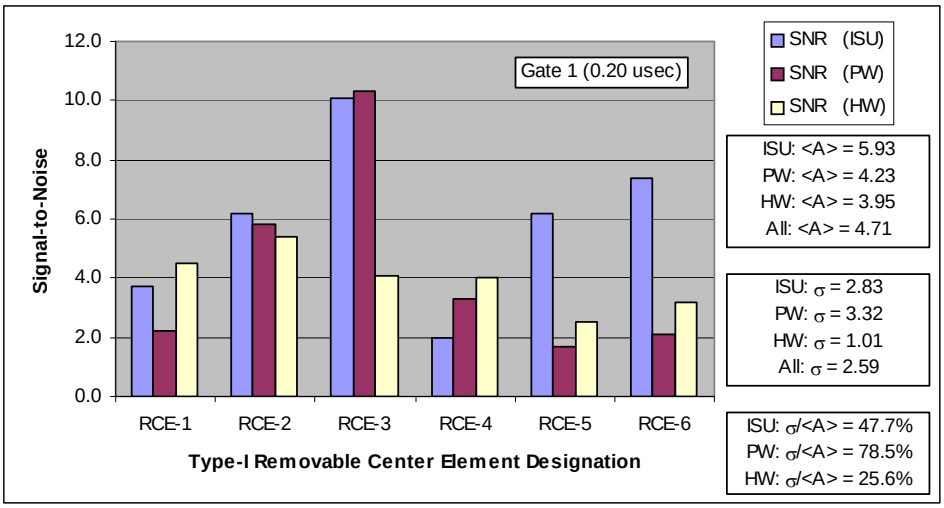


Figure 32. Examples of A-Scans Used in the Near-Surface Resolution Test (a) Beam Centered on the 0.5″ Deep #1 FBH Hole and (b) Beam Shifted Laterally Away From the FBH

The measured values of SNR are summarized in figure 33. As expected, SNR values tend to be lower for the shorter time gate (gate 1: 0.2 μsec duration) than for the longer one (gate 2: 0.3 μsec duration). Averaged over all 18 cases (six probes times three inspection facilities), the mean SNR was 4.7 for gate 1 and 3.0 for gate 2. Relatively large variations in SNR were seen from probe to probe and from facility to facility. This is perhaps expected since the SNR depends on the details of the front-wall ringdown, and these details are sensitive to many factors (e.g., the angulation of the transducer, the signal amplification hardware, signal filtering options, etc.). Measured SNRs tended to be about 30%-40% larger at ISU than at P&W or HW. Measured probe-to-probe differences as quantified by $\sigma/\langle A \rangle$ were considerably larger at P&W.

This may be due in part to the use of TomoView filters at that facility. In general, the probe-to-probe orderings of SNRs differed greatly from facility to facility; although ISU and P&W did agree on the probe having the best SNR performance (RCE-3). The specific procedure used for defining and measuring the SNR led to large facility-to-facility variations for a given transducer. It would be advantageous to have a measurement procedure that yields a value for SNR that is more a property of the transducer alone, and less dependent on the testing site.

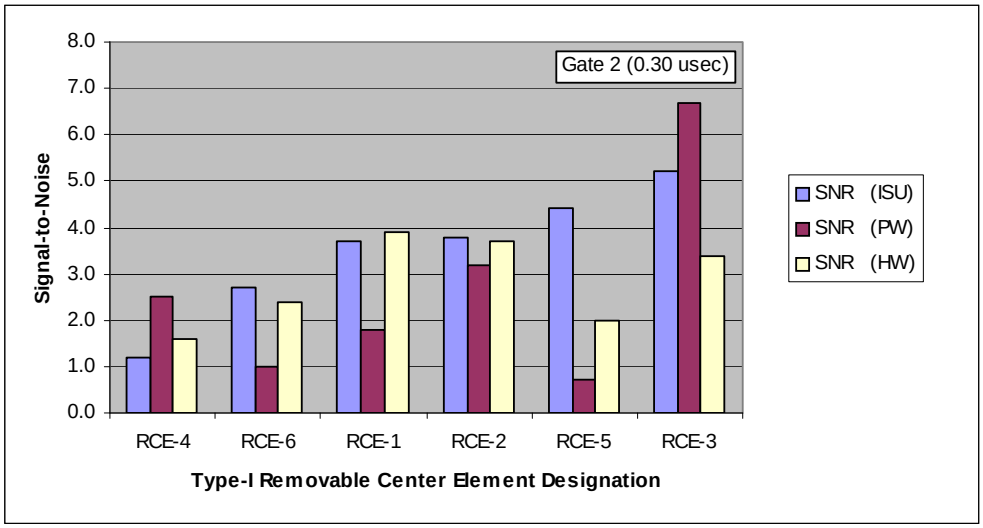




Manufacturers:	A & C	A & C	A & C	B & D	B & C	B
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403
Transducer ID:	RCE-1	RCE-2	RCE-3	RCE-4	RCE-5	RC
SNR (ISU)	3.7, 3.7	6.2, 3.8	10.1, 5.2	2.0, 1.2	6.2, 4.4	7.4
SNR (PW)	2.2, 1.8	5.8, 3.2	10.3, 6.7	3.3, 2.5	1.7, 0.7	2.1
SNR (HW)	4.5, 3.9	5.4, 3.7	4.1, 3.4	4.0, 1.6	2.5, 2.0	3.2
Average	3.5, 3.1	5.8, 3.6	8.2, 5.1	3.1, 1.8	3.5, 2.4	4.2
Std. Deviation	1.2, 1.2	0.4, 0.3	3.5, 1.7	1.0, 0.7	2.4, 1.9	2.8

Gate 1 value is listed first, followed by Gate 2 value.

Figure 33. Measured SNRs for a Near-Surface #1 FBH, Using the RCE of Each Type-I Transducer



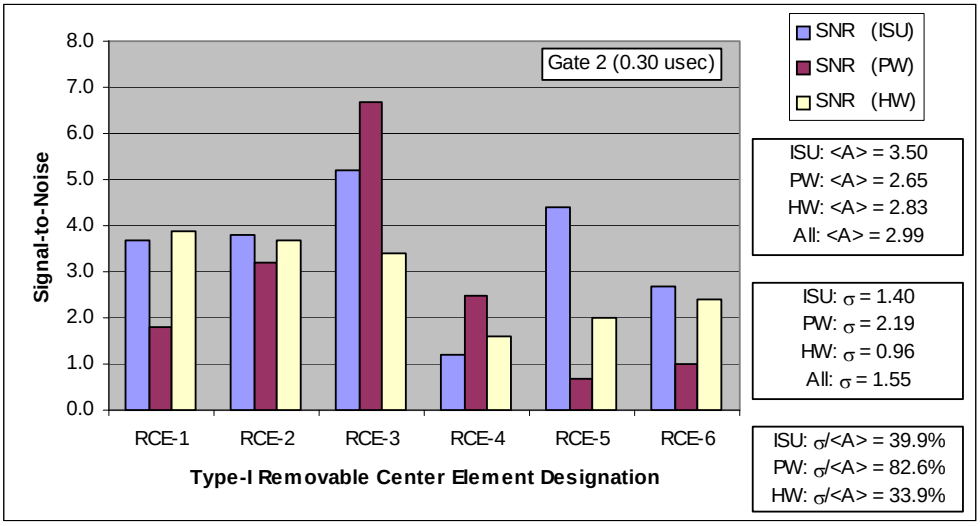


Figure 33. Measured SNRs for a Near-Surface #1 FBH
(Using the RCE of each Type-I transducer) (Continued)

2.1.5.8 Summary of Removable Center Element Measurements.

Table 6 summarizes the results of the various measurements performed on the RCE transducers. For each type of measurement, the second column from the left lists the mean value and fluctuation level (i.e., $<A> \pm [\sigma/<A>]\bullet$ 100%) for the full set of 18 measured values (six transducers times three facilities). The third column lists similar information for each facility individually. Thus, the values in the second column provide a rough guide to the range of values a third party might expect to obtain if nominally similar equipment were purchased (Tomoscan hardware and one transducer) and the same measurements were performed. The values in the second column similarly provide a rough guide to the transducer-to-transducer differences a third party might expect to find if a suite of nominally identical transducers were purchased and studied using a given Tomoscan system.

Table 6. Summary of Measured Values for RCE Transducers

Quantity Measured (units)	Overall Average and Variability (6 probes x 3 sites)	Single Facility Average and Variability (6 probes)	Ordering Similarity Between Facilities (1-5 scale)
Y+0 distance (inches)	3.27 ±2.4%	ISU: 3.28 ±1.6% P&W: 3.29 ±3.3% HW: 3.26 ±2.3%	2
Center frequency (MHz)	12.54 ±5.7%	ISU: 12.84 ±6.8% P&W: 12.29 ±5.9% HW: 12.48 ±4.4%	4
Bandwidth (%)	58.6 ±14%	ISU: 59.6 ±19.3% P&W: 56.6 ±14.8% HW: 59.7 ±7.9%	5
Beam diameter at Y+0 distance (mil)	48.8 ±5.7%	ISU: 50.0 ±7.0% P&W: 47.4 ±4.3% HW: 49.0 ±4.8%	2
Effective probe diameter, D (inches)	0.374 ±2.6%	ISU: 0.376 ±7.0% P&W: 0.377 ±4.3% HW: 0.370 ±4.8%	3
Geometric focal length, F (inches)	4.78 ±3.2%	ISU: 4.69 ±2.6% P&W: 4.82 ±3.2% HW: 4.83 ±3.5%	3
Near-surface SNR (gate 1: 0.20 µsec)	4.71 ±55%	ISU: 5.93 ±47.7% P&W: 4.23 ±78.5% HW: 3.95 ±25.6%	1
Near-surface SNR (gate 2: 0.30 µsec)	2.99 ±52%	ISU: 3.50 ±39.9% P&W: 2.65 ±82.6% HW: 2.83 ±33.9%	1
Peak response glass rod target (%FSH at 27 dB)	58.2 ±27%	ISU: 72.0 ±21.9% P&W: 54.8 ±18.2% HW: 47.8 ±23.0%	3
Peak response 0.1″ deep #1 FBH (%FSH at 45 dB)	68.90 ±24%	ISU: 62.1 ±24.4% P&W: 77.1 ±23.0% HW: 67.5 ±21.7%	4
Peak response 0.5″ deep #1 FBH (%FSH at 49 dB)	67.2 ±23%	ISU: 62.3 ±27.4% P&W: 73.3 ±%24.0 HW: 66.1 ±%19.0	4

Measurement differences, as quantified by $\sigma/\langle A \rangle$, arise from three basic sources:

- Differences in the performances of the various transducers themselves
- Differences in the performances of the measurement hardware and software (other than the transducer)
- The diligence of the person performing the measurements

It is not possible to cleanly separate the contributions of these sources to the $\sigma/\langle A \rangle$ values cited in table 6. That would require a larger study in which a set of qualified operators is rotated among various facilities with each operator redoing the measurements at each site. However, by looking at the similarities of the results at different sites, a rough conclusion can be drawn as to whether the measurements are finding clear differences in transducer performance.

In the rightmost column in table 6 a value from 1 to 5 has been assigned to indicate the degree to which experiments at the three sites resulted in the same ordering of measured values for the six transducers. A value of 5 indicates that the same (or very nearly the same) ordering was seen at all three facilities. A value of 1 indicates that there is no clear connection between the orderings found at different facilities. A value of 3 might indicate that two facilities agreed (or nearly agreed) on the ordering, but that many ordering differences were seen at the third facility. The assigned values, which are somewhat subjective, are based on a visual examination of the upper portions of the bar graphs in figures 17-33.

When the orderings of the measured values are very similar at different facilities, there is confidence that the measurement procedure is capable of reproducibly distinguishing between the transducers. This requires (1) a robust measurement procedure that is not overly sensitive to differences in system hardware or operator diligence and (2) real differences between probe performance that are sufficiently large to be clearly distinguished.

By and large, the six RCE transducers had quite similar performances. Some reproducible differences were seen in center frequency, bandwidth, and peak response values, but these differences were not extreme. Focal characteristics, as gauged by Y+0 values and fitted piston-probe parameters {D, F}, were very similar for all six transducers. Large differences were seen in measured near-surface SNRs, but those differences may reflect the inherent instability of the measurement procedure rather than performance differences between transducers. Recall that five of the RCE transducers were manufactured by supplier C, and one by supplier D (denoted RCE-4 in figures 17-33). There was no clear difference in the performance of the supplier D transducer compared to the other five. In nearly all categories, the measured values for the supplier D probe were bracketed by the values for the various supplier C probes. However, the supplier D probe did have a slightly higher center frequency and bandwidth than the set of supplier C probes. It also had a somewhat smaller value of effective diameter and a corresponding geometric focal length near the top of the supplier D range.

2.2 CHARACTERIZATION OF THE PHASED ARRAY ELEMENTS.

2.2.1 Introduction and Types of Measurements.

For both Type-I and Type-II phased array transducers, five types of measurements were performed. Four of these describe characteristics of the sound beam created when the transducer elements are fired in concert to form a focused beam. These are (1) the beam diameter at the target focal depth, (2) the center frequency, (3) the frequency bandwidth, and (4) the peak response from a small reference reflector located at the target focal depth. The fifth measurement examines TOF variability between individual elements of the array when the elements are fired one at a time. This last measurement can be used to assess spatial uniformity during manufacture, i.e., to look for deviations in the placements of the array elements from their ideal positions.

Beam diameter was measured by analyzing C-scans of #1/2 FBHs in test blocks at appropriate depths. The blocks, cut from a Ti-6-4 jet engine forging, were shown in figure 11. They contain #1/2 FBHs at depths of 0.7″, 1.6″, and 2.5″, respectively. The 1.6″ block was used with Type-I transducers, and the other two blocks were used with Type-II transducers. Just as in the earlier RCE analyses, the beam diameter was determined by noting the distance between half-amplitude points in the horizontal and vertical directions about the peak response position in the C-scan. An effective beam diameter was taken as the average of these two measurements. The C-scan analysis applied here is the same as described in connection with figure 19.

The center frequency and bandwidth of the response from the #1/2 FBH were determined by examining FFT spectra of waveforms recorded at the peak C-scan position of the #1/2 FBHs. The A-scan acquisition and spectral analysis were essentially identical to those described in connection with figures 22 through 26 for the RCEs.

The magnitude and uniformity in FBH response amplitude provided an indication of the piezoelectric efficiency of the transducer and the repeatability of the piezoelectric manufacturing process. Because the inspection of Ti was limited by material grain noise rather than system electronic noise, an increased magnitude of the FBH response due to better piezoelectric efficiency was not necessarily a significant benefit to the inspection performance. All other performance characteristics being the same, an increased piezoelectric efficiency will benefit the inspection to the extent that the resulting decrease in electronic noise will lower the overall inspection noise level. In the OEM forging inspections discussed in a companion report [1], for example, electronic noise made a minor contribution to the overall noise level. Here, overall transducer efficiency was assessed by measuring the peak response amplitude from an appropriate #1/2 FBH target, using the same element-firing protocol (focal law) for all transducers of the same type.

A straightforward means to examine the accuracy of the transducer surface geometry is to measure the time of flight from each element to an appropriate reference target. The simplest reference target to use is one that conforms to the shape of the array surface, such that all signals reflected from the target arrive back at the array at the same time. For the Type-I, 15-element array, this reference target was a planar surface, since the surface of the 15-element array was itself planar. For the Type-II 110-element array, the reference target was a spherical surface,

since the transducer surface was a compound spherical surface, consisting of three concentric spherical sections. A single spherical surface could be used for performing this test, provided the water paths were adjusted to make the spherical center of the reflecting target coincide with the spherical center of the transducer surface section on which the elements being tested laid. Such an approach would have required using a large range of water paths to test all three spherical sections. To avoid the problems associated with using long water paths, a set of three spherical glass reflectors were purchased, so that convenient water paths could be used to examine all three spherical sections. Details regarding these reflectors are shown in figure 10. The tests were performed by firing individual elements in pulse-echo mode one at a time and recording the signal received from the reflecting surface. The reflecting surfaces were chosen such that, when properly aligned with the transducer, the reflected signals should all arrive at the same time. Variation in the transducer surface was, therefore, directly measured by calculating the standard deviation of the arrival times over all elements.

In summary, four of the tests used to characterize the phased elements were very similar in nature to those described earlier in the discussion of RCE studies, namely, beam diameter, center frequency, bandwidth, and FBH response amplitude. In these four tests, a specific focal law was used that was designed to focus the beam at the depth of the FBH target. The focal law, which describes the firing and phasing of the array elements, was applied in the same manner to all transducers of a given type. Once the focal law was applied, data acquisition and analysis for these four tests was essentially identical to the corresponding measurements on RCE transducers. The fifth characterization test, which deals with the times of flight of sonic pulses from individual elements, had no RCE counterpart. Further details of all five tests can be found in appendix D.

Six different Type-I transducers with the same nominal design were tested. Figures summarizing the results follow the same format used in the RCE studies. The lower bar graph in each figure presents results using the standard ordering of figure 7 (supplier A transducers first, followed by supplier B transducers). The upper bar graph again reorders the transducers such that the ISU measurements increase from left to right. A small table at the bottom of each figure lists the individual measured values.

Only three Type-II transducers were tested, all manufactured by supplier A. For such a small sample, the use of a separate bar to display ordering trends was considered superfluous. Thus, for Type-II transducers, a single bar graph appears in each figure, using the standard transducer ordering.

2.2.2 Type-I Transducers: Introduction.

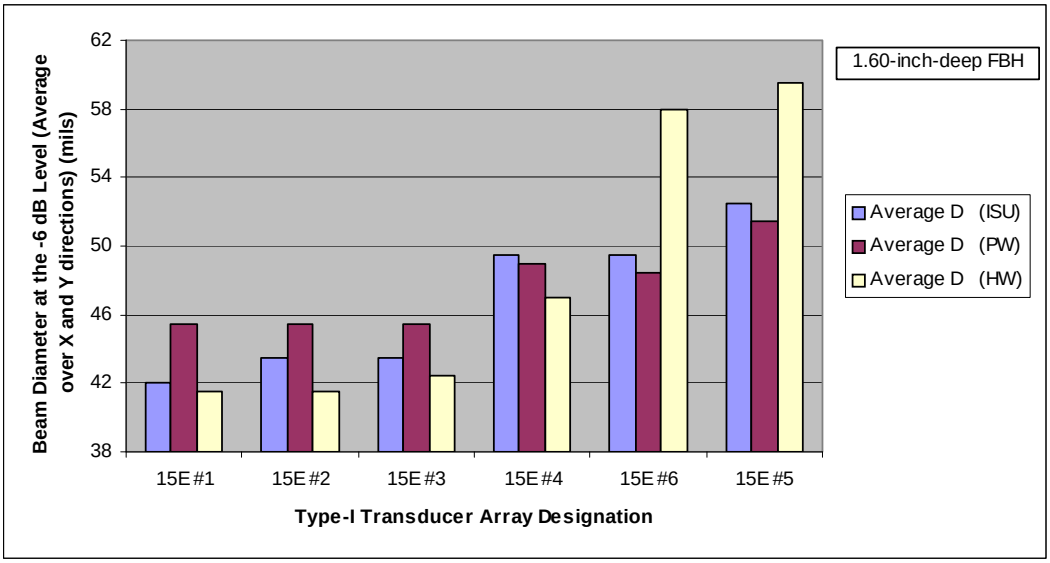
This transducer type consists of 14 annular rings surrounding an RCE where the RCE is designed for high near-surface resolution, shown in figure 7. The performance of the RCE was reported in the preceding section of this report. The work reported here assesses the performance of the 14 outer annular rings when used as an annular phased array. The complete technical specification of the Type-I transducer is included in appendix C. To test for variability in focusing performance, all 14 annular elements were used to focus to a depth of 1.6″ in Ti. Responses were recorded using the P&W test coupon containing a #1/2 FBH at a depth of 1.6″. These tests examined the beam width, signal amplitude, center frequency, and bandwidth, using the carefully

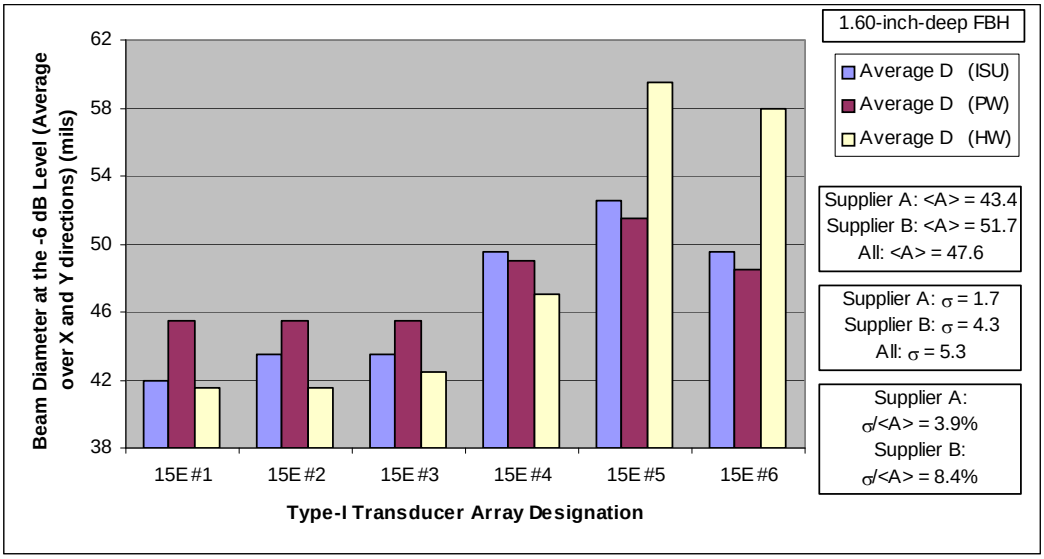
prescribed procedure detailed in appendix D. Data were collected using this procedure at ISU, P&W, and HW, in that order. From these data, the variability among the six transducers in the measured parameters was compiled and displayed for each investigating facility. The results for each of these tests will be discussed in turn.

2.2.3 Type-I Transducers: Beam Diameter.

Beam diameters for Type-I transducers, measured using a #1/2 FBH located 1.6″ deep in Ti alloy are summarized in figure 34. As in the RCE study, the diameter of a C-scan image at 1/2 the peak response amplitude was measured, with separate measurements made in the orthogonal X and Y scanning directions. The individual X and Y diameters are listed in the tabular portion of figure 34. A representative beam diameter, taken as the average of the beam widths measured in these two orthogonal directions, is then displayed in the bar graph portions of the figure. The right-hand portion of the lower bar graph in figure 34 and similar figures also lists selected mean values, standard deviations, and fluctuation ratios as defined in equations 2 through 4. In a minor departure from similar RCE graphs, the statistical results cited on the bar graphs are for groupings by transducer manufacturer rather than by inspection facility. This seemed more natural since there are three transducers from each manufacturer. Additional statistical data, for groupings by both test facility and manufacturer, can be found in table 7.

In figure 34, it appears that each laboratory introduced a consistent bias in its diameter measurements. However, the variation between probes appears to be consistent between laboratories. It is evident by comparing mean values of beam diameter that the beam generated by supplier A transducers is somewhat more tightly focused than those generated by supplier B transducers. The mean taken from all the test facilities for all probes from a given manufacturer indicates a 7 mil difference in beam diameter for supplier A probes compared to supplier B probes. A lower standard deviation is also consistently observed among supplier A transducers.





Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Array ID:	15E #1	15E #2	15E #3	15E #4	15E #5	15E #6
Dx, Dy (ISU)	43, 41	42, 45	43, 44	48, 51	52, 53	49, 50
Dx, Dy (PW)	45, 46	45, 46	45, 46	48, 50	50, 53	48, 49
Dx, Dy (HW)	42, 41	42, 41	44, 41	44, 50	57, 62	56, 60
Average	43.00	43.50	43.83	48.50	54.50	52.00
Std. Deviation	2.18	2.00	1.53	1.32	4.36	5.22

All values are in mils.

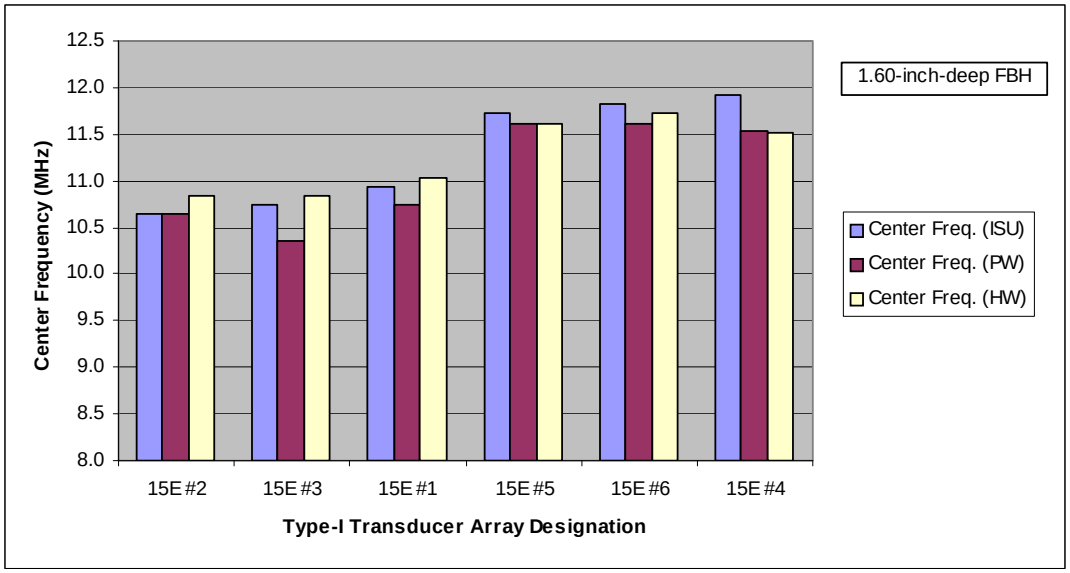
Figure 34. Measured Beam Widths for 15-Element Type-I Phased Arrays (Widths observed in orthogonal X and Y directions are listed individually, and their mean is graphed.)

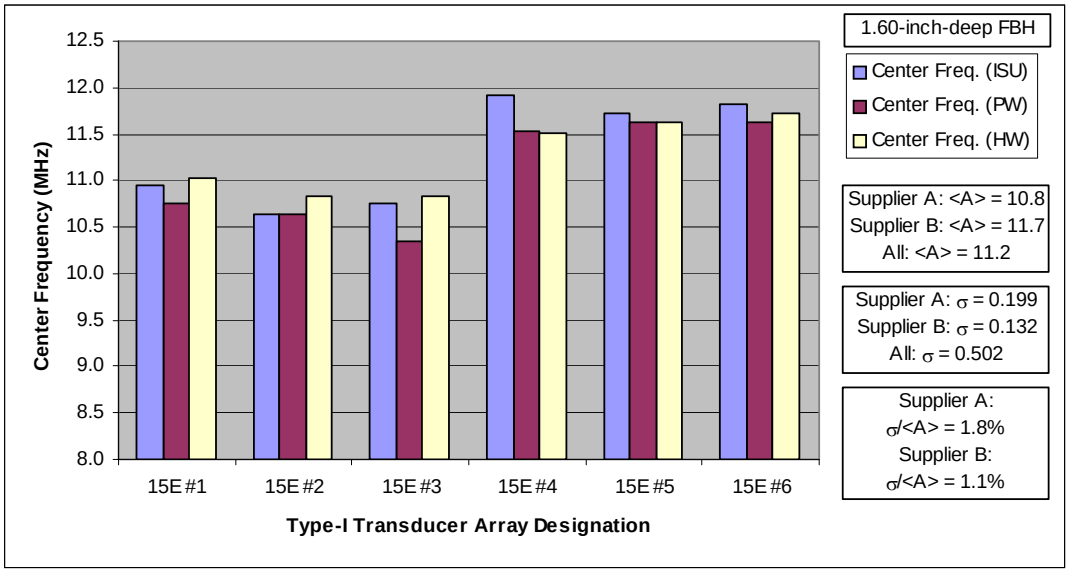
Table 7. Mean and Standard Deviation of the Beam Diameters for Type-I Transducers From a Given Manufacturer, as Measured by Each Test Facility

Manufacturer	Supplier A		Supplier B	
	Mean	Standard Deviation	Mean	Standard Deviation
Average D (ISU)	43.0	0.866	50.5	1.73
Average D (PW)	45.5	0.000	49.7	1.61
Average D (HW)	41.8	0.577	54.8	6.83

2.2.4 Type-I Transducers: Center Frequency and Bandwidth.

The center frequency and bandwidth of each Type-I transducer were measured using the same 1.6″ deep #1/2 FBH. In parallel with the RCE measurements, an RF waveform (A-scan) was acquired and stored at the C-scan location where the peak response was observed. An FFT analysis was performed to compute the center frequency and bandwidth, as defined in equations 5 and 6. The results are summarized in figures 35 and 36. Associated table 8 lists means and standard deviations of the measured center frequencies for groupings by transducer manufacturer and test facility. Table 9 does the same thing for measured bandwidths.

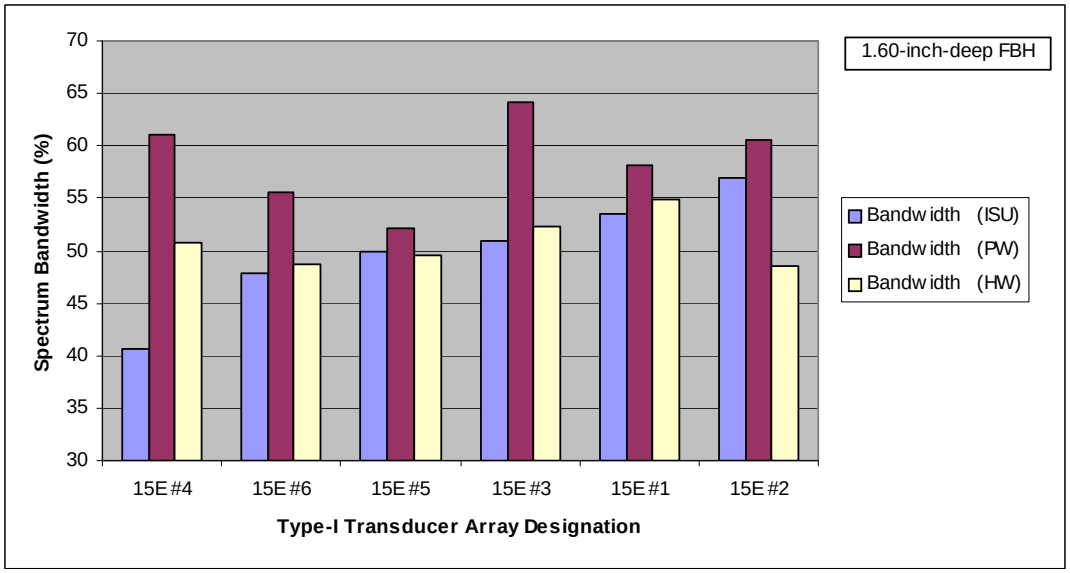


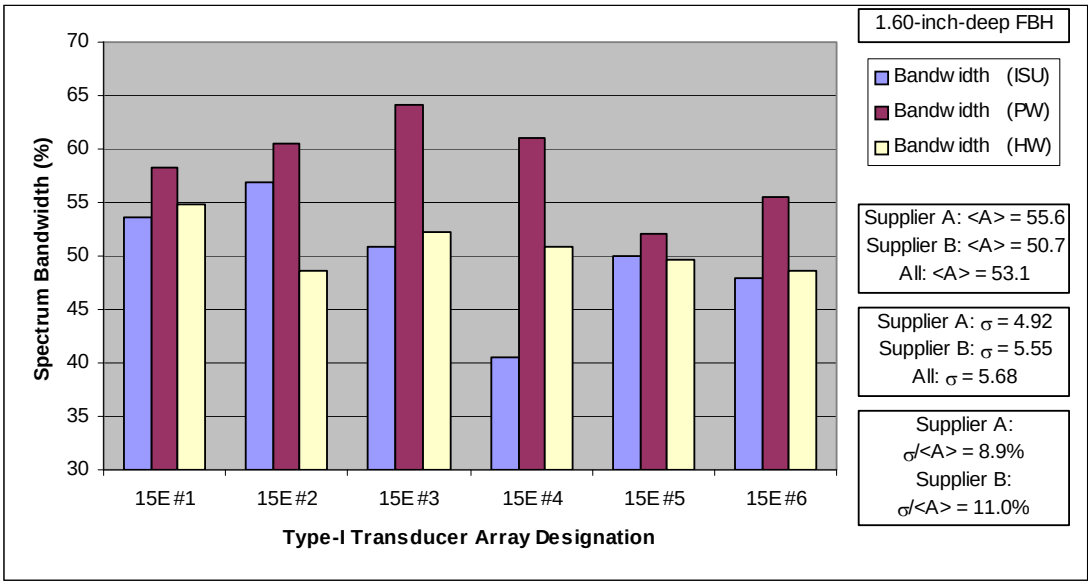


Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Array ID:	15E #1	15E #2	15E #3	15E #4	15E #5	15E #6
Center Freq. (ISU)	10.9	10.6	10.7	11.9	11.7	11.8
Center Freq. (PW)	10.7	10.6	10.4	11.5	11.6	11.6
Center Freq. (HW)	11.0	10.8	10.8	11.5	11.6	11.7
Average	10.9	10.7	10.6	11.7	11.7	11.7
Std. Deviation	0.15	0.11	0.26	0.23	0.06	0.10

All values are in MHz.

Figure 35. Measured Center Frequencies for 15-Element Type-I Phased Arrays





Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Array ID:	15E #1	15E #2	15E #3	15E #4	15E #5	15E #6
Bandwidth (ISU)	53.6	56.9	50.9	40.6	50.0	47.9
Bandwidth (PW)	58.2	60.6	64.2	61.0	52.1	55.5
Bandwidth (HW)	54.9	48.6	52.3	50.8	49.6	48.7
Average	55.6	55.4	55.8	50.8	50.6	50.7
Std. Deviation	2.4	6.1	7.3	10.2	1.3	4.2

All values are in MHz.

Figure 36. Measured Bandwidths for 15-Element Type-I Phased Arrays

Table 8. Mean and Standard Deviation of the Center Frequencies for Type-I Transducers From a Given Manufacturer, as Measured by Each Test Facility

Manufacturer	Supplier A		Supplier B	
	Mean	Standard Deviation	Mean	Standard Deviation
Center Frequency (ISU)	10.78	0.150	11.82	0.100
Center Frequency (P&W)	10.58	0.205	11.59	0.055
Center Frequency (HW)	10.91	0.113	11.62	0.100

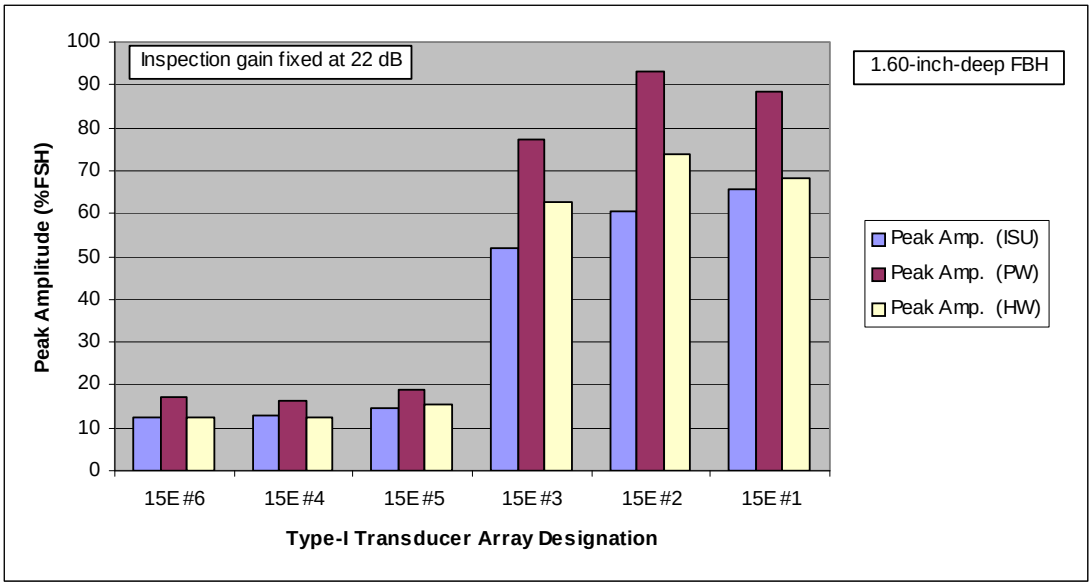
Table 9. Mean and Standard Deviation of the Bandwidths for Type-I Transducers From a Given Manufacturer, as Measured by Each Test Facility

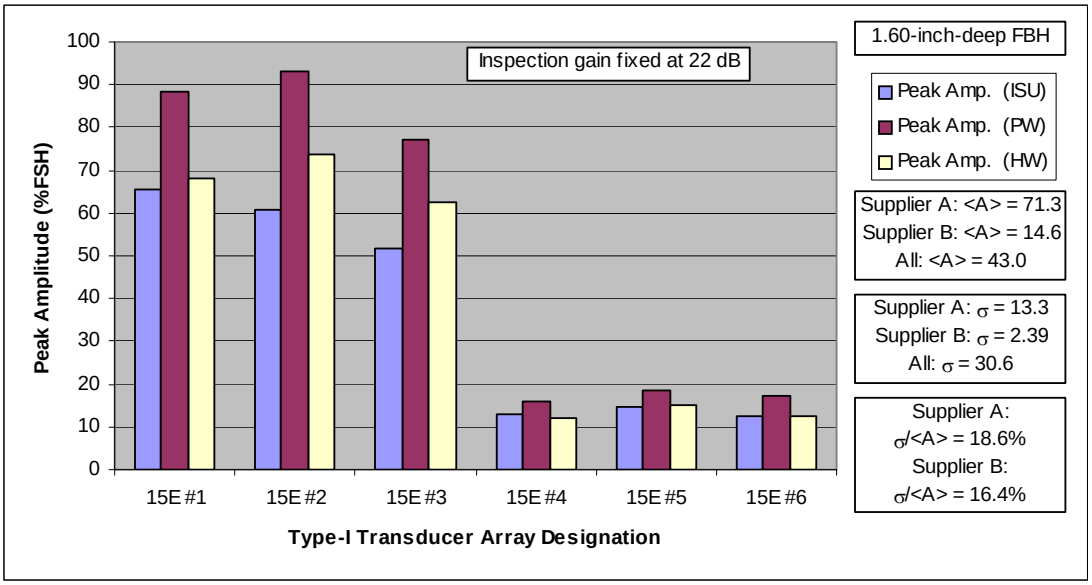
Manufacturer	Supplier A		Supplier B	
	Mean	Standard Deviation	Mean	Standard Deviation
Bandwidth (ISU)	53.8	3.01	46.2	4.93
Bandwidth (P&W)	61.0	3.02	56.2	4.49
Bandwidth (HW)	51.9	3.17	49.7	1.05

All measured center frequencies were above the target value of 10 MHz, but as mentioned earlier, the center frequency is generally expected to depend significantly on the measurement setup, including the path lengths and attenuations of the water and metal media. Again, it is of interest to compare mean values taken from all the test facilities for all probes from a given manufacturer. One notices that the mean measured center frequency for supplier A transducers (10.8 MHz) is slightly lower than for supplier B transducers (11.7 MHz). Similarly, the mean supplier A bandwidth (57%) is slightly larger than the supplier B value (51%). Associated standard deviation values for these two characteristics were reasonably small and fairly similar for the two manufacturers.

2.2.5 Type-I Transducers: Peak FBH Response Amplitude.

The C-scan of the 1.6″ deep #1/2 FBH was also used to quantify the relative efficiency of each Type-I transducer. Since all transducers were fired in the same manner and all responses were observed at the same gain, the measured FBH response at the peak amplitude position of the C-scan served as a ready measure of probe efficiency (or hotness). These peak amplitude values are summarized in figure 37 and associated table 10, after rescaling to a fixed inspection gain of 22 dB. It is evident that supplier A transducers, as a group, have a consistently greater piezoelectric efficiency than supplier B transducers. Comparing mean values from all the test facilities for all probes from a given manufacturer, an average response of 71.3% FSH was found for supplier A transducers, versus 14.6% FSH for supplier B probes. This approximately 14 dB difference may be significant in inspection situations where electronic noise exceeds microstructural noise.





Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Array ID:	15E #1	15E #2	15E #3	15E #4	15E #5	15E #6
Peak Amp. (ISU)	65.7	60.6	51.9	12.7	14.6	12.3
Peak Amp. (PW)	88.3	93.0	77.3	16.1	18.7	17.3
Peak Amp. (HW)	68.2	73.8	62.7	12.2	15.3	12.4
Average	74.1	75.8	64.0	13.7	16.2	14.0
Std. Deviation	12.4	16.3	12.7	2.1	2.2	2.8

All values are in %FSH.

Figure 37. Measured Peak FBH Amplitudes for 15-Element Type-I Phased Arrays

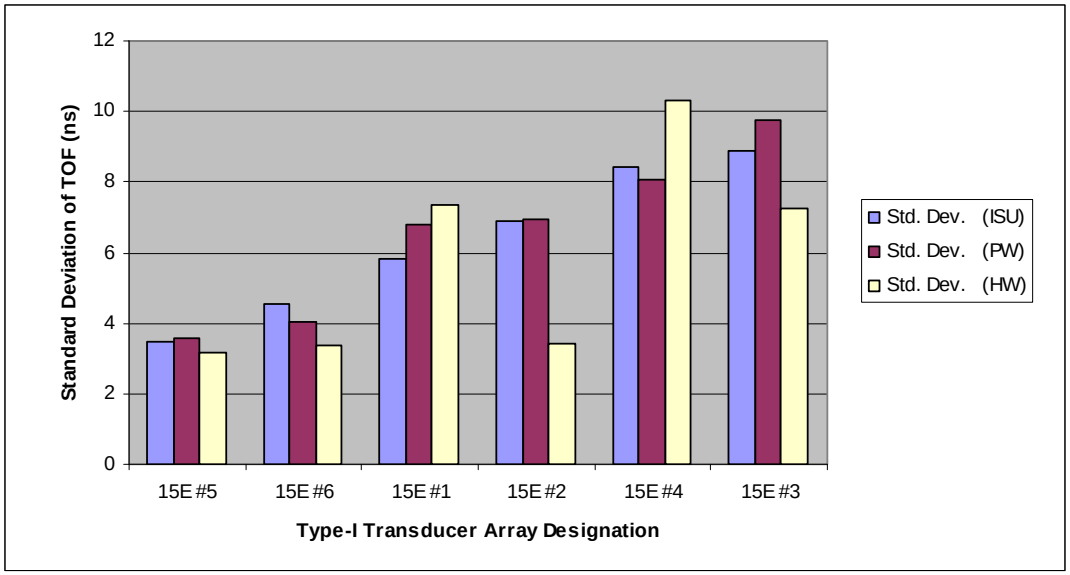
Table 10. Mean and Standard Deviation of Peak FBH Amplitude for Type-I Transducers From a Given Manufacturer, as Measured by Each Test Facility

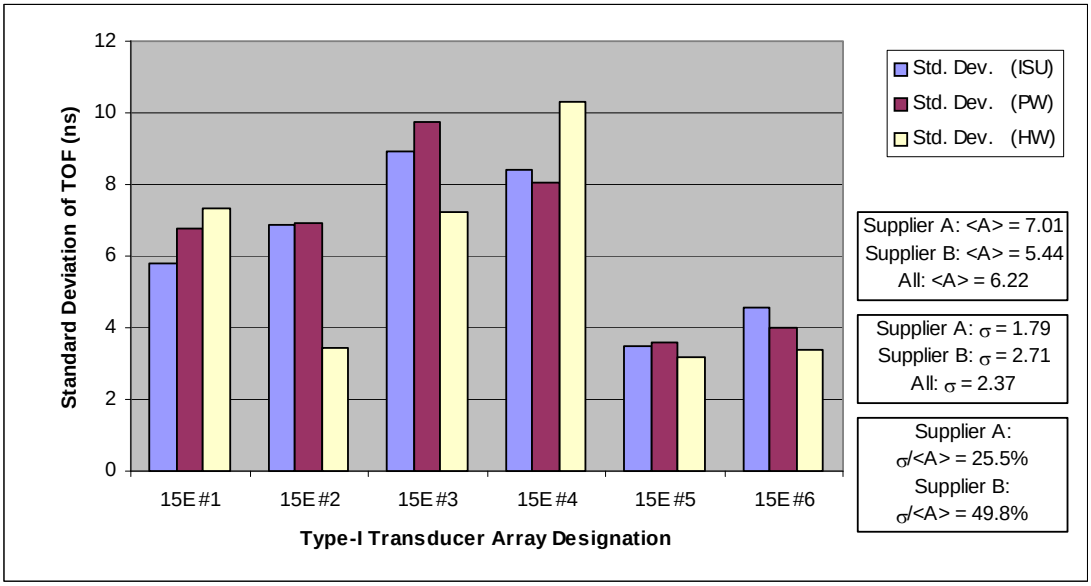
Manufacturer	Supplier A		Supplier B	
	Mean	Standard Deviation	Mean	Standard Deviation
Peak Amplitude (ISU)	59.4	6.98	13.2	1.21
Peak Amplitude (P&W)	86.2	8.06	17.4	1.29
Peak Amplitude (HW)	68.2	5.56	13.3	1.72

2.2.6 Type-I Transducers: Individual Element TOF.

The measurement of individual element responses for the 15-element array was performed using a planar surface as a reflecting target at a 3″ water path. The transducer was aligned for perpendicular incidence, and signals were recorded from the flat surface element by element, operating in pulse-echo mode. When the array is aligned with the reflecting surface, the arrival time of each signal should be identical, assuming that the transducer face conforms exactly to the nominal design. Therefore, a measure of the accuracy of the transducer surface geometry is provided by measuring the deviation of the individual arrival times about their mean value. Such an analysis was performed for each of the six transducers, and the standard deviation of the pulse arrival times measured over the 14 annular rings is reported here. The interested reader can consult appendix D for details of the measurements, including probe alignment procedures, typical appearances of single-element A-scans, and the specific A-scan features used for the TOF measurements.

Figure 38 summarizes the measured standard deviations in the echo arrival times for each of the six Type-I transducers, as measured at each test facility. As noted above, this standard deviation (having units of nanoseconds) served as a goodness parameter for assessing piezoelectric element positioning along the transducer surface, with smaller values indicating a closer correspondence to the ideal. Additional statistical information describing the variation in goodness parameter values, as measured at different facilities, is listed in table 11. A conservative criterion for an acceptable error in element phasing is 1/8 wavelength. For a 10-MHz transducer operating in pulse-echo, this translates into an increment in pulse arrival time of 25 nsec. It is seen that the observed standard deviation in arrival time is well below this value, indicating that errors in focusing due to surface geometry anomalies should be minimal.





Manufacturers:	A & C	A & C	A & C	B & D	B & C	B & C
PA Serial No.:	4608-A101	4608-A102	4608-A103	403Y004	403Y006	403Y007
Array ID:	15E #1	15E #2	15E #3	15E #4	15E #5	15E #6
Std. Dev. (ISU)	5.80	6.88	8.90	8.42	3.50	4.55
Std. Dev. (PW)	6.79	6.92	9.75	8.05	3.58	4.01
Std. Dev. (HW)	7.34	3.44	7.24	10.31	3.18	3.37
Average	6.65	5.75	8.63	8.92	3.42	3.98
Std. Deviation	0.78	2.00	1.28	1.21	0.21	0.59

All values are in ns.

Figure 38. Measured Standard Deviation in Individual Element Echo Arrival Times for Type-I Phased Arrays

Table 11. Mean and Standard Deviation of the TOF Goodness Parameter for Type-I Transducers From a Given Manufacturer, as Measured by Each Test Facility

Manufacturer	Supplier A		Supplier B	
	Mean	Standard Deviation	Mean	Standard Deviation
Standard deviation (ISU)	7.20	1.57	5.49	2.59
Standard deviation (P&W)	7.82	1.67	5.21	2.46
Standard deviation (HW)	6.00	2.23	5.62	4.06

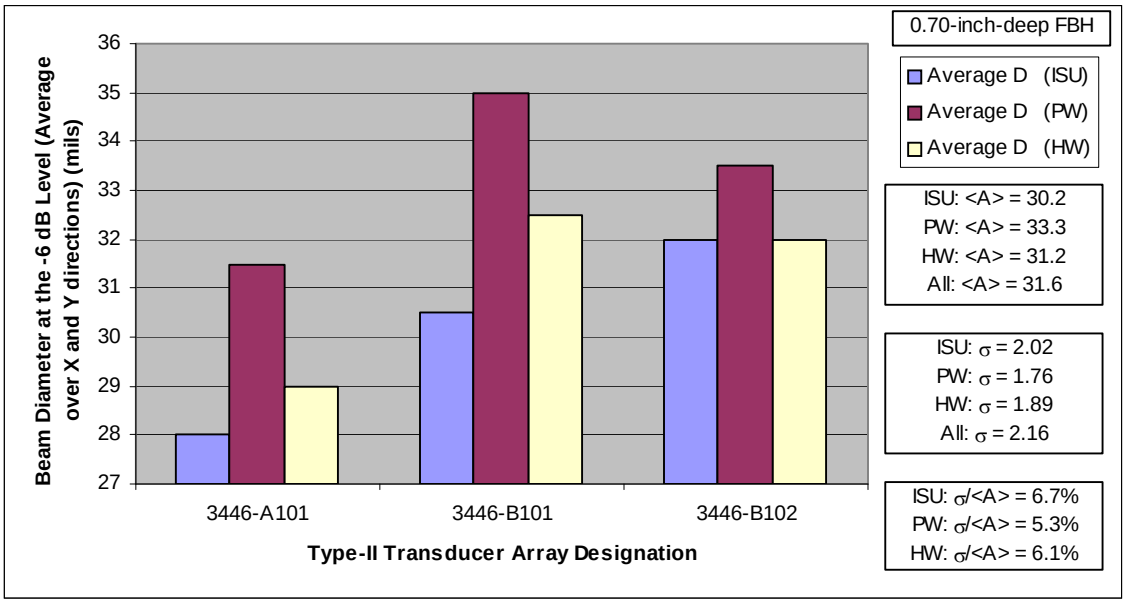
2.2.7 Type-II Transducers: Specific Measurements.

The 110-element annular-sectorial array was designed to maintain an F6 focus below a planar entry surface to a depth of 3.25″ in Ti. The F6 designation refers to a requirement that the transducer maintain the same focus as a fixed-focus transducer having the ratio (focal length in water)/(diameter) = 6. The transducer was designed such that all elements have equal area. To cover the entire range of focus, the surface of the transducer was designed as a compound spherical surface, consisting of three concentric spherical sections. The transducer has 36 annular rings, with the outer rings being divided into circumferential segments, to maintain an equal element area. The phased array instrumentation used to operate the transducers is capable of driving 32 annular rings at one time. The transducer focuses to a depth of 2.5″ when using the inner 32 rings. For this reason, tests were performed using two different focal laws. The first focal law focused to a depth of 0.7″ using the inner 14 rings of the array. The second focal law focused to a depth of 2.5″ using the inner 32 rings of the array.

Three Type-II transducers were tested, each manufactured by supplier A. Again, five phased element characterization tests were performed, measuring beam diameter, center frequency, bandwidth, FBH response amplitude, and single-element TOF, respectively. The measurements procedures for the Type-I and Type-II transducers were very similar, with the first four tests again essentially the same as in the RCE study. Complete details of the measurement procedures for Type-II transducers can be found in appendix D.

2.2.8 Type-II Transducers: Beam Diameter.

Beam diameters were measured separately for two inspection scenarios: nominal focusing at 0.7″ depth in Ti alloy and nominal focusing at 2.5″ depth. Test blocks having #1/2 FBHs at these depths were used, and different focal laws were applied for the two inspections. As before, ultrasonic C-scans were obtained, and beam diameters were measured separately in the X and Y scanning directions. These were averaged to obtain a representative beam diameter value for each transducer at each hole depth. The results are summarized in figures 39 and 40 for the 0.7″ depth and 2.5″ depth, respectively. Tables incorporated into the figures list both the individually measured diameters (Dx and Dy) and their mean value (D). Again, additional statistical information has been listed in the right-hand portion of each bar graph. As was done for the RCE study, mean values, standard deviations, and fluctuation ratios have been listed separately for each test facility.

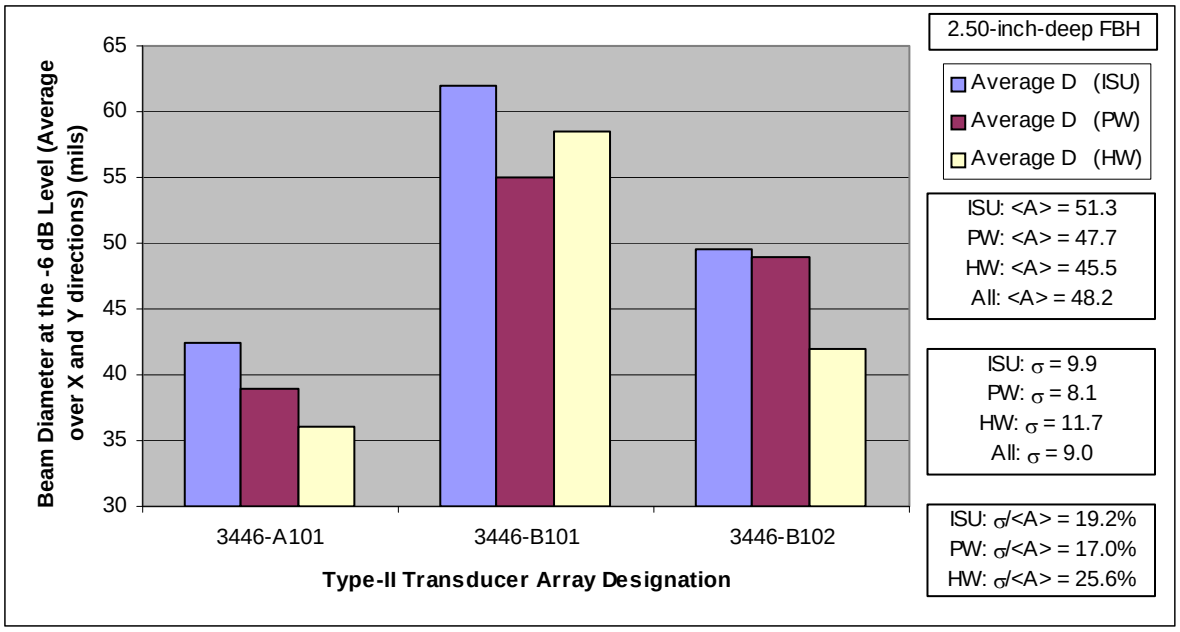


Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Dx, Dy (ISU)	27, 29	30, 31	32, 32
Dx, Dy (PW)	32, 31	33, 37	33, 34
Dx, Dy (HW)	30, 28	31, 34	32, 32

All values are in mils.

Figure 39. Measured Beam Widths for Type-II Phased Arrays Using an FBH Target in Ti at 0.7″ Depth. (Widths observed in orthogonal X and Y directions are listed individually and their mean is graphed.)

From figures 39 and 40, it is evident that a reasonably consistent beam diameter was measured on a given transducer by all three test facilities. For a given hole depth, each laboratory introduces a consistent bias in its measurements. However, the variation between probes appears to be consistent between laboratories. Some clear differences between the performances of the three transducers can be seen. For measurements at any given facility, transducer A101 has the smallest beam diameter, and transducer B101 tends to have the largest diameter. The F6 focus should ideally provide a 36-mil beam diameter. At the 0.7″ depth, the measured beam diameters are actually smaller than 36 mil. One possible reason is the observed center frequency, reported in section 2.2.9, was actually greater than the nominal 10 MHz. A second reason is due to the finite size of the transducer array elements. Except at a few discrete depths, the F6 focus requires using only a fraction of the outermost element in the active aperture. Since using only a portion of an element is not an option, the beam will generally be overfocused at most locations, since the focal laws were designed to maintain at least an F6 focus. The larger beam diameters measured at 2.5″ are to be expected for two reasons. First, the center frequency is lower due to material attenuation, resulting in less focusing. Second, the defocusing effects of phase aberration due to material inhomogeneity are expected to play a substantially greater role at 2.5″ than at 0.7″.



Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Dx, Dy (ISU)	33, 52	63, 61	39, 60
Dx, Dy (PW)	45, 33	62, 48	55, 43
Dx, Dy (HW)	32, 40	47, 70	31, 53

All values are in mils.

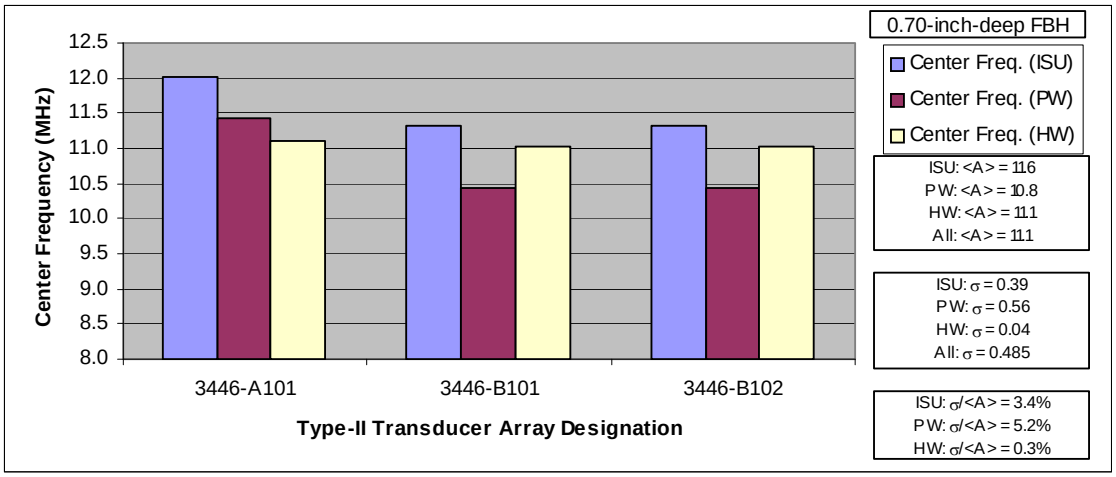
Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Average D (ISU)	42.5	62.0	49.5
Average D (PW)	39.0	55.0	49.0
Average D (HW)	36.0	58.5	42.0
Average	39.2	58.5	46.8
Std. Deviation	3.3	3.5	4.2

All values are in mils.

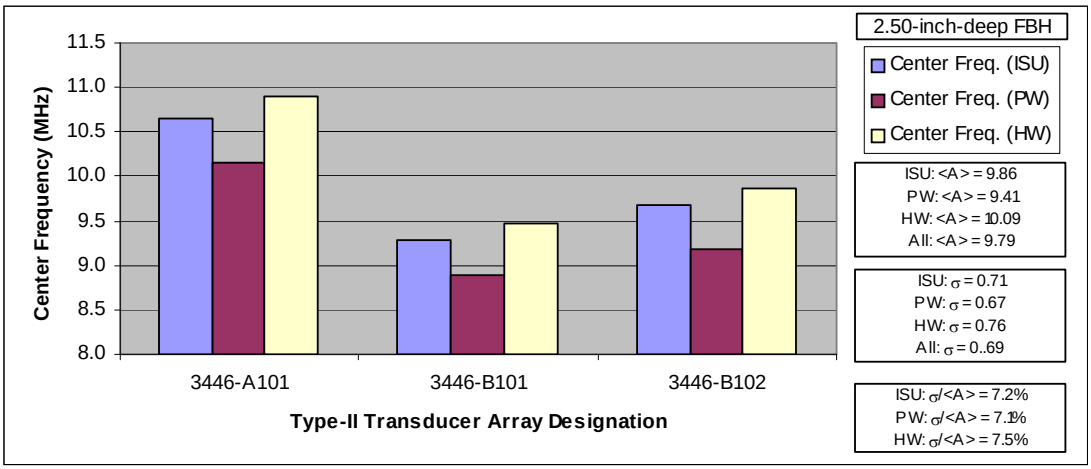
Figure 40. Measured Beam Widths for Type-II Phased Arrays Using a FBH Target in Ti at 2.5″ Depth. (Widths observed in orthogonal X and Y directions are listed individually, and their mean is graphed.)

2.2.9 Type-II Transducers: Center Frequency and Bandwidth.

Center frequencies and bandwidths were measured separately using the 0.7″ and 2.5″ deep FBH targets and their associated focal laws. As before, these quantities were obtained by analyzing FBH A-scans at the maximum amplitude locations seen in the ultrasonic C-scan images. Measured center frequencies and bandwidths are summarized in figures 41 and 42, respectively. For convenience, the results for both the 0.7″ and 2.5″ deep FBHs appear together in the same figure. As mentioned in the last section, a drop in center frequency is expected at the greater depth due to increased material attenuation.



bar graph for 0.7" FBH



bar graph for 2.5" FBH

table for 0.7" FBH

Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Center Freq. (ISU)	12.0	11.3	11.3
Center Freq. (PW)	11.4	10.5	10.5
Center Freq. (HW)	11.1	11.0	11.0
Average	11.5	10.9	10.9
Std. Deviation	0.46	0.45	0.45

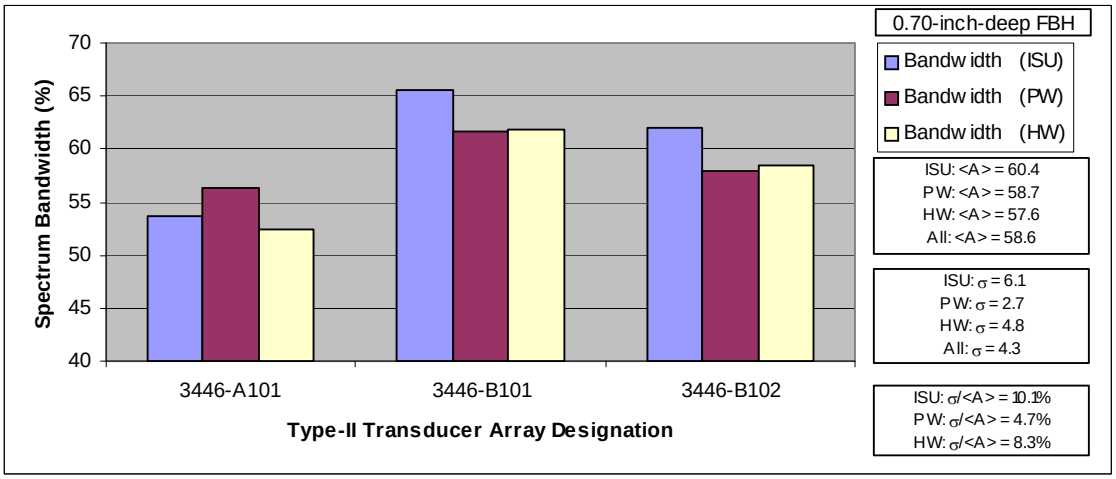
All values are in MHz.

table for 2.5" FBH

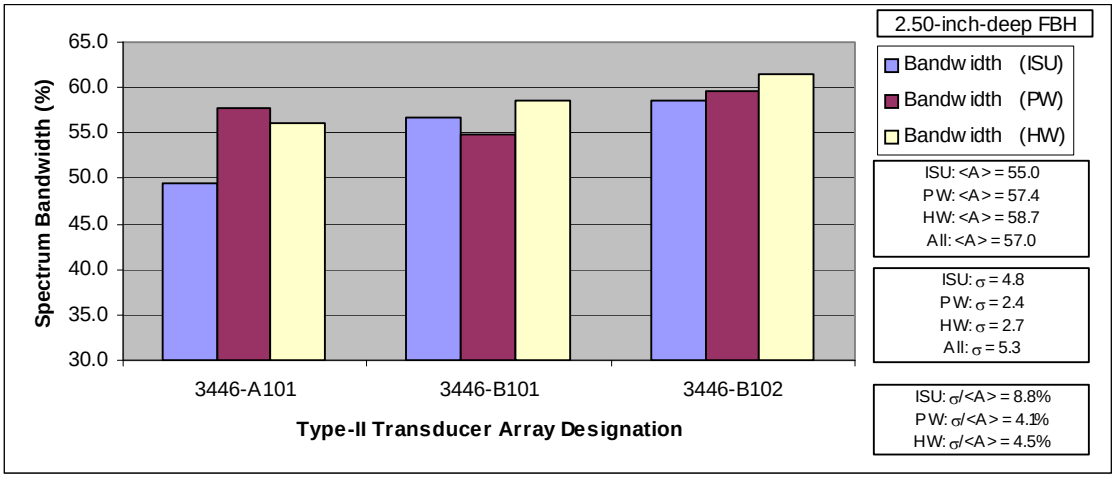
Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Center Freq. (ISU)	10.6	9.3	9.7
Center Freq. (PW)	10.2	8.9	9.2
Center Freq. (HW)	10.9	9.5	9.9
Average	10.6	9.2	9.6
Std. Deviation	0.38	0.30	0.35

All values are in MHz.

Figure 41. Measured Center Frequencies for Type-II Phased Arrays Using FBH Targets at Depths of 0.7″ and 2.5″



bar graph for 0.7" FBH



bar graph for 2.5" FBH

table for 0.7" FBH

Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Bandwidth (ISU)	53.7	65.5	62.1
Bandwidth (PW)	56.4	61.7	57.9
Bandwidth (HW)	52.5	61.9	58.4
Average	54.2	63.0	59.5
Std. Deviation	2.00	2.14	2.29

All values are in MHz.

table for 2.5" FBH

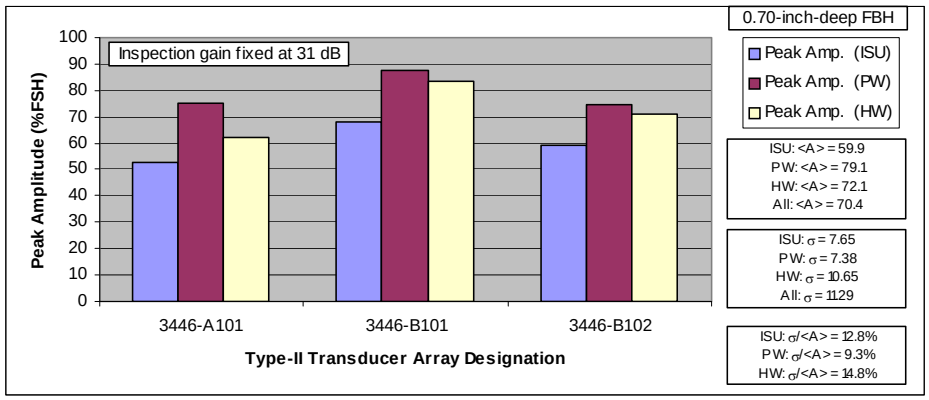
Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Bandwidth (ISU)	49.5	56.8	58.6
Bandwidth (PW)	57.7	54.9	59.6
Bandwidth (HW)	56.1	58.6	61.4
Average	54.4	56.8	59.9
Std. Deviation	4.35	1.85	1.42

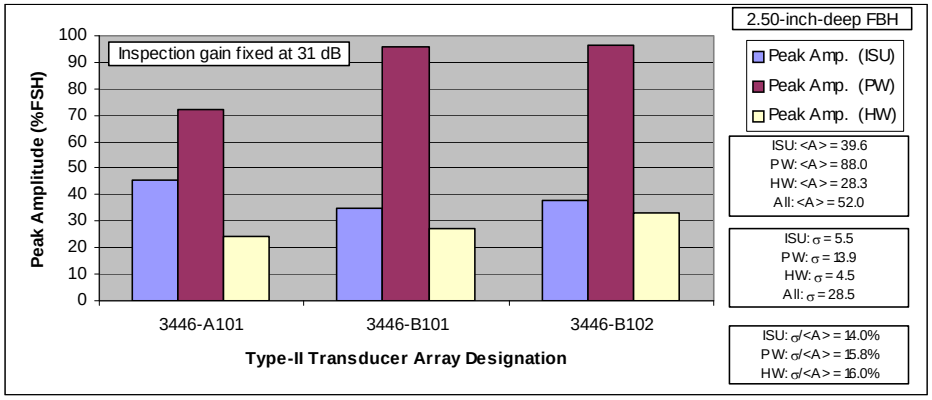
All values are in MHz.

Figure 42. Measured Bandwidths for Type-II Phased Arrays Using FBH Targets at Depths of 0.7″ and 2.5″

2.2.10 Type-II Transducers: Peaked FBH Response Amplitude.

The FBH response amplitude was measured at the peak amplitude position of the C-scans for both 0.7″ and 2.5″ deep #1/2 FBHs. The results for both FBH depths are summarized in figure 43, after rescaling to a uniform inspection gain of 31 dB for all cases. The observed drop in signal amplitude associated with the 2.5″ deep FBH is to be expected, due to an increased material attenuation.





bar graph for 0.7” FBH
bar graph for 2.5” FBH

table for 0.7” FBH

Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Peak Amp. (ISU)	52.7	67.9	59.1
Peak Amp. (PW)	75.2	87.6	74.5
Peak Amp. (HW)	62.0	83.3	71.0
Average	63.3	79.6	68.2
Std. Deviation	11.3	10.3	8.1

All values are in %FSH.

table for 2.5” FBH

Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Peak Amp. (ISU)	45.8	35.2	37.9
Peak Amp. (PW)	71.9	95.6	96.4
Peak Amp. (HW)	24.4	27.2	33.3
Average	47.4	52.6	55.9
Std. Deviation	23.79	37.41	35.16

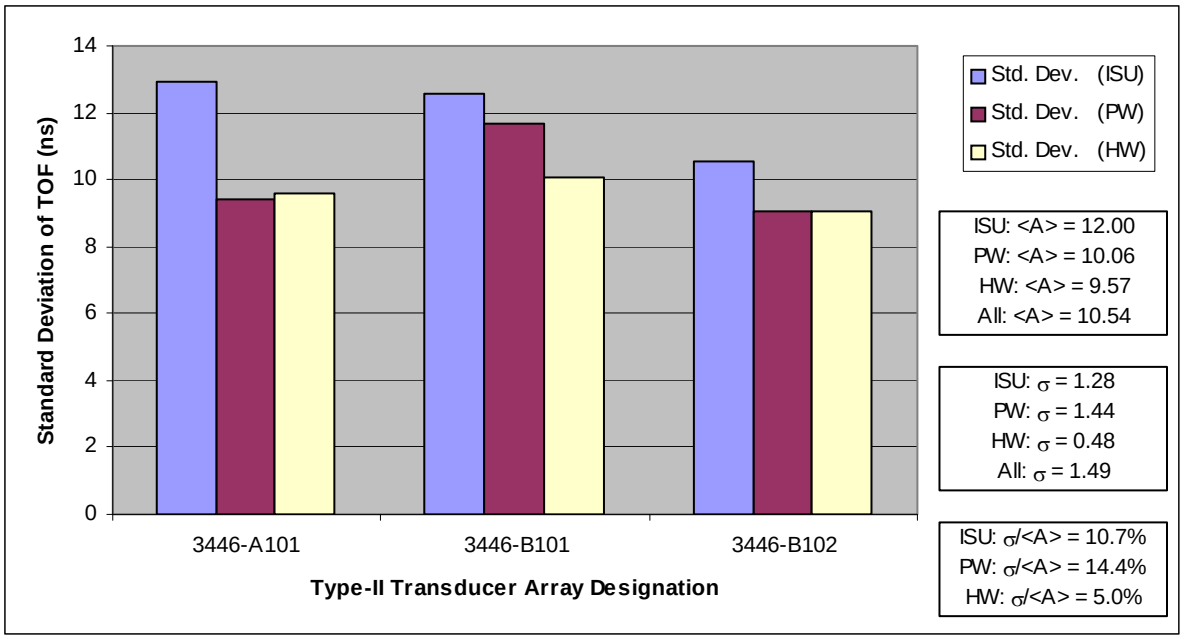
All values are in %FSH.

Figure 43. Measured Peak FBH Amplitudes for Type-II Phased Arrays Using FBH Targets at Depths of 0.7″ and 2.5″

2.2.11 Type-II Transducers: Individual Element TOF.

The measurement of individual element responses for the 110-element array Type-II transducer was performed using three spherical sections as reflectors. These glass reflectors are shown and described in figure 10. Recall that the surface of the transducer consists of three concentric spherical sections, having nominal radii of 418, 283, and 136 mm. To perform the measurement, glass spherical sections having radii of 50, 40, and 30 mm are used as reflecting surfaces, respectively. The probe orientation and water path were carefully adjusted to ensure that the transducer surface and reflecting surface had coincident centers of curvature, using the procedure described in appendix D. Once the probe had been properly positioned, signals were recorded from the reflecting surface element by element, operating in pulse-echo mode. For a given spherical reflector, the data acquisition and analysis procedures were essentially identical to the Type-I transducers. Again, for a given transducer, the measured standard deviations in the echo arrival times served as a goodness parameter for assessing piezoelectric element positioning along the transducer surface. In tabulating the results presented here, the deviations about the mean arrival time for the three different spherical sections of the transducer surface were analyzed together directly. It is noted that a given error in spatial position of an element will produce the same deviation in arrival time, regardless of the length of water path between the transducer and reflector. It is, therefore, appropriate to compare the deviations in arrival time obtained from the different spherical sections directly, even though different water paths were used to collect the data on the spherical sections. A conservative criterion for an acceptable error in element phasing is 1/8 wavelength. For a 10-MHz transducer operating in pulse-echo, this translates into an increment in pulse arrival time of 25 nsec. It is seen that the observed standard deviation in arrival time is well below this value, indicating that errors in focusing due to surface geometry anomalies should be minimal.

The TOF standard deviation results are summarized in figure 44.



Manufacturer:	A	A	A
PA Serial No.:	3446-A101	3446-B101	3446-B102
Std. Dev. (ISU)	12.92	12.54	10.54
Std. Dev. (PW)	9.44	11.71	9.03
Std. Dev. (HW)	9.58	10.04	9.08
Average	10.6	11.4	9.5
Std. Deviation	1.97	1.28	0.86

Figure 44. Measured Standard Deviation in Individual Element Echo Arrival Times for Type-II Phased Arrays

2.2.12 Summary of Phased Element Measurements.

Overall, the transducers examined in this study did not display a large variability in performance when compared to past observations of variability in conventional transducers. This is likely due to the care with which phased array transducers are manufactured. This fact is reflected in the cost of phased array transducers, which are often an order of magnitude more expensive than conventional transducers. For example, off-the-shelf, commercially available transducers may cost several hundred dollars, whereas the phased arrays studied here range from $7,000 to $15,000. When considering the 15-element phased array, the performance variability appeared roughly the same between the two manufacturers. The most significant difference between the two manufacturers was in the substantially greater piezoelectric efficiency displayed by the supplier A transducer. The significance of this difference on inspection performance is not clear, however, since this issue affects the level of electronic noise present in the measured signals. The inspection of Ti forgings examined by the ETC is predominantly limited by material noise, with electronic noise being a minor contributor. A summary of observations includes the following:

- For the 15-element Type-I transducers:

  - The supplier A transducer achieved a slightly tighter focus, with a smaller variation probe to probe.

  - The supplier A transducer had a mean center frequency of 10.8 MHz, and the supplier B transducer had a center frequency of 11.7 MHz. The variation of these mean values was small.

  - Transducers from both manufacturers had a comparable bandwidth, with small variations about the mean.

  - The FBH amplitude from the supplier A transducer was 14 dB greater than the FBH signal from the supplier B transducer. The variation about the mean signal level was comparable between the two manufacturers.

  - The individual element deviation from the mean TOF from the reference reflector was comparable between the two manufactures. The observed TOF variation was of insufficient magnitude to impact array-phasing performance.

- For the 110-element Type-II transducers:

  - A beam width of 31 mil was observed at 0.7″ and 48 mil at 2.5″. A small variation in beam diameter was observed at 0.7″. The variation between transducers was somewhat larger at 2.5″.

  - A mean center frequency of 11.3 MHz was observed at 0.7″ and 9.79 MHz at 2.5″. The reduction in center frequency, likely due to material attenuation, is a possible explanation for the increase in beam diameter observed at a 2.5″ depth. The variation in center frequency observed between transducers was comparable to the variation observed between the laboratories.

  - mean bandwidth of 63% is observed at 0.7″ and 56% at 2.5″. The range of variation in bandwidth observed between laboratories was comparable or exceeded that observed between transducers.

  - The FBH amplitude observed at 0.7″ displayed consistency between transducers and laboratories. The FBH amplitude observed at 2.5″ displayed a substantial difference between laboratories, but a fairly consistent response between transducers.

  - The observed TOF variation among individual array elements was of insufficient magnitude to impact array-phasing performance.

2.3 TRANSDUCER DESIGN STUDY.

The approach to forging surface curvature is to insert a mirror into the water path having a curvature which pre-distorts the ultrasound beam in a fashion complementary to the distortion caused by refraction at the curved entry surface [1]. When properly designed, the net effect of the mirror is to greatly reduce the distortion to the ultrasound beam due to surface curvature. Use of mirrors to correct for surface curvature is a long-established practice in conventional ultrasonic inspection. The challenge in this work is to implement the use of mirrors for large-aperture, highly focused beams and to operate the mirrors over a large range of focal depths. The configuration of the surface curvature-compensating mirror was described in reference 1. Although the approach of using mirrors has been proven to achieve very good results, it still requires careful design, manufacture, and setup of the mirror transducer combination. Also, each significantly different radius of curvature would require its own unique mirror. Another potential way of dealing with forging surface curvature is to attempt to design phased array probes that are capable of compensating for these different curvatures. This effort was aimed at exploring the possibility of designing phased array probes capable of maintaining an F6 focus down to 4.0″ below the entry surface in Ti-6Al-4V forgings through curved entry surfaces with different radii of curvature without the use of mirrors. The detection sensitivity goal is that of #1/2 FBH throughout all the zones with at least 3 dB signal to noise.

2.3.1 Design Criteria.

The ETC technical team adopted the following design criteria:

- The designed probe or probes should have a 10-MHz center frequency and a bandwidth greater than 60%.

- The ultrasonic beam diameter throughout the depth of each of the zones (outlined in table 12) in Ti-6Al-4V should be less than or equal to 0.045″.

- Maintain the above conditions in Ti-6Al-4V using 3″ water path through curved surfaces with the radii of curvature shown in table 13.

- The phase variation at 10 MHz over any transducer element never exceeds 60 degrees. This condition is illustrated in figure 45.

- All elements preferably have equal area but need to explore the design option of nonequal area elements.

Table 12. The Zone Configuration Used in the Inspection of Ti-6Al-4V Forgings

Zone No.	From (in.)	To (in.)
1	0.0000	0.4375
2	0.4375	0.8750
3	0.8750	1.3125
4	1.3125	1.7500
5	1.7500	2.1875
6	2.1875	2.6250
7	2.6250	3.0625
8	3.0625	3.5000
9	3.5000	3.9375

Table 13. The Types and Radii of Curvature Associated With the Curved Surfaces Under Consideration

Surface Type	Convex	Convex	Concave	Concave	Convex
Surface Radius (in.)	15.62	12.21	-11.83	-14.7	11.33

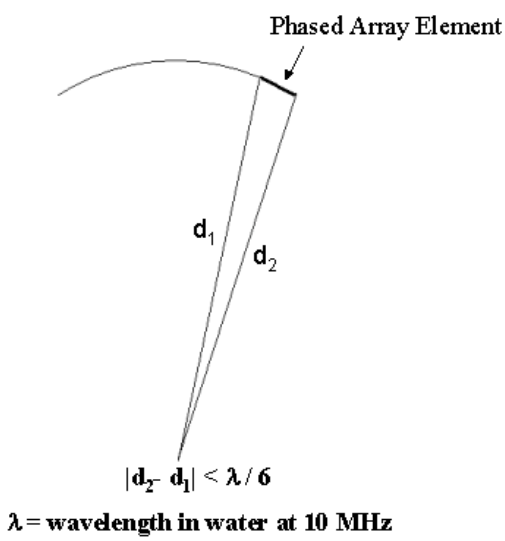


Figure 45. Illustration of the 60° Phase Variation Constraint on the Face of Each Individual Element on the Surface of the Desired Phased Array Probe

To explore the state of the art in phased array transducer design, two well-established vendors in the area of phased array probe design were contracted to provide the desired designs. Suppliers A and E were to consider the design requirements and engineer phased array probes that are capable of meeting these design constraints. The ETC technical team then studied the results of the two design exercises for consideration in future efforts. It should be mentioned here that the hardware constraints imposed by the electronics to be used to drive these phased array probes, such as the number of available channels and the number of delay generators, have not been emphasized in these exercises as the interest was in exploring the possibility of being able to address the previously outlined design criteria with the minimum number of probes. Imposing such hardware constraints is likely to result in a larger number of phased array probes needed to meet the desired inspection scenarios. In the remainder of this report, a summary of the results obtained by the two vendors is presented.

2.3.2 Design Results From Supplier A.

Based on the ETC transducer design criteria, supplier A undertook a design process that used the following assumptions:

- One transducer was provided for each curvature type (convex and concave)
- The transducer had a Fermat surface.
- The elements were divided in order to obtain a sectorial annular array.
- The elements were grouped by belts. Each belt was defined to obtain a constant angle at the desired depth of inspection. The angle was given by the F6 constraint (see figure 46).
- The sectorization of the elements was chosen to maintain in the zone of interest and the zones below a phase variation less than 60° (16.6 ns) at 10 MHz.
- Variable area elements were allowed in the design.

For the concave surfaces (concaved up) with radii of curvature of -11.82″ (-300 mm) and -14.7″ (-373 mm), a water path of 3″ (76.2 mm) was used. The assumed Fermat surface was focused at 3.66″ (93 mm) in a Ti piece with radius of curvature of -13.27″ (-337 mm). This is the average radius of the radii of curvature of interest and was chosen to minimize the phase variation. The resulting transducer had 74 rings with a total of 1551 elements before taking the design symmetries into consideration. The number of elements was reduced to 461 elements when these symmetries were considered. Figure 47 shows the top view of the resulting transducer with only belts and sectors shown on the figure (the Y axis is parallel with the axis of the piece).

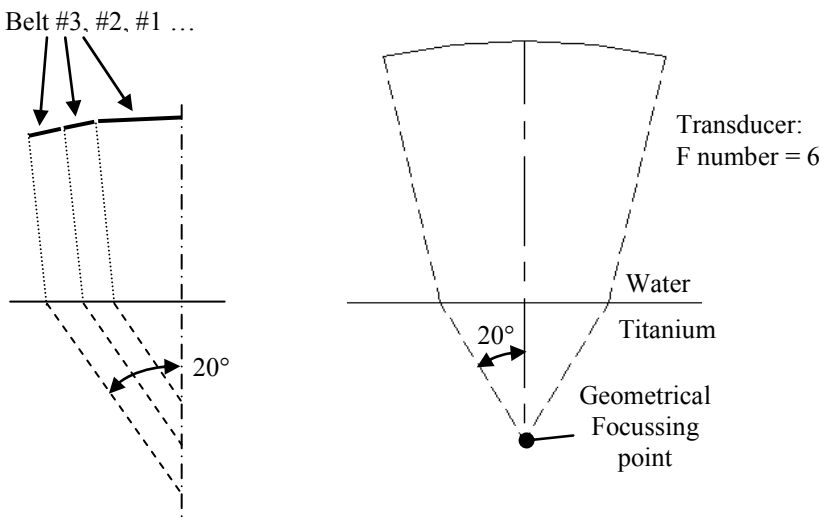


Figure 46. A Schematic Illustrating the Grouping of Elements Into Belts Defined to Obtain a Constant Angle at the Desired Depth of Inspection (The angle is given by the F6 constraint.)

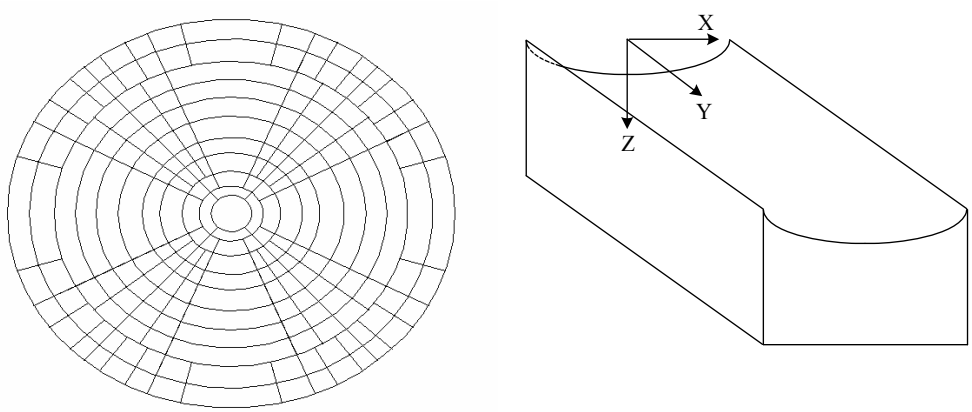


Figure 47. Top View of the Resulting Transducer for a Concave Entry Surface With a -13.27″ Radius of Curvature (Only the belts and sectors are shown on the figure. Also shown is a schematic of the entry surface.)

Table 14 shows detailed definition of the sectorization of the elements on the face of the transducer. Note that, for example, belt 1 is divided into three rings to allow a variable number of elements per ring. The transducer consists of 11 belts that are further subdivided into rings and elements. Figure 48 shows the maximum variation of phase at 10 MHz for all elements of belts 1 through 11. The lines give the maximum phase, which is computed for the two radii of curvature of interest, namely, -11.82″ (-300 mm) and -14.7″ (-373 mm).

Table 14. Detailed Definition of the Sectorization of the Elements on the Face of the Transducer for a Concave Entry Surface With a -13.27″ Radius of Curvature

Belt No.	External Dimensions (mm)	Number of Rings in the Belt	Zones to be Explored	Number of Elements per Ring
1	3.21 x 3.57	3	1 to 9	1
2	4.83 x 5.64	4	1 to 9	4
3	7.45 x 8.7	8	1 to 9	20
4	10.7 x 12.5	10	2 to 9	20
5	13.4 x 15.6	8	3 to 9	20
6	17.1 x 19.9	8	4 to 9	20
7	20.4 x 23.8	7	5 to 9	20
8	23.6 x 27.4	7	6 to 9	20
9	26.9 x 31.1	7	7 to 9	20
10	30.7 x 35.5	6	8 to 9	36
11	34.2 x 39.4	6	9	36

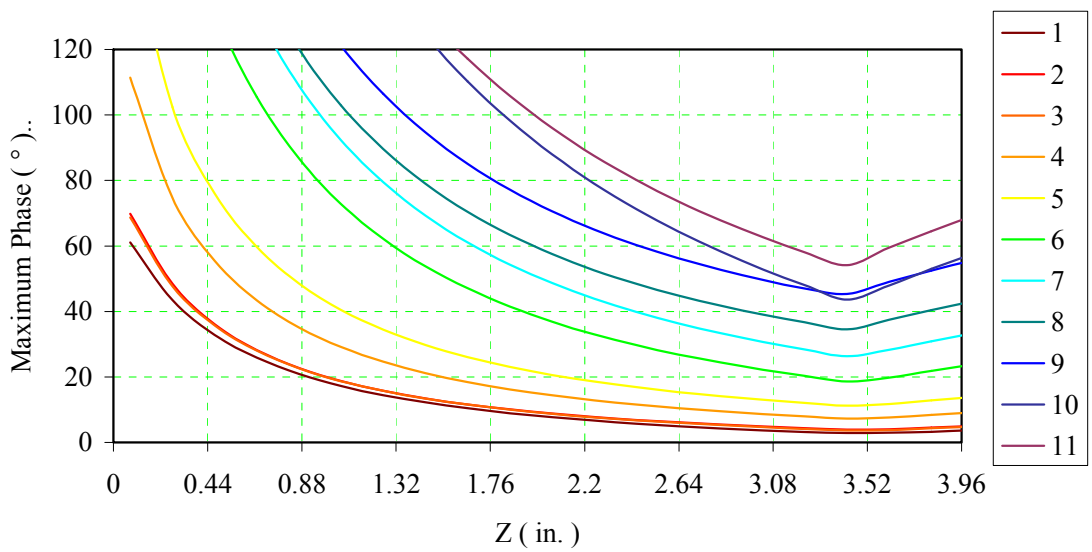


Figure 48. The Maximum Variation of Phase at 10 MHz for all Elements of Belts 1 Through 11 (The lines give the maximum phase, which is computed for the two radii of curvature of interest, namely, -11.82″ (-300 mm) and -14.7″ (-373 mm))

Figure 49 shows the resulting -6 dB maximum beam spot size calculated for radii of curvature of -11.82″ and -14.7″. In these calculations, investigations were limited to zones 1, 4, and 9. The total number of elements on the face of this transducer is so high that it cannot be totally described in the CIVA UT simulation software used by supplier A. Therefore, the researchers were forced to simplify the cutting of the transducer in the process of simulating the UT beam in zones 4 and 9. This simplified cutting of the transducer elements is reflected in table 15. It should be noted also that the CIVA software considers all the elements on the face of the

transducer to have the same amplitude displacement. CIVA does not take into account the effect of variable electrical impedance due to nonequal surface area of the different elements. This effect should be considered at the manufacturing stage. The three-dimensional (3D) coordinates of the points describing each element on the face of this transducer are listed in the tables included in appendix E.

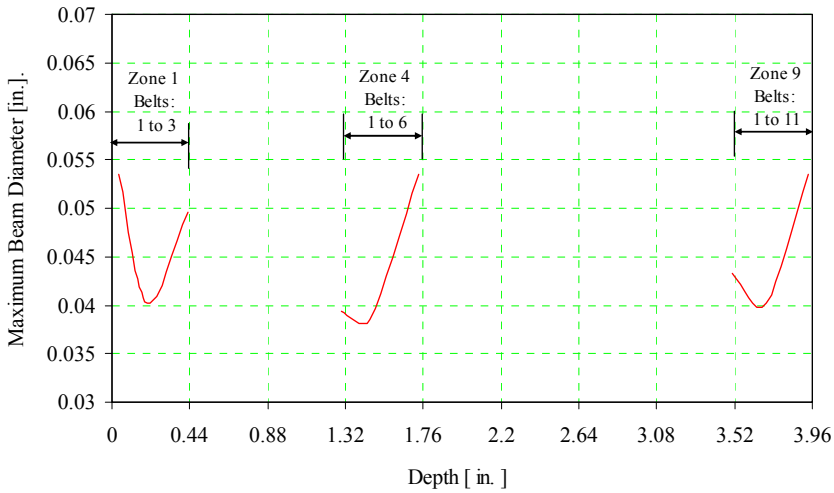


Figure 49. The Resulting -6 dB Maximum Beam Spot Size Calculated for Radii of Curvature of -11.82″ and -14.7″ (Concave Surface) (The actual radii of curvature of interest as defined in the design criteria in the selected zones.)

Table 15. Modified Element Cutting for the Simulation of the Ultrasonic Beam for a Concave Entry Surface in Zones 4 and 9

Belt No.	Number of Elements per Ring
1	1
2	1
3	1
4	4
5	4
6	4
7	4
8	4
9	4
10	8
11	8

(Note that the number of rings per belt is not changed.)

Similar analysis was performed by supplier A for the case of a convex surface (concave down). In this case, the radii of curvature of interest were 11.33″ (288 mm), 12.21″ (310 mm), and 15.62″ (397 mm). The water path was again set to 3″ (76.2 mm). The assumed Fermat surface was focused at 3.54″ (90 mm) in a Ti piece with radius of curvature of 13.39″ (340 mm). Again,

this is the average radius of the radii of curvature of interest and was chosen to minimize the phase variation. The resulting transducer had 89 rings with a total of 1234 elements before taking the design symmetries into consideration. The number of elements was reduced to 396 elements when these symmetries were accounted for. Figure 50 shows the top view of the resulting transducer with only belts and sectors shown on the figure (the Y axis is parallel with the axis of the piece).

Table 16 shows detailed definition of the sectorization of the elements on the face of the transducer. Note, for example, belt 1 is divided into six rings to allow variable number of elements per ring. The transducer consists of 11 belts that are further subdivided into rings and elements. Figure 51 shows the maximum variation of phase at 10 MHz for all elements of belts 1 through 11. The lines give the maximum phase that is computed for the two extreme radii of curvature of interest, namely, 11.33″ (288 mm) and -15.62″ (397 mm).

Figure 52 shows the resulting -6 dB maximum beam diameter calculated for radii of curvature of 11.33″ and 15.62″ that are the actual radii of curvature of interest, representing the extreme cases as defined in the design criteria. Again, in these calculations, investigations were limited to zones 1, 4, and 9. The total number of elements on the face of this transducer is again so high that it cannot be totally described in the CIVA UT simulation software. Therefore, similar to the concave case, supplier A was forced to simplify the cutting of the transducer in the process of simulating the UT beam in zones 4 and 9. This simplified cutting of the transducer elements is reflected in table 17. The 3D coordinates of the points describing each element on the face of this transducer are listed in the tables included in appendix F.

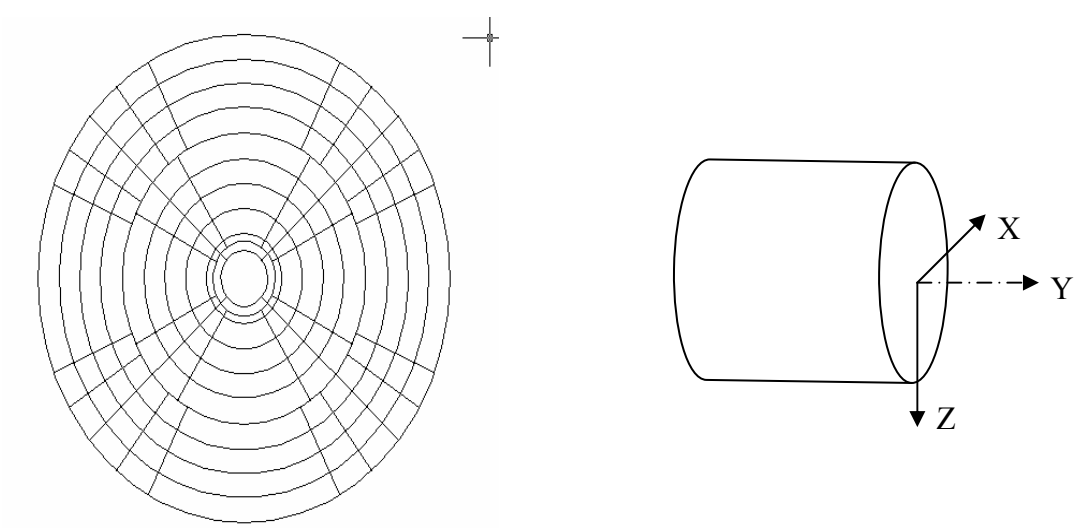


Figure 50. Top View of the Resulting Transducer for a Convex Entry Surface With a 13.56″ Radius of Curvature (Only the belts and sectors are shown on the figure. Also shown is a schematic of the entry surface.)

Table 16. Detailed Definition of the Sectorization of the Elements on the Face of the Transducer for a Concave Entry Surface With a -13.27″ Radius of Curvature

Belt No.	External Dimensions (mm)	Number of Rings per Belt	Zones to be Explored	Number of Elements per Ring
1	5.1 x 4.5	6	1 to 9	1
2	6.8 x 5.9	4	1 to 9	4
3	8.2 x 7.2	4	1 to 9	12
4	12.7 x11.1	12	2 to 9	12
5	17.2 x 15.1	12	3 to 9	12
6	21.6 x 19.0	9	4 to 9	12
7	26.3 x 23.2	9	5 to 9	12
8	31.0 x 27.4	9	6 to 9	20
9	35.4 x 31.3	8	7 to 9	20
10	39.7 x 35.1	8	8 to 9	20
11	44.2 x 39.3	8	9	20

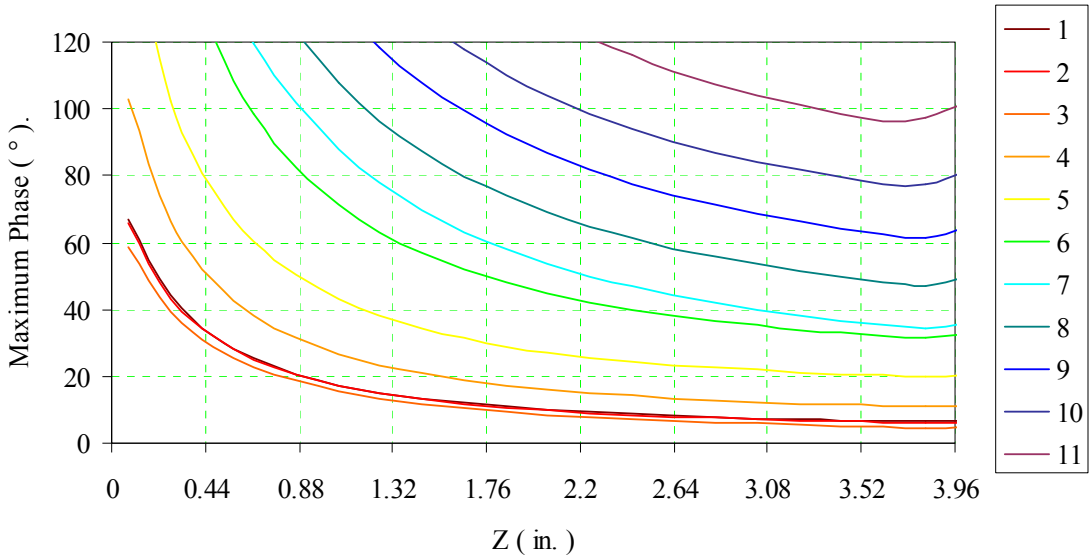


Figure 51. The Maximum Variation of Phase at 10 MHz for all Elements of Belts 1 Through 11 (The lines give the maximum phase, which is computed for the two extreme radii of curvature of interest, namely, 11.33″ (288 mm) and -15.62″ (397 mm.)

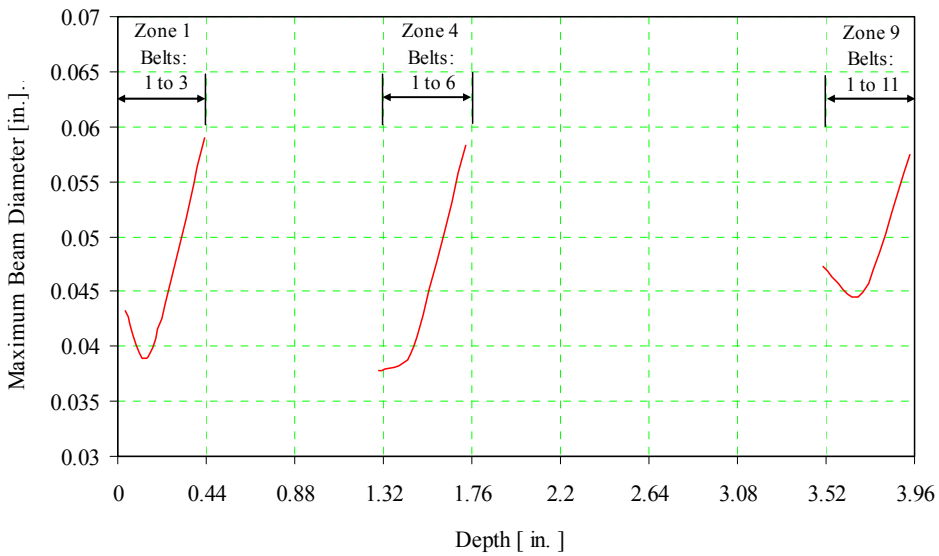


Figure 52. The Resulting -6 dB Maximum Beam Diameter Calculated for Radii of Curvature of 11.33″ and 15.62″ (Convex Surface) (The actual radii of curvature of interest as defined in the design criteria in selected zones.)

Table 17. Modified Element Cutting for the Simulation of the Ultrasonic Beam for a Convex Entry Surface in Zones 4 and 9

Belt No.	Number of Elements per Ring
1	1
2	1
3	1
4	4
5	4
6	4
7	4
8	4
9	4
10	8
11	8

(Note that the number of rings per belt is not changed.)

From the above results it is very clear that for the two transducers, using the previously outlined design assumptions gives a high number of elements, which implicitly requires a much more capable electronic driving system with a much larger number of channels than exists currently. The manufacturing of such transducers is very difficult and very expensive because of the large number of elements and the size of the elements (sometimes 0.2 mm wide and several millimeters long). A large number of elements means a large, cumulated nonactive area that decreases the efficiency of the device. The elements will not have the same electrical impedance

and then the homogeneity of the transducer will be affected. Simulations done using CIVA showed that the transducer defined by supplier A for the concave entry surface will give a maximum -6 dB beam spot size of 54 mil (20% higher than the 45-mil target), whereas for the case of the convex entry surface, the maximum resulting -6 dB spot size is 59 mil (31% higher than the 45-mil target).

2.3.3 Design Results From Supplier E.

Supplier E took a different approach to the design of the needed transducers. Their design assumption took into account that the transducer elements should, if possible, have equal area elements and should require fewer than 32 independent delays (128 total elements) to meet the limitations of today's phased array-driving electronics. Each element should experience no more than a maximum of 60 degrees of phase variation in any inspection condition. A supplier E optimized probe design method was used. This method was based on the determination of the array shape, which minimizes the number of elements required to satisfy the inspection criteria. Instead of the actual number of elements, the technique minimizes a related quantity that involves line integrals of the maximum phase rate on the probe face. The maximum phase rate is taken with respect to all inspection conditions, which in this problem, consist of the inspected depth points from 0.05″ to 4.0″ inside the different geometries.

The line integrals are taken along element subdivision parametric curves. These parametric curves may be chosen by the designer. For normal incidence-focusing applications, radial lines and generalized ellipses are natural element boundaries. The maximum phase rate line integral along each radial spoke reveals ring-break points. These ring-break points are the intersections of the ring-shaped element boundaries with that radial spoke.

In this effort, only radial lines were studied, yielding the number of rings required. The specific number of sectors per ring required by phase variation considerations is determined once it is decided which design option to pursue further. In any case, it is expected that the degree of sectorization imposed by the need to equalize element areas will surpass the sectorization needed to satisfy phase variation consideration; therefore, the radial spoke study combined with area variation minimization presents a nearly complete picture. The radial profiles were represented by polynomial curves (of order 2, 3, 4, or 5), with each curve constrained to have zero slope at the origin. Profiles at different azimuths were studied separately.

Supplier E presented preliminary results of the optimization to allow the ETC team to make a decision on which design scenario is most suitable to satisfy ETC needs. Based on this selection supplier E completed the design that was selected by the ETC technical team. The different design options are presented first, and then the details of the designs selected by the ETC team from among the different possible options follow, as discussed in section 2.3.4.

2.3.4 Discussion of Trade-Offs.

It is clear that there may not exist a transducer that satisfies the need for 32 or fewer independent elements. It is, therefore, helpful to think of strategies to relax the problem statement without violating its intent. Intuitively, it is expected that the number of elements required to satisfy the problem statement will be lower when

- separate transducers are used for the convex and concave cases.
- higher polynomial orders are used in the optimization process.
- the water path is allowed to vary separately for each geometry.

Supplier E used its patent-pending optimized probe design method to obtain transducer shapes meeting variations on the problem statement. Each variation entailed some trade-offs.

- Two transducers must be designed and built instead of one.

- The manufacturing complexity and transducer cost is increased as polynomial orders in the optimization process are increased.

- Changing the water path could involve additional scanning complexity if the various curved surfaces are on the same part. If they are on different parts or if their position on the parts is different, changing the water path presents no additional complexity as long as the water path change is not so large as to contaminate the signal with water multiples, cause undue attenuation of the signal, or render the probe size impractically large.

2.3.5 Results—Minimum Number of Rings.

The first study involved a probe design satisfying the two geometrical extremes in the problem statement: radii of curvature of 11.33″ and -11.82″. Any probe capable of satisfying these two extremes will be very close to satisfying all radii of curvature in the problem statement.

Studying the radial spoke at theta = 0 with a polynomial probe shape of order 5 reveals that a minimum of 74 ring breaks are required to satisfy a 60 degree maximum phase variation over each ring. Allowing the water path of the 11.33″ probe to vary helps to reduce the number of rings to about 69. The concave geometry requires 30-35 mm of radial aperture while the convex cases requires 40-45 mm. It is possible that using a probe-shaped functional form allowing the representation of two separate regimes—one covering the region between 0 and 30-35 mm where both convex and concave shapes are in play and one covering the region between 30-35 and 40-45 mm—would reduce this number a bit more. However, it is not expected that this effort will yield anywhere close to the required 32 rings.

Therefore, two separate probe designs were studied for convex and concave geometries. The minimum number of rings along the radial spoke as a function of polynomial order and the use of water path perturbation were determined. The results are shown in tables 18 and 19.

Table 18. Minimum Number of Rings for 10-MHz Transducer Optimized for Convex Geometries With Radii of Curvature 15.62″, 12.21″, and 11.33″

Probe Design	2nd Order Polynomial	3rd Order Polynomial	4th Order Polynomial	5th Order Polynomial
Constant water path	42	34	34	33
Varying water path	42	33	32	32

Each component is inspected at normal incidence from 0.05″ to 4.0″ depth, maintaining a 0.045″ beam diameter.

Table 19. Minimum Number of Rings for 10-MHz Transducer Optimized for Concave Geometries With Radii of Curvature -14.7″ and 11.82″

Probe Design	2nd Order Polynomial	3rd Order Polynomial	4th Order Polynomial	5th Order Polynomial
Constant water path	41	33	30	30
Varying water path	41	32	30	30

Each component is inspected at normal incidence from 0.05″ to 4.0″ depth, maintaining a 0.045″ beam diameter.

The most striking result is the sharp reduction in number of rings as the polynomial order increases from 2 to 3. The polynomial of order 2 corresponds roughly to a circular cross section, which would be easy to manufacture. However, the two tables show that great benefit is enjoyed if a complex probe profile is allowed—approximately 10 rings are eliminated in both the concave and convex cases.

2.3.6 Results—Constant-Area Elements.

If the goal is to ensure constant-area elements, the optimizations in tables 18 and 19 do not yield the best results. In a constant-area design, the element size is set by the smallest ring area. All other rings must be sectorized down to this value of area.

The number of equal-area elements in a design is easily estimated as the total area of the aperture divided by the smallest ring area. The best design for equal-area elements, therefore, consists in maximizing the smallest ring area. This of course comes at the cost of a larger number of rings. The results of this analysis are presented in tables 20 and 21. It should be noted here that for the results presented in these tables, for both cases, a polynomial of order 5 with no water path perturbation was used. It can be seen from table 20 that designing based on constant-area elements for the convex case led to a 33% increase in the number of rings but a 33% decrease in the total number of elements. Similarly, for the concave case, designing based on constant-area elements led to a 33% increase in the number of rings but a 25% decrease in the total number of elements.

Note that in both the convex and concave cases that the area equalization designs require more than 32 independent delays and, therefore, cannot be implemented on a 32-channel phased array system. If the element areas are allowed to vary to some degree, a sectorized version of the minimum number of ring design may be possible without excessive impedance mismatch or violation of the hardware limitations. For rigorously constant areas, a separate transducer could be used for each geometry. However, table 22 shows, using the radius of curvature 11.33″ as an example, that using one transducer per geometry cannot reduce the number of elements below 128. Satisfying the problem statement requires either varying area elements or using more powerful hardware, even when a separate transducer is used for each geometry.

Table 20. Comparison of Convex (Radii of Curvature = 15.62″, 12.21″, and 11.33″) Geometry Optimization Strategies Based on Minimization of Number of Rings or Minimization of Number of Elements Sectorized Based on Constant Area

	Design for Minimum Number of Rings	Design for Maximum Smallest Ring Area
Number of rings	33	45
Smallest ring area (mm^2)	20	30
Minimum number of elements (varying area)	33	45
Minimum number of elements (constant area)	250	168

Table 21. Comparison of Concave (Radii of Curvature = -14.7″-11.82″) Geometry Optimization Strategies Based on Minimization of Number of Rings and Maximum Smallest Ring Area

	Design for Minimum Number of Rings	Design for Maximum Smallest Ring Area
Number of rings	30	41
Smallest ring area (mm^2)	15	20
Minimum number of Elements (Varying Area)	30	41
Minimum number of elements (constant area)	188	141

Table 22. Comparison of Radius of Curvature 11.33″ Geometry Optimization Strategies Based on Minimization of Number of Rings and Maximum Smallest Ring Area

	Design For Minimum Number of Rings	Design For Maximum Smallest Ring Area
Number of rings	24	31
Smallest ring area (mm^2)	23	33
Minimum number of elements (varying area)	24	31
Minimum number of elements (constant area)	218	152

In both cases a polynomial of order 5 with no water path perturbation was used.

To summarize, given hardware with sufficient number of channels, i.e., a 128/512 system perhaps, a single transducer could be constructed to meet the problem statement. If 32/128 hardware is to be used, the problem statement must be segmented into concave and convex regions, and the transducer must be allowed to have varying element areas. Segmenting the problem further to provide one transducer per geometry does not yield designs with fewer than 128 elements. Varying area designs cannot be avoided for this application unless more powerful hardware is made available.

2.3.7 Detailed Design Results From Supplier E.

Following the preliminary results included in the previous section, supplier E proceeded to complete the design of two separate 10-MHz transducers optimized for convex and concave radii of curvature in the ranges 11.33″ to 15.62″ and -14.7″ to -11.82″, respectively. Using their patent-pending probe optimization algorithm, they have successfully designed two probes covering the desired curvature ranges, and maintained a 0.045″ or less focal spot size to a depth of 4.0″. Both of these transducers can be used with today's 32/128 phased array-driving electronics. The probe shape and sectorization were carefully designed, and complete detailed modeling was performed to verify the designs. The detailed results are provided in the following sections.

It had been concluded from the preliminary results (section 3.2.6) that each transducer would require a minimum of about 32 rings to keep a 0.045″ beam spot size to 4″ depth in each geometry.

As part of the supplier's optimized probe design technique, the water path can be made a design variable along with the array shape to see if it can help reduce the number of elements while accommodating different geometries. The preliminary results showed that varying the water path had negligible impact on the minimum number of ring boundaries that need to be crossed along any radial line emanating from the center of the array.

During the sectorization step of the design, however, water path plays a much more important role because it affects the shape of constant phase ellipses on the array. A poor choice of water path can lead to phase variation ellipses that are not consistent with the shape of the rings, thereby requiring a large number of sectors and driving up the number of elements. Once the sectorization was factored into the optimization process, optimal water paths quickly migrated away from the nominal 3″ for the extremes in radii both in the convex and concave cases. It turns out that a water path variation from 2.15″ to 3.9″ as the convex radius varies from 15.62″ down to 11.33″ ensures identically shaped phase contours without increasing the number of rings. Similarly, concentric ellipses are ensured by varying the water path from 2″ to 4″ as the concave radius varies from -14.7″ to -11.82″.

The fortuitous result of concentric phase contours implies that the acoustics demand little or no sectorization of the array. In essence, each array could be built with as few as 32 ring elements. However, the extreme area variation in such a design would lead to detrimentally large impedance variations. Therefore, sectorization is imposed by the electrical and piezoelectric realities of probe manufacture. The sectorization has the added advantage of providing what

little phase adaptation may be required around each ring while also providing for apertures that are not concentric to the rings in the array.

Sectorization would be trivial if it were not for limitations imposed by phased array hardware. Although upcoming phased array systems may support 128 independent channels, multiplexed to 512 (128/512), the design specifications in this project expressed the desired to use an array that can be powered by currently available 32/128 hardware. As was already discussed in section 3.2.6, it is not possible to satisfy the constant area requirement with only 32 independent pulsers. The sectorization process, therefore, involves a delicate balance between maximum area variation and number of elements.

To increase the number of elements as much as possible, delay generators are reused. The central rings for example take up one delay generator, but leave three multiplexed counterparts unused. The delay generator is reused at larger apertures by disabling the corresponding inner ring in favor of two or three sectors on a larger outside ring. At the larger apertures, the area of the inner rings is a negligible fraction of the total aperture, so this process has little effect on the beam. On outer rings, the multiplexed counterparts of an inner ring are arranged as sectors following the four-way symmetry of the problem. When two counterparts are used, they are placed opposite to each other so that the unique delay with which the system is able to fire happens to be the correct delay for both. When three counterparts are used, they are placed at three of four symmetrically located positions, with the fourth location left unconnected to the system. These unconnected elements form a small part of the aperture, and the extensive modeling results confirm that they have a negligible impact on the beam spot size, which is in no case larger than 0.043″ at any depth in the tested range of 0.2″ to 4.0″.

Supplier E took advantage of the two probes to try slightly different philosophies. The convex probe emphasizes active sectors, with a lower level of sharing multiplexed counterparts (maximum 12 disabled elements) and a resulting high degree of variation in element surface area (factor of 8 variation in area). The concave probe on the other hand emphasizes area uniformity at the cost of increased sharing of multiplexed counterparts. It has as many as 14 disabled elements for the largest aperture; however, it maintains a factor of 3 variation in area. The differences in area variation and disabled elements cannot be directly compared between the two probes because the convex probe has a greater variation in ring width.

The following sections detail the design results and the supporting modeling and simulation results are presented in appendices G and H.

2.3.8 Probe Design for Concave Geometries (Detailed Results).

Table 23 shows the specifications of supplier E convex and concave probe designs. For the concave case, note that a water path range from 2.0″ to 4.0″ is needed for the inspection of the concave radii of curvature of -14.7″ to -11.82″. The resulting number of rings is 30, with a total of 123 elements. The minimum element area is 12 mm^2, and the maximum area is 36 mm^2, which results in an element area ratio of 3. The number of permanently disabled elements is 6, and the maximum number of elements disabled in any possible inspection scenario is 14.

Table 23. Specifications of Supplier E Convex and Concave Final Probe Designs

Parameters	Convex	Concave
Radius range	11.33″ to 15.62″	-14.7″ to -11.82″
Water path range	2.15″ to 3.9″	2.0″ to 4.0″
Number of rings	28	30
Number of elements	117	123
Minimum element area	12 mm^2	12 mm^2
Maximum element area	95 mm^2	36 mm^2
Permanently disabled elements	4	6
Maximum disabled elements	12	14

Figure 53 shows the top view of the resulting transducer with the rings and elements shown on the face of the transducer (the X axis is parallel with the axis of the piece). The surface of the probe was calculated for the radius of curvature of -13.27″ (-337 mm). This is the average radius of the radii of curvature of interest and was chosen to minimize the phase variation. Note that the white areas on the face of the transducer correspond to missing elements by design. This point is mainly done to properly take advantage of the reusing of previously used delay generators.

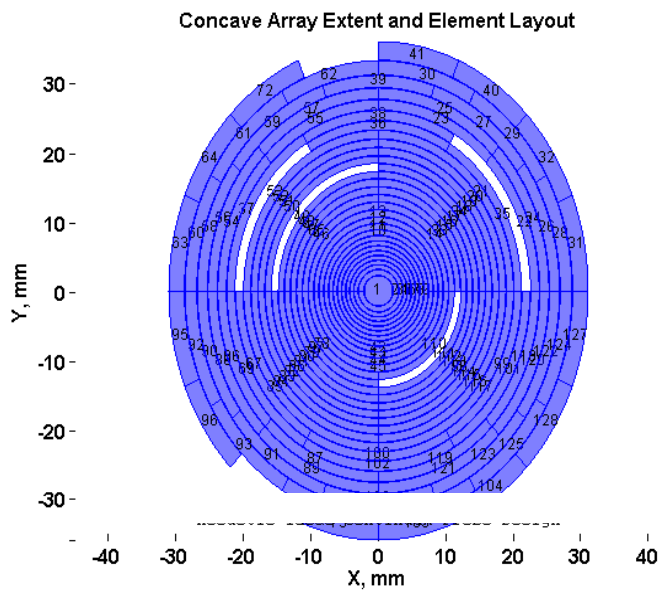


Figure 53. Top View of the Resulting Supplier E Transducer Design for the Concave Entry Surface With the Rings and Elements Shown on the Face of the Transducer

Figure 54 graphically illustrates the element area variation as a function of ring number on the face of the transducer. It is clear that the minimum element area is 12 mm^2, and the maximum element area is 36 mm^2, which results in a factor of 3 element area variation. Figure 55 shows the resulting transducer profiles in the (a) axial and (b) hoop directions for the case of the concave entry surface designed by supplier E.

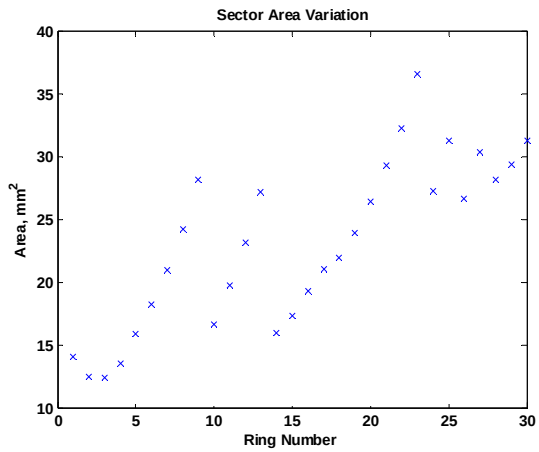
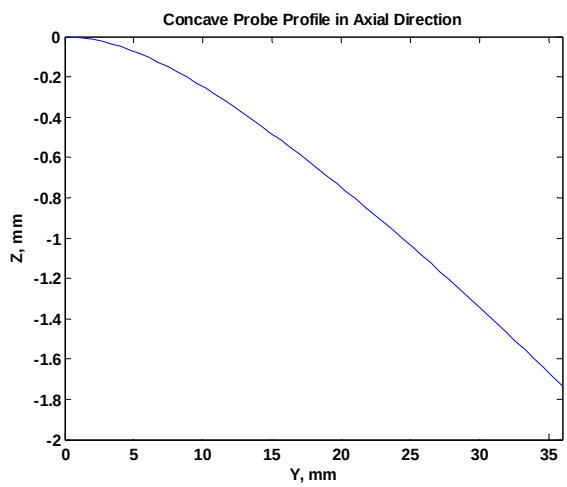
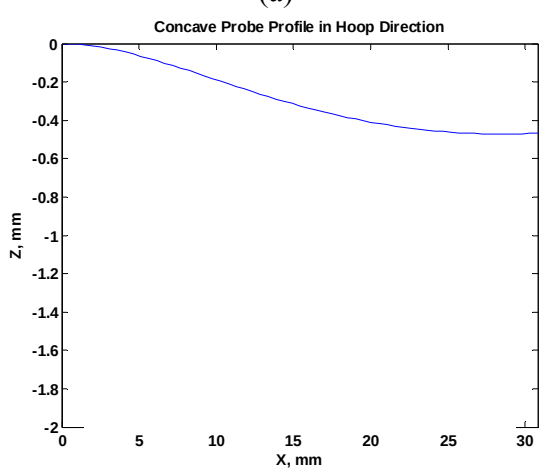


Figure 54. Element Area Variation as a Function of Ring Number



(a)



(b)

Figure 55. The Resulting Transducer Profiles in the (a) Axial and (b) Hoop Directions (Concave)

Several simulations were performed to assess the resulting beam profile spot size and assess the phase variation for the elements on the face of the resulting transducer design. Appendix G summarizes the extensive results from these simulations for all the radii of curvature of interest. Also included in appendix G is a detailed listing of all the elements on the face of the probe. It should be mentioned here that the UT beam spot diameter did not exceed 0.043″ for the inspection scenarios simulated. The phase variation was nominally held to 60 degrees with an occasional 20% deviation from this value, which was verified through these simulations to have negligible effect on the resulting UT beam.

2.3.9 Probe Design for Convex Geometries (Detailed Results).

For the convex case, note that (see table 23) a water path range from 2.15″ to 3.9″ is needed for the inspection of the convex radii of curvature of 15.62″ to 11.33″. The resulting number of rings is 28, with a total of 117 elements. The minimum element area is 12 mm^2, and the maximum area is 95 mm^2, which results in an element area ratio of approximately 8. The number of permanently disabled elements is 4, and the maximum number of elements disabled in any possible inspection scenario is 12.

Figure 56 shows the top view of the resulting transducer with the rings and elements shown on the face of the transducer (the X axis is parallel with the axis of the piece). The surface of the probe was calculated for the radius of curvature of 13.48″ (-342 mm). This is the average radius of the radii of curvature of interest and was chosen to minimize the phase variation. Note that the white areas on the face of the transducer correspond to missing elements by design. This is again mainly done to properly take advantage of reusing previously used delay generators as was previously discussed in section 2.3.8.

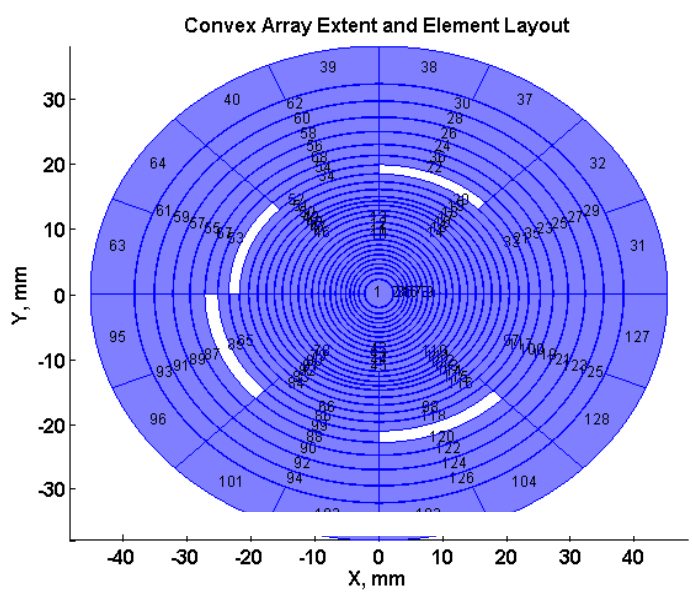


Figure 56. Top View of the Resulting Supplier E Transducer Design for the Convex Entry Surface With the Rings and Elements Shown on the Face of the Transducer

Figure 57 graphically illustrates the element area variation as a function of ring number on the face of the transducer. It is clear from the figure that the minimum element area is 12 mm^2, and the maximum element area is 95 mm^2, which results approximately in a factor of 8 element area variation. Figure 58 shows the resulting transducer profiles in the (a) axial and (b) hoop directions for the case of the convex entry surface.

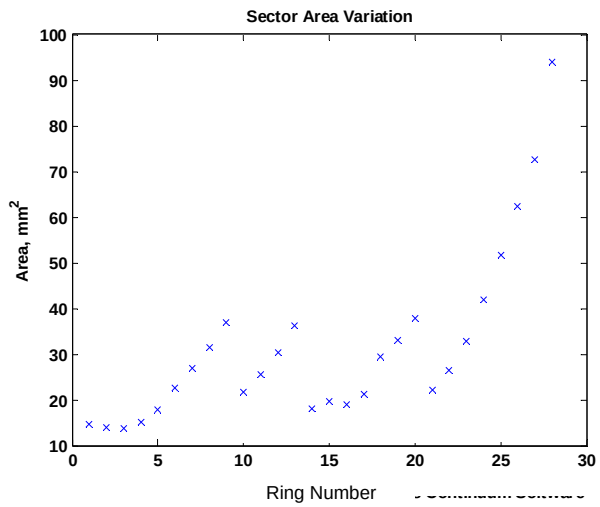
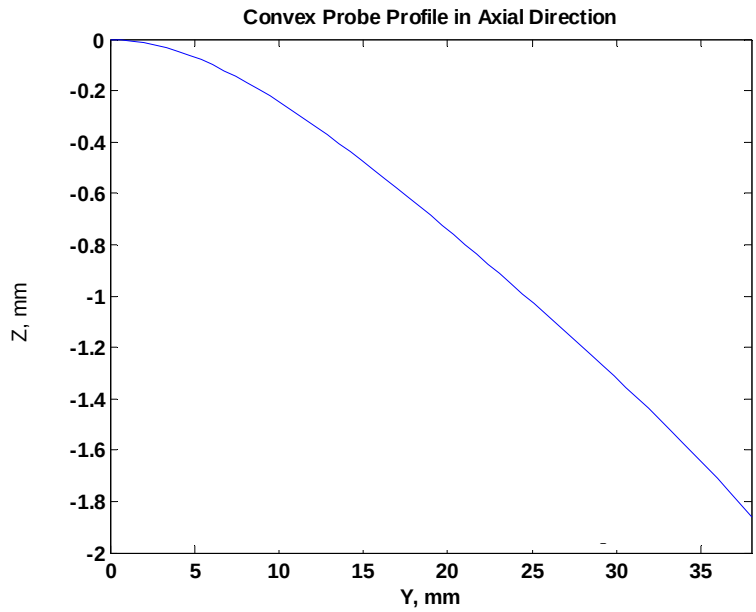
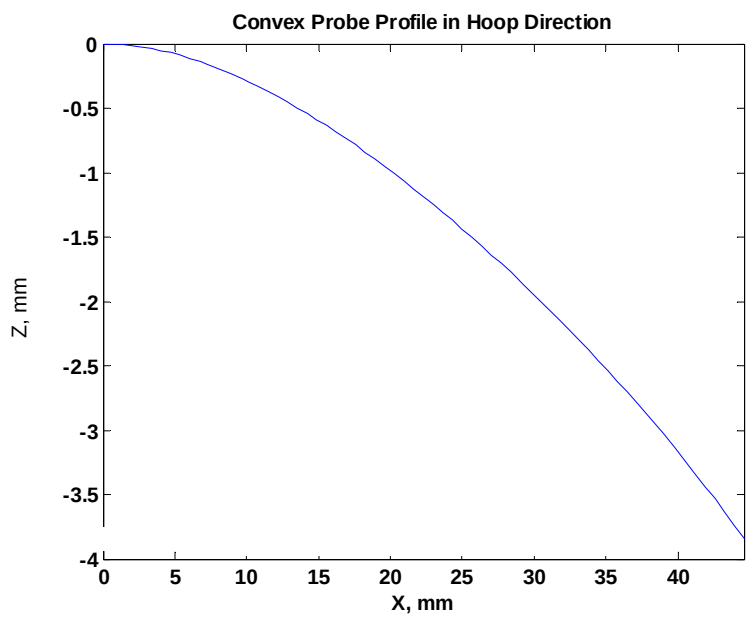


Figure 57. Element Area Variation as a Function of Ring Number

Several simulations were also performed for the convex entry surface case to assess the resulting beam profile spot size and the phase variation for the elements on the face of the resulting transducer design. Appendix H summarizes the extensive results from these simulations for all the radii of curvature of interest. Also included in appendix H is a detailed listing of all the elements on the face of the probe. It should be mentioned again that the UT beam spot diameter did not exceed 0.043″ for the inspection scenarios simulated, and the phase variation was nominally held to 60 degrees with an occasional 20% deviation from this value, which was verified through these simulations to have negligible effect on the resulting UT beam.



(a)



(b)

Figure 58. The Resulting Transducer Profiles in the (a) Axial and (b) Hoop Directions (Convex)

3. DESIGN STUDY SUMMARY.

Both suppliers concluded that two different transducers were needed to inspect two different curvature types, namely, convex and concave surfaces. Each vendor took a different approach to the design process, and therefore, the results from these two exercises differed significantly. The supplier A design efforts resulted in phased array probes that had significantly larger numbers of

elements than those presented by supplier E. The hardware constraints imposed by the electronics used to drive these phased array probes, such as the number of available channels and the number of delay generators, was not emphasized in these exercises, as interest was focused on exploring the possibility of being able to address the previously outlined design criteria with the minimum number of probes. Table 24 compares the main phased array probe characteristics resulting from the design process at both vendors.

Table 24. Comparison of the Main Phased Array Probe Characteristics

Probe Characteristic	Supplier A		Supplier E	
	Concave	Convex	Concave	Convex
Major axis	1.55″	1.74″	1.44″	1.77″
Minor axis	1.35″	1.55″	1.23″	1.53″
Number of eings	74	89	30	28
Number of elements	461	396	123	117
Water path	3″	3″	2.0″ to 4.0″	2.15″ to 3.9″
Use with current electronics	No	No	Yes	Yes
Maximum -6 dB UT beam spot size	120 mil	140 mil	43 mil	43 mil

For the supplier A-designed concave surfaces, a water path of 3″ (76.2 mm) was used. The assumed Fermat surface was focused at 3.66″ (93 mm) in Ti with a radius of curvature of -13.27″ (-337 mm). This was the average radius of the radii of curvature of interest and was chosen to minimize the phase variation. The resulting transducer had 74 rings with a total of 1551 elements before taking the design symmetries into consideration. The number of elements was reduced to 461 when these symmetries were accounted for. A similar analysis was performed by supplier A for convex surfaces. The water path was again set to 3″ (76.2 mm). The assumed Fermat surface was focused at 3.54″ (90 mm) in Ti with a radius of curvature of 13.39″ (340 mm). Again, this was the average radius of the radii of curvature of interest and was chosen to minimize the phase variation. The resulting transducer had 89 rings with a total of 1234 elements before taking the design symmetries into consideration. The number of elements was reduced to 396 when these symmetries were accounted for. Both transducers required variable-area elements.

For supplier E-designed concave entry surfaces, note that a water path range from 2.0″ to 4.0″ was needed for the inspection of the concave radii of curvature of -14.7″ to -11.82″. The resulting number of rings on the probe was 30, with a total of 123 elements. The minimum element area was 12 mm^2, and the maximum area was 36 mm^2, which resulted in an element area ratio of 3. For the convex entry surface, a water path ranging from 2.15″ to 3.9″ was needed for the inspection of the convex radii of curvature of 11.33″ to 15.62″. The resulting number of rings was 28 with a total of 117 elements. The minimum element area was 12 mm^2, and the maximum area is 95 mm^2, which resulted in an element area ratio of approximately 8.

Supplier A simulations of the designed phased arrays demonstrated that the maximum phase variation of 60 degrees criteria over the face of each element had been respected. However, the maximum 45-mil ultrasonic beam spot size had been occasionally violated. Similar simulations by supplier E of their probes showed that the maximum ultrasonic beam spot size of 45 mil was respected at all times, whereas an occasional 20% deviation from the phase variation criteria of 60 degrees occurred. However, supplier E's model results suggest that this deviation had negligible effect on the overall ultrasonic beam properties. It is clear that the probes designed by supplier A cannot be driven by the currently available electronics (this restriction might become obsolete as a number of vendors are working on developing more capable electronics). On the other hand, the designs offered by supplier E could be operated using the existing electronics, as they need less than 32 distinctive delay generators and less than 128 different channels (each probe has less than 32 rings and less than 128 elements).

Note that both suppliers have concluded that variable-area elements were needed to satisfy the design constraints. This area variation could present some challenges during manufacturing. Element area variations imply variations in the impedance of these elements that interface with the driving electronics and, if left unaddressed, could affect the overall sensitivity of the manufactured probe.

Finally, from the results presented in this study, it is feasible to design phased array transducers that are theoretically capable of inspecting curved entry surfaces (convex and concave) in the range of curvatures considered under this study. The various simulations have shown very clearly that the performance of these probes meets the design criteria in place. The manufacturability of these probes is a point of question that was not considered during this study. It is possible that significant challenges may emerge when an attempt is made to manufacture such transducers. However, these issues and the actual laboratory validation of the performance of such transducers are important issues to be considered in future research and development efforts for phased array inspection development.

4. GENERAL SUMMARY.

4.1 TRANSDUCER VARIABILITY STUDY.

To make a preliminary assessment of phased array transducer variability, two types of 10-MHz transducers were studied that could be applicable to forging inspections. Type-I transducers have 15 elements with the center element being a removable transducer that performs independently for near-surface inspection. The other 14 elements are concentric rings that can be phased to focus at various depths. Three such Type-I transducers were ordered from supplier A and three were ordered from supplier B, providing a total of six transducers for comparison. The second transducer type, referred to as Type-II, was of the design developed in ETC Phase II for achievement of #1/2 FBH sensitivity in Ti forgings [1]. The three Type-II transducers were all manufactured by supplier A. Three facilities participated in measurements to characterize beam diameter, center frequency, frequency bandwidth, signal amplitude, and individual element time of flight values. These characteristics describe the ability of the transducers to produce the sound fields that would play key roles in determining inspection reliability for forgings. As was expected, some variation in measured properties occurred from facility to facility for any given transducer. In some cases, the facility-to-facility differences were smaller than the measured

transducer-to-transducer differences, indicating that real differences in transducer performance were being revealed. In other cases, the facility-to-facility differences were similar in size or larger than measured transducer-to-transducer differences, indicating that any differences in operating performance were on the order of the measurement uncertainty.

As discussed in section 2, it was not intended to pass judgment on the suitability of the transducers for any particular inspection or to estimate what might be termed an acceptable variability for any given transducer characteristic. This is because the acceptable range of a transducer parameter will depend on the details of the specific inspection. Rather, the study concentrated on designing portable measurement protocols for transducer characteristics of interest, and then using those protocols in the round-robin measurement study. The variability data that was gathered was carefully summarized in a series of figures and tables. It is hoped that interested readers can use the documented variability values as a starting point for estimating how such variability might influence a particular inspection of interest. Although such analyses are feasible, they were beyond the planned scope of the present study. In accordance with the policy stated in section 2, the adjectives small, moderate, or large were used to describe a measured variability of less than 10%, 10% to 25%, or greater than 25%, respectively. Again, this does not necessarily imply, for example, that a small variability in an operating characteristic will have a small effect on detection sensitivity.

4.1.1 Type-I, 15-Element Transducers, 14 Annular Rings.

Table 25 summarizes the results for the phased array portions of the 15-element transducers (three transducers from supplier A and supplier B). Five operating characteristics were measured. Four of these relate to the sound beam created when the elements are driven in concert to form a focused beam: (1) beam diameter at the target focal depth, (2) center frequency, (3) frequency bandwidth, and (4) peak response from a small reference reflector located at the target depth. These four beam properties were measured using reflections from a #1/2 FBH located 1.6″ deep in a flat Ti-6-4 reference block. The fifth measurement examined time-variability between individual elements of the array. For the TOF measurements, a flat reflecting surface at a 3″ depth in water was used, and the annular elements were fired one at a time. Since the annular rings are nominally coplanar, they should all ideally yield equivalent TOF values for echoes from a properly aligned flat reflector. The TOF measurements were used to compute a goodness parameter, having units of nanoseconds, which measured the root mean squared average separation of the single-element TOF values from one another. For the 15-element transducers, the measured goodness parameter ranged from 3 to 10 nanoseconds, as summarized in figure 38.

Table 25. Summary of Variability in the 14 Annular Rings of the 15-Element Probes

Parameters	$\sigma/\langle A\rangle$ Supplier A	$\sigma/\langle A\rangle$ Supplier B	$\Delta/\langle A\rangle$
Center frequency	2%	1%	8%
Bandwidth	9%	11%	9%
Beam diameter	4%	8%	17%
Amplitude (FBH)	19%	16%	132%
TOF goodness	26%	50%	25%

The five operating characteristics were measured separately for each transducer at three test facilities, and all measured values are tabulated in the main body of this report (figures 34-38). For a given characteristic and a given set of three transducers, the nine measured values (three transducers times three sites) can be used to compute an average value and a standard deviation about that average. The first two numerical columns of table 25 list measured ratios of the standard deviation divided by the average value, expressed as a percentage. These ratios are listed for each supplier individually and, hence, serve as a rough measure of variability for transducers from a single supplier. The third column in table 25 lists the difference between the averages (of supplier A and B sets) divided by the mean value of the two sets. The results in the third column serve as a rough measure of supplier-to-supplier variability. One must keep in mind, however, that the variability values reported in table 25 do not arise solely from differences in transducer performance. They include contributions arising from differences in the performances of the measurement hardware (other than the transducer) at the three measurement sites and in the diligence of the persons performing the measurements. (This was discussed earlier in the report in reference to table 6.) Because they include facility-to-facility differences for each transducer (which can be characterized as measurement uncertainty), the values in table 25 tend to overstate the inherent variability of a given set of transducers, i.e., the variability due to real differences in operating performance alone.

As shown in table 25, intrasupplier variability in center frequency, bandwidth, and beam diameter were small to moderate, ranging from 1% to 11%. On average, the supplier A transducers were found to have smaller focal spots at the target depth than those of supplier B, with 43 mil and 52 mil average beam diameters, respectively. Average center frequencies for supplier A and B transducers were 10.8 MHz and 11.7 MHz, respectively, and the variations about these mean values were small for each supplier. Measured bandwidths averaged 56% and 51%, for suppliers A and B, respectively. However, the bandwidth measurement appeared to be somewhat equipment sensitive, with substantial facility-to-facility differences in the measured bandwidth of any given transducer (see figure 36).

The one characteristic in table 25 that most clearly differentiates the supplier A and B probes is the absolute amplitude of the #1/2 FBH echo. For a given supplier, transducer-to-transducer differences in FBH amplitude were moderate, being less than 20%. However, on average, the supplier A probes produced approximately 14 dB higher amplitude signals than the supplier B probes. Such a large difference could be significant when performing an inspection where electronic noise, rather than microstructural noise, is a limiting factor. However, if

microstructural noise dominates electronic noise (as is often the case in forging inspections), the absolute amplitude difference between the supplier A and B probes would be of little or no consequence. One could compensate for the amplitude differences by adjusting the absolute gain setting during inspection calibration.

While the variability in TOF goodness values in table 25 appears to be large, one must bear in mind that a ratio with a small denominator is being quoted. As discussed in reference to figure 38, the measured goodness value was 10.3 nanoseconds or less in all cases, thus well below the conservative criterion for an acceptable error in element phasing of 1/8 wavelength (25 nanoseconds). Since the measured goodness values of all transducers were quite small, their small variations from one another lead to large quoted values of standard deviation over mean. In principle, the small TOF differences measured for the individual elements of any given transducer are easily correctable. This can theoretically be done by small adjustments to the times at which the various annular rings are fired when a beam is being generated. Thus, the TOF studies of the six Type-I transducers revealed no significant shortcomings.

4.1.2 Type-I, 15-Element Transducers, Removable Center Elements.

The RCEs were conventional transducers, each having an inherent fixed focus as opposed to the variable focus achieved using the annular rings of the phased array transducers. With one exception, the supplier A and B array transducers had removable center elements that were manufactured by a single supplier, denoted as supplier C. The sole exception occurred for one of the supplier B array transducers, which had a center element manufactured by supplier D. Each RCE was a 10-MHz, broadband, circular element, spherically focused transducer, having a nominal diameter of 3/8″ and a nominal focal length in water of 3.0″.

Several tests were conducted to characterize the removable fixed-focus transducers. The first two tests made use of a ball-like target in water. First, the water path was found for which the pulse-echo response from the target had its maximum amplitude, and the peak response amplitude was recorded. This water path is traditionally denoted Y+0 and serves as one measure of the focal distance. Second, with the water path fixed at Y+0, a C-scan of the ball target was performed and used to determine the average beam diameter at the focus. Third, the echo (A-scan) from a #1 FBH located 0.5″ deep in a fine-grained IN100 test block was used to determine a center frequency, frequency bandwidth, and peak response amplitude. Next, echoes from a series of #1 FBHs at various depths were used to deduce an effective diameter (D) and geometric focal length (F) for the transducer. These parameters describe the ideal focused piston transducer having the most similar on-axis beam profile to the commercial transducer being tested. The F describes the curvature of the sound wave fronts in water as they leave the transducer face, i.e., the focal depth in water if attenuation and beam spread effects were absent. Because beam spread and attenuation act to shorten the focal distance, the Y+0 distance is generally shorter than the F. In the final test, near-surface resolution was quantified by using the SNR observed for a near-surface reflector, namely a 0.050″ deep #1 FBH in the IN100 test block. Here, noise refers to the ringdown of the front-surface echo in the vicinity of the FBH response.

Table 26 provides a partial summary of the variability measured in the characteristics of the RCE transducers. A more detailed summary is shown in table 6. In table 26, the six fixed-focus

transducers have been treated as a single set, and the measurements at all three test facilities have been combined when computing the average value and standard deviation. For a given characteristic of interest, the rightmost column lists the ratio of the standard deviation of the 18 measured values divided by the mean value.

Table 26. Summary of Variability in the RCEs of the 15-Element Probes

Operating Characteristic	$\sigma/\langle A \rangle$
Y+0 distance for ball target in water	2.4%
Effective transducer diameter	2.6%
Effective F	3.2%
Beam diameter at Y+0	5.7%
Center frequency (#1 FBH at 0.5″ in Ti-6-4)	5.4%
Bandwidth (#1 FBH at 0.5″ in Ti-6-4)	14%
Amplitude (#1 FBH at 0.5″ in Ti-6-4)	23%
Amplitude (ball target in water at Y+0)	27%

As can be seen in table 26, differences in the operating characteristics of the six RCE transducers were generally small to moderate and in most cases similar to those obtained for the 15-element phased array transducer. Focal characteristics, as gauged by the Y+0 values, the effective diameters, and the Fs, displayed the smallest percentage variations. Some larger reproducible differences (i.e., differences reported by all test sites) were seen in beam diameter, center frequency, and bandwidth values. However, such differences were typical of those expected for a suite of nominally identical, fixed-focus transducers. Each transducer was designed to have a 10-MHz center frequency, 3/8″ (0.375″) diameter, and 3″ focus in water. Moderate differences were seen between these nominal properties, and the average measured values (12.5-MHz center frequency, 3.27″ for Y+0, 0.374″ effective diameter). However, the differences between measured and nominal and properties may be due, in part, to differences in the measurement methods used by the ETC and the transducer manufacturers.

The largest percentage variations listed in table 26 are for the measured amplitudes from either a #1 FBH reflector in metal or a ball-like target in water. The largest such amplitude difference measured between any pair of transducers at any given test site was a factor of 2.14, or 6.6 dB. However, in practice, one can easily compensate for such absolute amplitude differences by adjusting the gain setting during calibration. Thus, the amplitude variations were considered to be of little practical importance for most applications.

Large percentage variations, on the order of 50%, were observed in near-surface resolution characteristics, but these do not appear in table 26. As discussed earlier in reference to figure 33, the specific procedure used for defining and measuring the near-surface SNR led to large facility-to-facility variation for a given transducer. Thus, the measurement procedure did not appear to be robust and portable. It would be advantageous to have a better procedure for near-surface resolution that measures a property of the transducer alone and is less dependent on the test site. This is a potential subject for future work.

4.1.3 Type-II, 110-Element Transducers.

The 110-element, annular-sectorial array was designed such that F6 focusing could be achieved at any chosen depth from 0″ to 3.25″ in a flat titanium specimen. Naturally, a different focal law was required for focusing at each depth. Three such transducers were tested, each manufactured by supplier A. Characterization tests were performed using two different focal laws. The first focused to a depth of 0.7″ in a Ti-6-4 test block and used the inner 14 rings of the array. The second focal law focused to a depth of 2.5″ and used the inner 32 rings. The #1/2 FBHs in the test blocks served as reflectors. For each of the two focal depths, four characteristics were measured, namely beam diameter, center frequency, frequency bandwidth, and peak FBH response amplitude. In addition, single-element, TOF measurements were made and used to compute a TOF goodness parameter. The TOF analysis was similar in spirit to Type-I transducers, but curved reflecting surfaces were used to match the various curvatures on the Type-II transducer face.

Table 27 summarizes the variability of the measured operating characteristics of the 110-element transducers using the basic format introduced earlier for the Type-I transducers (table 25). Each entry in the table was computed from nine measured values (three transducers times three test sites). Again, the entries included contributions from site-to-site differences (measurement uncertainty) and, hence, may have overstated the real differences between the properties of the three transducers. One sees that for the four beam-forming characteristics, the computed variability was 20% or smaller in all but one case, and tends to be larger when focusing deeper. Average center frequencies were 11.3 MHz at the 0.7″ depth and 9.8 MHz at 2.5″, and average bandwidths were 63% and 56% at the two depths, respectively. The average beam diameter was 31 mil when focusing 0.7″ deep and 48 mil when focusing 2.5″ deep. These values bracketed the 36 mil target value for F6 equivalent focusing. The reduction in center frequency and bandwidth as the focal depth increased was likely due to ultrasonic attenuation in the test blocks and contributed to the increase in beam diameter observed at the 2.5″ depth.

Table 27. Summary of Variability in 110-Element Transducers

Parameter	$\sigma/\langle A\rangle$ 0.7″ depth	$\sigma/\langle A\rangle$ 2.5″ depth	$\sigma/\langle A\rangle$ Curved Reflecting Surfaces
Center frequency	4%	7%	
Bandwidth	7%	6%	
Beam diameter	7%	19%	
Amplitude (FBH)	16%	(55%)	
TOF goodness			14%

The largest variability in table 27 was associated with the absolute amplitude of FBH responses, and the large value cited for the 2.5″ depth was likely the result of a measurement or recording error. At a given measurement site using a given focal depth, probe-to-probe differences in peak FBH amplitudes were moderate, with $\sigma/\langle A\rangle$ typically ranging between 10% and 15% (see figure 43). Because of ultrasonic attenuation in the test blocks, the average FBH amplitude was

expected to be smaller for the 2.5″ depth than for the 0.7″ depth. This effect was recorded at both the ISU and HW test sites. However, at the P&W site, recorded FBH amplitudes (renormalized to a fixed 31 dB gain setting) were higher for the 2.5″ depth than for the 0.7″ depth. This led to large site-to-site differences in the recorded absolute amplitudes for the 2.5″ depth, resulting in the very high (55%) value listed in table 27. The reason for the discrepancy is unknown, and time constraints prohibited performing the measurements a second time to check the results. Again, amplitude variability is expected to pose no major problem in practice for forging inspections, as gain adjustments during calibration can compensate for amplitude differences.

For the 110-element Type-II transducers, the measured TOF goodness parameters ranged from 9 to 13 nanoseconds, depending on the transducer being tested and the measurement site. These values were well below the conservative criterion for an acceptable average error in element phasing of 1/8 wavelength (25 nanoseconds). The observed TOF variation among individual array elements was of insufficient magnitude to impact array phasing performance.

4.1.4 Concluding Remarks on Transducer Characterizations.

A relatively small degree of variability was seen in most measured operating characteristics (tables 25-27). In fact, the variability seen when the phased elements acted together to form a sonic beam (tables 25 and 27) was roughly on a par with the fixed-focus removable transducers (table 26). Variability in operating characteristics will, of course, cause variability in detection sensitivity, with the sensitivity variability being dependent on the details of the inspection being performed. Relating differences in transducer-operating characteristics to differences in detection sensitivity was beyond the scope of the present study. The tabulated data itself should be used to form individual conclusions as to how transducer variability might impact any given inspection.

4.2 TRANSDUCER DESIGN STUDY.

The design of the 110-element transducer had been performed earlier by ISU to meet certain requirements for inspecting Ti-6-4 forgings to a #1/2 FBH sensitivity level [1 and 2]. The transducer was designed primarily for use through flat entry surfaces with compensation for curved surfaces by using curved mirrors. This transducer design study, which is unrelated to the transducer variability work, was intended to have other sources provide designs for complex inspections and thereby provide insight into other design approaches. To accomplish this task, the problem of designing for inspection through curved surfaces without the use of mirrors, i.e., using the beam-shaping capability of the phased array elements to compensate for curvature, was presented to two suppliers. One supplier, supplier A, is a manufacturer of transducers and was the supplier for the 110-element Type-II probes and three of the 15-element Type-I probes used in the variability study. The other supplier for the design study, supplier E, had several years of experience in transducer design.

Both suppliers were presented with a list of curvatures present in the forgings studied during ETC Phase II, together with the corresponding inspection criteria, and were asked to design transducers that could account for these curvatures. The supplied inspection criteria included the

beam diameter constraints, inspection depth zones, and the desired water path of 3″. Full details of the design criteria can be found in section 2.3.1.

Supplier A provided two designs, one to be used for the concave surfaces and one for the convex surfaces. The transducer for concave surfaces had 74 rings and 1551 elements. The transducer for the convex surfaces had 89 rings and 1234 elements. Considering the symmetry of the elements positions, the 1551 elements would be fired with 461 phasing delays, and the 1234 elements would be fired with 391 delays. Supplier A suggested that while these designs satisfied the constraints of the inspections that were specified, the transducer elements would be very difficult to manufacture using existing practices. Also, such a large number of elements could not be fired using the electronics currently available in ultrasonic phased array equipment. The designs presented by supplier A adhered to a single water path of 3″ but did allow for variable-element areas. The concept of using phased array transducers with variable-element areas has not been tested in practice, but was included in this design study as an allowable design option.

The supplier E designs also resulted in separate transducers for concave and convex applications, but after discussion with the ETC team, supplier E provided designs that allowed the use of different water paths for inspections of different curvatures. The designs resulted in 117 elements in 28 rings for the transducer with convex surfaces and 123 elements in 30 rings for concave surfaces. Both designs appear to have the focusing capability needed to maintain the required beam diameter through each of the depth zones. The smaller numbers of elements used in the supplier E designs would allow these transducers to be interfaced with the electronics in existing phased array pulser/receiver hardware. The supplier E design also made use of nonequal area elements. Again, the practical effects of this deviation from previously produced phased array transducers, where all element areas were held fixed, is yet to be determined.

Although it was not related to the transducer variability study, the transducer design exercise was conducted to observe independent approaches taken to design complex transducers. One of the designs provided evidence that there is a possibility, in the short-term, of using phased array transducers to correct for the range of surface curvatures considered in this study, as opposed to making such corrections with curved mirrors. Ultimately, the design exercises could benefit the aerospace industry at large as the application of phased array technology expands and the demands on the supply base for ready technology are increased.

5. REFERENCES.

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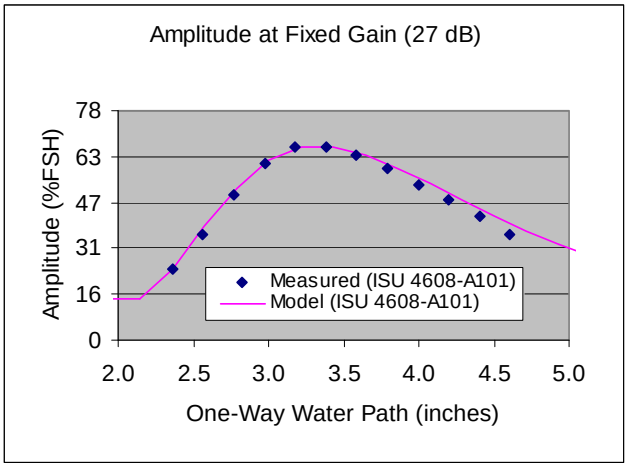
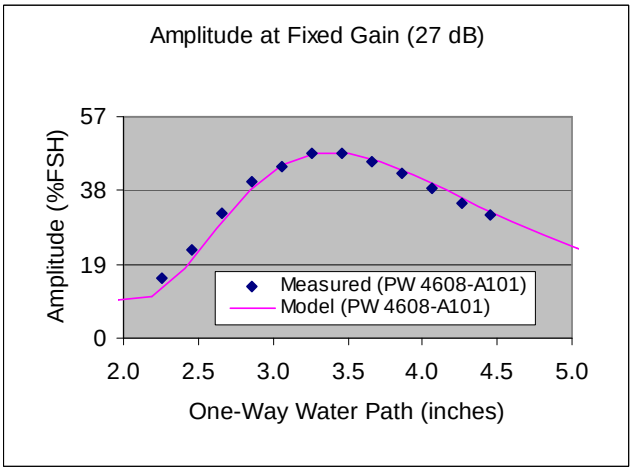
APPENDIX A—PEAKED RESPONSE AMPLITUDE VERSUS DEPTH USING A BALL TARGET IN WATER FOR EACH REMOVABLE CENTER ELEMENT TRANSDUCER

For each removable center element (RCE) transducer in a Type-I phased array, this appendix presents graphs of the measured peak responses from the glass rod target in water. In the experiments, the water path was varied, and for each water path, the lateral position of the transducer was adjusted to maximize the pulse-echo response. Thus, the graphs in this appendix display peak response (in % full screen height units) versus water path (in inch units). In addition to the experimental results, model predictions for an ideal piston probe are shown, which are based on the deduced geometrical focal length and effective diameter of the RCE transducer. Each graph is similar to the format shown in figure 16, and the interested reader is referred to the text discussing that figure for further details. Graphs on a given page of this appendix are for a single RCE transducer as measured at the three different test facilities; note however, that the gain settings for the three graphs may be different. For each graph, the transducer and test facility may be identified from the graph legend, which lists a facility code (Iowa State University, Pratt & Whitney, or Honeywell) and the serial number of the Type-I transducer containing the RCE in question. (See figure 7 in the main text for a complete list of serial numbers for the Type-I transducers studied and their corresponding RCEs.)





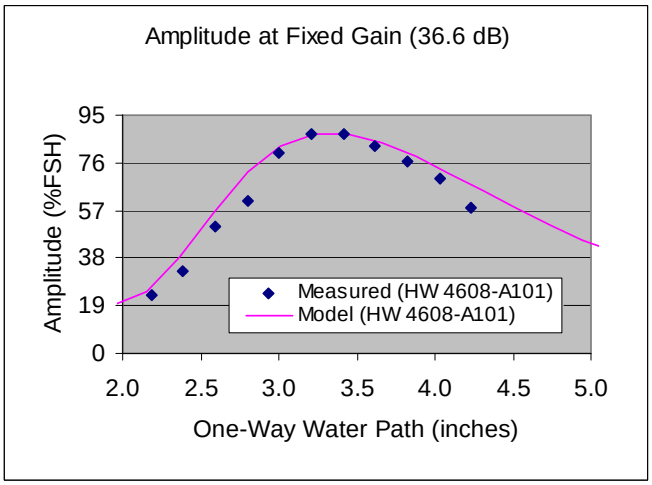
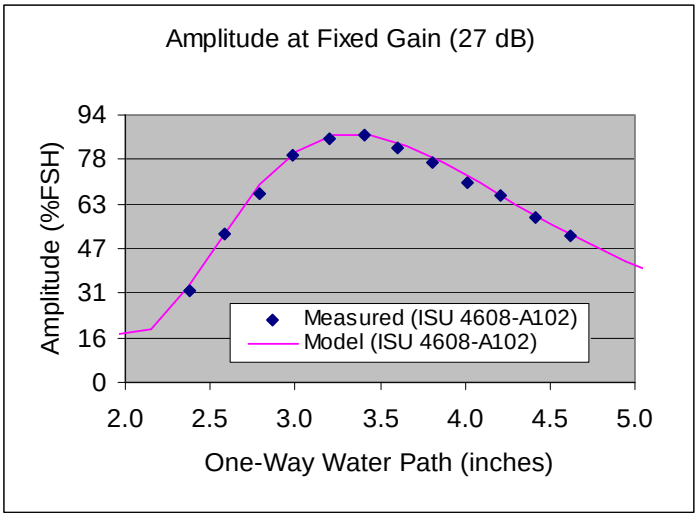
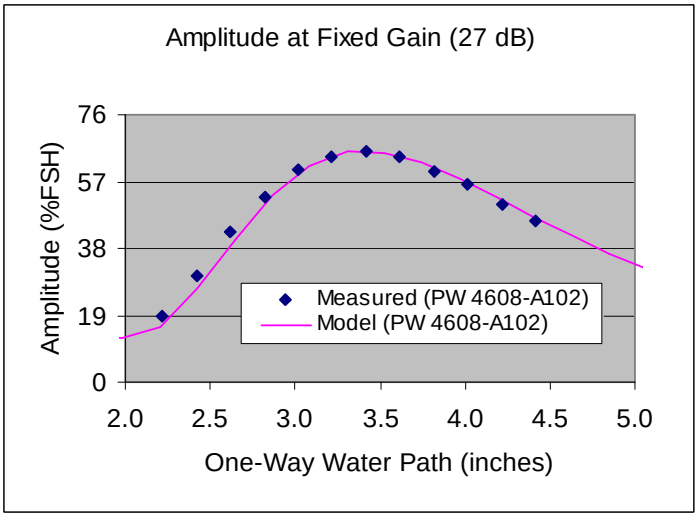


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target





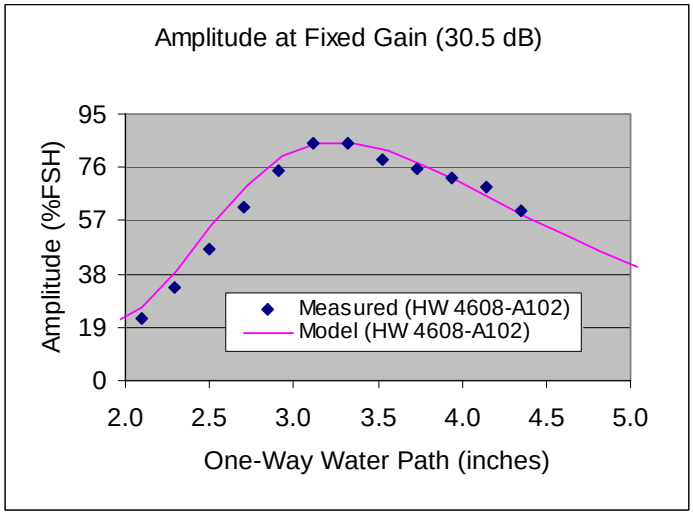
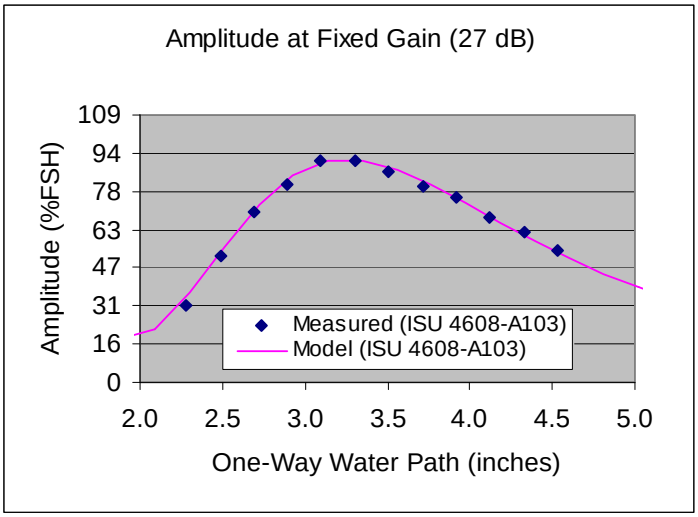
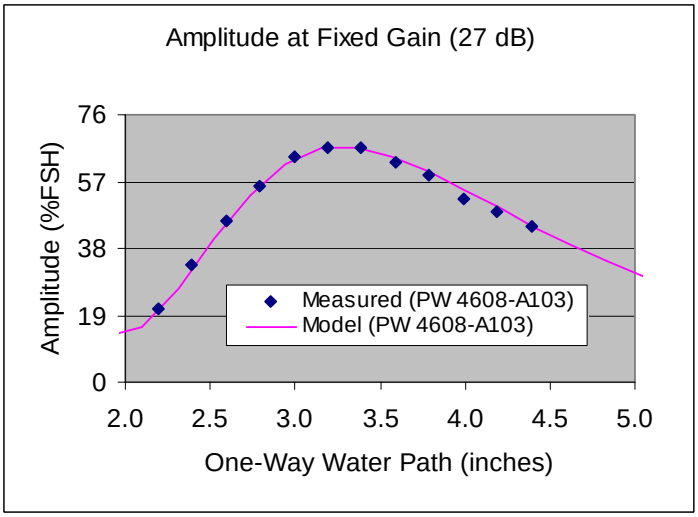


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target (Continued)





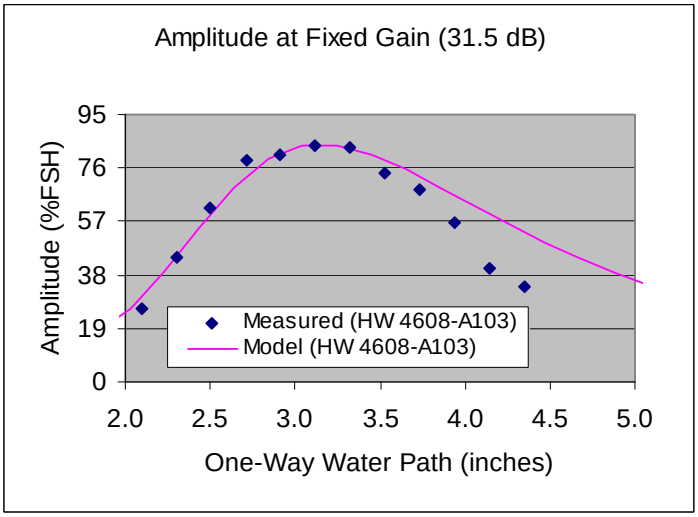


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target (Continued)

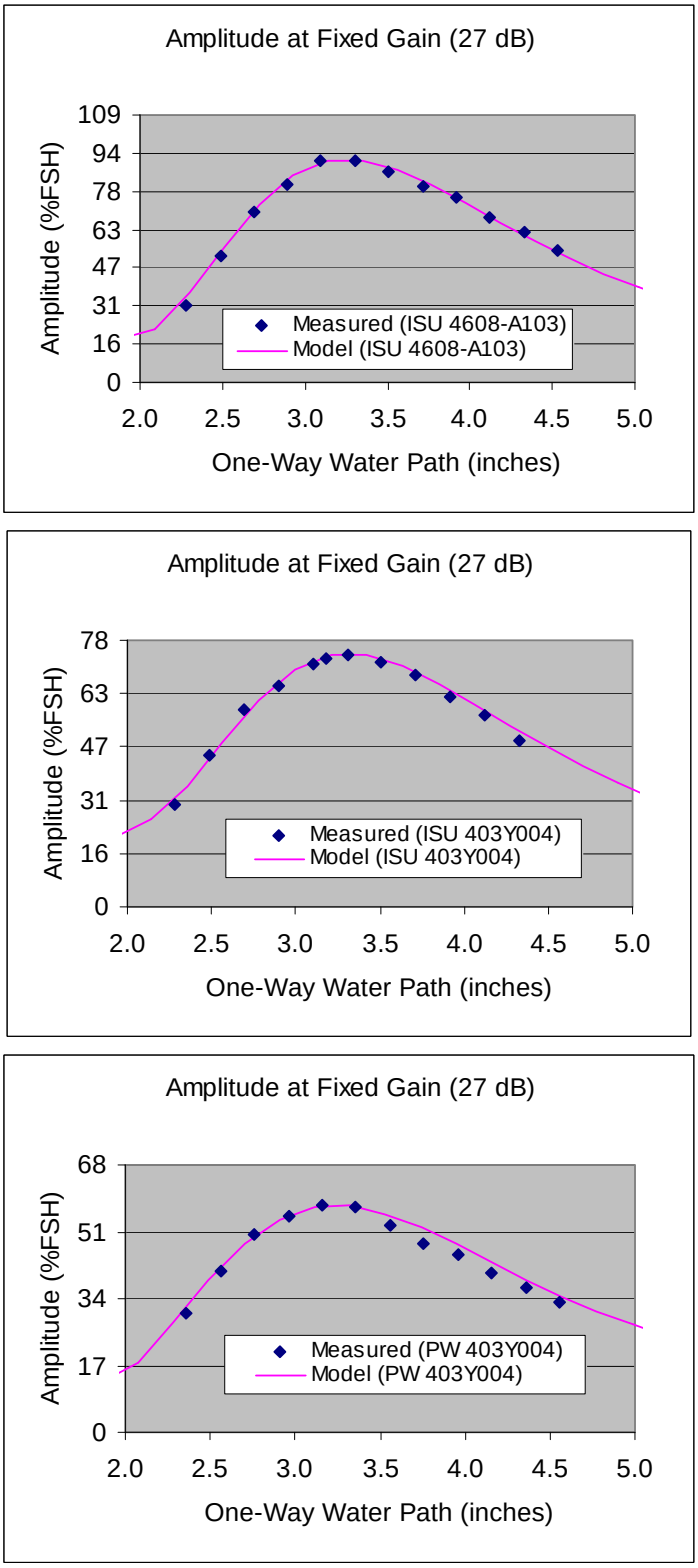
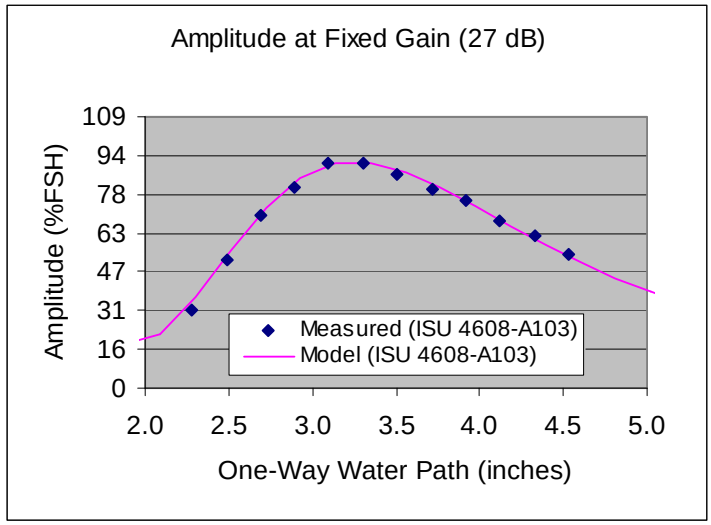
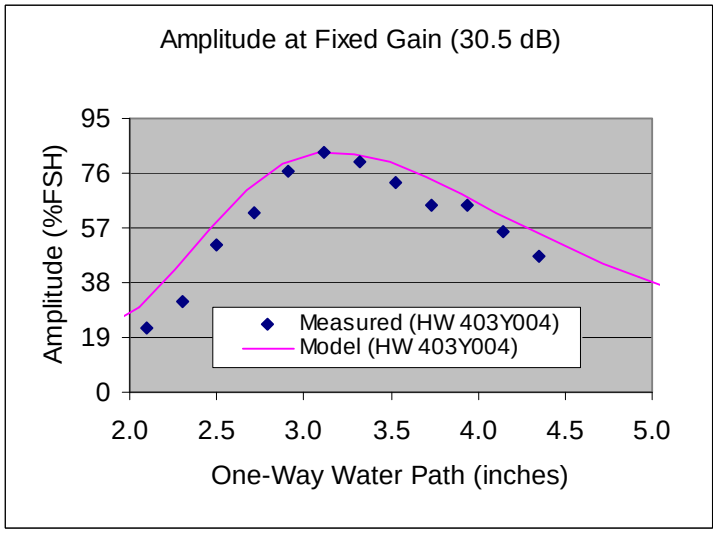


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target (Continued)





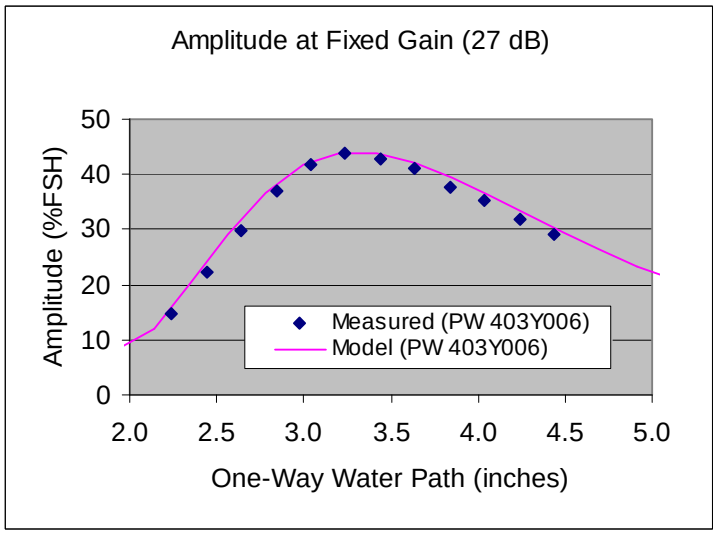
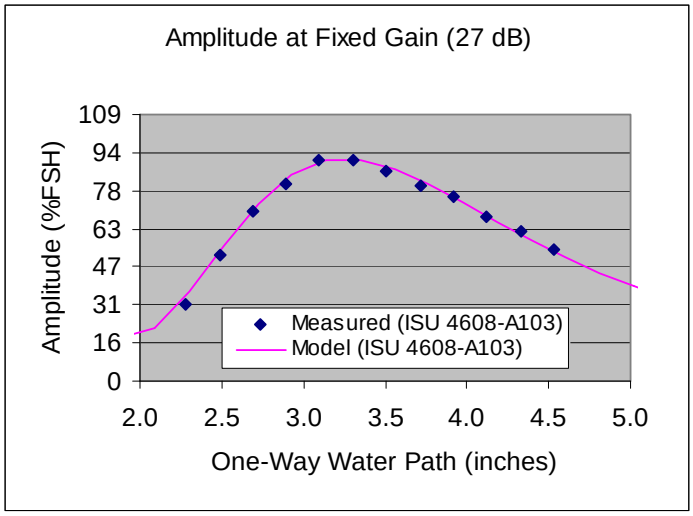
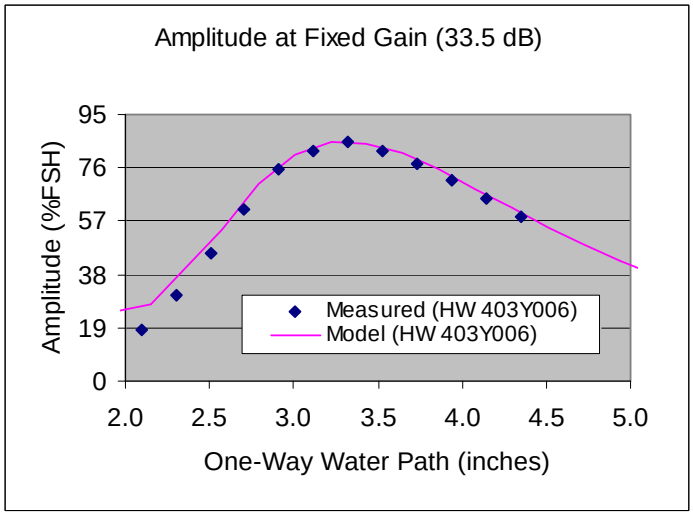


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target (Continued)





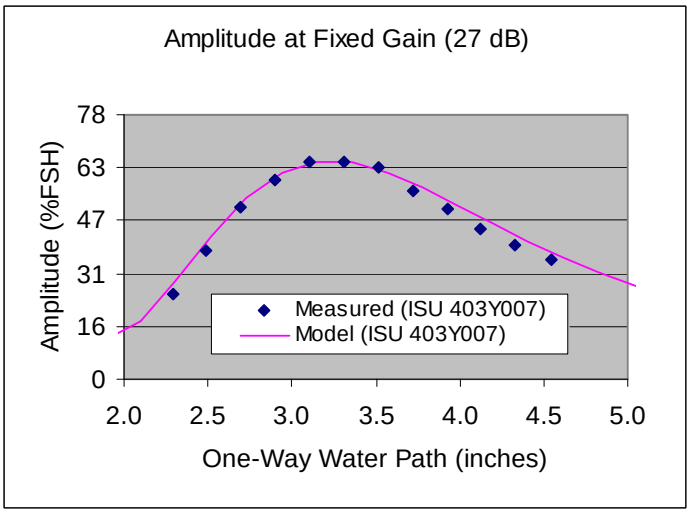
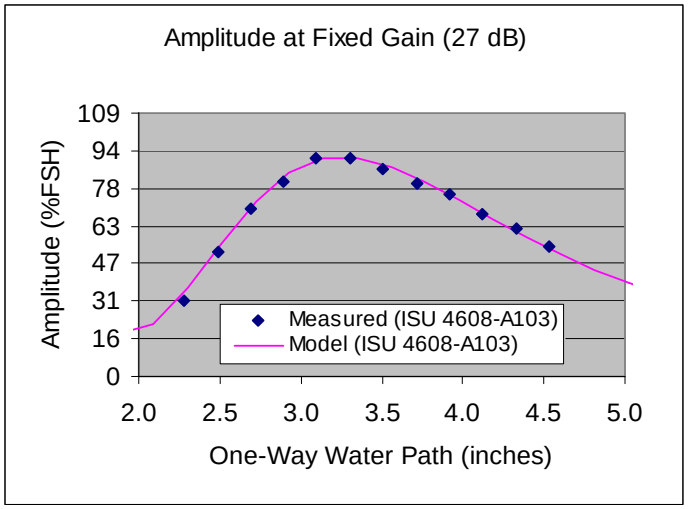
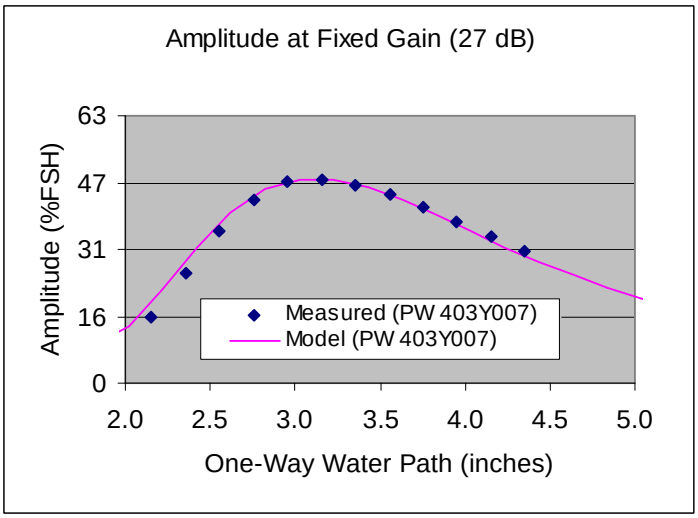


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target (Continued)





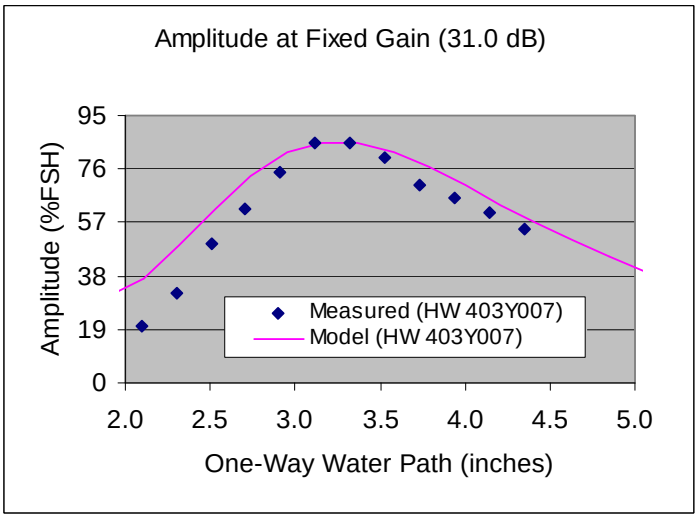


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target (Continued)

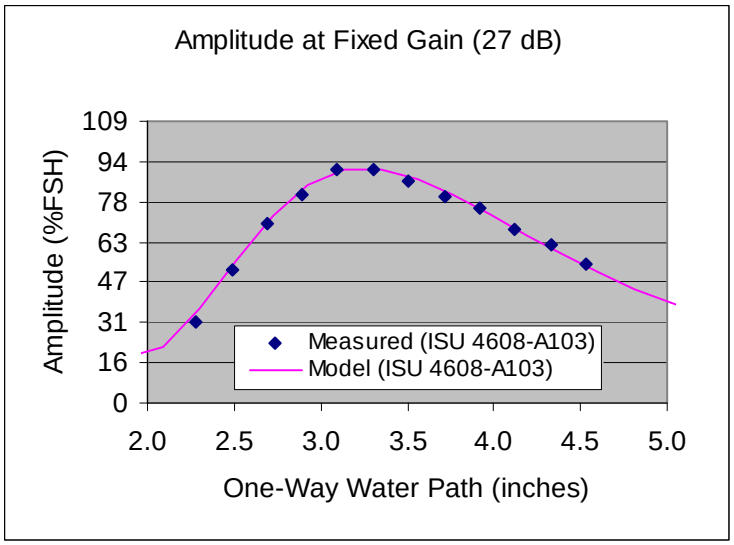
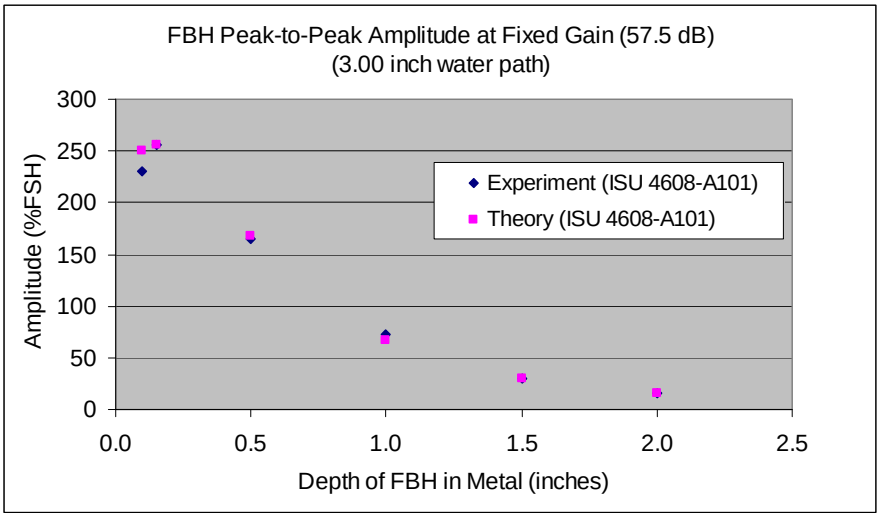
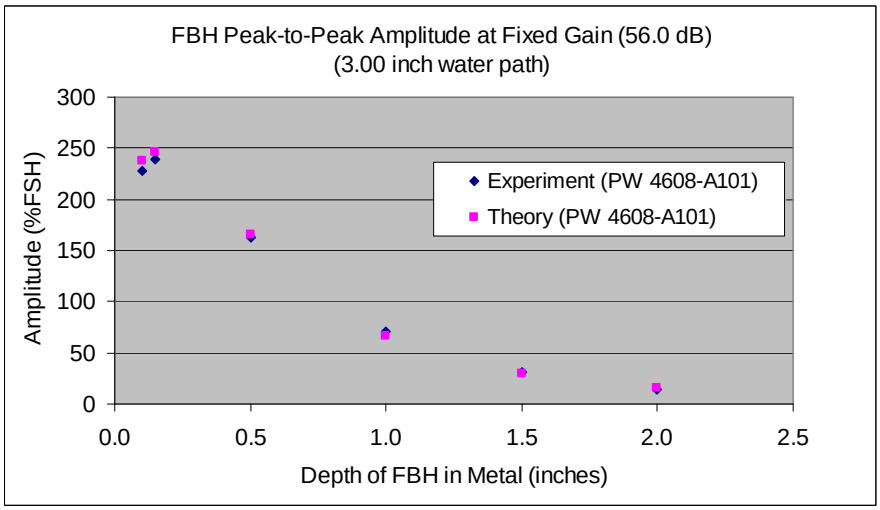


Figure A-1. Measured and Predicted Peak Response Versus Water Path for the RCE of Each Type-I Transducer, Using the Glass Rod Target (Continued)

APPENDIX B—PEAKED FLAT-BOTTOM HOLE RESPONSE AMPLITUDE VERSUS DEPTH FOR EACH REMOVABLE CENTER ELEMENT TRANSDUCER

For each removable center element (RCE) transducer in a Type-I phased array, this appendix presents graphs of the measured peak responses from the #1 flat-bottom hole (FBH) targets in the nickel alloy (IN100) step block. In the experiments, the water path was fixed at 3.0″, and the depths of the #1 FBH targets ranged from 0.1″ to 2.0″. For each FBH target, the lateral position of the transducer was adjusted to maximize the pulse-echo response. Thus, the graphs in this appendix display peak response (in % full screen height (FSH) units) versus FBH depth (in inch units). In addition to the experimental results, model predictions for an ideal piston probe are shown, which are based on the deduced geometrical focal length and effective diameter of the RCE transducer. Each graph is similar to the format shown in figure 26, and the interested reader is referred to the text discussing that figure for further details. Graphs on a given page of this appendix are for a single RCE transducer as measured at the three different test facilities; note however, that the gain settings for the three graphs may be different. For each graph, the transducer and test facility may be identified from the graph legend, which lists a facility code (Iowa State University, Pratt & Whitney, or Honeywell) and the serial number of the Type-I transducer containing the RCE in question. (See figure 7 in the main text for a complete list of serial numbers for the Type-I transducers studied and their corresponding RCEs.)





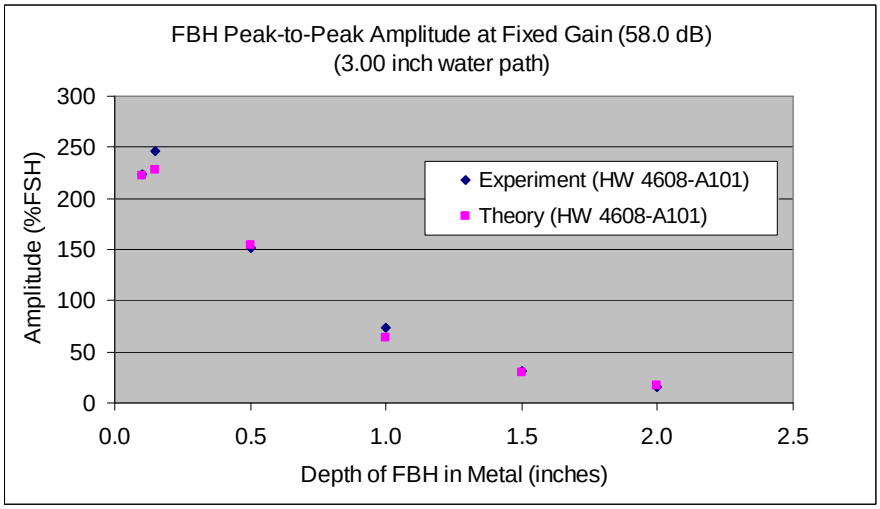
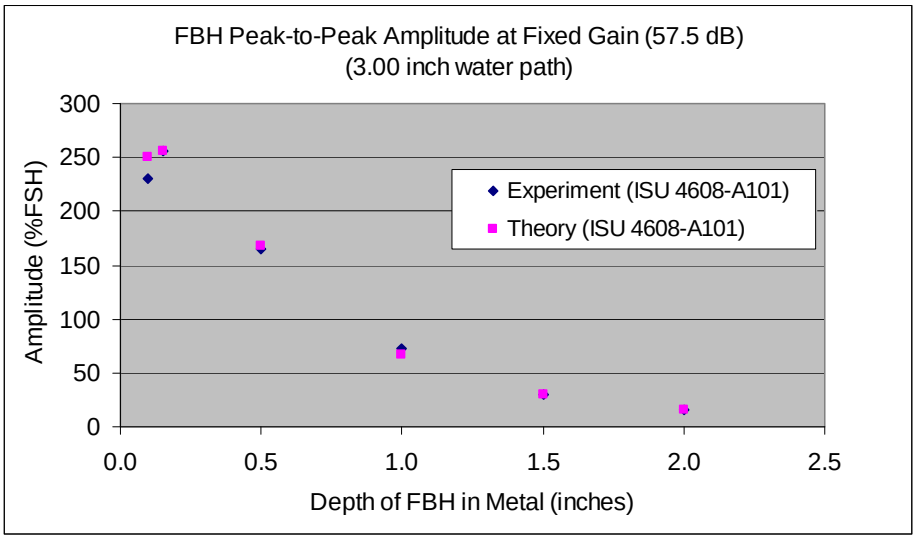
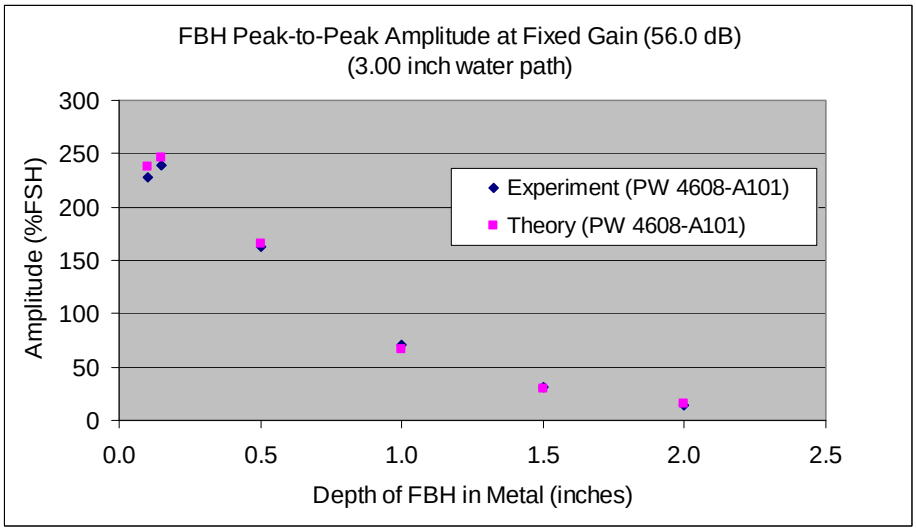


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block





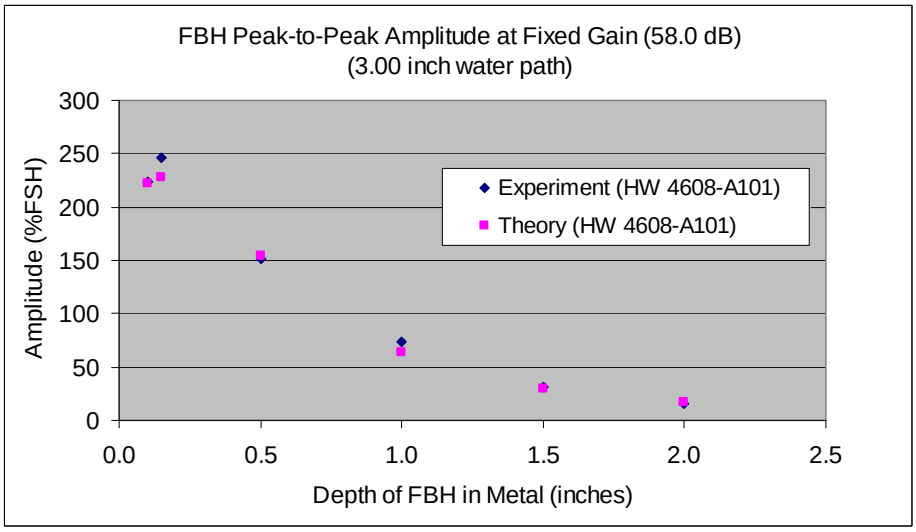
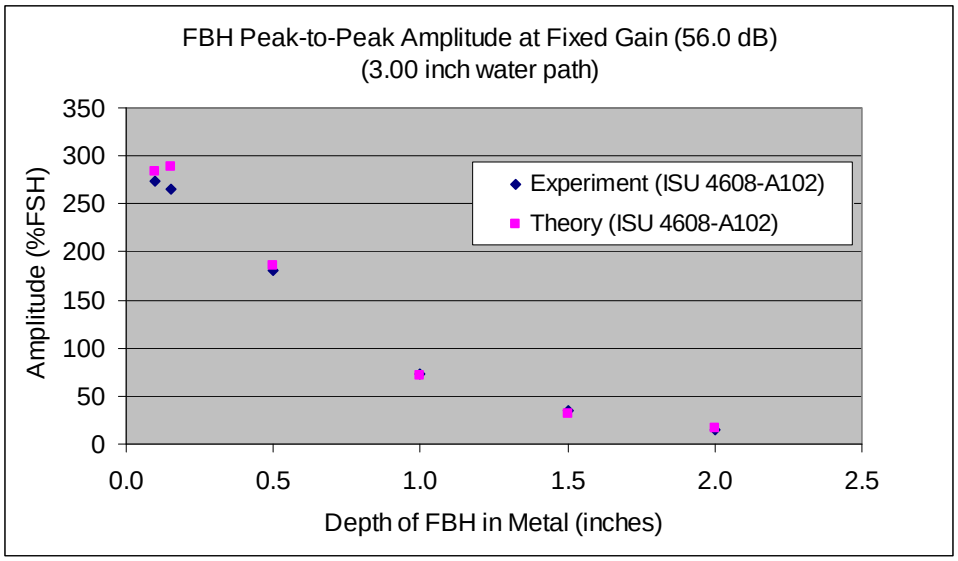


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block (Continued)



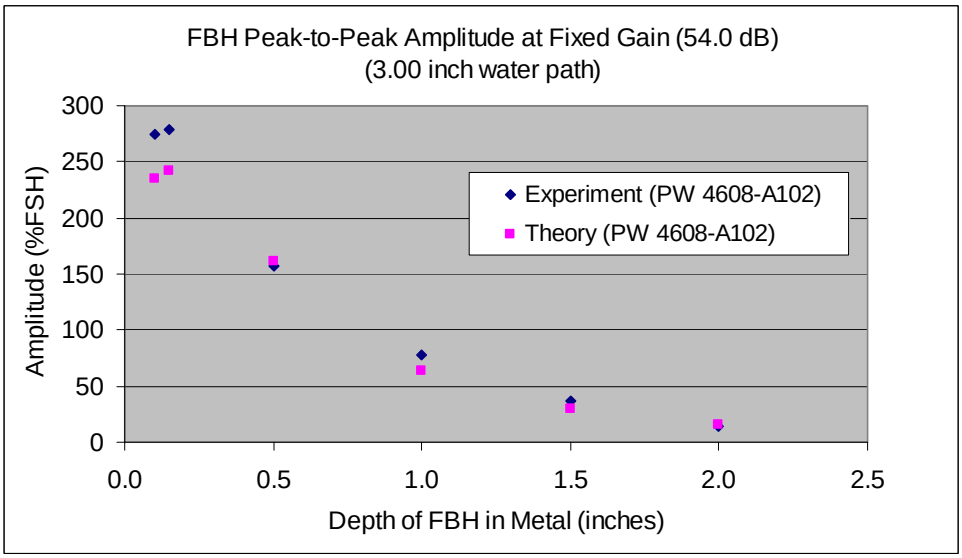
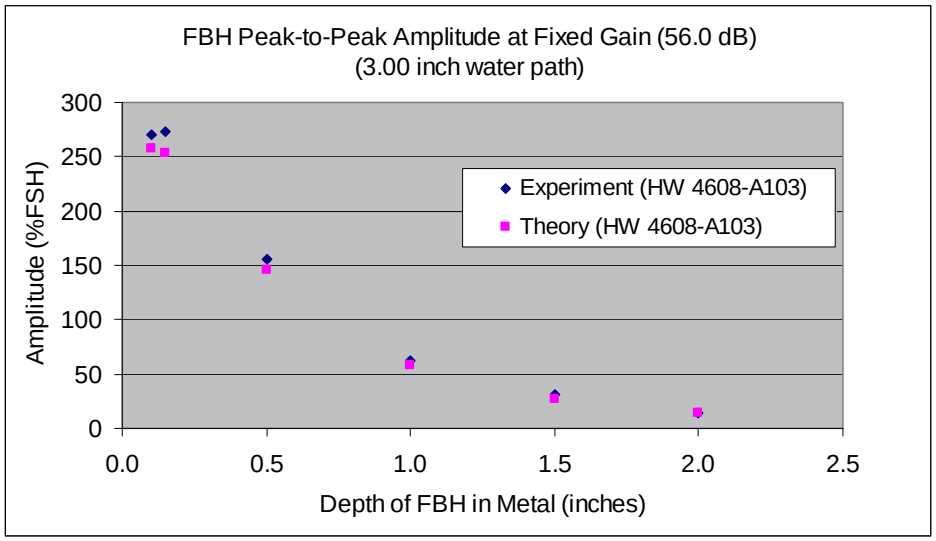
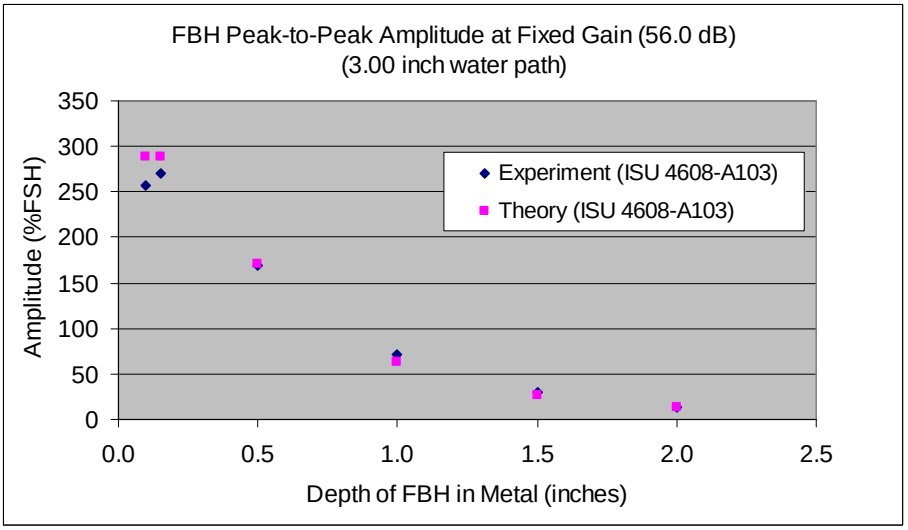


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block (Continued)





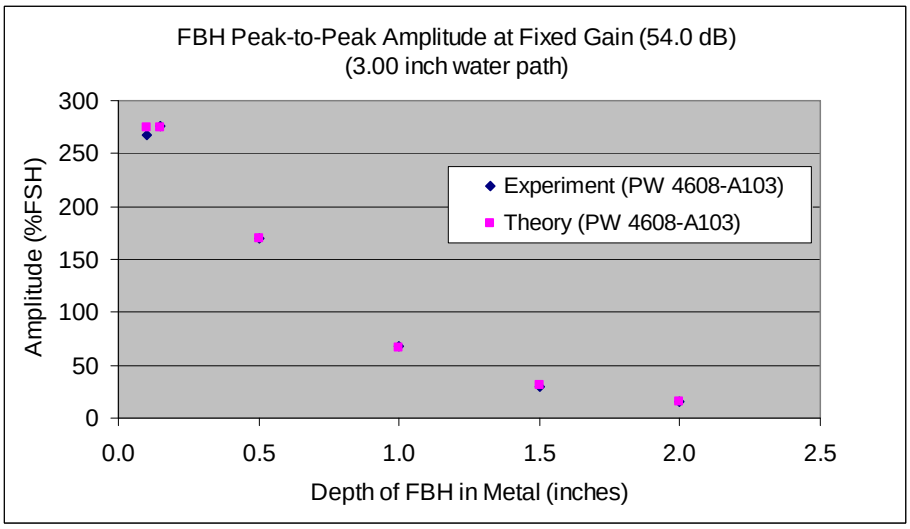
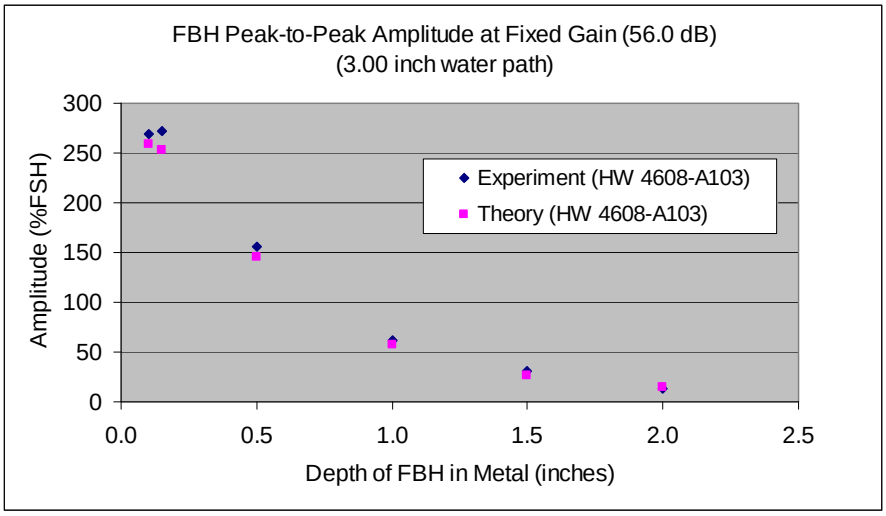
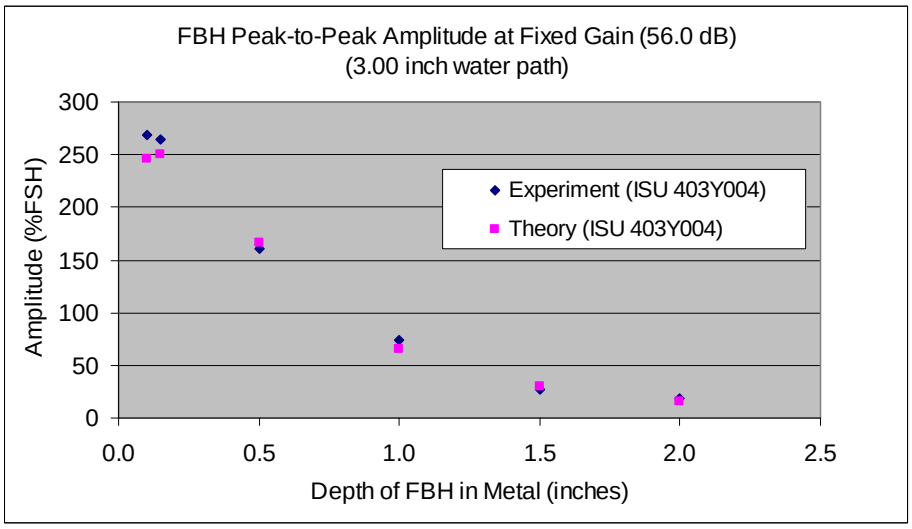


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block (Continued)





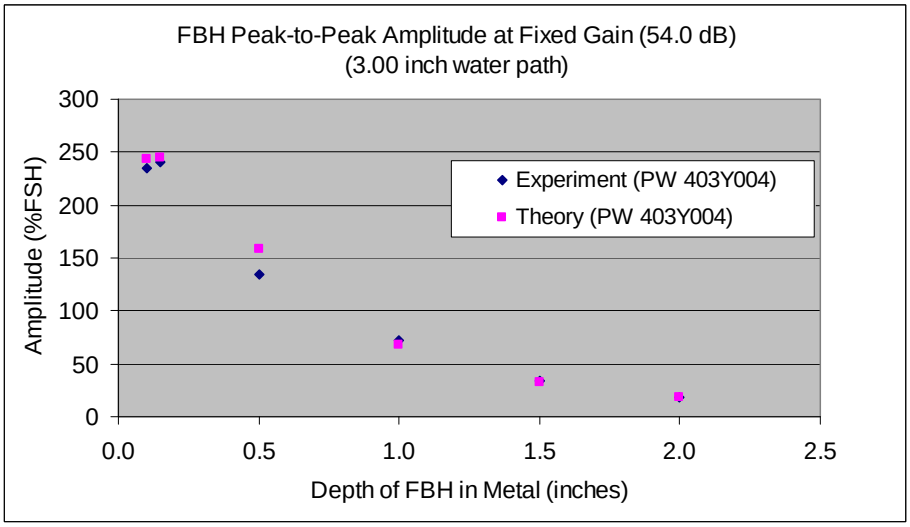
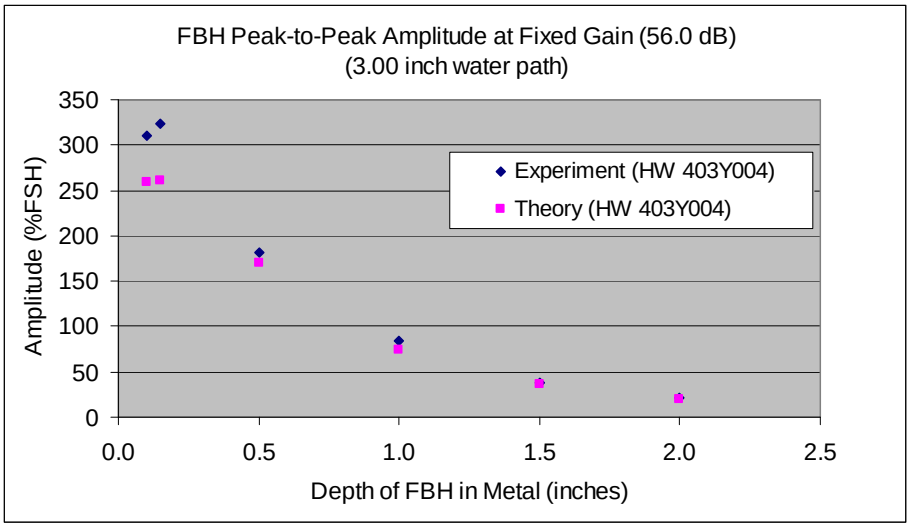
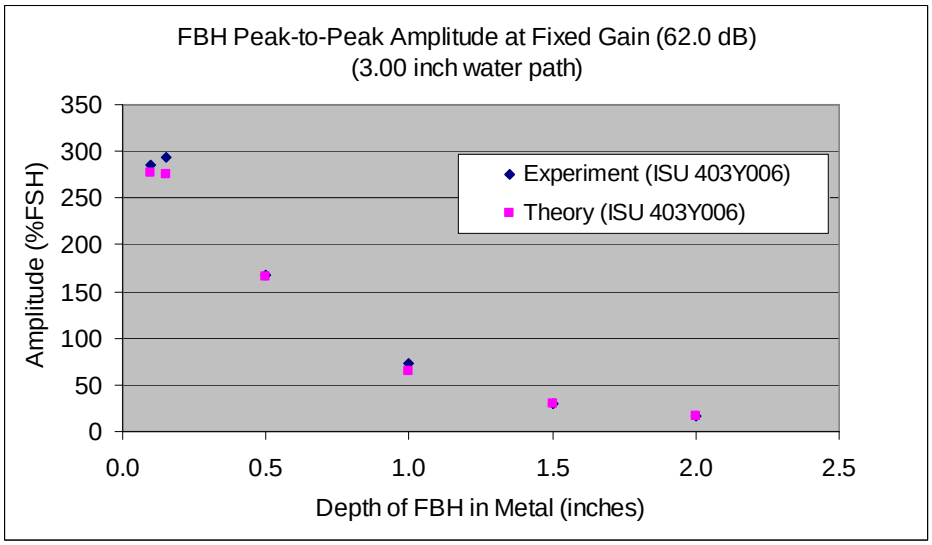


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block (Continued)





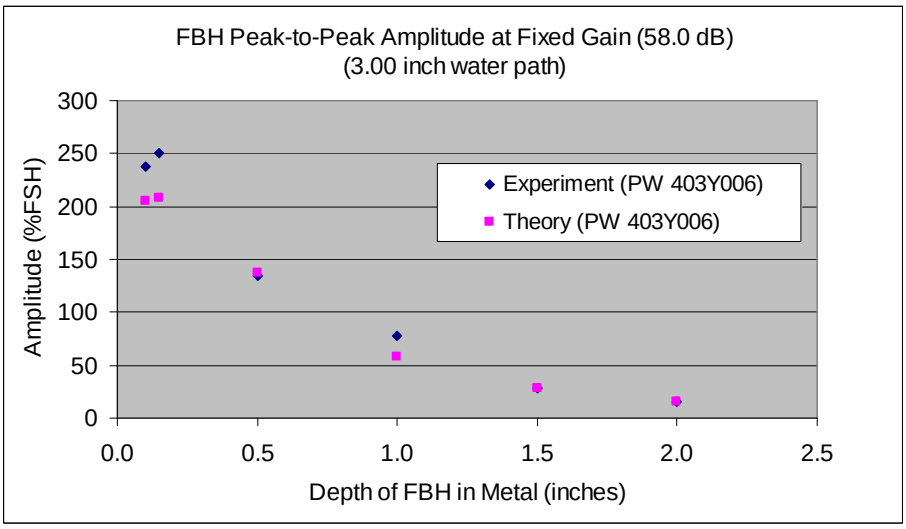
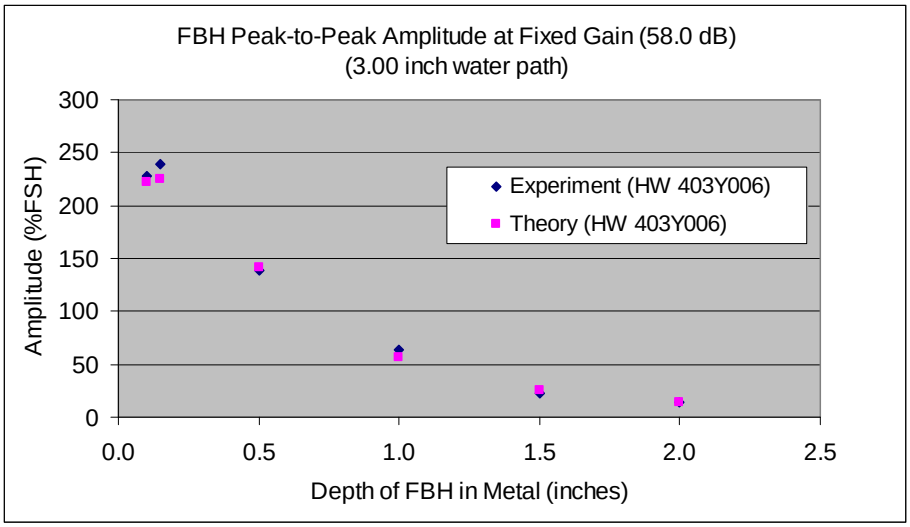
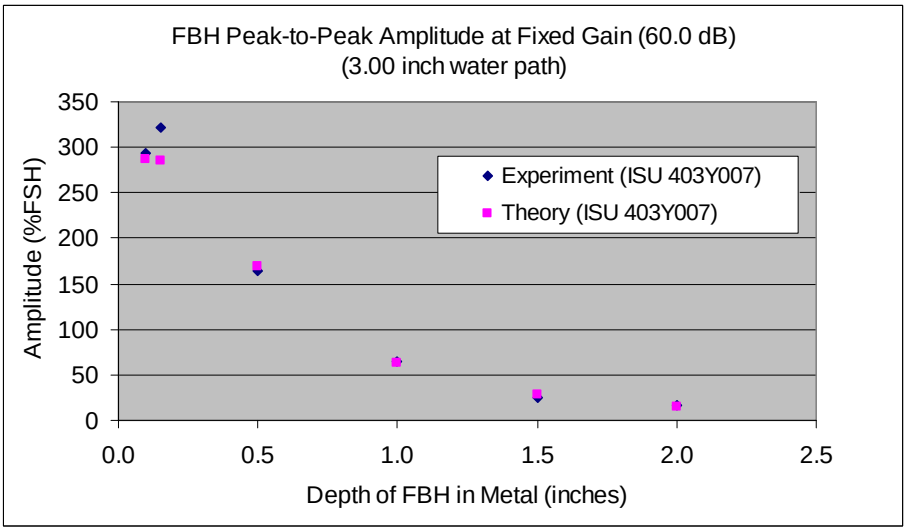


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block (Continued)





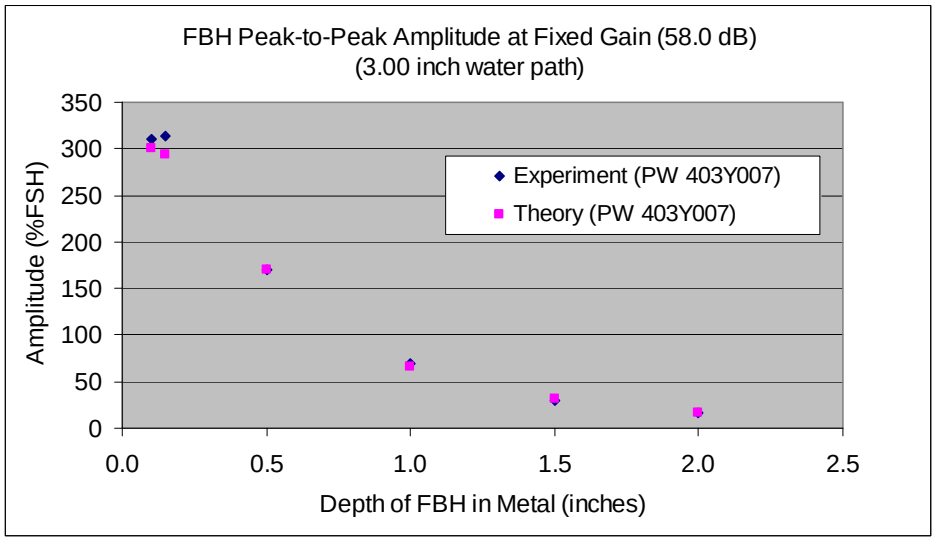


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block (Continued)

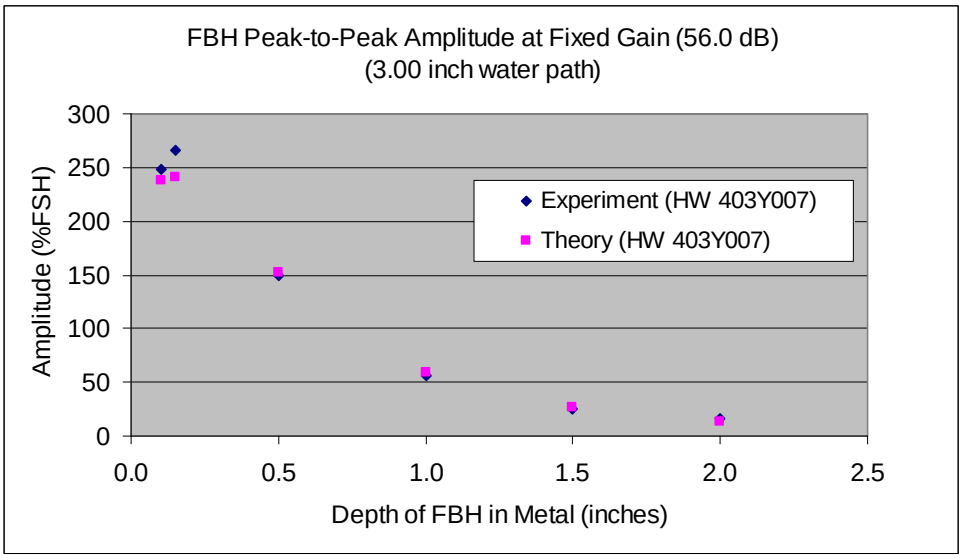


Figure B-1. Measured and Predicted Peak FBH Response Versus Metal Depth for the RCE of Each Type-I Transducer, Using the Nickel Alloy Step Block (Continued)

APPENDIX C—TECHNICAL DATA SHEETS FOR PHASED ARRAY TRANSDUCERS, AS SUPPLIED BY THE MANUFACTURERS

This appendix contains technical data sheets that describe the designs and nominal operating characteristics for the two types of phased array transducers studied. Data sheets for the Type-I transducers (14 elements + removable center element) appear first, as supplied by both supplier B and supplier A, in that order. Data sheets for the supplier A Type-II transducers (110 elements) appear last.

PROBE TECHNICAL DATA SHEET

PROBE REFERENCES

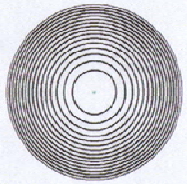
Model	10A15E32
R/D Tech order reference	AAWX074B

PROBE SPECIFICATIONS

Array

Type of array	Annular
Center frequency	10 MHz (+/-15%)
Number of elements	14 (annular array) + 1 central elt (focus = 3") removable

Elements configuration



Elts	Internal radius	External radius	kerf	Ring width
1	0.00	4.80	0	4.80
2	6.99	7.68	2.19	0.69
3	7.88	8.49	0.2	0.61
4	8.69	9.26	0.2	0.57
5	9.46	9.97	0.2	0.51
6	10.17	10.66	0.2	0.49
7	10.86	11.31	0.2	0.45
8	11.51	11.94	0.2	0.43
9	12.14	12.55	0.2	0.41
10	12.75	13.14	0.2	0.39
11	13.34	13.72	0.2	0.38
12	13.92	14.27	0.2	0.35
13	14.47	14.82	0.2	0.35
14	15.02	15.35	0.2	0.33
15	15.55	15.87	0.2	0.32

Active area (diameter)	32 mm
Typical bandwidth -6dB	>70%
Acoustic matching with	Water
Element to element sensitivity variation	+/-4 dB for the whole array
Probe to probe average sensitivity variation	+/-2 dB
Typical cross-talk between two successive elements	<-35 dB
Typical cross-talk between two elements separated by one element	<-40 dB

Connector

Number and type of connector	1 Hypertronics + 1 Lemo

Cable

Type of cable	Shielded multi-coaxial cable, 50 Ω
Length	5 m
Outer sheath	Very flexible PVC

Housing

Type	Stainless steel with waterproof UHF connector on top for mechanical fixing
Cable output	On side

Operating condition

Max input voltage	100 V
Max input pulse length	50 ns
Waterproof depth	1 m
Typical temperatures	0°C to 50°C in storage 10°C to 40°C in use

10MHz 16 elts annular array
Piezocomposite Technology

Technical Characteristics and acceptance levels

Acoustical characteristics

Centre frequency (-6dB): 15 MHz +/- 15%*
Bandwidth (-6dB): > 65 %*
Geometry: annular array
Focusing: flat active area
Kind of wave considered: longitudinal waves
Number of rings: 15 + 1 central element removable
Rings size

ring #	int. radius (mm)	ext. radius (mm)	spacing between elements i-1 and I (mm)	ring width (mm)	Area (mm^2)
1*	0.00	4.80	0	4.80	30.16
2	6.99	7.68	2.19	0.69	31.80
3	7.88	8.49	0.2	0.61	31.37
4	8.69	9.26	0.2	0.57	32.14
5	9.46	9.97	0.2	0.51	31.13
6	10.17	10.66	0.2	0.49	32.07
7	10.86	11.31	0.2	0.45	31.34
8	11.51	11.94	0.2	0.43	31.68
9	12.14	12.55	0.2	0.41	31.80
10	12.75	13.14	0.2	0.39	31.72
11	13.34	13.72	0.2	0.38	32.30
12	13.92	14.27	0.2	0.35	31.00
13	14.47	14.82	0.2	0.35	32.21
14	15.02	15.35	0.2	0.33	31.49
15	15.55	15.87	0.2	0.32	31.59

Acoustical matching: water
Pulse length (-20 dB): < 500 ns*
Electrical matching for each ring: $Zr = 50\Omega$ +/- 10Ω *
$Zi = 0j\Omega$ +/- 20Ω *
Sensitivity homogeneity: +/- 4 dB*
Inter element Cross coupling: < -30dB *
Parasitic echoes level : < -40dB compare to the main echo*

Central element specification: (TLC Black beauty transducer)
10MHz transducer
Spherically focused 3" in water
S/N ratio > 18 dB after reflex ion on fbh # 1 located 0.06" under the surface

*** Probe acceptance criteria's, see Implemented measurements**

Mechanical characteristics

Housing: Cylindrical Stainless steel with central hole for removable central transducer

Dimensions will be confirmed by a drawing after the mechanical design step first estimations :
Outer diameter 60 mm
Height: 60 mm

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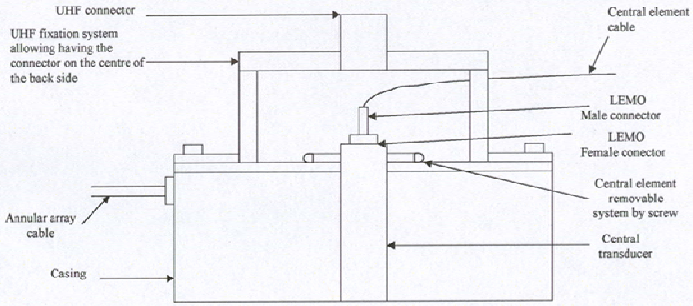
Figure C-1. Probe Technical Data Sheet

10MHz 16 elts annular array
Piezocomposite Technology



Electrical characteristics

Cable: 50Ω multi-coaxial with overall shielding connected to the casing
Length: 5 m +/- 10 cm
Connector: Hypertronix compatible RD-tech Focus for the annular array, LEMO for the central element (standard RD Tech Focus PIM/06)
Wiring diagram: standard RD tech system

Identification/Engraving

Imasonic
10 MHz – 15 elts
Serial n

Using conditions

Chemical constraints: Immersion under water, do not use the probe in other conditions.
Temperature: 0° to 30° (storage)
10 à 40° (functioning)
Excitation: negative pulse 200V maximum (measured in 50 Ω environment)
Max repetition frequency: 10 kHz
Shocks and vibrations: avoid shocks and vibration
Nuclear radiation: no specific constraints taken into account
Normative constraints: no specific constraints

Other using conditions must be validated by Imasonic

Implemented measurements

Impedance measurement for all the elements at the nominal frequency
(Imasonic procedure INP 410)
Performed with HP3577 network analyser (50 Ohms environment)
Acoustic load on the front face: 1.5MR

10MHz 16 elts annular array
Piezocomposite Technology

Inter-element coupling measurement
(Imasonic procedure INP 412)
Performed with HP3577 network analyser (50 Ohms environment)
Acoustic load on the front face: 1.5MR

Temporal response & frequency spectrum measurement for all the elements
(Imasonic procedure INP 413)
Performed in water on a flat target brass
Excitation signal: 1 negative pulse (50 Ohms environment)

Backing echo measurement
Performed in water on a flat target brass

Supplied documentation

Specifications of the probe
Overall drawing of the probe
Measurement results

Guarantee

One year against manufacturing defects in the conditions described

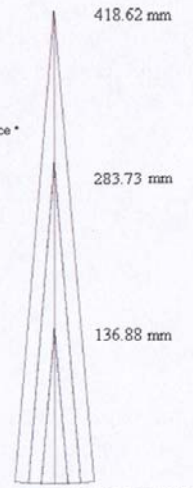
Figure C-1. Probe Technical Data Sheet (Continued)

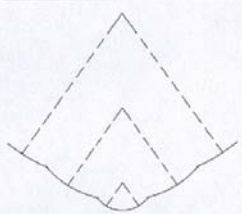
10 MHz 110 elts Phased-Array Transducer
Piezocomposite technology

Acoustical characteristics acceptance level

Frequency (-6dB) : Average value between 9.5 and 12 MHz
Bandwidth (-6dB) > 65 % (average value)
Acoustical matching : Water (1.5 MR)
Mechanical focalisation : spherical with three different radius of curvatures according to drawing hereinafter,
Precision objective : +/- 0.0125 mm with maximum 10 % of points out of tolerance *
(In the case of transducer 344A101, 29% of points was out of tolerance)

*see *"implemented measurements"* part





Concept of compound spherical surface
(not drawn to scale)

Number of channels: 110
Inter element spacing : 0.12 mm
Element size : according to specifications hereinafter

ring #	radius mm	height mm	width mm	# seg	f.l. H2O mm	f.l. H2O inch	f.l. Ti mm	f.l. Ti inch
Inner region: curvature radius = 136.88 mm								
1	3.1564	0.0364	3.0364	1				
2	4.5492	0.0756	1.2728	1				
3	5.6353	0.1161	0.9661	1				
4	6.5633	0.1574	0.8079	1				
5	7.3903	0.1996	0.7070	1	88.5744	3.4872	2.9783	0.1173
6	8.1454	0.2426	0.6352	1	97.6477	3.8444	5.1620	0.2032
7	8.8464	0.2862	0.5810	1	106.0738	4.1761	7.1901	0.2831
8	9.5044	0.3304	0.5380	1	113.9863	4.4876	9.0944	0.3580
9	10.1273	0.3752	0.5029	1	121.4799	4.7827	10.8980	0.4291
10	10.7208	0.4205	0.4735	1	128.6226	5.0639	12.6171	0.4967
11	11.2892	0.4663	0.4484	1	135.4652	5.3333	14.2640	0.5616

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10 MHz 110 elts Phased-Array Transducer
Piezocomposite technology

12	11.8358	0.5127	0.4267	1	142.0486	5.5925	15.8485	0.6240
Middle region: curvature radius = 283.73 mm								
13	12.3649	0.5352	0.4090	1	148.3974	5.8424	17.3765	0.6841
14	12.8772	0.5581	0.3924	1	154.5472	6.0845	18.8567	0.7424
15	13.3746	0.5811	0.3774	1	160.5178	6.3196	20.2937	0.7990
16	13.8582	0.6043	0.3636	1	166.3245	6.5482	21.6912	0.8540
17	14.6725	0.6453	0.6943	2	176.1033	6.9332	24.0448	0.9466
18	15.4501	0.6867	0.6575	2	185.4425	7.3009	26.2926	1.0351
19	16.1961	0.7283	0.6260	2	194.4056	7.6538	28.4498	1.1201
20	16.9143	0.7703	0.5982	2	203.0355	7.9935	30.5269	1.2018
21	17.6079	0.8126	0.5737	2	211.3730	8.3218	32.5335	1.2808
22	18.8158	0.8903	1.0879	4	225.8950	8.8935	36.0287	1.4185
23	19.9576	0.9685	1.0218	4	239.6272	9.4341	39.3338	1.5486
24	21.0439	1.0472	0.9662	4	252.6952	9.9486	42.4790	1.6724
25	22.0823	1.1263	0.9184	4	265.1920	10.4406	45.4867	1.7908
26	23.0791	1.2059	0.8768	4	277.1920	10.9131	48.3749	1.9045
Outer region: curvature radius = 418.62 mm								
27	24.0415	1.2602	0.8424	4	288.7545	11.3683	51.1578	2.0141
28	24.9712	1.3147	0.8097	4	299.9265	11.8081	53.8466	2.1199
29	25.8718	1.3695	0.7806	4	310.7511	12.2343	56.4519	2.2225
30	26.7459	1.4245	0.7541	4	321.2588	12.6480	58.9809	2.3221
31	27.5960	1.4798	0.7301	4	331.4796	13.0504	61.4409	2.4189
32	28.4242	1.5353	0.7082	4	341.4393	13.4425	63.8380	2.5133
33	29.9044	1.6387	1.3602	8	359.2431	14.1434	68.1230	2.6820
34	31.3200	1.7425	1.2956	8	376.2753	14.8140	72.2224	2.8434
35	33.2815	1.8943	1.8415	12	399.8834	15.7434	77.9044	3.0671
36	35.1398	2.0467	1.7383	12	422.2581	16.6243	83.2895	3.2791

Element situation : Rings 17 through 21 are divided into 2 non-contiguous elements
The non-contiguous elements are formed by segmenting the ring into 4 segments and hard wiring opposing segment together .

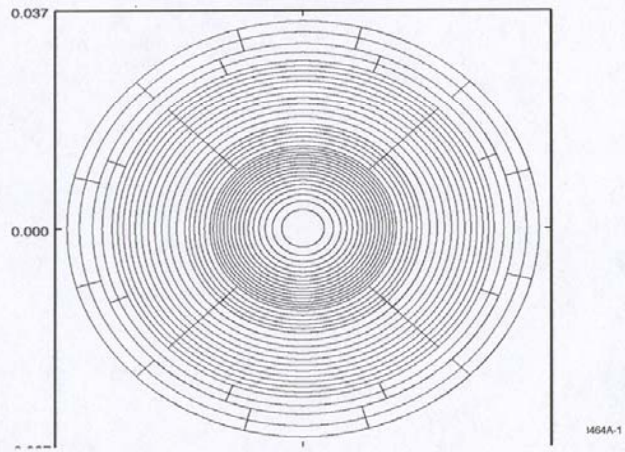

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Figure C-1. Probe Technical Data Sheet (Continued)

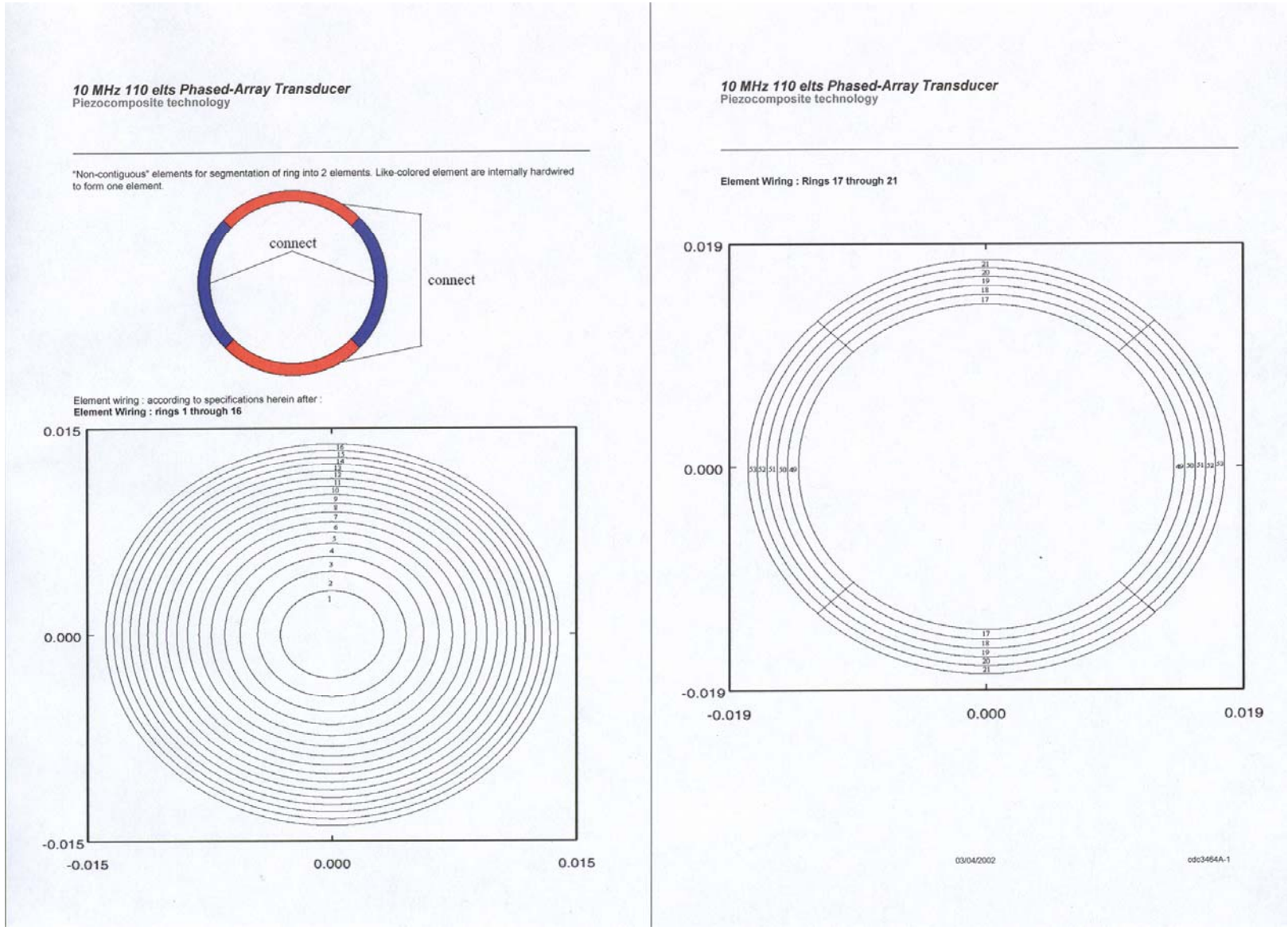
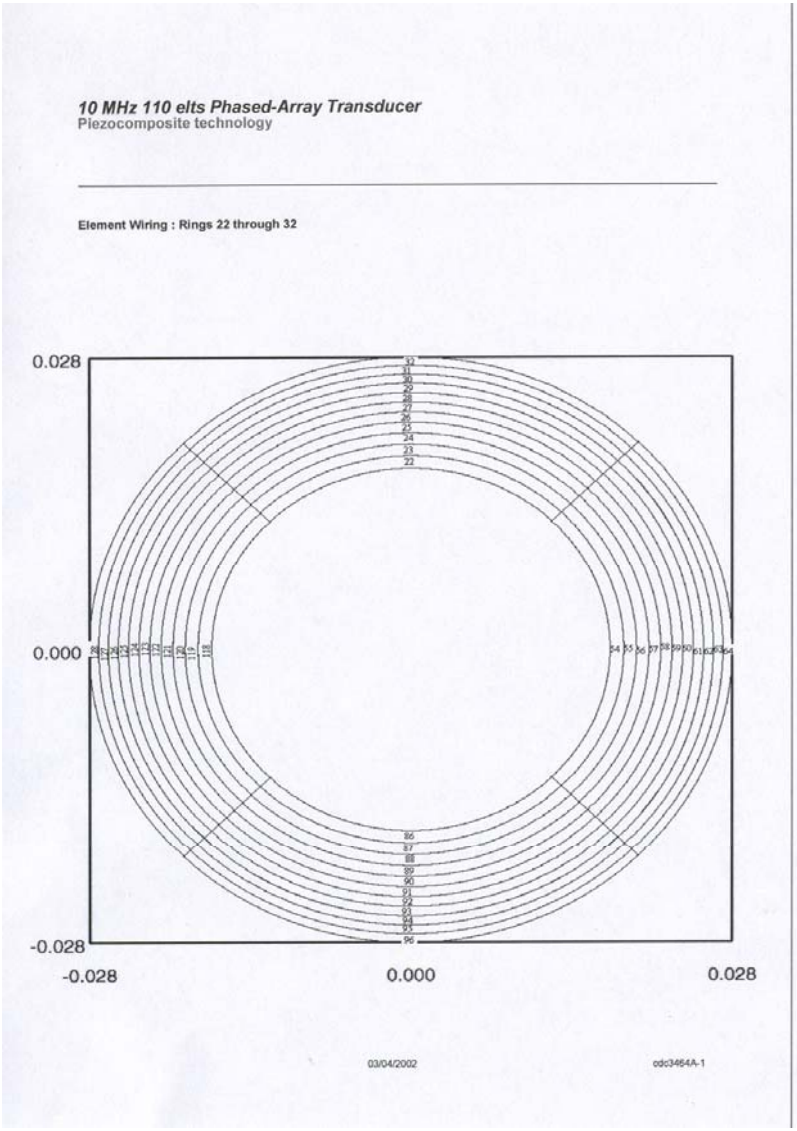


Figure C-1. Probe Technical Data Sheet (Continued)



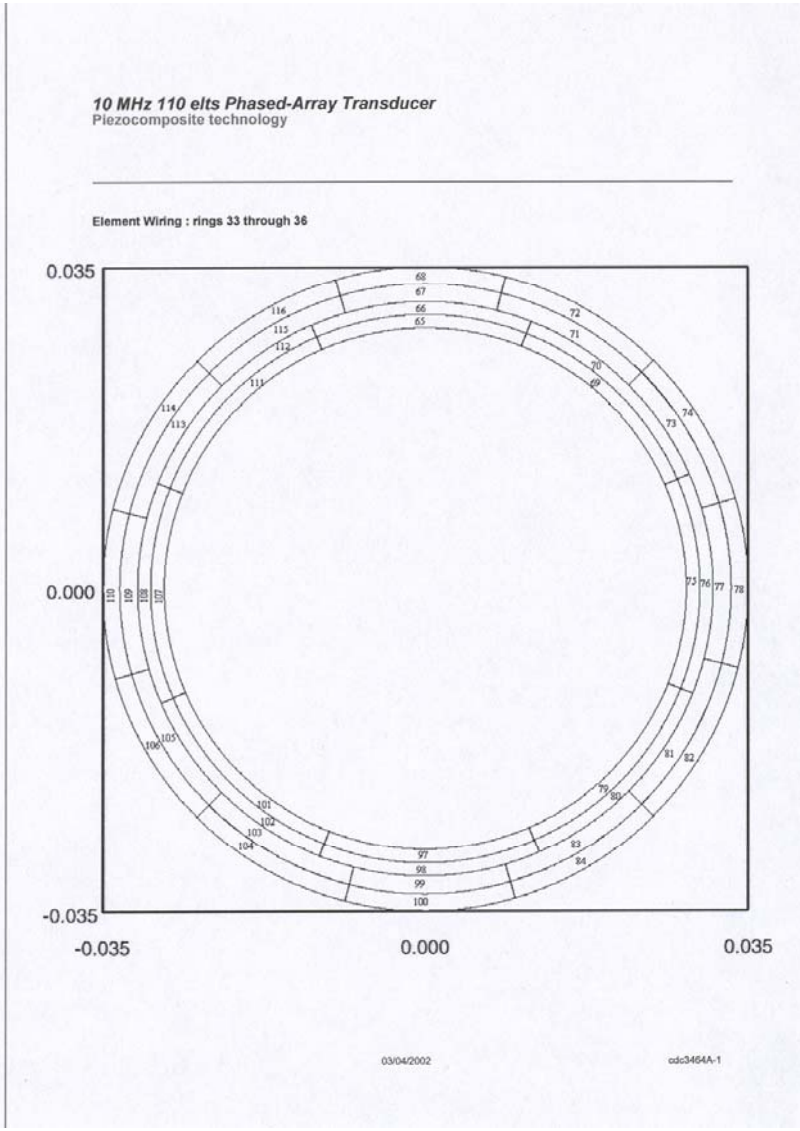


Figure C-1. Probe Technical Data Sheet (Continued)

10 MHz 110 elts Phased-Array Transducer
Piezocomposite technology

Mechanical characteristics

Housing
Material : Stainless steel 304 L
Dimensions : to be defined

Interconnections:

Cable : multi coaxial with shielding wiring to the housing - length 3 m – cable way out : axial
Connector : FRB – Wiring : standard RD Tech Focus

A general drawing and a cable layout will be supplied by Imasonic and validated by Pratt&Whitney before starting of the manufacturing.

Identification/Engraving

IMASONIC
10 MHz – F/6 – 0.05 to 3.25 "
3446 serial number

Using conditions*

Chemical constraints : Immersion in water of the front face

Temperature : 0°c to 50°c (storage)
10 to 40°c functioning

Excitation : Negative pulse 200 V maximum (measured in 50 Ω environment)
Max repetition frequency : 10 KHz

EMC : no specific constraints mentioned by the customer
Shocks and vibration : no specific constraints mentioned by the customer
Nuclear radiation : no specific constraints mentioned by the customer
Pressure constraints : no specific constraints mentioned by the customer

Cleaning : manual , with alcohol

Implemented measurements

Measurement of the geometrical surface.
Measurement of 4 rises for each ring (144 points)

Performed with HP3577A network analyser (50Ω environment)
Acoustic load on the active part : 1.5 MR
Impedance measurement for all the elements at the nominal frequency
Inter element cross coupling at the nominal frequency for 4 pairs of elements

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10 MHz 110 elts Phased-Array Transducer
Piezocomposite technology

Performed in water on a target complementary to the active surface in T/R mode (distance to be defined) for each element

Excitation signal : 1 negative pulse
Temporal response & frequency spectrum measurement for each element

Performed in water on a flat target brass in T/R mode at 137 mm, for element 1
Excitation signal : 1 negative pulse
Temporal response & frequency spectrum measurement

Performed in water on a flat target brass in T/R mode at 137 mm, for element 1
Excitation signal : 1 sinusoid 10 MHz – 16 Vpp

Temporal response & frequency spectrum measurement

Supplied documentation

Drawing of the transducer
Measurement results
Specifications of the transducer

Guarantee

1 year in the using conditions mentioned.

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Figure C-1. Probe Technical Data Sheet (Continued)

APPENDIX D—MEASUREMENT PROCEDURES FOLLOWED BY ALL ROUND-ROBIN PARTICIPANTS

ETC 1.3.2 Probe Characterization and Variability Study: Evaluating Probe Performance - Instructions

Part I : Removable center element (RCE) of 15-element transducer
- •estimated setup time: 1 hour
- •estimated measurement time (plus optional test): 2 hours per transducer

Part II: Planar, annular, 15-element transducer
- •estimated setup time: 30 minutes
- •estimated measurement time: 1 hour per transducer

Part III: Compound spherical, segmented annular, 110-element transducer
- •estimated setup time: 2 hour
- •estimated measurement time: 2 hours per transducer

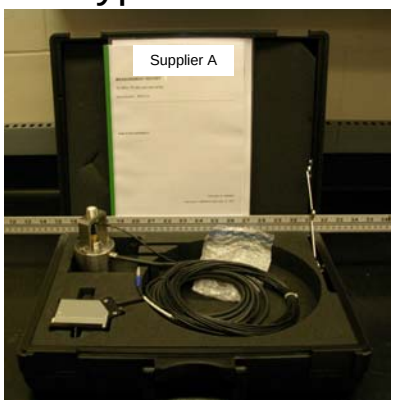
Jon Friedl
F. J. Margetan
Ron Roberts
Tim Gray
May 17, 2005
PA_char_plans_9.ppt

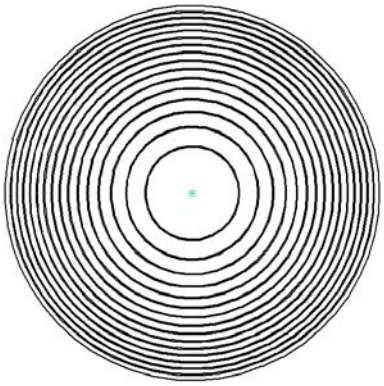
Overview of Instructions

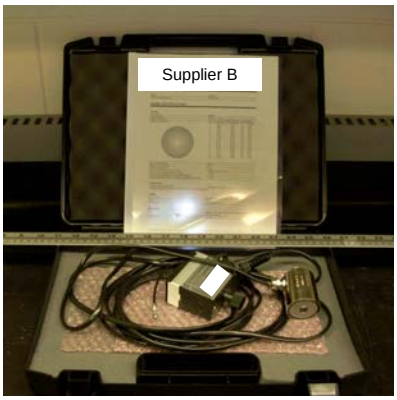
- Inventory List
  - Probe Type I - 15-element, planar, annular phased array (includes removable center element)
  - Probe Type II - 110-element, compound spherical, segmented annular phased array
  - Samples
- Some Measurement Ground Rules
- Procedures for Removable Center Element
  - Overview of types of data to be taken
  - Specific instructions and minimal data processing
  - Post-processing of data
- Procedures for 15-Element Annular Phased Array
- Procedures for 110-Element Segmented Annular Phased Array

Inventory List - Probe Type I

- Three (3) Supplier A 15-element annular probes with removable center element already inserted.
  - Probe Serial # 4608-A101
  - Probe Serial # 4608-A102
  - Probe Serial # 4608-A103
- Three (3) Supplier B 15-element annular probes with removable center element already inserted.
  - Probe Serial # 403Y004
  - Probe Serial # 403Y006
  - Probe Serial # 403Y007

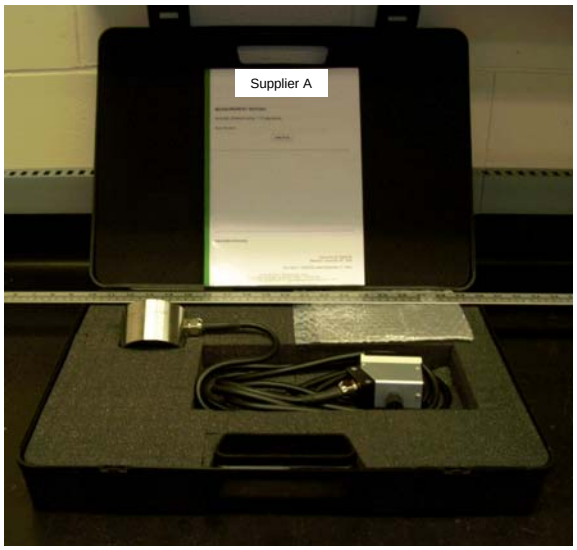


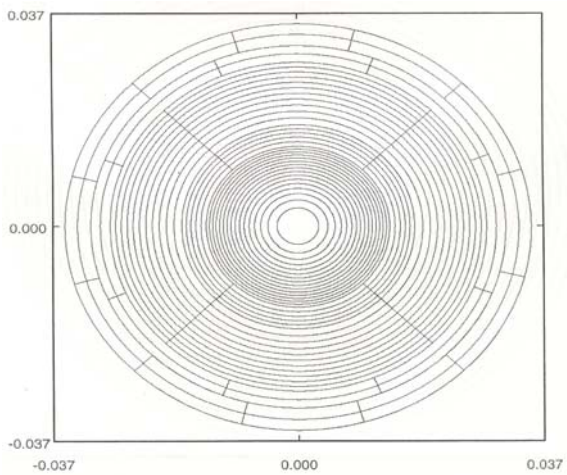


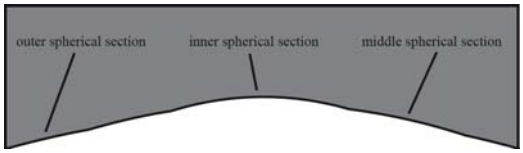


Inventory List - Probe Type II

- Three (3) Supplier A 110-element, compound spherical, segmented annular probes.
  - Serial # 3446-A101
  - Serial # 3446-B101
  - Serial # 3446-B102

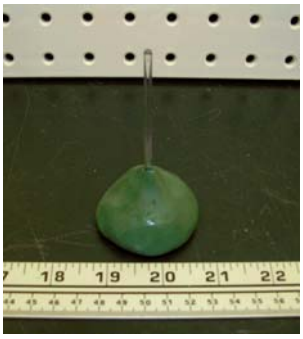




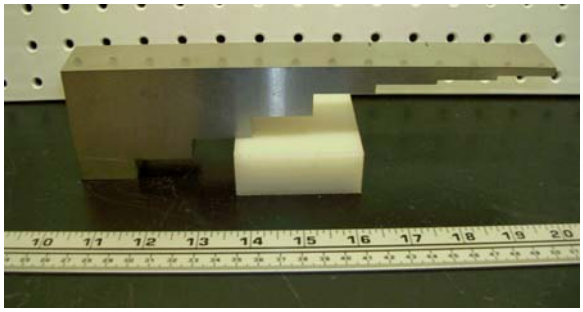


Inventory List - Samples I

- One (1) small glass rod with rounded tip with green clay base.

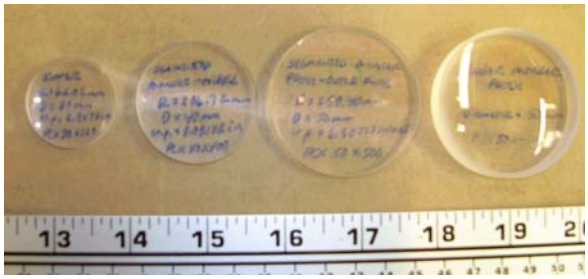


- One (1) IN100 step block with white plastic support.
  - longitudinal wave speed = 6138 m/s = 0.2417 in/us



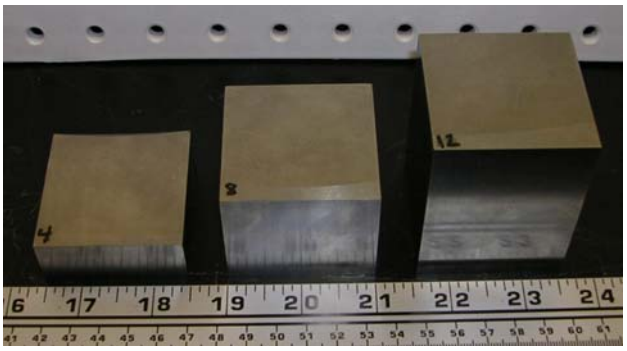
Inventory List - Samples II

- One (1) plano-convex glass reflector for use with inner section of 110-element probe.
  - Dimensions: diameter = 30 mm and radius of curvature = 62.02 mm
  - use 2.947-inch water path (as measured relative to rings in inner section of probe)
- One (1) plano-convex glass reflector for use with middle section of 110-element probe.
  - Dimensions: diameter = 40 mm and radius of curvature = 206.72 mm
  - use 3.031-inch water path (as measured relative to rings in middle section of probe)
- One (1) plano-convex glass reflector for use with outer section of 110-element probe.
  - Dimensions: diameter = 50 mm and radius of curvature = 258.40 mm
  - use 6.308-inch water path (as measured relative to rings in outer section of probe)
- One (1) plano-concave glass reflector for use with 15-element probe.
  - diameter = 50 mm
  - use planar side with 15-element probe at a water path of 3.000 inches



Inventory List - Samples III

- Three (3) blocks from a set PW planar-entry calibration blocks, each containing a #1/2 FBH.
  - PW block #4
  - PW block #8
  - PW block #12



Inventory List - Tomoview 2.2 Setup Files

File Name	Sample Used	Purpose
RCE-Y-zero-plus.acq	glass rod	For Y+0 determination and optional C-scan for spot size.
TVoffsetValue.acq	none	For determination of t0 offset time (big bang start).
RCE-SpotSize.acq	glass rod	For optional C-scan for spot size.
RCE-FBH-Ref_Ascan.acq	IN100 step block with #1 FBHs	For A-scan (ref signal) and six FBH amplitudes.
RCE-NearSR.acq	IN100 step block with #1 FBHs	For determining near surface resolution signal-to-noise.
015E-Delays.acq	plano-concave reflector, 50 mm D	For determining TOF variation over all array elements.
SupB-015E-FBH-block08.acq	PW block #8 of set of 13 blocks	For determining spot size via C-scan of mid-zone FBH using 15-element probes manufactured by Supplier B.
SupA-015E-FBH-block08.acq	PW block #8 of set of 13 blocks	For determining spot size via C-scan of mid-zone FBH using 15-element probes manufactured by Supplier A.
110E-Delays.acq	plano-convex reflector, 30 mm D plano-convex reflector, 40 mm D plano-convex reflector, 50 mm D	TOF variation over all array elements in inner, middle, and outer section of 110-element probe.
110E-FBH-block04.acq	PW block #4 of set of 13 blocks	For determining spot size of mid-zone FBH, zone 2.

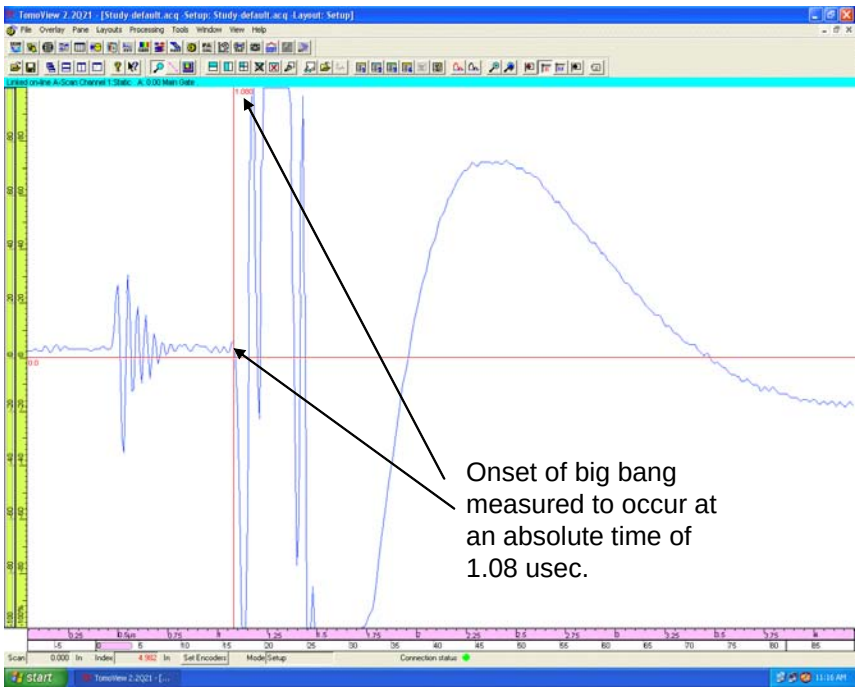
Inventory List - Other Files

File Name	Purpose
PA_char_plans_RCE_5.xls	Contains various spreadsheets for recording raw data and displaying results of data analysis (for removable center element only).
NMF5.exe	Software for analyzing data from removable center element to determine an effective diameter and focal length.
NMF5_ref_signal.txt	Prototype file for reference signal A-scan data, as input to NMF5.exe.
NMF5_input.txt	Prototype file for input of additional data to NMF5.exe.
PA_performance_015E_Delays-OUTFIT.xls	Contains various spreadsheets for recording raw data and displaying results of data analysis (for 15-element probe only).
PA_performance_110E_Delays-OUTFIT.xls	Contains various spreadsheets for recording raw data and displaying results of data analysis (for 110-element probe only).

Some Measurement Ground Rules

- During testing, the center element should not be removed from the array, nor should its orientation within the array be altered.
- Use Tomoview 2.2 version software for all data acquisition, including data from the removable center element.
- Setup files, incorporating the necessary PAC files and UT settings, will be provided.
- During measurements, use PAC files already provided. Unless specified otherwise, these PAC file will already be incorporated into Tomoview 2.2 Setup files (.acq).
- When specifying a P/E amplitude we will mean the peak-to-peak amplitude of the unrectified signal (not the peak or dominant amplitude), unless stated otherwise.
- The PA transducer, including the removable center element, should not be energized when it is out of the water. After the transducer has been energized, wait 10 minutes for the system to stabilize before taking any data.
- You will occasionally be asked to “set the water path” to a particular value. To simplify this procedure (and to use common industrial practice) all water paths will be set by time-of-flight (TOF) ignoring any time delay between the electronic “big bang” and emission of sonic energy by the transducer. However, the time difference between left edge of the system A-scan and the start of “big bang” cannot be ignored and will have to be recorded. Thus to set the one-way water path to Z, adjust the water path until the arrival time of the front-wall echo (dominant peak) is at time $t = (2Z / v) + t0$, where t0 is the measured time between $t = 0$ and the big bang. The water velocity (v) to use in this equation depends on temperature and is obtained from a look-up table (for pure water) - see spreadsheet labeled “sound speed in water” in MS Excel file “PA_char_plans_RCE_5.xls”.
- Do not load a setup file which energizes FEWER rings than the previous setup file without restarting Tomoview software and Tomoscan hardware.
- If electronic noise is present so that the instantaneous signal “jitters” noticeably, set the red and blue reference lines (used to measure peak amplitudes) at “mentally averaged” peak positive and peak negative amplitude values. I.e., the jittering peak amplitude should be above the reference line 50% of the time and below the reference line 50% of the time if the reference line is properly positioned.

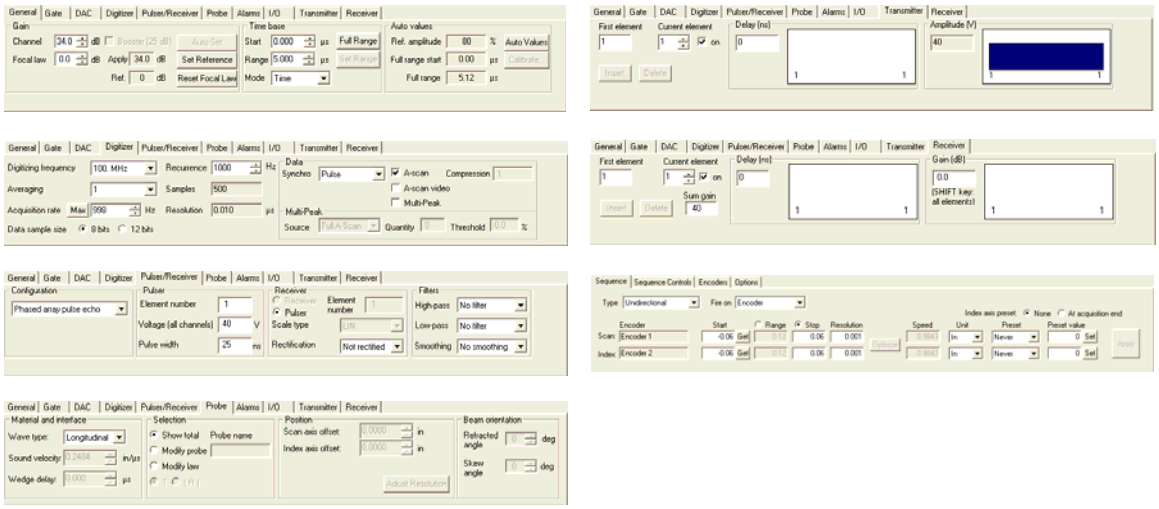
Measuring Tomoview's Time Offset Value, t0, Needed to Determine Accurate Water Paths



- After loading Tomoview setup file TVoffsetValue.acq, record the time offset t0, defined as the time difference from the far left edge of the A-scan to the onset of the big bang.
- See figure on left, indicating t0 = 1.08 microseconds for the ISU system.

Measuring Tomoview's Time Offset Value, t0, Needed to Determine Accurate Water Paths (con't)

- Verify Tomoview setup file TVoffsetValue.acq parameter values.



Example: Determining TOF Needed To Achieve a Specified Water

Example: Setting water path from the center element to a glass rod target to 3.00 inches at 72°F., where t0 = 1.08 microseconds:

From the look-up table in the Excel spreadsheet named "Sound speed in water" , we find that

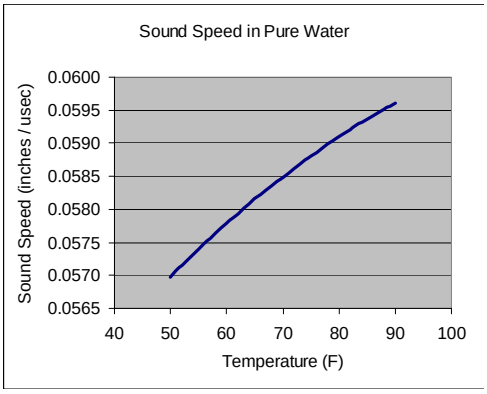
V = 0.058621 in/usec at 72 °F

Thus we need:

TOF = (2Z / v) + t0

= 2(3.00 in.)/(0.058621in./usec) + 1.08us

= 103.43 microseconds



Adjust water path until dominant central peak (+ or – as specified in later procedures) of the front wall echo is at 103.43 microseconds.

*Speed of sound in pure water at standard pressure using the formula of Bilaniuk and Wong (From http://www.npl.co.uk/acoustics/techguides/soundpurewater/):

$$V(m/s) = 1.40238744 \times 10^{3} + 5.03836171T - 5.81172916 \times 10^{-2}T^{2} + 3.34638117 \times 10^{-4}T^{3} - 1.48259672 \times 10^{-6}T^{4}$$
$$+3.16585020 \times 10^{-9}T^{5},$$ where T is in degrees Celsius

Example: Determining TOF Needed To Achieve a Specified Water (continued)

One can use the built-in calculator rather than the look-up table

The spreadsheet named "sound speed in water" also contains built in calculators for translating between degrees F and degrees C, and for translating between one-way water path and TOF (absolute observation time). Below the calculator is used to calculate the TOF for the problem at left.

Example: Setting water path from the center element to a glass rod target to 3.00 inches at 72°F., where t0 = 1.08 microseconds:

From the calculator in the Excel spreadsheet, we find that

V = 0.058621 in/usec at 72 °F

And that

TOF = (2Z / v) + t0

= 103.43 microseconds

One-way waterpath to/from TOF calculator				
Enter numbers into Yellow blocks only				
	Water temp (F) =		72	
	Time-offset (usec)=		1.08	
	One-way water path (inches)=		3	
	Water temp (C)=		22.22222	
	water sound speed (in/usec)=		0.058621	
	TOF (usec)=		103.432	

Similarly, all spreadsheets which require translations between Z and TOF have similar calculators "built in", so the user generally only has to enter water temperature and either Z or TOF.

Part I -
Characterization of the Removable Center Element (RCE) of a 15-element transducer

Sketches of Probe-Characterization Measurements Using Removable Center Element

- **Ball-Target in Water: Amplitude Versus Depth.**
  Measurements of peaked amplitudes as a function of water path for a ball target (actually, here, a glass-rod tip) in water. Used to determine Y+0, the water path at which the echo from a small target is maximized, and to also determine the shape of the axial beam profile in water for later comparison to model predictions.

- **C-scan of Ball Target in Water Located at Y+0.**
  (Optional) Used to determine beam diameter (at -6dB level) in water at the focus.

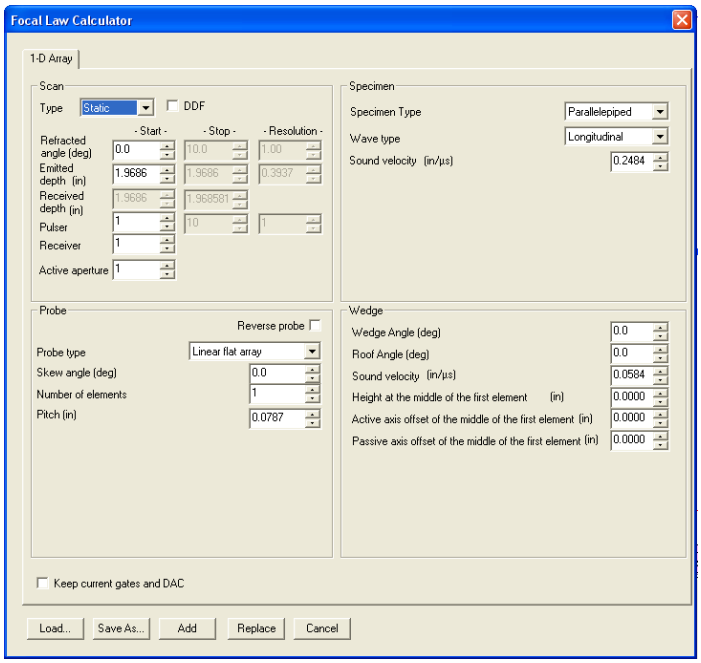
- **Acquisition of an A-scan Reference Signal.**
  Reflector is a #1 FBH located 0.5” deep in an IN100 step block. Water path = 3”. Move laterally to peak the signal. Digitize at 100 MHz sampling rate, gathering a 256-point waveform (2.55 usec gate). This A-scan serves as a “reference signal” for the later analysis, and is also used to determine a center frequency and bandwidth.

- **Peaked Amplitude Versus Depth for Six (6) #1 FBH Targets.**
  Targets are #1 FBHs at different depths in the same IN100 step block. Water path is again 3”. Just move the probe laterally to peak each signal and record the peak amplitude information.

- **Near-Surface Resolution Information:**
  Using the same IN100 test block, vary the water path to peak up the response from #1 FBH at 0.050” depth. Acquire A-scan for a gate which contains both the FBH signal and ring-down of front wall echo. Then move laterally away from the FBH to two other locations, and acquire A-scan using the same gate.

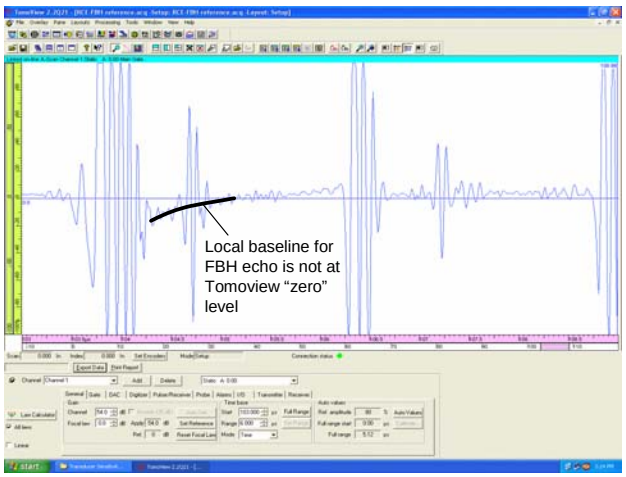
Energizing Removable Center Element with Zero Delay Time

- At right are the dialog box settings used for Tomoview's Law Calculator wizard.
  - The setting shown energize only the center element (element #1) of the 15 element array.
  - The length of the wedge, i.e., the water path in this case, is zero.
  - The aperture size, i.e., number of elements, is set to one element.
  - The only element used as a pulser and receiver is element #1 (the center element).
  - The value for emitted depth is irrelevant since only one element is used in this focal law.



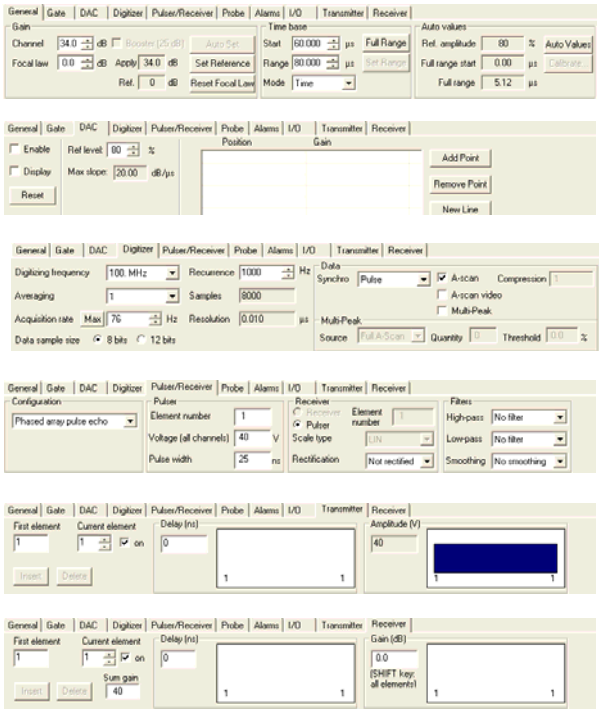
For Center Element Characterization We Will Always Measure Peak-to-Peak Amplitudes (Rather Than Rectified Peak)

- Observations leading to the need for measuring peak-to-peak amplitudes:
  - The figure at right shows an A-scan of one of a shallow FBHs in the IN100 step block.
  - Starting from the left edge of the A-scan, the first three responses are:
    - Front wall signal
    - FBH signal
    - Back wall signal
  - Note that due to front-wall ringdown, the local baseline for the FBH response starts at less than zero and slowly rises to approach the Tomoview zero reference line (horizontal blue line).
- A rectified amplitude measurement based on the observation of a single dominant (pos. or. neg.) peak alone tacitly assumes that the peak amplitude is measured relative to a zero amplitude reference line. As in this example, the Tomoview zero amplitude line, may not coincide with the "local baseline" of the echo whose amplitude we need to know.
- A peak-to-peak amplitude measurement involving the measurement of both the (nearby) maximum and minimum peak amplitudes, does not require that the local baseline coincide with the Tomoview zero level. (Although a slight error in the peak-to-peak amplitude is introduced by the slope of the local baseline.)



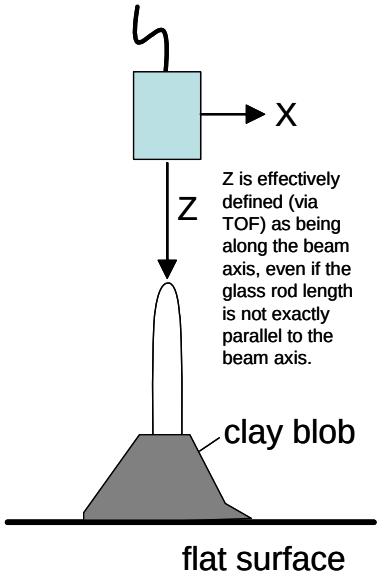
Removable Center Element (RCE): Setting Up for Ball-Target-in-Water Measurements

- Submerge the 15-element probe, clear away any water bubbles from probe face, and approximately center the probe over the tip of the glass rod with an approximate 2.5-inch water path.
- Probe cables to R/D Tech instrument interface.
  - Limo cable to port P1
  - Hypertronics cable connector is not connected
- Start computer and wait for it to finish, then turn on R/D Tech hardware (either FOCUS or Tomoscan III instruments) and Tomoview 2.2 software.
- Load Tomoview Setup file “RCE-Y-zero-plus.acq”. This setup file fires the center element only, using a zero delay time.
- Check Tomoview settings by comparing your information panels to those shown at right. All settings shown should agree.



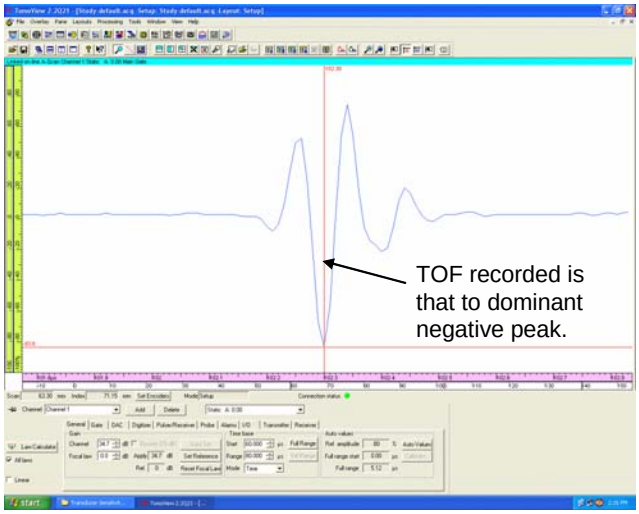
Ball-Target-in-Water: Initial Position of Probe

- Data will be recorded using the worksheet named “Ball_in_water (probe ID)” in the Microsoft Excel file “PA_char_plans_RCE_5.xls”. Make a copy of the template worksheet for each probe.
- Record the user and probe ID info requested by the yellow-highlighted cells. Also enter the water temperature in degrees °F, and the measured time offset (see a previous slide describing the offset measurement). The spreadsheet will calculate the water velocity, and also translate between water path (Z) and TOF.
- Position the glass-rod target on a flat surface as shown on right. Rod should be approximately perpendicular to the flat supporting structure (but need not be exactly perpendicular). Normalize the beam to the supporting structure by adjusting the two probe orientations angles. (Use reasonable care when normalizing, but no need to be exactly normal here.)
- Without being overly careful, roughly locate the water path for which the amplitude of the glass-rod echo is greatest, e.g. around 100 microseconds. At this water path, move the probe laterally (x and y) to maximize the echo amplitude.
- Adjust Tomoview’s “Start Time” and “Range” (or use zoom feature), as needed.



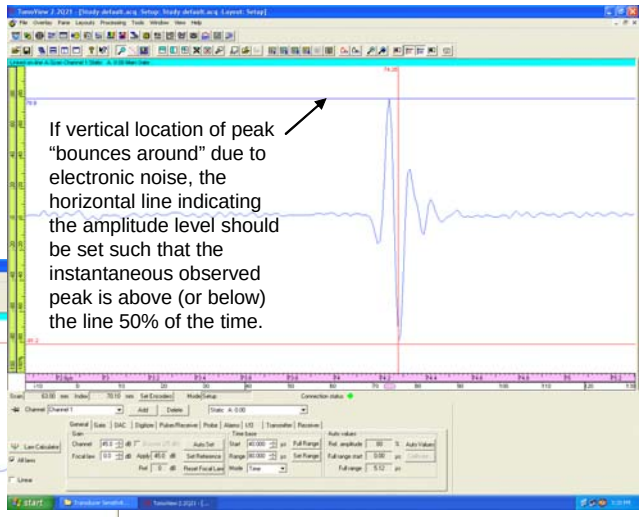
Ball-Target-in-Water: Amplitude-Versus-Depth Data

- Adjust gain until dominant amplitude is about 75% -90% FSH.
- Figure at right shows glass-rod response and gain setting when water path is chosen to maximize the amplitude.
- In the yellow spaces provided in the spreadsheet, record the gain setting (dB), maximum peak amplitude (%FSH), minimum peak amplitude (%FSH), and TOF (microseconds). For ball-target-in-water data, TOF will always refer to the absolute time of the dominant negative peak.
- Using your xyz positioning system, decrease the water path in steps of approximately 7 microseconds (about 0.2 inches). For each water path, center the probe over the glass rod target by "peaking-up" the amplitude on the A-scan. Again record the amplitude and TOF values in the spreadsheet.. Feel free to readjust the gain to keep %FSH value relatively large.
- Continue decreasing TOF in ~ 7 usec steps until the peak amplitude drops by roughly 6 dB from the first recorded value (typically about 6-7 data points).
- Returning to initial TOF, now increase the water path in steps of ~ 7 usec. Continue taking data until the amplitude drops roughly 6 dB from first recorded value (again, about 6-7 data points).
- Rearrange the amplitude-versus-TOF data in the worksheet so that TOF is always increasing. (Select tabulated measurements, then use Excel's Data -> Sort… drawdown menu option to sort data in ascending order.)
- See the example of a completed worksheet on a following slide.



Ball-Target-in-Water: Amplitude-Versus-Depth Data Examples of A-scan Data at Max and Min Water Paths

- Upper right figure shows the glass-rod response at the shortest water path for one of the ISU trials. (Note that while peak amplitudes are ~80% FSH, the gain setting has decreased ~ 6 dB from that used in the A-scan on the previous slide.)



- Lower left figure shows the glass-rod response at the largest water path. (Again the gain setting has decreased ~ 6 dB from that used in the A-scan on the previous slide.)

Ball-Target-in-Water: Amplitude-Versus-Depth
Appearance of Spreadsheet Data

PA_char_plans_RCE_4.xls

Worksheet for glass-rod target in water (including determination of Y+o point)
(Fill in only the cells that are highlighted in Yellow)

Date =	8-Feb-05		
User / outfit	Jon Friedl / ISU		
Probe ID number =	403 Y007		
Water temperature (F) =	67.46	(see C-to-F conversion below, if needed)	
Water temperature (C) =	19.70		(calculated)
Big bang start =	1.08	usec	
sound speed in water =	0.058324	in/usec	(calculated)
fixed gain for graphs =	28	dB	

Absolute time of dominant negative peak (measured)	Gain setting (measured)	Peak positive amplitude (measured)	Peak negative amplitude (measured)	Water path (calculated)	Peak amplitude at the fixed gain specified in cell D11 (calculated)
time(usec)	gain (dB)	%FSH	%FSH	Z(in)	%FSH
81.62	40.0	69.5	-87.5	2.349	39.44
88.63	37.0	70.3	-88.3	2.553	56.27
95.63	35.0	74.2	-86.7	2.757	71.87
102.63	34.0	78.1	-85.2	2.961	81.84
109.64	34.0	82.0	-85.2	3.166	83.80
116.64	34.0	80.5	-80.5	3.370	80.69
123.66	35.0	86.7	-84.4	3.575	76.43
130.64	35.0	82.8	-79.7	3.778	72.59
137.63	37.0	94.5	-88.3	3.982	64.86
144.63	38.0	90.6	-85.9	4.186	55.81
151.63	38.0	82.6	-75.0	4.390	49.84
158.62	40.0	90.6	-82.8	4.594	43.56
				-0.031	0.00
				-0.031	0.00
				-0.031	0.00
				-0.031	0.00
				-0.031	0.00
				-0.031	0.00
				-0.031	0.00
				-0.031	0.00

sound speed in water | Ball_in_water | FSH Amplitudes | Sound speed in IN100 | Sh

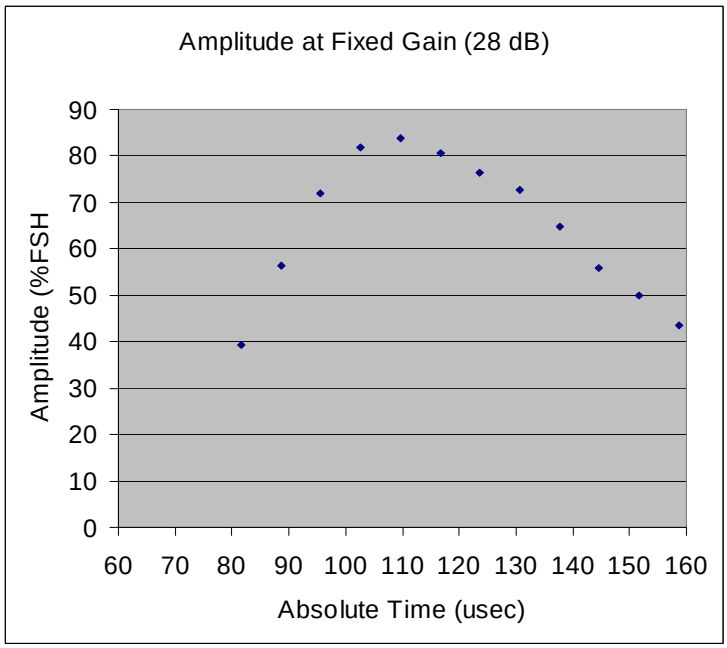
TOF and amplitude data in increasing TOF order

- Enter recorded data into the yellow highlighted spreadsheet cells:
  - Date
  - Name/outfit
  - Probe #
  - Water Temperature (F)
  - Big Bang Start, t0
  - Fixed gain level for graphs
- For each water path enter:
  - TOF (dominant neg. peak)
  - gain setting
  - maximum peak amplitude
  - minimum peak amplitude

The peak-to-peak amplitudes, recalculated for a fixed gain level, are tabulated here and plotted. The fixed gain level is chosen by the user, and 35 dB is recommended. If you use a value other than 35 dB, indicate that value in the title of each graph (see plot on next page).

Ball-Target-in-Water: Amplitude-Versus-Depth
Axial Profile in Water

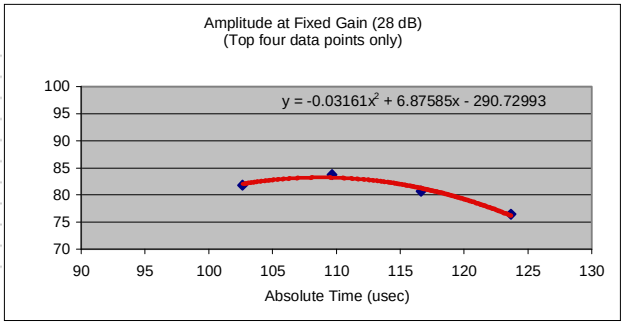
- The plot displays the measured axial profile in water, for later comparison with a model prediction.



Ball-Target-in-Water: Amplitude-Versus-Depth. Determination of the Y+0 Point

- A second graph on the spreadsheet displays only 4 of the plotted points.
- Follow the instructions to the left of the graph to choose the 4 adjacent points with the highest amplitudes.
- A parabolic fit through the four points is shown and its equation is listed.
- Enter the “A” and “B” parameters from the equation into the yellow spaces in the calculator to estimate the location of the peak in the amplitude-vs-depth profile (referred to as the Y+0 point).

Click on one of the plotted points. Then look at outlined ranges of points in columns B and G to make sure that only the topmost 4 points are plotted and fitted.



Calculator for Determination of Y+0		
Parabola is Y = Ax^2 + Bx +C		
From graph at right, enter:		
A =	-0.03161	
B =	6.87585	
(peak is at X = -B/2A)		
Y-Plus-Zero =	108.76	microseconds
Y-Plus-Zero =	3.140	inches

Optional RCE Test: C-scan of Glass Bead at Y+0 To Determine Beam Spot Size (Full Width at Half Max).

- Load Tomoview Setup file “RCE-SpotSize.acq”.
- Verify Tomoview parameter settings.
- Using xyz positioning system, set the TOF to the glass rod at the value of Y-plus-zero calculated by the worksheet “ball_in_water”. Then, center the probe over the glass rod by “peaking up” the A-scan amplitude.
- Zero the encoder position values using Tomoview’s Mechanical Settings panels. Note that the encoder resolution values may need to be updated for other systems. Also, adjust Tomoview’s “Start Time” until glass rod response appears near the center of the A-scan.

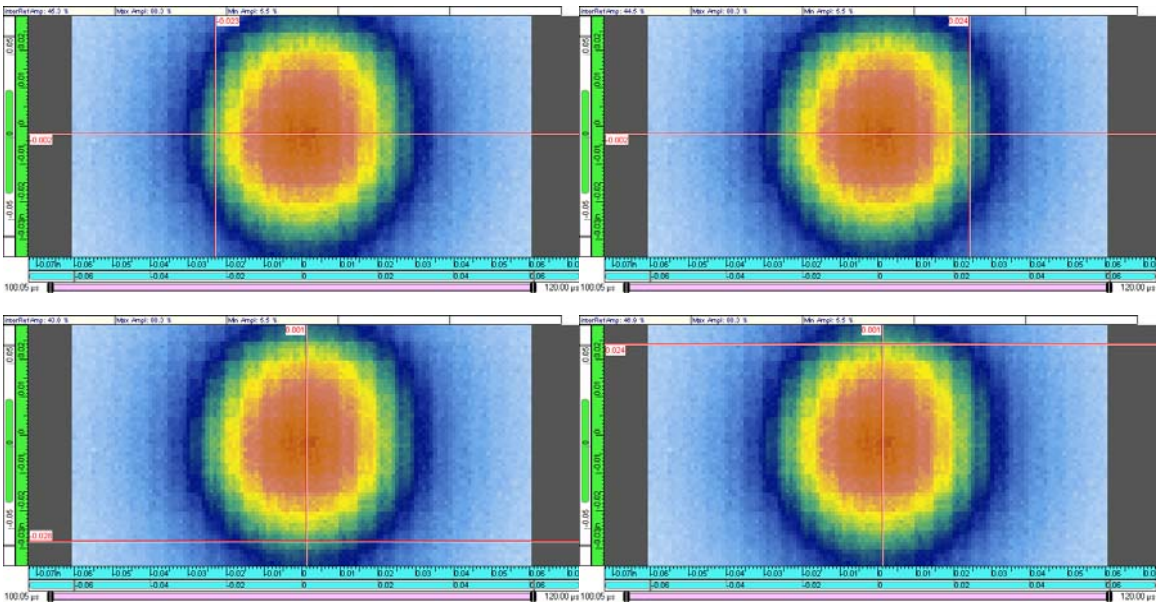
Optional RCE Test: C-scan of Glass Bead at Y+0 To Determine Beam Spot Size (Full Width at Half Max).

- Move off-axis from the glass rod by (x,y) = (-0.06, -0.06) (inches)
- Enter Tomoview's Inspection Mode to perform a waveform scan of the glass rod tip. A unidirectional raster scan with 0.05 in/sec forward scan velocity, 1 in/sec reverse scan velocity, and 0.001-inch resolution on both scan and index axes results in a 15-minute-long scan time.
- Save the resulting .rdt file when the scan is complete. Suggested file name: "probeID-glassBeadSpot-#.rdt".
- Select Tomoview's draw-down menu "Tools", then choose "Hide 3D Cursor" to remove the small pink dot from beam spot image.
- With beam spot roughly centered in C-scan, remove both red and blue reference lines from pane before using Tomoview's Grab Feature to capture C-scan image and save as bitmap file. Be sure to use the "Rectangle" capture option so that the C-scan's axes are also saved (see next page).
- Using mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press right arrow button on keyboard until A-scan pane indicates a peak value equal to half the "Maximum Amplitude" value from the C-scan pane. Record this 1st scan position. Press left arrow button on keyboard until A-scan pane again indicates a peak value equal to half the "Maximum Amplitude" value from the C-scan pane. Record this 2nd scan position.
- Using mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press down arrow button on keyboard until A-scan pane indicates a peak value equal to half the "Maximum Amplitude" value from the C-scan pane. Record this 1st index position. Press up arrow button on keyboard until A-scan pane again indicates a peak value equal to half the "Maximum Amplitude" value from the C-scan pane. Record this 2nd index position.

Optional RCE Test: C-scan of Glass Bead at Y+0

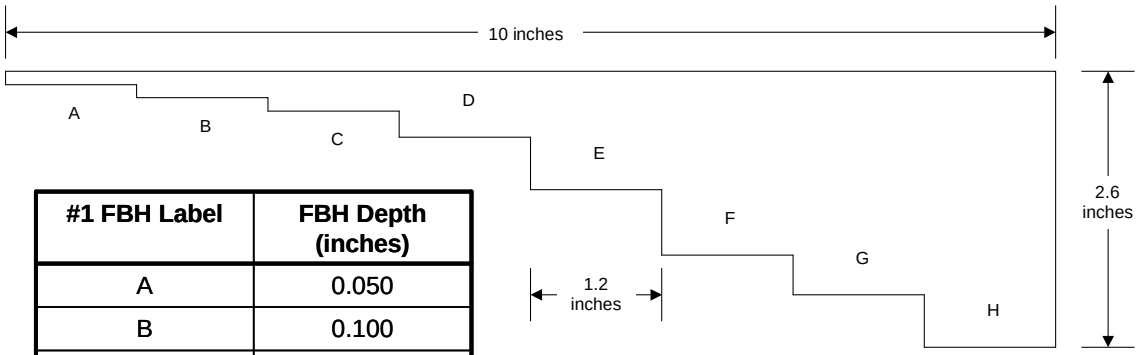
- Determine the horizontal and vertical beam widths from acquired Tomoview C-scan image.
- Enter the widths (full width at half maximum) into the space provided in the "ball_in_water (probe ID)" worksheet.

Measured beam widths from C-scan at Y+0 point:		
Full width at half max (X):	0.049	inches
Full width at half max (Y):	0.047	inches



Removable Center Element:
Details of Step Block Used for FBH Studies

- Diagram of step block with dimensions and hole depths indicated (width of 1.2 inches not shown).
- Density = 7.85 g/(cubic cm)
- Longitudinal wave speed = 0.6138 cm/us = 0.2417 in/us



#1 FBH Label	FBH Depth (inches)
A	0.050
B	0.100
C	0.150
D	0.500
E	1.000
F	1.500
G	2.000
H	2.500

Removable Center Element: Acquisition of Reference FBH A-Scan and Determination of Spectrum Peak Frequency and Bandwidth

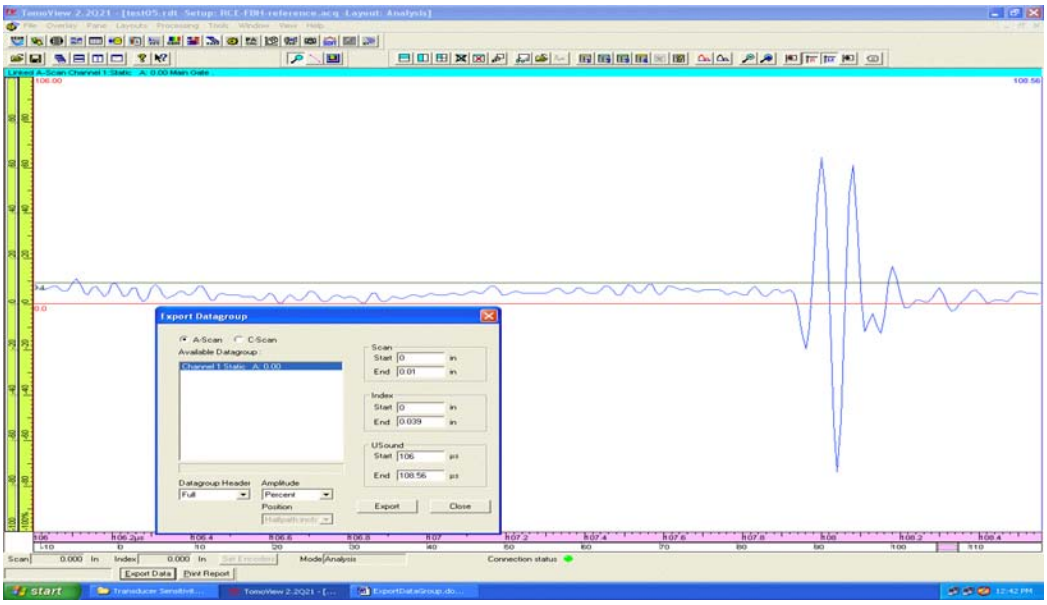
- Load Tomoview Setup file “RCE-RefAscan.acq”.
- Verify Tomoview parameter settings.

Removable Center Element: Acquisition of Reference FBH A-Scan and Determination of Spectrum Peak Frequency and Bandwidth

- Carefully level the top surface of the step block relative to the lateral axes (say, X and Y) of the scanning system. Set the one-way water path to approximately 3 inches. Normalize the sonic beam to the top surface of the IN100 step block by adjusting the probe tilt angles to maximize the front-wall echo. Then, carefully set the one-way water path to 3.00 inches.
  - To simplify FBH studies, orient one axis of the positioning system along the long dimension of IN100 step block.
  - When the step block is level, scanning in either X or Y should not change the TOF of the front-wall echo appreciably.
  - Since the step block is not very wide in one lateral dimension (1.25 inches), it may be useful to set a wider flat block on top of the step block when adjusting probe angles to normalize the beam. This will keep the beam footprint from running off the edge of the reflecting surface.
  - Use the TOF-water-path calculator in the "sound speed in water" spread sheet for calculating the TOF needed to set the water path to 3.00", using the appropriate temperature and t0 data. For FBH signals, TOF will always refer to the time of the dominant negative peak.
  - When setting the water path to 3.00", position the probe over the center of the step block (roughly between FBHs 4 and 5). This will insure an average water path of 3.00" if the the step block is not perfectly level.
- Locate the 1/2-inch deep #1 FBH in the step block. Locating this first FBH may require a low resolution scan in the vicinity of the FBH. Once located, center the probe over the position of the FBH by "peaking-up" its amplitude.
- Once centered, adjust gain until the peak amplitudes are 75%-90% FSH.
- Adjust Tomoview's "Start Time" and "Range" until FBH (but not front wall or back wall) is located within range. The value for Tomoview's "Range" should be set to 2.56 microseconds to acquire a 256-point A-scan (at 100 MHz sampling rate).

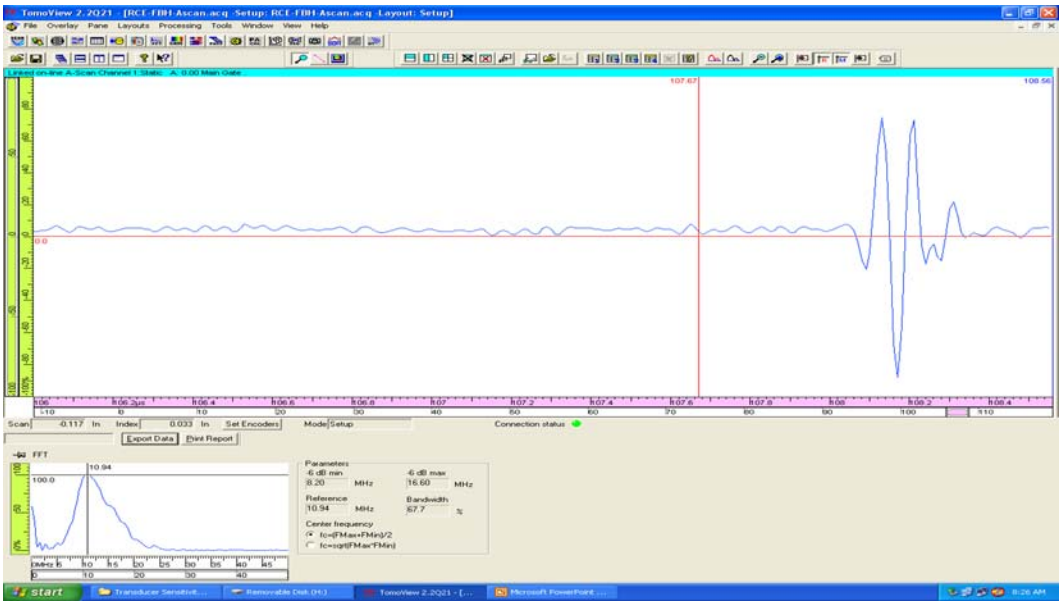
Removable Center Element: Acquisition of Reference FBH A-Scan and Export of A-scan to a Text File

- In Mechanical Settings, change "Sequence Type" from "unidirectional" to "free running".
- Switch to Tomoview's Inspection Mode, press "Stop" and save .rdt acquisition data file. Suggested file name: probeID_refAscan.rdt"
- Set vertical red reference line to far left of A-scan pane, set vertical blue reference line to far right of screen, start Tomoview's "ExportDataGroup" function (icon is located at top of Tomoview screen), and export A-scan data. The export parameters in the ExportDataGroup dialog box should already be properly set. Record the name of the exported file in the worksheet named "FBH amplitudes (probe ID)". Suggested file name: "probeID_refAscan-#.txt".



Removable Center Element: Acquisition of Reference FBH A-Scan and Determination of Spectrum Peak Frequency and Bandwidth (cont.)

- Activate FFT function using Tomoview icon at top of screen (only functions in Analysis Mode).
- Move blue reference line to far right of A-scan. Move red reference line approximately 1 microsecond left of blue reference line.
- Record displayed values for Center Frequency (MHz) and Bandwidth (%). Enter these in the worksheet named "FBH amplitudes (probe ID)" within the Excel file "PA_char_plans_RCE_5.xls".



Example of Exported Text File Containing a 256-point FBH A-scan

FBH-500mils.txt

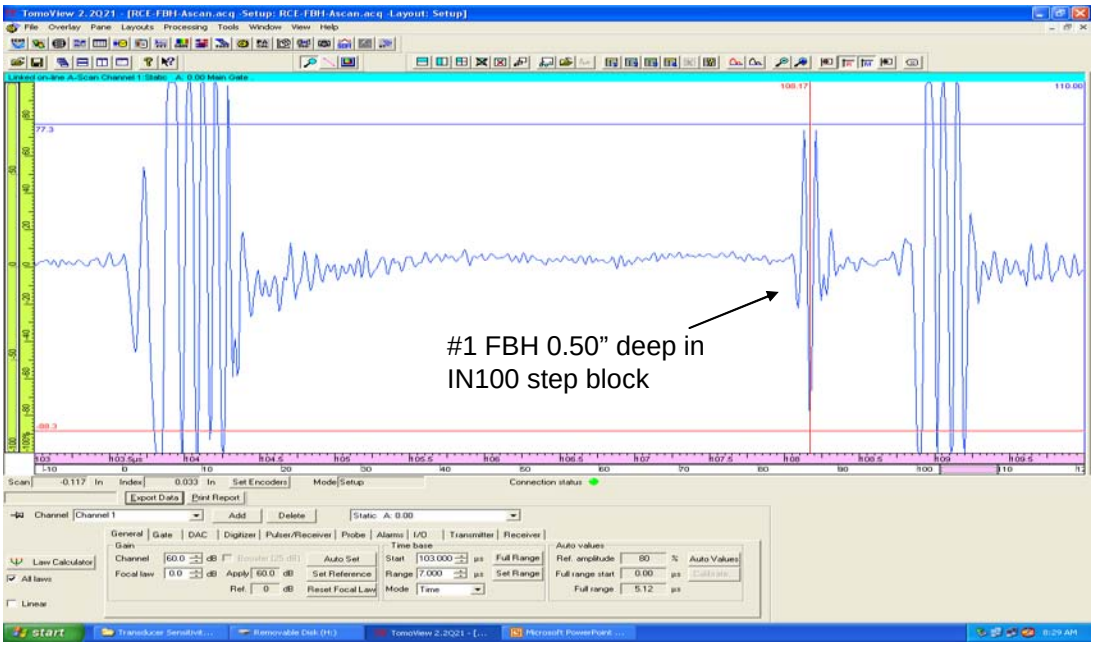
```
Channel = Channel 1
Focal Law = Static   A: 0.00
Type = A-Scan
ScanStart (in) = 0.0000
ScanQty (sample) = 1.0
ScanResol (in) = 0.0010
IndexStart (in) = 0.0000
IndexQty (sample) = 1.0
IndexResol (in) = 0.0010
USoundStart (in) = 13.1603
USoundQty (sample) = 256.0
USoundResol (in) = 0.0012
AmplMin (sample) = -128.0
AmplMax (sample) = 127.0
AmplStart (%) = 0.00
AmplResol (%) = 0.78
3.1     3.9     7.0     9.3     8.5     6.2     4.6     6.2     7.0     7.8     6.2     4.6     3.9     5.4
7.8     8.5     5.4     3.9     4.6     6.2     6.2     4.6     3.9     5.4     7.0     6.2     3.9     2.3
3.1     3.9     3.9     3.1     3.9     5.4     6.2     5.4     3.9     2.3     2.3     3.9     4.6     4.6
3.9     3.1     3.1     3.9     4.6     3.9     1.5     1.5     3.1     4.6     6.2     6.2     4.6     2.3
0.7     2.3     4.6     4.6     3.1     1.5     3.1     5.4     4.6     3.1     1.5     3.1     4.6     4.6
3.9     3.1     4.6     7.0     7.0     4.6     1.5     0.7     2.3     3.9     4.6     3.9     3.9     3.9
4.6     5.4     4.6     3.9     3.1     4.6     6.2     4.6     1.5     1.5     4.6     7.8     7.0     3.9
2.3     3.9     6.2     5.4     3.9     3.1     3.9     5.4     6.2     4.6     3.9     3.9     4.6     4.6
3.9     4.6     6.2     7.0     5.4     3.9     3.9     4.6     5.4     5.4     3.9     3.1     3.9     6.2
7.0     6.2     4.6     4.6     5.4     6.2     5.4     4.6     4.6     5.4     6.2     6.2     6.2     5.4
5.4     5.4     5.4     4.6     3.9     4.6     5.4     7.0     6.2     4.6     3.1     3.1     3.9     6.2
7.8     7.8     6.2     5.4     4.6     4.6     5.4     5.4     3.9     3.9     4.6     6.2     6.2     5.4
5.4     5.4     6.2     5.4     5.4     6.2     7.8     7.0     3.9     2.3     2.3     3.9     3.9     4.6
4.6     5.4     5.4     3.9     3.1     3.9     5.4     5.4     3.9     3.1     4.6     8.5     8.5     3.1
-9.3    -20.3   -20.3   -3.1    28.9    60.1    71.0    41.4    -20.3   -73.4   -86.7   -46.0   21.0    67.9
67.9    26.5    -10.1   -17.1   -7.8    -6.2    -14.8   -14.0   0.7     15.6    17.1    7.0     -2.3    -5.4
-3.9    -2.3    -0.7    -0.7    0.7     3.1     5.4     5.4     3.1     1.5     0.0     0.0     -0.7    -0.7
0.7     3.9     6.2     4.6     1.5     0.7     3.1     4.6     3.9     0.7     0.0     2.3     4.6     5.4
5.4     5.4     7.0     7.8
```

FBH Amplitude Measurements

- While still centered over the 0.500-inch deep FBH, record the gain setting (dB), maximum peak amplitude (%FSH), minimum peak amplitude (%FSH), and TOF (usec) of peaked up signal in the spreadsheet named “FBH amplitudes (probe ID)”.
- Recall that TOF for FBH echoes will always refer to the position of the dominant negative peak.
- Similar amplitude and TOF measurements will be performed for the other #1 FBHs at depths of 0.1”, 0.15”, 1.0”, 1.5”, and 2.0”.
- Adjust Tomoview’s “Range” to 20 microseconds and “Start Time” to 102 microseconds. Use zoom feature as necessary. Adjust gain (but not Sum Gain), as necessary.
- The general appearances of the A-scans (showing the front-wall, FBH, and back-wall reflections) are illustrated on the following five slides.
- Acquiring and exporting of the FBH A-scan is only required for the FBH at the 0.5-inch depth.

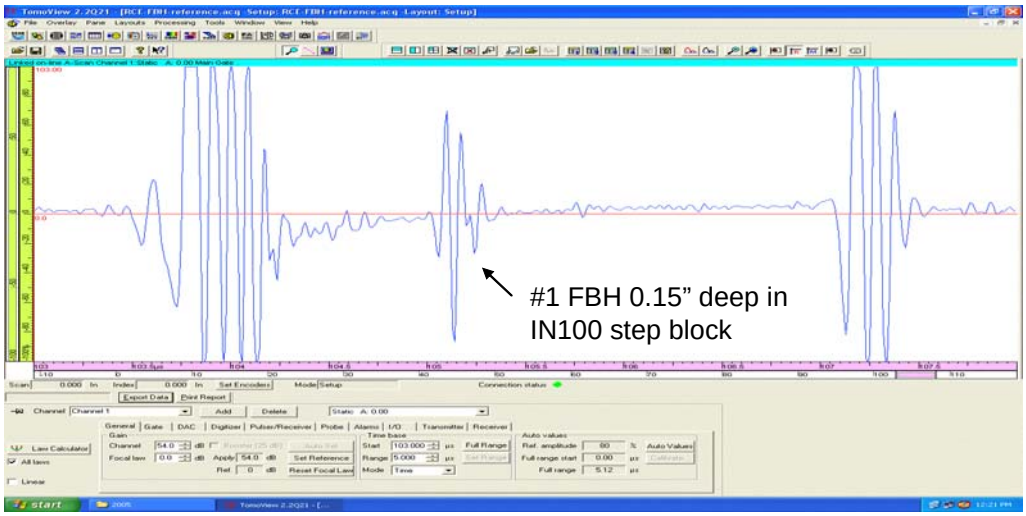
FBH “D” Amplitude Measurement: 0.500-inch Depth

- Note the positive and negative peak amplitude reference values shown below for the 0.500-inch deep FBH. Note also that TOF is measured from the dominant negative peak.



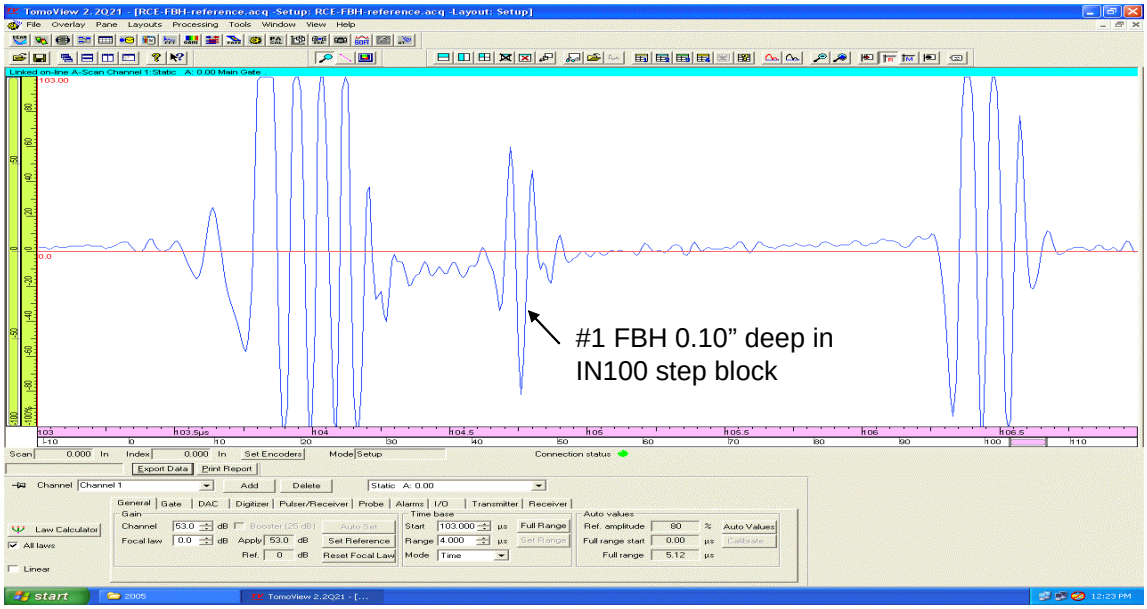
FBH “C” Amplitude Measurement: 0.150-inch Depth

- By moving approximately 1.2 inches along the long dimension of the IN100 step block, locate the 0.150-inch deep #1 FBH. Adjust Tomoview’s “Start Time” to display the FBH signal within an appropriate range. Once the FBH signal is located, center the probe above the FBH by “peaking-up” the amplitude.
- Once centered, adjust gain until the peak amplitudes are ~80% FSH.
- As before, record gain, amplitude and TOF data in the worksheet named “FBH amplitudes (probe ID)”.



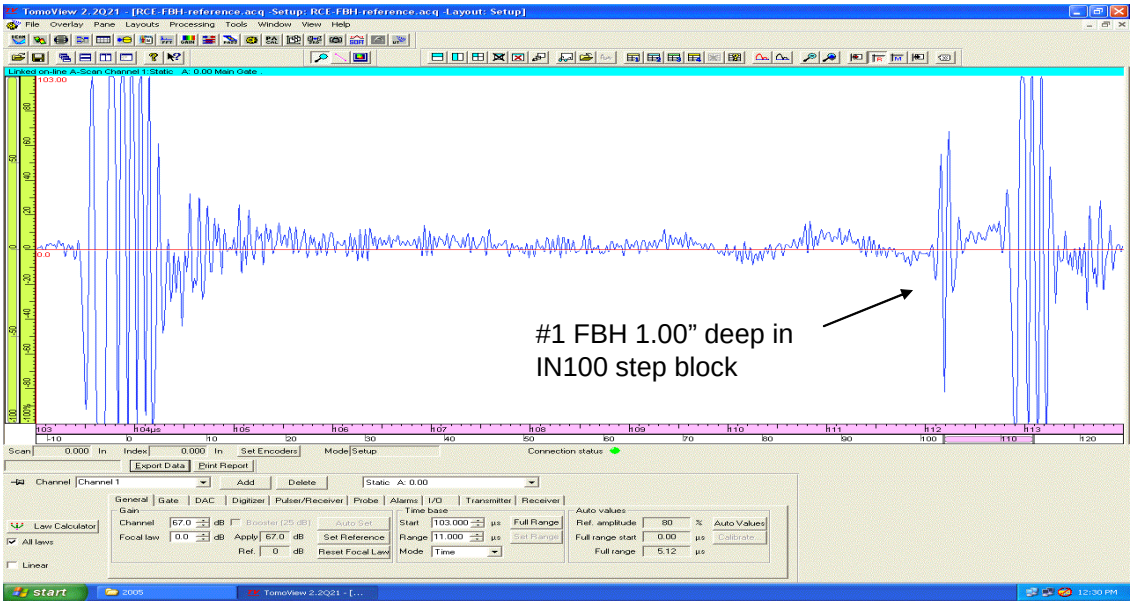
FBH “B” Amplitude Measurement: 0.100-inch Depth

- Similarly, proceed to the next FBH in the IN100 step block.
- Again, record the gain, amplitude and TOF data in the worksheet named “FBH amplitudes (probe ID)”.



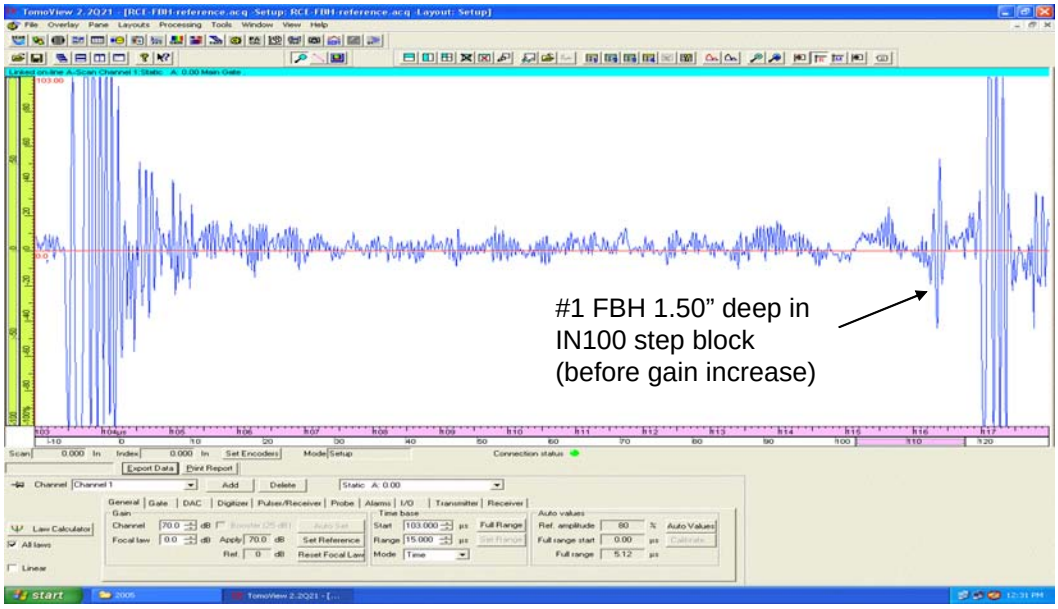
FBH “E” Amplitude Measurement: 1.00-inch Depth

- Similarly, proceed to the next FBH in the IN100 step block.
- Again, record the gain, amplitude and TOF data in the worksheet named “FBH amplitudes (probe ID)”.



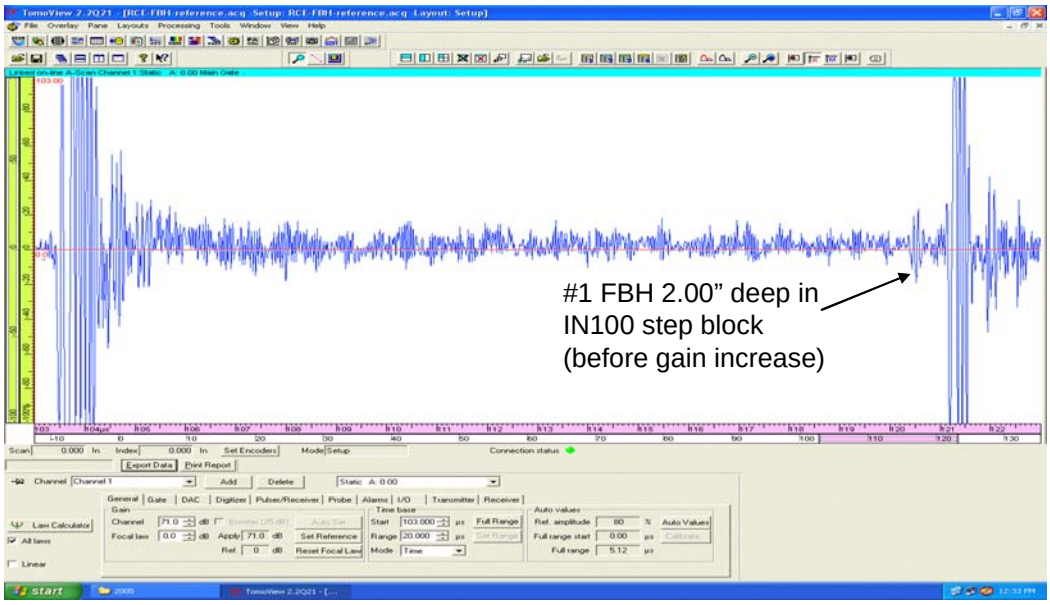
FBH “F” Amplitude Measurement: 1.500-inch Depth

- Similarly, proceed to the next FBH in the IN100 step block.
- Again, record the gain, amplitude and TOF data in the worksheet named “FBH amplitudes (probe ID)”.
- Under the UT Settings’ “Pulser/Receiver” panel, using the 5 MHz High Pass and 15 MHz Low Pass filter combination to greatly assist in “peaking up” on the amplitudes when moving the probe in the XY-plane. Turn off these filters before taking measurement data.
- Recall “mental averaging” concept from “Some Measurement Ground Rules” slide.

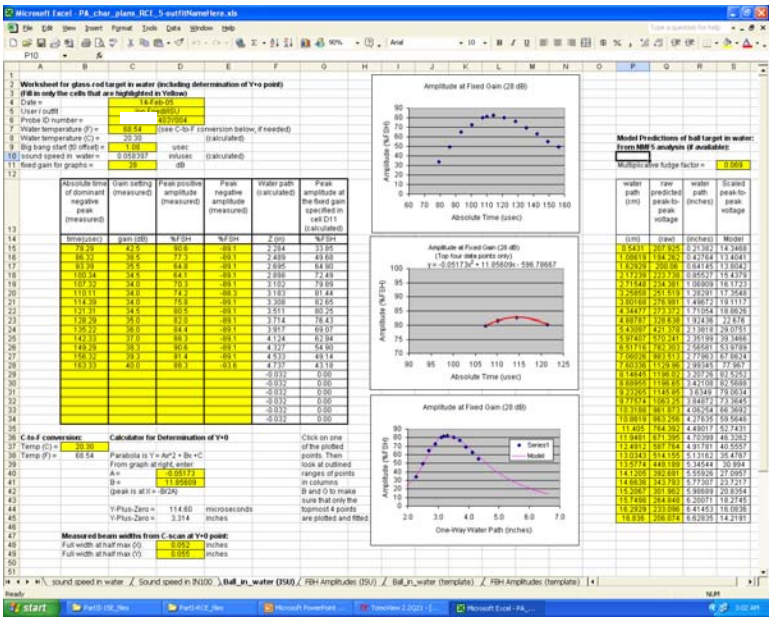


FBH “G” Amplitude Measurement: 2.000-inch Depth

- Similarly, proceed to the next FBH in the IN100 step block.
- Again, record the gain, amplitude and TOF data in the worksheet named “FBH amplitudes (probe ID)”.
- Under the UT Settings’ “Pulser/Receiver” panel, using the 5 MHz High Pass and 15 MHz Low Pass filter combination to greatly assist in “peaking up” on the amplitudes when moving the probe in the XY-plane. Turn off these filters before taking measurement data.
- Recall “mental averaging” concept from “Some Measurement Ground Rules” slide.



Appearance of the Spreadsheet “FBH Amplitudes (probe ID)” After Amplitude Data Entry



- As usual, the user fills in the worksheet cells highlighted in yellow. The amplitudes at a user-selected “fixed gain” are plotted on the graph (blue points).
- The “fixed gain” should be the same as that used when exporting the A-scan for the 0.5”-deep hole.
- After a separate analysis to determine the effective probe diameter and GFL, a model prediction of the FBH-amplitude-versus-depth data can be compared with experiment (purple plotted points).
- Table at right of worksheet contains data from NMF5.exe determined during post-processing or at a later date.

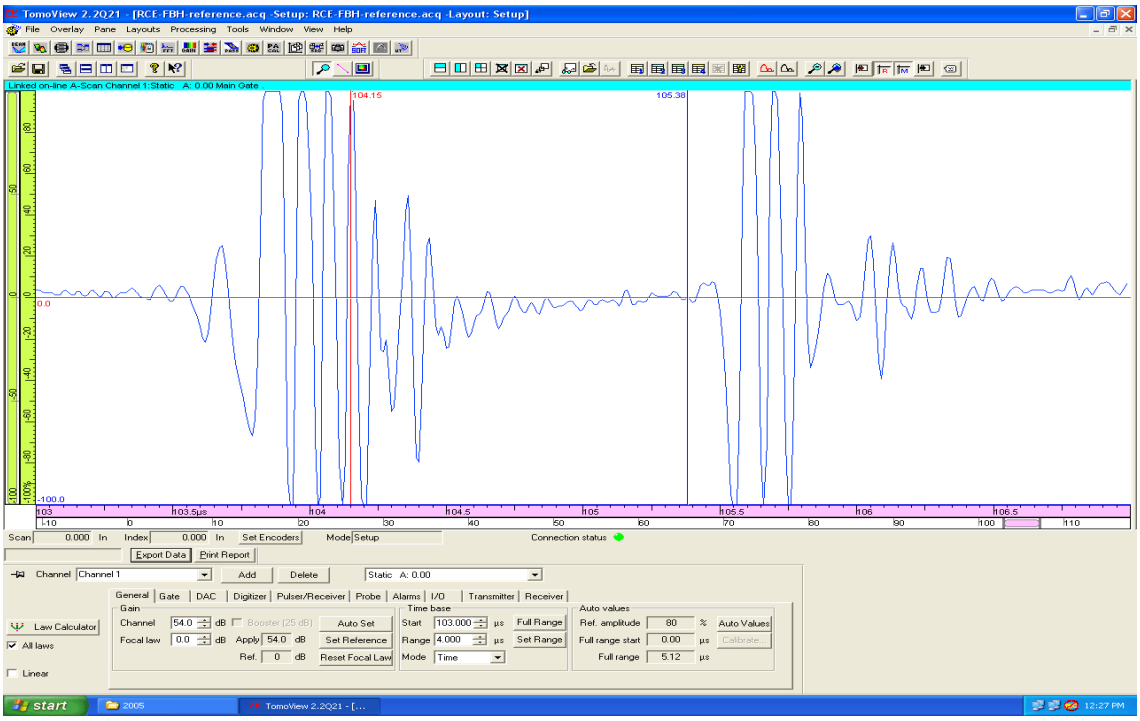
RCE Measurement: Near Surface Resolution

- Here we continue the FBH measurement procedure (assuming that the step block is level, the sonic beam is normal to the block, and the water path is 3.00 inches).
- Load Tomoview Setup file “RCE-NearSR.acq”.
- Verify Tomoview parameter settings.

RCE Measurement: Near Surface Resolution

- Move the probe laterally until it is centered over the shallowest FBH (at a depth of 0.050 inch).
- Locate the #1 FBH response in the A-scan display.
- Once centered over the shallowest FBH in the step block, adjust the water path to “peak-up” on the echo. Be sure to re-center the probe over the FBH after adjusting the water path. (This step may result in only a small increase in the peak amplitude.)
- Adjust Start Time to include front wall response.
- Adjust Range to include back wall response from step block.
- Switch to Tomoview’s Inspection Mode, press “Stop”, and save .rdt acquisition data file (suggested file names: “probeID_NSR_wFBH-#.rdt”). (See figure on next page.)

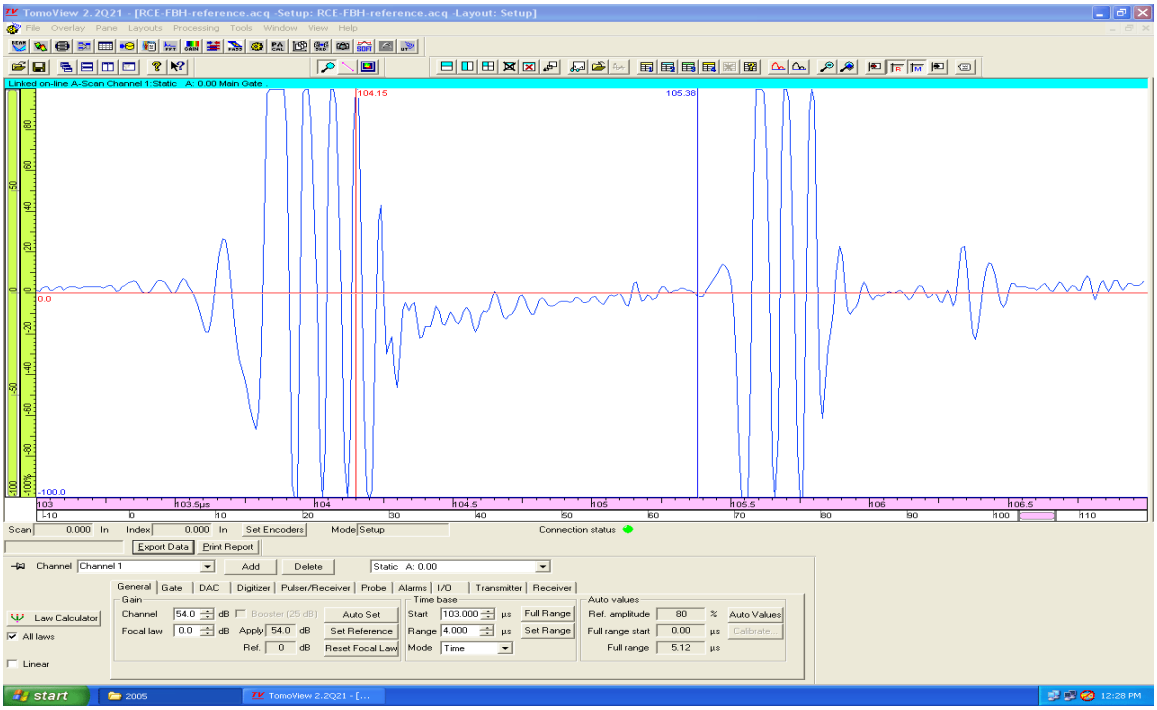
Near Surface Resolution: With FBH in A-scan



Near Surface Resolution: Without FBH in A-scan

- Set vertical red reference line in A-scan pane to include last part of front wall response. Record value for TOF location of red reference line for later reference.
- Set vertical blue reference line to exactly 2.55 microseconds after red reference line.
- Start Tomoview's "ExportDataGroup" function (icon is located at top of Tomoview screen), and export A-scan data. The export parameters in the ExportDataGroup dialog box should already be properly set. Record the name of the exported file in the spreadsheet named "FBH Amplitudes (probe ID)".
- Return to Tomoview's Setup Mode.
- Move probe off-axis slightly from FBH, just until FBH response is not longer visible in A-scan, but maintain current water path.
- Adjust Start Time to include all or part of front wall response.
- Adjust Range to to include back wall response from step block.
- Switch to Tomoview's Inspection Mode, press "Stop", and save .rdt acquisition data file (suggested file names: "probeID_NSR_woFBH-#.rdt"). (See figure on next page.)
- Set vertical red reference line in A-scan pane to previously recorded TOF value from when FBH response appeared in A-scan.
- Set vertical blue reference line to exactly 2.55 microseconds after red reference line.
- Acquire A-scan using ExportDataGroup function with exact same gate as previous A-scan acquisition. The dialog parameter settings should already be properly set.
- Enter the name of exported A-scan into the "FBA Amplitudes (probe ID)" worksheet.
- Using a procedure to be defined later, an approximate S/N ratio will be estimated from the "with FBH" and "without FBH" A-scans.

Near Surface Resolution: Without FBH in A-scan



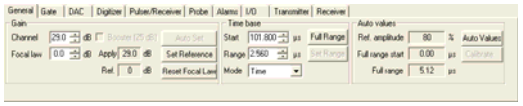
Part II -
Performance Evaluation Procedures
for
Planar, annular, 15-element transducer

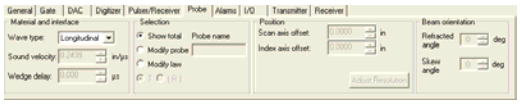
Sketches of Measurements
Using Entire 15-Element, Planar, Annular Probe

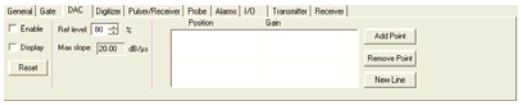
- **Reflecting Planar Surface in Water - TOF Variation Over Annular Elements:** Measurements of TOF from annular ring elements to planar reflecting surface are made in water with a 3-inch water path. Care must be taken that the transducer is level and centered over the 40-mm diameter reflector.
- **C-Scan of #1/2 FBH in PW Calibration Sample to Determine Beam Spot Size:** Determines beam diameter at the mid-zone FBH depth in zone 4 while the focus is also maintained at this mid-zone FBH depth. (The delay times used to establish this focal depth were generated via geometric ray-tracing.)
- **C-Scan of Glass Rod at 0.5-inch Water Path**: Provides a visual confirmation that each element of the array is firing uniformly over its surface.
- Note on wiring differences between 15-element probe models:
  - The Hypertronics connector for the two brands, Supplier A Model 4608 and Supplier B Model AAWX074A, are wired slightly differently. The center elements of both probe brands connect to Tomoscan through channel 1 because they the Limo 00 connector is attached to port P1 in the PIM/06. In the Hypertronics connector for the Supplier B model, channel 1 is not used, channel 2 in connected to the probe's element #2, channel 3 to element #3, etc. For the Supplier A model, channel 1 in the Hypertronics connector is connected to the probe's element #2, channel 2 to element #3, etc. Consequently, each test sketched above will require two slightly different setups, depending on the probe model being evaluated.
  - In the first test (TOF variation), the Supplier A model probe connections will require the test to be run twice: once for the center element only and once for the rest of the probe elements. This allows TOF variation to be found for both the removable center element (element #1) and the first annular ring (element #2), both connected via channel 1. The test of the Supplier B model probe will only need be run once because all channels are separate. Overall, only one Tomoview setup file will be needed for both probe models.
  - In the second and third tests, i.e., the C-scan tests, only the Hypertronics connector will be used. The Limo connector for the center element will <u>not</u> be used. However, two different Tomoview setup files will be needed so that each ring for each probe model is programmed with the correct delay time. Again, this is required due to the difference between the model's channel-to-element wiring configuration of the Hypertronics connector.

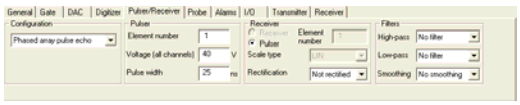
TOF Variation over 15 Annular Elements

- Submerge a 15-element probe and clear away any water bubbles from probe face.
- Connect probe cables to R/D Tech instrument interface (See note on previous slide concerning wiring differences.)
  - Limo cable to port P/1 <u>and</u> Hypertronics cable connector (Supplier B probe model only)
  - Limo cable to port P/1 <u>or</u> Hypertronics cable connector (Supplier A probe model only)
- Start computer and wait for it to finish. Turn on the R/D Tech hardware and Tomoview 2.2 software.
- Load the Tomoview setup file "015E-delayTimes.acq". This setup files incorporates the PAC file "015elements.pac".
- Verify Tomoview parameter settings.







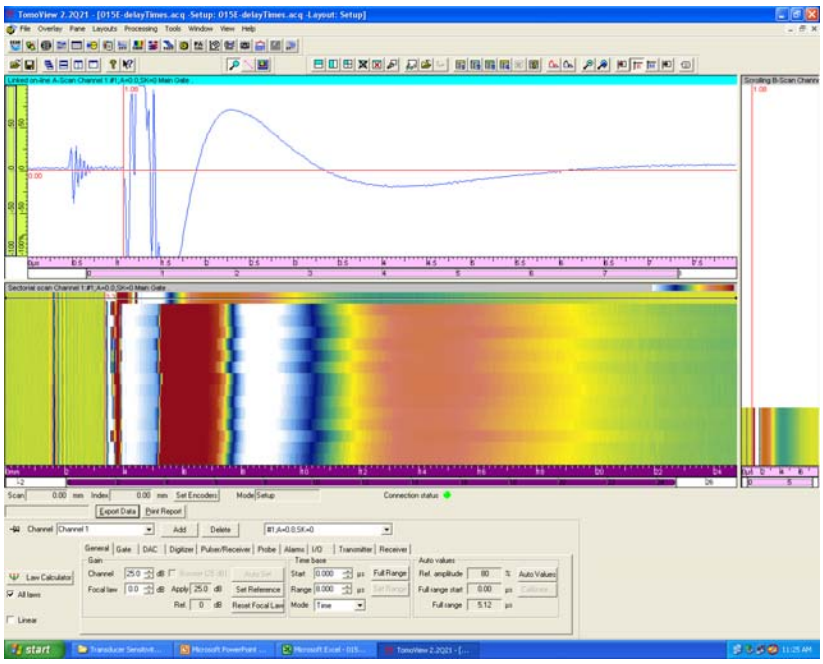


TOF Variation over 15 Annular Elements

- Load the Microsoft Excel file “PA_performance_015E-Delays-OUTFIT.xls”.
- Record water temperature of water bath. Use “waterVelocity” worksheet to determine water velocity.
- Record Tomoview’s time offset value, t0, by examining the A-scan response from any element. (See figure on next slide.)
- Together with water velocity, calculate the TOF equivalent to 3.00-inches of water path using the equation TOF = (2z/v) + t0. (See “waterVelocity” worksheet.)
- Position the planar, 50-mm diameter, reflector on a flat surface. (Of the two 50-mm diameter reflectors, select the planar side of the plano-concave lenses for reasons of reflector stability.)
- Carefully center probe over reflector by first approximately centering probe over reflector, then moving off-axis along x-direction until previously saturated A-scan response from center element drops to 80% FSH. Next, zero encoder value and move off-axis along negative x-direction until A-scan response from center element again drops to 80%FSH. Finally, move along x-axis to half of the value of this encoder location. Repeat this process along y-axis to precisely center probe over reflector.
- Establish water path of 3.00-inch to reflector using A-scan TOF response from center element.
- Adjust Tomoview’s “Start Time” until front wall response from reflector is displayed on A-scan.
- Carefully adjust level of probe until reflector and probe face are normal with each other. See the following screen captures for an illustration of this process. Re-center the probe on the reflector after leveling adjustments are performed.

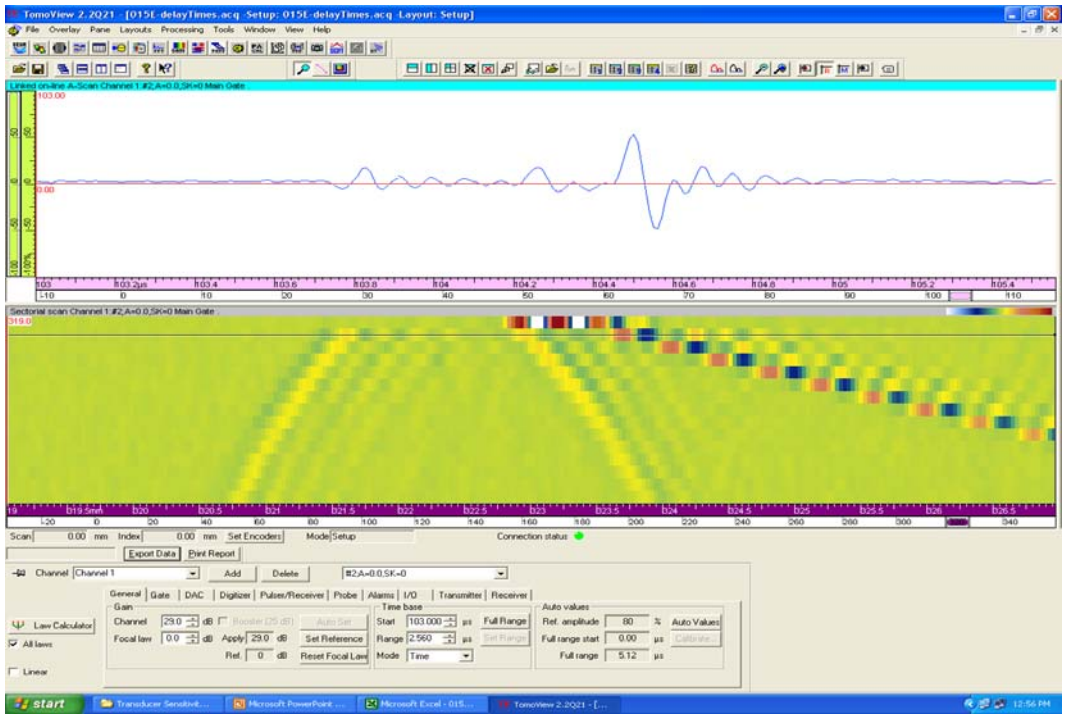
15E TOF Variation: Alignment

- This Sectorial scan image displays an A-scan from each individual transducer element as a color bar.
  - These 15 separate color bars display the individual element responses from the probe, starting with the center element and progressively moving outwards, ring-by-ring.
  - The top color bar represents the response from the center element.
  - The bottom color bar represents the outermost ring of the annular array.



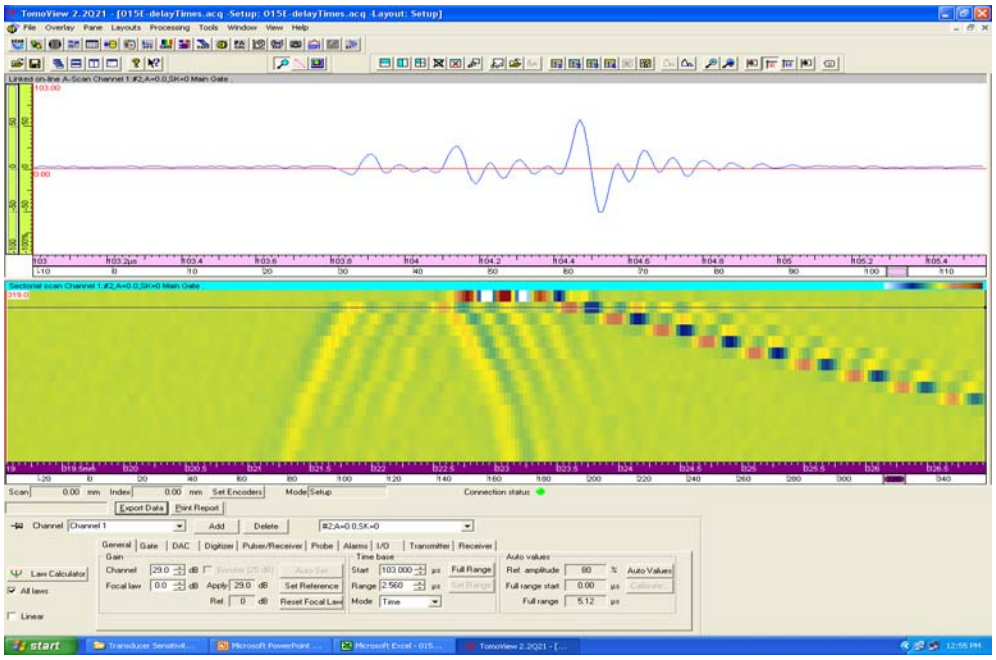
15E TOF Variation: Alignment (con't)

- This Sectorial scan shows the responses from a probe which is out of alignment with the reflector along both probe symmetry axes.



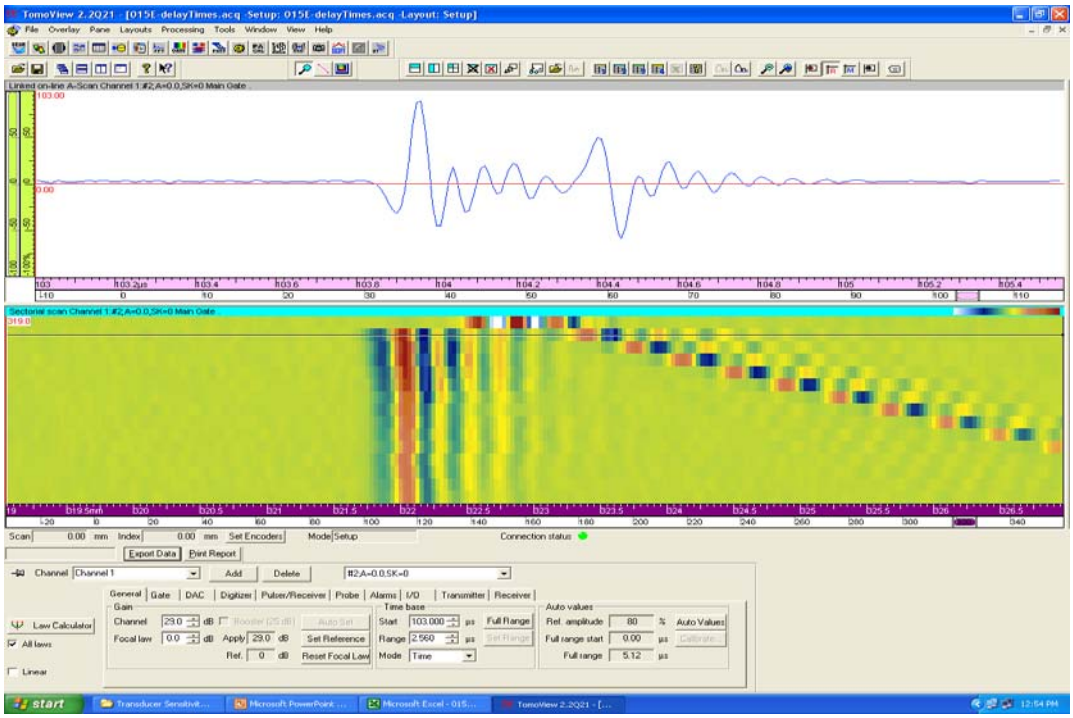
15E TOF Variation: Alignment (con't)

- This Sectorial scan shows the responses from a probe which is in alignment with the reflector along one probe symmetry axis but out of alignment along the other probe symmetry axis.



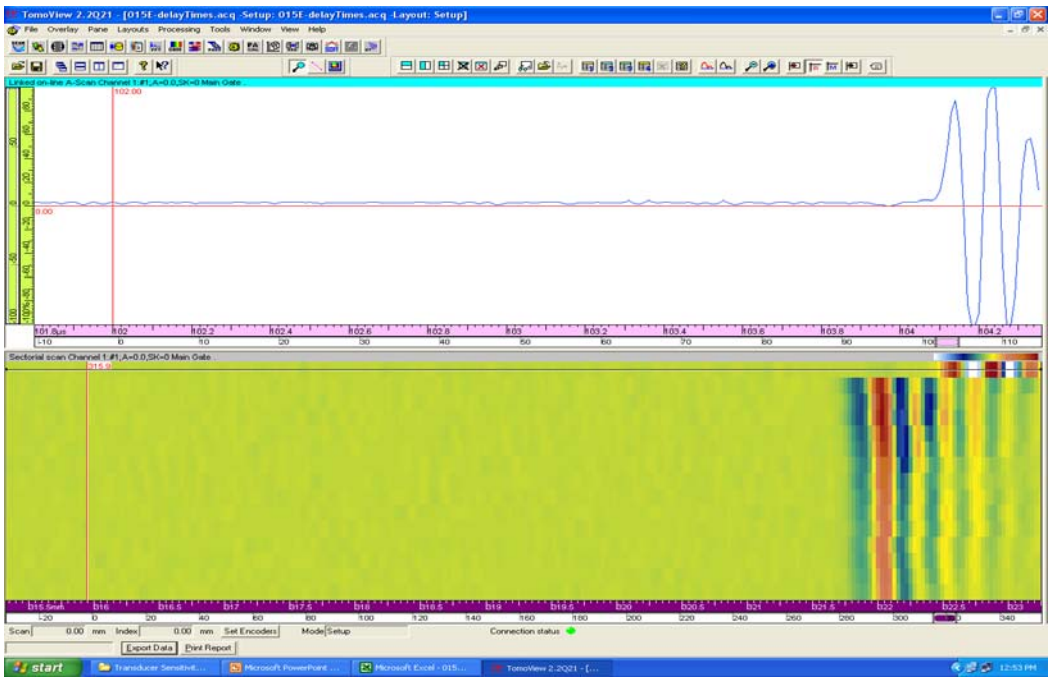
15E TOF Variation: Alignment (con't)

- This Sectorial scan shows the responses from a probe which is in alignment from the reflecting surface along both probe symmetry axes.



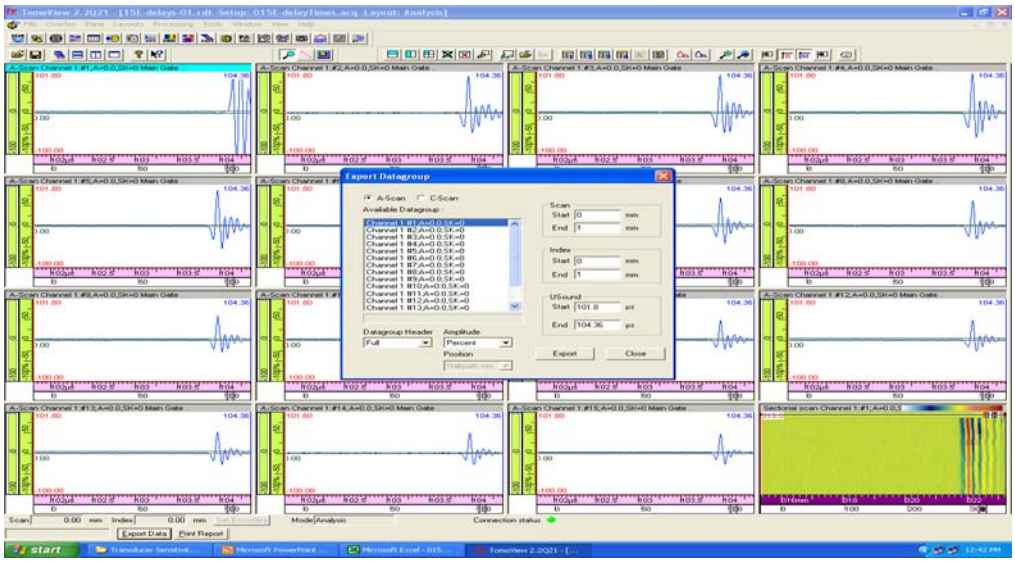
15E TOF Variation: Setting Gate for A-scan Data

- When the probe is correctly aligned with the reflector along both probe symmetry axes at a 3.00 inch water path, adjust gain until <u>Element #02's</u> peak amplitude is 80%FSH.
- Adjust Tomoview's "Start Time" until the reflector's front wall response appears near the end of the A-scan and set Tomoview's "Range" to 2.56 microseconds.



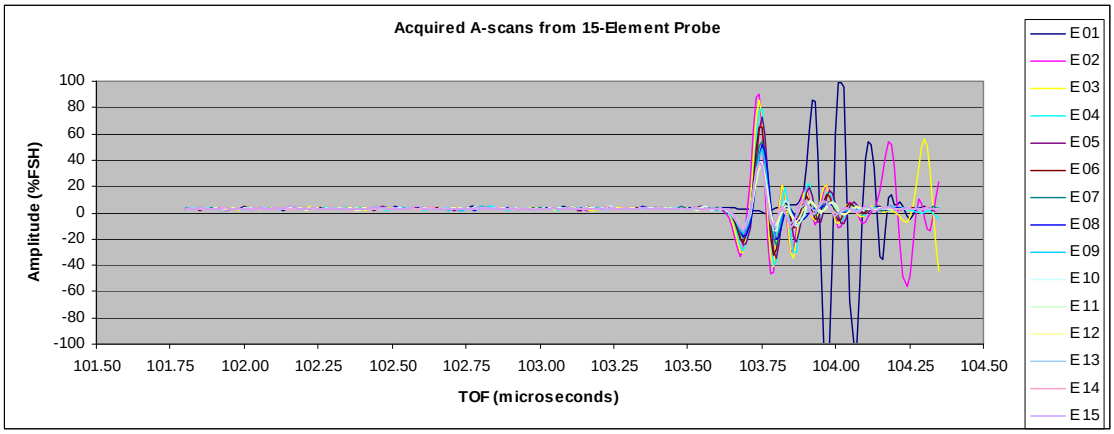
15E TOF Variation: A-scan Data Analysis

- Switch Tomoview to Inspection Mode, wait a few seconds, press Stop, and save the .rdt file. Suggested file name: “probeID_delays-#.rdt”.
- In Tomoview’s Analysis Mode, adjust the red reference bar until it is located at the far left of the A-scan. Also, adjust the blue reference bar until it is located at the far right of the A-scan.
- Choose the ExportDataGroup icon from the top row of Tomoview functions and export and save each channel’s A-scan data for this probe. Suggested file name: “probeID_delays-#_element#.txt”. (Note: Select all channels to save all A-scan data in one text file.)
- Note wiring differences between models: Channel number equals element number for Supplier B brand. For Supplier A brand, both element #1 and #2 use channel 1 followed by channel 2 connecting to element 3, channel 3 to element 4, etc.



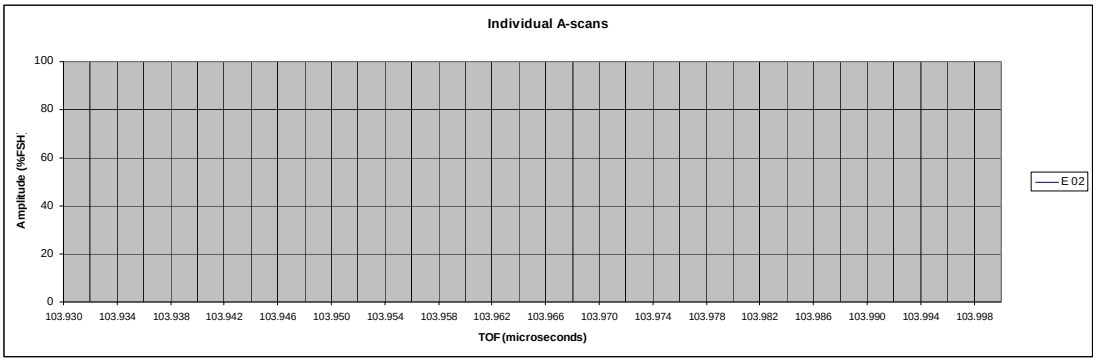
15E TOF Variation: A-scan Data Analysis

- Open the previously saved A-scan text files using Microsoft Excel.
- Copy all A-scan data in this text file and paste it into appropriate column in “15E-delays (probe ID)” worksheet. (To quickly select all cells containing A-scan data: highlight the first cell of data for the A-scan, then press ctrl-shift-rightArrow ONCE.)
- Select Microsoft Excel worksheet corresponding to serial number of probe currently being evaluated.
- Highlight the blue cell in the appropriate data column for this channel, select the “Paste Special” Edit function, check the “Value” and “Transpose” buttons in the dialog box, then click Ok.
- Repeat until the A-scan data from all 15 channels has been transferred from the text files to the worksheet.



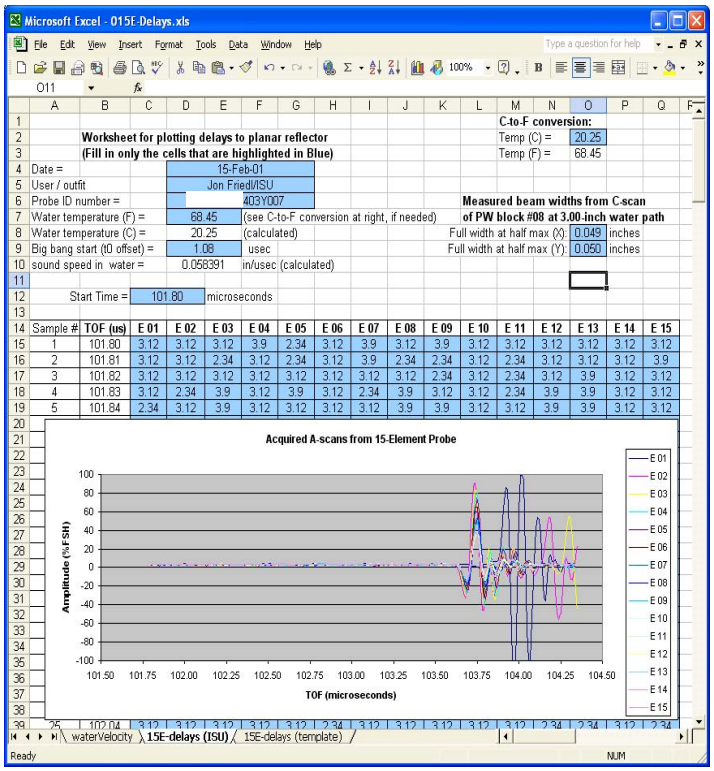
15E TOF Variation: A-scan Data Analysis (con't)

- Examine the chart in the worksheet entitled "Individual Acquired A-scans from 15-element Probe" for any obvious discrepancies from copying the A-scan data.
- Click on the chart in the worksheet entitled "Individual A-scans" and move highlighted box in A-scan table left or right to one element's column of data.
- Adjust chart's horizontal scale until maximum amplitude peak from A-scan fills the range of the chart (see chart below).
- Visually estimate the TOF of the maximum peak amplitude to within 0.002 microseconds using minor vertical grid lines (conveniently spaced 0.002 microseconds apart) and record TOF result in table.
- Click on the chart in the worksheet entitled "Individual A-scans" and move highlighted box in A-scan table left or right to another element's column of data.
- Continue previous two steps until TOF vs. Element Number table is complete.



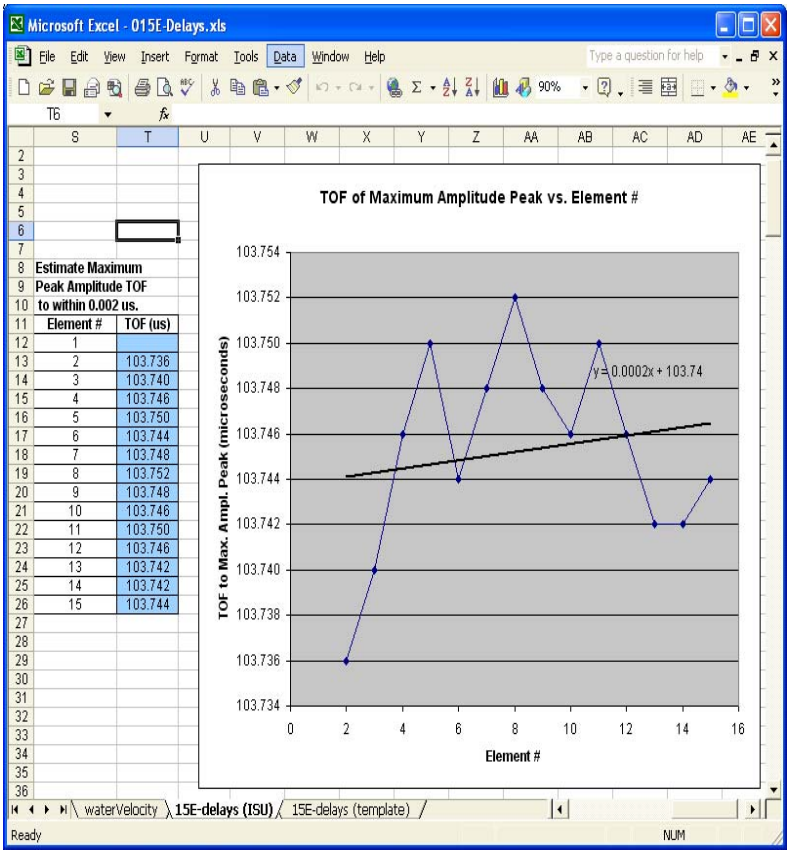
15E TOF Variation: A-scan Data Analysis (con't)

- Enter data in blue highlighted cells only.
  - Paste A-scan data into highlighted cells in table (using Paste special… and checking "Value" and "Transpose" functions).



15E TOF Variation: A-scan Data Analysis (con't)

- Enter data in blue highlighted cells only.
  - For each element A-scan, enter TOF values at maximum peak amplitude from bottom chart into small table.

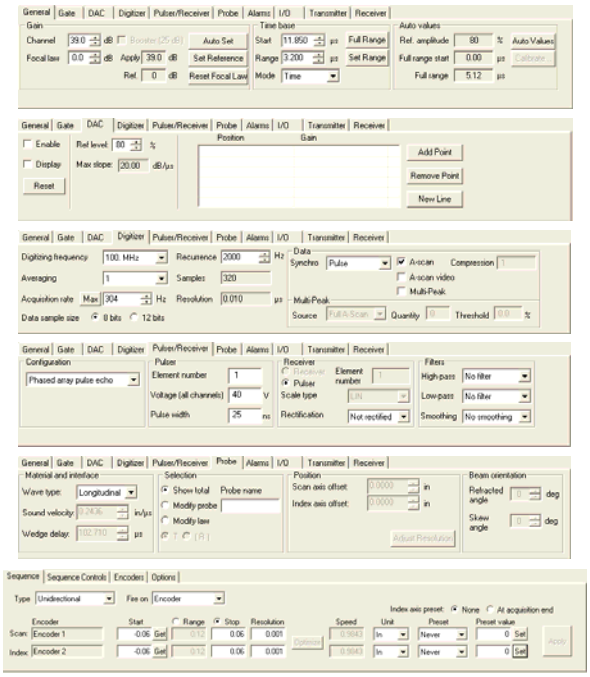


15E FBH C-Scan (PW Block 8): Setup

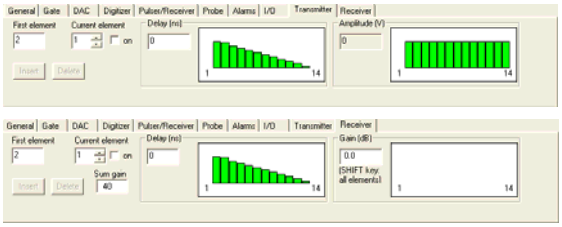
- Submerge the 15-element probe and clear away any water bubbles from probe face.
- Probe cables to R/D Tech instrument interface
  - Limo cable to port P/1 <u>is not connected</u>.
  - Hypertronics cable connector <u>is connected</u>.
- Start computer and wait for it to finish, then turn on R/D Tech hardware and Tomoview 2.2 software.
- Record water temperature of water bath. Use "waterVelocity" worksheet in Excel file "PA_performance_15E-Delays-OUTFIT.xls" to determine water velocity.
- Load Tomoview setup file "015E-delayTimes.acq" to assist with leveling the probe to the block.
- Record Tomoview's time offset value, t0.
- Together with water velocity, calculate the TOF equivalent to 3.00-inches of water path using the equation TOF = (2z/v) + t0. (See "waterVelocity" worksheet.)
- Position PW calibration block #8 on a flat surface which can be leveled.
- Approximately center probe over PW block #8 at precisely 3.00-inches of water path.
- Level probe on surface of block along both planes of symmetry. (See previous slides on leveling.)
- Turn off Tomoview and R/D Tech hardware. Since the next setup file uses fewer elements than the currently loaded setup file, the R/D Tech hardware memory must be cleared. (See "Some Measurement Ground Rules" slide.)
- After waiting several seconds, restart the R/D Tech hardware and Tomoview 2.2 software.

15E FBH C-Scan (PW Block 8): Setup

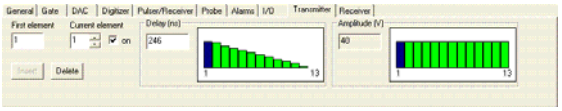
- Depending on probe manufacturer, load either Tomoview setup file “SupB-015E-block08.acq” incorporating PAC file “SupB-015E-F8-14rings-3p0inWP-b08.pac” or “SupA-015E-block08.acq” incorporating PAC file “SupA-015E-F8-14rings-3p0inWP-b08.pac”.
- Verify Tomoview parameter settings.

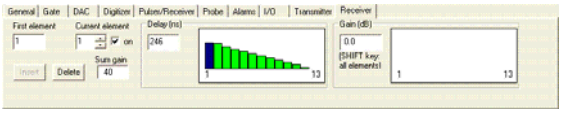


Supplier B Model AAWX074A parameter settings:



Supplier A Model 4608 parameter settings:





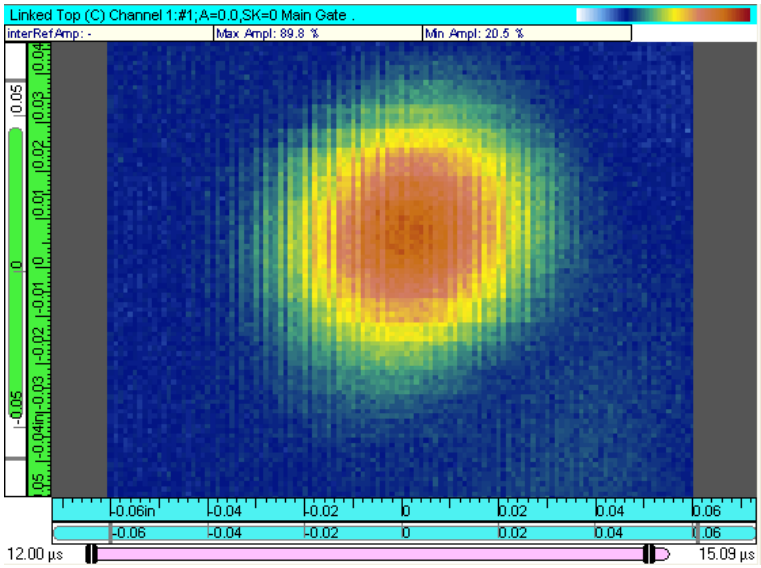
15E FBH C-Scan (PW Block 8): Scanning and Analysis

- Zero encoders and move off-axis from approximate center of block by (x,y) = (-0.06 inch, -0.06 inch).
- Scan 0.12-inch by 0.12-inch section of block #8 using a scan and index resolution of 0.001-inch. (A forward scan speed of 0.25 inches/second was used with the ISU system.)
- If the beam spot from the FBH is not entirely within the scan area, center the probe over the FBH, zero encoders, move off-axis from center of block by (x,y) = (-0.06 inch, -0.06 inch), and re-scan.
- Save the .rdt file for reference when the scan is complete. Suggested acquisition file name: “ProbeID_015E_FBH_b08-#.rdt”.
- Select Tomoview’s draw-down menu “Tools”, then choose “Hide 3D Cursor” to remove the small pink dot from beam spot image.
- With beam spot from the FBH roughly centered in the C-scan, remove both red and blue reference lines from pane before using Tomoview’s Grab Feature to capture C-scan image and save as bitmap file. Be sure to use the “Rectangle” capture option so that the C-scan’s axes are also saved (see next page). Suggested bitmap file name: “ProbeID_015E_FBH_b08-#.bmp”.
- Using the mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press right arrow button on keyboard until A-scan pane indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 1st scan position. Press left arrow button on keyboard until A-scan pane again indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 2nd scan position.
- Using the mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press down arrow button on keyboard until A-scan pane indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 1st index position. Press up arrow button on keyboard until A-scan pane again indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 2nd index position.

15E FBH C-Scan (PW Block 8): Measuring Beam Widths

- Enter the widths (full width at half maximum) into the space provided in the “15E-delays (probe ID)” worksheet in the Excel File “PA_performance_15E-Delays-OUTFIT.xls”.

Measured beam widths from C-scan of PW block #08 at 3.00-inch water path		
Full width at half max (X):	0.049	inches
Full width at half max (Y):	0.050	inches

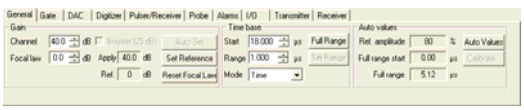
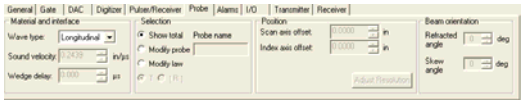


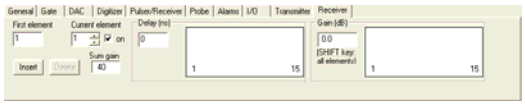
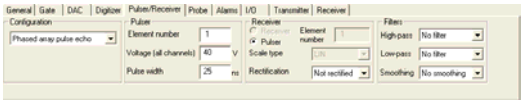
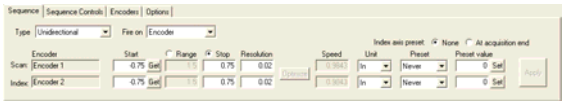
15E C-Scan (Glass Rod): Setup

- Submerge the 15-element probe and clear away any water bubbles from probe face.
- Probe cables to R/D Tech instrument interface
  - Limo cable to port P/1 <u>is not connected</u>.
  - Hypertronics cable connector <u>is connected</u>.
- Start computer and wait for it to finish, then turn on R/D Tech hardware and Tomoview 2.2 software.
- Record water temperature of water bath. Use “waterVelocity” worksheet in Excel file “PA_performance_15E-Delays-OUTFIT.xls” to determine water velocity.
- Load Tomoview setup file “015E-delayTimes.acq” to assist with leveling the probe to the block.
- Record Tomoview’s time offset value, t0.
- Together with water velocity, calculate the TOF equivalent to 0.5-inches of water path using the equation TOF = (2z/v) + t0. (See “waterVelocity” worksheet.)
- Level probe to flat surface on which glass rod with clay stand will be placed. (See previous slides on leveling.)
- Position glass rod with clay stand on a flat surface which was leveled.
- Center probe over glass rod at roughly 3.0-inches of water path using center element response.
- Zero encoders.
- After “peaking up” amplitude response from element #2 by moving slightly off-axis, readjust water path to precisely 0.5-inches using response from element #2, i.e., first annular ring.
- Load Tomoview setup file “015E-delayTimes-glassRod.acq” incorporating the PAC file “015elements.pac”.

15E C-Scan (Glass Rod): Setup

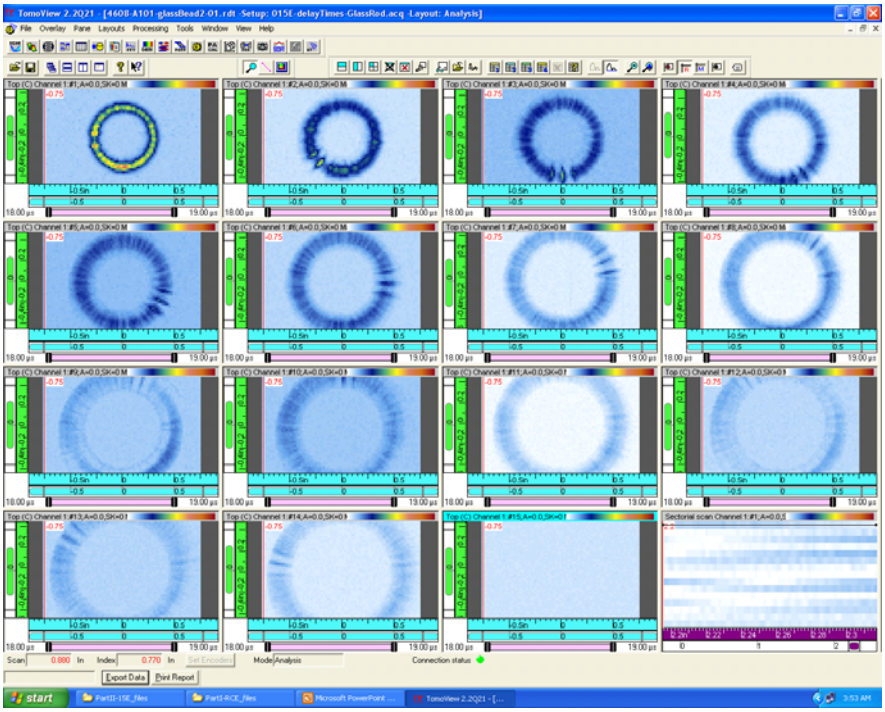
- Verify Tomoview parameter settings.
- Move off-axis from glass rod by (x,y) = (-0.75 inch, -0.75 inch).
- Scan 1.50-inch by 1.50-inch area around glass rod using a scan and index resolution of 0.020-inch. (A forward scan speed of 0.25 inches/second was used with the ISU system.)
- Save the .rdt file for reference when the scan is complete. Suggested acquisition file name: “ProbeID_015E_glassBead2-#.rdt”.

15E C-Scan (Glass Rod): Scanning and Analysis

- With images roughly centered in C-scans, use Tomoview’s Grab “Screen” Feature to capture C-scan images and save as bitmap file. Suggested bitmap file name: “ProbeID_015E_glassBead2-#.bmp”.



Part III -
Performance Evaluation Procedures
for
Compound spherical, segmented annular, 110-element transducer

Sketches of Measurements Using 110-Element, Compound Spherical, Segmented Annular Probe

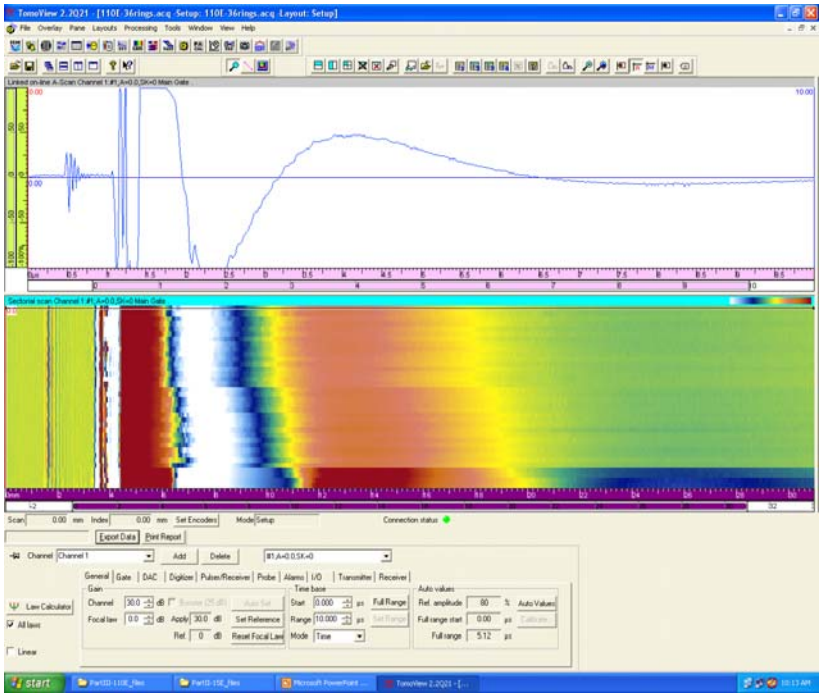
- **Reflecting Target in Water - TOF Variation Over All Elements:** Measurements of TOF from each segmented annular ring elements to a convex reflecting surface are made in water at a specified water path. The three spherical surfaces of the probe have three separate but matching spherical surfaces as reflectors. Care must be taken that the transducer is level and centered over the reflector.
  - **Leveling**: Level probe over 50-mm-diameter planar reflector using responses from all rings (when element responses from individual rings are summed together).
  - **Inner section of probe surface**: Replace planar reflector with 30-mm-diameter convex reflector, adjust water path, and center probe over reflector before acquiring delay times for rings 1-12, i.e., elements 1-12.
  - **Middle section of probe surface** : Replace previous reflector with 40-mm-diameter convex reflector, adjust water path, and center probe over reflector before acquiring delay times for rings 13-26, i.e., elements 13-26, 49-58, 86-90, and 118-122.
  - **Outer section of probe surface** : Replace previous reflector with 50-mm-diameter convex reflector, adjust water path, and center probe over reflector before acquiring delay times for rings 27-36, i.e., elements 27-32, 59-84, 91-116, and 123-128.
- **C-Scan of #1/2 FBHs in PW Calibration Samples to Determine Beam Spot Size:** Determines beam diameter when focused at the mid-zone FBH depth for zone 3 or zone 6. In each zone, the focus is maintained by phasing the array with delays times specific to the mid-zone FBH depth. (The delay times used to establish these focal depths were generated via geometric ray-tracing.)

TOF Variation over 110 Elements - Leveling Probe

- Submerge the 110-element probe and clear away any water bubbles from probe face.
- Connect probe cable to R/D Tech instrument interface.
- Start computer and wait for it to finish, then turn on the R/D Tech hardware (either FOCUS or Tomoscan III instruments) and Tomoview 2.2 software.
- Load the Tomoview setup file “110E-36rings.acq”. This setup file incorporates the PAC file “36rings.pac”.
- Load the Microsoft Excel file “PA_performance_110E-Delays-OUTFIT.xls”.
- Record water temperature of water bath. Use “waterVelocity” worksheet reproduced in the Excel file “PA_performance_110E-Delays-OUTFIT.xls” to determine water velocity.
- Record Tomoview’s time offset value, t0, by examining the A-scan response from any ring. (See figure on next slide.)
- Approximately center probe over level, planar surface at approximately 3.00-inch water path. (It is recommended that one of the PW blocks be used as a planar stand for the reflectors used in this evaluation procedure. It is critical that this surface be level before a reflector is placed on it.)
- Adjust Tomoview’s “Start Time” until front wall response from reflector is displayed on A-scan.
- Carefully adjust level of probe until planar surface and probe are level with each other. See the following screen captures for an illustration of this process.

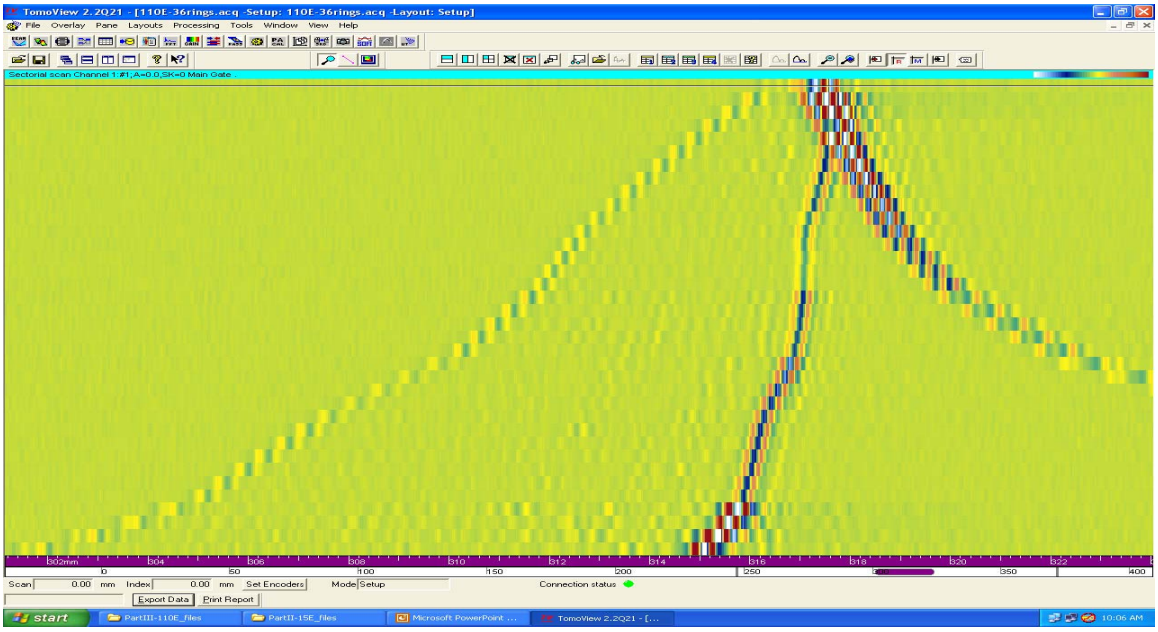
110E TOF Variation: Sectorial Scan Explanation

- This Sectorial scan image displays an A-scan from each individual transducer element as a color bar.
  - These 36 separate color bars display the individual ring responses from the probe, starting with the center element and progressively moving outwards, ring-by-ring. Responses from elements in the same ring have been summed.
  - The top color bar represents the response from the center element.
  - The bottom color bar represents the summed response from all elements in the outermost ring of the segmented, annular array.



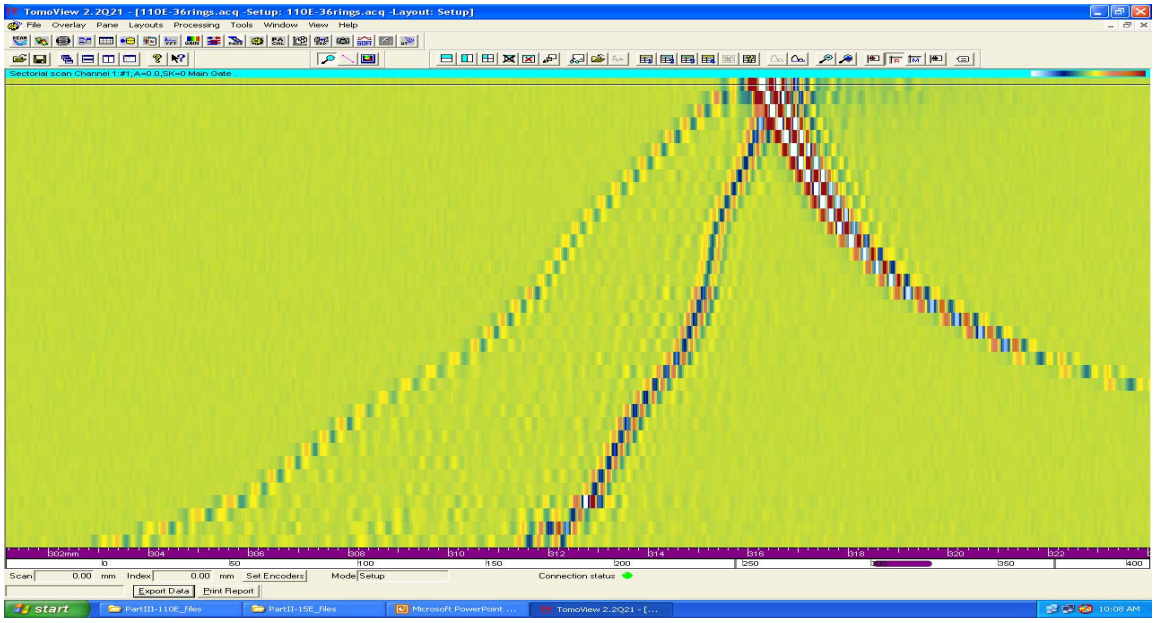
110E TOF Variation: Partially Aligned Probe

- This Sectorial scan shows the responses from a probe which is out of alignment with the reflector along both probe symmetry axes.



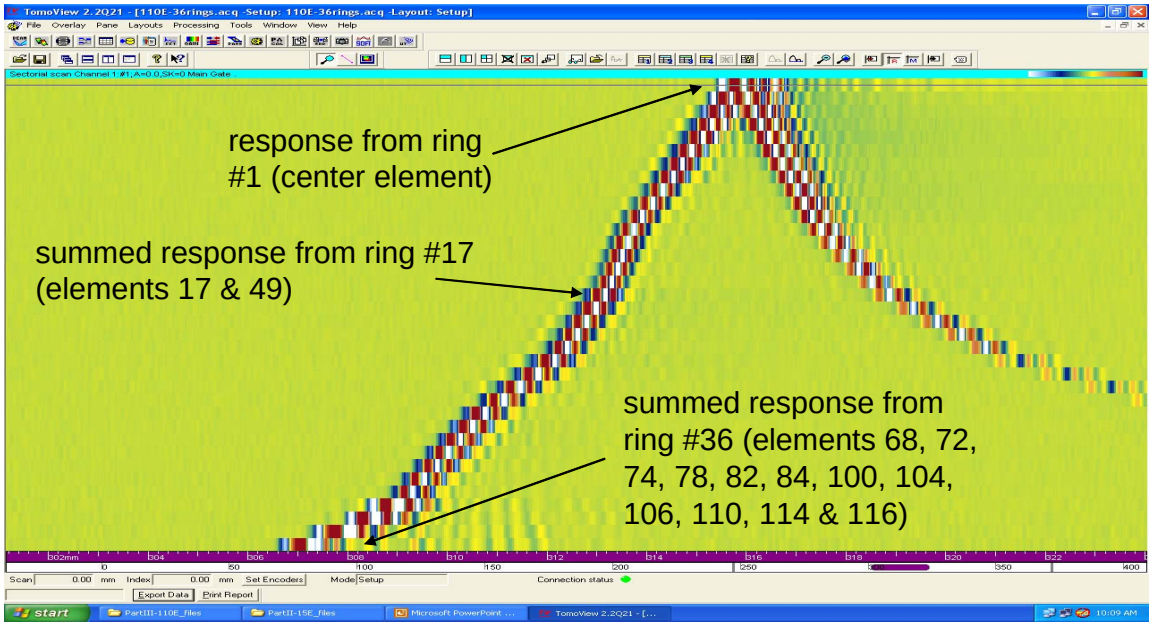
110E TOF Variation: Partially Aligned Probe (con't)

- This Sectorial scan shows the responses from a probe which is in alignment with the reflector along one probe symmetry axis but out of alignment along the other probe symmetry axis.



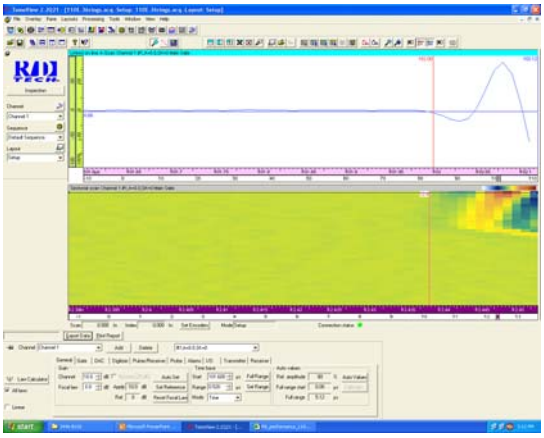
110E TOF Variation: Probe In Alignment

- This Sectorial scan shows the responses from a probe which is in alignment from the reflecting surface along both probe symmetry axes.



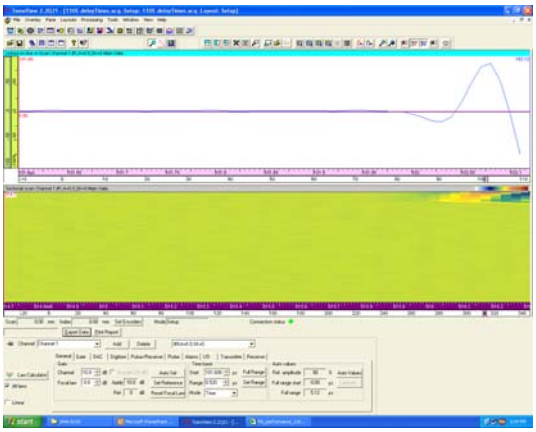
110E Inner Section TOF Variation: Setup

- Place 30-mm-diameter convex reflector on the planar surface beneath the 110-element probe and clear away any water bubbles from probe face. Note: The writing on the reflector is located on side <u>opposite</u> from convex surface.
- Together with water velocity and time offset value, calculate the TOF equivalent to 2.9473-inches of water path using the equation TOF = (2z/v) + t0. (See “waterVelocity” worksheet.)
- Carefully center probe over reflector by ”peaking up” the front wall response of element #1, the center element, from the reflector. (Note: the centering method described in the previous section doesn’t work for a spherical reflector.)
- Establish water path of precisely 2.9473-inches to reflector using A-scan TOF response from center element.
- <u>Very carefully</u> re-center probe over spherical reflector.
- Adjust gain until response from center element, element #1, is 80-90%FSH.
- Adjust the Tomoview’s “Start Time” until the reflector’s front wall response appears near the end of the A-scan when using a “Range” of 0.52 microseconds. For rings 1-12, only the first positive peak from the front wall should be visible.
- Make a note of values for “Start Time” and “Gain”. (Record “Start Time” in Excel worksheet where indicated.)



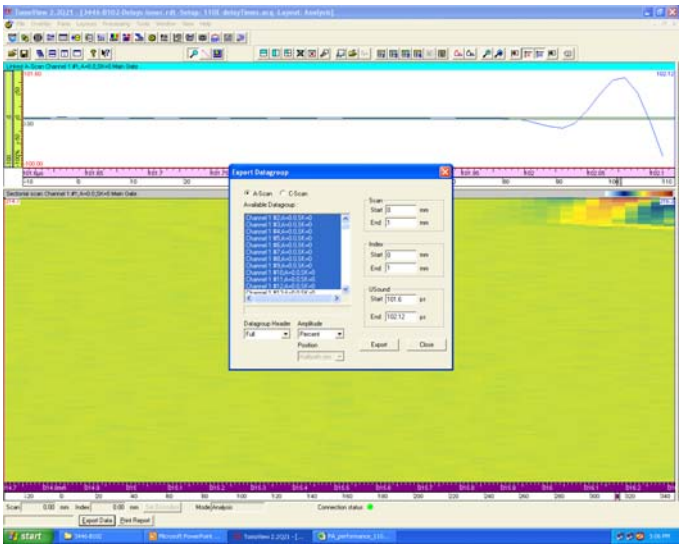
110E Inner Section TOF Variation: Saving A-scans

- Load the Tomoview setup file “110E-delayTimes.acq”. This setup file incorporates the PAC file “128elements.pac”. (Note on rule from “Some Measurement Ground Rules” slide: Tomoview software and Tomoscan hardware need not be restarted at this time as both Tomoview setup files energize all probe elements.)
- Load the Microsoft Excel file “PA_performance_110E-Delays-OUTFIT.xls”.
- Adjust the Tomoview’s “Start Time” and gain to the values noted above. Set Tomoview’s “Range” to 0.52 us.
- Switch Tomoview to Inspection Mode, wait a few seconds, press Stop, and save the .rdt file. Suggested file name: “probeID_Delays-inner.rdt”.



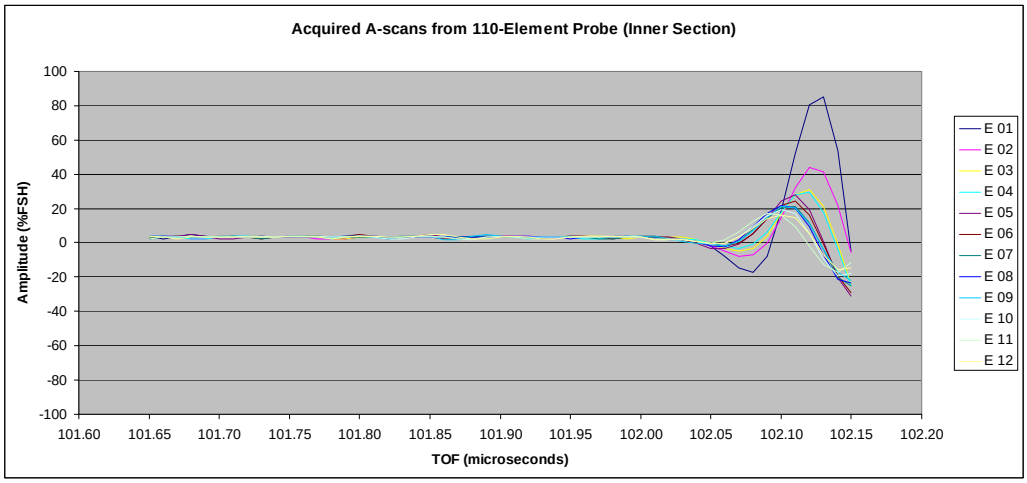
110E Inner Section TOF Variation: A-Scan Data

- In Tomoview’s Analysis Mode, adjust the red reference bar until it is located at the far left of the A-scan. Also, adjust the blue reference bar until it is located at the far right of the A-scan.
- Choose the ExportDataGroup icon from the top row of Tomoview functions and export and save A-scan data for rings 1-12 by selecting channels 1-12. Suggested file name: “probeID_Delays-inner.txt”.



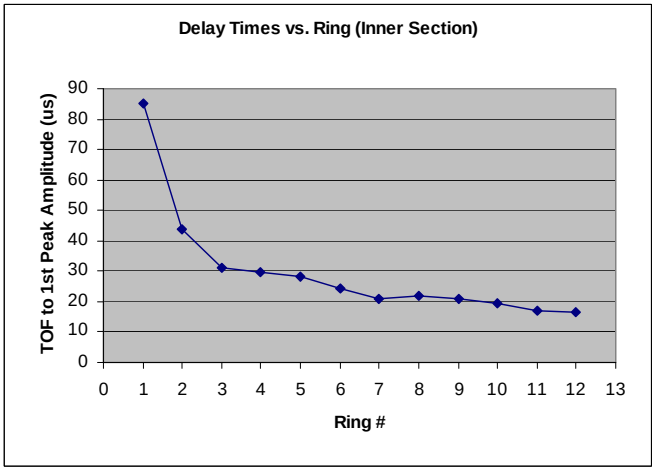
110E Inner Section TOF Variation: Plotting A-Scan Data

- Open the previously saved A-scan text file using Microsoft Excel.
- Copy all A-scan data in this text file and paste it into appropriate column in “110E-Delays (probe ID)” worksheet in the Excel file “PA_performance_110E-Delays-OUTFIT.xls”.
- Highlight the blue cell in the appropriate data column for this channel, select the “Paste Special” Edit function, check the “Value” and “Transpose” buttons in the dialog box, then click Ok.
- Repeat until the A-scan data from channels 1-12 has been transferred from the text file to the Excel worksheet.
- Examine the chart in the worksheet entitled “Individual Acquired A-scans from 110-element Probe (Inner Section)” for any discrepancies in copying the A-scan data.



110E Inner Section TOF Variation: A-scan Data Analysis (con’t)

- For each saved A-scan, the maximum peak amplitude from each element of the inner section of the probe has been located and plotted.
- A more advanced peak-finding algorithm may be applied to the data at a later date.

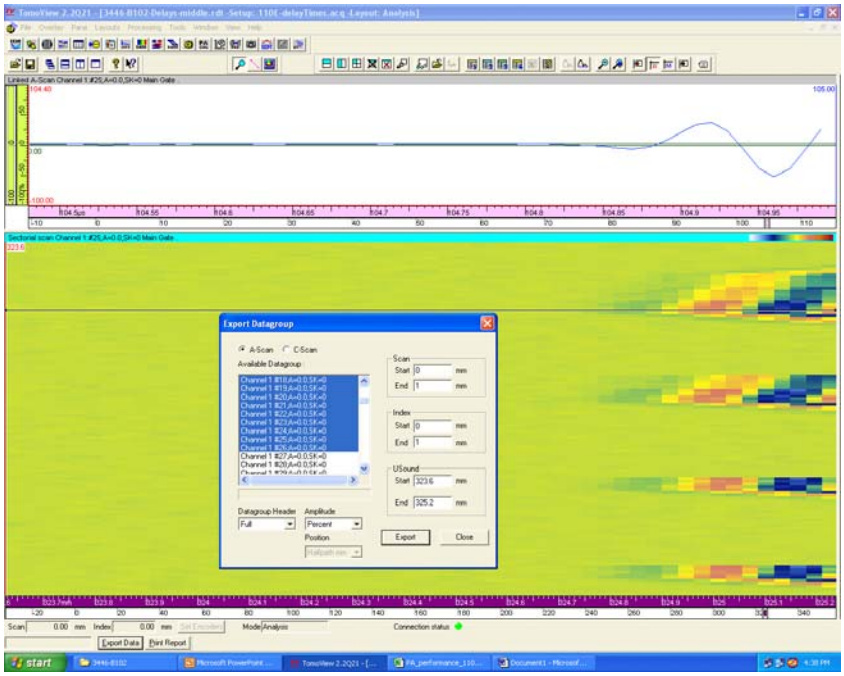


110E Middle Section TOF Variation: Setup and Saving A-Scans

- Load the Tomoview setup file “110E-36rings.acq”.
- Replace previous reflector with 40-mm-diameter convex reflector beneath the submerged 110-element probe and clear away any water bubbles from probe face. Note: The writing on the reflector is located on side opposite from convex surface.
- Together with water velocity, calculate the TOF equivalent to 3.0314-inches of water path using the equation TOF = (2z/v) + t0. (See “waterVelocity” worksheet.)
- Carefully center probe over reflector by ”peaking up” the front wall response of element #1, the center element, from the reflector. Alternatively, examine the responses from rings 13-26 and use “leveling” process already outlined except move xy-axes instead of probe tilt angles.
- Establish water path of precisely 3.0314-inches to reflector using A-scan TOF response from ring 13. Do not use center element to set water path distance from probe to reflector.
- Re-center probe over reflector.
- Adjust gain until response from rings 13-26 does not exceed 90%FSH.
- Adjust the Tomoview’s “Start Time” until the reflector’s front wall response appears near the end of the A-scan when using a “Range” of 0.52 microseconds. For rings 13-26, only the first positive peak from the front wall should be visible (if possible).
- Make a note of values for “Start Time” and gain. (Record “Start Time” in Excel worksheet where indicated.)
- Load the Tomoview Setup file “110E-delayTimes.acq”.
- Adjust Tomoview’s “Start Time” and gain to the values noted above. Set Tomoview’s “Range” to 0.52 us.
- Switch Tomoview to Inspection Mode, wait a few seconds, press Stop, and save the .rdt file. Suggested file name: “probeID_Delays-middle.rdt”.

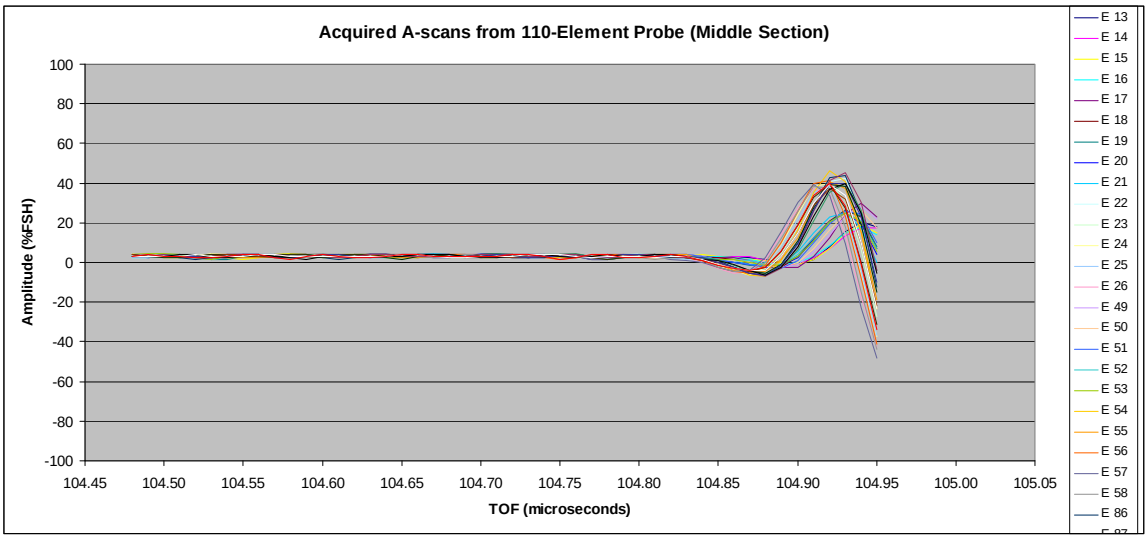
110E Middle Section TOF Variation: Saving A-Scans

- In Tomoview’s Analysis Mode, adjust the red reference bar until it is located at the far left of the A-scan. Also, adjust the blue reference bar until it is located at the far right of the A-scan.
- Choose the ExportDataGroup icon from the top row of Tomoview functions and export and save A-scan data for rings 13-26 by selecting channels 13-26, 49-58, 86-90, and 118-122. Suggested file name: “probeID_Delays-middle_ch#to#.txt”.



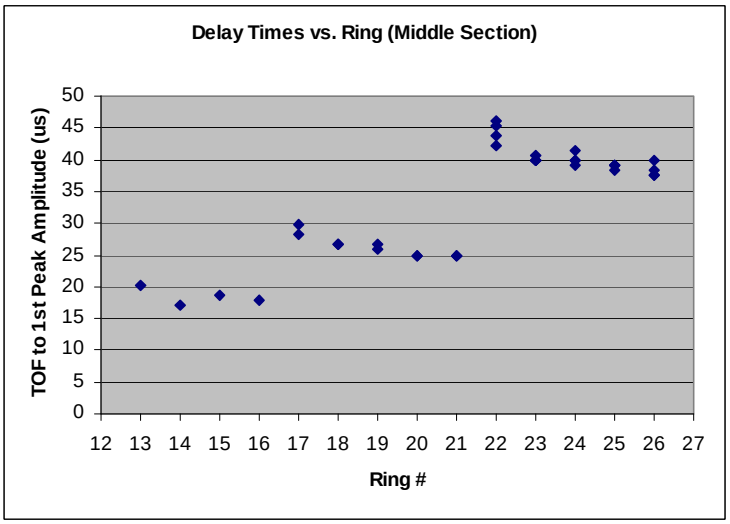
110E Middle Section TOF Variation: A-scan Data Analysis

- Open the previously saved A-scan text files using Microsoft Excel.
- Copy all A-scan data for elements 13-26, 49-58, 86-90, and 118-122 into the appropriate column in "110E_Delays (probeID)" worksheet in the Excel file "PA_performance_110E-Delays-OUTFIT.xls".
- Examine the chart entitled "Individual A-scans from 110-Element Probe (Middle Section)" for any discrepancies in copying the A-scan data.



110E Middle Section TOF Variation: A-scan Data Analysis (con't)

- For each saved A-scan, the maximum peak amplitude from each element of the middle section of the probe has been located and plotted.
- A more advanced peak-finding algorithm may be applied to the data at a later date.

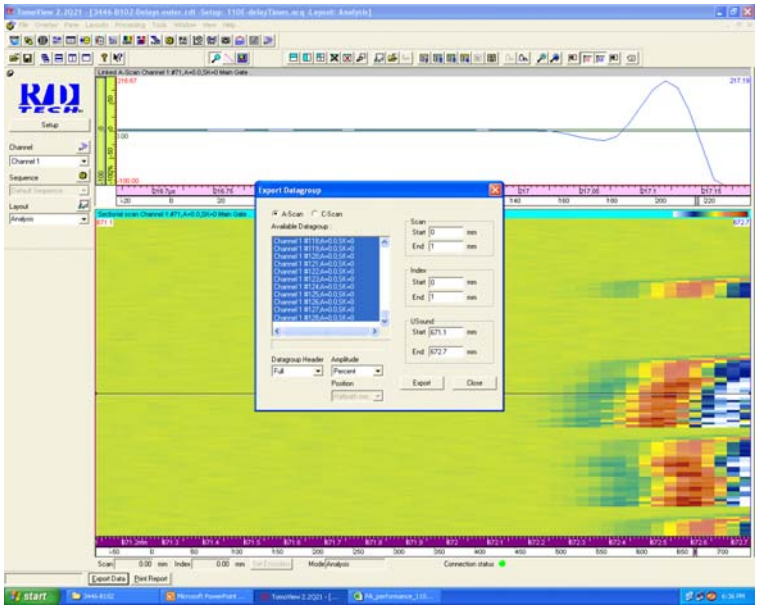


110E Outer Section TOF Variation: Setup and Saving A-Scans

- Load the Tomoview setup file “110E-36rings.acq”.
- Replace previous reflector with 50-mm-diameter convex reflector beneath the submerged 110-element probe and clear away any water bubbles from probe face. Note: The writing on the reflector is located on side opposite from convex surface.
- Together with water velocity, calculate the TOF equivalent to 6.3078-inches of water path using the equation TOF = (2z/v) + t0. (See “waterVelocity” worksheet.)
- Carefully center probe over reflector by ”peaking up” the front wall response of element #1, the center element, from the reflector. Alternatively, examine the responses from rings 27-36 and use “leveling” process already outlined except move xy-axes instead of probe tilt angles.
- Establish water path of precisely 6.3078-inches to reflector using A-scan TOF response from ring 27. Do not use center element to set water path distance from probe to reflector.
- Re-center probe over reflector.
- Adjust gain until response from rings 27-32 does not exceed 90%FSH. Record gain required. (The amplitude will appear saturated for rings 33-36 only because each ring sums many individual elements - the individual elements will not be saturated in the 110-element setup file.)
- Adjust the Tomoview’s “Start Time” until the reflector’s front wall response appears near the end of the A-scan when using a “Range” of 0.52 microseconds. For rings 27-36, only the first positive peak from the front wall should be visible (if possible).
- Make a note of values for “Start Time” and gain. (Record “Start Time” in Excel worksheet where indicated.)
- Load the Tomoview Setup file “110E-delayTimes.acq”.
- Adjust Tomoview’s “Start Time” and gain to the values noted above. Set Tomoview’s “Range” to 0.52 us. (Note that any adjustment to the gain will cause Tomoview to pause for >60 seconds while the softw.)
- Switch Tomoview to Inspection Mode, wait a few seconds, press Stop, and save the .rdt file. Suggested file name: “probeID_Delays-middle.rdt”.

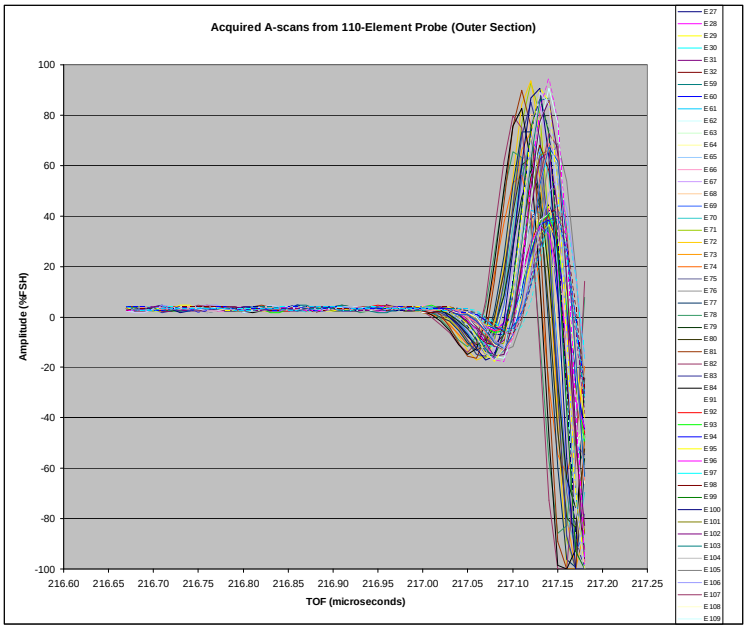
110E Outer Section TOF Variation: Saving A-Scans

- In Tomoview’s Analysis Mode, adjust the red reference bar until it is located at the far left of the A-scan. Also, adjust the blue reference bar until it is located at the far right of the A-scan.
- Choose the ExportDataGroup icon from the top row of Tomoview functions and export and save A-scan data for rings 27-36 by selecting channels 27-32, 59-84, 91-116, and 123-128. Suggested file name: “probeID_Delays-outer_ch#to#.txt”.



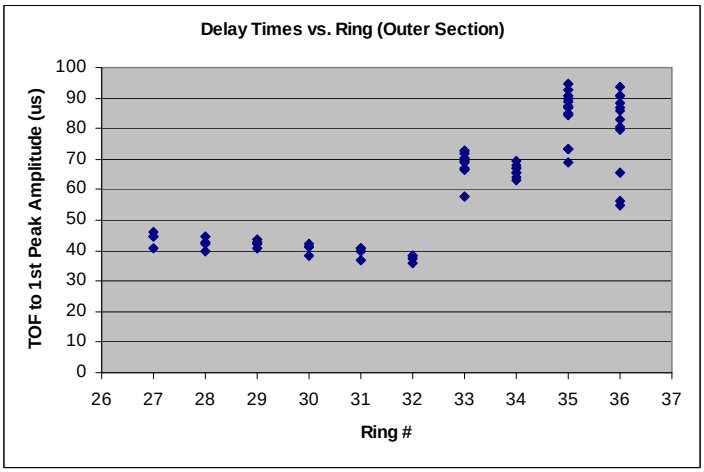
110E Outer Section TOF Variation: A-Scan Data Analysis

- Open the previously saved A-scan text files using Microsoft Excel.
- Copy all A-scan data for elements 27-32, 59-84, 91-116, and 123-128 into the appropriate column in "110E_Delays (probeID)" worksheet in the Excel file "PA_performance_110E-Delays-OUTFIT.xls".
- Examine the chart entitled "Individual A-scans from 110-Element Probe (Outer Section)" for any discrepancies in copying the A-scan data.



110E Outer Section TOF Variation: A-scan Data Analysis (con't)

- For each saved A-scan, the maximum peak amplitude from each element of the outer section of the probe has been located and plotted.
- A more advanced peak-finding algorithm may be applied to the data at a later date.

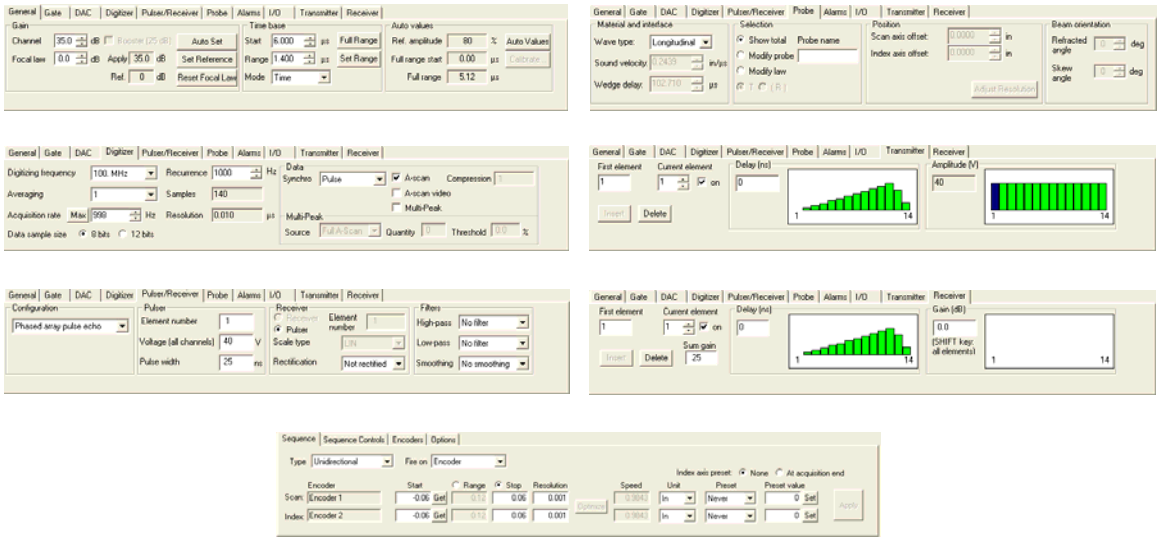


110E Probe C-Scan of #1/2 FBH: Block 4 Setup

- Submerge the 110-element probe and clear away any water bubbles from probe face.
- Start computer and wait for it to finish, then turn on R/D Tech hardware and Tomoview 2.2 software.
- Load the Tomoview setup file “110E-36rings.acq”. This setup files incorporates the PAC file “36rings.pac”.
- Load the Microsoft Excel file “PA_performance_110E-Delays-OUTFIT.xls”.
- Record water temperature of water bath. Use “waterVelocity” worksheet reproduced in the Excel file “110E-Delays” to determine water velocity.
- Record Tomoview’s time offset value, t0.
- Together with water velocity, calculate the TOF equivalent to 3.00-inches of water path using the equation TOF = (2z/v) + t0. (See “waterVelocity” worksheet.)
- Position PW calibration block #4 on a flat surface which can be leveled.
- Approximately center probe over leveled PW block #4 at precisely 3.00-inches of water path using TOF from A-scan of center element, ring #1.
- Approximately center probe over PW block.
- Level probe on surface of block along both planes of symmetry. (See previous slides on leveling.)
- Carefully center probe over PW block by moving off-axis along x-direction until previously saturated A-scan response from center element drops to 80% FSH. Next, zero encoder value and move off-axis along negative x-direction until A-scan response from center element again drops to 80%FSH. Finally, move along x-axis to half of the value of this encoder location. Zero x-axis encoder. Repeat this process along y-axis to precisely center probe over reflector.
- Turn off Tomoview and R/D Tech hardware. Since the next setup file uses fewer elements than the currently loaded setup file, the R/D Tech hardware memory must be cleared. (See “Some Measurement Ground Rules” slide.)
- After waiting several seconds, restart the R/D Tech hardware and Tomoview 2.2 software.
- Load Tomoview setup file “110E-block04.acq” incorporating PAC file “110E-F6-3p0inWP-b04.pac”

110E Probe C-Scan of #1/2 FBH: Block 4 Setup

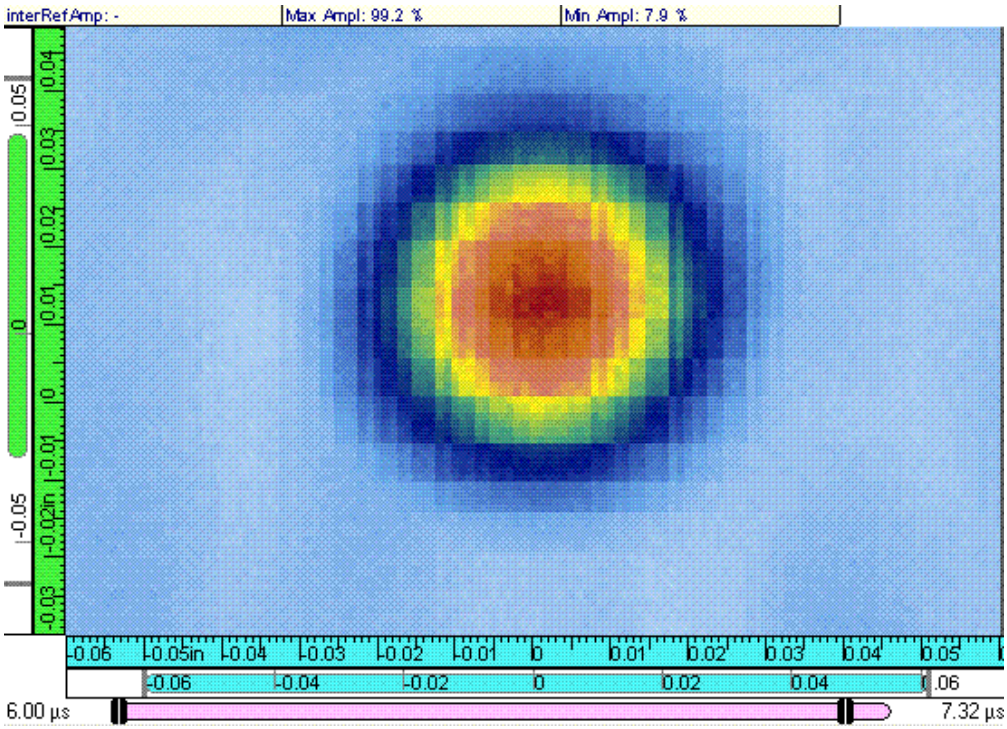
- Verify Tomoview parameter settings.



110E Probe C-Scan of #1/2 FBH: Scanning and Analysis (Block 4)

- Zero encoders and move off-axis from approximate center of block by (x,y) = (-0.06 inch, -0.06 inch).
- Scan 0.12-inch by 0.12-inch section of block #4 using a scan and index resolution of 0.001-inch. (A forward scan speed of 0.25 inches/second was used with the ISU system.)
- If the beam spot from the FBH is not entirely within the scan area, center the probe over the FBH, zero encoders, move off-axis from center of block by (x,y) = (-0.06 inch, -0.06 inch), and re-scan.
- Save the .rdt file for reference when scan is complete. Suggested file name: “ProbeID_110E_FBH_b04.rdt”
- With beam spot from FBH roughly centered in C-scan, remove 3D Cursor (pink dot) as well as both red and blue reference lines from pane before using Tomoview’s Grab Feature to capture C-scan image and save as bitmap file.
- Using the mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press right arrow button on keyboard until A-scan pane indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 1st scan position. Press left arrow button on keyboard until A-scan pane again indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 2nd scan position.
- Using the mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press down arrow button on keyboard until A-scan pane indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 1st index position. Press up arrow button on keyboard until A-scan pane again indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 2nd index position.
- Enter the widths (full width to half maximum) into the space provided at the top of the “110E delays (probe ID)” worksheet in the Excel File “PA_performance_110E-Delays-OUTFIT.xls”

110E Probe C-Scan of #1/2 FBH: Scanning and Analysis (Block 4) (con’t)

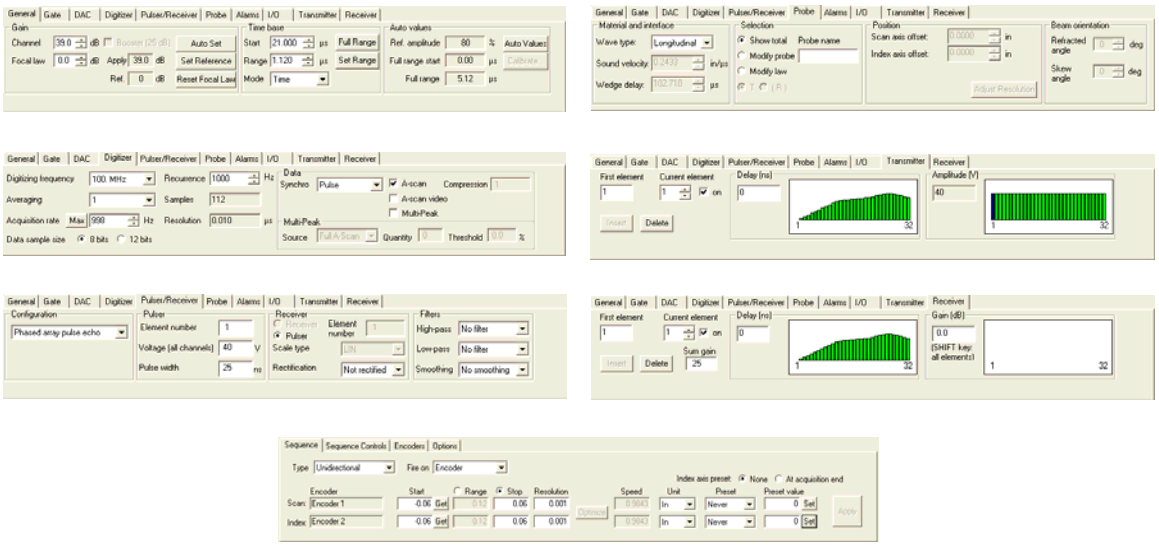


110E Probe C-Scan of #1/2 FBH: Block 12 Setup

- Submerge the 110-element probe and clear away any water bubbles from probe face.
- Start computer and wait for it to finish, then turn on R/D Tech hardware and Tomoview 2.2 software.
- Load the Tomoview setup file “110E-36rings.acq”. This setup files incorporates the PAC file “36rings.pac”.
- Load the Microsoft Excel file “PA_performance_110E-Delays-OUTFIT.xls”.
- Record water temperature of water bath. Use “waterVelocity” worksheet reproduced in the Excel file “110E-Delays” to determine water velocity.
- Record Tomoview’s time offset value, t0.
- Together with water velocity, calculate the TOF equivalent to 3.00-inches of water path using the equation TOF = (2z/v) + t0. (See “waterVelocity” worksheet.)
- Position PW calibration block #12 on a flat surface which can be leveled.
- Approximately center probe over leveled PW block #12 at precisely 3.00-inches of water path using TOF from A-scan of center element, ring #1.
- Approximately center probe over PW block.
- Level probe on surface of block along both planes of symmetry. (See previous slides on leveling.)
- Carefully center probe over PW block by moving off-axis along x-direction until previously saturated A-scan response from center element drops to 80% FSH. Next, zero encoder value and move off-axis along negative x-direction until A-scan response from center element again drops to 80%FSH. Finally, move along x-axis to half of the value of this encoder location. Zero x-axis encoder. Repeat this process along y-axis to precisely center probe over reflector.
- Turn off Tomoview and R/D Tech hardware. Since the next setup file uses fewer elements than the currently loaded setup file, the R/D Tech hardware memory must be cleared. (See “Some Measurement Ground Rules” slide.)
- After waiting several seconds, restart the R/D Tech hardware and Tomoview 2.2 software.
- Load Tomoview setup file “110E-block12.acq” incorporating PAC file “110E-F6-3p0inWP-b12.pac”

110E Probe C-Scan of #1/2 FBH: Block 12 Setup

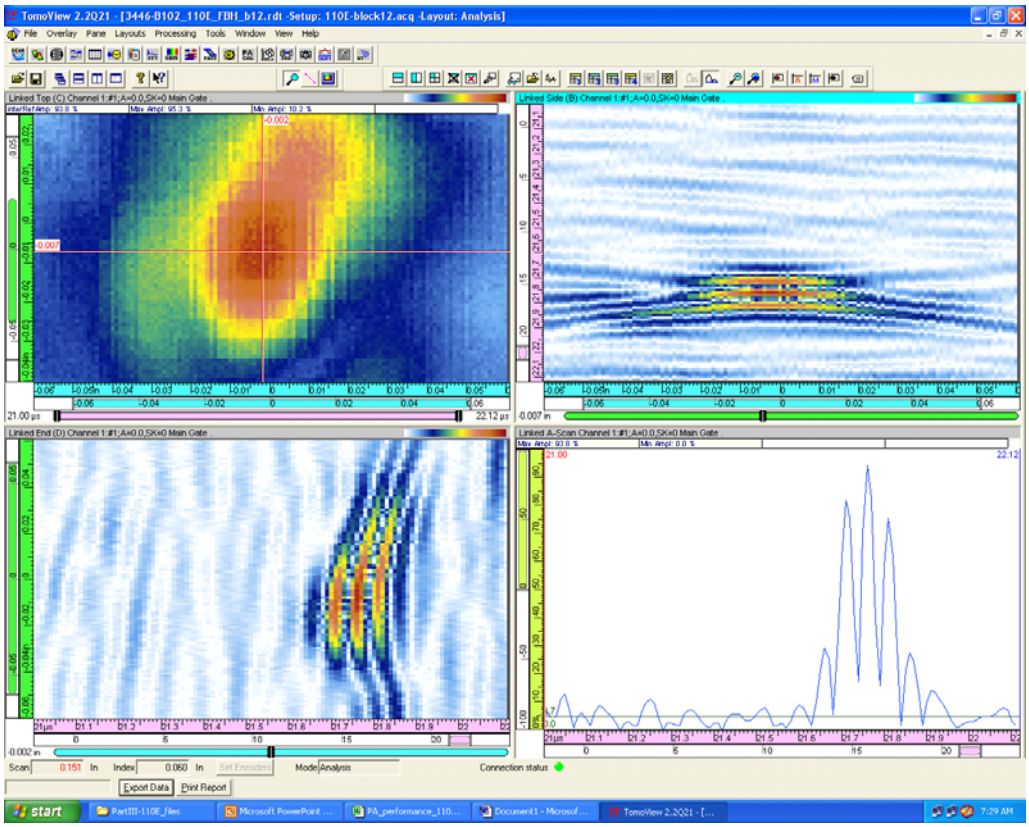
- Verify Tomoview parameter settings.



110E Probe C-Scan of #1/2 FBH: Scanning and Analysis (Block 12)

- Zero encoders and move off-axis from approximate center of block by (x,y) = (-0.06 inch, -0.06 inch).
- Scan 0.12-inch by 0.12-inch section of block #12 using a scan and index resolution of 0.001-inch. (A forward scan speed of 0.25 inches/second was used with the ISU system.)
- If the beam spot from the FBH is not entirely within the scan area, center the probe over the FBH, zero encoders, move off-axis from center of block by (x,y) = (-0.06 inch, -0.06 inch), and re-scan.
- Save the .rdt file for reference when scan is complete. Suggested file name: “ProbeID_110E_FBH_b12.rdt”
- With beam spot from FBH roughly centered in C-scan, remove 3D Cursor (pink dot) as well as both red and blue reference lines from pane before using Tomoview’s Grab Feature to capture C-scan image and save as bitmap file.
- Using the mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press right arrow button on keyboard until A-scan pane indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 1st scan position. Press left arrow button on keyboard until A-scan pane again indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 2nd scan position.
- Using the mouse, double-left-click on center of beam spot to place cross-hairs of red reference lines. Press down arrow button on keyboard until A-scan pane indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 1st index position. Press up arrow button on keyboard until A-scan pane again indicates a peak value equal to half the “Maximum Amplitude” value from the C-scan pane. Record this 2nd index position.
- Enter the widths (full width to half maximum) into the space provided at the top of the “110E delays (probe ID)” worksheet in the Excel File “PA_performance_110E-Delays-OUTFIT.xls”

110E Probe C-Scan of #1/2 FBH: Scanning and Analysis (Block 12) (con’t)

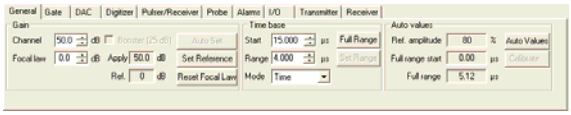


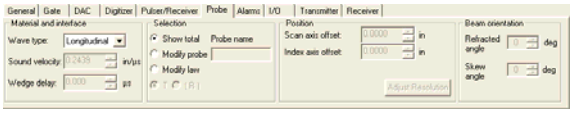
110E C-Scan (Glass Rod): Setup

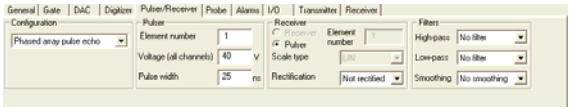
- Submerge the 110-element probe and clear away any water bubbles from probe face.
- Connect Hypertronics cable to R/D Tech instrument interface
- Start computer and wait for it to finish, then turn on R/D Tech hardware and Tomoview 2.2 software.
- Record water temperature of water bath. Use “waterVelocity” worksheet in Excel file “PA_performance_15E-Delays-OUTFIT.xls” to determine water velocity.
- Load Tomoview setup file “110E-delayTimes.acq” to assist with leveling the probe to the block.
- Level probe to flat (level) surface on which glass rod with clay stand will be placed. (See previous slides on leveling.)
- Position glass rod with clay stand on the flat surface.
- Approximately center probe over glass rod at precisely 18.2 microseconds TOF of water path (approximately 0.5-inches, depending on water bath temperature).
- Load the Tomoview setup file “110E-36rings-GlassRod.acq”. This setup files incorporates the PAC file “36rings.pac”.

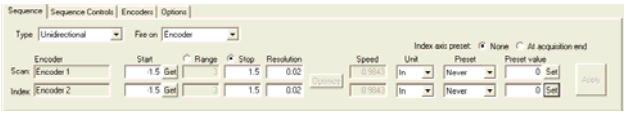
110E C-Scan (Glass Rod): Setup

- Verify Tomoview parameter settings.





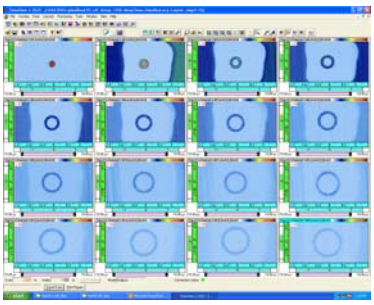




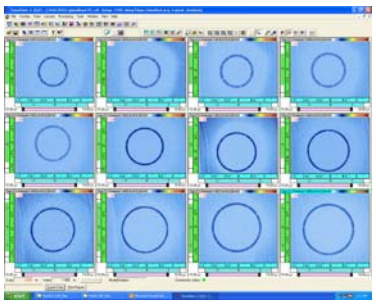
110E C-Scan (Glass Rod): Scanning

- Zero encoders and move off-axis from glass rod by (x,y) = (-1.50 inch, -1.50 inch).
- Scan 3.00-inch by 3.00-inch area around glass rod using a scan and index resolution of 0.020-inch. (A forward scan speed of 0.25 inches/second was used with the ISU system.) Save the .rdt file when the scan is complete. Suggested file name: “ProbeID_110E_glassBead-#.rdt”.
- Three “Layouts” have been saved, useful for examining the response from each of the 36 rings.

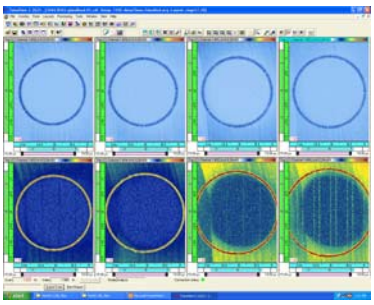
rings 1-16



rings 17-28



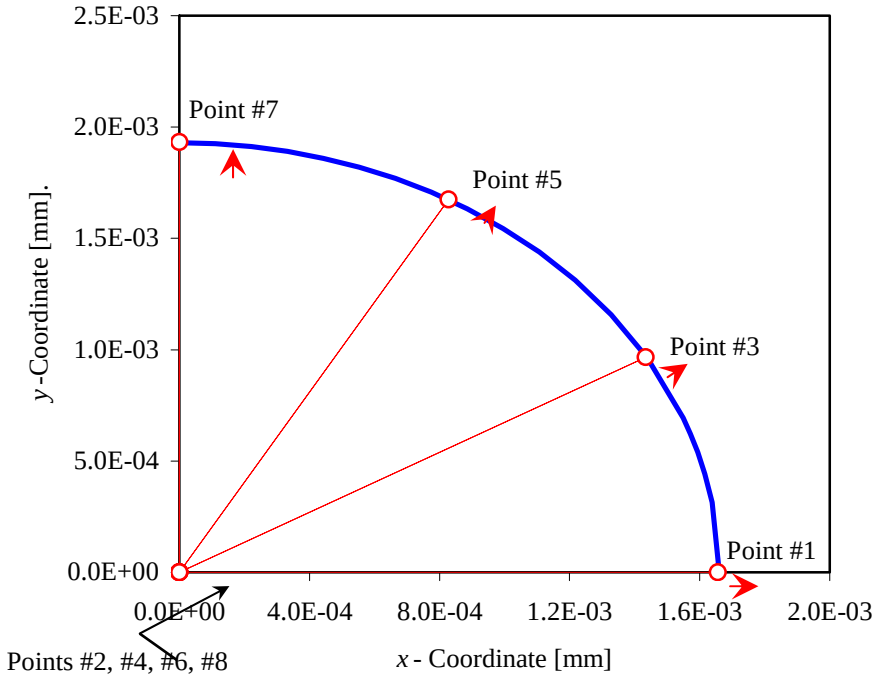
rings 29-36



APPENDIX E—ELEMENT POSITIONS FOR THE SUPPLIER A TRANSDUCER DESIGN (CONCAVE SURFACES)

Supplier A produced a phased array transducer design for inspection through concave surfaces and a design for inspection through convex surfaces. Appendix E presents details of the transducer designed for the concave entry surfaces by describing the geometric positions of the elements.

Figure E-1 and table E-1 together specify the three-dimensional coordinates of the points describing each element on the face of the phased array transducer designed by supplier A for the concave entry surface. Only one-quarter of the transducer face is described. The other quarters can be realized through symmetry by reflections about the x and y axes. Figure E-1 shows an example illustrating the meanings of the listed (x, y, and z) points, while table E-1 enumerates the coordinates of the points. Basically, each element is bounded by an inner contour (closer to the origin) and an outer contour (further from the origin), where the origin denotes the center of the transducer face. To specify a given element, the coordinates of several pairs of points are tabulated. For each pair of points listed, the first point lies on the outer contour and the second lies on the inner contour. Thus, connecting together the first, third, fifth, seventh, etc., points listed for a given element will define the element's outer boundary, while connecting together the second, fourth, sixth, eighth, etc., points will define the inner boundary. Line segments extending from the second point in a pair to the first point in the pair will be radial-like line segments that either lie within the boundaries of the element or on its borders. In the example shown in figure E-1, the inner contour is a point at the origin rather than an extended curve and hence has zero length. For all other elements, the inner and outer contours have nonzero lengths.



Belt 1 Point #	Ring	Element	x	y	z
1	0	1	1.66E-03	0.00E+00	4.43E-07
2	0	1	0.00E+00	0.00E+00	-1.39E-17
3	0	1	1.43E-03	9.67E-04	1.34E-06
4	0	1	0.00E+00	0.00E+00	-1.39E-17
5	0	1	8.28E-04	1.67E-03	3.14E-06
6	0	1	0.00E+00	0.00E+00	-1.39E-17
7	0	1	7.75E-11	1.93E-03	4.04E-06
8	0	1	0.00E+00	0.00E+00	-1.39E-17

Figure E-1. Illustration of the Meaning of Element Coordinates

Table E-1. Listing of Element Coordinates

Belt 1 Ring	Element	x	y	z
0	1	1.66E-03	0.00E+00	4.43E-07
0	1	0.00E+00	0.00E+00	-1.39E-17
0	1	1.43E-03	9.67E-04	1.34E-06
0	1	0.00E+00	0.00E+00	-1.39E-17
0	1	8.28E-04	1.67E-03	3.14E-06
0	1	0.00E+00	0.00E+00	-1.39E-17
0	1	7.75E-11	1.93E-03	4.04E-06
0	1	0.00E+00	0.00E+00	-1.39E-17
1	2	2.42E-03	0.00E+00	9.46E-07
1	2	1.76E-03	0.00E+00	5.03E-07
1	2	2.10E-03	1.41E-03	2.87E-06
1	2	1.53E-03	1.03E-03	1.52E-06
1	2	1.21E-03	2.45E-03	6.71E-06
1	2	8.82E-04	1.78E-03	3.56E-06
1	2	1.13E-10	2.83E-03	8.63E-06
1	2	8.26E-11	2.06E-03	4.58E-06
2	3	3.02E-03	0.00E+00	1.47E-06
2	3	2.53E-03	0.00E+00	1.03E-06
2	3	2.62E-03	1.76E-03	4.46E-06
2	3	2.19E-03	1.48E-03	3.13E-06
2	3	1.51E-03	3.05E-03	1.04E-05
2	3	1.26E-03	2.56E-03	7.32E-06
2	3	1.41E-10	3.53E-03	1.34E-05
2	3	1.18E-10	2.95E-03	9.42E-06

Table E-1. Listing of Element Coordinates (Continued)

Belt 2 Ring	Element	x	y	z
3	1	3.55E-03	0.00E+00	2.02E-06
3	1	3.13E-03	0.00E+00	1.58E-06
3	1	3.43E-03	1.07E-03	3.13E-06
3	1	3.02E-03	9.46E-04	2.44E-06
3	1	3.07E-03	2.07E-03	6.14E-06
3	1	2.71E-03	1.83E-03	4.79E-06
3	1	2.51E-03	2.93E-03	1.03E-05
3	1	2.21E-03	2.58E-03	8.00E-06
3	2	2.51E-03	2.93E-03	1.03E-05
3	2	2.21E-03	2.58E-03	8.00E-06
3	2	1.77E-03	3.59E-03	1.44E-05
3	2	1.56E-03	3.16E-03	1.12E-05
3	2	9.18E-04	4.00E-03	1.74E-05
3	2	8.10E-04	3.53E-03	1.36E-05
3	2	1.66E-10	4.14E-03	1.85E-05
3	2	1.46E-10	3.65E-03	1.44E-05
4	3	4.01E-03	0.00E+00	2.59E-06
4	3	3.65E-03	0.00E+00	2.15E-06
4	3	3.88E-03	1.21E-03	4.00E-06
4	3	3.53E-03	1.10E-03	3.32E-06
4	3	3.48E-03	2.34E-03	7.87E-06
4	3	3.16E-03	2.13E-03	6.53E-06
4	3	2.84E-03	3.31E-03	1.31E-05
4	3	2.58E-03	3.02E-03	1.09E-05
4	4	2.84E-03	3.31E-03	1.31E-05
4	4	2.58E-03	3.02E-03	1.09E-05
4	4	2.01E-03	4.06E-03	1.84E-05
4	4	1.83E-03	3.69E-03	1.53E-05
4	4	1.04E-03	4.52E-03	2.23E-05
4	4	9.46E-04	4.12E-03	1.85E-05
4	4	1.88E-10	4.68E-03	2.37E-05
4	4	1.71E-10	4.27E-03	1.96E-05
5	5	4.44E-03	0.00E+00	3.16E-06
5	5	4.11E-03	0.00E+00	2.72E-06
5	5	4.29E-03	1.34E-03	4.89E-06
5	5	3.97E-03	1.24E-03	4.20E-06

Table E-1. Listing of Element Coordinates (Continued)

Belt 2 Ring	Element	x	y	z
5	5	3.84E-03	2.59E-03	9.62E-06
5	5	3.56E-03	2.40E-03	8.26E-06
5	5	3.14E-03	3.66E-03	1.61E-05
5	5	2.91E-03	3.40E-03	1.38E-05
5	6	3.14E-03	3.66E-03	1.61E-05
5	6	2.91E-03	3.40E-03	1.38E-05
5	6	2.22E-03	4.49E-03	2.25E-05
5	6	2.06E-03	4.16E-03	1.93E-05
5	6	1.15E-03	5.00E-03	2.72E-05
5	6	1.06E-03	4.64E-03	2.34E-05
5	6	2.08E-10	5.18E-03	2.90E-05
5	6	1.92E-10	4.80E-03	2.49E-05
6	7	4.83E-03	0.00E+00	3.74E-06
6	7	4.54E-03	0.00E+00	3.31E-06
6	7	4.67E-03	1.46E-03	5.79E-06
6	7	4.38E-03	1.37E-03	5.11E-06
6	7	4.18E-03	2.82E-03	1.14E-05
6	7	3.93E-03	2.65E-03	1.01E-05
6	7	3.41E-03	3.99E-03	1.90E-05
6	7	3.21E-03	3.75E-03	1.68E-05
6	8	3.41E-03	3.99E-03	1.90E-05
6	8	3.21E-03	3.75E-03	1.68E-05
6	8	2.41E-03	4.88E-03	2.67E-05
6	8	2.27E-03	4.59E-03	2.35E-05
6	8	1.25E-03	5.45E-03	3.23E-05
6	8	1.17E-03	5.12E-03	2.85E-05
6	8	2.26E-10	5.64E-03	3.43E-05
6	8	2.12E-10	5.30E-03	3.03E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
7	1	5.21E-03	0.00E+00	4.34E-06
7	1	4.93E-03	0.00E+00	3.90E-06
7	1	5.19E-03	5.30E-04	4.61E-06
7	1	4.91E-03	5.02E-04	4.14E-06
7	1	5.13E-03	1.06E-03	5.41E-06
7	1	4.86E-03	1.00E-03	4.86E-06
7	1	5.03E-03	1.57E-03	6.72E-06
7	1	4.76E-03	1.49E-03	6.03E-06
7	1	4.89E-03	2.08E-03	8.50E-06
7	1	4.63E-03	1.97E-03	7.62E-06
7	1	4.72E-03	2.57E-03	1.07E-05
7	1	4.47E-03	2.43E-03	9.59E-06
7	2	4.72E-03	2.57E-03	1.07E-05
7	2	4.47E-03	2.43E-03	9.59E-06
7	2	4.51E-03	3.04E-03	1.32E-05
7	2	4.27E-03	2.88E-03	1.19E-05
7	2	4.26E-03	3.49E-03	1.60E-05
7	2	4.04E-03	3.30E-03	1.44E-05
7	3	4.26E-03	3.49E-03	1.60E-05
7	3	4.04E-03	3.30E-03	1.44E-05
7	3	3.99E-03	3.91E-03	1.90E-05
7	3	3.78E-03	3.70E-03	1.71E-05
7	3	3.68E-03	4.30E-03	2.21E-05
7	3	3.49E-03	4.07E-03	1.98E-05
7	4	3.68E-03	4.30E-03	2.21E-05
7	4	3.49E-03	4.07E-03	1.98E-05
7	4	3.35E-03	4.65E-03	2.52E-05
7	4	3.17E-03	4.41E-03	2.26E-05
7	4	2.99E-03	4.98E-03	2.82E-05
7	4	2.83E-03	4.71E-03	2.53E-05
7	5	2.99E-03	4.98E-03	2.82E-05
7	5	2.83E-03	4.71E-03	2.53E-05
7	5	2.60E-03	5.26E-03	3.10E-05
7	5	2.46E-03	4.98E-03	2.78E-05
7	5	2.20E-03	5.51E-03	3.35E-05
7	5	2.08E-03	5.22E-03	3.01E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
7	6	2.20E-03	5.51E-03	3.35E-05
7	6	2.08E-03	5.22E-03	3.01E-05
7	6	1.78E-03	5.71E-03	3.57E-05
7	6	1.69E-03	5.41E-03	3.20E-05
7	6	1.35E-03	5.87E-03	3.75E-05
7	6	1.28E-03	5.56E-03	3.36E-05
7	6	9.04E-04	5.98E-03	3.88E-05
7	6	8.56E-04	5.67E-03	3.48E-05
7	6	4.54E-04	6.05E-03	3.96E-05
7	6	4.30E-04	5.73E-03	3.55E-05
7	6	2.44E-10	6.08E-03	3.98E-05
7	6	2.31E-10	5.75E-03	3.57E-05
8	7	5.56E-03	0.00E+00	4.95E-06
8	7	5.31E-03	0.00E+00	4.51E-06
8	7	5.54E-03	5.66E-04	5.26E-06
8	7	5.29E-03	5.40E-04	4.79E-06
8	7	5.48E-03	1.13E-03	6.18E-06
8	7	5.22E-03	1.08E-03	5.62E-06
8	7	5.37E-03	1.68E-03	7.67E-06
8	7	5.12E-03	1.60E-03	6.98E-06
8	7	5.23E-03	2.22E-03	9.70E-06
8	7	4.99E-03	2.12E-03	8.82E-06
8	7	5.04E-03	2.75E-03	1.22E-05
8	7	4.81E-03	2.62E-03	1.11E-05
8	8	5.04E-03	2.75E-03	1.22E-05
8	8	4.81E-03	2.62E-03	1.11E-05
8	8	4.82E-03	3.25E-03	1.51E-05
8	8	4.59E-03	3.10E-03	1.37E-05
8	8	4.56E-03	3.73E-03	1.83E-05
8	8	4.35E-03	3.55E-03	1.66E-05
8	9	4.56E-03	3.73E-03	1.83E-05
8	9	4.35E-03	3.55E-03	1.66E-05
8	9	4.26E-03	4.18E-03	2.17E-05
8	9	4.06E-03	3.98E-03	1.98E-05
8	9	3.93E-03	4.59E-03	2.52E-05
8	9	3.75E-03	4.38E-03	2.30E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
8	10	3.93E-03	4.59E-03	2.52E-05
8	10	3.75E-03	4.38E-03	2.30E-05
8	10	3.58E-03	4.98E-03	2.88E-05
8	10	3.41E-03	4.74E-03	2.62E-05
8	10	3.19E-03	5.32E-03	3.22E-05
8	10	3.04E-03	5.07E-03	2.93E-05
8	11	3.19E-03	5.32E-03	3.22E-05
8	11	3.04E-03	5.07E-03	2.93E-05
8	11	2.78E-03	5.62E-03	3.54E-05
8	11	2.65E-03	5.36E-03	3.22E-05
8	11	2.35E-03	5.89E-03	3.83E-05
8	11	2.24E-03	5.61E-03	3.48E-05
8	12	2.35E-03	5.89E-03	3.83E-05
8	12	2.24E-03	5.61E-03	3.48E-05
8	12	1.90E-03	6.10E-03	4.08E-05
8	12	1.81E-03	5.82E-03	3.71E-05
8	12	1.44E-03	6.27E-03	4.28E-05
8	12	1.37E-03	5.98E-03	3.89E-05
8	12	9.66E-04	6.40E-03	4.43E-05
8	12	9.21E-04	6.10E-03	4.03E-05
8	12	4.85E-04	6.47E-03	4.52E-05
8	12	4.62E-04	6.17E-03	4.11E-05
8	12	2.60E-10	6.49E-03	4.55E-05
8	12	2.48E-10	6.19E-03	4.14E-05
9	13	5.91E-03	0.00E+00	5.57E-06
9	13	5.66E-03	0.00E+00	5.13E-06
9	13	5.88E-03	6.01E-04	5.92E-06
9	13	5.64E-03	5.76E-04	5.45E-06
9	13	5.82E-03	1.20E-03	6.95E-06
9	13	5.58E-03	1.15E-03	6.40E-06
9	13	5.71E-03	1.78E-03	8.64E-06
9	13	5.47E-03	1.71E-03	7.95E-06
9	13	5.55E-03	2.36E-03	1.09E-05
9	13	5.32E-03	2.26E-03	1.01E-05
9	13	5.35E-03	2.91E-03	1.37E-05
9	13	5.13E-03	2.79E-03	1.26E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
9	14	5.35E-03	2.91E-03	1.37E-05
9	14	5.13E-03	2.79E-03	1.26E-05
9	14	5.11E-03	3.45E-03	1.70E-05
9	14	4.91E-03	3.31E-03	1.56E-05
9	14	4.84E-03	3.96E-03	2.06E-05
9	14	4.64E-03	3.79E-03	1.90E-05
9	15	4.84E-03	3.96E-03	2.06E-05
9	15	4.64E-03	3.79E-03	1.90E-05
9	15	4.52E-03	4.43E-03	2.45E-05
9	15	4.34E-03	4.25E-03	2.25E-05
9	15	4.18E-03	4.88E-03	2.84E-05
9	15	4.00E-03	4.68E-03	2.62E-05
9	16	4.18E-03	4.88E-03	2.84E-05
9	16	4.00E-03	4.68E-03	2.62E-05
9	16	3.80E-03	5.28E-03	3.24E-05
9	16	3.64E-03	5.07E-03	2.98E-05
9	16	3.39E-03	5.65E-03	3.63E-05
9	16	3.25E-03	5.42E-03	3.33E-05
9	17	3.39E-03	5.65E-03	3.63E-05
9	17	3.25E-03	5.42E-03	3.33E-05
9	17	2.95E-03	5.97E-03	3.99E-05
9	17	2.83E-03	5.73E-03	3.67E-05
9	17	2.50E-03	6.25E-03	4.31E-05
9	17	2.39E-03	5.99E-03	3.97E-05
9	18	2.50E-03	6.25E-03	4.31E-05
9	18	2.39E-03	5.99E-03	3.97E-05
9	18	2.02E-03	6.48E-03	4.59E-05
9	18	1.94E-03	6.21E-03	4.23E-05
9	18	1.53E-03	6.66E-03	4.82E-05
9	18	1.47E-03	6.39E-03	4.44E-05
9	18	1.03E-03	6.79E-03	4.99E-05
9	18	9.83E-04	6.51E-03	4.59E-05
9	18	5.15E-04	6.87E-03	5.09E-05
9	18	4.94E-04	6.59E-03	4.69E-05
9	18	2.76E-10	6.89E-03	5.13E-05
9	18	2.65E-10	6.61E-03	4.72E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
10	19	6.23E-03	0.00E+00	6.20E-06
10	19	6.01E-03	0.00E+00	5.76E-06
10	19	6.21E-03	6.34E-04	6.58E-06
10	19	5.98E-03	6.11E-04	6.12E-06
10	19	6.14E-03	1.26E-03	7.73E-06
10	19	5.92E-03	1.22E-03	7.19E-06
10	19	6.02E-03	1.88E-03	9.61E-06
10	19	5.80E-03	1.82E-03	8.93E-06
10	19	5.86E-03	2.49E-03	1.22E-05
10	19	5.64E-03	2.40E-03	1.13E-05
10	19	5.65E-03	3.08E-03	1.53E-05
10	19	5.44E-03	2.96E-03	1.42E-05
10	20	5.65E-03	3.08E-03	1.53E-05
10	20	5.44E-03	2.96E-03	1.42E-05
10	20	5.40E-03	3.64E-03	1.89E-05
10	20	5.20E-03	3.51E-03	1.76E-05
10	20	5.10E-03	4.17E-03	2.30E-05
10	20	4.92E-03	4.02E-03	2.13E-05
10	21	5.10E-03	4.17E-03	2.30E-05
10	21	4.92E-03	4.02E-03	2.13E-05
10	21	4.77E-03	4.68E-03	2.72E-05
10	21	4.60E-03	4.51E-03	2.53E-05
10	21	4.41E-03	5.14E-03	3.17E-05
10	21	4.25E-03	4.96E-03	2.94E-05
10	22	4.41E-03	5.14E-03	3.17E-05
10	22	4.25E-03	4.96E-03	2.94E-05
10	22	4.01E-03	5.57E-03	3.61E-05
10	22	3.86E-03	5.37E-03	3.35E-05
10	22	3.57E-03	5.96E-03	4.04E-05
10	22	3.44E-03	5.74E-03	3.75E-05
10	23	3.57E-03	5.96E-03	4.04E-05
10	23	3.44E-03	5.74E-03	3.75E-05
10	23	3.12E-03	6.30E-03	4.44E-05
10	23	3.00E-03	6.07E-03	4.12E-05
10	23	2.63E-03	6.59E-03	4.80E-05
10	23	2.54E-03	6.35E-03	4.46E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
10	24	2.63E-03	6.59E-03	4.80E-05
10	24	2.54E-03	6.35E-03	4.46E-05
10	24	2.13E-03	6.84E-03	5.11E-05
10	24	2.05E-03	6.59E-03	4.75E-05
10	24	1.61E-03	7.03E-03	5.37E-05
10	24	1.55E-03	6.77E-03	4.99E-05
10	24	1.08E-03	7.16E-03	5.56E-05
10	24	1.04E-03	6.90E-03	5.16E-05
10	24	5.43E-04	7.25E-03	5.67E-05
10	24	5.23E-04	6.98E-03	5.27E-05
10	24	2.92E-10	7.27E-03	5.71E-05
10	24	2.81E-10	7.01E-03	5.30E-05
11	25	6.55E-03	0.00E+00	6.83E-06
11	25	6.33E-03	0.00E+00	6.40E-06
11	25	6.52E-03	6.67E-04	7.26E-06
11	25	6.31E-03	6.44E-04	6.79E-06
11	25	6.45E-03	1.33E-03	8.53E-06
11	25	6.24E-03	1.28E-03	7.98E-06
11	25	6.33E-03	1.98E-03	1.06E-05
11	25	6.12E-03	1.91E-03	9.92E-06
11	25	6.15E-03	2.62E-03	1.34E-05
11	25	5.95E-03	2.53E-03	1.25E-05
11	25	5.94E-03	3.23E-03	1.69E-05
11	25	5.74E-03	3.12E-03	1.58E-05
11	26	5.94E-03	3.23E-03	1.69E-05
11	26	5.74E-03	3.12E-03	1.58E-05
11	26	5.67E-03	3.82E-03	2.09E-05
11	26	5.48E-03	3.70E-03	1.95E-05
11	26	5.36E-03	4.39E-03	2.53E-05
11	26	5.19E-03	4.24E-03	2.37E-05
11	27	5.36E-03	4.39E-03	2.53E-05
11	27	5.19E-03	4.24E-03	2.37E-05
11	27	5.02E-03	4.91E-03	3.01E-05
11	27	4.85E-03	4.75E-03	2.81E-05
11	27	4.63E-03	5.41E-03	3.50E-05
11	27	4.48E-03	5.23E-03	3.27E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
11	28	4.63E-03	5.41E-03	3.50E-05
11	28	4.48E-03	5.23E-03	3.27E-05
11	28	4.21E-03	5.86E-03	3.98E-05
11	28	4.07E-03	5.66E-03	3.72E-05
11	28	3.76E-03	6.26E-03	4.46E-05
11	28	3.63E-03	6.05E-03	4.17E-05
11	29	3.76E-03	6.26E-03	4.46E-05
11	29	3.63E-03	6.05E-03	4.17E-05
11	29	3.27E-03	6.62E-03	4.90E-05
11	29	3.17E-03	6.40E-03	4.58E-05
11	29	2.77E-03	6.93E-03	5.30E-05
11	29	2.68E-03	6.70E-03	4.96E-05
11	30	2.77E-03	6.93E-03	5.30E-05
11	30	2.68E-03	6.70E-03	4.96E-05
11	30	2.24E-03	7.18E-03	5.65E-05
11	30	2.17E-03	6.95E-03	5.28E-05
11	30	1.69E-03	7.38E-03	5.93E-05
11	30	1.64E-03	7.14E-03	5.54E-05
11	30	1.14E-03	7.53E-03	6.14E-05
11	30	1.10E-03	7.28E-03	5.74E-05
11	30	5.71E-04	7.61E-03	6.26E-05
11	30	5.52E-04	7.36E-03	5.85E-05
11	30	3.06E-10	7.64E-03	6.30E-05
11	30	2.96E-10	7.39E-03	5.89E-05
12	31	6.86E-03	0.00E+00	7.49E-06
12	31	6.65E-03	0.00E+00	7.04E-06
12	31	6.83E-03	6.98E-04	7.95E-06
12	31	6.62E-03	6.77E-04	7.48E-06
12	31	6.75E-03	1.39E-03	9.35E-06
12	31	6.55E-03	1.35E-03	8.79E-06
12	31	6.63E-03	2.07E-03	1.16E-05
12	31	6.42E-03	2.01E-03	1.09E-05
12	31	6.45E-03	2.74E-03	1.47E-05
12	31	6.25E-03	2.66E-03	1.38E-05
12	31	6.22E-03	3.38E-03	1.85E-05
12	31	6.03E-03	3.28E-03	1.74E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
12	32	6.22E-03	3.38E-03	1.85E-05
12	32	6.03E-03	3.28E-03	1.74E-05
12	32	5.94E-03	4.00E-03	2.29E-05
12	32	5.76E-03	3.88E-03	2.15E-05
12	32	5.62E-03	4.59E-03	2.78E-05
12	32	5.45E-03	4.45E-03	2.61E-05
12	33	5.62E-03	4.59E-03	2.78E-05
12	33	5.45E-03	4.45E-03	2.61E-05
12	33	5.25E-03	5.15E-03	3.30E-05
12	33	5.09E-03	4.99E-03	3.10E-05
12	33	4.85E-03	5.66E-03	3.83E-05
12	33	4.70E-03	5.49E-03	3.60E-05
12	34	4.85E-03	5.66E-03	3.83E-05
12	34	4.70E-03	5.49E-03	3.60E-05
12	34	4.41E-03	6.13E-03	4.37E-05
12	34	4.27E-03	5.95E-03	4.11E-05
12	34	3.93E-03	6.56E-03	4.89E-05
12	34	3.81E-03	6.36E-03	4.59E-05
12	35	3.93E-03	6.56E-03	4.89E-05
12	35	3.81E-03	6.36E-03	4.59E-05
12	35	3.43E-03	6.93E-03	5.37E-05
12	35	3.32E-03	6.72E-03	5.05E-05
12	35	2.90E-03	7.26E-03	5.81E-05
12	35	2.81E-03	7.03E-03	5.46E-05
12	36	2.90E-03	7.26E-03	5.81E-05
12	36	2.81E-03	7.03E-03	5.46E-05
12	36	2.34E-03	7.52E-03	6.19E-05
12	36	2.27E-03	7.29E-03	5.82E-05
12	36	1.77E-03	7.73E-03	6.50E-05
12	36	1.72E-03	7.50E-03	6.11E-05
12	36	1.19E-03	7.88E-03	6.73E-05
12	36	1.15E-03	7.64E-03	6.32E-05
12	36	5.98E-04	7.97E-03	6.87E-05
12	36	5.79E-04	7.73E-03	6.45E-05
12	36	3.21E-10	8.00E-03	6.91E-05
12	36	3.11E-10	7.76E-03	6.50E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
13	37	7.16E-03	0.00E+00	8.14E-06
13	37	6.96E-03	0.00E+00	7.70E-06
13	37	7.13E-03	7.29E-04	8.66E-06
13	37	6.93E-03	7.08E-04	8.18E-06
13	37	7.05E-03	1.45E-03	1.02E-05
13	37	6.85E-03	1.41E-03	9.62E-06
13	37	6.92E-03	2.16E-03	1.27E-05
13	37	6.72E-03	2.10E-03	1.20E-05
13	37	6.73E-03	2.86E-03	1.60E-05
13	37	6.54E-03	2.78E-03	1.51E-05
13	37	6.49E-03	3.53E-03	2.02E-05
13	37	6.31E-03	3.43E-03	1.90E-05
13	38	6.49E-03	3.53E-03	2.02E-05
13	38	6.31E-03	3.43E-03	1.90E-05
13	38	6.20E-03	4.18E-03	2.50E-05
13	38	6.03E-03	4.06E-03	2.36E-05
13	38	5.86E-03	4.79E-03	3.03E-05
13	38	5.70E-03	4.66E-03	2.86E-05
13	39	5.86E-03	4.79E-03	3.03E-05
13	39	5.70E-03	4.66E-03	2.86E-05
13	39	5.48E-03	5.37E-03	3.59E-05
13	39	5.33E-03	5.22E-03	3.39E-05
13	39	5.06E-03	5.91E-03	4.18E-05
13	39	4.92E-03	5.74E-03	3.95E-05
13	40	5.06E-03	5.91E-03	4.18E-05
13	40	4.92E-03	5.74E-03	3.95E-05
13	40	4.60E-03	6.40E-03	4.76E-05
13	40	4.47E-03	6.22E-03	4.50E-05
13	40	4.11E-03	6.85E-03	5.32E-05
13	40	3.99E-03	6.65E-03	5.03E-05
13	41	4.11E-03	6.85E-03	5.32E-05
13	41	3.99E-03	6.65E-03	5.03E-05
13	41	3.58E-03	7.24E-03	5.85E-05
13	41	3.48E-03	7.03E-03	5.53E-05
13	41	3.02E-03	7.57E-03	6.33E-05
13	41	2.94E-03	7.36E-03	5.98E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
13	42	3.02E-03	7.57E-03	6.33E-05
13	42	2.94E-03	7.36E-03	5.98E-05
13	42	2.45E-03	7.85E-03	6.75E-05
13	42	2.38E-03	7.63E-03	6.37E-05
13	42	1.85E-03	8.07E-03	7.08E-05
13	42	1.80E-03	7.85E-03	6.69E-05
13	42	1.24E-03	8.23E-03	7.33E-05
13	42	1.21E-03	8.00E-03	6.93E-05
13	42	6.24E-04	8.32E-03	7.48E-05
13	42	6.06E-04	8.09E-03	7.07E-05
13	42	3.35E-10	8.36E-03	7.53E-05
13	42	3.25E-10	8.12E-03	7.12E-05
14	43	7.45E-03	0.00E+00	8.81E-06
14	43	7.26E-03	0.00E+00	8.37E-06
14	43	7.42E-03	7.58E-04	9.37E-06
14	43	7.23E-03	7.39E-04	8.90E-06
14	43	7.34E-03	1.51E-03	1.10E-05
14	43	7.15E-03	1.47E-03	1.05E-05
14	43	7.20E-03	2.25E-03	1.37E-05
14	43	7.01E-03	2.19E-03	1.30E-05
14	43	7.00E-03	2.98E-03	1.73E-05
14	43	6.82E-03	2.90E-03	1.65E-05
14	43	6.75E-03	3.68E-03	2.18E-05
14	43	6.58E-03	3.58E-03	2.07E-05
14	44	6.75E-03	3.68E-03	2.18E-05
14	44	6.58E-03	3.58E-03	2.07E-05
14	44	6.45E-03	4.35E-03	2.70E-05
14	44	6.29E-03	4.24E-03	2.57E-05
14	44	6.10E-03	4.99E-03	3.28E-05
14	44	5.95E-03	4.86E-03	3.11E-05
14	45	6.10E-03	4.99E-03	3.28E-05
14	45	5.95E-03	4.86E-03	3.11E-05
14	45	5.71E-03	5.59E-03	3.89E-05
14	45	5.56E-03	5.45E-03	3.69E-05
14	45	5.27E-03	6.15E-03	4.52E-05
14	45	5.13E-03	5.99E-03	4.29E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
14	46	5.27E-03	6.15E-03	4.52E-05
14	46	5.13E-03	5.99E-03	4.29E-05
14	46	4.79E-03	6.66E-03	5.15E-05
14	46	4.67E-03	6.49E-03	4.89E-05
14	46	4.27E-03	7.13E-03	5.77E-05
14	46	4.16E-03	6.94E-03	5.47E-05
14	47	4.27E-03	7.13E-03	5.77E-05
14	47	4.16E-03	6.94E-03	5.47E-05
14	47	3.72E-03	7.53E-03	6.34E-05
14	47	3.63E-03	7.34E-03	6.02E-05
14	47	3.15E-03	7.88E-03	6.86E-05
14	47	3.07E-03	7.68E-03	6.51E-05
14	48	3.15E-03	7.88E-03	6.86E-05
14	48	3.07E-03	7.68E-03	6.51E-05
14	48	2.55E-03	8.17E-03	7.31E-05
14	48	2.48E-03	7.96E-03	6.94E-05
14	48	1.93E-03	8.40E-03	7.67E-05
14	48	1.88E-03	8.18E-03	7.28E-05
14	48	1.29E-03	8.56E-03	7.94E-05
14	48	1.26E-03	8.34E-03	7.54E-05
14	48	6.49E-04	8.66E-03	8.10E-05
14	48	6.32E-04	8.44E-03	7.69E-05
14	48	3.49E-10	8.70E-03	8.16E-05
14	48	3.40E-10	8.47E-03	7.74E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
15	1	7.82E-03	0.00E+00	9.69E-06
15	1	7.55E-03	0.00E+00	9.05E-06
15	1	7.79E-03	7.96E-04	1.03E-05
15	1	7.52E-03	7.69E-04	9.61E-06
15	1	7.70E-03	1.59E-03	1.21E-05
15	1	7.44E-03	1.53E-03	1.13E-05
15	1	7.55E-03	2.36E-03	1.51E-05
15	1	7.30E-03	2.28E-03	1.41E-05
15	1	7.35E-03	3.12E-03	1.91E-05
15	1	7.10E-03	3.02E-03	1.78E-05
15	1	7.09E-03	3.86E-03	2.40E-05
15	1	6.84E-03	3.73E-03	2.24E-05
15	2	7.09E-03	3.86E-03	2.40E-05
15	2	6.84E-03	3.73E-03	2.24E-05
15	2	6.77E-03	4.57E-03	2.97E-05
15	2	6.54E-03	4.41E-03	2.78E-05
15	2	6.41E-03	5.24E-03	3.61E-05
15	2	6.19E-03	5.06E-03	3.37E-05
15	3	6.41E-03	5.24E-03	3.61E-05
15	3	6.19E-03	5.06E-03	3.37E-05
15	3	5.99E-03	5.87E-03	4.28E-05
15	3	5.78E-03	5.67E-03	4.00E-05
15	3	5.53E-03	6.46E-03	4.98E-05
15	3	5.34E-03	6.23E-03	4.65E-05
15	4	5.53E-03	6.46E-03	4.98E-05
15	4	5.34E-03	6.23E-03	4.65E-05
15	4	5.03E-03	6.99E-03	5.68E-05
15	4	4.85E-03	6.75E-03	5.29E-05
15	4	4.48E-03	7.48E-03	6.35E-05
15	4	4.33E-03	7.22E-03	5.92E-05
15	5	4.48E-03	7.48E-03	6.35E-05
15	5	4.33E-03	7.22E-03	5.92E-05
15	5	3.91E-03	7.90E-03	6.98E-05
15	5	3.77E-03	7.63E-03	6.51E-05
15	5	3.30E-03	8.27E-03	7.55E-05
15	5	3.19E-03	7.99E-03	7.05E-05
15	6	3.30E-03	8.27E-03	7.55E-05
15	6	3.19E-03	7.99E-03	7.05E-05
15	6	2.67E-03	8.58E-03	8.05E-05
15	6	2.58E-03	8.28E-03	7.51E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
15	6	2.02E-03	8.82E-03	8.45E-05
15	6	1.95E-03	8.51E-03	7.88E-05
15	6	1.36E-03	8.99E-03	8.74E-05
15	6	1.31E-03	8.68E-03	8.15E-05
15	6	6.81E-04	9.09E-03	8.92E-05
15	6	6.58E-04	8.78E-03	8.32E-05
15	6	3.66E-10	9.13E-03	8.98E-05
15	6	3.53E-10	8.81E-03	8.38E-05
16	7	8.18E-03	0.00E+00	1.06E-05
16	7	7.92E-03	0.00E+00	9.93E-06
16	7	8.15E-03	8.33E-04	1.12E-05
16	7	7.89E-03	8.06E-04	1.06E-05
16	7	8.06E-03	1.66E-03	1.32E-05
16	7	7.80E-03	1.61E-03	1.24E-05
16	7	7.90E-03	2.47E-03	1.65E-05
16	7	7.65E-03	2.39E-03	1.54E-05
16	7	7.69E-03	3.27E-03	2.09E-05
16	7	7.44E-03	3.16E-03	1.96E-05
16	7	7.41E-03	4.04E-03	2.63E-05
16	7	7.18E-03	3.91E-03	2.46E-05
16	8	7.41E-03	4.04E-03	2.63E-05
16	8	7.18E-03	3.91E-03	2.46E-05
16	8	7.08E-03	4.78E-03	3.25E-05
16	8	6.86E-03	4.62E-03	3.05E-05
16	8	6.70E-03	5.48E-03	3.95E-05
16	8	6.49E-03	5.30E-03	3.70E-05
16	9	6.70E-03	5.48E-03	3.95E-05
16	9	6.49E-03	5.30E-03	3.70E-05
16	9	6.27E-03	6.14E-03	4.69E-05
16	9	6.07E-03	5.94E-03	4.39E-05
16	9	5.78E-03	6.75E-03	5.45E-05
16	9	5.60E-03	6.54E-03	5.11E-05
16	10	5.78E-03	6.75E-03	5.45E-05
16	10	5.60E-03	6.54E-03	5.11E-05
16	10	5.26E-03	7.32E-03	6.21E-05
16	10	5.09E-03	7.08E-03	5.82E-05
16	10	4.69E-03	7.82E-03	6.95E-05
16	10	4.54E-03	7.57E-03	6.51E-05
16	11	4.69E-03	7.82E-03	6.95E-05
16	11	4.54E-03	7.57E-03	6.51E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
16	11	4.09E-03	8.27E-03	7.64E-05
16	11	3.96E-03	8.01E-03	7.16E-05
16	11	3.46E-03	8.65E-03	8.26E-05
16	11	3.35E-03	8.38E-03	7.75E-05
16	12	3.46E-03	8.65E-03	8.26E-05
16	12	3.35E-03	8.38E-03	7.75E-05
16	12	2.80E-03	8.97E-03	8.80E-05
16	12	2.71E-03	8.69E-03	8.25E-05
16	12	2.12E-03	9.22E-03	9.24E-05
16	12	2.05E-03	8.93E-03	8.67E-05
16	12	1.42E-03	9.40E-03	9.56E-05
16	12	1.37E-03	9.10E-03	8.97E-05
16	12	7.13E-04	9.51E-03	9.76E-05
16	12	6.90E-04	9.21E-03	9.15E-05
16	12	3.83E-10	9.55E-03	9.83E-05
16	12	3.70E-10	9.24E-03	9.22E-05
17	13	8.53E-03	0.00E+00	1.15E-05
17	13	8.28E-03	0.00E+00	1.08E-05
17	13	8.50E-03	8.68E-04	1.22E-05
17	13	8.25E-03	8.43E-04	1.15E-05
17	13	8.40E-03	1.73E-03	1.44E-05
17	13	8.16E-03	1.68E-03	1.35E-05
17	13	8.24E-03	2.58E-03	1.79E-05
17	13	8.00E-03	2.50E-03	1.69E-05
17	13	8.02E-03	3.41E-03	2.27E-05
17	13	7.78E-03	3.31E-03	2.14E-05
17	13	7.73E-03	4.21E-03	2.86E-05
17	13	7.51E-03	4.09E-03	2.69E-05
17	14	7.73E-03	4.21E-03	2.86E-05
17	14	7.51E-03	4.09E-03	2.69E-05
17	14	7.39E-03	4.98E-03	3.54E-05
17	14	7.17E-03	4.83E-03	3.33E-05
17	14	6.99E-03	5.71E-03	4.29E-05
17	14	6.78E-03	5.55E-03	4.04E-05
17	15	6.99E-03	5.71E-03	4.29E-05
17	15	6.78E-03	5.55E-03	4.04E-05
17	15	6.53E-03	6.40E-03	5.09E-05
17	15	6.34E-03	6.21E-03	4.80E-05
17	15	6.03E-03	7.04E-03	5.92E-05
17	15	5.85E-03	6.84E-03	5.58E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
17	16	6.03E-03	7.04E-03	5.92E-05
17	16	5.85E-03	6.84E-03	5.58E-05
17	16	5.48E-03	7.63E-03	6.75E-05
17	16	5.32E-03	7.40E-03	6.36E-05
17	16	4.89E-03	8.16E-03	7.55E-05
17	16	4.75E-03	7.92E-03	7.12E-05
17	17	4.89E-03	8.16E-03	7.55E-05
17	17	4.75E-03	7.92E-03	7.12E-05
17	17	4.26E-03	8.62E-03	8.31E-05
17	17	4.14E-03	8.37E-03	7.83E-05
17	17	3.60E-03	9.02E-03	8.99E-05
17	17	3.50E-03	8.76E-03	8.47E-05
17	18	3.60E-03	9.02E-03	8.99E-05
17	18	3.50E-03	8.76E-03	8.47E-05
17	18	2.92E-03	9.36E-03	9.58E-05
17	18	2.83E-03	9.08E-03	9.02E-05
17	18	2.21E-03	9.62E-03	1.01E-04
17	18	2.14E-03	9.33E-03	9.47E-05
17	18	1.48E-03	9.81E-03	1.04E-04
17	18	1.44E-03	9.52E-03	9.80E-05
17	18	7.43E-04	9.92E-03	1.06E-04
17	18	7.21E-04	9.63E-03	1.00E-04
17	18	3.99E-10	9.96E-03	1.07E-04
17	18	3.87E-10	9.66E-03	1.01E-04
18	19	8.87E-03	0.00E+00	1.24E-05
18	19	8.63E-03	0.00E+00	1.17E-05
18	19	8.84E-03	9.03E-04	1.32E-05
18	19	8.60E-03	8.79E-04	1.25E-05
18	19	8.73E-03	1.80E-03	1.55E-05
18	19	8.50E-03	1.75E-03	1.47E-05
18	19	8.57E-03	2.68E-03	1.93E-05
18	19	8.34E-03	2.61E-03	1.83E-05
18	19	8.33E-03	3.54E-03	2.45E-05
18	19	8.11E-03	3.45E-03	2.32E-05
18	19	8.04E-03	4.38E-03	3.08E-05
18	19	7.82E-03	4.26E-03	2.92E-05
18	20	8.04E-03	4.38E-03	3.08E-05
18	20	7.82E-03	4.26E-03	2.92E-05
18	20	7.68E-03	5.18E-03	3.82E-05
18	20	7.48E-03	5.04E-03	3.62E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
18	20	7.26E-03	5.94E-03	4.63E-05
18	20	7.07E-03	5.78E-03	4.39E-05
18	21	7.26E-03	5.94E-03	4.63E-05
18	21	7.07E-03	5.78E-03	4.39E-05
18	21	6.79E-03	6.65E-03	5.50E-05
18	21	6.61E-03	6.48E-03	5.22E-05
18	21	6.27E-03	7.32E-03	6.40E-05
18	21	6.10E-03	7.13E-03	6.06E-05
18	22	6.27E-03	7.32E-03	6.40E-05
18	22	6.10E-03	7.13E-03	6.06E-05
18	22	5.70E-03	7.93E-03	7.29E-05
18	22	5.55E-03	7.72E-03	6.91E-05
18	22	5.08E-03	8.48E-03	8.16E-05
18	22	4.95E-03	8.25E-03	7.73E-05
18	23	5.08E-03	8.48E-03	8.16E-05
18	23	4.95E-03	8.25E-03	7.73E-05
18	23	4.43E-03	8.96E-03	8.97E-05
18	23	4.31E-03	8.73E-03	8.50E-05
18	23	3.75E-03	9.38E-03	9.71E-05
18	23	3.65E-03	9.13E-03	9.20E-05
18	24	3.75E-03	9.38E-03	9.71E-05
18	24	3.65E-03	9.13E-03	9.20E-05
18	24	3.03E-03	9.72E-03	1.03E-04
18	24	2.95E-03	9.47E-03	9.80E-05
18	24	2.29E-03	9.99E-03	1.09E-04
18	24	2.23E-03	9.73E-03	1.03E-04
18	24	1.54E-03	1.02E-02	1.12E-04
18	24	1.50E-03	9.92E-03	1.06E-04
18	24	7.72E-04	1.03E-02	1.15E-04
18	24	7.52E-04	1.00E-02	1.09E-04
18	24	4.15E-10	1.03E-02	1.15E-04
18	24	4.04E-10	1.01E-02	1.09E-04
19	25	9.20E-03	0.00E+00	1.33E-05
19	25	8.97E-03	0.00E+00	1.27E-05
19	25	9.16E-03	9.36E-04	1.41E-05
19	25	8.94E-03	9.13E-04	1.35E-05
19	25	9.06E-03	1.86E-03	1.66E-05
19	25	8.83E-03	1.82E-03	1.58E-05
19	25	8.88E-03	2.78E-03	2.07E-05
19	25	8.66E-03	2.71E-03	1.97E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
19	25	8.64E-03	3.67E-03	2.63E-05
19	25	8.43E-03	3.58E-03	2.50E-05
19	25	8.33E-03	4.54E-03	3.31E-05
19	25	8.13E-03	4.43E-03	3.15E-05
19	26	8.33E-03	4.54E-03	3.31E-05
19	26	8.13E-03	4.43E-03	3.15E-05
19	26	7.96E-03	5.37E-03	4.10E-05
19	26	7.77E-03	5.24E-03	3.90E-05
19	26	7.53E-03	6.16E-03	4.98E-05
19	26	7.35E-03	6.01E-03	4.74E-05
19	27	7.53E-03	6.16E-03	4.98E-05
19	27	7.35E-03	6.01E-03	4.74E-05
19	27	7.04E-03	6.90E-03	5.91E-05
19	27	6.87E-03	6.73E-03	5.63E-05
19	27	6.50E-03	7.59E-03	6.87E-05
19	27	6.34E-03	7.40E-03	6.54E-05
19	28	6.50E-03	7.59E-03	6.87E-05
19	28	6.34E-03	7.40E-03	6.54E-05
19	28	5.91E-03	8.22E-03	7.84E-05
19	28	5.76E-03	8.02E-03	7.46E-05
19	28	5.27E-03	8.79E-03	8.77E-05
19	28	5.14E-03	8.57E-03	8.34E-05
19	29	5.27E-03	8.79E-03	8.77E-05
19	29	5.14E-03	8.57E-03	8.34E-05
19	29	4.59E-03	9.29E-03	9.64E-05
19	29	4.48E-03	9.06E-03	9.18E-05
19	29	3.88E-03	9.72E-03	1.04E-04
19	29	3.79E-03	9.49E-03	9.93E-05
19	30	3.88E-03	9.72E-03	1.04E-04
19	30	3.79E-03	9.49E-03	9.93E-05
19	30	3.14E-03	1.01E-02	1.11E-04
19	30	3.07E-03	9.83E-03	1.06E-04
19	30	2.38E-03	1.04E-02	1.17E-04
19	30	2.32E-03	1.01E-02	1.11E-04
19	30	1.60E-03	1.06E-02	1.21E-04
19	30	1.56E-03	1.03E-02	1.15E-04
19	30	8.01E-04	1.07E-02	1.23E-04
19	30	7.81E-04	1.04E-02	1.17E-04
19	30	4.30E-10	1.07E-02	1.24E-04
19	30	4.19E-10	1.05E-02	1.18E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
20	31	9.52E-03	0.00E+00	1.42E-05
20	31	9.30E-03	0.00E+00	1.36E-05
20	31	9.48E-03	9.68E-04	1.51E-05
20	31	9.26E-03	9.46E-04	1.44E-05
20	31	9.37E-03	1.93E-03	1.78E-05
20	31	9.16E-03	1.89E-03	1.70E-05
20	31	9.19E-03	2.88E-03	2.22E-05
20	31	8.98E-03	2.81E-03	2.12E-05
20	31	8.94E-03	3.80E-03	2.81E-05
20	31	8.74E-03	3.71E-03	2.68E-05
20	31	8.62E-03	4.70E-03	3.54E-05
20	31	8.42E-03	4.59E-03	3.38E-05
20	32	8.62E-03	4.70E-03	3.54E-05
20	32	8.42E-03	4.59E-03	3.38E-05
20	32	8.24E-03	5.55E-03	4.39E-05
20	32	8.05E-03	5.43E-03	4.19E-05
20	32	7.79E-03	6.37E-03	5.33E-05
20	32	7.61E-03	6.23E-03	5.09E-05
20	33	7.79E-03	6.37E-03	5.33E-05
20	33	7.61E-03	6.23E-03	5.09E-05
20	33	7.29E-03	7.14E-03	6.33E-05
20	33	7.12E-03	6.98E-03	6.04E-05
20	33	6.72E-03	7.85E-03	7.36E-05
20	33	6.57E-03	7.67E-03	7.03E-05
20	34	6.72E-03	7.85E-03	7.36E-05
20	34	6.57E-03	7.67E-03	7.03E-05
20	34	6.11E-03	8.51E-03	8.39E-05
20	34	5.97E-03	8.31E-03	8.01E-05
20	34	5.45E-03	9.10E-03	9.38E-05
20	34	5.33E-03	8.89E-03	8.96E-05
20	35	5.45E-03	9.10E-03	9.38E-05
20	35	5.33E-03	8.89E-03	8.96E-05
20	35	4.75E-03	9.62E-03	1.03E-04
20	35	4.65E-03	9.39E-03	9.85E-05
20	35	4.02E-03	1.01E-02	1.12E-04
20	35	3.93E-03	9.83E-03	1.07E-04
20	36	4.02E-03	1.01E-02	1.12E-04
20	36	3.93E-03	9.83E-03	1.07E-04
20	36	3.25E-03	1.04E-02	1.19E-04
20	36	3.18E-03	1.02E-02	1.14E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
20	36	2.46E-03	1.07E-02	1.25E-04
20	36	2.40E-03	1.05E-02	1.19E-04
20	36	1.65E-03	1.09E-02	1.29E-04
20	36	1.61E-03	1.07E-02	1.23E-04
20	36	8.28E-04	1.11E-02	1.32E-04
20	36	8.10E-04	1.08E-02	1.26E-04
20	36	4.45E-10	1.11E-02	1.33E-04
20	36	4.35E-10	1.08E-02	1.27E-04
21	37	9.83E-03	0.00E+00	1.51E-05
21	37	9.62E-03	0.00E+00	1.45E-05
21	37	9.80E-03	1.00E-03	1.61E-05
21	37	9.58E-03	9.79E-04	1.54E-05
21	37	9.68E-03	1.99E-03	1.90E-05
21	37	9.47E-03	1.95E-03	1.81E-05
21	37	9.50E-03	2.97E-03	2.36E-05
21	37	9.29E-03	2.91E-03	2.26E-05
21	37	9.24E-03	3.93E-03	3.00E-05
21	37	9.03E-03	3.84E-03	2.87E-05
21	37	8.91E-03	4.85E-03	3.78E-05
21	37	8.71E-03	4.74E-03	3.62E-05
21	38	8.91E-03	4.85E-03	3.78E-05
21	38	8.71E-03	4.74E-03	3.62E-05
21	38	8.51E-03	5.74E-03	4.69E-05
21	38	8.33E-03	5.61E-03	4.48E-05
21	38	8.05E-03	6.58E-03	5.69E-05
21	38	7.87E-03	6.44E-03	5.44E-05
21	39	8.05E-03	6.58E-03	5.69E-05
21	39	7.87E-03	6.44E-03	5.44E-05
21	39	7.53E-03	7.38E-03	6.76E-05
21	39	7.36E-03	7.21E-03	6.46E-05
21	39	6.95E-03	8.12E-03	7.86E-05
21	39	6.80E-03	7.94E-03	7.51E-05
21	40	6.95E-03	8.12E-03	7.86E-05
21	40	6.80E-03	7.94E-03	7.51E-05
21	40	6.32E-03	8.79E-03	8.96E-05
21	40	6.18E-03	8.60E-03	8.56E-05
21	40	5.64E-03	9.40E-03	1.00E-04
21	40	5.51E-03	9.19E-03	9.58E-05
21	41	5.64E-03	9.40E-03	1.00E-04
21	41	5.51E-03	9.19E-03	9.58E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
21	41	4.91E-03	9.94E-03	1.10E-04
21	41	4.80E-03	9.72E-03	1.05E-04
21	41	4.15E-03	1.04E-02	1.19E-04
21	41	4.06E-03	1.02E-02	1.14E-04
21	42	4.15E-03	1.04E-02	1.19E-04
21	42	4.06E-03	1.02E-02	1.14E-04
21	42	3.36E-03	1.08E-02	1.27E-04
21	42	3.29E-03	1.05E-02	1.21E-04
21	42	2.54E-03	1.11E-02	1.33E-04
21	42	2.49E-03	1.08E-02	1.28E-04
21	42	1.71E-03	1.13E-02	1.38E-04
21	42	1.67E-03	1.10E-02	1.32E-04
21	42	8.56E-04	1.14E-02	1.41E-04
21	42	8.37E-04	1.12E-02	1.35E-04
21	42	4.60E-10	1.15E-02	1.42E-04
21	42	4.50E-10	1.12E-02	1.36E-04
22	43	1.01E-02	0.00E+00	1.61E-05
22	43	9.94E-03	0.00E+00	1.54E-05
22	43	1.01E-02	1.03E-03	1.71E-05
22	43	9.90E-03	1.01E-03	1.64E-05
22	43	9.99E-03	2.06E-03	2.01E-05
22	43	9.78E-03	2.01E-03	1.93E-05
22	43	9.80E-03	3.07E-03	2.51E-05
22	43	9.60E-03	3.00E-03	2.41E-05
22	43	9.53E-03	4.05E-03	3.19E-05
22	43	9.33E-03	3.97E-03	3.06E-05
22	43	9.19E-03	5.01E-03	4.02E-05
22	43	9.00E-03	4.90E-03	3.86E-05
22	44	9.19E-03	5.01E-03	4.02E-05
22	44	9.00E-03	4.90E-03	3.86E-05
22	44	8.78E-03	5.92E-03	4.98E-05
22	44	8.60E-03	5.80E-03	4.78E-05
22	44	8.31E-03	6.79E-03	6.05E-05
22	44	8.14E-03	6.65E-03	5.80E-05
22	45	8.31E-03	6.79E-03	6.05E-05
22	45	8.14E-03	6.65E-03	5.80E-05
22	45	7.77E-03	7.61E-03	7.19E-05
22	45	7.61E-03	7.45E-03	6.89E-05
22	45	7.17E-03	8.37E-03	8.36E-05
22	45	7.02E-03	8.20E-03	8.02E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
22	46	7.17E-03	8.37E-03	8.36E-05
22	46	7.02E-03	8.20E-03	8.02E-05
22	46	6.52E-03	9.07E-03	9.53E-05
22	46	6.38E-03	8.88E-03	9.14E-05
22	46	5.81E-03	9.70E-03	1.07E-04
22	46	5.69E-03	9.50E-03	1.02E-04
22	47	5.81E-03	9.70E-03	1.07E-04
22	47	5.69E-03	9.50E-03	1.02E-04
22	47	5.07E-03	1.03E-02	1.17E-04
22	47	4.96E-03	1.00E-02	1.12E-04
22	47	4.28E-03	1.07E-02	1.27E-04
22	47	4.20E-03	1.05E-02	1.22E-04
22	48	4.28E-03	1.07E-02	1.27E-04
22	48	4.20E-03	1.05E-02	1.22E-04
22	48	3.47E-03	1.11E-02	1.35E-04
22	48	3.39E-03	1.09E-02	1.30E-04
22	48	2.62E-03	1.14E-02	1.42E-04
22	48	2.57E-03	1.12E-02	1.36E-04
22	48	1.76E-03	1.17E-02	1.47E-04
22	48	1.72E-03	1.14E-02	1.41E-04
22	48	8.83E-04	1.18E-02	1.50E-04
22	48	8.65E-04	1.15E-02	1.44E-04
22	48	4.74E-10	1.18E-02	1.51E-04
22	48	4.64E-10	1.16E-02	1.45E-04
23	49	1.04E-02	0.00E+00	1.70E-05
23	49	1.02E-02	0.00E+00	1.64E-05
23	49	1.04E-02	1.06E-03	1.81E-05
23	49	1.02E-02	1.04E-03	1.74E-05
23	49	1.03E-02	2.12E-03	2.13E-05
23	49	1.01E-02	2.08E-03	2.05E-05
23	49	1.01E-02	3.16E-03	2.66E-05
23	49	9.90E-03	3.10E-03	2.56E-05
23	49	9.82E-03	4.17E-03	3.38E-05
23	49	9.63E-03	4.09E-03	3.25E-05
23	49	9.47E-03	5.16E-03	4.26E-05
23	49	9.28E-03	5.06E-03	4.10E-05
23	50	9.47E-03	5.16E-03	4.26E-05
23	50	9.28E-03	5.06E-03	4.10E-05
23	50	9.05E-03	6.10E-03	5.28E-05
23	50	8.87E-03	5.98E-03	5.08E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
23	50	8.56E-03	7.00E-03	6.41E-05
23	50	8.39E-03	6.86E-03	6.17E-05
23	51	8.56E-03	7.00E-03	6.41E-05
23	51	8.39E-03	6.86E-03	6.17E-05
23	51	8.00E-03	7.84E-03	7.62E-05
23	51	7.85E-03	7.69E-03	7.33E-05
23	51	7.38E-03	8.62E-03	8.86E-05
23	51	7.24E-03	8.46E-03	8.52E-05
23	52	7.38E-03	8.62E-03	8.86E-05
23	52	7.24E-03	8.46E-03	8.52E-05
23	52	6.71E-03	9.34E-03	1.01E-04
23	52	6.58E-03	9.16E-03	9.72E-05
23	52	5.99E-03	9.99E-03	1.13E-04
23	52	5.87E-03	9.79E-03	1.09E-04
23	53	5.99E-03	9.99E-03	1.13E-04
23	53	5.87E-03	9.79E-03	1.09E-04
23	53	5.22E-03	1.06E-02	1.24E-04
23	53	5.12E-03	1.04E-02	1.20E-04
23	53	4.41E-03	1.10E-02	1.35E-04
23	53	4.33E-03	1.08E-02	1.29E-04
23	54	4.41E-03	1.10E-02	1.35E-04
23	54	4.33E-03	1.08E-02	1.29E-04
23	54	3.57E-03	1.15E-02	1.43E-04
23	54	3.50E-03	1.12E-02	1.38E-04
23	54	2.70E-03	1.18E-02	1.50E-04
23	54	2.65E-03	1.15E-02	1.45E-04
23	54	1.81E-03	1.20E-02	1.56E-04
23	54	1.78E-03	1.18E-02	1.50E-04
23	54	9.10E-04	1.21E-02	1.59E-04
23	54	8.92E-04	1.19E-02	1.53E-04
23	54	4.88E-10	1.22E-02	1.60E-04
23	54	4.79E-10	1.20E-02	1.54E-04
24	55	1.07E-02	0.00E+00	1.79E-05
24	55	1.05E-02	0.00E+00	1.73E-05
24	55	1.07E-02	1.09E-03	1.91E-05
24	55	1.05E-02	1.07E-03	1.84E-05
24	55	1.06E-02	2.18E-03	2.25E-05
24	55	1.04E-02	2.14E-03	2.17E-05
24	55	1.04E-02	3.25E-03	2.81E-05
24	55	1.02E-02	3.19E-03	2.71E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
24	55	1.01E-02	4.29E-03	3.57E-05
24	55	9.91E-03	4.21E-03	3.44E-05
24	55	9.73E-03	5.30E-03	4.50E-05
24	55	9.56E-03	5.21E-03	4.34E-05
24	56	9.73E-03	5.30E-03	4.50E-05
24	56	9.56E-03	5.21E-03	4.34E-05
24	56	9.30E-03	6.27E-03	5.58E-05
24	56	9.13E-03	6.16E-03	5.38E-05
24	56	8.80E-03	7.19E-03	6.78E-05
24	56	8.64E-03	7.06E-03	6.54E-05
24	57	8.80E-03	7.19E-03	6.78E-05
24	57	8.64E-03	7.06E-03	6.54E-05
24	57	8.23E-03	8.06E-03	8.05E-05
24	57	8.08E-03	7.91E-03	7.77E-05
24	57	7.59E-03	8.87E-03	9.36E-05
24	57	7.45E-03	8.71E-03	9.03E-05
24	58	7.59E-03	8.87E-03	9.36E-05
24	58	7.45E-03	8.71E-03	9.03E-05
24	58	6.90E-03	9.60E-03	1.07E-04
24	58	6.78E-03	9.43E-03	1.03E-04
24	58	6.16E-03	1.03E-02	1.19E-04
24	58	6.05E-03	1.01E-02	1.15E-04
24	59	6.16E-03	1.03E-02	1.19E-04
24	59	6.05E-03	1.01E-02	1.15E-04
24	59	5.37E-03	1.09E-02	1.31E-04
24	59	5.27E-03	1.07E-02	1.27E-04
24	59	4.54E-03	1.14E-02	1.42E-04
24	59	4.45E-03	1.12E-02	1.37E-04
24	60	4.54E-03	1.14E-02	1.42E-04
24	60	4.45E-03	1.12E-02	1.37E-04
24	60	3.67E-03	1.18E-02	1.51E-04
24	60	3.60E-03	1.16E-02	1.46E-04
24	60	2.78E-03	1.21E-02	1.59E-04
24	60	2.73E-03	1.19E-02	1.53E-04
24	60	1.86E-03	1.23E-02	1.65E-04
24	60	1.83E-03	1.21E-02	1.59E-04
24	60	9.35E-04	1.25E-02	1.68E-04
24	60	9.18E-04	1.23E-02	1.62E-04
24	60	5.02E-10	1.25E-02	1.69E-04
24	60	4.93E-10	1.23E-02	1.63E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
25	1	1.11E-02	0.00E+00	1.91E-05
25	1	1.08E-02	0.00E+00	1.83E-05
25	1	1.11E-02	1.13E-03	2.03E-05
25	1	1.08E-02	1.10E-03	1.94E-05
25	1	1.09E-02	2.25E-03	2.40E-05
25	1	1.07E-02	2.20E-03	2.29E-05
25	1	1.07E-02	3.35E-03	2.99E-05
25	1	1.05E-02	3.28E-03	2.86E-05
25	1	1.04E-02	4.43E-03	3.80E-05
25	1	1.02E-02	4.33E-03	3.63E-05
25	1	1.01E-02	5.48E-03	4.80E-05
25	1	9.83E-03	5.35E-03	4.58E-05
25	2	1.01E-02	5.48E-03	4.80E-05
25	2	9.83E-03	5.35E-03	4.58E-05
25	2	9.61E-03	6.48E-03	5.95E-05
25	2	9.39E-03	6.33E-03	5.69E-05
25	2	9.09E-03	7.43E-03	7.23E-05
25	2	8.88E-03	7.26E-03	6.90E-05
25	3	9.09E-03	7.43E-03	7.23E-05
25	3	8.88E-03	7.26E-03	6.90E-05
25	3	8.50E-03	8.33E-03	8.59E-05
25	3	8.30E-03	8.14E-03	8.20E-05
25	3	7.84E-03	9.16E-03	9.99E-05
25	3	7.66E-03	8.95E-03	9.54E-05
25	4	7.84E-03	9.16E-03	9.99E-05
25	4	7.66E-03	8.95E-03	9.54E-05
25	4	7.13E-03	9.92E-03	1.14E-04
25	4	6.97E-03	9.69E-03	1.09E-04
25	4	6.36E-03	1.06E-02	1.27E-04
25	4	6.21E-03	1.04E-02	1.22E-04
25	5	6.36E-03	1.06E-02	1.27E-04
25	5	6.21E-03	1.04E-02	1.22E-04
25	5	5.54E-03	1.12E-02	1.40E-04
25	5	5.42E-03	1.10E-02	1.34E-04
25	5	4.68E-03	1.17E-02	1.52E-04
25	5	4.58E-03	1.15E-02	1.45E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
25	6	4.68E-03	1.17E-02	1.52E-04
25	6	4.58E-03	1.15E-02	1.45E-04
25	6	3.79E-03	1.22E-02	1.62E-04
25	6	3.70E-03	1.19E-02	1.54E-04
25	6	2.87E-03	1.25E-02	1.70E-04
25	6	2.80E-03	1.22E-02	1.62E-04
25	6	1.92E-03	1.27E-02	1.76E-04
25	6	1.88E-03	1.25E-02	1.68E-04
25	6	9.66E-04	1.29E-02	1.79E-04
25	6	9.44E-04	1.26E-02	1.71E-04
25	6	5.19E-10	1.29E-02	1.80E-04
25	6	5.07E-10	1.26E-02	1.72E-04
26	7	1.14E-02	0.00E+00	2.02E-05
26	7	1.12E-02	0.00E+00	1.94E-05
26	7	1.14E-02	1.16E-03	2.15E-05
26	7	1.12E-02	1.14E-03	2.07E-05
26	7	1.13E-02	2.32E-03	2.54E-05
26	7	1.10E-02	2.27E-03	2.44E-05
26	7	1.11E-02	3.46E-03	3.18E-05
26	7	1.08E-02	3.38E-03	3.05E-05
26	7	1.08E-02	4.57E-03	4.04E-05
26	7	1.05E-02	4.47E-03	3.87E-05
26	7	1.04E-02	5.65E-03	5.10E-05
26	7	1.01E-02	5.53E-03	4.88E-05
26	8	1.04E-02	5.65E-03	5.10E-05
26	8	1.01E-02	5.53E-03	4.88E-05
26	8	9.91E-03	6.68E-03	6.32E-05
26	8	9.69E-03	6.54E-03	6.06E-05
26	8	9.37E-03	7.66E-03	7.68E-05
26	8	9.17E-03	7.50E-03	7.36E-05
26	9	9.37E-03	7.66E-03	7.68E-05
26	9	9.17E-03	7.50E-03	7.36E-05
26	9	8.76E-03	8.58E-03	9.12E-05
26	9	8.57E-03	8.40E-03	8.74E-05
26	9	8.09E-03	9.44E-03	1.06E-04
26	9	7.91E-03	9.24E-03	1.02E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
26	10	8.09E-03	9.44E-03	1.06E-04
26	10	7.91E-03	9.24E-03	1.02E-04
26	10	7.35E-03	1.02E-02	1.21E-04
26	10	7.19E-03	1.00E-02	1.16E-04
26	10	6.56E-03	1.09E-02	1.35E-04
26	10	6.42E-03	1.07E-02	1.30E-04
26	11	6.56E-03	1.09E-02	1.35E-04
26	11	6.42E-03	1.07E-02	1.30E-04
26	11	5.72E-03	1.16E-02	1.49E-04
26	11	5.59E-03	1.13E-02	1.43E-04
26	11	4.83E-03	1.21E-02	1.61E-04
26	11	4.73E-03	1.18E-02	1.54E-04
26	12	4.83E-03	1.21E-02	1.61E-04
26	12	4.73E-03	1.18E-02	1.54E-04
26	12	3.91E-03	1.25E-02	1.72E-04
26	12	3.83E-03	1.23E-02	1.65E-04
26	12	2.96E-03	1.29E-02	1.80E-04
26	12	2.89E-03	1.26E-02	1.73E-04
26	12	1.98E-03	1.31E-02	1.87E-04
26	12	1.94E-03	1.29E-02	1.79E-04
26	12	9.96E-04	1.33E-02	1.90E-04
26	12	9.75E-04	1.30E-02	1.82E-04
26	12	5.35E-10	1.33E-02	1.92E-04
26	12	5.23E-10	1.31E-02	1.84E-04
27	13	1.18E-02	0.00E+00	2.14E-05
27	13	1.15E-02	0.00E+00	2.06E-05
27	13	1.17E-02	1.20E-03	2.28E-05
27	13	1.15E-02	1.18E-03	2.19E-05
27	13	1.16E-02	2.39E-03	2.69E-05
27	13	1.14E-02	2.34E-03	2.59E-05
27	13	1.14E-02	3.56E-03	3.36E-05
27	13	1.11E-02	3.49E-03	3.23E-05
27	13	1.11E-02	4.70E-03	4.27E-05
27	13	1.08E-02	4.61E-03	4.11E-05
27	13	1.07E-02	5.81E-03	5.40E-05
27	13	1.05E-02	5.70E-03	5.18E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
27	14	1.07E-02	5.81E-03	5.40E-05
27	14	1.05E-02	5.70E-03	5.18E-05
27	14	1.02E-02	6.88E-03	6.70E-05
27	14	9.99E-03	6.74E-03	6.43E-05
27	14	9.64E-03	7.89E-03	8.13E-05
27	14	9.45E-03	7.73E-03	7.81E-05
27	15	9.64E-03	7.89E-03	8.13E-05
27	15	9.45E-03	7.73E-03	7.81E-05
27	15	9.02E-03	8.84E-03	9.67E-05
27	15	8.84E-03	8.66E-03	9.29E-05
27	15	8.32E-03	9.72E-03	1.12E-04
27	15	8.16E-03	9.53E-03	1.08E-04
27	16	8.32E-03	9.72E-03	1.12E-04
27	16	8.16E-03	9.53E-03	1.08E-04
27	16	7.57E-03	1.05E-02	1.28E-04
27	16	7.41E-03	1.03E-02	1.23E-04
27	16	6.75E-03	1.13E-02	1.44E-04
27	16	6.61E-03	1.10E-02	1.38E-04
27	17	6.75E-03	1.13E-02	1.44E-04
27	17	6.61E-03	1.10E-02	1.38E-04
27	17	5.88E-03	1.19E-02	1.58E-04
27	17	5.77E-03	1.17E-02	1.52E-04
27	17	4.97E-03	1.25E-02	1.71E-04
27	17	4.87E-03	1.22E-02	1.64E-04
27	18	4.97E-03	1.25E-02	1.71E-04
27	18	4.87E-03	1.22E-02	1.64E-04
27	18	4.02E-03	1.29E-02	1.82E-04
27	18	3.94E-03	1.27E-02	1.75E-04
27	18	3.04E-03	1.33E-02	1.91E-04
27	18	2.98E-03	1.30E-02	1.83E-04
27	18	2.04E-03	1.35E-02	1.98E-04
27	18	2.00E-03	1.33E-02	1.90E-04
27	18	1.03E-03	1.37E-02	2.02E-04
27	18	1.00E-03	1.34E-02	1.94E-04
27	18	5.50E-10	1.37E-02	2.03E-04
27	18	5.39E-10	1.35E-02	1.95E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
28	19	1.21E-02	0.00E+00	2.25E-05
28	19	1.19E-02	0.00E+00	2.17E-05
28	19	1.21E-02	1.23E-03	2.40E-05
28	19	1.18E-02	1.21E-03	2.31E-05
28	19	1.19E-02	2.46E-03	2.83E-05
28	19	1.17E-02	2.41E-03	2.73E-05
28	19	1.17E-02	3.66E-03	3.55E-05
28	19	1.15E-02	3.59E-03	3.42E-05
28	19	1.14E-02	4.84E-03	4.51E-05
28	19	1.12E-02	4.75E-03	4.34E-05
28	19	1.10E-02	5.98E-03	5.70E-05
28	19	1.08E-02	5.86E-03	5.49E-05
28	20	1.10E-02	5.98E-03	5.70E-05
28	20	1.08E-02	5.86E-03	5.49E-05
28	20	1.05E-02	7.07E-03	7.07E-05
28	20	1.03E-02	6.94E-03	6.81E-05
28	20	9.91E-03	8.11E-03	8.59E-05
28	20	9.73E-03	7.95E-03	8.27E-05
28	21	9.91E-03	8.11E-03	8.59E-05
28	21	9.73E-03	7.95E-03	8.27E-05
28	21	9.27E-03	9.08E-03	1.02E-04
28	21	9.10E-03	8.91E-03	9.83E-05
28	21	8.56E-03	9.99E-03	1.19E-04
28	21	8.39E-03	9.80E-03	1.14E-04
28	22	8.56E-03	9.99E-03	1.19E-04
28	22	8.39E-03	9.80E-03	1.14E-04
28	22	7.78E-03	1.08E-02	1.35E-04
28	22	7.63E-03	1.06E-02	1.30E-04
28	22	6.94E-03	1.16E-02	1.52E-04
28	22	6.81E-03	1.14E-02	1.46E-04
28	23	6.94E-03	1.16E-02	1.52E-04
28	23	6.81E-03	1.14E-02	1.46E-04
28	23	6.05E-03	1.22E-02	1.67E-04
28	23	5.93E-03	1.20E-02	1.61E-04
28	23	5.11E-03	1.28E-02	1.80E-04
28	23	5.01E-03	1.26E-02	1.74E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
28	24	5.11E-03	1.28E-02	1.80E-04
28	24	5.01E-03	1.26E-02	1.74E-04
28	24	4.14E-03	1.33E-02	1.92E-04
28	24	4.06E-03	1.30E-02	1.85E-04
28	24	3.13E-03	1.36E-02	2.02E-04
28	24	3.07E-03	1.34E-02	1.94E-04
28	24	2.10E-03	1.39E-02	2.09E-04
28	24	2.06E-03	1.36E-02	2.01E-04
28	24	1.05E-03	1.41E-02	2.13E-04
28	24	1.03E-03	1.38E-02	2.05E-04
28	24	5.66E-10	1.41E-02	2.15E-04
28	24	5.55E-10	1.39E-02	2.07E-04
29	25	1.24E-02	0.00E+00	2.37E-05
29	25	1.22E-02	0.00E+00	2.29E-05
29	25	1.24E-02	1.27E-03	2.53E-05
29	25	1.22E-02	1.24E-03	2.44E-05
29	25	1.22E-02	2.52E-03	2.98E-05
29	25	1.20E-02	2.48E-03	2.88E-05
29	25	1.20E-02	3.76E-03	3.73E-05
29	25	1.18E-02	3.69E-03	3.60E-05
29	25	1.17E-02	4.97E-03	4.75E-05
29	25	1.15E-02	4.88E-03	4.58E-05
29	25	1.13E-02	6.14E-03	6.00E-05
29	25	1.11E-02	6.03E-03	5.79E-05
29	26	1.13E-02	6.14E-03	6.00E-05
29	26	1.11E-02	6.03E-03	5.79E-05
29	26	1.08E-02	7.26E-03	7.45E-05
29	26	1.06E-02	7.13E-03	7.19E-05
29	26	1.02E-02	8.33E-03	9.06E-05
29	26	1.00E-02	8.18E-03	8.73E-05
29	27	1.02E-02	8.33E-03	9.06E-05
29	27	1.00E-02	8.18E-03	8.73E-05
29	27	9.52E-03	9.33E-03	1.08E-04
29	27	9.35E-03	9.16E-03	1.04E-04
29	27	8.79E-03	1.03E-02	1.25E-04
29	27	8.63E-03	1.01E-02	1.21E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
29	28	8.79E-03	1.03E-02	1.25E-04
29	28	8.63E-03	1.01E-02	1.21E-04
29	28	7.99E-03	1.11E-02	1.43E-04
29	28	7.84E-03	1.09E-02	1.38E-04
29	28	7.13E-03	1.19E-02	1.60E-04
29	28	7.00E-03	1.17E-02	1.54E-04
29	29	7.13E-03	1.19E-02	1.60E-04
29	29	7.00E-03	1.17E-02	1.54E-04
29	29	6.21E-03	1.26E-02	1.76E-04
29	29	6.10E-03	1.23E-02	1.70E-04
29	29	5.25E-03	1.31E-02	1.90E-04
29	29	5.15E-03	1.29E-02	1.83E-04
29	30	5.25E-03	1.31E-02	1.90E-04
29	30	5.15E-03	1.29E-02	1.83E-04
29	30	4.25E-03	1.36E-02	2.03E-04
29	30	4.17E-03	1.34E-02	1.95E-04
29	30	3.21E-03	1.40E-02	2.13E-04
29	30	3.16E-03	1.38E-02	2.05E-04
29	30	2.16E-03	1.43E-02	2.20E-04
29	30	2.12E-03	1.40E-02	2.12E-04
29	30	1.08E-03	1.44E-02	2.25E-04
29	30	1.06E-03	1.42E-02	2.17E-04
29	30	5.81E-10	1.45E-02	2.26E-04
29	30	5.70E-10	1.42E-02	2.18E-04
30	31	1.28E-02	0.00E+00	2.49E-05
30	31	1.25E-02	0.00E+00	2.41E-05
30	31	1.27E-02	1.30E-03	2.65E-05
30	31	1.25E-02	1.28E-03	2.56E-05
30	31	1.26E-02	2.59E-03	3.13E-05
30	31	1.23E-02	2.54E-03	3.03E-05
30	31	1.23E-02	3.86E-03	3.92E-05
30	31	1.21E-02	3.79E-03	3.79E-05
30	31	1.20E-02	5.10E-03	4.99E-05
30	31	1.18E-02	5.01E-03	4.83E-05
30	31	1.16E-02	6.30E-03	6.31E-05
30	31	1.14E-02	6.19E-03	6.10E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
30	32	1.16E-02	6.30E-03	6.31E-05
30	32	1.14E-02	6.19E-03	6.10E-05
30	32	1.10E-02	7.45E-03	7.84E-05
30	32	1.09E-02	7.32E-03	7.57E-05
30	32	1.04E-02	8.54E-03	9.53E-05
30	32	1.03E-02	8.40E-03	9.20E-05
30	33	1.04E-02	8.54E-03	9.53E-05
30	33	1.03E-02	8.40E-03	9.20E-05
30	33	9.77E-03	9.57E-03	1.13E-04
30	33	9.60E-03	9.41E-03	1.09E-04
30	33	9.01E-03	1.05E-02	1.32E-04
30	33	8.86E-03	1.03E-02	1.27E-04
30	34	9.01E-03	1.05E-02	1.32E-04
30	34	8.86E-03	1.03E-02	1.27E-04
30	34	8.19E-03	1.14E-02	1.50E-04
30	34	8.05E-03	1.12E-02	1.45E-04
30	34	7.31E-03	1.22E-02	1.68E-04
30	34	7.18E-03	1.20E-02	1.63E-04
30	35	7.31E-03	1.22E-02	1.68E-04
30	35	7.18E-03	1.20E-02	1.63E-04
30	35	6.37E-03	1.29E-02	1.85E-04
30	35	6.26E-03	1.27E-02	1.79E-04
30	35	5.38E-03	1.35E-02	2.00E-04
30	35	5.29E-03	1.33E-02	1.93E-04
30	36	5.38E-03	1.35E-02	2.00E-04
30	36	5.29E-03	1.33E-02	1.93E-04
30	36	4.36E-03	1.40E-02	2.13E-04
30	36	4.28E-03	1.37E-02	2.06E-04
30	36	3.30E-03	1.44E-02	2.24E-04
30	36	3.24E-03	1.41E-02	2.16E-04
30	36	2.21E-03	1.46E-02	2.32E-04
30	36	2.17E-03	1.44E-02	2.24E-04
30	36	1.11E-03	1.48E-02	2.37E-04
30	36	1.09E-03	1.46E-02	2.29E-04
30	36	5.96E-10	1.49E-02	2.38E-04
30	36	5.86E-10	1.46E-02	2.30E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
31	37	1.31E-02	0.00E+00	2.60E-05
31	37	1.29E-02	0.00E+00	2.53E-05
31	37	1.30E-02	1.33E-03	2.78E-05
31	37	1.28E-02	1.31E-03	2.69E-05
31	37	1.29E-02	2.65E-03	3.28E-05
31	37	1.27E-02	2.61E-03	3.18E-05
31	37	1.26E-02	3.95E-03	4.11E-05
31	37	1.24E-02	3.89E-03	3.98E-05
31	37	1.23E-02	5.22E-03	5.23E-05
31	37	1.21E-02	5.14E-03	5.07E-05
31	37	1.18E-02	6.45E-03	6.62E-05
31	37	1.17E-02	6.35E-03	6.41E-05
31	38	1.18E-02	6.45E-03	6.62E-05
31	38	1.17E-02	6.35E-03	6.41E-05
31	38	1.13E-02	7.63E-03	8.22E-05
31	38	1.11E-02	7.51E-03	7.96E-05
31	38	1.07E-02	8.75E-03	9.99E-05
31	38	1.05E-02	8.61E-03	9.68E-05
31	39	1.07E-02	8.75E-03	9.99E-05
31	39	1.05E-02	8.61E-03	9.68E-05
31	39	1.00E-02	9.81E-03	1.19E-04
31	39	9.85E-03	9.65E-03	1.15E-04
31	39	9.24E-03	1.08E-02	1.38E-04
31	39	9.09E-03	1.06E-02	1.34E-04
31	40	9.24E-03	1.08E-02	1.38E-04
31	40	9.09E-03	1.06E-02	1.34E-04
31	40	8.39E-03	1.17E-02	1.58E-04
31	40	8.26E-03	1.15E-02	1.53E-04
31	40	7.49E-03	1.25E-02	1.76E-04
31	40	7.37E-03	1.23E-02	1.71E-04
31	41	7.49E-03	1.25E-02	1.76E-04
31	41	7.37E-03	1.23E-02	1.71E-04
31	41	6.53E-03	1.32E-02	1.94E-04
31	41	6.42E-03	1.30E-02	1.88E-04
31	41	5.52E-03	1.38E-02	2.10E-04
31	41	5.43E-03	1.36E-02	2.03E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
31	42	5.52E-03	1.38E-02	2.10E-04
31	42	5.43E-03	1.36E-02	2.03E-04
31	42	4.46E-03	1.43E-02	2.24E-04
31	42	4.39E-03	1.41E-02	2.17E-04
31	42	3.38E-03	1.47E-02	2.35E-04
31	42	3.32E-03	1.45E-02	2.27E-04
31	42	2.27E-03	1.50E-02	2.43E-04
31	42	2.23E-03	1.48E-02	2.35E-04
31	42	1.14E-03	1.52E-02	2.48E-04
31	42	1.12E-03	1.49E-02	2.40E-04
31	42	6.11E-10	1.52E-02	2.50E-04
31	42	6.01E-10	1.50E-02	2.42E-04
32	43	1.34E-02	0.00E+00	2.72E-05
32	43	1.32E-02	0.00E+00	2.64E-05
32	43	1.33E-02	1.36E-03	2.90E-05
32	43	1.31E-02	1.34E-03	2.82E-05
32	43	1.32E-02	2.72E-03	3.43E-05
32	43	1.30E-02	2.67E-03	3.33E-05
32	43	1.29E-02	4.05E-03	4.30E-05
32	43	1.27E-02	3.98E-03	4.17E-05
32	43	1.26E-02	5.35E-03	5.48E-05
32	43	1.24E-02	5.26E-03	5.31E-05
32	43	1.21E-02	6.61E-03	6.93E-05
32	43	1.19E-02	6.50E-03	6.72E-05
32	44	1.21E-02	6.61E-03	6.93E-05
32	44	1.19E-02	6.50E-03	6.72E-05
32	44	1.16E-02	7.81E-03	8.61E-05
32	44	1.14E-02	7.69E-03	8.35E-05
32	44	1.10E-02	8.96E-03	1.05E-04
32	44	1.08E-02	8.82E-03	1.01E-04
32	45	1.10E-02	8.96E-03	1.05E-04
32	45	1.08E-02	8.82E-03	1.01E-04
32	45	1.02E-02	1.00E-02	1.24E-04
32	45	1.01E-02	9.88E-03	1.21E-04
32	45	9.46E-03	1.10E-02	1.45E-04
32	45	9.31E-03	1.09E-02	1.40E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
32	46	9.46E-03	1.10E-02	1.45E-04
32	46	9.31E-03	1.09E-02	1.40E-04
32	46	8.60E-03	1.20E-02	1.65E-04
32	46	8.46E-03	1.18E-02	1.60E-04
32	46	7.67E-03	1.28E-02	1.85E-04
32	46	7.55E-03	1.26E-02	1.79E-04
32	47	7.67E-03	1.28E-02	1.85E-04
32	47	7.55E-03	1.26E-02	1.79E-04
32	47	6.68E-03	1.35E-02	2.03E-04
32	47	6.58E-03	1.33E-02	1.97E-04
32	47	5.65E-03	1.41E-02	2.20E-04
32	47	5.56E-03	1.39E-02	2.13E-04
32	48	5.65E-03	1.41E-02	2.20E-04
32	48	5.56E-03	1.39E-02	2.13E-04
32	48	4.57E-03	1.47E-02	2.35E-04
32	48	4.50E-03	1.44E-02	2.27E-04
32	48	3.46E-03	1.51E-02	2.46E-04
32	48	3.40E-03	1.48E-02	2.39E-04
32	48	2.32E-03	1.54E-02	2.55E-04
32	48	2.28E-03	1.51E-02	2.47E-04
32	48	1.16E-03	1.55E-02	2.60E-04
32	48	1.15E-03	1.53E-02	2.52E-04
32	48	6.25E-10	1.56E-02	2.62E-04
32	48	6.15E-10	1.54E-02	2.54E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
33	1	1.39E-02	0.00E+00	2.92E-05
33	1	1.35E-02	0.00E+00	2.76E-05
33	1	1.38E-02	1.41E-03	3.11E-05
33	1	1.34E-02	1.37E-03	2.94E-05
33	1	1.37E-02	2.82E-03	3.69E-05
33	1	1.33E-02	2.74E-03	3.48E-05
33	1	1.34E-02	4.20E-03	4.62E-05
33	1	1.30E-02	4.08E-03	4.37E-05
33	1	1.31E-02	5.55E-03	5.89E-05
33	1	1.27E-02	5.39E-03	5.56E-05
33	1	1.26E-02	6.86E-03	7.46E-05
33	1	1.22E-02	6.66E-03	7.04E-05
33	2	1.26E-02	6.86E-03	7.46E-05
33	2	1.22E-02	6.66E-03	7.04E-05
33	2	1.20E-02	8.11E-03	9.27E-05
33	2	1.17E-02	7.87E-03	8.74E-05
33	2	1.14E-02	9.30E-03	1.13E-04
33	2	1.10E-02	9.03E-03	1.06E-04
33	3	1.14E-02	9.30E-03	1.13E-04
33	3	1.10E-02	9.03E-03	1.06E-04
33	3	1.06E-02	1.04E-02	1.34E-04
33	3	1.03E-02	1.01E-02	1.26E-04
33	3	9.82E-03	1.15E-02	1.56E-04
33	3	9.53E-03	1.11E-02	1.47E-04
33	4	9.82E-03	1.15E-02	1.56E-04
33	4	9.53E-03	1.11E-02	1.47E-04
33	4	8.92E-03	1.24E-02	1.78E-04
33	4	8.66E-03	1.21E-02	1.68E-04
33	4	7.96E-03	1.33E-02	1.99E-04
33	4	7.73E-03	1.29E-02	1.88E-04
33	5	7.96E-03	1.33E-02	1.99E-04
33	5	7.73E-03	1.29E-02	1.88E-04
33	5	6.94E-03	1.40E-02	2.19E-04
33	5	6.73E-03	1.36E-02	2.07E-04
33	5	5.86E-03	1.47E-02	2.37E-04
33	5	5.69E-03	1.43E-02	2.24E-04
33	6	5.86E-03	1.47E-02	2.37E-04
33	6	5.69E-03	1.43E-02	2.24E-04
33	6	4.74E-03	1.52E-02	2.53E-04
33	6	4.61E-03	1.48E-02	2.38E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
33	6	3.59E-03	1.56E-02	2.65E-04
33	6	3.48E-03	1.52E-02	2.50E-04
33	6	2.41E-03	1.59E-02	2.75E-04
33	6	2.34E-03	1.55E-02	2.59E-04
33	6	1.21E-03	1.61E-02	2.80E-04
33	6	1.17E-03	1.57E-02	2.64E-04
33	6	6.49E-10	1.62E-02	2.82E-04
33	6	6.30E-10	1.57E-02	2.66E-04
34	7	1.44E-02	0.00E+00	3.11E-05
34	7	1.40E-02	0.00E+00	2.96E-05
34	7	1.43E-02	1.46E-03	3.32E-05
34	7	1.39E-02	1.43E-03	3.16E-05
34	7	1.42E-02	2.92E-03	3.94E-05
34	7	1.38E-02	2.84E-03	3.74E-05
34	7	1.39E-02	4.35E-03	4.94E-05
34	7	1.35E-02	4.23E-03	4.69E-05
34	7	1.35E-02	5.75E-03	6.30E-05
34	7	1.32E-02	5.59E-03	5.98E-05
34	7	1.30E-02	7.10E-03	7.98E-05
34	7	1.27E-02	6.91E-03	7.56E-05
34	8	1.30E-02	7.10E-03	7.98E-05
34	8	1.27E-02	6.91E-03	7.56E-05
34	8	1.25E-02	8.40E-03	9.92E-05
34	8	1.21E-02	8.17E-03	9.40E-05
34	8	1.18E-02	9.63E-03	1.21E-04
34	8	1.15E-02	9.37E-03	1.14E-04
34	9	1.18E-02	9.63E-03	1.21E-04
34	9	1.15E-02	9.37E-03	1.14E-04
34	9	1.10E-02	1.08E-02	1.44E-04
34	9	1.07E-02	1.05E-02	1.36E-04
34	9	1.02E-02	1.19E-02	1.67E-04
34	9	9.89E-03	1.15E-02	1.58E-04
34	10	1.02E-02	1.19E-02	1.67E-04
34	10	9.89E-03	1.15E-02	1.58E-04
34	10	9.24E-03	1.29E-02	1.91E-04
34	10	8.99E-03	1.25E-02	1.81E-04
34	10	8.24E-03	1.37E-02	2.13E-04
34	10	8.02E-03	1.34E-02	2.02E-04
34	11	8.24E-03	1.37E-02	2.13E-04
34	11	8.02E-03	1.34E-02	2.02E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
34	11	7.18E-03	1.45E-02	2.35E-04
34	11	6.99E-03	1.41E-02	2.22E-04
34	11	6.07E-03	1.52E-02	2.54E-04
34	11	5.91E-03	1.48E-02	2.41E-04
34	12	6.07E-03	1.52E-02	2.54E-04
34	12	5.91E-03	1.48E-02	2.41E-04
34	12	4.91E-03	1.58E-02	2.71E-04
34	12	4.78E-03	1.53E-02	2.56E-04
34	12	3.72E-03	1.62E-02	2.84E-04
34	12	3.62E-03	1.58E-02	2.69E-04
34	12	2.49E-03	1.65E-02	2.94E-04
34	12	2.43E-03	1.61E-02	2.79E-04
34	12	1.25E-03	1.67E-02	3.00E-04
34	12	1.22E-03	1.63E-02	2.84E-04
34	12	6.72E-10	1.68E-02	3.02E-04
34	12	6.54E-10	1.63E-02	2.86E-04
35	13	1.49E-02	0.00E+00	3.31E-05
35	13	1.45E-02	0.00E+00	3.16E-05
35	13	1.48E-02	1.51E-03	3.53E-05
35	13	1.44E-02	1.48E-03	3.37E-05
35	13	1.46E-02	3.02E-03	4.18E-05
35	13	1.43E-02	2.94E-03	3.99E-05
35	13	1.44E-02	4.49E-03	5.26E-05
35	13	1.40E-02	4.38E-03	5.01E-05
35	13	1.40E-02	5.94E-03	6.71E-05
35	13	1.36E-02	5.79E-03	6.39E-05
35	13	1.35E-02	7.34E-03	8.50E-05
35	13	1.31E-02	7.15E-03	8.09E-05
35	14	1.35E-02	7.34E-03	8.50E-05
35	14	1.31E-02	7.15E-03	8.09E-05
35	14	1.29E-02	8.68E-03	1.06E-04
35	14	1.25E-02	8.46E-03	1.01E-04
35	14	1.22E-02	9.95E-03	1.29E-04
35	14	1.19E-02	9.70E-03	1.22E-04
35	15	1.22E-02	9.95E-03	1.29E-04
35	15	1.19E-02	9.70E-03	1.22E-04
35	15	1.14E-02	1.11E-02	1.53E-04
35	15	1.11E-02	1.09E-02	1.46E-04
35	15	1.05E-02	1.23E-02	1.78E-04
35	15	1.02E-02	1.20E-02	1.69E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
35	16	1.05E-02	1.23E-02	1.78E-04
35	16	1.02E-02	1.20E-02	1.69E-04
35	16	9.54E-03	1.33E-02	2.03E-04
35	16	9.30E-03	1.29E-02	1.93E-04
35	16	8.51E-03	1.42E-02	2.28E-04
35	16	8.30E-03	1.38E-02	2.16E-04
35	17	8.51E-03	1.42E-02	2.28E-04
35	17	8.30E-03	1.38E-02	2.16E-04
35	17	7.42E-03	1.50E-02	2.50E-04
35	17	7.23E-03	1.46E-02	2.38E-04
35	17	6.27E-03	1.57E-02	2.71E-04
35	17	6.11E-03	1.53E-02	2.58E-04
35	18	6.27E-03	1.57E-02	2.71E-04
35	18	6.11E-03	1.53E-02	2.58E-04
35	18	5.07E-03	1.63E-02	2.89E-04
35	18	4.95E-03	1.59E-02	2.75E-04
35	18	3.84E-03	1.67E-02	3.03E-04
35	18	3.74E-03	1.63E-02	2.88E-04
35	18	2.58E-03	1.71E-02	3.14E-04
35	18	2.51E-03	1.66E-02	2.98E-04
35	18	1.29E-03	1.73E-02	3.20E-04
35	18	1.26E-03	1.68E-02	3.05E-04
35	18	6.94E-10	1.73E-02	3.22E-04
35	18	6.77E-10	1.69E-02	3.07E-04
36	19	1.53E-02	0.00E+00	3.50E-05
36	19	1.50E-02	0.00E+00	3.35E-05
36	19	1.53E-02	1.56E-03	3.74E-05
36	19	1.49E-02	1.52E-03	3.57E-05
36	19	1.51E-02	3.11E-03	4.44E-05
36	19	1.47E-02	3.04E-03	4.24E-05
36	19	1.48E-02	4.64E-03	5.58E-05
36	19	1.45E-02	4.52E-03	5.33E-05
36	19	1.44E-02	6.12E-03	7.12E-05
36	19	1.41E-02	5.98E-03	6.80E-05
36	19	1.39E-02	7.57E-03	9.03E-05
36	19	1.36E-02	7.39E-03	8.62E-05
36	20	1.39E-02	7.57E-03	9.03E-05
36	20	1.36E-02	7.39E-03	8.62E-05
36	20	1.33E-02	8.95E-03	1.12E-04
36	20	1.30E-02	8.74E-03	1.07E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
36	20	1.25E-02	1.03E-02	1.37E-04
36	20	1.23E-02	1.00E-02	1.30E-04
36	21	1.25E-02	1.03E-02	1.37E-04
36	21	1.23E-02	1.00E-02	1.30E-04
36	21	1.17E-02	1.15E-02	1.63E-04
36	21	1.15E-02	1.12E-02	1.55E-04
36	21	1.08E-02	1.26E-02	1.89E-04
36	21	1.06E-02	1.23E-02	1.81E-04
36	22	1.08E-02	1.26E-02	1.89E-04
36	22	1.06E-02	1.23E-02	1.81E-04
36	22	9.84E-03	1.37E-02	2.16E-04
36	22	9.61E-03	1.34E-02	2.06E-04
36	22	8.78E-03	1.46E-02	2.42E-04
36	22	8.57E-03	1.43E-02	2.31E-04
36	23	8.78E-03	1.46E-02	2.42E-04
36	23	8.57E-03	1.43E-02	2.31E-04
36	23	7.65E-03	1.55E-02	2.66E-04
36	23	7.47E-03	1.51E-02	2.54E-04
36	23	6.47E-03	1.62E-02	2.88E-04
36	23	6.31E-03	1.58E-02	2.75E-04
36	24	6.47E-03	1.62E-02	2.88E-04
36	24	6.31E-03	1.58E-02	2.75E-04
36	24	5.23E-03	1.68E-02	3.07E-04
36	24	5.11E-03	1.64E-02	2.93E-04
36	24	3.96E-03	1.73E-02	3.22E-04
36	24	3.86E-03	1.68E-02	3.07E-04
36	24	2.66E-03	1.76E-02	3.34E-04
36	24	2.59E-03	1.72E-02	3.18E-04
36	24	1.33E-03	1.78E-02	3.41E-04
36	24	1.30E-03	1.74E-02	3.25E-04
36	24	7.16E-10	1.79E-02	3.43E-04
36	24	6.99E-10	1.74E-02	3.27E-04
37	25	1.58E-02	0.00E+00	3.70E-05
37	25	1.54E-02	0.00E+00	3.54E-05
37	25	1.57E-02	1.61E-03	3.95E-05
37	25	1.54E-02	1.57E-03	3.78E-05
37	25	1.56E-02	3.20E-03	4.69E-05
37	25	1.52E-02	3.13E-03	4.49E-05
37	25	1.53E-02	4.77E-03	5.90E-05
37	25	1.49E-02	4.67E-03	5.65E-05

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
37	25	1.48E-02	6.31E-03	7.54E-05
37	25	1.45E-02	6.17E-03	7.21E-05
37	25	1.43E-02	7.79E-03	9.56E-05
37	25	1.40E-02	7.62E-03	9.15E-05
37	26	1.43E-02	7.79E-03	9.56E-05
37	26	1.40E-02	7.62E-03	9.15E-05
37	26	1.37E-02	9.22E-03	1.19E-04
37	26	1.34E-02	9.01E-03	1.14E-04
37	26	1.29E-02	1.06E-02	1.45E-04
37	26	1.26E-02	1.03E-02	1.39E-04
37	27	1.29E-02	1.06E-02	1.45E-04
37	27	1.26E-02	1.03E-02	1.39E-04
37	27	1.21E-02	1.18E-02	1.72E-04
37	27	1.18E-02	1.16E-02	1.65E-04
37	27	1.12E-02	1.30E-02	2.01E-04
37	27	1.09E-02	1.27E-02	1.92E-04
37	28	1.12E-02	1.30E-02	2.01E-04
37	28	1.09E-02	1.27E-02	1.92E-04
37	28	1.01E-02	1.41E-02	2.29E-04
37	28	9.91E-03	1.38E-02	2.19E-04
37	28	9.04E-03	1.51E-02	2.57E-04
37	28	8.84E-03	1.47E-02	2.45E-04
37	29	9.04E-03	1.51E-02	2.57E-04
37	29	8.84E-03	1.47E-02	2.45E-04
37	29	7.88E-03	1.59E-02	2.82E-04
37	29	7.70E-03	1.56E-02	2.70E-04
37	29	6.66E-03	1.67E-02	3.06E-04
37	29	6.51E-03	1.63E-02	2.92E-04
37	30	6.66E-03	1.67E-02	3.06E-04
37	30	6.51E-03	1.63E-02	2.92E-04
37	30	5.39E-03	1.73E-02	3.26E-04
37	30	5.27E-03	1.69E-02	3.11E-04
37	30	4.08E-03	1.78E-02	3.42E-04
37	30	3.99E-03	1.74E-02	3.27E-04
37	30	2.74E-03	1.81E-02	3.54E-04
37	30	2.67E-03	1.77E-02	3.38E-04
37	30	1.37E-03	1.83E-02	3.61E-04
37	30	1.34E-03	1.79E-02	3.45E-04
37	30	7.37E-10	1.84E-02	3.64E-04
37	30	7.20E-10	1.80E-02	3.48E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
38	31	1.62E-02	0.00E+00	3.89E-05
38	31	1.59E-02	0.00E+00	3.74E-05
38	31	1.62E-02	1.65E-03	4.15E-05
38	31	1.58E-02	1.62E-03	3.99E-05
38	31	1.60E-02	3.29E-03	4.93E-05
38	31	1.57E-02	3.22E-03	4.74E-05
38	31	1.57E-02	4.91E-03	6.21E-05
38	31	1.54E-02	4.81E-03	5.97E-05
38	31	1.53E-02	6.49E-03	7.95E-05
38	31	1.49E-02	6.35E-03	7.63E-05
38	31	1.47E-02	8.01E-03	1.01E-04
38	31	1.44E-02	7.84E-03	9.68E-05
38	32	1.47E-02	8.01E-03	1.01E-04
38	32	1.44E-02	7.84E-03	9.68E-05
38	32	1.41E-02	9.48E-03	1.26E-04
38	32	1.38E-02	9.28E-03	1.21E-04
38	32	1.33E-02	1.09E-02	1.53E-04
38	32	1.30E-02	1.06E-02	1.47E-04
38	33	1.33E-02	1.09E-02	1.53E-04
38	33	1.30E-02	1.06E-02	1.47E-04
38	33	1.24E-02	1.22E-02	1.82E-04
38	33	1.22E-02	1.19E-02	1.75E-04
38	33	1.15E-02	1.34E-02	2.12E-04
38	33	1.12E-02	1.31E-02	2.03E-04
38	34	1.15E-02	1.34E-02	2.12E-04
38	34	1.12E-02	1.31E-02	2.03E-04
38	34	1.04E-02	1.45E-02	2.42E-04
38	34	1.02E-02	1.42E-02	2.32E-04
38	34	9.30E-03	1.55E-02	2.71E-04
38	34	9.10E-03	1.52E-02	2.60E-04
38	35	9.30E-03	1.55E-02	2.71E-04
38	35	9.10E-03	1.52E-02	2.60E-04
38	35	8.10E-03	1.64E-02	2.98E-04
38	35	7.93E-03	1.60E-02	2.86E-04
38	35	6.85E-03	1.71E-02	3.23E-04
38	35	6.70E-03	1.68E-02	3.10E-04
38	36	6.85E-03	1.71E-02	3.23E-04
38	36	6.70E-03	1.68E-02	3.10E-04
38	36	5.54E-03	1.78E-02	3.44E-04
38	36	5.42E-03	1.74E-02	3.30E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
38	36	4.19E-03	1.83E-02	3.61E-04
38	36	4.10E-03	1.79E-02	3.46E-04
38	36	2.81E-03	1.86E-02	3.74E-04
38	36	2.75E-03	1.82E-02	3.58E-04
38	36	1.41E-03	1.88E-02	3.82E-04
38	36	1.38E-03	1.84E-02	3.66E-04
38	36	7.58E-10	1.89E-02	3.84E-04
38	36	7.42E-10	1.85E-02	3.68E-04
39	37	1.67E-02	0.00E+00	4.08E-05
39	37	1.63E-02	0.00E+00	3.93E-05
39	37	1.66E-02	1.70E-03	4.35E-05
39	37	1.63E-02	1.66E-03	4.20E-05
39	37	1.64E-02	3.38E-03	5.18E-05
39	37	1.61E-02	3.31E-03	4.99E-05
39	37	1.61E-02	5.04E-03	6.53E-05
39	37	1.58E-02	4.94E-03	6.29E-05
39	37	1.57E-02	6.66E-03	8.36E-05
39	37	1.54E-02	6.53E-03	8.05E-05
39	37	1.51E-02	8.23E-03	1.06E-04
39	37	1.48E-02	8.06E-03	1.02E-04
39	38	1.51E-02	8.23E-03	1.06E-04
39	38	1.48E-02	8.06E-03	1.02E-04
39	38	1.44E-02	9.73E-03	1.32E-04
39	38	1.41E-02	9.54E-03	1.27E-04
39	38	1.36E-02	1.12E-02	1.61E-04
39	38	1.34E-02	1.09E-02	1.55E-04
39	39	1.36E-02	1.12E-02	1.61E-04
39	39	1.34E-02	1.09E-02	1.55E-04
39	39	1.28E-02	1.25E-02	1.92E-04
39	39	1.25E-02	1.23E-02	1.84E-04
39	39	1.18E-02	1.38E-02	2.24E-04
39	39	1.15E-02	1.35E-02	2.15E-04
39	40	1.18E-02	1.38E-02	2.24E-04
39	40	1.15E-02	1.35E-02	2.15E-04
39	40	1.07E-02	1.49E-02	2.55E-04
39	40	1.05E-02	1.46E-02	2.45E-04
39	40	9.54E-03	1.59E-02	2.86E-04
39	40	9.35E-03	1.56E-02	2.75E-04
39	41	9.54E-03	1.59E-02	2.86E-04
39	41	9.35E-03	1.56E-02	2.75E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
39	41	8.32E-03	1.68E-02	3.14E-04
39	41	8.15E-03	1.65E-02	3.02E-04
39	41	7.03E-03	1.76E-02	3.40E-04
39	41	6.89E-03	1.73E-02	3.27E-04
39	42	7.03E-03	1.76E-02	3.40E-04
39	42	6.89E-03	1.73E-02	3.27E-04
39	42	5.69E-03	1.83E-02	3.63E-04
39	42	5.57E-03	1.79E-02	3.48E-04
39	42	4.30E-03	1.88E-02	3.81E-04
39	42	4.22E-03	1.84E-02	3.66E-04
39	42	2.89E-03	1.91E-02	3.94E-04
39	42	2.83E-03	1.87E-02	3.79E-04
39	42	1.45E-03	1.93E-02	4.02E-04
39	42	1.42E-03	1.90E-02	3.86E-04
39	42	7.78E-10	1.94E-02	4.05E-04
39	42	7.62E-10	1.90E-02	3.89E-04
40	43	1.71E-02	0.00E+00	4.27E-05
40	43	1.68E-02	0.00E+00	4.12E-05
40	43	1.70E-02	1.74E-03	4.56E-05
40	43	1.67E-02	1.71E-03	4.40E-05
40	43	1.68E-02	3.47E-03	5.43E-05
40	43	1.65E-02	3.40E-03	5.24E-05
40	43	1.65E-02	5.17E-03	6.85E-05
40	43	1.62E-02	5.07E-03	6.61E-05
40	43	1.61E-02	6.83E-03	8.78E-05
40	43	1.58E-02	6.70E-03	8.46E-05
40	43	1.55E-02	8.44E-03	1.12E-04
40	43	1.52E-02	8.28E-03	1.07E-04
40	44	1.55E-02	8.44E-03	1.12E-04
40	44	1.52E-02	8.28E-03	1.07E-04
40	44	1.48E-02	9.98E-03	1.39E-04
40	44	1.45E-02	9.79E-03	1.34E-04
40	44	1.40E-02	1.14E-02	1.69E-04
40	44	1.37E-02	1.12E-02	1.63E-04
40	45	1.40E-02	1.14E-02	1.69E-04
40	45	1.37E-02	1.12E-02	1.63E-04
40	45	1.31E-02	1.28E-02	2.02E-04
40	45	1.28E-02	1.26E-02	1.94E-04
40	45	1.21E-02	1.41E-02	2.35E-04
40	45	1.18E-02	1.38E-02	2.26E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
40	46	1.21E-02	1.41E-02	2.35E-04
40	46	1.18E-02	1.38E-02	2.26E-04
40	46	1.10E-02	1.53E-02	2.68E-04
40	46	1.08E-02	1.50E-02	2.58E-04
40	46	9.79E-03	1.63E-02	3.00E-04
40	46	9.60E-03	1.60E-02	2.89E-04
40	47	9.79E-03	1.63E-02	3.00E-04
40	47	9.60E-03	1.60E-02	2.89E-04
40	47	8.53E-03	1.73E-02	3.31E-04
40	47	8.37E-03	1.69E-02	3.18E-04
40	47	7.21E-03	1.81E-02	3.58E-04
40	47	7.07E-03	1.77E-02	3.44E-04
40	48	7.21E-03	1.81E-02	3.58E-04
40	48	7.07E-03	1.77E-02	3.44E-04
40	48	5.83E-03	1.87E-02	3.81E-04
40	48	5.72E-03	1.84E-02	3.67E-04
40	48	4.41E-03	1.92E-02	4.00E-04
40	48	4.33E-03	1.89E-02	3.85E-04
40	48	2.96E-03	1.96E-02	4.14E-04
40	48	2.90E-03	1.92E-02	3.99E-04
40	48	1.49E-03	1.98E-02	4.23E-04
40	48	1.46E-03	1.95E-02	4.07E-04
40	48	7.98E-10	1.99E-02	4.26E-04
40	48	7.83E-10	1.95E-02	4.10E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
41	1	1.76E-02	0.00E+00	4.49E-05
41	1	1.72E-02	0.00E+00	4.31E-05
41	1	1.75E-02	1.79E-03	4.80E-05
41	1	1.71E-02	1.75E-03	4.61E-05
41	1	1.73E-02	3.57E-03	5.72E-05
41	1	1.69E-02	3.49E-03	5.49E-05
41	1	1.70E-02	5.32E-03	7.23E-05
41	1	1.66E-02	5.20E-03	6.93E-05
41	1	1.65E-02	7.03E-03	9.27E-05
41	1	1.62E-02	6.87E-03	8.88E-05
41	1	1.59E-02	8.69E-03	1.18E-04
41	1	1.56E-02	8.49E-03	1.13E-04
41	2	1.59E-02	8.69E-03	1.18E-04
41	2	1.56E-02	8.49E-03	1.13E-04
41	2	1.52E-02	1.03E-02	1.47E-04
41	2	1.49E-02	1.00E-02	1.41E-04
41	2	1.44E-02	1.18E-02	1.79E-04
41	2	1.41E-02	1.15E-02	1.71E-04
41	3	1.44E-02	1.18E-02	1.79E-04
41	3	1.41E-02	1.15E-02	1.71E-04
41	3	1.35E-02	1.32E-02	2.13E-04
41	3	1.32E-02	1.29E-02	2.04E-04
41	3	1.24E-02	1.45E-02	2.49E-04
41	3	1.21E-02	1.42E-02	2.38E-04
41	4	1.24E-02	1.45E-02	2.49E-04
41	4	1.21E-02	1.42E-02	2.38E-04
41	4	1.13E-02	1.57E-02	2.84E-04
41	4	1.10E-02	1.54E-02	2.71E-04
41	4	1.01E-02	1.68E-02	3.18E-04
41	4	9.85E-03	1.64E-02	3.04E-04
41	5	1.01E-02	1.68E-02	3.18E-04
41	5	9.85E-03	1.64E-02	3.04E-04
41	5	8.78E-03	1.78E-02	3.50E-04
41	5	8.58E-03	1.74E-02	3.34E-04
41	5	7.42E-03	1.86E-02	3.79E-04
41	5	7.25E-03	1.82E-02	3.62E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
41	6	7.42E-03	1.86E-02	3.79E-04
41	6	7.25E-03	1.82E-02	3.62E-04
41	6	6.00E-03	1.93E-02	4.03E-04
41	6	5.87E-03	1.88E-02	3.86E-04
41	6	4.54E-03	1.98E-02	4.24E-04
41	6	4.44E-03	1.94E-02	4.05E-04
41	6	3.05E-03	2.02E-02	4.38E-04
41	6	2.98E-03	1.97E-02	4.19E-04
41	6	1.53E-03	2.04E-02	4.48E-04
41	6	1.49E-03	2.00E-02	4.28E-04
41	6	8.21E-10	2.05E-02	4.51E-04
41	6	8.03E-10	2.00E-02	4.31E-04
42	7	1.81E-02	0.00E+00	4.71E-05
42	7	1.77E-02	0.00E+00	4.54E-05
42	7	1.80E-02	1.84E-03	5.04E-05
42	7	1.76E-02	1.80E-03	4.85E-05
42	7	1.78E-02	3.67E-03	6.02E-05
42	7	1.74E-02	3.59E-03	5.78E-05
42	7	1.75E-02	5.47E-03	7.61E-05
42	7	1.71E-02	5.35E-03	7.31E-05
42	7	1.70E-02	7.23E-03	9.76E-05
42	7	1.66E-02	7.07E-03	9.37E-05
42	7	1.64E-02	8.93E-03	1.24E-04
42	7	1.60E-02	8.74E-03	1.19E-04
42	8	1.64E-02	8.93E-03	1.24E-04
42	8	1.60E-02	8.74E-03	1.19E-04
42	8	1.57E-02	1.06E-02	1.55E-04
42	8	1.53E-02	1.03E-02	1.49E-04
42	8	1.48E-02	1.21E-02	1.89E-04
42	8	1.45E-02	1.19E-02	1.81E-04
42	9	1.48E-02	1.21E-02	1.89E-04
42	9	1.45E-02	1.19E-02	1.81E-04
42	9	1.38E-02	1.36E-02	2.25E-04
42	9	1.35E-02	1.33E-02	2.16E-04
42	9	1.28E-02	1.49E-02	2.62E-04
42	9	1.25E-02	1.46E-02	2.51E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
42	10	1.28E-02	1.49E-02	2.62E-04
42	10	1.25E-02	1.46E-02	2.51E-04
42	10	1.16E-02	1.62E-02	3.00E-04
42	10	1.14E-02	1.58E-02	2.87E-04
42	10	1.04E-02	1.73E-02	3.36E-04
42	10	1.01E-02	1.69E-02	3.22E-04
42	11	1.04E-02	1.73E-02	3.36E-04
42	11	1.01E-02	1.69E-02	3.22E-04
42	11	9.02E-03	1.83E-02	3.69E-04
42	11	8.83E-03	1.79E-02	3.54E-04
42	11	7.62E-03	1.91E-02	4.00E-04
42	11	7.46E-03	1.87E-02	3.83E-04
42	12	7.62E-03	1.91E-02	4.00E-04
42	12	7.46E-03	1.87E-02	3.83E-04
42	12	6.17E-03	1.98E-02	4.26E-04
42	12	6.04E-03	1.94E-02	4.08E-04
42	12	4.67E-03	2.03E-02	4.47E-04
42	12	4.57E-03	1.99E-02	4.29E-04
42	12	3.13E-03	2.07E-02	4.63E-04
42	12	3.06E-03	2.03E-02	4.44E-04
42	12	1.57E-03	2.10E-02	4.72E-04
42	12	1.54E-03	2.05E-02	4.53E-04
42	12	8.44E-10	2.11E-02	4.76E-04
42	12	8.26E-10	2.06E-02	4.56E-04
43	13	1.86E-02	0.00E+00	4.93E-05
43	13	1.82E-02	0.00E+00	4.76E-05
43	13	1.85E-02	1.89E-03	5.28E-05
43	13	1.81E-02	1.85E-03	5.09E-05
43	13	1.83E-02	3.77E-03	6.31E-05
43	13	1.79E-02	3.69E-03	6.08E-05
43	13	1.79E-02	5.62E-03	7.99E-05
43	13	1.76E-02	5.50E-03	7.69E-05
43	13	1.74E-02	7.42E-03	1.03E-04
43	13	1.71E-02	7.27E-03	9.87E-05
43	13	1.68E-02	9.17E-03	1.31E-04
43	13	1.65E-02	8.98E-03	1.26E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
43	14	1.68E-02	9.17E-03	1.31E-04
43	14	1.65E-02	8.98E-03	1.26E-04
43	14	1.61E-02	1.08E-02	1.63E-04
43	14	1.57E-02	1.06E-02	1.57E-04
43	14	1.52E-02	1.24E-02	1.99E-04
43	14	1.49E-02	1.22E-02	1.91E-04
43	15	1.52E-02	1.24E-02	1.99E-04
43	15	1.49E-02	1.22E-02	1.91E-04
43	15	1.42E-02	1.39E-02	2.37E-04
43	15	1.39E-02	1.36E-02	2.28E-04
43	15	1.31E-02	1.53E-02	2.76E-04
43	15	1.28E-02	1.50E-02	2.65E-04
43	16	1.31E-02	1.53E-02	2.76E-04
43	16	1.28E-02	1.50E-02	2.65E-04
43	16	1.19E-02	1.66E-02	3.15E-04
43	16	1.17E-02	1.62E-02	3.03E-04
43	16	1.06E-02	1.77E-02	3.53E-04
43	16	1.04E-02	1.74E-02	3.39E-04
43	17	1.06E-02	1.77E-02	3.53E-04
43	17	1.04E-02	1.74E-02	3.39E-04
43	17	9.26E-03	1.87E-02	3.89E-04
43	17	9.07E-03	1.84E-02	3.73E-04
43	17	7.83E-03	1.96E-02	4.21E-04
43	17	7.67E-03	1.92E-02	4.04E-04
43	18	7.83E-03	1.96E-02	4.21E-04
43	18	7.67E-03	1.92E-02	4.04E-04
43	18	6.33E-03	2.03E-02	4.49E-04
43	18	6.20E-03	1.99E-02	4.31E-04
43	18	4.79E-03	2.09E-02	4.71E-04
43	18	4.69E-03	2.05E-02	4.52E-04
43	18	3.21E-03	2.13E-02	4.88E-04
43	18	3.15E-03	2.09E-02	4.68E-04
43	18	1.61E-03	2.15E-02	4.98E-04
43	18	1.58E-03	2.11E-02	4.78E-04
43	18	8.66E-10	2.16E-02	5.01E-04
43	18	8.48E-10	2.12E-02	4.81E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
44	19	1.90E-02	0.00E+00	5.15E-05
44	19	1.87E-02	0.00E+00	4.98E-05
44	19	1.90E-02	1.94E-03	5.52E-05
44	19	1.86E-02	1.90E-03	5.33E-05
44	19	1.88E-02	3.86E-03	6.60E-05
44	19	1.84E-02	3.79E-03	6.37E-05
44	19	1.84E-02	5.76E-03	8.37E-05
44	19	1.80E-02	5.65E-03	8.07E-05
44	19	1.79E-02	7.61E-03	1.08E-04
44	19	1.75E-02	7.46E-03	1.04E-04
44	19	1.73E-02	9.40E-03	1.37E-04
44	19	1.69E-02	9.22E-03	1.32E-04
44	20	1.73E-02	9.40E-03	1.37E-04
44	20	1.69E-02	9.22E-03	1.32E-04
44	20	1.65E-02	1.11E-02	1.71E-04
44	20	1.62E-02	1.09E-02	1.65E-04
44	20	1.56E-02	1.27E-02	2.09E-04
44	20	1.53E-02	1.25E-02	2.01E-04
44	21	1.56E-02	1.27E-02	2.09E-04
44	21	1.53E-02	1.25E-02	2.01E-04
44	21	1.46E-02	1.43E-02	2.49E-04
44	21	1.43E-02	1.40E-02	2.40E-04
44	21	1.34E-02	1.57E-02	2.90E-04
44	21	1.32E-02	1.54E-02	2.79E-04
44	22	1.34E-02	1.57E-02	2.90E-04
44	22	1.32E-02	1.54E-02	2.79E-04
44	22	1.22E-02	1.70E-02	3.31E-04
44	22	1.20E-02	1.67E-02	3.19E-04
44	22	1.09E-02	1.82E-02	3.71E-04
44	22	1.07E-02	1.78E-02	3.57E-04
44	23	1.09E-02	1.82E-02	3.71E-04
44	23	1.07E-02	1.78E-02	3.57E-04
44	23	9.50E-03	1.92E-02	4.09E-04
44	23	9.31E-03	1.88E-02	3.93E-04
44	23	8.02E-03	2.01E-02	4.42E-04
44	23	7.87E-03	1.97E-02	4.26E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
44	24	8.02E-03	2.01E-02	4.42E-04
44	24	7.87E-03	1.97E-02	4.26E-04
44	24	6.49E-03	2.08E-02	4.72E-04
44	24	6.37E-03	2.04E-02	4.54E-04
44	24	4.91E-03	2.14E-02	4.95E-04
44	24	4.82E-03	2.10E-02	4.76E-04
44	24	3.30E-03	2.18E-02	5.12E-04
44	24	3.23E-03	2.14E-02	4.93E-04
44	24	1.65E-03	2.21E-02	5.23E-04
44	24	1.62E-03	2.17E-02	5.03E-04
44	24	8.88E-10	2.22E-02	5.27E-04
44	24	8.71E-10	2.17E-02	5.07E-04
45	25	1.95E-02	0.00E+00	5.37E-05
45	25	1.92E-02	0.00E+00	5.20E-05
45	25	1.94E-02	1.99E-03	5.76E-05
45	25	1.91E-02	1.95E-03	5.57E-05
45	25	1.92E-02	3.96E-03	6.89E-05
45	25	1.89E-02	3.89E-03	6.67E-05
45	25	1.88E-02	5.90E-03	8.75E-05
45	25	1.85E-02	5.79E-03	8.45E-05
45	25	1.83E-02	7.80E-03	1.13E-04
45	25	1.80E-02	7.65E-03	1.09E-04
45	25	1.77E-02	9.63E-03	1.44E-04
45	25	1.73E-02	9.45E-03	1.39E-04
45	26	1.77E-02	9.63E-03	1.44E-04
45	26	1.73E-02	9.45E-03	1.39E-04
45	26	1.69E-02	1.14E-02	1.79E-04
45	26	1.66E-02	1.12E-02	1.73E-04
45	26	1.60E-02	1.31E-02	2.19E-04
45	26	1.57E-02	1.28E-02	2.11E-04
45	27	1.60E-02	1.31E-02	2.19E-04
45	27	1.57E-02	1.28E-02	2.11E-04
45	27	1.49E-02	1.46E-02	2.61E-04
45	27	1.46E-02	1.44E-02	2.52E-04
45	27	1.38E-02	1.61E-02	3.04E-04
45	27	1.35E-02	1.58E-02	2.93E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
45	28	1.38E-02	1.61E-02	3.04E-04
45	28	1.35E-02	1.58E-02	2.93E-04
45	28	1.25E-02	1.74E-02	3.48E-04
45	28	1.23E-02	1.71E-02	3.35E-04
45	28	1.12E-02	1.86E-02	3.89E-04
45	28	1.10E-02	1.83E-02	3.75E-04
45	29	1.12E-02	1.86E-02	3.89E-04
45	29	1.10E-02	1.83E-02	3.75E-04
45	29	9.73E-03	1.97E-02	4.29E-04
45	29	9.55E-03	1.93E-02	4.13E-04
45	29	8.22E-03	2.06E-02	4.64E-04
45	29	8.07E-03	2.02E-02	4.47E-04
45	30	8.22E-03	2.06E-02	4.64E-04
45	30	8.07E-03	2.02E-02	4.47E-04
45	30	6.65E-03	2.13E-02	4.95E-04
45	30	6.53E-03	2.09E-02	4.77E-04
45	30	5.03E-03	2.19E-02	5.19E-04
45	30	4.94E-03	2.15E-02	5.00E-04
45	30	3.38E-03	2.24E-02	5.38E-04
45	30	3.31E-03	2.19E-02	5.18E-04
45	30	1.69E-03	2.26E-02	5.49E-04
45	30	1.66E-03	2.22E-02	5.29E-04
45	30	9.09E-10	2.27E-02	5.52E-04
45	30	8.93E-10	2.23E-02	5.32E-04
46	31	2.00E-02	0.00E+00	5.59E-05
46	31	1.96E-02	0.00E+00	5.42E-05
46	31	1.99E-02	2.03E-03	5.99E-05
46	31	1.95E-02	2.00E-03	5.81E-05
46	31	1.97E-02	4.05E-03	7.18E-05
46	31	1.93E-02	3.98E-03	6.96E-05
46	31	1.93E-02	6.04E-03	9.13E-05
46	31	1.89E-02	5.93E-03	8.83E-05
46	31	1.88E-02	7.98E-03	1.18E-04
46	31	1.84E-02	7.84E-03	1.14E-04
46	31	1.81E-02	9.86E-03	1.50E-04
46	31	1.78E-02	9.68E-03	1.45E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
46	32	1.81E-02	9.86E-03	1.50E-04
46	32	1.78E-02	9.68E-03	1.45E-04
46	32	1.73E-02	1.17E-02	1.88E-04
46	32	1.70E-02	1.15E-02	1.81E-04
46	32	1.63E-02	1.34E-02	2.29E-04
46	32	1.60E-02	1.31E-02	2.21E-04
46	33	1.63E-02	1.34E-02	2.29E-04
46	33	1.60E-02	1.31E-02	2.21E-04
46	33	1.53E-02	1.50E-02	2.73E-04
46	33	1.50E-02	1.47E-02	2.64E-04
46	33	1.41E-02	1.65E-02	3.18E-04
46	33	1.38E-02	1.62E-02	3.08E-04
46	34	1.41E-02	1.65E-02	3.18E-04
46	34	1.38E-02	1.62E-02	3.08E-04
46	34	1.28E-02	1.78E-02	3.64E-04
46	34	1.26E-02	1.75E-02	3.51E-04
46	34	1.14E-02	1.91E-02	4.08E-04
46	34	1.12E-02	1.87E-02	3.94E-04
46	35	1.14E-02	1.91E-02	4.08E-04
46	35	1.12E-02	1.87E-02	3.94E-04
46	35	9.95E-03	2.01E-02	4.49E-04
46	35	9.78E-03	1.98E-02	4.33E-04
46	35	8.41E-03	2.11E-02	4.86E-04
46	35	8.26E-03	2.07E-02	4.69E-04
46	36	8.41E-03	2.11E-02	4.86E-04
46	36	8.26E-03	2.07E-02	4.69E-04
46	36	6.81E-03	2.18E-02	5.18E-04
46	36	6.69E-03	2.15E-02	5.00E-04
46	36	5.15E-03	2.24E-02	5.44E-04
46	36	5.06E-03	2.21E-02	5.25E-04
46	36	3.45E-03	2.29E-02	5.63E-04
46	36	3.39E-03	2.25E-02	5.43E-04
46	36	1.73E-03	2.31E-02	5.74E-04
46	36	1.70E-03	2.27E-02	5.54E-04
46	36	9.31E-10	2.32E-02	5.78E-04
46	36	9.14E-10	2.28E-02	5.58E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
47	37	2.04E-02	0.00E+00	5.81E-05
47	37	2.01E-02	0.00E+00	5.64E-05
47	37	2.03E-02	2.08E-03	6.23E-05
47	37	2.00E-02	2.05E-03	6.05E-05
47	37	2.01E-02	4.14E-03	7.47E-05
47	37	1.98E-02	4.07E-03	7.25E-05
47	37	1.97E-02	6.18E-03	9.50E-05
47	37	1.94E-02	6.07E-03	9.21E-05
47	37	1.92E-02	8.16E-03	1.23E-04
47	37	1.89E-02	8.02E-03	1.19E-04
47	37	1.85E-02	1.01E-02	1.57E-04
47	37	1.82E-02	9.91E-03	1.52E-04
47	38	1.85E-02	1.01E-02	1.57E-04
47	38	1.82E-02	9.91E-03	1.52E-04
47	38	1.77E-02	1.19E-02	1.96E-04
47	38	1.74E-02	1.17E-02	1.89E-04
47	38	1.67E-02	1.37E-02	2.39E-04
47	38	1.64E-02	1.34E-02	2.31E-04
47	39	1.67E-02	1.37E-02	2.39E-04
47	39	1.64E-02	1.34E-02	2.31E-04
47	39	1.56E-02	1.53E-02	2.85E-04
47	39	1.54E-02	1.51E-02	2.76E-04
47	39	1.44E-02	1.68E-02	3.33E-04
47	39	1.42E-02	1.66E-02	3.22E-04
47	40	1.44E-02	1.68E-02	3.33E-04
47	40	1.42E-02	1.66E-02	3.22E-04
47	40	1.31E-02	1.82E-02	3.80E-04
47	40	1.29E-02	1.79E-02	3.68E-04
47	40	1.17E-02	1.95E-02	4.26E-04
47	40	1.15E-02	1.92E-02	4.12E-04
47	41	1.17E-02	1.95E-02	4.26E-04
47	41	1.15E-02	1.92E-02	4.12E-04
47	41	1.02E-02	2.06E-02	4.69E-04
47	41	1.00E-02	2.02E-02	4.53E-04
47	41	8.60E-03	2.15E-02	5.08E-04
47	41	8.45E-03	2.12E-02	4.91E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
47	42	8.60E-03	2.15E-02	5.08E-04
47	42	8.45E-03	2.12E-02	4.91E-04
47	42	6.96E-03	2.23E-02	5.41E-04
47	42	6.84E-03	2.20E-02	5.23E-04
47	42	5.26E-03	2.30E-02	5.68E-04
47	42	5.18E-03	2.26E-02	5.49E-04
47	42	3.53E-03	2.34E-02	5.88E-04
47	42	3.47E-03	2.30E-02	5.68E-04
47	42	1.77E-03	2.37E-02	6.00E-04
47	42	1.74E-03	2.33E-02	5.80E-04
47	42	9.51E-10	2.38E-02	6.04E-04
47	42	9.35E-10	2.34E-02	5.84E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
48	1	2.09E-02	0.00E+00	6.03E-05
48	1	2.05E-02	0.00E+00	5.86E-05
48	1	2.08E-02	2.13E-03	6.47E-05
48	1	2.05E-02	2.09E-03	6.28E-05
48	1	2.06E-02	4.24E-03	7.77E-05
48	1	2.02E-02	4.17E-03	7.54E-05
48	1	2.02E-02	6.32E-03	9.90E-05
48	1	1.98E-02	6.21E-03	9.59E-05
48	1	1.96E-02	8.35E-03	1.28E-04
48	1	1.93E-02	8.20E-03	1.24E-04
48	1	1.89E-02	1.03E-02	1.63E-04
48	1	1.86E-02	1.01E-02	1.58E-04
48	2	1.89E-02	1.03E-02	1.63E-04
48	2	1.86E-02	1.01E-02	1.58E-04
48	2	1.81E-02	1.22E-02	2.04E-04
48	2	1.78E-02	1.20E-02	1.98E-04
48	2	1.71E-02	1.40E-02	2.50E-04
48	2	1.68E-02	1.37E-02	2.41E-04
48	3	1.71E-02	1.40E-02	2.50E-04
48	3	1.68E-02	1.37E-02	2.41E-04
48	3	1.60E-02	1.57E-02	2.98E-04
48	3	1.57E-02	1.54E-02	2.88E-04
48	3	1.47E-02	1.72E-02	3.48E-04
48	3	1.45E-02	1.69E-02	3.36E-04
48	4	1.47E-02	1.72E-02	3.48E-04
48	4	1.45E-02	1.69E-02	3.36E-04
48	4	1.34E-02	1.87E-02	3.97E-04
48	4	1.32E-02	1.83E-02	3.84E-04
48	4	1.19E-02	1.99E-02	4.45E-04
48	4	1.17E-02	1.96E-02	4.30E-04
48	5	1.19E-02	1.99E-02	4.45E-04
48	5	1.17E-02	1.96E-02	4.30E-04
48	5	1.04E-02	2.11E-02	4.90E-04
48	5	1.02E-02	2.07E-02	4.74E-04
48	5	8.80E-03	2.20E-02	5.31E-04
48	5	8.64E-03	2.17E-02	5.13E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
48	6	8.80E-03	2.20E-02	5.31E-04
48	6	8.64E-03	2.17E-02	5.13E-04
48	6	7.12E-03	2.28E-02	5.66E-04
48	6	6.99E-03	2.24E-02	5.46E-04
48	6	5.38E-03	2.35E-02	5.94E-04
48	6	5.29E-03	2.31E-02	5.74E-04
48	6	3.61E-03	2.39E-02	6.15E-04
48	6	3.55E-03	2.35E-02	5.94E-04
48	6	1.81E-03	2.42E-02	6.28E-04
48	6	1.78E-03	2.38E-02	6.06E-04
48	6	9.73E-10	2.43E-02	6.32E-04
48	6	9.56E-10	2.39E-02	6.10E-04
49	7	2.14E-02	0.00E+00	6.25E-05
49	7	2.10E-02	0.00E+00	6.08E-05
49	7	2.13E-02	2.18E-03	6.71E-05
49	7	2.09E-02	2.14E-03	6.52E-05
49	7	2.10E-02	4.33E-03	8.08E-05
49	7	2.07E-02	4.26E-03	7.84E-05
49	7	2.06E-02	6.46E-03	1.03E-04
49	7	2.03E-02	6.35E-03	9.99E-05
49	7	2.01E-02	8.53E-03	1.33E-04
49	7	1.97E-02	8.39E-03	1.29E-04
49	7	1.93E-02	1.05E-02	1.70E-04
49	7	1.90E-02	1.04E-02	1.65E-04
49	8	1.93E-02	1.05E-02	1.70E-04
49	8	1.90E-02	1.04E-02	1.65E-04
49	8	1.85E-02	1.25E-02	2.13E-04
49	8	1.82E-02	1.23E-02	2.06E-04
49	8	1.75E-02	1.43E-02	2.61E-04
49	8	1.72E-02	1.41E-02	2.52E-04
49	9	1.75E-02	1.43E-02	2.61E-04
49	9	1.72E-02	1.41E-02	2.52E-04
49	9	1.63E-02	1.60E-02	3.11E-04
49	9	1.61E-02	1.57E-02	3.01E-04
49	9	1.51E-02	1.76E-02	3.63E-04
49	9	1.48E-02	1.73E-02	3.51E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
49	10	1.51E-02	1.76E-02	3.63E-04
49	10	1.48E-02	1.73E-02	3.51E-04
49	10	1.37E-02	1.91E-02	4.15E-04
49	10	1.35E-02	1.87E-02	4.01E-04
49	10	1.22E-02	2.04E-02	4.65E-04
49	10	1.20E-02	2.00E-02	4.50E-04
49	11	1.22E-02	2.04E-02	4.65E-04
49	11	1.20E-02	2.00E-02	4.50E-04
49	11	1.06E-02	2.15E-02	5.12E-04
49	11	1.05E-02	2.12E-02	4.95E-04
49	11	8.99E-03	2.25E-02	5.54E-04
49	11	8.84E-03	2.21E-02	5.36E-04
49	12	8.99E-03	2.25E-02	5.54E-04
49	12	8.84E-03	2.21E-02	5.36E-04
49	12	7.27E-03	2.33E-02	5.91E-04
49	12	7.15E-03	2.30E-02	5.71E-04
49	12	5.50E-03	2.40E-02	6.20E-04
49	12	5.41E-03	2.36E-02	6.00E-04
49	12	3.69E-03	2.45E-02	6.42E-04
49	12	3.63E-03	2.40E-02	6.21E-04
49	12	1.85E-03	2.47E-02	6.55E-04
49	12	1.82E-03	2.43E-02	6.34E-04
49	12	9.94E-10	2.48E-02	6.60E-04
49	12	9.78E-10	2.44E-02	6.38E-04
50	13	2.18E-02	0.00E+00	6.48E-05
50	13	2.15E-02	0.00E+00	6.30E-05
50	13	2.17E-02	2.22E-03	6.96E-05
50	13	2.14E-02	2.19E-03	6.77E-05
50	13	2.15E-02	4.43E-03	8.38E-05
50	13	2.11E-02	4.36E-03	8.14E-05
50	13	2.11E-02	6.60E-03	1.07E-04
50	13	2.07E-02	6.49E-03	1.04E-04
50	13	2.05E-02	8.72E-03	1.39E-04
50	13	2.02E-02	8.57E-03	1.34E-04
50	13	1.98E-02	1.08E-02	1.77E-04
50	13	1.94E-02	1.06E-02	1.72E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
50	14	1.98E-02	1.08E-02	1.77E-04
50	14	1.94E-02	1.06E-02	1.72E-04
50	14	1.89E-02	1.27E-02	2.22E-04
50	14	1.86E-02	1.25E-02	2.15E-04
50	14	1.78E-02	1.46E-02	2.72E-04
50	14	1.76E-02	1.44E-02	2.63E-04
50	15	1.78E-02	1.46E-02	2.72E-04
50	15	1.76E-02	1.44E-02	2.63E-04
50	15	1.67E-02	1.64E-02	3.24E-04
50	15	1.64E-02	1.61E-02	3.14E-04
50	15	1.54E-02	1.80E-02	3.78E-04
50	15	1.51E-02	1.77E-02	3.66E-04
50	16	1.54E-02	1.80E-02	3.78E-04
50	16	1.51E-02	1.77E-02	3.66E-04
50	16	1.40E-02	1.95E-02	4.32E-04
50	16	1.38E-02	1.92E-02	4.19E-04
50	16	1.25E-02	2.08E-02	4.85E-04
50	16	1.23E-02	2.05E-02	4.69E-04
50	17	1.25E-02	2.08E-02	4.85E-04
50	17	1.23E-02	2.05E-02	4.69E-04
50	17	1.09E-02	2.20E-02	5.34E-04
50	17	1.07E-02	2.16E-02	5.17E-04
50	17	9.18E-03	2.30E-02	5.78E-04
50	17	9.03E-03	2.26E-02	5.59E-04
50	18	9.18E-03	2.30E-02	5.78E-04
50	18	9.03E-03	2.26E-02	5.59E-04
50	18	7.43E-03	2.38E-02	6.16E-04
50	18	7.31E-03	2.35E-02	5.96E-04
50	18	5.62E-03	2.45E-02	6.47E-04
50	18	5.53E-03	2.41E-02	6.26E-04
50	18	3.77E-03	2.50E-02	6.69E-04
50	18	3.71E-03	2.46E-02	6.48E-04
50	18	1.89E-03	2.53E-02	6.83E-04
50	18	1.86E-03	2.49E-02	6.61E-04
50	18	1.02E-09	2.54E-02	6.88E-04
50	18	9.99E-10	2.49E-02	6.66E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
51	19	2.23E-02	0.00E+00	6.70E-05
51	19	2.19E-02	0.00E+00	6.53E-05
51	19	2.22E-02	2.27E-03	7.20E-05
51	19	2.18E-02	2.23E-03	7.01E-05
51	19	2.19E-02	4.52E-03	8.68E-05
51	19	2.16E-02	4.45E-03	8.45E-05
51	19	2.15E-02	6.74E-03	1.11E-04
51	19	2.12E-02	6.63E-03	1.08E-04
51	19	2.09E-02	8.90E-03	1.44E-04
51	19	2.06E-02	8.76E-03	1.40E-04
51	19	2.02E-02	1.10E-02	1.84E-04
51	19	1.99E-02	1.08E-02	1.79E-04
51	20	2.02E-02	1.10E-02	1.84E-04
51	20	1.99E-02	1.08E-02	1.79E-04
51	20	1.93E-02	1.30E-02	2.31E-04
51	20	1.90E-02	1.28E-02	2.24E-04
51	20	1.82E-02	1.49E-02	2.83E-04
51	20	1.79E-02	1.47E-02	2.74E-04
51	21	1.82E-02	1.49E-02	2.83E-04
51	21	1.79E-02	1.47E-02	2.74E-04
51	21	1.70E-02	1.67E-02	3.37E-04
51	21	1.68E-02	1.64E-02	3.27E-04
51	21	1.57E-02	1.84E-02	3.94E-04
51	21	1.55E-02	1.81E-02	3.82E-04
51	22	1.57E-02	1.84E-02	3.94E-04
51	22	1.55E-02	1.81E-02	3.82E-04
51	22	1.43E-02	1.99E-02	4.50E-04
51	22	1.40E-02	1.96E-02	4.36E-04
51	22	1.27E-02	2.12E-02	5.05E-04
51	22	1.25E-02	2.09E-02	4.89E-04
51	23	1.27E-02	2.12E-02	5.05E-04
51	23	1.25E-02	2.09E-02	4.89E-04
51	23	1.11E-02	2.24E-02	5.56E-04
51	23	1.09E-02	2.21E-02	5.39E-04
51	23	9.37E-03	2.35E-02	6.02E-04
51	23	9.23E-03	2.31E-02	5.83E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
51	24	9.37E-03	2.35E-02	6.02E-04
51	24	9.23E-03	2.31E-02	5.83E-04
51	24	7.58E-03	2.43E-02	6.41E-04
51	24	7.46E-03	2.40E-02	6.22E-04
51	24	5.74E-03	2.50E-02	6.73E-04
51	24	5.65E-03	2.46E-02	6.53E-04
51	24	3.85E-03	2.55E-02	6.97E-04
51	24	3.79E-03	2.51E-02	6.76E-04
51	24	1.93E-03	2.58E-02	7.12E-04
51	24	1.90E-03	2.54E-02	6.90E-04
51	24	1.04E-09	2.59E-02	7.16E-04
51	24	1.02E-09	2.55E-02	6.95E-04
52	25	2.27E-02	0.00E+00	6.91E-05
52	25	2.24E-02	0.00E+00	6.75E-05
52	25	2.26E-02	2.32E-03	7.43E-05
52	25	2.23E-02	2.28E-03	7.25E-05
52	25	2.24E-02	4.61E-03	8.98E-05
52	25	2.20E-02	4.54E-03	8.75E-05
52	25	2.19E-02	6.87E-03	1.15E-04
52	25	2.16E-02	6.77E-03	1.12E-04
52	25	2.13E-02	9.08E-03	1.49E-04
52	25	2.10E-02	8.94E-03	1.45E-04
52	25	2.06E-02	1.12E-02	1.91E-04
52	25	2.03E-02	1.10E-02	1.86E-04
52	26	2.06E-02	1.12E-02	1.91E-04
52	26	2.03E-02	1.10E-02	1.86E-04
52	26	1.97E-02	1.33E-02	2.40E-04
52	26	1.94E-02	1.31E-02	2.33E-04
52	26	1.86E-02	1.52E-02	2.94E-04
52	26	1.83E-02	1.50E-02	2.85E-04
52	27	1.86E-02	1.52E-02	2.94E-04
52	27	1.83E-02	1.50E-02	2.85E-04
52	27	1.74E-02	1.70E-02	3.51E-04
52	27	1.71E-02	1.68E-02	3.41E-04
52	27	1.60E-02	1.87E-02	4.09E-04
52	27	1.58E-02	1.84E-02	3.97E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
52	28	1.60E-02	1.87E-02	4.09E-04
52	28	1.58E-02	1.84E-02	3.97E-04
52	28	1.46E-02	2.03E-02	4.68E-04
52	28	1.43E-02	2.00E-02	4.54E-04
52	28	1.30E-02	2.17E-02	5.25E-04
52	28	1.28E-02	2.13E-02	5.09E-04
52	29	1.30E-02	2.17E-02	5.25E-04
52	29	1.28E-02	2.13E-02	5.09E-04
52	29	1.13E-02	2.29E-02	5.78E-04
52	29	1.11E-02	2.26E-02	5.61E-04
52	29	9.56E-03	2.40E-02	6.26E-04
52	29	9.42E-03	2.36E-02	6.07E-04
52	30	9.56E-03	2.40E-02	6.26E-04
52	30	9.42E-03	2.36E-02	6.07E-04
52	30	7.73E-03	2.48E-02	6.67E-04
52	30	7.62E-03	2.45E-02	6.47E-04
52	30	5.85E-03	2.55E-02	7.00E-04
52	30	5.76E-03	2.51E-02	6.80E-04
52	30	3.92E-03	2.60E-02	7.25E-04
52	30	3.87E-03	2.56E-02	7.04E-04
52	30	1.97E-03	2.63E-02	7.40E-04
52	30	1.94E-03	2.59E-02	7.18E-04
52	30	1.06E-09	2.64E-02	7.45E-04
52	30	1.04E-09	2.60E-02	7.23E-04
53	31	2.32E-02	0.00E+00	7.13E-05
53	31	2.28E-02	0.00E+00	6.96E-05
53	31	2.31E-02	2.36E-03	7.67E-05
53	31	2.27E-02	2.33E-03	7.49E-05
53	31	2.28E-02	4.70E-03	9.27E-05
53	31	2.25E-02	4.63E-03	9.05E-05
53	31	2.24E-02	7.01E-03	1.19E-04
53	31	2.20E-02	6.90E-03	1.16E-04
53	31	2.18E-02	9.25E-03	1.54E-04
53	31	2.14E-02	9.12E-03	1.50E-04
53	31	2.10E-02	1.14E-02	1.98E-04
53	31	2.07E-02	1.13E-02	1.93E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
53	32	2.10E-02	1.14E-02	1.98E-04
53	32	2.07E-02	1.13E-02	1.93E-04
53	32	2.00E-02	1.35E-02	2.49E-04
53	32	1.97E-02	1.33E-02	2.42E-04
53	32	1.89E-02	1.55E-02	3.05E-04
53	32	1.87E-02	1.53E-02	2.96E-04
53	33	1.89E-02	1.55E-02	3.05E-04
53	33	1.87E-02	1.53E-02	2.96E-04
53	33	1.77E-02	1.74E-02	3.64E-04
53	33	1.74E-02	1.71E-02	3.54E-04
53	33	1.63E-02	1.91E-02	4.25E-04
53	33	1.61E-02	1.88E-02	4.13E-04
53	34	1.63E-02	1.91E-02	4.25E-04
53	34	1.61E-02	1.88E-02	4.13E-04
53	34	1.48E-02	2.07E-02	4.86E-04
53	34	1.46E-02	2.04E-02	4.72E-04
53	34	1.32E-02	2.21E-02	5.45E-04
53	34	1.30E-02	2.18E-02	5.29E-04
53	35	1.32E-02	2.21E-02	5.45E-04
53	35	1.30E-02	2.18E-02	5.29E-04
53	35	1.15E-02	2.33E-02	6.00E-04
53	35	1.14E-02	2.30E-02	5.83E-04
53	35	9.74E-03	2.44E-02	6.49E-04
53	35	9.60E-03	2.41E-02	6.31E-04
53	36	9.74E-03	2.44E-02	6.49E-04
53	36	9.60E-03	2.41E-02	6.31E-04
53	36	7.88E-03	2.53E-02	6.92E-04
53	36	7.77E-03	2.49E-02	6.73E-04
53	36	5.96E-03	2.60E-02	7.27E-04
53	36	5.88E-03	2.56E-02	7.07E-04
53	36	4.00E-03	2.65E-02	7.52E-04
53	36	3.94E-03	2.61E-02	7.31E-04
53	36	2.01E-03	2.68E-02	7.68E-04
53	36	1.98E-03	2.64E-02	7.47E-04
53	36	1.08E-09	2.69E-02	7.73E-04
53	36	1.06E-09	2.65E-02	7.52E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
54	37	2.36E-02	0.00E+00	7.34E-05
54	37	2.33E-02	0.00E+00	7.18E-05
54	37	2.35E-02	2.40E-03	7.90E-05
54	37	2.32E-02	2.37E-03	7.72E-05
54	37	2.32E-02	4.79E-03	9.56E-05
54	37	2.29E-02	4.72E-03	9.34E-05
54	37	2.28E-02	7.14E-03	1.23E-04
54	37	2.25E-02	7.04E-03	1.20E-04
54	37	2.22E-02	9.43E-03	1.60E-04
54	37	2.18E-02	9.30E-03	1.56E-04
54	37	2.14E-02	1.16E-02	2.05E-04
54	37	2.11E-02	1.15E-02	2.00E-04
54	38	2.14E-02	1.16E-02	2.05E-04
54	38	2.11E-02	1.15E-02	2.00E-04
54	38	2.04E-02	1.38E-02	2.58E-04
54	38	2.01E-02	1.36E-02	2.51E-04
54	38	1.93E-02	1.58E-02	3.15E-04
54	38	1.90E-02	1.56E-02	3.07E-04
54	39	1.93E-02	1.58E-02	3.15E-04
54	39	1.90E-02	1.56E-02	3.07E-04
54	39	1.80E-02	1.77E-02	3.77E-04
54	39	1.78E-02	1.74E-02	3.67E-04
54	39	1.66E-02	1.94E-02	4.40E-04
54	39	1.64E-02	1.92E-02	4.29E-04
54	40	1.66E-02	1.94E-02	4.40E-04
54	40	1.64E-02	1.92E-02	4.29E-04
54	40	1.51E-02	2.10E-02	5.03E-04
54	40	1.49E-02	2.08E-02	4.90E-04
54	40	1.35E-02	2.25E-02	5.65E-04
54	40	1.33E-02	2.22E-02	5.49E-04
54	41	1.35E-02	2.25E-02	5.65E-04
54	41	1.33E-02	2.22E-02	5.49E-04
54	41	1.17E-02	2.38E-02	6.22E-04
54	41	1.16E-02	2.34E-02	6.05E-04
54	41	9.92E-03	2.49E-02	6.73E-04
54	41	9.79E-03	2.45E-02	6.55E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
54	42	9.92E-03	2.49E-02	6.73E-04
54	42	9.79E-03	2.45E-02	6.55E-04
54	42	8.03E-03	2.58E-02	7.18E-04
54	42	7.92E-03	2.54E-02	6.98E-04
54	42	6.07E-03	2.65E-02	7.54E-04
54	42	5.99E-03	2.61E-02	7.33E-04
54	42	4.07E-03	2.70E-02	7.80E-04
54	42	4.02E-03	2.66E-02	7.59E-04
54	42	2.04E-03	2.73E-02	7.96E-04
54	42	2.02E-03	2.69E-02	7.75E-04
54	42	1.10E-09	2.74E-02	8.02E-04
54	42	1.08E-09	2.70E-02	7.80E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
55	1	2.41E-02	0.00E+00	7.57E-05
55	1	2.37E-02	0.00E+00	7.39E-05
55	1	2.40E-02	2.45E-03	8.15E-05
55	1	2.36E-02	2.41E-03	7.95E-05
55	1	2.37E-02	4.89E-03	9.89E-05
55	1	2.33E-02	4.81E-03	9.64E-05
55	1	2.32E-02	7.28E-03	1.27E-04
55	1	2.29E-02	7.17E-03	1.24E-04
55	1	2.26E-02	9.62E-03	1.66E-04
55	1	2.23E-02	9.47E-03	1.61E-04
55	1	2.18E-02	1.19E-02	2.13E-04
55	1	2.15E-02	1.17E-02	2.07E-04
55	2	2.18E-02	1.19E-02	2.13E-04
55	2	2.15E-02	1.17E-02	2.07E-04
55	2	2.08E-02	1.41E-02	2.68E-04
55	2	2.05E-02	1.38E-02	2.60E-04
55	2	1.97E-02	1.61E-02	3.28E-04
55	2	1.94E-02	1.59E-02	3.18E-04
55	3	1.97E-02	1.61E-02	3.28E-04
55	3	1.94E-02	1.59E-02	3.18E-04
55	3	1.84E-02	1.80E-02	3.92E-04
55	3	1.81E-02	1.78E-02	3.80E-04
55	3	1.70E-02	1.98E-02	4.58E-04
55	3	1.67E-02	1.95E-02	4.44E-04
55	4	1.70E-02	1.98E-02	4.58E-04
55	4	1.67E-02	1.95E-02	4.44E-04
55	4	1.54E-02	2.15E-02	5.24E-04
55	4	1.52E-02	2.11E-02	5.08E-04
55	4	1.38E-02	2.30E-02	5.87E-04
55	4	1.35E-02	2.26E-02	5.70E-04
55	5	1.38E-02	2.30E-02	5.87E-04
55	5	1.35E-02	2.26E-02	5.70E-04
55	5	1.20E-02	2.43E-02	6.47E-04
55	5	1.18E-02	2.39E-02	6.27E-04
55	5	1.01E-02	2.54E-02	7.01E-04
55	5	9.96E-03	2.50E-02	6.79E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
55	6	1.01E-02	2.54E-02	7.01E-04
55	6	9.96E-03	2.50E-02	6.79E-04
55	6	8.19E-03	2.63E-02	7.47E-04
55	6	8.06E-03	2.59E-02	7.24E-04
55	6	6.20E-03	2.70E-02	7.84E-04
55	6	6.10E-03	2.66E-02	7.60E-04
55	6	4.16E-03	2.75E-02	8.12E-04
55	6	4.09E-03	2.71E-02	7.87E-04
55	6	2.09E-03	2.79E-02	8.29E-04
55	6	2.05E-03	2.74E-02	8.03E-04
55	6	1.12E-09	2.80E-02	8.34E-04
55	6	1.10E-09	2.75E-02	8.09E-04
56	7	2.46E-02	0.00E+00	7.80E-05
56	7	2.42E-02	0.00E+00	7.62E-05
56	7	2.45E-02	2.50E-03	8.41E-05
56	7	2.41E-02	2.46E-03	8.21E-05
56	7	2.42E-02	4.99E-03	1.02E-04
56	7	2.38E-02	4.91E-03	9.96E-05
56	7	2.37E-02	7.43E-03	1.32E-04
56	7	2.34E-02	7.32E-03	1.28E-04
56	7	2.31E-02	9.81E-03	1.72E-04
56	7	2.27E-02	9.66E-03	1.67E-04
56	7	2.22E-02	1.21E-02	2.21E-04
56	7	2.19E-02	1.19E-02	2.15E-04
56	8	2.22E-02	1.21E-02	2.21E-04
56	8	2.19E-02	1.19E-02	2.15E-04
56	8	2.12E-02	1.43E-02	2.78E-04
56	8	2.09E-02	1.41E-02	2.70E-04
56	8	2.01E-02	1.64E-02	3.40E-04
56	8	1.98E-02	1.62E-02	3.31E-04
56	9	2.01E-02	1.64E-02	3.40E-04
56	9	1.98E-02	1.62E-02	3.31E-04
56	9	1.88E-02	1.84E-02	4.07E-04
56	9	1.85E-02	1.81E-02	3.95E-04
56	9	1.73E-02	2.02E-02	4.76E-04
56	9	1.70E-02	1.99E-02	4.62E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
56	10	1.73E-02	2.02E-02	4.76E-04
56	10	1.70E-02	1.99E-02	4.62E-04
56	10	1.57E-02	2.19E-02	5.44E-04
56	10	1.55E-02	2.16E-02	5.28E-04
56	10	1.40E-02	2.34E-02	6.10E-04
56	10	1.38E-02	2.31E-02	5.92E-04
56	11	1.40E-02	2.34E-02	6.10E-04
56	11	1.38E-02	2.31E-02	5.92E-04
56	11	1.22E-02	2.47E-02	6.72E-04
56	11	1.20E-02	2.44E-02	6.53E-04
56	11	1.03E-02	2.59E-02	7.28E-04
56	11	1.02E-02	2.55E-02	7.07E-04
56	12	1.03E-02	2.59E-02	7.28E-04
56	12	1.02E-02	2.55E-02	7.07E-04
56	12	8.35E-03	2.68E-02	7.76E-04
56	12	8.22E-03	2.64E-02	7.53E-04
56	12	6.32E-03	2.75E-02	8.15E-04
56	12	6.22E-03	2.71E-02	7.91E-04
56	12	4.24E-03	2.81E-02	8.44E-04
56	12	4.17E-03	2.77E-02	8.19E-04
56	12	2.13E-03	2.84E-02	8.61E-04
56	12	2.09E-03	2.80E-02	8.36E-04
56	12	1.14E-09	2.85E-02	8.67E-04
56	12	1.12E-09	2.81E-02	8.42E-04
57	13	2.50E-02	0.00E+00	8.02E-05
57	13	2.47E-02	0.00E+00	7.85E-05
57	13	2.49E-02	2.55E-03	8.66E-05
57	13	2.46E-02	2.51E-03	8.46E-05
57	13	2.46E-02	5.08E-03	1.05E-04
57	13	2.43E-02	5.01E-03	1.03E-04
57	13	2.42E-02	7.57E-03	1.36E-04
57	13	2.38E-02	7.46E-03	1.33E-04
57	13	2.35E-02	1.00E-02	1.78E-04
57	13	2.32E-02	9.85E-03	1.73E-04
57	13	2.27E-02	1.24E-02	2.29E-04
57	13	2.23E-02	1.22E-02	2.23E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
57	14	2.27E-02	1.24E-02	2.29E-04
57	14	2.23E-02	1.22E-02	2.23E-04
57	14	2.16E-02	1.46E-02	2.88E-04
57	14	2.13E-02	1.44E-02	2.80E-04
57	14	2.05E-02	1.67E-02	3.53E-04
57	14	2.02E-02	1.65E-02	3.43E-04
57	15	2.05E-02	1.67E-02	3.53E-04
57	15	2.02E-02	1.65E-02	3.43E-04
57	15	1.91E-02	1.88E-02	4.22E-04
57	15	1.88E-02	1.85E-02	4.11E-04
57	15	1.76E-02	2.06E-02	4.93E-04
57	15	1.74E-02	2.03E-02	4.80E-04
57	16	1.76E-02	2.06E-02	4.93E-04
57	16	1.74E-02	2.03E-02	4.80E-04
57	16	1.60E-02	2.23E-02	5.64E-04
57	16	1.58E-02	2.20E-02	5.49E-04
57	16	1.43E-02	2.38E-02	6.33E-04
57	16	1.41E-02	2.35E-02	6.15E-04
57	17	1.43E-02	2.38E-02	6.33E-04
57	17	1.41E-02	2.35E-02	6.15E-04
57	17	1.24E-02	2.52E-02	6.97E-04
57	17	1.23E-02	2.48E-02	6.78E-04
57	17	1.05E-02	2.64E-02	7.55E-04
57	17	1.04E-02	2.60E-02	7.34E-04
57	18	1.05E-02	2.64E-02	7.55E-04
57	18	1.04E-02	2.60E-02	7.34E-04
57	18	8.51E-03	2.73E-02	8.05E-04
57	18	8.39E-03	2.69E-02	7.83E-04
57	18	6.44E-03	2.81E-02	8.46E-04
57	18	6.34E-03	2.77E-02	8.22E-04
57	18	4.32E-03	2.86E-02	8.75E-04
57	18	4.25E-03	2.82E-02	8.51E-04
57	18	2.17E-03	2.89E-02	8.94E-04
57	18	2.14E-03	2.85E-02	8.68E-04
57	18	1.16E-09	2.90E-02	9.00E-04
57	18	1.15E-09	2.86E-02	8.74E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
58	19	2.55E-02	0.00E+00	8.24E-05
58	19	2.51E-02	0.00E+00	8.07E-05
58	19	2.54E-02	2.60E-03	8.90E-05
58	19	2.50E-02	2.56E-03	8.71E-05
58	19	2.51E-02	5.17E-03	1.09E-04
58	19	2.47E-02	5.10E-03	1.06E-04
58	19	2.46E-02	7.71E-03	1.40E-04
58	19	2.43E-02	7.60E-03	1.37E-04
58	19	2.39E-02	1.02E-02	1.83E-04
58	19	2.36E-02	1.00E-02	1.79E-04
58	19	2.31E-02	1.26E-02	2.36E-04
58	19	2.28E-02	1.24E-02	2.30E-04
58	20	2.31E-02	1.26E-02	2.36E-04
58	20	2.28E-02	1.24E-02	2.30E-04
58	20	2.20E-02	1.49E-02	2.98E-04
58	20	2.17E-02	1.47E-02	2.90E-04
58	20	2.08E-02	1.71E-02	3.65E-04
58	20	2.05E-02	1.68E-02	3.56E-04
58	21	2.08E-02	1.71E-02	3.65E-04
58	21	2.05E-02	1.68E-02	3.56E-04
58	21	1.95E-02	1.91E-02	4.37E-04
58	21	1.92E-02	1.88E-02	4.26E-04
58	21	1.80E-02	2.10E-02	5.11E-04
58	21	1.77E-02	2.07E-02	4.98E-04
58	22	1.80E-02	2.10E-02	5.11E-04
58	22	1.77E-02	2.07E-02	4.98E-04
58	22	1.63E-02	2.27E-02	5.85E-04
58	22	1.61E-02	2.24E-02	5.69E-04
58	22	1.45E-02	2.43E-02	6.56E-04
58	22	1.43E-02	2.39E-02	6.38E-04
58	23	1.45E-02	2.43E-02	6.56E-04
58	23	1.43E-02	2.39E-02	6.38E-04
58	23	1.27E-02	2.57E-02	7.23E-04
58	23	1.25E-02	2.53E-02	7.03E-04
58	23	1.07E-02	2.68E-02	7.83E-04
58	23	1.06E-02	2.65E-02	7.62E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
58	24	1.07E-02	2.68E-02	7.83E-04
58	24	1.06E-02	2.65E-02	7.62E-04
58	24	8.66E-03	2.78E-02	8.35E-04
58	24	8.54E-03	2.74E-02	8.12E-04
58	24	6.55E-03	2.86E-02	8.76E-04
58	24	6.46E-03	2.82E-02	8.53E-04
58	24	4.40E-03	2.91E-02	9.07E-04
58	24	4.33E-03	2.87E-02	8.83E-04
58	24	2.21E-03	2.95E-02	9.26E-04
58	24	2.18E-03	2.91E-02	9.01E-04
58	24	1.18E-09	2.96E-02	9.32E-04
58	24	1.17E-09	2.92E-02	9.07E-04
59	25	2.60E-02	0.00E+00	8.46E-05
59	25	2.56E-02	0.00E+00	8.29E-05
59	25	2.59E-02	2.65E-03	9.14E-05
59	25	2.55E-02	2.61E-03	8.96E-05
59	25	2.56E-02	5.27E-03	1.12E-04
59	25	2.52E-02	5.20E-03	1.09E-04
59	25	2.51E-02	7.85E-03	1.45E-04
59	25	2.47E-02	7.74E-03	1.41E-04
59	25	2.44E-02	1.04E-02	1.89E-04
59	25	2.40E-02	1.02E-02	1.85E-04
59	25	2.35E-02	1.28E-02	2.44E-04
59	25	2.32E-02	1.26E-02	2.38E-04
59	26	2.35E-02	1.28E-02	2.44E-04
59	26	2.32E-02	1.26E-02	2.38E-04
59	26	2.24E-02	1.51E-02	3.08E-04
59	26	2.21E-02	1.49E-02	3.00E-04
59	26	2.12E-02	1.74E-02	3.78E-04
59	26	2.09E-02	1.71E-02	3.68E-04
59	27	2.12E-02	1.74E-02	3.78E-04
59	27	2.09E-02	1.71E-02	3.68E-04
59	27	1.98E-02	1.94E-02	4.53E-04
59	27	1.95E-02	1.92E-02	4.41E-04
59	27	1.83E-02	2.14E-02	5.29E-04
59	27	1.80E-02	2.11E-02	5.15E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
59	28	1.83E-02	2.14E-02	5.29E-04
59	28	1.80E-02	2.11E-02	5.15E-04
59	28	1.66E-02	2.31E-02	6.06E-04
59	28	1.64E-02	2.28E-02	5.90E-04
59	28	1.48E-02	2.47E-02	6.79E-04
59	28	1.46E-02	2.44E-02	6.61E-04
59	29	1.48E-02	2.47E-02	6.79E-04
59	29	1.46E-02	2.44E-02	6.61E-04
59	29	1.29E-02	2.61E-02	7.48E-04
59	29	1.27E-02	2.58E-02	7.29E-04
59	29	1.09E-02	2.73E-02	8.11E-04
59	29	1.08E-02	2.69E-02	7.89E-04
59	30	1.09E-02	2.73E-02	8.11E-04
59	30	1.08E-02	2.69E-02	7.89E-04
59	30	8.82E-03	2.83E-02	8.64E-04
59	30	8.70E-03	2.79E-02	8.41E-04
59	30	6.67E-03	2.91E-02	9.08E-04
59	30	6.58E-03	2.87E-02	8.84E-04
59	30	4.47E-03	2.97E-02	9.40E-04
59	30	4.41E-03	2.92E-02	9.15E-04
59	30	2.25E-03	3.00E-02	9.59E-04
59	30	2.21E-03	2.96E-02	9.34E-04
59	30	1.21E-09	3.01E-02	9.66E-04
59	30	1.19E-09	2.97E-02	9.40E-04
60	31	2.64E-02	0.00E+00	8.67E-05
60	31	2.61E-02	0.00E+00	8.51E-05
60	31	2.63E-02	2.69E-03	9.38E-05
60	31	2.60E-02	2.66E-03	9.20E-05
60	31	2.60E-02	5.36E-03	1.15E-04
60	31	2.57E-02	5.29E-03	1.12E-04
60	31	2.55E-02	7.99E-03	1.49E-04
60	31	2.52E-02	7.88E-03	1.46E-04
60	31	2.48E-02	1.06E-02	1.95E-04
60	31	2.45E-02	1.04E-02	1.91E-04
60	31	2.39E-02	1.30E-02	2.52E-04
60	31	2.36E-02	1.29E-02	2.46E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
60	32	2.39E-02	1.30E-02	2.52E-04
60	32	2.36E-02	1.29E-02	2.46E-04
60	32	2.28E-02	1.54E-02	3.18E-04
60	32	2.25E-02	1.52E-02	3.10E-04
60	32	2.16E-02	1.77E-02	3.91E-04
60	32	2.13E-02	1.74E-02	3.81E-04
60	33	2.16E-02	1.77E-02	3.91E-04
60	33	2.13E-02	1.74E-02	3.81E-04
60	33	2.02E-02	1.98E-02	4.68E-04
60	33	1.99E-02	1.95E-02	4.56E-04
60	33	1.86E-02	2.17E-02	5.47E-04
60	33	1.84E-02	2.15E-02	5.33E-04
60	34	1.86E-02	2.17E-02	5.47E-04
60	34	1.84E-02	2.15E-02	5.33E-04
60	34	1.69E-02	2.35E-02	6.26E-04
60	34	1.67E-02	2.32E-02	6.10E-04
60	34	1.51E-02	2.52E-02	7.03E-04
60	34	1.49E-02	2.48E-02	6.85E-04
60	35	1.51E-02	2.52E-02	7.03E-04
60	35	1.49E-02	2.48E-02	6.85E-04
60	35	1.31E-02	2.66E-02	7.74E-04
60	35	1.30E-02	2.62E-02	7.54E-04
60	35	1.11E-02	2.78E-02	8.39E-04
60	35	1.09E-02	2.74E-02	8.17E-04
60	36	1.11E-02	2.78E-02	8.39E-04
60	36	1.09E-02	2.74E-02	8.17E-04
60	36	8.97E-03	2.88E-02	8.94E-04
60	36	8.85E-03	2.84E-02	8.71E-04
60	36	6.79E-03	2.96E-02	9.39E-04
60	36	6.70E-03	2.92E-02	9.15E-04
60	36	4.55E-03	3.02E-02	9.72E-04
60	36	4.49E-03	2.98E-02	9.47E-04
60	36	2.28E-03	3.05E-02	9.92E-04
60	36	2.25E-03	3.01E-02	9.67E-04
60	36	1.23E-09	3.06E-02	9.99E-04
60	36	1.21E-09	3.02E-02	9.74E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
61	37	2.69E-02	0.00E+00	8.88E-05
61	37	2.65E-02	0.00E+00	8.72E-05
61	37	2.68E-02	2.74E-03	9.61E-05
61	37	2.64E-02	2.70E-03	9.44E-05
61	37	2.64E-02	5.45E-03	1.18E-04
61	37	2.61E-02	5.38E-03	1.15E-04
61	37	2.59E-02	8.13E-03	1.53E-04
61	37	2.56E-02	8.02E-03	1.50E-04
61	37	2.52E-02	1.07E-02	2.01E-04
61	37	2.49E-02	1.06E-02	1.97E-04
61	37	2.43E-02	1.33E-02	2.60E-04
61	37	2.40E-02	1.31E-02	2.54E-04
61	38	2.43E-02	1.33E-02	2.60E-04
61	38	2.40E-02	1.31E-02	2.54E-04
61	38	2.32E-02	1.57E-02	3.28E-04
61	38	2.29E-02	1.55E-02	3.20E-04
61	38	2.19E-02	1.80E-02	4.03E-04
61	38	2.17E-02	1.77E-02	3.94E-04
61	39	2.19E-02	1.80E-02	4.03E-04
61	39	2.17E-02	1.77E-02	3.94E-04
61	39	2.05E-02	2.01E-02	4.83E-04
61	39	2.02E-02	1.99E-02	4.71E-04
61	39	1.89E-02	2.21E-02	5.65E-04
61	39	1.87E-02	2.18E-02	5.51E-04
61	40	1.89E-02	2.21E-02	5.65E-04
61	40	1.87E-02	2.18E-02	5.51E-04
61	40	1.72E-02	2.39E-02	6.47E-04
61	40	1.70E-02	2.36E-02	6.31E-04
61	40	1.53E-02	2.56E-02	7.26E-04
61	40	1.51E-02	2.53E-02	7.08E-04
61	41	1.53E-02	2.56E-02	7.26E-04
61	41	1.51E-02	2.53E-02	7.08E-04
61	41	1.33E-02	2.70E-02	8.00E-04
61	41	1.32E-02	2.67E-02	7.80E-04
61	41	1.13E-02	2.83E-02	8.66E-04
61	41	1.11E-02	2.79E-02	8.45E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
61	42	1.13E-02	2.83E-02	8.66E-04
61	42	1.11E-02	2.79E-02	8.45E-04
61	42	9.12E-03	2.93E-02	9.24E-04
61	42	9.01E-03	2.89E-02	9.01E-04
61	42	6.90E-03	3.01E-02	9.70E-04
61	42	6.81E-03	2.97E-02	9.46E-04
61	42	4.63E-03	3.07E-02	1.00E-03
61	42	4.57E-03	3.03E-02	9.80E-04
61	42	2.32E-03	3.10E-02	1.03E-03
61	42	2.29E-03	3.06E-02	1.00E-03
61	42	1.25E-09	3.11E-02	1.03E-03
61	42	1.23E-09	3.07E-02	1.01E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
62	1	2.75E-02	0.00E+00	9.19E-05
62	1	2.70E-02	0.00E+00	8.93E-05
62	1	2.75E-02	5.62E-04	9.22E-05
62	1	2.70E-02	5.50E-04	8.96E-05
62	1	2.75E-02	1.12E-03	9.31E-05
62	1	2.69E-02	1.10E-03	9.05E-05
62	1	2.75E-02	1.69E-03	9.46E-05
62	1	2.69E-02	1.65E-03	9.20E-05
62	1	2.75E-02	2.25E-03	9.68E-05
62	1	2.69E-02	2.20E-03	9.40E-05
62	1	2.74E-02	2.81E-03	9.96E-05
62	1	2.69E-02	2.75E-03	9.67E-05
62	1	2.74E-02	3.37E-03	1.03E-04
62	1	2.68E-02	3.30E-03	9.99E-05
62	1	2.73E-02	3.92E-03	1.07E-04
62	1	2.68E-02	3.84E-03	1.04E-04
62	1	2.73E-02	4.48E-03	1.11E-04
62	1	2.67E-02	4.39E-03	1.08E-04
62	1	2.72E-02	5.04E-03	1.17E-04
62	1	2.66E-02	4.93E-03	1.13E-04
62	1	2.71E-02	5.59E-03	1.22E-04
62	1	2.66E-02	5.48E-03	1.19E-04
62	1	2.70E-02	6.14E-03	1.29E-04
62	1	2.65E-02	6.02E-03	1.25E-04
62	1	2.69E-02	6.69E-03	1.36E-04
62	1	2.64E-02	6.55E-03	1.31E-04
62	1	2.68E-02	7.24E-03	1.43E-04
62	1	2.63E-02	7.09E-03	1.38E-04
62	1	2.67E-02	7.79E-03	1.51E-04
62	1	2.62E-02	7.63E-03	1.46E-04
62	1	2.66E-02	8.33E-03	1.60E-04
62	1	2.60E-02	8.16E-03	1.54E-04
62	2	2.66E-02	8.33E-03	1.60E-04
62	2	2.60E-02	8.16E-03	1.54E-04
62	2	2.64E-02	8.87E-03	1.69E-04
62	2	2.59E-02	8.69E-03	1.63E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
62	2	2.63E-02	9.41E-03	1.78E-04
62	2	2.58E-02	9.21E-03	1.72E-04
62	2	2.62E-02	9.94E-03	1.88E-04
62	2	2.56E-02	9.74E-03	1.82E-04
62	2	2.60E-02	1.05E-02	1.99E-04
62	2	2.55E-02	1.03E-02	1.92E-04
62	2	2.58E-02	1.10E-02	2.10E-04
62	2	2.53E-02	1.08E-02	2.03E-04
62	2	2.57E-02	1.15E-02	2.21E-04
62	2	2.51E-02	1.13E-02	2.14E-04
62	2	2.55E-02	1.20E-02	2.33E-04
62	2	2.50E-02	1.18E-02	2.25E-04
62	2	2.53E-02	1.26E-02	2.46E-04
62	2	2.48E-02	1.23E-02	2.37E-04
62	2	2.51E-02	1.31E-02	2.59E-04
62	2	2.46E-02	1.28E-02	2.49E-04
62	2	2.49E-02	1.36E-02	2.72E-04
62	2	2.44E-02	1.33E-02	2.62E-04
62	3	2.49E-02	1.36E-02	2.72E-04
62	3	2.44E-02	1.33E-02	2.62E-04
62	3	2.47E-02	1.41E-02	2.86E-04
62	3	2.42E-02	1.38E-02	2.75E-04
62	3	2.45E-02	1.46E-02	3.00E-04
62	3	2.40E-02	1.43E-02	2.88E-04
62	3	2.43E-02	1.51E-02	3.14E-04
62	3	2.38E-02	1.48E-02	3.02E-04
62	3	2.40E-02	1.56E-02	3.29E-04
62	3	2.35E-02	1.53E-02	3.16E-04
62	3	2.38E-02	1.61E-02	3.44E-04
62	3	2.33E-02	1.57E-02	3.31E-04
62	3	2.35E-02	1.65E-02	3.59E-04
62	3	2.31E-02	1.62E-02	3.45E-04
62	3	2.33E-02	1.70E-02	3.74E-04
62	3	2.28E-02	1.67E-02	3.60E-04
62	4	2.33E-02	1.70E-02	3.74E-04
62	4	2.28E-02	1.67E-02	3.60E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
62	4	2.30E-02	1.75E-02	3.90E-04
62	4	2.26E-02	1.71E-02	3.75E-04
62	4	2.28E-02	1.80E-02	4.06E-04
62	4	2.23E-02	1.76E-02	3.91E-04
62	4	2.25E-02	1.84E-02	4.23E-04
62	4	2.20E-02	1.80E-02	4.06E-04
62	4	2.22E-02	1.89E-02	4.39E-04
62	4	2.18E-02	1.85E-02	4.22E-04
62	4	2.19E-02	1.93E-02	4.56E-04
62	4	2.15E-02	1.89E-02	4.38E-04
62	4	2.16E-02	1.98E-02	4.72E-04
62	4	2.12E-02	1.94E-02	4.54E-04
62	4	2.13E-02	2.02E-02	4.89E-04
62	4	2.09E-02	1.98E-02	4.70E-04
62	4	2.10E-02	2.06E-02	5.06E-04
62	4	2.06E-02	2.02E-02	4.87E-04
62	5	2.10E-02	2.06E-02	5.06E-04
62	5	2.06E-02	2.02E-02	4.87E-04
62	5	2.07E-02	2.10E-02	5.24E-04
62	5	2.03E-02	2.06E-02	5.03E-04
62	5	2.04E-02	2.15E-02	5.41E-04
62	5	2.00E-02	2.10E-02	5.20E-04
62	5	2.01E-02	2.19E-02	5.58E-04
62	5	1.96E-02	2.14E-02	5.36E-04
62	5	1.97E-02	2.23E-02	5.75E-04
62	5	1.93E-02	2.18E-02	5.53E-04
62	5	1.94E-02	2.27E-02	5.93E-04
62	5	1.90E-02	2.22E-02	5.69E-04
62	6	1.94E-02	2.27E-02	5.93E-04
62	6	1.90E-02	2.22E-02	5.69E-04
62	6	1.90E-02	2.31E-02	6.10E-04
62	6	1.87E-02	2.26E-02	5.86E-04
62	6	1.87E-02	2.34E-02	6.27E-04
62	6	1.83E-02	2.30E-02	6.03E-04
62	6	1.83E-02	2.38E-02	6.44E-04
62	6	1.80E-02	2.33E-02	6.19E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
62	6	1.80E-02	2.42E-02	6.61E-04
62	6	1.76E-02	2.37E-02	6.36E-04
62	6	1.76E-02	2.45E-02	6.78E-04
62	6	1.73E-02	2.40E-02	6.52E-04
62	7	1.76E-02	2.45E-02	6.78E-04
62	7	1.73E-02	2.40E-02	6.52E-04
62	7	1.72E-02	2.49E-02	6.95E-04
62	7	1.69E-02	2.44E-02	6.68E-04
62	7	1.69E-02	2.52E-02	7.12E-04
62	7	1.65E-02	2.47E-02	6.84E-04
62	7	1.65E-02	2.56E-02	7.29E-04
62	7	1.61E-02	2.50E-02	7.00E-04
62	7	1.61E-02	2.59E-02	7.45E-04
62	7	1.58E-02	2.54E-02	7.16E-04
62	7	1.57E-02	2.62E-02	7.61E-04
62	7	1.54E-02	2.57E-02	7.32E-04
62	7	1.53E-02	2.65E-02	7.78E-04
62	7	1.50E-02	2.60E-02	7.47E-04
62	7	1.49E-02	2.68E-02	7.93E-04
62	7	1.46E-02	2.63E-02	7.62E-04
62	7	1.45E-02	2.71E-02	8.09E-04
62	7	1.42E-02	2.66E-02	7.77E-04
62	8	1.45E-02	2.71E-02	8.09E-04
62	8	1.42E-02	2.66E-02	7.77E-04
62	8	1.41E-02	2.74E-02	8.24E-04
62	8	1.38E-02	2.69E-02	7.92E-04
62	8	1.37E-02	2.77E-02	8.39E-04
62	8	1.34E-02	2.71E-02	8.06E-04
62	8	1.33E-02	2.80E-02	8.54E-04
62	8	1.30E-02	2.74E-02	8.20E-04
62	8	1.28E-02	2.82E-02	8.68E-04
62	8	1.26E-02	2.77E-02	8.34E-04
62	8	1.24E-02	2.85E-02	8.82E-04
62	8	1.22E-02	2.79E-02	8.47E-04
62	8	1.20E-02	2.87E-02	8.96E-04
62	8	1.17E-02	2.81E-02	8.60E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
62	8	1.16E-02	2.90E-02	9.09E-04
62	8	1.13E-02	2.84E-02	8.73E-04
62	9	1.16E-02	2.90E-02	9.09E-04
62	9	1.13E-02	2.84E-02	8.73E-04
62	9	1.11E-02	2.92E-02	9.22E-04
62	9	1.09E-02	2.86E-02	8.86E-04
62	9	1.07E-02	2.94E-02	9.34E-04
62	9	1.05E-02	2.88E-02	8.97E-04
62	9	1.02E-02	2.96E-02	9.46E-04
62	9	1.00E-02	2.90E-02	9.09E-04
62	9	9.79E-03	2.98E-02	9.58E-04
62	9	9.60E-03	2.92E-02	9.20E-04
62	9	9.35E-03	3.00E-02	9.69E-04
62	9	9.16E-03	2.94E-02	9.31E-04
62	9	8.90E-03	3.02E-02	9.80E-04
62	9	8.72E-03	2.96E-02	9.41E-04
62	9	8.44E-03	3.04E-02	9.90E-04
62	9	8.27E-03	2.98E-02	9.51E-04
62	9	7.99E-03	3.05E-02	1.00E-03
62	9	7.83E-03	2.99E-02	9.60E-04
62	9	7.53E-03	3.07E-02	1.01E-03
62	9	7.38E-03	3.01E-02	9.69E-04
62	9	7.07E-03	3.08E-02	1.02E-03
62	9	6.93E-03	3.02E-02	9.78E-04
62	10	7.07E-03	3.08E-02	1.02E-03
62	10	6.93E-03	3.02E-02	9.78E-04
62	10	6.61E-03	3.10E-02	1.03E-03
62	10	6.47E-03	3.03E-02	9.86E-04
62	10	6.14E-03	3.11E-02	1.03E-03
62	10	6.02E-03	3.05E-02	9.93E-04
62	10	5.68E-03	3.12E-02	1.04E-03
62	10	5.56E-03	3.06E-02	1.00E-03
62	10	5.21E-03	3.13E-02	1.05E-03
62	10	5.11E-03	3.07E-02	1.01E-03
62	10	4.74E-03	3.14E-02	1.05E-03
62	10	4.65E-03	3.08E-02	1.01E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
62	10	4.27E-03	3.15E-02	1.06E-03
62	10	4.19E-03	3.09E-02	1.02E-03
62	10	3.80E-03	3.16E-02	1.06E-03
62	10	3.72E-03	3.10E-02	1.02E-03
62	10	3.33E-03	3.17E-02	1.07E-03
62	10	3.26E-03	3.10E-02	1.03E-03
62	10	2.85E-03	3.17E-02	1.07E-03
62	10	2.80E-03	3.11E-02	1.03E-03
62	10	2.38E-03	3.18E-02	1.08E-03
62	10	2.33E-03	3.11E-02	1.03E-03
62	10	1.90E-03	3.18E-02	1.08E-03
62	10	1.87E-03	3.12E-02	1.04E-03
62	10	1.43E-03	3.19E-02	1.08E-03
62	10	1.40E-03	3.12E-02	1.04E-03
62	10	9.53E-04	3.19E-02	1.08E-03
62	10	9.33E-04	3.12E-02	1.04E-03
62	10	4.76E-04	3.19E-02	1.08E-03
62	10	4.67E-04	3.13E-02	1.04E-03
62	10	1.28E-09	3.19E-02	1.08E-03
62	10	1.25E-09	3.13E-02	1.04E-03
63	11	2.82E-02	0.00E+00	9.48E-05
63	11	2.76E-02	0.00E+00	9.24E-05
63	11	2.82E-02	5.76E-04	9.51E-05
63	11	2.76E-02	5.64E-04	9.27E-05
63	11	2.82E-02	1.15E-03	9.61E-05
63	11	2.76E-02	1.13E-03	9.36E-05
63	11	2.82E-02	1.73E-03	9.77E-05
63	11	2.76E-02	1.69E-03	9.52E-05
63	11	2.81E-02	2.30E-03	1.00E-04
63	11	2.76E-02	2.26E-03	9.73E-05
63	11	2.81E-02	2.87E-03	1.03E-04
63	11	2.75E-02	2.82E-03	1.00E-04
63	11	2.80E-02	3.45E-03	1.06E-04
63	11	2.75E-02	3.38E-03	1.03E-04
63	11	2.80E-02	4.02E-03	1.11E-04
63	11	2.74E-02	3.94E-03	1.08E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
63	11	2.79E-02	4.59E-03	1.15E-04
63	11	2.74E-02	4.50E-03	1.12E-04
63	11	2.78E-02	5.16E-03	1.21E-04
63	11	2.73E-02	5.06E-03	1.17E-04
63	11	2.78E-02	5.72E-03	1.27E-04
63	11	2.72E-02	5.61E-03	1.23E-04
63	11	2.77E-02	6.29E-03	1.33E-04
63	11	2.71E-02	6.17E-03	1.29E-04
63	11	2.76E-02	6.85E-03	1.41E-04
63	11	2.70E-02	6.72E-03	1.36E-04
63	11	2.75E-02	7.41E-03	1.48E-04
63	11	2.69E-02	7.27E-03	1.44E-04
63	11	2.73E-02	7.97E-03	1.57E-04
63	11	2.68E-02	7.82E-03	1.52E-04
63	11	2.72E-02	8.53E-03	1.66E-04
63	11	2.67E-02	8.36E-03	1.61E-04
63	12	2.72E-02	8.53E-03	1.66E-04
63	12	2.67E-02	8.36E-03	1.61E-04
63	12	2.71E-02	9.08E-03	1.75E-04
63	12	2.66E-02	8.90E-03	1.70E-04
63	12	2.69E-02	9.63E-03	1.85E-04
63	12	2.64E-02	9.44E-03	1.79E-04
63	12	2.68E-02	1.02E-02	1.96E-04
63	12	2.63E-02	9.98E-03	1.90E-04
63	12	2.66E-02	1.07E-02	2.07E-04
63	12	2.61E-02	1.05E-02	2.00E-04
63	12	2.65E-02	1.13E-02	2.19E-04
63	12	2.59E-02	1.10E-02	2.11E-04
63	12	2.63E-02	1.18E-02	2.31E-04
63	12	2.58E-02	1.16E-02	2.23E-04
63	12	2.61E-02	1.23E-02	2.43E-04
63	12	2.56E-02	1.21E-02	2.35E-04
63	12	2.59E-02	1.29E-02	2.56E-04
63	12	2.54E-02	1.26E-02	2.48E-04
63	12	2.57E-02	1.34E-02	2.70E-04
63	12	2.52E-02	1.31E-02	2.61E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
63	12	2.55E-02	1.39E-02	2.84E-04
63	12	2.50E-02	1.36E-02	2.74E-04
63	13	2.55E-02	1.39E-02	2.84E-04
63	13	2.50E-02	1.36E-02	2.74E-04
63	13	2.53E-02	1.44E-02	2.98E-04
63	13	2.48E-02	1.41E-02	2.88E-04
63	13	2.51E-02	1.49E-02	3.13E-04
63	13	2.46E-02	1.46E-02	3.02E-04
63	13	2.48E-02	1.54E-02	3.28E-04
63	13	2.44E-02	1.51E-02	3.16E-04
63	13	2.46E-02	1.60E-02	3.43E-04
63	13	2.41E-02	1.56E-02	3.31E-04
63	13	2.44E-02	1.64E-02	3.59E-04
63	13	2.39E-02	1.61E-02	3.46E-04
63	13	2.41E-02	1.69E-02	3.75E-04
63	13	2.36E-02	1.66E-02	3.61E-04
63	13	2.38E-02	1.74E-02	3.91E-04
63	13	2.34E-02	1.71E-02	3.77E-04
63	14	2.38E-02	1.74E-02	3.91E-04
63	14	2.34E-02	1.71E-02	3.77E-04
63	14	2.36E-02	1.79E-02	4.08E-04
63	14	2.31E-02	1.76E-02	3.93E-04
63	14	2.33E-02	1.84E-02	4.25E-04
63	14	2.29E-02	1.80E-02	4.09E-04
63	14	2.30E-02	1.89E-02	4.42E-04
63	14	2.26E-02	1.85E-02	4.26E-04
63	14	2.27E-02	1.93E-02	4.59E-04
63	14	2.23E-02	1.89E-02	4.42E-04
63	14	2.24E-02	1.98E-02	4.76E-04
63	14	2.20E-02	1.94E-02	4.59E-04
63	14	2.21E-02	2.02E-02	4.94E-04
63	14	2.17E-02	1.98E-02	4.76E-04
63	14	2.18E-02	2.07E-02	5.12E-04
63	14	2.14E-02	2.03E-02	4.93E-04
63	14	2.15E-02	2.11E-02	5.30E-04
63	14	2.11E-02	2.07E-02	5.10E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
63	15	2.15E-02	2.11E-02	5.30E-04
63	15	2.11E-02	2.07E-02	5.10E-04
63	15	2.12E-02	2.15E-02	5.48E-04
63	15	2.08E-02	2.11E-02	5.27E-04
63	15	2.09E-02	2.20E-02	5.66E-04
63	15	2.05E-02	2.15E-02	5.45E-04
63	15	2.05E-02	2.24E-02	5.84E-04
63	15	2.01E-02	2.20E-02	5.62E-04
63	15	2.02E-02	2.28E-02	6.02E-04
63	15	1.98E-02	2.24E-02	5.80E-04
63	15	1.98E-02	2.32E-02	6.20E-04
63	15	1.95E-02	2.28E-02	5.97E-04
63	16	1.98E-02	2.32E-02	6.20E-04
63	16	1.95E-02	2.28E-02	5.97E-04
63	16	1.95E-02	2.36E-02	6.38E-04
63	16	1.91E-02	2.31E-02	6.14E-04
63	16	1.91E-02	2.40E-02	6.56E-04
63	16	1.88E-02	2.35E-02	6.32E-04
63	16	1.88E-02	2.44E-02	6.74E-04
63	16	1.84E-02	2.39E-02	6.49E-04
63	16	1.84E-02	2.47E-02	6.92E-04
63	16	1.80E-02	2.43E-02	6.66E-04
63	16	1.80E-02	2.51E-02	7.10E-04
63	16	1.77E-02	2.46E-02	6.84E-04
63	17	1.80E-02	2.51E-02	7.10E-04
63	17	1.77E-02	2.46E-02	6.84E-04
63	17	1.76E-02	2.55E-02	7.28E-04
63	17	1.73E-02	2.50E-02	7.01E-04
63	17	1.73E-02	2.58E-02	7.45E-04
63	17	1.69E-02	2.53E-02	7.18E-04
63	17	1.69E-02	2.62E-02	7.63E-04
63	17	1.65E-02	2.57E-02	7.34E-04
63	17	1.65E-02	2.65E-02	7.80E-04
63	17	1.62E-02	2.60E-02	7.51E-04
63	17	1.61E-02	2.68E-02	7.97E-04
63	17	1.58E-02	2.63E-02	7.67E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
63	17	1.57E-02	2.72E-02	8.14E-04
63	17	1.54E-02	2.66E-02	7.83E-04
63	17	1.53E-02	2.75E-02	8.30E-04
63	17	1.50E-02	2.69E-02	7.99E-04
63	17	1.48E-02	2.78E-02	8.47E-04
63	17	1.46E-02	2.72E-02	8.15E-04
63	18	1.48E-02	2.78E-02	8.47E-04
63	18	1.46E-02	2.72E-02	8.15E-04
63	18	1.44E-02	2.81E-02	8.63E-04
63	18	1.41E-02	2.75E-02	8.30E-04
63	18	1.40E-02	2.83E-02	8.78E-04
63	18	1.37E-02	2.78E-02	8.45E-04
63	18	1.36E-02	2.86E-02	8.94E-04
63	18	1.33E-02	2.81E-02	8.60E-04
63	18	1.31E-02	2.89E-02	9.09E-04
63	18	1.29E-02	2.83E-02	8.75E-04
63	18	1.27E-02	2.92E-02	9.23E-04
63	18	1.25E-02	2.86E-02	8.89E-04
63	18	1.23E-02	2.94E-02	9.38E-04
63	18	1.20E-02	2.88E-02	9.03E-04
63	18	1.18E-02	2.96E-02	9.52E-04
63	18	1.16E-02	2.91E-02	9.16E-04
63	19	1.18E-02	2.96E-02	9.52E-04
63	19	1.16E-02	2.91E-02	9.16E-04
63	19	1.14E-02	2.99E-02	9.65E-04
63	19	1.12E-02	2.93E-02	9.29E-04
63	19	1.09E-02	3.01E-02	9.78E-04
63	19	1.07E-02	2.95E-02	9.42E-04
63	19	1.05E-02	3.03E-02	9.91E-04
63	19	1.03E-02	2.97E-02	9.54E-04
63	19	1.00E-02	3.05E-02	1.00E-03
63	19	9.83E-03	2.99E-02	9.65E-04
63	19	9.57E-03	3.07E-02	1.01E-03
63	19	9.38E-03	3.01E-02	9.77E-04
63	19	9.11E-03	3.09E-02	1.03E-03
63	19	8.93E-03	3.03E-02	9.87E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
63	19	8.64E-03	3.11E-02	1.04E-03
63	19	8.48E-03	3.05E-02	9.98E-04
63	19	8.18E-03	3.13E-02	1.05E-03
63	19	8.02E-03	3.07E-02	1.01E-03
63	19	7.71E-03	3.14E-02	1.06E-03
63	19	7.56E-03	3.08E-02	1.02E-03
63	19	7.24E-03	3.16E-02	1.07E-03
63	19	7.10E-03	3.10E-02	1.03E-03
63	20	7.24E-03	3.16E-02	1.07E-03
63	20	7.10E-03	3.10E-02	1.03E-03
63	20	6.76E-03	3.17E-02	1.07E-03
63	20	6.63E-03	3.11E-02	1.03E-03
63	20	6.29E-03	3.18E-02	1.08E-03
63	20	6.17E-03	3.12E-02	1.04E-03
63	20	5.81E-03	3.20E-02	1.09E-03
63	20	5.70E-03	3.13E-02	1.05E-03
63	20	5.33E-03	3.21E-02	1.10E-03
63	20	5.23E-03	3.14E-02	1.06E-03
63	20	4.85E-03	3.22E-02	1.10E-03
63	20	4.76E-03	3.15E-02	1.06E-03
63	20	4.37E-03	3.23E-02	1.11E-03
63	20	4.29E-03	3.16E-02	1.07E-03
63	20	3.89E-03	3.23E-02	1.11E-03
63	20	3.81E-03	3.17E-02	1.07E-03
63	20	3.41E-03	3.24E-02	1.12E-03
63	20	3.34E-03	3.18E-02	1.08E-03
63	20	2.92E-03	3.25E-02	1.12E-03
63	20	2.86E-03	3.19E-02	1.08E-03
63	20	2.44E-03	3.25E-02	1.13E-03
63	20	2.39E-03	3.19E-02	1.08E-03
63	20	1.95E-03	3.26E-02	1.13E-03
63	20	1.91E-03	3.20E-02	1.09E-03
63	20	1.46E-03	3.26E-02	1.13E-03
63	20	1.43E-03	3.20E-02	1.09E-03
63	20	9.75E-04	3.26E-02	1.13E-03
63	20	9.56E-04	3.20E-02	1.09E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
63	20	4.88E-04	3.27E-02	1.13E-03
63	20	4.78E-04	3.20E-02	1.09E-03
63	20	1.31E-09	3.27E-02	1.13E-03
63	20	1.28E-09	3.20E-02	1.09E-03
64	21	2.88E-02	0.00E+00	9.76E-05
64	21	2.83E-02	0.00E+00	9.53E-05
64	21	2.88E-02	5.89E-04	9.79E-05
64	21	2.83E-02	5.78E-04	9.56E-05
64	21	2.88E-02	1.18E-03	9.89E-05
64	21	2.83E-02	1.16E-03	9.66E-05
64	21	2.88E-02	1.77E-03	1.01E-04
64	21	2.83E-02	1.73E-03	9.82E-05
64	21	2.88E-02	2.35E-03	1.03E-04
64	21	2.82E-02	2.31E-03	1.00E-04
64	21	2.87E-02	2.94E-03	1.06E-04
64	21	2.82E-02	2.88E-03	1.03E-04
64	21	2.87E-02	3.53E-03	1.10E-04
64	21	2.81E-02	3.46E-03	1.07E-04
64	21	2.86E-02	4.11E-03	1.14E-04
64	21	2.81E-02	4.03E-03	1.11E-04
64	21	2.85E-02	4.69E-03	1.19E-04
64	21	2.80E-02	4.61E-03	1.16E-04
64	21	2.85E-02	5.28E-03	1.25E-04
64	21	2.79E-02	5.18E-03	1.21E-04
64	21	2.84E-02	5.86E-03	1.31E-04
64	21	2.79E-02	5.75E-03	1.28E-04
64	21	2.83E-02	6.43E-03	1.38E-04
64	21	2.78E-02	6.31E-03	1.34E-04
64	21	2.82E-02	7.01E-03	1.46E-04
64	21	2.77E-02	6.88E-03	1.41E-04
64	21	2.81E-02	7.58E-03	1.54E-04
64	21	2.76E-02	7.44E-03	1.49E-04
64	21	2.80E-02	8.16E-03	1.63E-04
64	21	2.74E-02	8.00E-03	1.58E-04
64	21	2.78E-02	8.72E-03	1.72E-04
64	21	2.73E-02	8.56E-03	1.67E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
64	22	2.78E-02	8.72E-03	1.72E-04
64	22	2.73E-02	8.56E-03	1.67E-04
64	22	2.77E-02	9.29E-03	1.82E-04
64	22	2.72E-02	9.12E-03	1.76E-04
64	22	2.76E-02	9.85E-03	1.92E-04
64	22	2.70E-02	9.67E-03	1.87E-04
64	22	2.74E-02	1.04E-02	2.04E-04
64	22	2.69E-02	1.02E-02	1.97E-04
64	22	2.72E-02	1.10E-02	2.15E-04
64	22	2.67E-02	1.08E-02	2.08E-04
64	22	2.71E-02	1.15E-02	2.27E-04
64	22	2.66E-02	1.13E-02	2.20E-04
64	22	2.69E-02	1.21E-02	2.40E-04
64	22	2.64E-02	1.18E-02	2.32E-04
64	22	2.67E-02	1.26E-02	2.53E-04
64	22	2.62E-02	1.24E-02	2.45E-04
64	22	2.65E-02	1.32E-02	2.67E-04
64	22	2.60E-02	1.29E-02	2.58E-04
64	22	2.63E-02	1.37E-02	2.81E-04
64	22	2.58E-02	1.34E-02	2.72E-04
64	22	2.61E-02	1.42E-02	2.95E-04
64	22	2.56E-02	1.40E-02	2.86E-04
64	23	2.61E-02	1.42E-02	2.95E-04
64	23	2.56E-02	1.40E-02	2.86E-04
64	23	2.59E-02	1.48E-02	3.10E-04
64	23	2.54E-02	1.45E-02	3.00E-04
64	23	2.56E-02	1.53E-02	3.26E-04
64	23	2.52E-02	1.50E-02	3.15E-04
64	23	2.54E-02	1.58E-02	3.41E-04
64	23	2.49E-02	1.55E-02	3.30E-04
64	23	2.52E-02	1.63E-02	3.58E-04
64	23	2.47E-02	1.60E-02	3.46E-04
64	23	2.49E-02	1.68E-02	3.74E-04
64	23	2.45E-02	1.65E-02	3.61E-04
64	23	2.47E-02	1.73E-02	3.91E-04
64	23	2.42E-02	1.70E-02	3.78E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
64	23	2.44E-02	1.78E-02	4.08E-04
64	23	2.39E-02	1.75E-02	3.94E-04
64	24	2.44E-02	1.78E-02	4.08E-04
64	24	2.39E-02	1.75E-02	3.94E-04
64	24	2.41E-02	1.83E-02	4.25E-04
64	24	2.37E-02	1.80E-02	4.11E-04
64	24	2.38E-02	1.88E-02	4.43E-04
64	24	2.34E-02	1.85E-02	4.28E-04
64	24	2.35E-02	1.93E-02	4.61E-04
64	24	2.31E-02	1.89E-02	4.45E-04
64	24	2.33E-02	1.98E-02	4.79E-04
64	24	2.28E-02	1.94E-02	4.62E-04
64	24	2.29E-02	2.02E-02	4.97E-04
64	24	2.25E-02	1.99E-02	4.80E-04
64	24	2.26E-02	2.07E-02	5.15E-04
64	24	2.22E-02	2.03E-02	4.98E-04
64	24	2.23E-02	2.11E-02	5.34E-04
64	24	2.19E-02	2.08E-02	5.15E-04
64	24	2.20E-02	2.16E-02	5.53E-04
64	24	2.16E-02	2.12E-02	5.33E-04
64	25	2.20E-02	2.16E-02	5.53E-04
64	25	2.16E-02	2.12E-02	5.33E-04
64	25	2.17E-02	2.20E-02	5.71E-04
64	25	2.13E-02	2.16E-02	5.52E-04
64	25	2.13E-02	2.25E-02	5.90E-04
64	25	2.09E-02	2.21E-02	5.70E-04
64	25	2.10E-02	2.29E-02	6.09E-04
64	25	2.06E-02	2.25E-02	5.88E-04
64	25	2.06E-02	2.33E-02	6.28E-04
64	25	2.03E-02	2.29E-02	6.06E-04
64	25	2.03E-02	2.37E-02	6.47E-04
64	25	1.99E-02	2.33E-02	6.25E-04
64	26	2.03E-02	2.37E-02	6.47E-04
64	26	1.99E-02	2.33E-02	6.25E-04
64	26	1.99E-02	2.41E-02	6.66E-04
64	26	1.96E-02	2.37E-02	6.43E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
64	26	1.96E-02	2.45E-02	6.85E-04
64	26	1.92E-02	2.41E-02	6.61E-04
64	26	1.92E-02	2.49E-02	7.04E-04
64	26	1.88E-02	2.45E-02	6.79E-04
64	26	1.88E-02	2.53E-02	7.23E-04
64	26	1.85E-02	2.48E-02	6.97E-04
64	26	1.84E-02	2.57E-02	7.41E-04
64	26	1.81E-02	2.52E-02	7.15E-04
64	27	1.84E-02	2.57E-02	7.41E-04
64	27	1.81E-02	2.52E-02	7.15E-04
64	27	1.80E-02	2.61E-02	7.60E-04
64	27	1.77E-02	2.56E-02	7.33E-04
64	27	1.76E-02	2.64E-02	7.78E-04
64	27	1.73E-02	2.59E-02	7.51E-04
64	27	1.72E-02	2.68E-02	7.97E-04
64	27	1.69E-02	2.63E-02	7.68E-04
64	27	1.68E-02	2.71E-02	8.15E-04
64	27	1.65E-02	2.66E-02	7.86E-04
64	27	1.64E-02	2.74E-02	8.32E-04
64	27	1.61E-02	2.69E-02	8.03E-04
64	27	1.60E-02	2.78E-02	8.50E-04
64	27	1.57E-02	2.73E-02	8.20E-04
64	27	1.56E-02	2.81E-02	8.67E-04
64	27	1.53E-02	2.76E-02	8.36E-04
64	27	1.52E-02	2.84E-02	8.84E-04
64	27	1.49E-02	2.79E-02	8.53E-04
64	28	1.52E-02	2.84E-02	8.84E-04
64	28	1.49E-02	2.79E-02	8.53E-04
64	28	1.47E-02	2.87E-02	9.01E-04
64	28	1.45E-02	2.82E-02	8.69E-04
64	28	1.43E-02	2.90E-02	9.17E-04
64	28	1.41E-02	2.85E-02	8.85E-04
64	28	1.39E-02	2.93E-02	9.33E-04
64	28	1.36E-02	2.87E-02	9.00E-04
64	28	1.34E-02	2.95E-02	9.49E-04
64	28	1.32E-02	2.90E-02	9.15E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
64	28	1.30E-02	2.98E-02	9.64E-04
64	28	1.28E-02	2.93E-02	9.30E-04
64	28	1.25E-02	3.01E-02	9.79E-04
64	28	1.23E-02	2.95E-02	9.45E-04
64	28	1.21E-02	3.03E-02	9.94E-04
64	28	1.19E-02	2.98E-02	9.59E-04
64	29	1.21E-02	3.03E-02	9.94E-04
64	29	1.19E-02	2.98E-02	9.59E-04
64	29	1.16E-02	3.06E-02	1.01E-03
64	29	1.14E-02	3.00E-02	9.72E-04
64	29	1.12E-02	3.08E-02	1.02E-03
64	29	1.10E-02	3.02E-02	9.85E-04
64	29	1.07E-02	3.10E-02	1.03E-03
64	29	1.05E-02	3.04E-02	9.98E-04
64	29	1.02E-02	3.12E-02	1.05E-03
64	29	1.01E-02	3.06E-02	1.01E-03
64	29	9.78E-03	3.14E-02	1.06E-03
64	29	9.60E-03	3.08E-02	1.02E-03
64	29	9.31E-03	3.16E-02	1.07E-03
64	29	9.14E-03	3.10E-02	1.03E-03
64	29	8.84E-03	3.18E-02	1.08E-03
64	29	8.67E-03	3.12E-02	1.04E-03
64	29	8.36E-03	3.20E-02	1.09E-03
64	29	8.21E-03	3.14E-02	1.05E-03
64	29	7.88E-03	3.21E-02	1.10E-03
64	29	7.74E-03	3.15E-02	1.06E-03
64	29	7.40E-03	3.23E-02	1.11E-03
64	29	7.26E-03	3.17E-02	1.07E-03
64	30	7.40E-03	3.23E-02	1.11E-03
64	30	7.26E-03	3.17E-02	1.07E-03
64	30	6.91E-03	3.24E-02	1.12E-03
64	30	6.79E-03	3.18E-02	1.08E-03
64	30	6.43E-03	3.25E-02	1.13E-03
64	30	6.31E-03	3.20E-02	1.09E-03
64	30	5.94E-03	3.27E-02	1.14E-03
64	30	5.83E-03	3.21E-02	1.10E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
64	30	5.45E-03	3.28E-02	1.15E-03
64	30	5.35E-03	3.22E-02	1.11E-03
64	30	4.96E-03	3.29E-02	1.15E-03
64	30	4.87E-03	3.23E-02	1.11E-03
64	30	4.47E-03	3.30E-02	1.16E-03
64	30	4.39E-03	3.24E-02	1.12E-03
64	30	3.98E-03	3.31E-02	1.16E-03
64	30	3.90E-03	3.25E-02	1.12E-03
64	30	3.48E-03	3.31E-02	1.17E-03
64	30	3.42E-03	3.25E-02	1.13E-03
64	30	2.99E-03	3.32E-02	1.17E-03
64	30	2.93E-03	3.26E-02	1.13E-03
64	30	2.49E-03	3.33E-02	1.18E-03
64	30	2.44E-03	3.27E-02	1.13E-03
64	30	1.99E-03	3.33E-02	1.18E-03
64	30	1.96E-03	3.27E-02	1.14E-03
64	30	1.50E-03	3.33E-02	1.18E-03
64	30	1.47E-03	3.27E-02	1.14E-03
64	30	9.97E-04	3.34E-02	1.18E-03
64	30	9.79E-04	3.28E-02	1.14E-03
64	30	4.99E-04	3.34E-02	1.18E-03
64	30	4.89E-04	3.28E-02	1.14E-03
64	30	1.34E-09	3.34E-02	1.18E-03
64	30	1.31E-09	3.28E-02	1.14E-03
65	31	2.95E-02	0.00E+00	1.00E-04
65	31	2.89E-02	0.00E+00	9.81E-05
65	31	2.95E-02	6.02E-04	1.01E-04
65	31	2.89E-02	5.91E-04	9.84E-05
65	31	2.95E-02	1.20E-03	1.02E-04
65	31	2.89E-02	1.18E-03	9.94E-05
65	31	2.94E-02	1.80E-03	1.03E-04
65	31	2.89E-02	1.77E-03	1.01E-04
65	31	2.94E-02	2.41E-03	1.06E-04
65	31	2.89E-02	2.36E-03	1.04E-04
65	31	2.94E-02	3.00E-03	1.09E-04
65	31	2.88E-02	2.95E-03	1.07E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
65	31	2.93E-02	3.60E-03	1.13E-04
65	31	2.88E-02	3.54E-03	1.10E-04
65	31	2.92E-02	4.20E-03	1.18E-04
65	31	2.87E-02	4.13E-03	1.15E-04
65	31	2.92E-02	4.80E-03	1.23E-04
65	31	2.87E-02	4.71E-03	1.20E-04
65	31	2.91E-02	5.39E-03	1.29E-04
65	31	2.86E-02	5.30E-03	1.25E-04
65	31	2.90E-02	5.99E-03	1.35E-04
65	31	2.85E-02	5.88E-03	1.32E-04
65	31	2.89E-02	6.58E-03	1.43E-04
65	31	2.84E-02	6.46E-03	1.39E-04
65	31	2.88E-02	7.17E-03	1.50E-04
65	31	2.83E-02	7.04E-03	1.46E-04
65	31	2.87E-02	7.75E-03	1.59E-04
65	31	2.82E-02	7.61E-03	1.55E-04
65	31	2.86E-02	8.34E-03	1.68E-04
65	31	2.81E-02	8.19E-03	1.64E-04
65	31	2.84E-02	8.92E-03	1.78E-04
65	31	2.79E-02	8.76E-03	1.73E-04
65	32	2.84E-02	8.92E-03	1.78E-04
65	32	2.79E-02	8.76E-03	1.73E-04
65	32	2.83E-02	9.50E-03	1.88E-04
65	32	2.78E-02	9.33E-03	1.83E-04
65	32	2.82E-02	1.01E-02	1.99E-04
65	32	2.77E-02	9.89E-03	1.94E-04
65	32	2.80E-02	1.06E-02	2.11E-04
65	32	2.75E-02	1.05E-02	2.05E-04
65	32	2.78E-02	1.12E-02	2.23E-04
65	32	2.73E-02	1.10E-02	2.17E-04
65	32	2.77E-02	1.18E-02	2.36E-04
65	32	2.72E-02	1.16E-02	2.29E-04
65	32	2.75E-02	1.23E-02	2.49E-04
65	32	2.70E-02	1.21E-02	2.42E-04
65	32	2.73E-02	1.29E-02	2.63E-04
65	32	2.68E-02	1.27E-02	2.55E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
65	32	2.71E-02	1.34E-02	2.77E-04
65	32	2.66E-02	1.32E-02	2.69E-04
65	32	2.69E-02	1.40E-02	2.92E-04
65	32	2.64E-02	1.37E-02	2.83E-04
65	32	2.67E-02	1.45E-02	3.07E-04
65	32	2.62E-02	1.43E-02	2.97E-04
65	33	2.67E-02	1.45E-02	3.07E-04
65	33	2.62E-02	1.43E-02	2.97E-04
65	33	2.64E-02	1.51E-02	3.23E-04
65	33	2.60E-02	1.48E-02	3.12E-04
65	33	2.62E-02	1.56E-02	3.39E-04
65	33	2.57E-02	1.53E-02	3.28E-04
65	33	2.60E-02	1.61E-02	3.55E-04
65	33	2.55E-02	1.59E-02	3.44E-04
65	33	2.57E-02	1.67E-02	3.72E-04
65	33	2.53E-02	1.64E-02	3.60E-04
65	33	2.55E-02	1.72E-02	3.89E-04
65	33	2.50E-02	1.69E-02	3.77E-04
65	33	2.52E-02	1.77E-02	4.07E-04
65	33	2.47E-02	1.74E-02	3.93E-04
65	33	2.49E-02	1.82E-02	4.25E-04
65	33	2.45E-02	1.79E-02	4.11E-04
65	34	2.49E-02	1.82E-02	4.25E-04
65	34	2.45E-02	1.79E-02	4.11E-04
65	34	2.46E-02	1.87E-02	4.43E-04
65	34	2.42E-02	1.84E-02	4.28E-04
65	34	2.44E-02	1.92E-02	4.61E-04
65	34	2.39E-02	1.89E-02	4.46E-04
65	34	2.41E-02	1.97E-02	4.80E-04
65	34	2.36E-02	1.94E-02	4.64E-04
65	34	2.38E-02	2.02E-02	4.99E-04
65	34	2.33E-02	1.98E-02	4.82E-04
65	34	2.35E-02	2.07E-02	5.18E-04
65	34	2.30E-02	2.03E-02	5.00E-04
65	34	2.31E-02	2.11E-02	5.37E-04
65	34	2.27E-02	2.08E-02	5.19E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
65	34	2.28E-02	2.16E-02	5.56E-04
65	34	2.24E-02	2.12E-02	5.38E-04
65	34	2.25E-02	2.21E-02	5.76E-04
65	34	2.21E-02	2.17E-02	5.57E-04
65	35	2.25E-02	2.21E-02	5.76E-04
65	35	2.21E-02	2.17E-02	5.57E-04
65	35	2.21E-02	2.25E-02	5.96E-04
65	35	2.18E-02	2.21E-02	5.76E-04
65	35	2.18E-02	2.30E-02	6.15E-04
65	35	2.14E-02	2.26E-02	5.95E-04
65	35	2.15E-02	2.34E-02	6.35E-04
65	35	2.11E-02	2.30E-02	6.14E-04
65	35	2.11E-02	2.38E-02	6.55E-04
65	35	2.07E-02	2.34E-02	6.33E-04
65	35	2.07E-02	2.42E-02	6.75E-04
65	35	2.04E-02	2.38E-02	6.52E-04
65	36	2.07E-02	2.42E-02	6.75E-04
65	36	2.04E-02	2.38E-02	6.52E-04
65	36	2.04E-02	2.47E-02	6.94E-04
65	36	2.00E-02	2.42E-02	6.71E-04
65	36	2.00E-02	2.51E-02	7.14E-04
65	36	1.96E-02	2.46E-02	6.90E-04
65	36	1.96E-02	2.55E-02	7.34E-04
65	36	1.93E-02	2.50E-02	7.09E-04
65	36	1.92E-02	2.59E-02	7.53E-04
65	36	1.89E-02	2.54E-02	7.28E-04
65	36	1.88E-02	2.62E-02	7.73E-04
65	36	1.85E-02	2.58E-02	7.47E-04
65	37	1.88E-02	2.62E-02	7.73E-04
65	37	1.85E-02	2.58E-02	7.47E-04
65	37	1.84E-02	2.66E-02	7.92E-04
65	37	1.81E-02	2.61E-02	7.65E-04
65	37	1.80E-02	2.70E-02	8.12E-04
65	37	1.77E-02	2.65E-02	7.84E-04
65	37	1.76E-02	2.73E-02	8.31E-04
65	37	1.73E-02	2.69E-02	8.02E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
65	37	1.72E-02	2.77E-02	8.49E-04
65	37	1.69E-02	2.72E-02	8.20E-04
65	37	1.68E-02	2.80E-02	8.68E-04
65	37	1.65E-02	2.75E-02	8.38E-04
65	37	1.64E-02	2.84E-02	8.86E-04
65	37	1.61E-02	2.79E-02	8.56E-04
65	37	1.59E-02	2.87E-02	9.04E-04
65	37	1.57E-02	2.82E-02	8.74E-04
65	37	1.55E-02	2.90E-02	9.22E-04
65	37	1.52E-02	2.85E-02	8.91E-04
65	38	1.55E-02	2.90E-02	9.22E-04
65	38	1.52E-02	2.85E-02	8.91E-04
65	38	1.51E-02	2.93E-02	9.40E-04
65	38	1.48E-02	2.88E-02	9.08E-04
65	38	1.46E-02	2.96E-02	9.57E-04
65	38	1.44E-02	2.91E-02	9.24E-04
65	38	1.42E-02	2.99E-02	9.74E-04
65	38	1.39E-02	2.94E-02	9.40E-04
65	38	1.37E-02	3.02E-02	9.90E-04
65	38	1.35E-02	2.97E-02	9.56E-04
65	38	1.33E-02	3.05E-02	1.01E-03
65	38	1.30E-02	2.99E-02	9.72E-04
65	38	1.28E-02	3.07E-02	1.02E-03
65	38	1.26E-02	3.02E-02	9.87E-04
65	38	1.24E-02	3.10E-02	1.04E-03
65	38	1.21E-02	3.04E-02	1.00E-03
65	39	1.24E-02	3.10E-02	1.04E-03
65	39	1.21E-02	3.04E-02	1.00E-03
65	39	1.19E-02	3.12E-02	1.05E-03
65	39	1.17E-02	3.07E-02	1.02E-03
65	39	1.14E-02	3.14E-02	1.07E-03
65	39	1.12E-02	3.09E-02	1.03E-03
65	39	1.09E-02	3.17E-02	1.08E-03
65	39	1.08E-02	3.11E-02	1.04E-03
65	39	1.05E-02	3.19E-02	1.09E-03
65	39	1.03E-02	3.13E-02	1.06E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
65	39	9.99E-03	3.21E-02	1.11E-03
65	39	9.82E-03	3.15E-02	1.07E-03
65	39	9.51E-03	3.23E-02	1.12E-03
65	39	9.34E-03	3.17E-02	1.08E-03
65	39	9.03E-03	3.25E-02	1.13E-03
65	39	8.87E-03	3.19E-02	1.09E-03
65	39	8.54E-03	3.26E-02	1.14E-03
65	39	8.39E-03	3.21E-02	1.10E-03
65	39	8.05E-03	3.28E-02	1.15E-03
65	39	7.91E-03	3.22E-02	1.11E-03
65	39	7.56E-03	3.30E-02	1.16E-03
65	39	7.43E-03	3.24E-02	1.12E-03
65	40	7.56E-03	3.30E-02	1.16E-03
65	40	7.43E-03	3.24E-02	1.12E-03
65	40	7.06E-03	3.31E-02	1.17E-03
65	40	6.94E-03	3.25E-02	1.13E-03
65	40	6.57E-03	3.33E-02	1.18E-03
65	40	6.45E-03	3.27E-02	1.14E-03
65	40	6.07E-03	3.34E-02	1.19E-03
65	40	5.96E-03	3.28E-02	1.15E-03
65	40	5.57E-03	3.35E-02	1.20E-03
65	40	5.47E-03	3.29E-02	1.15E-03
65	40	5.07E-03	3.36E-02	1.20E-03
65	40	4.98E-03	3.30E-02	1.16E-03
65	40	4.57E-03	3.37E-02	1.21E-03
65	40	4.49E-03	3.31E-02	1.17E-03
65	40	4.06E-03	3.38E-02	1.21E-03
65	40	3.99E-03	3.32E-02	1.17E-03
65	40	3.56E-03	3.39E-02	1.22E-03
65	40	3.49E-03	3.33E-02	1.18E-03
65	40	3.05E-03	3.39E-02	1.22E-03
65	40	3.00E-03	3.33E-02	1.18E-03
65	40	2.54E-03	3.40E-02	1.23E-03
65	40	2.50E-03	3.34E-02	1.19E-03
65	40	2.04E-03	3.40E-02	1.23E-03
65	40	2.00E-03	3.34E-02	1.19E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
65	40	1.53E-03	3.41E-02	1.23E-03
65	40	1.50E-03	3.35E-02	1.19E-03
65	40	1.02E-03	3.41E-02	1.23E-03
65	40	1.00E-03	3.35E-02	1.19E-03
65	40	5.09E-04	3.41E-02	1.24E-03
65	40	5.00E-04	3.35E-02	1.19E-03
65	40	1.37E-09	3.41E-02	1.24E-03
65	40	1.34E-09	3.35E-02	1.19E-03
66	41	3.01E-02	0.00E+00	1.03E-04
66	41	2.96E-02	0.00E+00	1.01E-04
66	41	3.01E-02	6.14E-04	1.03E-04
66	41	2.96E-02	6.04E-04	1.01E-04
66	41	3.01E-02	1.23E-03	1.04E-04
66	41	2.96E-02	1.21E-03	1.02E-04
66	41	3.01E-02	1.84E-03	1.06E-04
66	41	2.95E-02	1.81E-03	1.04E-04
66	41	3.00E-02	2.46E-03	1.09E-04
66	41	2.95E-02	2.41E-03	1.06E-04
66	41	3.00E-02	3.07E-03	1.12E-04
66	41	2.95E-02	3.02E-03	1.10E-04
66	41	2.99E-02	3.68E-03	1.16E-04
66	41	2.94E-02	3.62E-03	1.13E-04
66	41	2.99E-02	4.29E-03	1.21E-04
66	41	2.93E-02	4.22E-03	1.18E-04
66	41	2.98E-02	4.90E-03	1.26E-04
66	41	2.93E-02	4.81E-03	1.23E-04
66	41	2.97E-02	5.51E-03	1.32E-04
66	41	2.92E-02	5.41E-03	1.29E-04
66	41	2.96E-02	6.11E-03	1.39E-04
66	41	2.91E-02	6.01E-03	1.36E-04
66	41	2.95E-02	6.72E-03	1.47E-04
66	41	2.90E-02	6.60E-03	1.43E-04
66	41	2.94E-02	7.32E-03	1.55E-04
66	41	2.89E-02	7.19E-03	1.51E-04
66	41	2.93E-02	7.92E-03	1.64E-04
66	41	2.88E-02	7.78E-03	1.60E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
66	41	2.92E-02	8.51E-03	1.74E-04
66	41	2.87E-02	8.36E-03	1.69E-04
66	41	2.90E-02	9.11E-03	1.84E-04
66	41	2.85E-02	8.95E-03	1.79E-04
66	42	2.90E-02	9.11E-03	1.84E-04
66	42	2.85E-02	8.95E-03	1.79E-04
66	42	2.89E-02	9.70E-03	1.95E-04
66	42	2.84E-02	9.53E-03	1.89E-04
66	42	2.88E-02	1.03E-02	2.06E-04
66	42	2.83E-02	1.01E-02	2.01E-04
66	42	2.86E-02	1.09E-02	2.18E-04
66	42	2.81E-02	1.07E-02	2.12E-04
66	42	2.84E-02	1.14E-02	2.31E-04
66	42	2.79E-02	1.13E-02	2.24E-04
66	42	2.82E-02	1.20E-02	2.44E-04
66	42	2.78E-02	1.18E-02	2.37E-04
66	42	2.81E-02	1.26E-02	2.58E-04
66	42	2.76E-02	1.24E-02	2.51E-04
66	42	2.79E-02	1.32E-02	2.72E-04
66	42	2.74E-02	1.29E-02	2.64E-04
66	42	2.77E-02	1.37E-02	2.87E-04
66	42	2.72E-02	1.35E-02	2.79E-04
66	42	2.74E-02	1.43E-02	3.03E-04
66	42	2.70E-02	1.40E-02	2.94E-04
66	42	2.72E-02	1.48E-02	3.19E-04
66	42	2.68E-02	1.46E-02	3.09E-04
66	43	2.72E-02	1.48E-02	3.19E-04
66	43	2.68E-02	1.46E-02	3.09E-04
66	43	2.70E-02	1.54E-02	3.35E-04
66	43	2.65E-02	1.51E-02	3.25E-04
66	43	2.68E-02	1.59E-02	3.52E-04
66	43	2.63E-02	1.57E-02	3.41E-04
66	43	2.65E-02	1.65E-02	3.69E-04
66	43	2.61E-02	1.62E-02	3.57E-04
66	43	2.63E-02	1.70E-02	3.86E-04
66	43	2.58E-02	1.67E-02	3.74E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
66	43	2.60E-02	1.76E-02	4.04E-04
66	43	2.55E-02	1.73E-02	3.92E-04
66	43	2.57E-02	1.81E-02	4.22E-04
66	43	2.53E-02	1.78E-02	4.09E-04
66	43	2.54E-02	1.86E-02	4.41E-04
66	43	2.50E-02	1.83E-02	4.27E-04
66	44	2.54E-02	1.86E-02	4.41E-04
66	44	2.50E-02	1.83E-02	4.27E-04
66	44	2.52E-02	1.91E-02	4.60E-04
66	44	2.47E-02	1.88E-02	4.45E-04
66	44	2.49E-02	1.96E-02	4.79E-04
66	44	2.44E-02	1.93E-02	4.64E-04
66	44	2.46E-02	2.01E-02	4.99E-04
66	44	2.41E-02	1.98E-02	4.83E-04
66	44	2.43E-02	2.06E-02	5.18E-04
66	44	2.38E-02	2.03E-02	5.02E-04
66	44	2.39E-02	2.11E-02	5.38E-04
66	44	2.35E-02	2.07E-02	5.21E-04
66	44	2.36E-02	2.16E-02	5.58E-04
66	44	2.32E-02	2.12E-02	5.40E-04
66	44	2.33E-02	2.21E-02	5.79E-04
66	44	2.29E-02	2.17E-02	5.60E-04
66	44	2.30E-02	2.25E-02	5.99E-04
66	44	2.26E-02	2.21E-02	5.80E-04
66	45	2.30E-02	2.25E-02	5.99E-04
66	45	2.26E-02	2.21E-02	5.80E-04
66	45	2.26E-02	2.30E-02	6.19E-04
66	45	2.22E-02	2.26E-02	5.99E-04
66	45	2.23E-02	2.34E-02	6.40E-04
66	45	2.19E-02	2.30E-02	6.19E-04
66	45	2.19E-02	2.39E-02	6.61E-04
66	45	2.15E-02	2.35E-02	6.39E-04
66	45	2.15E-02	2.43E-02	6.81E-04
66	45	2.12E-02	2.39E-02	6.59E-04
66	45	2.12E-02	2.48E-02	7.02E-04
66	45	2.08E-02	2.43E-02	6.79E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
66	46	2.12E-02	2.48E-02	7.02E-04
66	46	2.08E-02	2.43E-02	6.79E-04
66	46	2.08E-02	2.52E-02	7.22E-04
66	46	2.04E-02	2.47E-02	6.99E-04
66	46	2.04E-02	2.56E-02	7.43E-04
66	46	2.01E-02	2.52E-02	7.19E-04
66	46	2.00E-02	2.60E-02	7.64E-04
66	46	1.97E-02	2.56E-02	7.39E-04
66	46	1.96E-02	2.64E-02	7.84E-04
66	46	1.93E-02	2.59E-02	7.58E-04
66	46	1.92E-02	2.68E-02	8.04E-04
66	46	1.89E-02	2.63E-02	7.78E-04
66	47	1.92E-02	2.68E-02	8.04E-04
66	47	1.89E-02	2.63E-02	7.78E-04
66	47	1.88E-02	2.72E-02	8.25E-04
66	47	1.85E-02	2.67E-02	7.98E-04
66	47	1.84E-02	2.76E-02	8.45E-04
66	47	1.81E-02	2.71E-02	8.17E-04
66	47	1.80E-02	2.79E-02	8.64E-04
66	47	1.77E-02	2.74E-02	8.36E-04
66	47	1.76E-02	2.83E-02	8.84E-04
66	47	1.73E-02	2.78E-02	8.55E-04
66	47	1.71E-02	2.86E-02	9.03E-04
66	47	1.68E-02	2.81E-02	8.74E-04
66	47	1.67E-02	2.90E-02	9.22E-04
66	47	1.64E-02	2.85E-02	8.92E-04
66	47	1.63E-02	2.93E-02	9.41E-04
66	47	1.60E-02	2.88E-02	9.10E-04
66	47	1.58E-02	2.96E-02	9.60E-04
66	47	1.56E-02	2.91E-02	9.28E-04
66	48	1.58E-02	2.96E-02	9.60E-04
66	48	1.56E-02	2.91E-02	9.28E-04
66	48	1.54E-02	2.99E-02	9.78E-04
66	48	1.51E-02	2.94E-02	9.46E-04
66	48	1.49E-02	3.02E-02	9.96E-04
66	48	1.47E-02	2.97E-02	9.63E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
66	48	1.45E-02	3.05E-02	1.01E-03
66	48	1.42E-02	3.00E-02	9.80E-04
66	48	1.40E-02	3.08E-02	1.03E-03
66	48	1.38E-02	3.03E-02	9.96E-04
66	48	1.36E-02	3.11E-02	1.05E-03
66	48	1.33E-02	3.06E-02	1.01E-03
66	48	1.31E-02	3.14E-02	1.06E-03
66	48	1.29E-02	3.08E-02	1.03E-03
66	48	1.26E-02	3.16E-02	1.08E-03
66	48	1.24E-02	3.11E-02	1.04E-03
66	49	1.26E-02	3.16E-02	1.08E-03
66	49	1.24E-02	3.11E-02	1.04E-03
66	49	1.21E-02	3.19E-02	1.09E-03
66	49	1.19E-02	3.13E-02	1.06E-03
66	49	1.17E-02	3.21E-02	1.11E-03
66	49	1.15E-02	3.16E-02	1.07E-03
66	49	1.12E-02	3.23E-02	1.12E-03
66	49	1.10E-02	3.18E-02	1.09E-03
66	49	1.07E-02	3.25E-02	1.14E-03
66	49	1.05E-02	3.20E-02	1.10E-03
66	49	1.02E-02	3.28E-02	1.15E-03
66	49	1.00E-02	3.22E-02	1.11E-03
66	49	9.71E-03	3.30E-02	1.16E-03
66	49	9.54E-03	3.24E-02	1.13E-03
66	49	9.21E-03	3.31E-02	1.18E-03
66	49	9.06E-03	3.26E-02	1.14E-03
66	49	8.72E-03	3.33E-02	1.19E-03
66	49	8.57E-03	3.28E-02	1.15E-03
66	49	8.22E-03	3.35E-02	1.20E-03
66	49	8.08E-03	3.29E-02	1.16E-03
66	49	7.71E-03	3.37E-02	1.21E-03
66	49	7.58E-03	3.31E-02	1.17E-03
66	50	7.71E-03	3.37E-02	1.21E-03
66	50	7.58E-03	3.31E-02	1.17E-03
66	50	7.21E-03	3.38E-02	1.22E-03
66	50	7.09E-03	3.32E-02	1.18E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
66	50	6.70E-03	3.39E-02	1.23E-03
66	50	6.59E-03	3.34E-02	1.19E-03
66	50	6.20E-03	3.41E-02	1.24E-03
66	50	6.09E-03	3.35E-02	1.20E-03
66	50	5.69E-03	3.42E-02	1.24E-03
66	50	5.59E-03	3.36E-02	1.20E-03
66	50	5.17E-03	3.43E-02	1.25E-03
66	50	5.09E-03	3.37E-02	1.21E-03
66	50	4.66E-03	3.44E-02	1.26E-03
66	50	4.58E-03	3.38E-02	1.22E-03
66	50	4.15E-03	3.45E-02	1.26E-03
66	50	4.08E-03	3.39E-02	1.22E-03
66	50	3.63E-03	3.46E-02	1.27E-03
66	50	3.57E-03	3.40E-02	1.23E-03
66	50	3.11E-03	3.46E-02	1.27E-03
66	50	3.06E-03	3.40E-02	1.23E-03
66	50	2.60E-03	3.47E-02	1.28E-03
66	50	2.55E-03	3.41E-02	1.24E-03
66	50	2.08E-03	3.47E-02	1.28E-03
66	50	2.04E-03	3.41E-02	1.24E-03
66	50	1.56E-03	3.48E-02	1.28E-03
66	50	1.53E-03	3.42E-02	1.24E-03
66	50	1.04E-03	3.48E-02	1.28E-03
66	50	1.02E-03	3.42E-02	1.24E-03
66	50	5.20E-04	3.48E-02	1.29E-03
66	50	5.11E-04	3.42E-02	1.24E-03
66	50	1.39E-09	3.48E-02	1.29E-03
66	50	1.37E-09	3.42E-02	1.24E-03
67	51	3.07E-02	0.00E+00	1.05E-04
67	51	3.02E-02	0.00E+00	1.03E-04
67	51	3.07E-02	6.27E-04	1.06E-04
67	51	3.02E-02	6.17E-04	1.04E-04
67	51	3.07E-02	1.25E-03	1.07E-04
67	51	3.02E-02	1.23E-03	1.05E-04
67	51	3.07E-02	1.88E-03	1.09E-04
67	51	3.02E-02	1.85E-03	1.07E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
67	51	3.06E-02	2.51E-03	1.11E-04
67	51	3.01E-02	2.46E-03	1.09E-04
67	51	3.06E-02	3.13E-03	1.15E-04
67	51	3.01E-02	3.08E-03	1.12E-04
67	51	3.05E-02	3.75E-03	1.19E-04
67	51	3.00E-02	3.69E-03	1.17E-04
67	51	3.05E-02	4.38E-03	1.24E-04
67	51	3.00E-02	4.30E-03	1.21E-04
67	51	3.04E-02	5.00E-03	1.30E-04
67	51	2.99E-02	4.92E-03	1.27E-04
67	51	3.03E-02	5.62E-03	1.36E-04
67	51	2.98E-02	5.52E-03	1.33E-04
67	51	3.02E-02	6.24E-03	1.43E-04
67	51	2.97E-02	6.13E-03	1.40E-04
67	51	3.01E-02	6.85E-03	1.51E-04
67	51	2.96E-02	6.74E-03	1.48E-04
67	51	3.00E-02	7.46E-03	1.60E-04
67	51	2.95E-02	7.34E-03	1.56E-04
67	51	2.99E-02	8.08E-03	1.69E-04
67	51	2.94E-02	7.94E-03	1.65E-04
67	51	2.98E-02	8.68E-03	1.79E-04
67	51	2.93E-02	8.54E-03	1.75E-04
67	51	2.96E-02	9.29E-03	1.90E-04
67	51	2.91E-02	9.14E-03	1.85E-04
67	52	2.96E-02	9.29E-03	1.90E-04
67	52	2.91E-02	9.14E-03	1.85E-04
67	52	2.95E-02	9.89E-03	2.01E-04
67	52	2.90E-02	9.73E-03	1.96E-04
67	52	2.93E-02	1.05E-02	2.13E-04
67	52	2.88E-02	1.03E-02	2.07E-04
67	52	2.92E-02	1.11E-02	2.26E-04
67	52	2.87E-02	1.09E-02	2.20E-04
67	52	2.90E-02	1.17E-02	2.39E-04
67	52	2.85E-02	1.15E-02	2.32E-04
67	52	2.88E-02	1.23E-02	2.53E-04
67	52	2.83E-02	1.21E-02	2.46E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
67	52	2.86E-02	1.29E-02	2.67E-04
67	52	2.82E-02	1.26E-02	2.60E-04
67	52	2.84E-02	1.34E-02	2.82E-04
67	52	2.80E-02	1.32E-02	2.74E-04
67	52	2.82E-02	1.40E-02	2.97E-04
67	52	2.77E-02	1.38E-02	2.89E-04
67	52	2.80E-02	1.46E-02	3.13E-04
67	52	2.75E-02	1.43E-02	3.04E-04
67	52	2.78E-02	1.51E-02	3.30E-04
67	52	2.73E-02	1.49E-02	3.20E-04
67	53	2.78E-02	1.51E-02	3.30E-04
67	53	2.73E-02	1.49E-02	3.20E-04
67	53	2.75E-02	1.57E-02	3.47E-04
67	53	2.71E-02	1.55E-02	3.37E-04
67	53	2.73E-02	1.63E-02	3.64E-04
67	53	2.68E-02	1.60E-02	3.54E-04
67	53	2.70E-02	1.68E-02	3.82E-04
67	53	2.66E-02	1.65E-02	3.71E-04
67	53	2.68E-02	1.74E-02	4.00E-04
67	53	2.63E-02	1.71E-02	3.89E-04
67	53	2.65E-02	1.79E-02	4.19E-04
67	53	2.61E-02	1.76E-02	4.07E-04
67	53	2.62E-02	1.84E-02	4.38E-04
67	53	2.58E-02	1.81E-02	4.25E-04
67	53	2.60E-02	1.90E-02	4.57E-04
67	53	2.55E-02	1.87E-02	4.44E-04
67	54	2.60E-02	1.90E-02	4.57E-04
67	54	2.55E-02	1.87E-02	4.44E-04
67	54	2.57E-02	1.95E-02	4.77E-04
67	54	2.52E-02	1.92E-02	4.63E-04
67	54	2.54E-02	2.00E-02	4.97E-04
67	54	2.50E-02	1.97E-02	4.82E-04
67	54	2.51E-02	2.05E-02	5.17E-04
67	54	2.46E-02	2.02E-02	5.02E-04
67	54	2.47E-02	2.10E-02	5.38E-04
67	54	2.43E-02	2.07E-02	5.22E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
67	54	2.44E-02	2.15E-02	5.59E-04
67	54	2.40E-02	2.12E-02	5.42E-04
67	54	2.41E-02	2.20E-02	5.79E-04
67	54	2.37E-02	2.17E-02	5.62E-04
67	54	2.38E-02	2.25E-02	6.00E-04
67	54	2.34E-02	2.21E-02	5.82E-04
67	54	2.34E-02	2.30E-02	6.22E-04
67	54	2.30E-02	2.26E-02	6.03E-04
67	55	2.34E-02	2.30E-02	6.22E-04
67	55	2.30E-02	2.26E-02	6.03E-04
67	55	2.31E-02	2.34E-02	6.43E-04
67	55	2.27E-02	2.31E-02	6.23E-04
67	55	2.27E-02	2.39E-02	6.64E-04
67	55	2.23E-02	2.35E-02	6.44E-04
67	55	2.23E-02	2.44E-02	6.86E-04
67	55	2.20E-02	2.40E-02	6.65E-04
67	55	2.20E-02	2.48E-02	7.07E-04
67	55	2.16E-02	2.44E-02	6.86E-04
67	55	2.16E-02	2.52E-02	7.29E-04
67	55	2.12E-02	2.48E-02	7.06E-04
67	56	2.16E-02	2.52E-02	7.29E-04
67	56	2.12E-02	2.48E-02	7.06E-04
67	56	2.12E-02	2.57E-02	7.50E-04
67	56	2.09E-02	2.53E-02	7.27E-04
67	56	2.08E-02	2.61E-02	7.72E-04
67	56	2.05E-02	2.57E-02	7.48E-04
67	56	2.04E-02	2.65E-02	7.93E-04
67	56	2.01E-02	2.61E-02	7.68E-04
67	56	2.00E-02	2.69E-02	8.14E-04
67	56	1.97E-02	2.65E-02	7.89E-04
67	56	1.96E-02	2.73E-02	8.35E-04
67	56	1.93E-02	2.69E-02	8.09E-04
67	57	1.96E-02	2.73E-02	8.35E-04
67	57	1.93E-02	2.69E-02	8.09E-04
67	57	1.92E-02	2.77E-02	8.56E-04
67	57	1.89E-02	2.73E-02	8.30E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
67	57	1.88E-02	2.81E-02	8.77E-04
67	57	1.85E-02	2.76E-02	8.50E-04
67	57	1.83E-02	2.85E-02	8.98E-04
67	57	1.81E-02	2.80E-02	8.70E-04
67	57	1.79E-02	2.88E-02	9.18E-04
67	57	1.76E-02	2.84E-02	8.90E-04
67	57	1.75E-02	2.92E-02	9.38E-04
67	57	1.72E-02	2.87E-02	9.09E-04
67	57	1.70E-02	2.95E-02	9.58E-04
67	57	1.68E-02	2.91E-02	9.28E-04
67	57	1.66E-02	2.99E-02	9.78E-04
67	57	1.63E-02	2.94E-02	9.47E-04
67	57	1.61E-02	3.02E-02	9.97E-04
67	57	1.59E-02	2.97E-02	9.66E-04
67	58	1.61E-02	3.02E-02	9.97E-04
67	58	1.59E-02	2.97E-02	9.66E-04
67	58	1.57E-02	3.05E-02	1.02E-03
67	58	1.54E-02	3.00E-02	9.84E-04
67	58	1.52E-02	3.08E-02	1.03E-03
67	58	1.50E-02	3.03E-02	1.00E-03
67	58	1.48E-02	3.11E-02	1.05E-03
67	58	1.45E-02	3.06E-02	1.02E-03
67	58	1.43E-02	3.14E-02	1.07E-03
67	58	1.41E-02	3.09E-02	1.04E-03
67	58	1.38E-02	3.17E-02	1.09E-03
67	58	1.36E-02	3.12E-02	1.05E-03
67	58	1.33E-02	3.20E-02	1.10E-03
67	58	1.31E-02	3.15E-02	1.07E-03
67	58	1.29E-02	3.22E-02	1.12E-03
67	58	1.27E-02	3.17E-02	1.09E-03
67	59	1.29E-02	3.22E-02	1.12E-03
67	59	1.27E-02	3.17E-02	1.09E-03
67	59	1.24E-02	3.25E-02	1.14E-03
67	59	1.22E-02	3.20E-02	1.10E-03
67	59	1.19E-02	3.27E-02	1.15E-03
67	59	1.17E-02	3.22E-02	1.12E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
67	59	1.14E-02	3.30E-02	1.17E-03
67	59	1.12E-02	3.24E-02	1.13E-03
67	59	1.09E-02	3.32E-02	1.18E-03
67	59	1.07E-02	3.27E-02	1.14E-03
67	59	1.04E-02	3.34E-02	1.20E-03
67	59	1.02E-02	3.29E-02	1.16E-03
67	59	9.90E-03	3.36E-02	1.21E-03
67	59	9.74E-03	3.31E-02	1.17E-03
67	59	9.40E-03	3.38E-02	1.22E-03
67	59	9.24E-03	3.33E-02	1.18E-03
67	59	8.89E-03	3.40E-02	1.23E-03
67	59	8.74E-03	3.34E-02	1.20E-03
67	59	8.38E-03	3.42E-02	1.25E-03
67	59	8.24E-03	3.36E-02	1.21E-03
67	59	7.87E-03	3.43E-02	1.26E-03
67	59	7.74E-03	3.38E-02	1.22E-03
67	60	7.87E-03	3.43E-02	1.26E-03
67	60	7.74E-03	3.38E-02	1.22E-03
67	60	7.35E-03	3.45E-02	1.27E-03
67	60	7.23E-03	3.39E-02	1.23E-03
67	60	6.84E-03	3.46E-02	1.28E-03
67	60	6.73E-03	3.41E-02	1.24E-03
67	60	6.32E-03	3.47E-02	1.28E-03
67	60	6.22E-03	3.42E-02	1.24E-03
67	60	5.80E-03	3.49E-02	1.29E-03
67	60	5.70E-03	3.43E-02	1.25E-03
67	60	5.28E-03	3.50E-02	1.30E-03
67	60	5.19E-03	3.44E-02	1.26E-03
67	60	4.75E-03	3.51E-02	1.31E-03
67	60	4.68E-03	3.45E-02	1.27E-03
67	60	4.23E-03	3.52E-02	1.31E-03
67	60	4.16E-03	3.46E-02	1.27E-03
67	60	3.70E-03	3.52E-02	1.32E-03
67	60	3.64E-03	3.47E-02	1.28E-03
67	60	3.18E-03	3.53E-02	1.32E-03
67	60	3.12E-03	3.47E-02	1.28E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
67	60	2.65E-03	3.54E-02	1.33E-03
67	60	2.60E-03	3.48E-02	1.29E-03
67	60	2.12E-03	3.54E-02	1.33E-03
67	60	2.08E-03	3.48E-02	1.29E-03
67	60	1.59E-03	3.55E-02	1.33E-03
67	60	1.56E-03	3.49E-02	1.29E-03
67	60	1.06E-03	3.55E-02	1.34E-03
67	60	1.04E-03	3.49E-02	1.29E-03
67	60	5.30E-04	3.55E-02	1.34E-03
67	60	5.22E-04	3.49E-02	1.29E-03
67	60	1.42E-09	3.55E-02	1.34E-03
67	60	1.40E-09	3.49E-02	1.29E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
68	1	3.13E-02	0.00E+00	1.07E-04
68	1	3.08E-02	0.00E+00	1.06E-04
68	1	3.13E-02	6.39E-04	1.08E-04
68	1	3.08E-02	6.29E-04	1.06E-04
68	1	3.13E-02	1.28E-03	1.09E-04
68	1	3.08E-02	1.26E-03	1.07E-04
68	1	3.13E-02	1.92E-03	1.11E-04
68	1	3.08E-02	1.89E-03	1.09E-04
68	1	3.12E-02	2.55E-03	1.14E-04
68	1	3.07E-02	2.51E-03	1.12E-04
68	1	3.12E-02	3.19E-03	1.17E-04
68	1	3.07E-02	3.14E-03	1.15E-04
68	1	3.11E-02	3.83E-03	1.22E-04
68	1	3.06E-02	3.77E-03	1.19E-04
68	1	3.11E-02	4.46E-03	1.27E-04
68	1	3.06E-02	4.39E-03	1.24E-04
68	1	3.10E-02	5.10E-03	1.33E-04
68	1	3.05E-02	5.01E-03	1.30E-04
68	1	3.09E-02	5.73E-03	1.40E-04
68	1	3.04E-02	5.64E-03	1.37E-04
68	1	3.08E-02	6.36E-03	1.47E-04
68	1	3.03E-02	6.26E-03	1.44E-04
68	1	3.07E-02	6.98E-03	1.55E-04
68	1	3.02E-02	6.87E-03	1.52E-04
68	1	3.06E-02	7.61E-03	1.64E-04
68	1	3.01E-02	7.49E-03	1.61E-04
68	1	3.05E-02	8.23E-03	1.74E-04
68	1	3.00E-02	8.10E-03	1.70E-04
68	1	3.03E-02	8.85E-03	1.84E-04
68	1	2.99E-02	8.71E-03	1.80E-04
68	1	3.02E-02	9.47E-03	1.95E-04
68	1	2.97E-02	9.32E-03	1.91E-04
68	2	3.02E-02	9.47E-03	1.95E-04
68	2	2.97E-02	9.32E-03	1.91E-04
68	2	3.01E-02	1.01E-02	2.07E-04
68	2	2.96E-02	9.92E-03	2.02E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
68	2	2.99E-02	1.07E-02	2.20E-04
68	2	2.94E-02	1.05E-02	2.14E-04
68	2	2.97E-02	1.13E-02	2.33E-04
68	2	2.93E-02	1.11E-02	2.27E-04
68	2	2.96E-02	1.19E-02	2.46E-04
68	2	2.91E-02	1.17E-02	2.40E-04
68	2	2.94E-02	1.25E-02	2.61E-04
68	2	2.89E-02	1.23E-02	2.54E-04
68	2	2.92E-02	1.31E-02	2.76E-04
68	2	2.87E-02	1.29E-02	2.68E-04
68	2	2.90E-02	1.37E-02	2.91E-04
68	2	2.85E-02	1.35E-02	2.83E-04
68	2	2.88E-02	1.43E-02	3.07E-04
68	2	2.83E-02	1.41E-02	2.99E-04
68	2	2.85E-02	1.49E-02	3.24E-04
68	2	2.81E-02	1.46E-02	3.15E-04
68	2	2.83E-02	1.54E-02	3.41E-04
68	2	2.79E-02	1.52E-02	3.32E-04
68	3	2.83E-02	1.54E-02	3.41E-04
68	3	2.79E-02	1.52E-02	3.32E-04
68	3	2.81E-02	1.60E-02	3.59E-04
68	3	2.76E-02	1.58E-02	3.49E-04
68	3	2.78E-02	1.66E-02	3.77E-04
68	3	2.74E-02	1.63E-02	3.66E-04
68	3	2.76E-02	1.71E-02	3.95E-04
68	3	2.71E-02	1.69E-02	3.84E-04
68	3	2.73E-02	1.77E-02	4.14E-04
68	3	2.69E-02	1.74E-02	4.03E-04
68	3	2.70E-02	1.83E-02	4.34E-04
68	3	2.66E-02	1.80E-02	4.22E-04
68	3	2.67E-02	1.88E-02	4.54E-04
68	3	2.63E-02	1.85E-02	4.41E-04
68	3	2.65E-02	1.93E-02	4.74E-04
68	3	2.60E-02	1.90E-02	4.60E-04
68	4	2.65E-02	1.93E-02	4.74E-04
68	4	2.60E-02	1.90E-02	4.60E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
68	4	2.62E-02	1.99E-02	4.94E-04
68	4	2.57E-02	1.96E-02	4.80E-04
68	4	2.59E-02	2.04E-02	5.15E-04
68	4	2.54E-02	2.01E-02	5.00E-04
68	4	2.55E-02	2.09E-02	5.36E-04
68	4	2.51E-02	2.06E-02	5.20E-04
68	4	2.52E-02	2.14E-02	5.57E-04
68	4	2.48E-02	2.11E-02	5.41E-04
68	4	2.49E-02	2.19E-02	5.79E-04
68	4	2.45E-02	2.16E-02	5.62E-04
68	4	2.46E-02	2.24E-02	6.01E-04
68	4	2.42E-02	2.21E-02	5.83E-04
68	4	2.42E-02	2.29E-02	6.22E-04
68	4	2.38E-02	2.26E-02	6.04E-04
68	4	2.39E-02	2.34E-02	6.45E-04
68	4	2.35E-02	2.31E-02	6.26E-04
68	5	2.39E-02	2.34E-02	6.45E-04
68	5	2.35E-02	2.31E-02	6.26E-04
68	5	2.35E-02	2.39E-02	6.67E-04
68	5	2.31E-02	2.35E-02	6.47E-04
68	5	2.31E-02	2.44E-02	6.89E-04
68	5	2.28E-02	2.40E-02	6.68E-04
68	5	2.28E-02	2.48E-02	7.11E-04
68	5	2.24E-02	2.44E-02	6.90E-04
68	5	2.24E-02	2.53E-02	7.34E-04
68	5	2.20E-02	2.49E-02	7.12E-04
68	5	2.20E-02	2.57E-02	7.56E-04
68	5	2.17E-02	2.53E-02	7.33E-04
68	6	2.20E-02	2.57E-02	7.56E-04
68	6	2.17E-02	2.53E-02	7.33E-04
68	6	2.16E-02	2.62E-02	7.78E-04
68	6	2.13E-02	2.58E-02	7.55E-04
68	6	2.12E-02	2.66E-02	8.00E-04
68	6	2.09E-02	2.62E-02	7.77E-04
68	6	2.08E-02	2.70E-02	8.23E-04
68	6	2.05E-02	2.66E-02	7.98E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
68	6	2.04E-02	2.74E-02	8.45E-04
68	6	2.01E-02	2.70E-02	8.19E-04
68	6	2.00E-02	2.79E-02	8.67E-04
68	6	1.97E-02	2.74E-02	8.41E-04
68	7	2.00E-02	2.79E-02	8.67E-04
68	7	1.97E-02	2.74E-02	8.41E-04
68	7	1.96E-02	2.83E-02	8.88E-04
68	7	1.93E-02	2.78E-02	8.62E-04
68	7	1.91E-02	2.86E-02	9.10E-04
68	7	1.88E-02	2.82E-02	8.83E-04
68	7	1.87E-02	2.90E-02	9.32E-04
68	7	1.84E-02	2.86E-02	9.04E-04
68	7	1.83E-02	2.94E-02	9.53E-04
68	7	1.80E-02	2.89E-02	9.24E-04
68	7	1.78E-02	2.98E-02	9.74E-04
68	7	1.75E-02	2.93E-02	9.44E-04
68	7	1.74E-02	3.01E-02	9.94E-04
68	7	1.71E-02	2.96E-02	9.64E-04
68	7	1.69E-02	3.05E-02	1.01E-03
68	7	1.66E-02	3.00E-02	9.84E-04
68	7	1.65E-02	3.08E-02	1.03E-03
68	7	1.62E-02	3.03E-02	1.00E-03
68	8	1.65E-02	3.08E-02	1.03E-03
68	8	1.62E-02	3.03E-02	1.00E-03
68	8	1.60E-02	3.11E-02	1.05E-03
68	8	1.57E-02	3.06E-02	1.02E-03
68	8	1.55E-02	3.14E-02	1.07E-03
68	8	1.53E-02	3.09E-02	1.04E-03
68	8	1.50E-02	3.17E-02	1.09E-03
68	8	1.48E-02	3.12E-02	1.06E-03
68	8	1.46E-02	3.20E-02	1.11E-03
68	8	1.43E-02	3.15E-02	1.08E-03
68	8	1.41E-02	3.23E-02	1.13E-03
68	8	1.39E-02	3.18E-02	1.09E-03
68	8	1.36E-02	3.26E-02	1.15E-03
68	8	1.34E-02	3.21E-02	1.11E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
68	8	1.31E-02	3.29E-02	1.16E-03
68	8	1.29E-02	3.23E-02	1.13E-03
68	9	1.31E-02	3.29E-02	1.16E-03
68	9	1.29E-02	3.23E-02	1.13E-03
68	9	1.26E-02	3.31E-02	1.18E-03
68	9	1.24E-02	3.26E-02	1.14E-03
68	9	1.21E-02	3.34E-02	1.20E-03
68	9	1.19E-02	3.28E-02	1.16E-03
68	9	1.16E-02	3.36E-02	1.21E-03
68	9	1.14E-02	3.31E-02	1.17E-03
68	9	1.11E-02	3.38E-02	1.23E-03
68	9	1.09E-02	3.33E-02	1.19E-03
68	9	1.06E-02	3.40E-02	1.24E-03
68	9	1.04E-02	3.35E-02	1.20E-03
68	9	1.01E-02	3.43E-02	1.25E-03
68	9	9.93E-03	3.37E-02	1.22E-03
68	9	9.57E-03	3.44E-02	1.27E-03
68	9	9.43E-03	3.39E-02	1.23E-03
68	9	9.06E-03	3.46E-02	1.28E-03
68	9	8.92E-03	3.41E-02	1.24E-03
68	9	8.54E-03	3.48E-02	1.29E-03
68	9	8.41E-03	3.43E-02	1.25E-03
68	9	8.02E-03	3.50E-02	1.30E-03
68	9	7.89E-03	3.44E-02	1.26E-03
68	10	8.02E-03	3.50E-02	1.30E-03
68	10	7.89E-03	3.44E-02	1.26E-03
68	10	7.49E-03	3.51E-02	1.31E-03
68	10	7.38E-03	3.46E-02	1.27E-03
68	10	6.97E-03	3.53E-02	1.32E-03
68	10	6.86E-03	3.47E-02	1.28E-03
68	10	6.44E-03	3.54E-02	1.33E-03
68	10	6.34E-03	3.49E-02	1.29E-03
68	10	5.91E-03	3.55E-02	1.34E-03
68	10	5.82E-03	3.50E-02	1.30E-03
68	10	5.38E-03	3.56E-02	1.35E-03
68	10	5.29E-03	3.51E-02	1.31E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
68	10	4.84E-03	3.57E-02	1.36E-03
68	10	4.77E-03	3.52E-02	1.32E-03
68	10	4.31E-03	3.58E-02	1.36E-03
68	10	4.24E-03	3.53E-02	1.32E-03
68	10	3.77E-03	3.59E-02	1.37E-03
68	10	3.71E-03	3.54E-02	1.33E-03
68	10	3.24E-03	3.60E-02	1.37E-03
68	10	3.19E-03	3.54E-02	1.33E-03
68	10	2.70E-03	3.60E-02	1.38E-03
68	10	2.66E-03	3.55E-02	1.34E-03
68	10	2.16E-03	3.61E-02	1.38E-03
68	10	2.13E-03	3.55E-02	1.34E-03
68	10	1.62E-03	3.61E-02	1.38E-03
68	10	1.59E-03	3.56E-02	1.34E-03
68	10	1.08E-03	3.62E-02	1.39E-03
68	10	1.06E-03	3.56E-02	1.34E-03
68	10	5.40E-04	3.62E-02	1.39E-03
68	10	5.32E-04	3.56E-02	1.34E-03
68	10	1.45E-09	3.62E-02	1.39E-03
68	10	1.43E-09	3.56E-02	1.35E-03
69	11	3.19E-02	0.00E+00	1.10E-04
69	11	3.14E-02	0.00E+00	1.08E-04
69	11	3.19E-02	6.51E-04	1.10E-04
69	11	3.14E-02	6.41E-04	1.08E-04
69	11	3.19E-02	1.30E-03	1.11E-04
69	11	3.14E-02	1.28E-03	1.09E-04
69	11	3.18E-02	1.95E-03	1.13E-04
69	11	3.14E-02	1.92E-03	1.11E-04
69	11	3.18E-02	2.60E-03	1.16E-04
69	11	3.13E-02	2.56E-03	1.14E-04
69	11	3.18E-02	3.25E-03	1.20E-04
69	11	3.13E-02	3.20E-03	1.18E-04
69	11	3.17E-02	3.90E-03	1.25E-04
69	11	3.12E-02	3.84E-03	1.22E-04
69	11	3.16E-02	4.55E-03	1.30E-04
69	11	3.12E-02	4.48E-03	1.27E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
69	11	3.16E-02	5.19E-03	1.36E-04
69	11	3.11E-02	5.11E-03	1.33E-04
69	11	3.15E-02	5.84E-03	1.43E-04
69	11	3.10E-02	5.75E-03	1.40E-04
69	11	3.14E-02	6.48E-03	1.51E-04
69	11	3.09E-02	6.38E-03	1.48E-04
69	11	3.13E-02	7.12E-03	1.59E-04
69	11	3.08E-02	7.01E-03	1.56E-04
69	11	3.12E-02	7.75E-03	1.69E-04
69	11	3.07E-02	7.63E-03	1.65E-04
69	11	3.11E-02	8.39E-03	1.79E-04
69	11	3.06E-02	8.26E-03	1.75E-04
69	11	3.09E-02	9.02E-03	1.89E-04
69	11	3.04E-02	8.88E-03	1.85E-04
69	11	3.08E-02	9.65E-03	2.01E-04
69	11	3.03E-02	9.50E-03	1.96E-04
69	12	3.08E-02	9.65E-03	2.01E-04
69	12	3.03E-02	9.50E-03	1.96E-04
69	12	3.06E-02	1.03E-02	2.13E-04
69	12	3.02E-02	1.01E-02	2.08E-04
69	12	3.05E-02	1.09E-02	2.26E-04
69	12	3.00E-02	1.07E-02	2.21E-04
69	12	3.03E-02	1.15E-02	2.40E-04
69	12	2.98E-02	1.13E-02	2.34E-04
69	12	3.01E-02	1.21E-02	2.54E-04
69	12	2.97E-02	1.19E-02	2.48E-04
69	12	2.99E-02	1.27E-02	2.69E-04
69	12	2.95E-02	1.25E-02	2.62E-04
69	12	2.97E-02	1.34E-02	2.84E-04
69	12	2.93E-02	1.31E-02	2.77E-04
69	12	2.95E-02	1.40E-02	3.01E-04
69	12	2.91E-02	1.37E-02	2.93E-04
69	12	2.93E-02	1.46E-02	3.17E-04
69	12	2.89E-02	1.43E-02	3.09E-04
69	12	2.91E-02	1.51E-02	3.35E-04
69	12	2.86E-02	1.49E-02	3.26E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
69	12	2.88E-02	1.57E-02	3.52E-04
69	12	2.84E-02	1.55E-02	3.43E-04
69	13	2.88E-02	1.57E-02	3.52E-04
69	13	2.84E-02	1.55E-02	3.43E-04
69	13	2.86E-02	1.63E-02	3.71E-04
69	13	2.82E-02	1.61E-02	3.61E-04
69	13	2.83E-02	1.69E-02	3.90E-04
69	13	2.79E-02	1.66E-02	3.79E-04
69	13	2.81E-02	1.75E-02	4.09E-04
69	13	2.77E-02	1.72E-02	3.98E-04
69	13	2.78E-02	1.80E-02	4.29E-04
69	13	2.74E-02	1.78E-02	4.17E-04
69	13	2.75E-02	1.86E-02	4.49E-04
69	13	2.71E-02	1.83E-02	4.36E-04
69	13	2.72E-02	1.92E-02	4.69E-04
69	13	2.68E-02	1.89E-02	4.56E-04
69	13	2.70E-02	1.97E-02	4.90E-04
69	13	2.65E-02	1.94E-02	4.77E-04
69	14	2.70E-02	1.97E-02	4.90E-04
69	14	2.65E-02	1.94E-02	4.77E-04
69	14	2.67E-02	2.02E-02	5.11E-04
69	14	2.62E-02	1.99E-02	4.97E-04
69	14	2.63E-02	2.08E-02	5.33E-04
69	14	2.59E-02	2.05E-02	5.18E-04
69	14	2.60E-02	2.13E-02	5.55E-04
69	14	2.56E-02	2.10E-02	5.39E-04
69	14	2.57E-02	2.18E-02	5.77E-04
69	14	2.53E-02	2.15E-02	5.61E-04
69	14	2.54E-02	2.24E-02	5.99E-04
69	14	2.50E-02	2.20E-02	5.82E-04
69	14	2.50E-02	2.29E-02	6.22E-04
69	14	2.46E-02	2.25E-02	6.04E-04
69	14	2.47E-02	2.34E-02	6.45E-04
69	14	2.43E-02	2.30E-02	6.26E-04
69	14	2.43E-02	2.39E-02	6.67E-04
69	14	2.39E-02	2.35E-02	6.48E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
69	15	2.43E-02	2.39E-02	6.67E-04
69	15	2.39E-02	2.35E-02	6.48E-04
69	15	2.39E-02	2.43E-02	6.90E-04
69	15	2.36E-02	2.40E-02	6.71E-04
69	15	2.36E-02	2.48E-02	7.13E-04
69	15	2.32E-02	2.44E-02	6.93E-04
69	15	2.32E-02	2.53E-02	7.37E-04
69	15	2.28E-02	2.49E-02	7.16E-04
69	15	2.28E-02	2.58E-02	7.60E-04
69	15	2.25E-02	2.54E-02	7.38E-04
69	15	2.24E-02	2.62E-02	7.83E-04
69	15	2.21E-02	2.58E-02	7.60E-04
69	16	2.24E-02	2.62E-02	7.83E-04
69	16	2.21E-02	2.58E-02	7.60E-04
69	16	2.20E-02	2.67E-02	8.06E-04
69	16	2.17E-02	2.63E-02	7.83E-04
69	16	2.16E-02	2.71E-02	8.29E-04
69	16	2.13E-02	2.67E-02	8.05E-04
69	16	2.12E-02	2.75E-02	8.52E-04
69	16	2.09E-02	2.71E-02	8.28E-04
69	16	2.08E-02	2.80E-02	8.75E-04
69	16	2.05E-02	2.75E-02	8.50E-04
69	16	2.04E-02	2.84E-02	8.98E-04
69	16	2.00E-02	2.79E-02	8.72E-04
69	17	2.04E-02	2.84E-02	8.98E-04
69	17	2.00E-02	2.79E-02	8.72E-04
69	17	1.99E-02	2.88E-02	9.21E-04
69	17	1.96E-02	2.83E-02	8.94E-04
69	17	1.95E-02	2.92E-02	9.43E-04
69	17	1.92E-02	2.87E-02	9.16E-04
69	17	1.90E-02	2.96E-02	9.65E-04
69	17	1.88E-02	2.91E-02	9.37E-04
69	17	1.86E-02	2.99E-02	9.87E-04
69	17	1.83E-02	2.95E-02	9.59E-04
69	17	1.81E-02	3.03E-02	1.01E-03
69	17	1.79E-02	2.98E-02	9.80E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
69	17	1.77E-02	3.07E-02	1.03E-03
69	17	1.74E-02	3.02E-02	1.00E-03
69	17	1.72E-02	3.10E-02	1.05E-03
69	17	1.70E-02	3.05E-02	1.02E-03
69	17	1.68E-02	3.14E-02	1.07E-03
69	17	1.65E-02	3.09E-02	1.04E-03
69	18	1.68E-02	3.14E-02	1.07E-03
69	18	1.65E-02	3.09E-02	1.04E-03
69	18	1.63E-02	3.17E-02	1.09E-03
69	18	1.60E-02	3.12E-02	1.06E-03
69	18	1.58E-02	3.20E-02	1.11E-03
69	18	1.56E-02	3.15E-02	1.08E-03
69	18	1.53E-02	3.23E-02	1.13E-03
69	18	1.51E-02	3.18E-02	1.10E-03
69	18	1.48E-02	3.26E-02	1.15E-03
69	18	1.46E-02	3.21E-02	1.12E-03
69	18	1.43E-02	3.29E-02	1.17E-03
69	18	1.41E-02	3.24E-02	1.14E-03
69	18	1.38E-02	3.32E-02	1.19E-03
69	18	1.36E-02	3.27E-02	1.15E-03
69	18	1.33E-02	3.35E-02	1.21E-03
69	18	1.31E-02	3.30E-02	1.17E-03
69	19	1.33E-02	3.35E-02	1.21E-03
69	19	1.31E-02	3.30E-02	1.17E-03
69	19	1.28E-02	3.37E-02	1.22E-03
69	19	1.27E-02	3.32E-02	1.19E-03
69	19	1.23E-02	3.40E-02	1.24E-03
69	19	1.22E-02	3.35E-02	1.20E-03
69	19	1.18E-02	3.42E-02	1.26E-03
69	19	1.16E-02	3.37E-02	1.22E-03
69	19	1.13E-02	3.45E-02	1.27E-03
69	19	1.11E-02	3.39E-02	1.23E-03
69	19	1.08E-02	3.47E-02	1.29E-03
69	19	1.06E-02	3.42E-02	1.25E-03
69	19	1.03E-02	3.49E-02	1.30E-03
69	19	1.01E-02	3.44E-02	1.26E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
69	19	9.75E-03	3.51E-02	1.31E-03
69	19	9.60E-03	3.46E-02	1.28E-03
69	19	9.23E-03	3.53E-02	1.33E-03
69	19	9.09E-03	3.47E-02	1.29E-03
69	19	8.70E-03	3.55E-02	1.34E-03
69	19	8.57E-03	3.49E-02	1.30E-03
69	19	8.16E-03	3.56E-02	1.35E-03
69	19	8.04E-03	3.51E-02	1.31E-03
69	20	8.16E-03	3.56E-02	1.35E-03
69	20	8.04E-03	3.51E-02	1.31E-03
69	20	7.63E-03	3.58E-02	1.36E-03
69	20	7.52E-03	3.52E-02	1.32E-03
69	20	7.09E-03	3.59E-02	1.37E-03
69	20	6.99E-03	3.54E-02	1.33E-03
69	20	6.56E-03	3.61E-02	1.38E-03
69	20	6.46E-03	3.55E-02	1.34E-03
69	20	6.02E-03	3.62E-02	1.39E-03
69	20	5.93E-03	3.56E-02	1.35E-03
69	20	5.48E-03	3.63E-02	1.40E-03
69	20	5.39E-03	3.58E-02	1.36E-03
69	20	4.93E-03	3.64E-02	1.41E-03
69	20	4.86E-03	3.59E-02	1.37E-03
69	20	4.39E-03	3.65E-02	1.41E-03
69	20	4.32E-03	3.59E-02	1.37E-03
69	20	3.84E-03	3.66E-02	1.42E-03
69	20	3.78E-03	3.60E-02	1.38E-03
69	20	3.30E-03	3.67E-02	1.42E-03
69	20	3.25E-03	3.61E-02	1.38E-03
69	20	2.75E-03	3.67E-02	1.43E-03
69	20	2.71E-03	3.62E-02	1.39E-03
69	20	2.20E-03	3.68E-02	1.43E-03
69	20	2.17E-03	3.62E-02	1.39E-03
69	20	1.65E-03	3.68E-02	1.43E-03
69	20	1.63E-03	3.62E-02	1.39E-03
69	20	1.10E-03	3.68E-02	1.44E-03
69	20	1.08E-03	3.63E-02	1.39E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
69	20	5.50E-04	3.68E-02	1.44E-03
69	20	5.42E-04	3.63E-02	1.40E-03
69	20	1.48E-09	3.68E-02	1.44E-03
69	20	1.45E-09	3.63E-02	1.40E-03
70	21	3.25E-02	0.00E+00	1.12E-04
70	21	3.20E-02	0.00E+00	1.10E-04
70	21	3.25E-02	6.63E-04	1.12E-04
70	21	3.20E-02	6.53E-04	1.10E-04
70	21	3.25E-02	1.33E-03	1.13E-04
70	21	3.20E-02	1.31E-03	1.12E-04
70	21	3.24E-02	1.99E-03	1.16E-04
70	21	3.19E-02	1.96E-03	1.14E-04
70	21	3.24E-02	2.65E-03	1.19E-04
70	21	3.19E-02	2.61E-03	1.17E-04
70	21	3.23E-02	3.31E-03	1.22E-04
70	21	3.19E-02	3.26E-03	1.20E-04
70	21	3.23E-02	3.97E-03	1.27E-04
70	21	3.18E-02	3.91E-03	1.25E-04
70	21	3.22E-02	4.63E-03	1.33E-04
70	21	3.17E-02	4.56E-03	1.30E-04
70	21	3.21E-02	5.29E-03	1.39E-04
70	21	3.17E-02	5.21E-03	1.37E-04
70	21	3.21E-02	5.94E-03	1.46E-04
70	21	3.16E-02	5.85E-03	1.44E-04
70	21	3.20E-02	6.60E-03	1.54E-04
70	21	3.15E-02	6.50E-03	1.51E-04
70	21	3.19E-02	7.25E-03	1.63E-04
70	21	3.14E-02	7.14E-03	1.60E-04
70	21	3.17E-02	7.90E-03	1.73E-04
70	21	3.13E-02	7.78E-03	1.69E-04
70	21	3.16E-02	8.54E-03	1.83E-04
70	21	3.12E-02	8.42E-03	1.79E-04
70	21	3.15E-02	9.19E-03	1.94E-04
70	21	3.10E-02	9.05E-03	1.90E-04
70	21	3.13E-02	9.83E-03	2.06E-04
70	21	3.09E-02	9.68E-03	2.02E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
70	22	3.13E-02	9.83E-03	2.06E-04
70	22	3.09E-02	9.68E-03	2.02E-04
70	22	3.12E-02	1.05E-02	2.19E-04
70	22	3.07E-02	1.03E-02	2.14E-04
70	22	3.10E-02	1.11E-02	2.33E-04
70	22	3.06E-02	1.09E-02	2.27E-04
70	22	3.08E-02	1.17E-02	2.47E-04
70	22	3.04E-02	1.16E-02	2.41E-04
70	22	3.07E-02	1.24E-02	2.61E-04
70	22	3.02E-02	1.22E-02	2.55E-04
70	22	3.05E-02	1.30E-02	2.77E-04
70	22	3.00E-02	1.28E-02	2.70E-04
70	22	3.03E-02	1.36E-02	2.93E-04
70	22	2.98E-02	1.34E-02	2.86E-04
70	22	3.01E-02	1.42E-02	3.10E-04
70	22	2.96E-02	1.40E-02	3.02E-04
70	22	2.98E-02	1.48E-02	3.27E-04
70	22	2.94E-02	1.46E-02	3.19E-04
70	22	2.96E-02	1.54E-02	3.45E-04
70	22	2.92E-02	1.52E-02	3.36E-04
70	22	2.94E-02	1.60E-02	3.64E-04
70	22	2.89E-02	1.58E-02	3.54E-04
70	23	2.94E-02	1.60E-02	3.64E-04
70	23	2.89E-02	1.58E-02	3.54E-04
70	23	2.91E-02	1.66E-02	3.83E-04
70	23	2.87E-02	1.64E-02	3.73E-04
70	23	2.89E-02	1.72E-02	4.02E-04
70	23	2.84E-02	1.70E-02	3.92E-04
70	23	2.86E-02	1.78E-02	4.22E-04
70	23	2.82E-02	1.75E-02	4.11E-04
70	23	2.83E-02	1.84E-02	4.43E-04
70	23	2.79E-02	1.81E-02	4.31E-04
70	23	2.80E-02	1.89E-02	4.63E-04
70	23	2.76E-02	1.87E-02	4.51E-04
70	23	2.77E-02	1.95E-02	4.85E-04
70	23	2.73E-02	1.92E-02	4.72E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
70	23	2.74E-02	2.01E-02	5.06E-04
70	23	2.70E-02	1.98E-02	4.93E-04
70	24	2.74E-02	2.01E-02	5.06E-04
70	24	2.70E-02	1.98E-02	4.93E-04
70	24	2.71E-02	2.06E-02	5.29E-04
70	24	2.67E-02	2.03E-02	5.14E-04
70	24	2.68E-02	2.12E-02	5.51E-04
70	24	2.64E-02	2.08E-02	5.36E-04
70	24	2.65E-02	2.17E-02	5.74E-04
70	24	2.61E-02	2.14E-02	5.58E-04
70	24	2.62E-02	2.22E-02	5.96E-04
70	24	2.58E-02	2.19E-02	5.80E-04
70	24	2.58E-02	2.28E-02	6.20E-04
70	24	2.54E-02	2.24E-02	6.03E-04
70	24	2.55E-02	2.33E-02	6.43E-04
70	24	2.51E-02	2.29E-02	6.26E-04
70	24	2.51E-02	2.38E-02	6.67E-04
70	24	2.47E-02	2.34E-02	6.48E-04
70	24	2.48E-02	2.43E-02	6.90E-04
70	24	2.44E-02	2.39E-02	6.71E-04
70	25	2.48E-02	2.43E-02	6.90E-04
70	25	2.44E-02	2.39E-02	6.71E-04
70	25	2.44E-02	2.48E-02	7.14E-04
70	25	2.40E-02	2.44E-02	6.95E-04
70	25	2.40E-02	2.53E-02	7.38E-04
70	25	2.36E-02	2.49E-02	7.18E-04
70	25	2.36E-02	2.58E-02	7.62E-04
70	25	2.33E-02	2.54E-02	7.41E-04
70	25	2.32E-02	2.62E-02	7.86E-04
70	25	2.29E-02	2.58E-02	7.64E-04
70	25	2.28E-02	2.67E-02	8.10E-04
70	25	2.25E-02	2.63E-02	7.88E-04
70	26	2.28E-02	2.67E-02	8.10E-04
70	26	2.25E-02	2.63E-02	7.88E-04
70	26	2.24E-02	2.72E-02	8.34E-04
70	26	2.21E-02	2.68E-02	8.11E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
70	26	2.20E-02	2.76E-02	8.58E-04
70	26	2.17E-02	2.72E-02	8.34E-04
70	26	2.16E-02	2.80E-02	8.82E-04
70	26	2.13E-02	2.76E-02	8.57E-04
70	26	2.12E-02	2.85E-02	9.06E-04
70	26	2.08E-02	2.80E-02	8.80E-04
70	26	2.07E-02	2.89E-02	9.29E-04
70	26	2.04E-02	2.85E-02	9.03E-04
70	27	2.07E-02	2.89E-02	9.29E-04
70	27	2.04E-02	2.85E-02	9.03E-04
70	27	2.03E-02	2.93E-02	9.53E-04
70	27	2.00E-02	2.89E-02	9.26E-04
70	27	1.98E-02	2.97E-02	9.76E-04
70	27	1.96E-02	2.93E-02	9.49E-04
70	27	1.94E-02	3.01E-02	9.99E-04
70	27	1.91E-02	2.97E-02	9.71E-04
70	27	1.89E-02	3.05E-02	1.02E-03
70	27	1.87E-02	3.00E-02	9.93E-04
70	27	1.85E-02	3.09E-02	1.04E-03
70	27	1.82E-02	3.04E-02	1.02E-03
70	27	1.80E-02	3.12E-02	1.07E-03
70	27	1.77E-02	3.08E-02	1.04E-03
70	27	1.75E-02	3.16E-02	1.09E-03
70	27	1.73E-02	3.11E-02	1.06E-03
70	27	1.71E-02	3.19E-02	1.11E-03
70	27	1.68E-02	3.15E-02	1.08E-03
70	28	1.71E-02	3.19E-02	1.11E-03
70	28	1.68E-02	3.15E-02	1.08E-03
70	28	1.66E-02	3.23E-02	1.13E-03
70	28	1.63E-02	3.18E-02	1.10E-03
70	28	1.61E-02	3.26E-02	1.15E-03
70	28	1.59E-02	3.21E-02	1.12E-03
70	28	1.56E-02	3.29E-02	1.17E-03
70	28	1.54E-02	3.24E-02	1.14E-03
70	28	1.51E-02	3.32E-02	1.19E-03
70	28	1.49E-02	3.27E-02	1.16E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
70	28	1.46E-02	3.35E-02	1.21E-03
70	28	1.44E-02	3.30E-02	1.18E-03
70	28	1.41E-02	3.38E-02	1.23E-03
70	28	1.39E-02	3.33E-02	1.20E-03
70	28	1.36E-02	3.41E-02	1.25E-03
70	28	1.34E-02	3.36E-02	1.21E-03
70	29	1.36E-02	3.41E-02	1.25E-03
70	29	1.34E-02	3.36E-02	1.21E-03
70	29	1.31E-02	3.43E-02	1.27E-03
70	29	1.29E-02	3.38E-02	1.23E-03
70	29	1.26E-02	3.46E-02	1.28E-03
70	29	1.24E-02	3.41E-02	1.25E-03
70	29	1.20E-02	3.48E-02	1.30E-03
70	29	1.19E-02	3.43E-02	1.26E-03
70	29	1.15E-02	3.51E-02	1.32E-03
70	29	1.13E-02	3.46E-02	1.28E-03
70	29	1.10E-02	3.53E-02	1.33E-03
70	29	1.08E-02	3.48E-02	1.29E-03
70	29	1.05E-02	3.55E-02	1.35E-03
70	29	1.03E-02	3.50E-02	1.31E-03
70	29	9.93E-03	3.57E-02	1.36E-03
70	29	9.78E-03	3.52E-02	1.32E-03
70	29	9.39E-03	3.59E-02	1.37E-03
70	29	9.25E-03	3.54E-02	1.34E-03
70	29	8.85E-03	3.61E-02	1.39E-03
70	29	8.72E-03	3.56E-02	1.35E-03
70	29	8.31E-03	3.63E-02	1.40E-03
70	29	8.19E-03	3.57E-02	1.36E-03
70	30	8.31E-03	3.63E-02	1.40E-03
70	30	8.19E-03	3.57E-02	1.36E-03
70	30	7.77E-03	3.64E-02	1.41E-03
70	30	7.65E-03	3.59E-02	1.37E-03
70	30	7.22E-03	3.66E-02	1.42E-03
70	30	7.12E-03	3.60E-02	1.38E-03
70	30	6.67E-03	3.67E-02	1.43E-03
70	30	6.58E-03	3.62E-02	1.39E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
70	30	6.12E-03	3.68E-02	1.44E-03
70	30	6.04E-03	3.63E-02	1.40E-03
70	30	5.57E-03	3.70E-02	1.45E-03
70	30	5.49E-03	3.64E-02	1.41E-03
70	30	5.02E-03	3.71E-02	1.46E-03
70	30	4.95E-03	3.65E-02	1.41E-03
70	30	4.47E-03	3.72E-02	1.46E-03
70	30	4.40E-03	3.66E-02	1.42E-03
70	30	3.91E-03	3.72E-02	1.47E-03
70	30	3.85E-03	3.67E-02	1.43E-03
70	30	3.35E-03	3.73E-02	1.47E-03
70	30	3.31E-03	3.68E-02	1.43E-03
70	30	2.80E-03	3.74E-02	1.48E-03
70	30	2.76E-03	3.68E-02	1.44E-03
70	30	2.24E-03	3.74E-02	1.48E-03
70	30	2.21E-03	3.69E-02	1.44E-03
70	30	1.68E-03	3.75E-02	1.49E-03
70	30	1.65E-03	3.69E-02	1.44E-03
70	30	1.12E-03	3.75E-02	1.49E-03
70	30	1.10E-03	3.69E-02	1.45E-03
70	30	5.60E-04	3.75E-02	1.49E-03
70	30	5.52E-04	3.70E-02	1.45E-03
70	30	1.50E-09	3.75E-02	1.49E-03
70	30	1.48E-09	3.70E-02	1.45E-03
71	31	3.31E-02	0.00E+00	1.14E-04
71	31	3.26E-02	0.00E+00	1.12E-04
71	31	3.30E-02	6.75E-04	1.14E-04
71	31	3.26E-02	6.65E-04	1.12E-04
71	31	3.30E-02	1.35E-03	1.15E-04
71	31	3.26E-02	1.33E-03	1.14E-04
71	31	3.30E-02	2.02E-03	1.18E-04
71	31	3.25E-02	2.00E-03	1.16E-04
71	31	3.30E-02	2.70E-03	1.21E-04
71	31	3.25E-02	2.66E-03	1.19E-04
71	31	3.29E-02	3.37E-03	1.25E-04
71	31	3.24E-02	3.32E-03	1.23E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
71	31	3.29E-02	4.04E-03	1.30E-04
71	31	3.24E-02	3.98E-03	1.28E-04
71	31	3.28E-02	4.71E-03	1.35E-04
71	31	3.23E-02	4.65E-03	1.33E-04
71	31	3.27E-02	5.38E-03	1.42E-04
71	31	3.23E-02	5.30E-03	1.40E-04
71	31	3.26E-02	6.05E-03	1.49E-04
71	31	3.22E-02	5.96E-03	1.47E-04
71	31	3.25E-02	6.71E-03	1.58E-04
71	31	3.21E-02	6.62E-03	1.55E-04
71	31	3.24E-02	7.38E-03	1.67E-04
71	31	3.20E-02	7.27E-03	1.64E-04
71	31	3.23E-02	8.04E-03	1.77E-04
71	31	3.18E-02	7.92E-03	1.74E-04
71	31	3.22E-02	8.70E-03	1.88E-04
71	31	3.17E-02	8.57E-03	1.84E-04
71	31	3.20E-02	9.35E-03	1.99E-04
71	31	3.16E-02	9.22E-03	1.95E-04
71	31	3.19E-02	1.00E-02	2.12E-04
71	31	3.14E-02	9.86E-03	2.07E-04
71	32	3.19E-02	1.00E-02	2.12E-04
71	32	3.14E-02	9.86E-03	2.07E-04
71	32	3.17E-02	1.07E-02	2.25E-04
71	32	3.13E-02	1.05E-02	2.20E-04
71	32	3.16E-02	1.13E-02	2.39E-04
71	32	3.11E-02	1.11E-02	2.34E-04
71	32	3.14E-02	1.19E-02	2.54E-04
71	32	3.09E-02	1.18E-02	2.48E-04
71	32	3.12E-02	1.26E-02	2.69E-04
71	32	3.08E-02	1.24E-02	2.63E-04
71	32	3.10E-02	1.32E-02	2.85E-04
71	32	3.06E-02	1.30E-02	2.78E-04
71	32	3.08E-02	1.38E-02	3.02E-04
71	32	3.04E-02	1.36E-02	2.95E-04
71	32	3.06E-02	1.45E-02	3.19E-04
71	32	3.02E-02	1.43E-02	3.11E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
71	32	3.04E-02	1.51E-02	3.37E-04
71	32	2.99E-02	1.49E-02	3.29E-04
71	32	3.01E-02	1.57E-02	3.56E-04
71	32	2.97E-02	1.55E-02	3.47E-04
71	32	2.99E-02	1.63E-02	3.75E-04
71	32	2.95E-02	1.61E-02	3.66E-04
71	33	2.99E-02	1.63E-02	3.75E-04
71	33	2.95E-02	1.61E-02	3.66E-04
71	33	2.96E-02	1.69E-02	3.94E-04
71	33	2.92E-02	1.67E-02	3.85E-04
71	33	2.94E-02	1.75E-02	4.15E-04
71	33	2.90E-02	1.73E-02	4.04E-04
71	33	2.91E-02	1.81E-02	4.35E-04
71	33	2.87E-02	1.78E-02	4.24E-04
71	33	2.88E-02	1.87E-02	4.57E-04
71	33	2.84E-02	1.84E-02	4.45E-04
71	33	2.85E-02	1.93E-02	4.78E-04
71	33	2.81E-02	1.90E-02	4.66E-04
71	33	2.82E-02	1.98E-02	5.00E-04
71	33	2.78E-02	1.96E-02	4.88E-04
71	33	2.79E-02	2.04E-02	5.23E-04
71	33	2.75E-02	2.01E-02	5.09E-04
71	34	2.79E-02	2.04E-02	5.23E-04
71	34	2.75E-02	2.01E-02	5.09E-04
71	34	2.76E-02	2.10E-02	5.46E-04
71	34	2.72E-02	2.07E-02	5.32E-04
71	34	2.73E-02	2.15E-02	5.69E-04
71	34	2.69E-02	2.12E-02	5.54E-04
71	34	2.70E-02	2.21E-02	5.92E-04
71	34	2.66E-02	2.18E-02	5.77E-04
71	34	2.66E-02	2.26E-02	6.16E-04
71	34	2.62E-02	2.23E-02	6.00E-04
71	34	2.63E-02	2.32E-02	6.40E-04
71	34	2.59E-02	2.28E-02	6.23E-04
71	34	2.59E-02	2.37E-02	6.64E-04
71	34	2.56E-02	2.34E-02	6.47E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
71	34	2.56E-02	2.42E-02	6.89E-04
71	34	2.52E-02	2.39E-02	6.71E-04
71	34	2.52E-02	2.47E-02	7.13E-04
71	34	2.48E-02	2.44E-02	6.94E-04
71	35	2.52E-02	2.47E-02	7.13E-04
71	35	2.48E-02	2.44E-02	6.94E-04
71	35	2.48E-02	2.52E-02	7.38E-04
71	35	2.45E-02	2.49E-02	7.18E-04
71	35	2.44E-02	2.57E-02	7.63E-04
71	35	2.41E-02	2.54E-02	7.42E-04
71	35	2.40E-02	2.62E-02	7.88E-04
71	35	2.37E-02	2.58E-02	7.67E-04
71	35	2.36E-02	2.67E-02	8.13E-04
71	35	2.33E-02	2.63E-02	7.91E-04
71	35	2.32E-02	2.72E-02	8.37E-04
71	35	2.29E-02	2.68E-02	8.15E-04
71	36	2.32E-02	2.72E-02	8.37E-04
71	36	2.29E-02	2.68E-02	8.15E-04
71	36	2.28E-02	2.76E-02	8.62E-04
71	36	2.25E-02	2.72E-02	8.39E-04
71	36	2.24E-02	2.81E-02	8.87E-04
71	36	2.21E-02	2.77E-02	8.63E-04
71	36	2.20E-02	2.85E-02	9.12E-04
71	36	2.17E-02	2.81E-02	8.87E-04
71	36	2.15E-02	2.90E-02	9.36E-04
71	36	2.12E-02	2.86E-02	9.11E-04
71	36	2.11E-02	2.94E-02	9.61E-04
71	36	2.08E-02	2.90E-02	9.35E-04
71	37	2.11E-02	2.94E-02	9.61E-04
71	37	2.08E-02	2.90E-02	9.35E-04
71	37	2.06E-02	2.98E-02	9.85E-04
71	37	2.03E-02	2.94E-02	9.59E-04
71	37	2.02E-02	3.02E-02	1.01E-03
71	37	1.99E-02	2.98E-02	9.82E-04
71	37	1.97E-02	3.06E-02	1.03E-03
71	37	1.95E-02	3.02E-02	1.01E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
71	37	1.93E-02	3.10E-02	1.06E-03
71	37	1.90E-02	3.06E-02	1.03E-03
71	37	1.88E-02	3.14E-02	1.08E-03
71	37	1.85E-02	3.10E-02	1.05E-03
71	37	1.83E-02	3.18E-02	1.10E-03
71	37	1.81E-02	3.13E-02	1.07E-03
71	37	1.78E-02	3.21E-02	1.13E-03
71	37	1.76E-02	3.17E-02	1.10E-03
71	37	1.74E-02	3.25E-02	1.15E-03
71	37	1.71E-02	3.20E-02	1.12E-03
71	38	1.74E-02	3.25E-02	1.15E-03
71	38	1.71E-02	3.20E-02	1.12E-03
71	38	1.69E-02	3.28E-02	1.17E-03
71	38	1.66E-02	3.24E-02	1.14E-03
71	38	1.64E-02	3.32E-02	1.19E-03
71	38	1.61E-02	3.27E-02	1.16E-03
71	38	1.59E-02	3.35E-02	1.21E-03
71	38	1.56E-02	3.30E-02	1.18E-03
71	38	1.54E-02	3.38E-02	1.23E-03
71	38	1.51E-02	3.33E-02	1.20E-03
71	38	1.49E-02	3.41E-02	1.25E-03
71	38	1.46E-02	3.36E-02	1.22E-03
71	38	1.43E-02	3.44E-02	1.27E-03
71	38	1.41E-02	3.39E-02	1.24E-03
71	38	1.38E-02	3.47E-02	1.29E-03
71	38	1.36E-02	3.42E-02	1.26E-03
71	39	1.38E-02	3.47E-02	1.29E-03
71	39	1.36E-02	3.42E-02	1.26E-03
71	39	1.33E-02	3.49E-02	1.31E-03
71	39	1.31E-02	3.44E-02	1.27E-03
71	39	1.28E-02	3.52E-02	1.33E-03
71	39	1.26E-02	3.47E-02	1.29E-03
71	39	1.22E-02	3.54E-02	1.34E-03
71	39	1.21E-02	3.49E-02	1.31E-03
71	39	1.17E-02	3.57E-02	1.36E-03
71	39	1.16E-02	3.52E-02	1.32E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
71	39	1.12E-02	3.59E-02	1.38E-03
71	39	1.10E-02	3.54E-02	1.34E-03
71	39	1.06E-02	3.61E-02	1.39E-03
71	39	1.05E-02	3.56E-02	1.35E-03
71	39	1.01E-02	3.63E-02	1.41E-03
71	39	9.96E-03	3.58E-02	1.37E-03
71	39	9.55E-03	3.65E-02	1.42E-03
71	39	9.42E-03	3.60E-02	1.38E-03
71	39	9.01E-03	3.67E-02	1.43E-03
71	39	8.88E-03	3.62E-02	1.40E-03
71	39	8.46E-03	3.69E-02	1.45E-03
71	39	8.34E-03	3.64E-02	1.41E-03
71	40	8.46E-03	3.69E-02	1.45E-03
71	40	8.34E-03	3.64E-02	1.41E-03
71	40	7.90E-03	3.71E-02	1.46E-03
71	40	7.79E-03	3.65E-02	1.42E-03
71	40	7.35E-03	3.72E-02	1.47E-03
71	40	7.24E-03	3.67E-02	1.43E-03
71	40	6.79E-03	3.73E-02	1.48E-03
71	40	6.69E-03	3.68E-02	1.44E-03
71	40	6.23E-03	3.75E-02	1.49E-03
71	40	6.14E-03	3.69E-02	1.45E-03
71	40	5.67E-03	3.76E-02	1.50E-03
71	40	5.59E-03	3.71E-02	1.46E-03
71	40	5.11E-03	3.77E-02	1.51E-03
71	40	5.04E-03	3.72E-02	1.46E-03
71	40	4.54E-03	3.78E-02	1.51E-03
71	40	4.48E-03	3.73E-02	1.47E-03
71	40	3.98E-03	3.79E-02	1.52E-03
71	40	3.92E-03	3.74E-02	1.48E-03
71	40	3.41E-03	3.80E-02	1.52E-03
71	40	3.36E-03	3.74E-02	1.48E-03
71	40	2.85E-03	3.80E-02	1.53E-03
71	40	2.81E-03	3.75E-02	1.49E-03
71	40	2.28E-03	3.81E-02	1.53E-03
71	40	2.25E-03	3.75E-02	1.49E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
71	40	1.71E-03	3.81E-02	1.54E-03
71	40	1.68E-03	3.76E-02	1.49E-03
71	40	1.14E-03	3.81E-02	1.54E-03
71	40	1.12E-03	3.76E-02	1.50E-03
71	40	5.70E-04	3.82E-02	1.54E-03
71	40	5.62E-04	3.76E-02	1.50E-03
71	40	1.53E-09	3.82E-02	1.54E-03
71	40	1.51E-09	3.76E-02	1.50E-03
72	41	3.36E-02	0.00E+00	1.15E-04
72	41	3.32E-02	0.00E+00	1.14E-04
72	41	3.36E-02	6.87E-04	1.16E-04
72	41	3.31E-02	6.77E-04	1.14E-04
72	41	3.36E-02	1.37E-03	1.17E-04
72	41	3.31E-02	1.35E-03	1.16E-04
72	41	3.36E-02	2.06E-03	1.19E-04
72	41	3.31E-02	2.03E-03	1.18E-04
72	41	3.35E-02	2.75E-03	1.23E-04
72	41	3.31E-02	2.71E-03	1.21E-04
72	41	3.35E-02	3.43E-03	1.27E-04
72	41	3.30E-02	3.38E-03	1.25E-04
72	41	3.34E-02	4.11E-03	1.32E-04
72	41	3.30E-02	4.06E-03	1.30E-04
72	41	3.34E-02	4.80E-03	1.38E-04
72	41	3.29E-02	4.73E-03	1.36E-04
72	41	3.33E-02	5.48E-03	1.45E-04
72	41	3.28E-02	5.40E-03	1.43E-04
72	41	3.32E-02	6.15E-03	1.53E-04
72	41	3.27E-02	6.07E-03	1.50E-04
72	41	3.31E-02	6.83E-03	1.61E-04
72	41	3.26E-02	6.74E-03	1.58E-04
72	41	3.30E-02	7.51E-03	1.71E-04
72	41	3.25E-02	7.40E-03	1.68E-04
72	41	3.29E-02	8.18E-03	1.81E-04
72	41	3.24E-02	8.06E-03	1.78E-04
72	41	3.27E-02	8.85E-03	1.92E-04
72	41	3.23E-02	8.72E-03	1.89E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
72	41	3.26E-02	9.51E-03	2.04E-04
72	41	3.21E-02	9.38E-03	2.00E-04
72	41	3.24E-02	1.02E-02	2.17E-04
72	41	3.20E-02	1.00E-02	2.13E-04
72	42	3.24E-02	1.02E-02	2.17E-04
72	42	3.20E-02	1.00E-02	2.13E-04
72	42	3.23E-02	1.08E-02	2.31E-04
72	42	3.18E-02	1.07E-02	2.26E-04
72	42	3.21E-02	1.15E-02	2.45E-04
72	42	3.17E-02	1.13E-02	2.40E-04
72	42	3.19E-02	1.21E-02	2.60E-04
72	42	3.15E-02	1.20E-02	2.55E-04
72	42	3.17E-02	1.28E-02	2.76E-04
72	42	3.13E-02	1.26E-02	2.70E-04
72	42	3.15E-02	1.34E-02	2.93E-04
72	42	3.11E-02	1.32E-02	2.86E-04
72	42	3.13E-02	1.41E-02	3.10E-04
72	42	3.09E-02	1.39E-02	3.03E-04
72	42	3.11E-02	1.47E-02	3.28E-04
72	42	3.07E-02	1.45E-02	3.21E-04
72	42	3.09E-02	1.53E-02	3.47E-04
72	42	3.05E-02	1.51E-02	3.39E-04
72	42	3.06E-02	1.60E-02	3.66E-04
72	42	3.02E-02	1.57E-02	3.57E-04
72	42	3.04E-02	1.66E-02	3.86E-04
72	42	3.00E-02	1.64E-02	3.77E-04
72	43	3.04E-02	1.66E-02	3.86E-04
72	43	3.00E-02	1.64E-02	3.77E-04
72	43	3.01E-02	1.72E-02	4.06E-04
72	43	2.97E-02	1.70E-02	3.96E-04
72	43	2.99E-02	1.78E-02	4.27E-04
72	43	2.95E-02	1.76E-02	4.17E-04
72	43	2.96E-02	1.84E-02	4.49E-04
72	43	2.92E-02	1.82E-02	4.38E-04
72	43	2.93E-02	1.90E-02	4.71E-04
72	43	2.89E-02	1.88E-02	4.59E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
72	43	2.90E-02	1.96E-02	4.93E-04
72	43	2.86E-02	1.93E-02	4.81E-04
72	43	2.87E-02	2.02E-02	5.16E-04
72	43	2.83E-02	1.99E-02	5.03E-04
72	43	2.84E-02	2.08E-02	5.39E-04
72	43	2.80E-02	2.05E-02	5.26E-04
72	44	2.84E-02	2.08E-02	5.39E-04
72	44	2.80E-02	2.05E-02	5.26E-04
72	44	2.81E-02	2.13E-02	5.63E-04
72	44	2.77E-02	2.10E-02	5.49E-04
72	44	2.78E-02	2.19E-02	5.87E-04
72	44	2.74E-02	2.16E-02	5.72E-04
72	44	2.74E-02	2.25E-02	6.11E-04
72	44	2.70E-02	2.22E-02	5.96E-04
72	44	2.71E-02	2.30E-02	6.36E-04
72	44	2.67E-02	2.27E-02	6.20E-04
72	44	2.67E-02	2.36E-02	6.60E-04
72	44	2.64E-02	2.32E-02	6.44E-04
72	44	2.64E-02	2.41E-02	6.86E-04
72	44	2.60E-02	2.38E-02	6.68E-04
72	44	2.60E-02	2.46E-02	7.11E-04
72	44	2.56E-02	2.43E-02	6.93E-04
72	44	2.56E-02	2.51E-02	7.36E-04
72	44	2.53E-02	2.48E-02	7.17E-04
72	45	2.56E-02	2.51E-02	7.36E-04
72	45	2.53E-02	2.48E-02	7.17E-04
72	45	2.52E-02	2.57E-02	7.62E-04
72	45	2.49E-02	2.53E-02	7.42E-04
72	45	2.48E-02	2.62E-02	7.87E-04
72	45	2.45E-02	2.58E-02	7.67E-04
72	45	2.44E-02	2.67E-02	8.13E-04
72	45	2.41E-02	2.63E-02	7.92E-04
72	45	2.40E-02	2.71E-02	8.39E-04
72	45	2.37E-02	2.68E-02	8.17E-04
72	45	2.36E-02	2.76E-02	8.65E-04
72	45	2.33E-02	2.72E-02	8.42E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
72	46	2.36E-02	2.76E-02	8.65E-04
72	46	2.33E-02	2.72E-02	8.42E-04
72	46	2.32E-02	2.81E-02	8.90E-04
72	46	2.29E-02	2.77E-02	8.67E-04
72	46	2.28E-02	2.86E-02	9.16E-04
72	46	2.25E-02	2.82E-02	8.92E-04
72	46	2.23E-02	2.90E-02	9.42E-04
72	46	2.20E-02	2.86E-02	9.17E-04
72	46	2.19E-02	2.95E-02	9.67E-04
72	46	2.16E-02	2.91E-02	9.42E-04
72	46	2.14E-02	2.99E-02	9.92E-04
72	46	2.12E-02	2.95E-02	9.67E-04
72	47	2.14E-02	2.99E-02	9.92E-04
72	47	2.12E-02	2.95E-02	9.67E-04
72	47	2.10E-02	3.03E-02	1.02E-03
72	47	2.07E-02	2.99E-02	9.91E-04
72	47	2.05E-02	3.07E-02	1.04E-03
72	47	2.03E-02	3.03E-02	1.02E-03
72	47	2.01E-02	3.11E-02	1.07E-03
72	47	1.98E-02	3.07E-02	1.04E-03
72	47	1.96E-02	3.15E-02	1.09E-03
72	47	1.93E-02	3.11E-02	1.06E-03
72	47	1.91E-02	3.19E-02	1.12E-03
72	47	1.89E-02	3.15E-02	1.09E-03
72	47	1.86E-02	3.23E-02	1.14E-03
72	47	1.84E-02	3.19E-02	1.11E-03
72	47	1.81E-02	3.27E-02	1.16E-03
72	47	1.79E-02	3.22E-02	1.13E-03
72	47	1.77E-02	3.30E-02	1.19E-03
72	47	1.74E-02	3.26E-02	1.15E-03
72	48	1.77E-02	3.30E-02	1.19E-03
72	48	1.74E-02	3.26E-02	1.15E-03
72	48	1.72E-02	3.34E-02	1.21E-03
72	48	1.69E-02	3.29E-02	1.18E-03
72	48	1.66E-02	3.37E-02	1.23E-03
72	48	1.64E-02	3.33E-02	1.20E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
72	48	1.61E-02	3.40E-02	1.25E-03
72	48	1.59E-02	3.36E-02	1.22E-03
72	48	1.56E-02	3.44E-02	1.27E-03
72	48	1.54E-02	3.39E-02	1.24E-03
72	48	1.51E-02	3.47E-02	1.29E-03
72	48	1.49E-02	3.42E-02	1.26E-03
72	48	1.46E-02	3.50E-02	1.31E-03
72	48	1.44E-02	3.45E-02	1.28E-03
72	48	1.41E-02	3.53E-02	1.33E-03
72	48	1.39E-02	3.48E-02	1.30E-03
72	49	1.41E-02	3.53E-02	1.33E-03
72	49	1.39E-02	3.48E-02	1.30E-03
72	49	1.35E-02	3.55E-02	1.35E-03
72	49	1.33E-02	3.50E-02	1.32E-03
72	49	1.30E-02	3.58E-02	1.37E-03
72	49	1.28E-02	3.53E-02	1.34E-03
72	49	1.25E-02	3.60E-02	1.39E-03
72	49	1.23E-02	3.56E-02	1.35E-03
72	49	1.19E-02	3.63E-02	1.41E-03
72	49	1.18E-02	3.58E-02	1.37E-03
72	49	1.14E-02	3.65E-02	1.42E-03
72	49	1.12E-02	3.60E-02	1.39E-03
72	49	1.08E-02	3.67E-02	1.44E-03
72	49	1.07E-02	3.62E-02	1.40E-03
72	49	1.03E-02	3.70E-02	1.45E-03
72	49	1.01E-02	3.64E-02	1.42E-03
72	49	9.71E-03	3.72E-02	1.47E-03
72	49	9.58E-03	3.66E-02	1.43E-03
72	49	9.16E-03	3.73E-02	1.48E-03
72	49	9.03E-03	3.68E-02	1.44E-03
72	49	8.60E-03	3.75E-02	1.50E-03
72	49	8.48E-03	3.70E-02	1.46E-03
72	50	8.60E-03	3.75E-02	1.50E-03
72	50	8.48E-03	3.70E-02	1.46E-03
72	50	8.04E-03	3.77E-02	1.51E-03
72	50	7.93E-03	3.72E-02	1.47E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
72	50	7.47E-03	3.78E-02	1.52E-03
72	50	7.37E-03	3.73E-02	1.48E-03
72	50	6.90E-03	3.80E-02	1.53E-03
72	50	6.81E-03	3.75E-02	1.49E-03
72	50	6.34E-03	3.81E-02	1.54E-03
72	50	6.25E-03	3.76E-02	1.50E-03
72	50	5.77E-03	3.82E-02	1.55E-03
72	50	5.69E-03	3.77E-02	1.51E-03
72	50	5.19E-03	3.83E-02	1.56E-03
72	50	5.12E-03	3.78E-02	1.51E-03
72	50	4.62E-03	3.84E-02	1.56E-03
72	50	4.56E-03	3.79E-02	1.52E-03
72	50	4.05E-03	3.85E-02	1.57E-03
72	50	3.99E-03	3.80E-02	1.53E-03
72	50	3.47E-03	3.86E-02	1.58E-03
72	50	3.42E-03	3.81E-02	1.53E-03
72	50	2.89E-03	3.87E-02	1.58E-03
72	50	2.85E-03	3.81E-02	1.54E-03
72	50	2.32E-03	3.87E-02	1.58E-03
72	50	2.28E-03	3.82E-02	1.54E-03
72	50	1.74E-03	3.88E-02	1.59E-03
72	50	1.71E-03	3.82E-02	1.55E-03
72	50	1.16E-03	3.88E-02	1.59E-03
72	50	1.14E-03	3.83E-02	1.55E-03
72	50	5.79E-04	3.88E-02	1.59E-03
72	50	5.71E-04	3.83E-02	1.55E-03
72	50	1.55E-09	3.88E-02	1.59E-03
72	50	1.53E-09	3.83E-02	1.55E-03
73	51	3.42E-02	0.00E+00	1.17E-04
73	51	3.37E-02	0.00E+00	1.16E-04
73	51	3.42E-02	6.98E-04	1.17E-04
73	51	3.37E-02	6.89E-04	1.16E-04
73	51	3.42E-02	1.40E-03	1.19E-04
73	51	3.37E-02	1.38E-03	1.17E-04
73	51	3.41E-02	2.09E-03	1.21E-04
73	51	3.37E-02	2.07E-03	1.20E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
73	51	3.41E-02	2.79E-03	1.25E-04
73	51	3.36E-02	2.75E-03	1.23E-04
73	51	3.41E-02	3.49E-03	1.29E-04
73	51	3.36E-02	3.44E-03	1.27E-04
73	51	3.40E-02	4.18E-03	1.34E-04
73	51	3.35E-02	4.13E-03	1.32E-04
73	51	3.39E-02	4.88E-03	1.40E-04
73	51	3.35E-02	4.81E-03	1.38E-04
73	51	3.38E-02	5.57E-03	1.47E-04
73	51	3.34E-02	5.49E-03	1.45E-04
73	51	3.38E-02	6.26E-03	1.55E-04
73	51	3.33E-02	6.17E-03	1.53E-04
73	51	3.37E-02	6.95E-03	1.64E-04
73	51	3.32E-02	6.85E-03	1.62E-04
73	51	3.35E-02	7.63E-03	1.74E-04
73	51	3.31E-02	7.53E-03	1.71E-04
73	51	3.34E-02	8.31E-03	1.85E-04
73	51	3.30E-02	8.20E-03	1.82E-04
73	51	3.33E-02	8.99E-03	1.97E-04
73	51	3.28E-02	8.87E-03	1.93E-04
73	51	3.31E-02	9.67E-03	2.09E-04
73	51	3.27E-02	9.54E-03	2.05E-04
73	51	3.30E-02	1.03E-02	2.22E-04
73	51	3.25E-02	1.02E-02	2.18E-04
73	52	3.30E-02	1.03E-02	2.22E-04
73	52	3.25E-02	1.02E-02	2.18E-04
73	52	3.28E-02	1.10E-02	2.36E-04
73	52	3.24E-02	1.09E-02	2.32E-04
73	52	3.27E-02	1.17E-02	2.51E-04
73	52	3.22E-02	1.15E-02	2.46E-04
73	52	3.25E-02	1.23E-02	2.67E-04
73	52	3.20E-02	1.22E-02	2.61E-04
73	52	3.23E-02	1.30E-02	2.83E-04
73	52	3.18E-02	1.28E-02	2.77E-04
73	52	3.21E-02	1.37E-02	3.01E-04
73	52	3.16E-02	1.35E-02	2.94E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
73	52	3.19E-02	1.43E-02	3.18E-04
73	52	3.14E-02	1.41E-02	3.12E-04
73	52	3.16E-02	1.50E-02	3.37E-04
73	52	3.12E-02	1.48E-02	3.30E-04
73	52	3.14E-02	1.56E-02	3.56E-04
73	52	3.10E-02	1.54E-02	3.48E-04
73	52	3.12E-02	1.62E-02	3.76E-04
73	52	3.07E-02	1.60E-02	3.68E-04
73	52	3.09E-02	1.69E-02	3.97E-04
73	52	3.05E-02	1.66E-02	3.88E-04
73	53	3.09E-02	1.69E-02	3.97E-04
73	53	3.05E-02	1.66E-02	3.88E-04
73	53	3.06E-02	1.75E-02	4.18E-04
73	53	3.02E-02	1.73E-02	4.08E-04
73	53	3.04E-02	1.81E-02	4.39E-04
73	53	3.00E-02	1.79E-02	4.29E-04
73	53	3.01E-02	1.87E-02	4.62E-04
73	53	2.97E-02	1.85E-02	4.51E-04
73	53	2.98E-02	1.93E-02	4.84E-04
73	53	2.94E-02	1.91E-02	4.73E-04
73	53	2.95E-02	1.99E-02	5.08E-04
73	53	2.91E-02	1.97E-02	4.96E-04
73	53	2.92E-02	2.05E-02	5.31E-04
73	53	2.88E-02	2.03E-02	5.19E-04
73	53	2.89E-02	2.11E-02	5.55E-04
73	53	2.85E-02	2.08E-02	5.42E-04
73	54	2.89E-02	2.11E-02	5.55E-04
73	54	2.85E-02	2.08E-02	5.42E-04
73	54	2.86E-02	2.17E-02	5.80E-04
73	54	2.82E-02	2.14E-02	5.66E-04
73	54	2.82E-02	2.23E-02	6.05E-04
73	54	2.78E-02	2.20E-02	5.90E-04
73	54	2.79E-02	2.28E-02	6.30E-04
73	54	2.75E-02	2.25E-02	6.14E-04
73	54	2.75E-02	2.34E-02	6.55E-04
73	54	2.72E-02	2.31E-02	6.39E-04

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
73	54	2.72E-02	2.40E-02	6.81E-04
73	54	2.68E-02	2.36E-02	6.64E-04
73	54	2.68E-02	2.45E-02	7.07E-04
73	54	2.64E-02	2.42E-02	6.89E-04
73	54	2.64E-02	2.50E-02	7.33E-04
73	54	2.61E-02	2.47E-02	7.15E-04
73	54	2.60E-02	2.56E-02	7.59E-04
73	54	2.57E-02	2.52E-02	7.40E-04
73	55	2.60E-02	2.56E-02	7.59E-04
73	55	2.57E-02	2.52E-02	7.40E-04
73	55	2.56E-02	2.61E-02	7.86E-04
73	55	2.53E-02	2.57E-02	7.66E-04
73	55	2.53E-02	2.66E-02	8.12E-04
73	55	2.49E-02	2.62E-02	7.92E-04
73	55	2.48E-02	2.71E-02	8.39E-04
73	55	2.45E-02	2.67E-02	8.18E-04
73	55	2.44E-02	2.76E-02	8.65E-04
73	55	2.41E-02	2.72E-02	8.44E-04
73	55	2.40E-02	2.81E-02	8.92E-04
73	55	2.37E-02	2.77E-02	8.70E-04
73	56	2.40E-02	2.81E-02	8.92E-04
73	56	2.37E-02	2.77E-02	8.70E-04
73	56	2.36E-02	2.86E-02	9.18E-04
73	56	2.33E-02	2.82E-02	8.95E-04
73	56	2.31E-02	2.90E-02	9.45E-04
73	56	2.28E-02	2.86E-02	9.21E-04
73	56	2.27E-02	2.95E-02	9.71E-04
73	56	2.24E-02	2.91E-02	9.47E-04
73	56	2.23E-02	2.99E-02	9.98E-04
73	56	2.20E-02	2.95E-02	9.73E-04
73	56	2.18E-02	3.04E-02	1.02E-03
73	56	2.15E-02	3.00E-02	9.98E-04
73	57	2.18E-02	3.04E-02	1.02E-03
73	57	2.15E-02	3.00E-02	9.98E-04
73	57	2.13E-02	3.08E-02	1.05E-03
73	57	2.11E-02	3.04E-02	1.02E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
73	57	2.09E-02	3.12E-02	1.08E-03
73	57	2.06E-02	3.08E-02	1.05E-03
73	57	2.04E-02	3.17E-02	1.10E-03
73	57	2.01E-02	3.12E-02	1.07E-03
73	57	1.99E-02	3.21E-02	1.13E-03
73	57	1.97E-02	3.16E-02	1.10E-03
73	57	1.94E-02	3.25E-02	1.15E-03
73	57	1.92E-02	3.20E-02	1.12E-03
73	57	1.89E-02	3.28E-02	1.18E-03
73	57	1.87E-02	3.24E-02	1.15E-03
73	57	1.84E-02	3.32E-02	1.20E-03
73	57	1.82E-02	3.28E-02	1.17E-03
73	57	1.79E-02	3.36E-02	1.22E-03
73	57	1.77E-02	3.31E-02	1.19E-03
73	58	1.79E-02	3.36E-02	1.22E-03
73	58	1.77E-02	3.31E-02	1.19E-03
73	58	1.74E-02	3.39E-02	1.25E-03
73	58	1.72E-02	3.35E-02	1.22E-03
73	58	1.69E-02	3.43E-02	1.27E-03
73	58	1.67E-02	3.38E-02	1.24E-03
73	58	1.64E-02	3.46E-02	1.29E-03
73	58	1.62E-02	3.42E-02	1.26E-03
73	58	1.59E-02	3.49E-02	1.31E-03
73	58	1.57E-02	3.45E-02	1.28E-03
73	58	1.54E-02	3.52E-02	1.34E-03
73	58	1.52E-02	3.48E-02	1.30E-03
73	58	1.48E-02	3.55E-02	1.36E-03
73	58	1.46E-02	3.51E-02	1.32E-03
73	58	1.43E-02	3.58E-02	1.38E-03
73	58	1.41E-02	3.54E-02	1.34E-03
73	59	1.43E-02	3.58E-02	1.38E-03
73	59	1.41E-02	3.54E-02	1.34E-03
73	59	1.37E-02	3.61E-02	1.40E-03
73	59	1.36E-02	3.56E-02	1.36E-03
73	59	1.32E-02	3.64E-02	1.42E-03
73	59	1.30E-02	3.59E-02	1.38E-03

Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
73	59	1.27E-02	3.66E-02	1.43E-03
73	59	1.25E-02	3.62E-02	1.40E-03
73	59	1.21E-02	3.69E-02	1.45E-03
73	59	1.19E-02	3.64E-02	1.41E-03
73	59	1.16E-02	3.71E-02	1.47E-03
73	59	1.14E-02	3.66E-02	1.43E-03
73	59	1.10E-02	3.73E-02	1.49E-03
73	59	1.09E-02	3.69E-02	1.45E-03
73	59	1.04E-02	3.76E-02	1.50E-03
73	59	1.03E-02	3.71E-02	1.46E-03
73	59	9.87E-03	3.78E-02	1.52E-03
73	59	9.74E-03	3.73E-02	1.48E-03
73	59	9.31E-03	3.79E-02	1.53E-03
73	59	9.18E-03	3.75E-02	1.49E-03
73	59	8.74E-03	3.81E-02	1.54E-03
73	59	8.62E-03	3.76E-02	1.50E-03
73	60	8.74E-03	3.81E-02	1.54E-03
73	60	8.62E-03	3.76E-02	1.50E-03
73	60	8.17E-03	3.83E-02	1.56E-03
73	60	8.06E-03	3.78E-02	1.52E-03
73	60	7.59E-03	3.85E-02	1.57E-03
73	60	7.49E-03	3.79E-02	1.53E-03
73	60	7.02E-03	3.86E-02	1.58E-03
73	60	6.93E-03	3.81E-02	1.54E-03
73	60	6.44E-03	3.87E-02	1.59E-03
73	60	6.35E-03	3.82E-02	1.55E-03
73	60	5.86E-03	3.89E-02	1.60E-03
73	60	5.78E-03	3.83E-02	1.56E-03
73	60	5.28E-03	3.90E-02	1.61E-03
73	60	5.21E-03	3.85E-02	1.57E-03
73	60	4.70E-03	3.91E-02	1.61E-03
73	60	4.63E-03	3.86E-02	1.57E-03
73	60	4.11E-03	3.92E-02	1.62E-03
73	60	4.06E-03	3.86E-02	1.58E-03
73	60	3.53E-03	3.92E-02	1.63E-03
73	60	3.48E-03	3.87E-02	1.58E-03

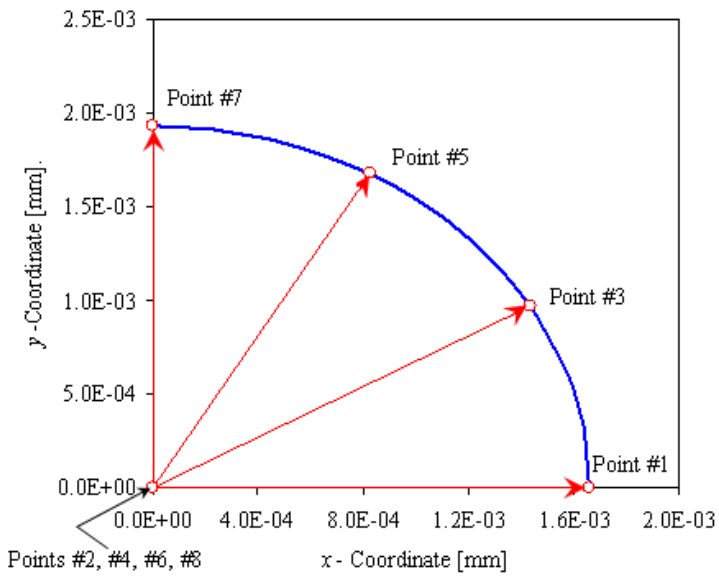
Table E-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
73	60	2.94E-03	3.93E-02	1.63E-03
73	60	2.90E-03	3.88E-02	1.59E-03
73	60	2.35E-03	3.93E-02	1.64E-03
73	60	2.32E-03	3.88E-02	1.59E-03
73	60	1.77E-03	3.94E-02	1.64E-03
73	60	1.74E-03	3.89E-02	1.60E-03
73	60	1.18E-03	3.94E-02	1.64E-03
73	60	1.16E-03	3.89E-02	1.60E-03
73	60	5.89E-04	3.94E-02	1.64E-03
73	60	5.81E-04	3.89E-02	1.60E-03
73	60	1.58E-09	3.94E-02	1.64E-03
73	60	1.56E-09	3.89E-02	1.60E-03

APPENDIX F—ELEMENT POSITIONS FOR THE SUPPLIER A TRANSDUCER DESIGN (CONVEX SURFACES)

Supplier A produced a phased array transducer design for inspection through concave surfaces and through convex surfaces. This appendix presents the details of the transducer designed for the convex entry surfaces by describing the geometric positions of the elements.

Figure F-1 and table F-1 together specify the three-dimensional coordinates of the points describing each element on the face of the phased array transducer designed by supplier A for the convex entry surface. Only one-quarter of the transducer face is described. The other quarters can be realized through symmetry by reflections about the x and y axes. Figure F-1 shows an example illustrating the meanings of the listed (x, y, and z) points, while table F-1 enumerates the coordinates of the points. See the earlier discussion of figure E-1 and table E-1 in appendix E for an explanation of the conventions being used to specify the locations of the phased array elements.



Belt 1-1 Point	Ring	Element	x	y	z
1	0	1	1.91E-03	0.00E+00	6.51E-06
2	0	1	0.00E+00	0.00E+00	-1.39E-17
3	0	1	1.65E-03	8.37E-04	5.66E-06
4	0	1	0.00E+00	0.00E+00	-1.39E-17
5	0	1	9.55E-04	1.45E-03	3.96E-06
6	0	1	0.00E+00	0.00E+00	-1.39E-17
7	0	1	8.94E-11	1.67E-03	3.11E-06
8	0	1	0.00E+00	0.00E+00	-1.39E-17

Figure F-1. Illustration of the Meaning of Element Coordinates

Table F-1. Listing of Element Coordinates

Belt 1 Ring	Element	x	y	z
0	1	1.91E-03	0.00E+00	6.51E-06
0	1	0.00E+00	0.00E+00	-1.39E-17
0	1	1.65E-03	8.37E-04	5.66E-06
0	1	0.00E+00	0.00E+00	-1.39E-17
0	1	9.55E-04	1.45E-03	3.96E-06
0	1	0.00E+00	0.00E+00	-1.39E-17
0	1	8.94E-11	1.67E-03	3.11E-06
0	1	0.00E+00	0.00E+00	-1.39E-17
1	2	2.78E-03	0.00E+00	1.38E-05
1	2	2.02E-03	0.00E+00	7.27E-06
1	2	2.41E-03	1.22E-03	1.20E-05
1	2	1.75E-03	8.84E-04	6.32E-06
1	2	1.39E-03	2.11E-03	8.41E-06
1	2	1.01E-03	1.53E-03	4.42E-06
1	2	1.30E-10	2.44E-03	6.60E-06
1	2	9.44E-11	1.77E-03	3.47E-06
2	3	3.46E-03	0.00E+00	2.14E-05
2	3	2.89E-03	0.00E+00	1.49E-05
2	3	3.00E-03	1.52E-03	1.86E-05
2	3	2.50E-03	1.27E-03	1.30E-05
2	3	1.73E-03	2.63E-03	1.30E-05
2	3	1.45E-03	2.19E-03	9.08E-06
2	3	1.62E-10	3.03E-03	1.02E-05
2	3	1.35E-10	2.53E-03	7.12E-06
3	4	4.06E-03	0.00E+00	2.94E-05
3	4	3.57E-03	0.00E+00	2.28E-05
3	4	3.51E-03	1.78E-03	2.56E-05
3	4	3.09E-03	1.56E-03	1.98E-05
3	4	2.03E-03	3.08E-03	1.79E-05
3	4	1.79E-03	2.71E-03	1.38E-05
3	4	1.90E-10	3.56E-03	1.40E-05
3	4	1.67E-10	3.13E-03	1.09E-05
4	5	4.59E-03	0.00E+00	3.76E-05
4	5	4.17E-03	0.00E+00	3.10E-05
4	5	3.97E-03	2.01E-03	3.26E-05
4	5	3.61E-03	1.82E-03	2.69E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 1 Ring	Element	x	y	z
4	5	2.29E-03	3.48E-03	2.28E-05
4	5	2.08E-03	3.16E-03	1.88E-05
4	5	2.15E-10	4.02E-03	1.79E-05
4	5	1.95E-10	3.65E-03	1.48E-05
5	6	5.07E-03	0.00E+00	4.59E-05
5	6	4.69E-03	0.00E+00	3.93E-05
5	6	4.39E-03	2.22E-03	3.99E-05
5	6	4.07E-03	2.06E-03	3.42E-05
5	6	2.54E-03	3.85E-03	2.79E-05
5	6	2.35E-03	3.56E-03	2.39E-05
5	6	2.37E-10	4.44E-03	2.19E-05
5	6	2.20E-10	4.11E-03	1.88E-05
6	1	5.53E-03	0.00E+00	5.45E-05
6	1	5.18E-03	0.00E+00	4.79E-05
6	1	5.34E-03	1.25E-03	5.26E-05
6	1	5.00E-03	1.17E-03	4.62E-05
6	1	4.79E-03	2.42E-03	4.74E-05
6	1	4.49E-03	2.27E-03	4.17E-05
6	1	3.91E-03	3.42E-03	4.03E-05
6	1	3.66E-03	3.21E-03	3.54E-05
6	2	3.91E-03	3.42E-03	4.03E-05
6	2	3.66E-03	3.21E-03	3.54E-05
6	2	2.76E-03	4.19E-03	3.31E-05
6	2	2.59E-03	3.93E-03	2.91E-05
6	2	1.43E-03	4.68E-03	2.79E-05
6	2	1.34E-03	4.38E-03	2.45E-05
6	2	2.59E-10	4.84E-03	2.60E-05
6	2	2.42E-10	4.54E-03	2.29E-05
7	3	5.96E-03	0.00E+00	6.34E-05
7	3	5.63E-03	0.00E+00	5.67E-05
7	3	5.75E-03	1.35E-03	6.12E-05
7	3	5.44E-03	1.28E-03	5.47E-05
7	3	5.16E-03	2.61E-03	5.51E-05
7	3	4.88E-03	2.47E-03	4.93E-05
7	3	4.21E-03	3.69E-03	4.68E-05
7	3	3.98E-03	3.49E-03	4.19E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 1 Ring	Element	x	y	z
7	4	4.21E-03	3.69E-03	4.68E-05
7	4	3.98E-03	3.49E-03	4.19E-05
7	4	2.98E-03	4.52E-03	3.85E-05
7	4	2.82E-03	4.28E-03	3.44E-05
7	4	1.54E-03	5.04E-03	3.25E-05
7	4	1.46E-03	4.77E-03	2.90E-05
7	4	2.79E-10	5.22E-03	3.02E-05
7	4	2.64E-10	4.94E-03	2.70E-05
8	5	6.37E-03	0.00E+00	7.24E-05
8	5	6.07E-03	0.00E+00	6.57E-05
8	5	6.15E-03	1.44E-03	6.99E-05
8	5	5.86E-03	1.38E-03	6.34E-05
8	5	5.52E-03	2.79E-03	6.29E-05
8	5	5.25E-03	2.66E-03	5.71E-05
8	5	4.50E-03	3.95E-03	5.35E-05
8	5	4.29E-03	3.76E-03	4.85E-05
8	6	4.50E-03	3.95E-03	5.35E-05
8	6	4.29E-03	3.76E-03	4.85E-05
8	6	3.18E-03	4.83E-03	4.40E-05
8	6	3.03E-03	4.60E-03	3.99E-05
8	6	1.65E-03	5.39E-03	3.71E-05
8	6	1.57E-03	5.13E-03	3.36E-05
8	6	2.98E-10	5.58E-03	3.45E-05
8	6	2.84E-10	5.32E-03	3.13E-05
9	7	6.76E-03	0.00E+00	8.15E-05
9	7	6.48E-03	0.00E+00	7.49E-05
9	7	6.53E-03	1.53E-03	7.87E-05
9	7	6.26E-03	1.47E-03	7.23E-05
9	7	5.85E-03	2.96E-03	7.09E-05
9	7	5.61E-03	2.84E-03	6.51E-05
9	7	4.78E-03	4.19E-03	6.02E-05
9	7	4.58E-03	4.01E-03	5.53E-05
9	8	4.78E-03	4.19E-03	6.02E-05
9	8	4.58E-03	4.01E-03	5.53E-05
9	8	3.38E-03	5.13E-03	4.96E-05
9	8	3.24E-03	4.91E-03	4.55E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 1 Ring	Element	x	y	z
9	8	1.75E-03	5.72E-03	4.18E-05
9	8	1.68E-03	5.48E-03	3.84E-05
9	8	3.16E-10	5.92E-03	3.89E-05
9	8	3.03E-10	5.68E-03	3.57E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
10	1	7.14E-03	0.00E+00	9.09E-05
10	1	6.86E-03	0.00E+00	8.41E-05
10	1	6.89E-03	1.62E-03	8.77E-05
10	1	6.63E-03	1.56E-03	8.12E-05
10	1	6.18E-03	3.13E-03	7.90E-05
10	1	5.95E-03	3.01E-03	7.31E-05
10	2	6.18E-03	3.13E-03	7.90E-05
10	2	5.95E-03	3.01E-03	7.31E-05
10	2	5.05E-03	4.42E-03	6.71E-05
10	2	4.86E-03	4.25E-03	6.22E-05
10	3	5.05E-03	4.42E-03	6.71E-05
10	3	4.86E-03	4.25E-03	6.22E-05
10	3	3.57E-03	5.41E-03	5.53E-05
10	3	3.43E-03	5.21E-03	5.12E-05
10	4	3.57E-03	5.41E-03	5.53E-05
10	4	3.43E-03	5.21E-03	5.12E-05
10	4	1.85E-03	6.04E-03	4.66E-05
10	4	1.78E-03	5.81E-03	4.31E-05
10	4	3.34E-10	6.25E-03	4.34E-05
10	4	3.21E-10	6.02E-03	4.01E-05
11	5	7.49E-03	0.00E+00	1.00E-04
11	5	7.24E-03	0.00E+00	9.37E-05
11	5	7.24E-03	1.70E-03	9.67E-05
11	5	7.00E-03	1.64E-03	9.04E-05
11	5	6.49E-03	3.28E-03	8.71E-05
11	5	6.27E-03	3.17E-03	8.14E-05
11	6	6.49E-03	3.28E-03	8.71E-05
11	6	6.27E-03	3.17E-03	8.14E-05
11	6	5.30E-03	4.64E-03	7.40E-05
11	6	5.12E-03	4.49E-03	6.92E-05
11	7	5.30E-03	4.64E-03	7.40E-05
11	7	5.12E-03	4.49E-03	6.92E-05
11	7	3.75E-03	5.69E-03	6.09E-05
11	7	3.62E-03	5.50E-03	5.69E-05
11	8	3.75E-03	5.69E-03	6.09E-05
11	8	3.62E-03	5.50E-03	5.69E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
11	8	1.94E-03	6.34E-03	5.13E-05
11	8	1.88E-03	6.13E-03	4.80E-05
11	8	3.51E-10	6.57E-03	4.78E-05
11	8	3.39E-10	6.35E-03	4.47E-05
12	9	7.84E-03	0.00E+00	1.10E-04
12	9	7.60E-03	0.00E+00	1.03E-04
12	9	7.57E-03	1.78E-03	1.06E-04
12	9	7.34E-03	1.72E-03	9.95E-05
12	9	6.79E-03	3.43E-03	9.53E-05
12	9	6.58E-03	3.33E-03	8.96E-05
12	10	6.79E-03	3.43E-03	9.53E-05
12	10	6.58E-03	3.33E-03	8.96E-05
12	10	5.54E-03	4.86E-03	8.10E-05
12	10	5.37E-03	4.71E-03	7.62E-05
12	11	5.54E-03	4.86E-03	8.10E-05
12	11	5.37E-03	4.71E-03	7.62E-05
12	11	3.92E-03	5.95E-03	6.67E-05
12	11	3.80E-03	5.77E-03	6.27E-05
12	12	3.92E-03	5.95E-03	6.67E-05
12	12	3.80E-03	5.77E-03	6.27E-05
12	12	2.03E-03	6.63E-03	5.62E-05
12	12	1.97E-03	6.43E-03	5.28E-05
12	12	3.67E-10	6.87E-03	5.23E-05
12	12	3.56E-10	6.66E-03	4.92E-05
13	13	8.17E-03	0.00E+00	1.19E-04
13	13	7.95E-03	0.00E+00	1.13E-04
13	13	7.89E-03	1.85E-03	1.15E-04
13	13	7.67E-03	1.80E-03	1.09E-04
13	13	7.08E-03	3.58E-03	1.04E-04
13	13	6.88E-03	3.48E-03	9.80E-05
13	14	7.08E-03	3.58E-03	1.04E-04
13	14	6.88E-03	3.48E-03	9.80E-05
13	14	5.78E-03	5.06E-03	8.81E-05
13	14	5.62E-03	4.92E-03	8.33E-05
13	15	5.78E-03	5.06E-03	8.81E-05
13	15	5.62E-03	4.92E-03	8.33E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 3 Ring	Element	x	y	z
13	15	4.09E-03	6.20E-03	7.25E-05
13	15	3.97E-03	6.03E-03	6.85E-05
13	16	4.09E-03	6.20E-03	7.25E-05
13	16	3.97E-03	6.03E-03	6.85E-05
13	16	2.12E-03	6.92E-03	6.11E-05
13	16	2.06E-03	6.73E-03	5.77E-05
13	16	3.83E-10	7.16E-03	5.69E-05
13	16	3.72E-10	6.96E-03	5.38E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
14	1	8.60E-03	0.00E+00	1.32E-04
14	1	8.28E-03	0.00E+00	1.22E-04
14	1	8.57E-03	6.57E-04	1.32E-04
14	1	8.25E-03	6.32E-04	1.22E-04
14	1	8.47E-03	1.31E-03	1.30E-04
14	1	8.15E-03	1.26E-03	1.20E-04
14	1	8.31E-03	1.95E-03	1.28E-04
14	1	8.00E-03	1.88E-03	1.18E-04
14	1	8.09E-03	2.58E-03	1.24E-04
14	1	7.78E-03	2.48E-03	1.15E-04
14	1	7.80E-03	3.19E-03	1.20E-04
14	1	7.51E-03	3.07E-03	1.11E-04
14	1	7.45E-03	3.77E-03	1.15E-04
14	1	7.17E-03	3.63E-03	1.06E-04
14	2	7.45E-03	3.77E-03	1.15E-04
14	2	7.17E-03	3.63E-03	1.06E-04
14	2	7.05E-03	4.32E-03	1.09E-04
14	2	6.78E-03	4.16E-03	1.01E-04
14	2	6.59E-03	4.85E-03	1.04E-04
14	2	6.34E-03	4.66E-03	9.60E-05
14	2	6.09E-03	5.33E-03	9.77E-05
14	2	5.86E-03	5.13E-03	9.04E-05
14	3	6.09E-03	5.33E-03	9.77E-05
14	3	5.86E-03	5.13E-03	9.04E-05
14	3	5.53E-03	5.78E-03	9.17E-05
14	3	5.32E-03	5.56E-03	8.49E-05
14	3	4.94E-03	6.18E-03	8.58E-05
14	3	4.75E-03	5.94E-03	7.95E-05
14	3	4.30E-03	6.53E-03	8.04E-05
14	3	4.14E-03	6.28E-03	7.44E-05
14	4	4.30E-03	6.53E-03	8.04E-05
14	4	4.14E-03	6.28E-03	7.44E-05
14	4	3.64E-03	6.83E-03	7.54E-05
14	4	3.50E-03	6.58E-03	6.99E-05
14	4	2.94E-03	7.09E-03	7.12E-05
14	4	2.83E-03	6.82E-03	6.59E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
14	4	2.23E-03	7.28E-03	6.77E-05
14	4	2.14E-03	7.01E-03	6.27E-05
14	4	1.49E-03	7.43E-03	6.52E-05
14	4	1.44E-03	7.15E-03	6.03E-05
14	4	7.50E-04	7.51E-03	6.36E-05
14	4	7.22E-04	7.23E-03	5.89E-05
14	4	4.03E-10	7.54E-03	6.31E-05
14	4	3.88E-10	7.26E-03	5.84E-05
15	5	9.03E-03	0.00E+00	1.45E-04
15	5	8.71E-03	0.00E+00	1.36E-04
15	5	8.99E-03	6.89E-04	1.45E-04
15	5	8.68E-03	6.65E-04	1.35E-04
15	5	8.89E-03	1.37E-03	1.43E-04
15	5	8.58E-03	1.33E-03	1.33E-04
15	5	8.72E-03	2.05E-03	1.40E-04
15	5	8.42E-03	1.98E-03	1.31E-04
15	5	8.48E-03	2.70E-03	1.37E-04
15	5	8.19E-03	2.61E-03	1.27E-04
15	5	8.18E-03	3.34E-03	1.32E-04
15	5	7.90E-03	3.23E-03	1.23E-04
15	5	7.82E-03	3.95E-03	1.26E-04
15	5	7.55E-03	3.82E-03	1.18E-04
15	6	7.82E-03	3.95E-03	1.26E-04
15	6	7.55E-03	3.82E-03	1.18E-04
15	6	7.40E-03	4.54E-03	1.20E-04
15	6	7.14E-03	4.38E-03	1.12E-04
15	6	6.92E-03	5.08E-03	1.14E-04
15	6	6.68E-03	4.91E-03	1.06E-04
15	6	6.38E-03	5.59E-03	1.07E-04
15	6	6.16E-03	5.40E-03	1.00E-04
15	7	6.38E-03	5.59E-03	1.07E-04
15	7	6.16E-03	5.40E-03	1.00E-04
15	7	5.80E-03	6.06E-03	1.01E-04
15	7	5.60E-03	5.85E-03	9.40E-05
15	7	5.18E-03	6.48E-03	9.45E-05
15	7	5.00E-03	6.25E-03	8.80E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
15	7	4.52E-03	6.85E-03	8.84E-05
15	7	4.36E-03	6.61E-03	8.24E-05
15	8	4.52E-03	6.85E-03	8.84E-05
15	8	4.36E-03	6.61E-03	8.24E-05
15	8	3.82E-03	7.17E-03	8.30E-05
15	8	3.68E-03	6.92E-03	7.73E-05
15	8	3.09E-03	7.43E-03	7.83E-05
15	8	2.98E-03	7.18E-03	7.30E-05
15	8	2.34E-03	7.64E-03	7.45E-05
15	8	2.26E-03	7.38E-03	6.94E-05
15	8	1.57E-03	7.79E-03	7.17E-05
15	8	1.51E-03	7.52E-03	6.68E-05
15	8	7.87E-04	7.88E-03	7.00E-05
15	8	7.60E-04	7.61E-03	6.52E-05
15	8	4.23E-10	7.91E-03	6.94E-05
15	8	4.08E-10	7.64E-03	6.47E-05
16	9	9.44E-03	0.00E+00	1.59E-04
16	9	9.13E-03	0.00E+00	1.49E-04
16	9	9.40E-03	7.21E-04	1.58E-04
16	9	9.10E-03	6.97E-04	1.48E-04
16	9	9.29E-03	1.44E-03	1.57E-04
16	9	9.00E-03	1.39E-03	1.47E-04
16	9	9.12E-03	2.14E-03	1.53E-04
16	9	8.82E-03	2.07E-03	1.44E-04
16	9	8.87E-03	2.83E-03	1.49E-04
16	9	8.58E-03	2.74E-03	1.40E-04
16	9	8.55E-03	3.49E-03	1.44E-04
16	9	8.28E-03	3.38E-03	1.35E-04
16	9	8.17E-03	4.13E-03	1.38E-04
16	9	7.91E-03	4.00E-03	1.30E-04
16	10	8.17E-03	4.13E-03	1.38E-04
16	10	7.91E-03	4.00E-03	1.30E-04
16	10	7.73E-03	4.74E-03	1.32E-04
16	10	7.48E-03	4.59E-03	1.23E-04
16	10	7.23E-03	5.32E-03	1.25E-04
16	10	7.00E-03	5.15E-03	1.17E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
16	10	6.68E-03	5.85E-03	1.17E-04
16	10	6.46E-03	5.66E-03	1.10E-04
16	11	6.68E-03	5.85E-03	1.17E-04
16	11	6.46E-03	5.66E-03	1.10E-04
16	11	6.07E-03	6.34E-03	1.10E-04
16	11	5.87E-03	6.13E-03	1.03E-04
16	11	5.42E-03	6.78E-03	1.03E-04
16	11	5.24E-03	6.56E-03	9.67E-05
16	11	4.72E-03	7.16E-03	9.67E-05
16	11	4.57E-03	6.93E-03	9.06E-05
16	12	4.72E-03	7.16E-03	9.67E-05
16	12	4.57E-03	6.93E-03	9.06E-05
16	12	3.99E-03	7.50E-03	9.07E-05
16	12	3.86E-03	7.26E-03	8.50E-05
16	12	3.23E-03	7.77E-03	8.56E-05
16	12	3.13E-03	7.52E-03	8.02E-05
16	12	2.44E-03	7.99E-03	8.14E-05
16	12	2.37E-03	7.73E-03	7.63E-05
16	12	1.64E-03	8.15E-03	7.84E-05
16	12	1.59E-03	7.89E-03	7.34E-05
16	12	8.23E-04	8.24E-03	7.65E-05
16	12	7.97E-04	7.98E-03	7.17E-05
16	12	4.42E-10	8.27E-03	7.59E-05
16	12	4.28E-10	8.01E-03	7.11E-05
17	13	9.83E-03	0.00E+00	1.72E-04
17	13	9.55E-03	0.00E+00	1.63E-04
17	13	9.79E-03	7.50E-04	1.72E-04
17	13	9.51E-03	7.29E-04	1.62E-04
17	13	9.68E-03	1.49E-03	1.70E-04
17	13	9.40E-03	1.45E-03	1.60E-04
17	13	9.49E-03	2.23E-03	1.66E-04
17	13	9.22E-03	2.16E-03	1.57E-04
17	13	9.23E-03	2.94E-03	1.62E-04
17	13	8.97E-03	2.86E-03	1.53E-04
17	13	8.91E-03	3.64E-03	1.56E-04
17	13	8.65E-03	3.53E-03	1.48E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
17	13	8.51E-03	4.31E-03	1.50E-04
17	13	8.27E-03	4.18E-03	1.41E-04
17	14	8.51E-03	4.31E-03	1.50E-04
17	14	8.27E-03	4.18E-03	1.41E-04
17	14	8.05E-03	4.94E-03	1.43E-04
17	14	7.82E-03	4.80E-03	1.35E-04
17	14	7.53E-03	5.54E-03	1.35E-04
17	14	7.31E-03	5.38E-03	1.28E-04
17	14	6.95E-03	6.09E-03	1.27E-04
17	14	6.75E-03	5.91E-03	1.20E-04
17	15	6.95E-03	6.09E-03	1.27E-04
17	15	6.75E-03	5.91E-03	1.20E-04
17	15	6.32E-03	6.60E-03	1.20E-04
17	15	6.14E-03	6.41E-03	1.13E-04
17	15	5.64E-03	7.05E-03	1.12E-04
17	15	5.48E-03	6.85E-03	1.06E-04
17	15	4.92E-03	7.46E-03	1.05E-04
17	15	4.78E-03	7.25E-03	9.89E-05
17	16	4.92E-03	7.46E-03	1.05E-04
17	16	4.78E-03	7.25E-03	9.89E-05
17	16	4.16E-03	7.81E-03	9.84E-05
17	16	4.04E-03	7.58E-03	9.28E-05
17	16	3.36E-03	8.09E-03	9.28E-05
17	16	3.27E-03	7.86E-03	8.76E-05
17	16	2.54E-03	8.32E-03	8.83E-05
17	16	2.47E-03	8.08E-03	8.33E-05
17	16	1.71E-03	8.48E-03	8.50E-05
17	16	1.66E-03	8.24E-03	8.02E-05
17	16	8.57E-04	8.58E-03	8.29E-05
17	16	8.32E-04	8.34E-03	7.83E-05
17	16	4.60E-10	8.61E-03	8.23E-05
17	16	4.47E-10	8.37E-03	7.76E-05
18	17	1.02E-02	0.00E+00	1.86E-04
18	17	9.93E-03	0.00E+00	1.76E-04
18	17	1.02E-02	7.79E-04	1.85E-04
18	17	9.90E-03	7.59E-04	1.76E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
18	17	1.01E-02	1.55E-03	1.83E-04
18	17	9.78E-03	1.51E-03	1.73E-04
18	17	9.86E-03	2.31E-03	1.79E-04
18	17	9.60E-03	2.25E-03	1.70E-04
18	17	9.59E-03	3.06E-03	1.75E-04
18	17	9.34E-03	2.98E-03	1.65E-04
18	17	9.25E-03	3.78E-03	1.69E-04
18	17	9.01E-03	3.68E-03	1.60E-04
18	17	8.84E-03	4.47E-03	1.62E-04
18	17	8.61E-03	4.35E-03	1.53E-04
18	18	8.84E-03	4.47E-03	1.62E-04
18	18	8.61E-03	4.35E-03	1.53E-04
18	18	8.36E-03	5.13E-03	1.54E-04
18	18	8.14E-03	4.99E-03	1.46E-04
18	18	7.82E-03	5.75E-03	1.46E-04
18	18	7.61E-03	5.60E-03	1.38E-04
18	18	7.22E-03	6.32E-03	1.37E-04
18	18	7.03E-03	6.16E-03	1.30E-04
18	19	7.22E-03	6.32E-03	1.37E-04
18	19	7.03E-03	6.16E-03	1.30E-04
18	19	6.56E-03	6.85E-03	1.29E-04
18	19	6.39E-03	6.67E-03	1.22E-04
18	19	5.86E-03	7.33E-03	1.21E-04
18	19	5.70E-03	7.13E-03	1.14E-04
18	19	5.11E-03	7.75E-03	1.13E-04
18	19	4.97E-03	7.54E-03	1.07E-04
18	20	5.11E-03	7.75E-03	1.13E-04
18	20	4.97E-03	7.54E-03	1.07E-04
18	20	4.32E-03	8.11E-03	1.06E-04
18	20	4.20E-03	7.89E-03	1.01E-04
18	20	3.49E-03	8.41E-03	1.00E-04
18	20	3.40E-03	8.18E-03	9.49E-05
18	20	2.64E-03	8.64E-03	9.52E-05
18	20	2.57E-03	8.41E-03	9.03E-05
18	20	1.77E-03	8.81E-03	9.17E-05
18	20	1.73E-03	8.58E-03	8.69E-05

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
18	20	8.90E-04	8.91E-03	8.95E-05
18	20	8.66E-04	8.68E-03	8.48E-05
18	20	4.78E-10	8.95E-03	8.87E-05
18	20	4.65E-10	8.71E-03	8.41E-05
19	21	1.06E-02	0.00E+00	2.00E-04
19	21	1.03E-02	0.00E+00	1.90E-04
19	21	1.05E-02	8.08E-04	1.99E-04
19	21	1.03E-02	7.87E-04	1.89E-04
19	21	1.04E-02	1.61E-03	1.97E-04
19	21	1.02E-02	1.57E-03	1.87E-04
19	21	1.02E-02	2.40E-03	1.93E-04
19	21	9.96E-03	2.34E-03	1.83E-04
19	21	9.95E-03	3.17E-03	1.88E-04
19	21	9.69E-03	3.09E-03	1.78E-04
19	21	9.59E-03	3.92E-03	1.81E-04
19	21	9.35E-03	3.82E-03	1.72E-04
19	21	9.17E-03	4.64E-03	1.74E-04
19	21	8.93E-03	4.52E-03	1.65E-04
19	22	9.17E-03	4.64E-03	1.74E-04
19	22	8.93E-03	4.52E-03	1.65E-04
19	22	8.67E-03	5.32E-03	1.66E-04
19	22	8.45E-03	5.18E-03	1.57E-04
19	22	8.11E-03	5.96E-03	1.57E-04
19	22	7.90E-03	5.81E-03	1.49E-04
19	22	7.49E-03	6.56E-03	1.48E-04
19	22	7.30E-03	6.39E-03	1.40E-04
19	23	7.49E-03	6.56E-03	1.48E-04
19	23	7.30E-03	6.39E-03	1.40E-04
19	23	6.81E-03	7.11E-03	1.39E-04
19	23	6.63E-03	6.92E-03	1.32E-04
19	23	6.07E-03	7.60E-03	1.30E-04
19	23	5.92E-03	7.40E-03	1.23E-04
19	23	5.30E-03	8.03E-03	1.22E-04
19	23	5.16E-03	7.83E-03	1.15E-04
19	24	5.30E-03	8.03E-03	1.22E-04
19	24	5.16E-03	7.83E-03	1.15E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
19	24	4.48E-03	8.41E-03	1.14E-04
19	24	4.36E-03	8.19E-03	1.08E-04
19	24	3.62E-03	8.72E-03	1.08E-04
19	24	3.53E-03	8.50E-03	1.02E-04
19	24	2.74E-03	8.96E-03	1.02E-04
19	24	2.67E-03	8.73E-03	9.73E-05
19	24	1.84E-03	9.14E-03	9.86E-05
19	24	1.79E-03	8.90E-03	9.36E-05
19	24	9.23E-04	9.24E-03	9.62E-05
19	24	9.00E-04	9.01E-03	9.14E-05
19	24	4.96E-10	9.28E-03	9.54E-05
19	24	4.83E-10	9.04E-03	9.06E-05
20	25	1.10E-02	0.00E+00	2.14E-04
20	25	1.07E-02	0.00E+00	2.04E-04
20	25	1.09E-02	8.36E-04	2.13E-04
20	25	1.07E-02	8.16E-04	2.03E-04
20	25	1.08E-02	1.67E-03	2.11E-04
20	25	1.05E-02	1.63E-03	2.01E-04
20	25	1.06E-02	2.48E-03	2.07E-04
20	25	1.03E-02	2.42E-03	1.97E-04
20	25	1.03E-02	3.28E-03	2.01E-04
20	25	1.00E-02	3.20E-03	1.92E-04
20	25	9.93E-03	4.06E-03	1.94E-04
20	25	9.69E-03	3.96E-03	1.85E-04
20	25	9.49E-03	4.80E-03	1.86E-04
20	25	9.26E-03	4.68E-03	1.77E-04
20	26	9.49E-03	4.80E-03	1.86E-04
20	26	9.26E-03	4.68E-03	1.77E-04
20	26	8.97E-03	5.50E-03	1.77E-04
20	26	8.76E-03	5.37E-03	1.69E-04
20	26	8.39E-03	6.17E-03	1.68E-04
20	26	8.19E-03	6.02E-03	1.60E-04
20	26	7.75E-03	6.79E-03	1.58E-04
20	26	7.56E-03	6.63E-03	1.51E-04
20	27	7.75E-03	6.79E-03	1.58E-04
20	27	7.56E-03	6.63E-03	1.51E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
20	27	7.04E-03	7.35E-03	1.48E-04
20	27	6.88E-03	7.18E-03	1.42E-04
20	27	6.29E-03	7.86E-03	1.39E-04
20	27	6.14E-03	7.68E-03	1.33E-04
20	27	5.48E-03	8.31E-03	1.30E-04
20	27	5.35E-03	8.12E-03	1.24E-04
20	28	5.48E-03	8.31E-03	1.30E-04
20	28	5.35E-03	8.12E-03	1.24E-04
20	28	4.63E-03	8.70E-03	1.22E-04
20	28	4.52E-03	8.49E-03	1.16E-04
20	28	3.75E-03	9.02E-03	1.15E-04
20	28	3.66E-03	8.81E-03	1.10E-04
20	28	2.84E-03	9.27E-03	1.10E-04
20	28	2.77E-03	9.05E-03	1.05E-04
20	28	1.90E-03	9.46E-03	1.06E-04
20	28	1.86E-03	9.23E-03	1.01E-04
20	28	9.55E-04	9.57E-03	1.03E-04
20	28	9.33E-04	9.34E-03	9.82E-05
20	28	5.13E-10	9.60E-03	1.02E-04
20	28	5.01E-10	9.37E-03	9.74E-05
21	29	1.13E-02	0.00E+00	2.28E-04
21	29	1.11E-02	0.00E+00	2.18E-04
21	29	1.13E-02	8.63E-04	2.27E-04
21	29	1.10E-02	8.44E-04	2.18E-04
21	29	1.11E-02	1.72E-03	2.25E-04
21	29	1.09E-02	1.68E-03	2.15E-04
21	29	1.09E-02	2.56E-03	2.20E-04
21	29	1.07E-02	2.51E-03	2.11E-04
21	29	1.06E-02	3.39E-03	2.14E-04
21	29	1.04E-02	3.31E-03	2.05E-04
21	29	1.03E-02	4.19E-03	2.07E-04
21	29	1.00E-02	4.10E-03	1.98E-04
21	29	9.80E-03	4.95E-03	1.99E-04
21	29	9.58E-03	4.85E-03	1.90E-04
21	30	9.80E-03	4.95E-03	1.99E-04
21	30	9.58E-03	4.85E-03	1.90E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
21	30	9.27E-03	5.68E-03	1.89E-04
21	30	9.06E-03	5.56E-03	1.81E-04
21	30	8.67E-03	6.37E-03	1.79E-04
21	30	8.48E-03	6.23E-03	1.71E-04
21	30	8.00E-03	7.01E-03	1.69E-04
21	30	7.82E-03	6.85E-03	1.61E-04
21	31	8.00E-03	7.01E-03	1.69E-04
21	31	7.82E-03	6.85E-03	1.61E-04
21	31	7.27E-03	7.59E-03	1.58E-04
21	31	7.11E-03	7.43E-03	1.51E-04
21	31	6.49E-03	8.12E-03	1.48E-04
21	31	6.35E-03	7.94E-03	1.42E-04
21	31	5.66E-03	8.59E-03	1.39E-04
21	31	5.53E-03	8.40E-03	1.33E-04
21	32	5.66E-03	8.59E-03	1.39E-04
21	32	5.53E-03	8.40E-03	1.33E-04
21	32	4.78E-03	8.99E-03	1.30E-04
21	32	4.68E-03	8.79E-03	1.25E-04
21	32	3.87E-03	9.32E-03	1.23E-04
21	32	3.79E-03	9.11E-03	1.18E-04
21	32	2.93E-03	9.58E-03	1.17E-04
21	32	2.86E-03	9.37E-03	1.12E-04
21	32	1.97E-03	9.76E-03	1.13E-04
21	32	1.92E-03	9.55E-03	1.08E-04
21	32	9.87E-04	9.88E-03	1.10E-04
21	32	9.65E-04	9.66E-03	1.05E-04
21	32	5.30E-10	9.92E-03	1.09E-04
21	32	5.18E-10	9.70E-03	1.04E-04
22	33	1.17E-02	0.00E+00	2.43E-04
22	33	1.14E-02	0.00E+00	2.33E-04
22	33	1.16E-02	8.90E-04	2.42E-04
22	33	1.14E-02	8.72E-04	2.32E-04
22	33	1.15E-02	1.77E-03	2.39E-04
22	33	1.12E-02	1.74E-03	2.29E-04
22	33	1.13E-02	2.64E-03	2.34E-04
22	33	1.10E-02	2.59E-03	2.25E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
22	33	1.10E-02	3.49E-03	2.28E-04
22	33	1.07E-02	3.42E-03	2.19E-04
22	33	1.06E-02	4.32E-03	2.20E-04
22	33	1.03E-02	4.23E-03	2.11E-04
22	33	1.01E-02	5.11E-03	2.11E-04
22	33	9.89E-03	5.00E-03	2.02E-04
22	34	1.01E-02	5.11E-03	2.11E-04
22	34	9.89E-03	5.00E-03	2.02E-04
22	34	9.55E-03	5.86E-03	2.01E-04
22	34	9.36E-03	5.74E-03	1.93E-04
22	34	8.93E-03	6.57E-03	1.90E-04
22	34	8.75E-03	6.43E-03	1.83E-04
22	34	8.25E-03	7.22E-03	1.79E-04
22	34	8.08E-03	7.08E-03	1.72E-04
22	35	8.25E-03	7.22E-03	1.79E-04
22	35	8.08E-03	7.08E-03	1.72E-04
22	35	7.50E-03	7.83E-03	1.68E-04
22	35	7.34E-03	7.67E-03	1.61E-04
22	35	6.69E-03	8.37E-03	1.58E-04
22	35	6.55E-03	8.20E-03	1.51E-04
22	35	5.83E-03	8.85E-03	1.47E-04
22	35	5.71E-03	8.67E-03	1.42E-04
22	36	5.83E-03	8.85E-03	1.47E-04
22	36	5.71E-03	8.67E-03	1.42E-04
22	36	4.93E-03	9.26E-03	1.38E-04
22	36	4.83E-03	9.07E-03	1.33E-04
22	36	3.99E-03	9.60E-03	1.31E-04
22	36	3.91E-03	9.41E-03	1.25E-04
22	36	3.02E-03	9.87E-03	1.24E-04
22	36	2.96E-03	9.67E-03	1.19E-04
22	36	2.03E-03	1.01E-02	1.20E-04
22	36	1.98E-03	9.86E-03	1.15E-04
22	36	1.02E-03	1.02E-02	1.17E-04
22	36	9.96E-04	9.97E-03	1.12E-04
22	36	5.46E-10	1.02E-02	1.16E-04
22	36	5.35E-10	1.00E-02	1.11E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
23	37	1.20E-02	0.00E+00	2.57E-04
23	37	1.18E-02	0.00E+00	2.47E-04
23	37	1.20E-02	9.16E-04	2.56E-04
23	37	1.17E-02	8.98E-04	2.46E-04
23	37	1.18E-02	1.83E-03	2.53E-04
23	37	1.16E-02	1.79E-03	2.43E-04
23	37	1.16E-02	2.72E-03	2.48E-04
23	37	1.14E-02	2.67E-03	2.38E-04
23	37	1.13E-02	3.60E-03	2.41E-04
23	37	1.11E-02	3.53E-03	2.32E-04
23	37	1.09E-02	4.44E-03	2.33E-04
23	37	1.07E-02	4.36E-03	2.24E-04
23	37	1.04E-02	5.26E-03	2.24E-04
23	37	1.02E-02	5.15E-03	2.15E-04
23	38	1.04E-02	5.26E-03	2.24E-04
23	38	1.02E-02	5.15E-03	2.15E-04
23	38	9.83E-03	6.03E-03	2.13E-04
23	38	9.64E-03	5.91E-03	2.05E-04
23	38	9.20E-03	6.76E-03	2.02E-04
23	38	9.02E-03	6.63E-03	1.94E-04
23	38	8.49E-03	7.44E-03	1.90E-04
23	38	8.32E-03	7.29E-03	1.83E-04
23	39	8.49E-03	7.44E-03	1.90E-04
23	39	8.32E-03	7.29E-03	1.83E-04
23	39	7.72E-03	8.06E-03	1.78E-04
23	39	7.57E-03	7.90E-03	1.71E-04
23	39	6.89E-03	8.62E-03	1.67E-04
23	39	6.75E-03	8.45E-03	1.60E-04
23	39	6.01E-03	9.11E-03	1.56E-04
23	39	5.89E-03	8.93E-03	1.50E-04
23	40	6.01E-03	9.11E-03	1.56E-04
23	40	5.89E-03	8.93E-03	1.50E-04
23	40	5.08E-03	9.54E-03	1.47E-04
23	40	4.98E-03	9.35E-03	1.41E-04
23	40	4.11E-03	9.89E-03	1.38E-04
23	40	4.03E-03	9.69E-03	1.33E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
23	40	3.11E-03	1.02E-02	1.32E-04
23	40	3.05E-03	9.96E-03	1.27E-04
23	40	2.09E-03	1.04E-02	1.27E-04
23	40	2.04E-03	1.02E-02	1.22E-04
23	40	1.05E-03	1.05E-02	1.24E-04
23	40	1.03E-03	1.03E-02	1.19E-04
23	40	5.62E-10	1.05E-02	1.23E-04
23	40	5.51E-10	1.03E-02	1.18E-04
24	41	1.23E-02	0.00E+00	2.72E-04
24	41	1.21E-02	0.00E+00	2.62E-04
24	41	1.23E-02	9.42E-04	2.71E-04
24	41	1.21E-02	9.25E-04	2.61E-04
24	41	1.22E-02	1.88E-03	2.67E-04
24	41	1.19E-02	1.84E-03	2.58E-04
24	41	1.19E-02	2.80E-03	2.62E-04
24	41	1.17E-02	2.75E-03	2.53E-04
24	41	1.16E-02	3.70E-03	2.55E-04
24	41	1.14E-02	3.63E-03	2.46E-04
24	41	1.12E-02	4.57E-03	2.46E-04
24	41	1.10E-02	4.48E-03	2.37E-04
24	41	1.07E-02	5.41E-03	2.36E-04
24	41	1.05E-02	5.31E-03	2.28E-04
24	42	1.07E-02	5.41E-03	2.36E-04
24	42	1.05E-02	5.31E-03	2.28E-04
24	42	1.01E-02	6.20E-03	2.25E-04
24	42	9.92E-03	6.09E-03	2.17E-04
24	42	9.46E-03	6.95E-03	2.13E-04
24	42	9.28E-03	6.82E-03	2.05E-04
24	42	8.73E-03	7.65E-03	2.01E-04
24	42	8.57E-03	7.51E-03	1.93E-04
24	43	8.73E-03	7.65E-03	2.01E-04
24	43	8.57E-03	7.51E-03	1.93E-04
24	43	7.94E-03	8.28E-03	1.88E-04
24	43	7.79E-03	8.13E-03	1.82E-04
24	43	7.08E-03	8.86E-03	1.76E-04
24	43	6.95E-03	8.70E-03	1.70E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
24	43	6.17E-03	9.37E-03	1.65E-04
24	43	6.06E-03	9.19E-03	1.59E-04
24	44	6.17E-03	9.37E-03	1.65E-04
24	44	6.06E-03	9.19E-03	1.59E-04
24	44	5.22E-03	9.80E-03	1.55E-04
24	44	5.12E-03	9.62E-03	1.49E-04
24	44	4.22E-03	1.02E-02	1.46E-04
24	44	4.15E-03	9.98E-03	1.41E-04
24	44	3.20E-03	1.04E-02	1.39E-04
24	44	3.14E-03	1.03E-02	1.34E-04
24	44	2.14E-03	1.07E-02	1.34E-04
24	44	2.11E-03	1.05E-02	1.29E-04
24	44	1.08E-03	1.08E-02	1.31E-04
24	44	1.06E-03	1.06E-02	1.26E-04
24	44	5.78E-10	1.08E-02	1.30E-04
24	44	5.67E-10	1.06E-02	1.25E-04
25	45	1.27E-02	0.00E+00	2.86E-04
25	45	1.24E-02	0.00E+00	2.77E-04
25	45	1.26E-02	9.67E-04	2.85E-04
25	45	1.24E-02	9.50E-04	2.75E-04
25	45	1.25E-02	1.93E-03	2.82E-04
25	45	1.23E-02	1.89E-03	2.72E-04
25	45	1.22E-02	2.87E-03	2.76E-04
25	45	1.20E-02	2.82E-03	2.67E-04
25	45	1.19E-02	3.79E-03	2.69E-04
25	45	1.17E-02	3.73E-03	2.60E-04
25	45	1.15E-02	4.69E-03	2.60E-04
25	45	1.13E-02	4.61E-03	2.51E-04
25	45	1.10E-02	5.55E-03	2.49E-04
25	45	1.08E-02	5.45E-03	2.40E-04
25	46	1.10E-02	5.55E-03	2.49E-04
25	46	1.08E-02	5.45E-03	2.40E-04
25	46	1.04E-02	6.36E-03	2.37E-04
25	46	1.02E-02	6.26E-03	2.29E-04
25	46	9.70E-03	7.13E-03	2.25E-04
25	46	9.54E-03	7.01E-03	2.17E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 4 Ring	Element	x	y	z
25	46	8.96E-03	7.85E-03	2.12E-04
25	46	8.81E-03	7.71E-03	2.04E-04
25	47	8.96E-03	7.85E-03	2.12E-04
25	47	8.81E-03	7.71E-03	2.04E-04
25	47	8.14E-03	8.50E-03	1.99E-04
25	47	8.01E-03	8.36E-03	1.92E-04
25	47	7.27E-03	9.09E-03	1.86E-04
25	47	7.14E-03	8.94E-03	1.80E-04
25	47	6.34E-03	9.61E-03	1.74E-04
25	47	6.23E-03	9.45E-03	1.68E-04
25	48	6.34E-03	9.61E-03	1.74E-04
25	48	6.23E-03	9.45E-03	1.68E-04
25	48	5.36E-03	1.01E-02	1.63E-04
25	48	5.26E-03	9.89E-03	1.58E-04
25	48	4.34E-03	1.04E-02	1.54E-04
25	48	4.26E-03	1.03E-02	1.49E-04
25	48	3.28E-03	1.07E-02	1.47E-04
25	48	3.22E-03	1.05E-02	1.42E-04
25	48	2.20E-03	1.09E-02	1.41E-04
25	48	2.16E-03	1.07E-02	1.36E-04
25	48	1.10E-03	1.11E-02	1.38E-04
25	48	1.09E-03	1.09E-02	1.33E-04
25	48	5.93E-10	1.11E-02	1.37E-04
25	48	5.83E-10	1.09E-02	1.32E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
26	1	1.31E-02	0.00E+00	3.06E-04
26	1	1.28E-02	0.00E+00	2.91E-04
26	1	1.30E-02	9.99E-04	3.04E-04
26	1	1.27E-02	9.75E-04	2.90E-04
26	1	1.29E-02	1.99E-03	3.01E-04
26	1	1.26E-02	1.94E-03	2.87E-04
26	1	1.26E-02	2.97E-03	2.95E-04
26	1	1.23E-02	2.90E-03	2.81E-04
26	1	1.23E-02	3.92E-03	2.87E-04
26	1	1.20E-02	3.83E-03	2.73E-04
26	1	1.19E-02	4.85E-03	2.77E-04
26	1	1.16E-02	4.73E-03	2.64E-04
26	1	1.13E-02	5.73E-03	2.66E-04
26	1	1.11E-02	5.60E-03	2.53E-04
26	2	1.13E-02	5.73E-03	2.66E-04
26	2	1.11E-02	5.60E-03	2.53E-04
26	2	1.07E-02	6.58E-03	2.53E-04
26	2	1.05E-02	6.42E-03	2.41E-04
26	2	1.00E-02	7.37E-03	2.40E-04
26	2	9.79E-03	7.19E-03	2.28E-04
26	2	9.26E-03	8.11E-03	2.26E-04
26	2	9.04E-03	7.92E-03	2.15E-04
26	3	9.26E-03	8.11E-03	2.26E-04
26	3	9.04E-03	7.92E-03	2.15E-04
26	3	8.42E-03	8.79E-03	2.12E-04
26	3	8.21E-03	8.58E-03	2.02E-04
26	3	7.51E-03	9.40E-03	1.99E-04
26	3	7.33E-03	9.17E-03	1.89E-04
26	3	6.55E-03	9.94E-03	1.86E-04
26	3	6.39E-03	9.70E-03	1.77E-04
26	4	6.55E-03	9.94E-03	1.86E-04
26	4	6.39E-03	9.70E-03	1.77E-04
26	4	5.54E-03	1.04E-02	1.74E-04
26	4	5.40E-03	1.01E-02	1.66E-04
26	4	4.48E-03	1.08E-02	1.65E-04
26	4	4.37E-03	1.05E-02	1.57E-04
26	4	3.39E-03	1.11E-02	1.57E-04
26	4	3.31E-03	1.08E-02	1.49E-04
26	4	2.27E-03	1.13E-02	1.51E-04
26	4	2.22E-03	1.10E-02	1.44E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
26	4	1.14E-03	1.14E-02	1.47E-04
26	4	1.11E-03	1.12E-02	1.40E-04
26	4	6.13E-10	1.15E-02	1.46E-04
26	4	5.98E-10	1.12E-02	1.39E-04
27	5	1.35E-02	0.00E+00	3.25E-04
27	5	1.32E-02	0.00E+00	3.11E-04
27	5	1.34E-02	1.03E-03	3.24E-04
27	5	1.31E-02	1.01E-03	3.10E-04
27	5	1.33E-02	2.05E-03	3.20E-04
27	5	1.30E-02	2.01E-03	3.06E-04
27	5	1.30E-02	3.06E-03	3.14E-04
27	5	1.27E-02	2.99E-03	3.00E-04
27	5	1.27E-02	4.04E-03	3.05E-04
27	5	1.24E-02	3.95E-03	2.92E-04
27	5	1.22E-02	5.00E-03	2.95E-04
27	5	1.20E-02	4.89E-03	2.82E-04
27	5	1.17E-02	5.91E-03	2.83E-04
27	5	1.14E-02	5.78E-03	2.70E-04
27	6	1.17E-02	5.91E-03	2.83E-04
27	6	1.14E-02	5.78E-03	2.70E-04
27	6	1.11E-02	6.78E-03	2.69E-04
27	6	1.08E-02	6.63E-03	2.57E-04
27	6	1.03E-02	7.60E-03	2.55E-04
27	6	1.01E-02	7.43E-03	2.44E-04
27	6	9.55E-03	8.37E-03	2.40E-04
27	6	9.33E-03	8.18E-03	2.30E-04
27	7	9.55E-03	8.37E-03	2.40E-04
27	7	9.33E-03	8.18E-03	2.30E-04
27	7	8.68E-03	9.06E-03	2.26E-04
27	7	8.49E-03	8.86E-03	2.16E-04
27	7	7.75E-03	9.69E-03	2.11E-04
27	7	7.57E-03	9.48E-03	2.02E-04
27	7	6.75E-03	1.02E-02	1.98E-04
27	7	6.60E-03	1.00E-02	1.89E-04
27	8	6.75E-03	1.02E-02	1.98E-04
27	8	6.60E-03	1.00E-02	1.89E-04
27	8	5.71E-03	1.07E-02	1.86E-04
27	8	5.58E-03	1.05E-02	1.77E-04
27	8	4.62E-03	1.11E-02	1.75E-04
27	8	4.52E-03	1.09E-02	1.67E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
27	8	3.50E-03	1.14E-02	1.67E-04
27	8	3.42E-03	1.12E-02	1.59E-04
27	8	2.35E-03	1.17E-02	1.60E-04
27	8	2.29E-03	1.14E-02	1.53E-04
27	8	1.18E-03	1.18E-02	1.56E-04
27	8	1.15E-03	1.15E-02	1.50E-04
27	8	6.32E-10	1.18E-02	1.55E-04
27	8	6.18E-10	1.16E-02	1.48E-04
28	9	1.39E-02	0.00E+00	3.45E-04
28	9	1.36E-02	0.00E+00	3.30E-04
28	9	1.38E-02	1.06E-03	3.43E-04
28	9	1.36E-02	1.04E-03	3.29E-04
28	9	1.37E-02	2.11E-03	3.39E-04
28	9	1.34E-02	2.07E-03	3.25E-04
28	9	1.34E-02	3.15E-03	3.33E-04
28	9	1.31E-02	3.09E-03	3.19E-04
28	9	1.31E-02	4.16E-03	3.24E-04
28	9	1.28E-02	4.08E-03	3.10E-04
28	9	1.26E-02	5.15E-03	3.13E-04
28	9	1.23E-02	5.04E-03	3.00E-04
28	9	1.20E-02	6.09E-03	3.00E-04
28	9	1.18E-02	5.96E-03	2.87E-04
28	10	1.20E-02	6.09E-03	3.00E-04
28	10	1.18E-02	5.96E-03	2.87E-04
28	10	1.14E-02	6.99E-03	2.86E-04
28	10	1.11E-02	6.84E-03	2.74E-04
28	10	1.07E-02	7.83E-03	2.70E-04
28	10	1.04E-02	7.67E-03	2.59E-04
28	10	9.83E-03	8.61E-03	2.55E-04
28	10	9.63E-03	8.43E-03	2.44E-04
28	11	9.83E-03	8.61E-03	2.55E-04
28	11	9.63E-03	8.43E-03	2.44E-04
28	11	8.94E-03	9.33E-03	2.39E-04
28	11	8.75E-03	9.14E-03	2.29E-04
28	11	7.98E-03	9.98E-03	2.24E-04
28	11	7.81E-03	9.77E-03	2.15E-04
28	11	6.96E-03	1.06E-02	2.10E-04
28	11	6.81E-03	1.03E-02	2.01E-04
28	12	6.96E-03	1.06E-02	2.10E-04
28	12	6.81E-03	1.03E-02	2.01E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
28	12	5.88E-03	1.10E-02	1.97E-04
28	12	5.76E-03	1.08E-02	1.89E-04
28	12	4.76E-03	1.15E-02	1.86E-04
28	12	4.66E-03	1.12E-02	1.78E-04
28	12	3.60E-03	1.18E-02	1.77E-04
28	12	3.53E-03	1.15E-02	1.69E-04
28	12	2.42E-03	1.20E-02	1.70E-04
28	12	2.37E-03	1.18E-02	1.63E-04
28	12	1.21E-03	1.21E-02	1.66E-04
28	12	1.19E-03	1.19E-02	1.59E-04
28	12	6.51E-10	1.22E-02	1.65E-04
28	12	6.37E-10	1.19E-02	1.58E-04
29	13	1.43E-02	0.00E+00	3.64E-04
29	13	1.40E-02	0.00E+00	3.50E-04
29	13	1.42E-02	1.09E-03	3.63E-04
29	13	1.40E-02	1.07E-03	3.49E-04
29	13	1.41E-02	2.17E-03	3.59E-04
29	13	1.38E-02	2.13E-03	3.45E-04
29	13	1.38E-02	3.24E-03	3.52E-04
29	13	1.35E-02	3.18E-03	3.38E-04
29	13	1.34E-02	4.28E-03	3.42E-04
29	13	1.32E-02	4.20E-03	3.29E-04
29	13	1.30E-02	5.29E-03	3.31E-04
29	13	1.27E-02	5.19E-03	3.18E-04
29	13	1.24E-02	6.26E-03	3.17E-04
29	13	1.21E-02	6.14E-03	3.05E-04
29	14	1.24E-02	6.26E-03	3.17E-04
29	14	1.21E-02	6.14E-03	3.05E-04
29	14	1.17E-02	7.18E-03	3.02E-04
29	14	1.15E-02	7.04E-03	2.90E-04
29	14	1.10E-02	8.05E-03	2.86E-04
29	14	1.07E-02	7.89E-03	2.75E-04
29	14	1.01E-02	8.86E-03	2.69E-04
29	14	9.91E-03	8.68E-03	2.59E-04
29	15	1.01E-02	8.86E-03	2.69E-04
29	15	9.91E-03	8.68E-03	2.59E-04
29	15	9.19E-03	9.60E-03	2.53E-04
29	15	9.01E-03	9.41E-03	2.43E-04
29	15	8.20E-03	1.03E-02	2.37E-04
29	15	8.04E-03	1.01E-02	2.28E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
29	15	7.15E-03	1.09E-02	2.22E-04
29	15	7.01E-03	1.06E-02	2.13E-04
29	16	7.15E-03	1.09E-02	2.22E-04
29	16	7.01E-03	1.06E-02	2.13E-04
29	16	6.05E-03	1.14E-02	2.08E-04
29	16	5.93E-03	1.11E-02	2.00E-04
29	16	4.89E-03	1.18E-02	1.96E-04
29	16	4.80E-03	1.15E-02	1.89E-04
29	16	3.70E-03	1.21E-02	1.87E-04
29	16	3.63E-03	1.19E-02	1.79E-04
29	16	2.48E-03	1.23E-02	1.80E-04
29	16	2.44E-03	1.21E-02	1.73E-04
29	16	1.25E-03	1.25E-02	1.75E-04
29	16	1.22E-03	1.22E-02	1.69E-04
29	16	6.70E-10	1.25E-02	1.74E-04
29	16	6.56E-10	1.23E-02	1.67E-04
30	17	1.47E-02	0.00E+00	3.85E-04
30	17	1.44E-02	0.00E+00	3.70E-04
30	17	1.46E-02	1.12E-03	3.83E-04
30	17	1.43E-02	1.10E-03	3.69E-04
30	17	1.45E-02	2.23E-03	3.79E-04
30	17	1.42E-02	2.19E-03	3.64E-04
30	17	1.42E-02	3.33E-03	3.71E-04
30	17	1.39E-02	3.26E-03	3.57E-04
30	17	1.38E-02	4.40E-03	3.61E-04
30	17	1.35E-02	4.31E-03	3.47E-04
30	17	1.33E-02	5.44E-03	3.49E-04
30	17	1.31E-02	5.33E-03	3.36E-04
30	17	1.27E-02	6.43E-03	3.35E-04
30	17	1.25E-02	6.31E-03	3.22E-04
30	18	1.27E-02	6.43E-03	3.35E-04
30	18	1.25E-02	6.31E-03	3.22E-04
30	18	1.20E-02	7.38E-03	3.19E-04
30	18	1.18E-02	7.24E-03	3.07E-04
30	18	1.13E-02	8.27E-03	3.02E-04
30	18	1.10E-02	8.11E-03	2.90E-04
30	18	1.04E-02	9.10E-03	2.84E-04
30	18	1.02E-02	8.92E-03	2.73E-04
30	19	1.04E-02	9.10E-03	2.84E-04
30	19	1.02E-02	8.92E-03	2.73E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
30	19	9.44E-03	9.86E-03	2.67E-04
30	19	9.26E-03	9.67E-03	2.57E-04
30	19	8.43E-03	1.05E-02	2.50E-04
30	19	8.27E-03	1.03E-02	2.40E-04
30	19	7.35E-03	1.11E-02	2.34E-04
30	19	7.21E-03	1.09E-02	2.25E-04
30	20	7.35E-03	1.11E-02	2.34E-04
30	20	7.21E-03	1.09E-02	2.25E-04
30	20	6.21E-03	1.17E-02	2.20E-04
30	20	6.09E-03	1.14E-02	2.11E-04
30	20	5.03E-03	1.21E-02	2.07E-04
30	20	4.93E-03	1.19E-02	1.99E-04
30	20	3.80E-03	1.24E-02	1.97E-04
30	20	3.73E-03	1.22E-02	1.90E-04
30	20	2.55E-03	1.27E-02	1.90E-04
30	20	2.50E-03	1.24E-02	1.82E-04
30	20	1.28E-03	1.28E-02	1.85E-04
30	20	1.26E-03	1.26E-02	1.78E-04
30	20	6.88E-10	1.29E-02	1.84E-04
30	20	6.75E-10	1.26E-02	1.77E-04
31	21	1.51E-02	0.00E+00	4.05E-04
31	21	1.48E-02	0.00E+00	3.90E-04
31	21	1.50E-02	1.15E-03	4.03E-04
31	21	1.47E-02	1.13E-03	3.89E-04
31	21	1.48E-02	2.29E-03	3.98E-04
31	21	1.46E-02	2.25E-03	3.84E-04
31	21	1.45E-02	3.41E-03	3.91E-04
31	21	1.43E-02	3.35E-03	3.77E-04
31	21	1.42E-02	4.51E-03	3.80E-04
31	21	1.39E-02	4.43E-03	3.67E-04
31	21	1.37E-02	5.58E-03	3.67E-04
31	21	1.34E-02	5.48E-03	3.54E-04
31	21	1.30E-02	6.60E-03	3.52E-04
31	21	1.28E-02	6.48E-03	3.39E-04
31	22	1.30E-02	6.60E-03	3.52E-04
31	22	1.28E-02	6.48E-03	3.39E-04
31	22	1.23E-02	7.57E-03	3.35E-04
31	22	1.21E-02	7.43E-03	3.23E-04
31	22	1.15E-02	8.48E-03	3.18E-04
31	22	1.13E-02	8.33E-03	3.06E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
31	22	1.07E-02	9.33E-03	2.99E-04
31	22	1.05E-02	9.17E-03	2.89E-04
31	23	1.07E-02	9.33E-03	2.99E-04
31	23	1.05E-02	9.17E-03	2.89E-04
31	23	9.69E-03	1.01E-02	2.81E-04
31	23	9.51E-03	9.93E-03	2.71E-04
31	23	8.65E-03	1.08E-02	2.63E-04
31	23	8.49E-03	1.06E-02	2.54E-04
31	23	7.54E-03	1.14E-02	2.46E-04
31	23	7.40E-03	1.12E-02	2.37E-04
31	24	7.54E-03	1.14E-02	2.46E-04
31	24	7.40E-03	1.12E-02	2.37E-04
31	24	6.37E-03	1.20E-02	2.31E-04
31	24	6.26E-03	1.18E-02	2.23E-04
31	24	5.16E-03	1.24E-02	2.18E-04
31	24	5.06E-03	1.22E-02	2.10E-04
31	24	3.90E-03	1.28E-02	2.07E-04
31	24	3.83E-03	1.25E-02	2.00E-04
31	24	2.62E-03	1.30E-02	2.00E-04
31	24	2.57E-03	1.28E-02	1.92E-04
31	24	1.31E-03	1.32E-02	1.95E-04
31	24	1.29E-03	1.29E-02	1.88E-04
31	24	7.06E-10	1.32E-02	1.93E-04
31	24	6.93E-10	1.30E-02	1.86E-04
32	25	1.54E-02	0.00E+00	4.26E-04
32	25	1.52E-02	0.00E+00	4.11E-04
32	25	1.54E-02	1.18E-03	4.24E-04
32	25	1.51E-02	1.16E-03	4.09E-04
32	25	1.52E-02	2.35E-03	4.19E-04
32	25	1.49E-02	2.31E-03	4.04E-04
32	25	1.49E-02	3.50E-03	4.11E-04
32	25	1.47E-02	3.44E-03	3.96E-04
32	25	1.45E-02	4.63E-03	4.00E-04
32	25	1.43E-02	4.55E-03	3.86E-04
32	25	1.40E-02	5.72E-03	3.86E-04
32	25	1.37E-02	5.62E-03	3.72E-04
32	25	1.34E-02	6.76E-03	3.70E-04
32	25	1.31E-02	6.65E-03	3.57E-04
32	26	1.34E-02	6.76E-03	3.70E-04
32	26	1.31E-02	6.65E-03	3.57E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
32	26	1.27E-02	7.76E-03	3.53E-04
32	26	1.24E-02	7.62E-03	3.40E-04
32	26	1.18E-02	8.70E-03	3.34E-04
32	26	1.16E-02	8.55E-03	3.22E-04
32	26	1.09E-02	9.57E-03	3.14E-04
32	26	1.07E-02	9.40E-03	3.04E-04
32	27	1.09E-02	9.57E-03	3.14E-04
32	27	1.07E-02	9.40E-03	3.04E-04
32	27	9.93E-03	1.04E-02	2.95E-04
32	27	9.76E-03	1.02E-02	2.85E-04
32	27	8.87E-03	1.11E-02	2.76E-04
32	27	8.71E-03	1.09E-02	2.67E-04
32	27	7.73E-03	1.17E-02	2.59E-04
32	27	7.59E-03	1.15E-02	2.50E-04
32	28	7.73E-03	1.17E-02	2.59E-04
32	28	7.59E-03	1.15E-02	2.50E-04
32	28	6.53E-03	1.23E-02	2.43E-04
32	28	6.42E-03	1.21E-02	2.34E-04
32	28	5.29E-03	1.27E-02	2.29E-04
32	28	5.19E-03	1.25E-02	2.21E-04
32	28	4.00E-03	1.31E-02	2.18E-04
32	28	3.93E-03	1.29E-02	2.10E-04
32	28	2.69E-03	1.33E-02	2.10E-04
32	28	2.64E-03	1.31E-02	2.02E-04
32	28	1.35E-03	1.35E-02	2.05E-04
32	28	1.32E-03	1.33E-02	1.98E-04
32	28	7.24E-10	1.35E-02	2.03E-04
32	28	7.11E-10	1.33E-02	1.96E-04
33	29	1.58E-02	0.00E+00	4.46E-04
33	29	1.55E-02	0.00E+00	4.32E-04
33	29	1.57E-02	1.21E-03	4.44E-04
33	29	1.55E-02	1.19E-03	4.30E-04
33	29	1.56E-02	2.40E-03	4.39E-04
33	29	1.53E-02	2.37E-03	4.25E-04
33	29	1.53E-02	3.58E-03	4.31E-04
33	29	1.50E-02	3.53E-03	4.16E-04
33	29	1.49E-02	4.74E-03	4.19E-04
33	29	1.46E-02	4.66E-03	4.05E-04
33	29	1.43E-02	5.85E-03	4.05E-04
33	29	1.41E-02	5.76E-03	3.91E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
33	29	1.37E-02	6.93E-03	3.88E-04
33	29	1.35E-02	6.81E-03	3.75E-04
33	30	1.37E-02	6.93E-03	3.88E-04
33	30	1.35E-02	6.81E-03	3.75E-04
33	30	1.30E-02	7.95E-03	3.70E-04
33	30	1.27E-02	7.82E-03	3.57E-04
33	30	1.21E-02	8.91E-03	3.50E-04
33	30	1.19E-02	8.76E-03	3.39E-04
33	30	1.12E-02	9.80E-03	3.30E-04
33	30	1.10E-02	9.64E-03	3.19E-04
33	31	1.12E-02	9.80E-03	3.30E-04
33	31	1.10E-02	9.64E-03	3.19E-04
33	31	1.02E-02	1.06E-02	3.09E-04
33	31	1.00E-02	1.04E-02	2.99E-04
33	31	9.08E-03	1.14E-02	2.90E-04
33	31	8.93E-03	1.12E-02	2.80E-04
33	31	7.91E-03	1.20E-02	2.71E-04
33	31	7.78E-03	1.18E-02	2.62E-04
33	32	7.91E-03	1.20E-02	2.71E-04
33	32	7.78E-03	1.18E-02	2.62E-04
33	32	6.69E-03	1.26E-02	2.55E-04
33	32	6.58E-03	1.24E-02	2.46E-04
33	32	5.41E-03	1.30E-02	2.40E-04
33	32	5.33E-03	1.28E-02	2.32E-04
33	32	4.10E-03	1.34E-02	2.29E-04
33	32	4.03E-03	1.32E-02	2.21E-04
33	32	2.75E-03	1.37E-02	2.20E-04
33	32	2.70E-03	1.34E-02	2.13E-04
33	32	1.38E-03	1.38E-02	2.15E-04
33	32	1.36E-03	1.36E-02	2.08E-04
33	32	7.41E-10	1.39E-02	2.13E-04
33	32	7.29E-10	1.36E-02	2.06E-04
34	33	1.62E-02	0.00E+00	4.67E-04
34	33	1.59E-02	0.00E+00	4.52E-04
34	33	1.61E-02	1.23E-03	4.65E-04
34	33	1.59E-02	1.22E-03	4.50E-04
34	33	1.59E-02	2.46E-03	4.59E-04
34	33	1.57E-02	2.42E-03	4.45E-04
34	33	1.56E-02	3.67E-03	4.50E-04
34	33	1.54E-02	3.61E-03	4.36E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
34	33	1.52E-02	4.84E-03	4.38E-04
34	33	1.50E-02	4.77E-03	4.25E-04
34	33	1.47E-02	5.99E-03	4.23E-04
34	33	1.44E-02	5.89E-03	4.10E-04
34	33	1.40E-02	7.08E-03	4.06E-04
34	33	1.38E-02	6.97E-03	3.93E-04
34	34	1.40E-02	7.08E-03	4.06E-04
34	34	1.38E-02	6.97E-03	3.93E-04
34	34	1.33E-02	8.13E-03	3.87E-04
34	34	1.30E-02	8.00E-03	3.75E-04
34	34	1.24E-02	9.11E-03	3.66E-04
34	34	1.22E-02	8.97E-03	3.55E-04
34	34	1.14E-02	1.00E-02	3.45E-04
34	34	1.13E-02	9.87E-03	3.34E-04
34	35	1.14E-02	1.00E-02	3.45E-04
34	35	1.13E-02	9.87E-03	3.34E-04
34	35	1.04E-02	1.09E-02	3.24E-04
34	35	1.02E-02	1.07E-02	3.14E-04
34	35	9.28E-03	1.16E-02	3.03E-04
34	35	9.14E-03	1.14E-02	2.94E-04
34	35	8.09E-03	1.23E-02	2.84E-04
34	35	7.97E-03	1.21E-02	2.75E-04
34	36	8.09E-03	1.23E-02	2.84E-04
34	36	7.97E-03	1.21E-02	2.75E-04
34	36	6.84E-03	1.29E-02	2.66E-04
34	36	6.74E-03	1.27E-02	2.58E-04
34	36	5.54E-03	1.33E-02	2.51E-04
34	36	5.45E-03	1.31E-02	2.44E-04
34	36	4.19E-03	1.37E-02	2.39E-04
34	36	4.13E-03	1.35E-02	2.32E-04
34	36	2.81E-03	1.40E-02	2.30E-04
34	36	2.77E-03	1.38E-02	2.23E-04
34	36	1.41E-03	1.41E-02	2.25E-04
34	36	1.39E-03	1.39E-02	2.18E-04
34	36	7.58E-10	1.42E-02	2.23E-04
34	36	7.46E-10	1.40E-02	2.16E-04
35	37	1.65E-02	0.00E+00	4.87E-04
35	37	1.63E-02	0.00E+00	4.73E-04
35	37	1.65E-02	1.26E-03	4.86E-04
35	37	1.62E-02	1.24E-03	4.71E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
35	37	1.63E-02	2.51E-03	4.80E-04
35	37	1.60E-02	2.48E-03	4.65E-04
35	37	1.60E-02	3.75E-03	4.70E-04
35	37	1.57E-02	3.69E-03	4.56E-04
35	37	1.55E-02	4.95E-03	4.58E-04
35	37	1.53E-02	4.88E-03	4.44E-04
35	37	1.50E-02	6.12E-03	4.42E-04
35	37	1.48E-02	6.03E-03	4.29E-04
35	37	1.43E-02	7.24E-03	4.24E-04
35	37	1.41E-02	7.13E-03	4.11E-04
35	38	1.43E-02	7.24E-03	4.24E-04
35	38	1.41E-02	7.13E-03	4.11E-04
35	38	1.35E-02	8.31E-03	4.04E-04
35	38	1.33E-02	8.18E-03	3.92E-04
35	38	1.27E-02	9.31E-03	3.82E-04
35	38	1.25E-02	9.17E-03	3.71E-04
35	38	1.17E-02	1.02E-02	3.60E-04
35	38	1.15E-02	1.01E-02	3.50E-04
35	39	1.17E-02	1.02E-02	3.60E-04
35	39	1.15E-02	1.01E-02	3.50E-04
35	39	1.06E-02	1.11E-02	3.38E-04
35	39	1.05E-02	1.09E-02	3.28E-04
35	39	9.49E-03	1.19E-02	3.17E-04
35	39	9.35E-03	1.17E-02	3.07E-04
35	39	8.27E-03	1.26E-02	2.97E-04
35	39	8.15E-03	1.24E-02	2.88E-04
35	40	8.27E-03	1.26E-02	2.97E-04
35	40	8.15E-03	1.24E-02	2.88E-04
35	40	6.99E-03	1.31E-02	2.78E-04
35	40	6.89E-03	1.29E-02	2.70E-04
35	40	5.66E-03	1.36E-02	2.63E-04
35	40	5.58E-03	1.34E-02	2.55E-04
35	40	4.28E-03	1.40E-02	2.50E-04
35	40	4.22E-03	1.38E-02	2.42E-04
35	40	2.87E-03	1.43E-02	2.40E-04
35	40	2.83E-03	1.41E-02	2.33E-04
35	40	1.44E-03	1.44E-02	2.35E-04
35	40	1.42E-03	1.42E-02	2.28E-04
35	40	7.75E-10	1.45E-02	2.33E-04
35	40	7.63E-10	1.43E-02	2.26E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
36	41	1.69E-02	0.00E+00	5.08E-04
36	41	1.66E-02	0.00E+00	4.94E-04
36	41	1.68E-02	1.29E-03	5.06E-04
36	41	1.66E-02	1.27E-03	4.92E-04
36	41	1.66E-02	2.57E-03	5.00E-04
36	41	1.64E-02	2.53E-03	4.86E-04
36	41	1.63E-02	3.83E-03	4.90E-04
36	41	1.61E-02	3.77E-03	4.77E-04
36	41	1.59E-02	5.06E-03	4.77E-04
36	41	1.56E-02	4.98E-03	4.64E-04
36	41	1.53E-02	6.25E-03	4.61E-04
36	41	1.51E-02	6.16E-03	4.48E-04
36	41	1.46E-02	7.39E-03	4.42E-04
36	41	1.44E-02	7.29E-03	4.30E-04
36	42	1.46E-02	7.39E-03	4.42E-04
36	42	1.44E-02	7.29E-03	4.30E-04
36	42	1.38E-02	8.48E-03	4.21E-04
36	42	1.36E-02	8.36E-03	4.09E-04
36	42	1.29E-02	9.51E-03	3.99E-04
36	42	1.28E-02	9.37E-03	3.87E-04
36	42	1.19E-02	1.05E-02	3.76E-04
36	42	1.18E-02	1.03E-02	3.65E-04
36	43	1.19E-02	1.05E-02	3.76E-04
36	43	1.18E-02	1.03E-02	3.65E-04
36	43	1.09E-02	1.13E-02	3.53E-04
36	43	1.07E-02	1.12E-02	3.43E-04
36	43	9.69E-03	1.21E-02	3.30E-04
36	43	9.55E-03	1.20E-02	3.21E-04
36	43	8.45E-03	1.28E-02	3.09E-04
36	43	8.33E-03	1.26E-02	3.00E-04
36	44	8.45E-03	1.28E-02	3.09E-04
36	44	8.33E-03	1.26E-02	3.00E-04
36	44	7.14E-03	1.34E-02	2.90E-04
36	44	7.04E-03	1.32E-02	2.82E-04
36	44	5.78E-03	1.39E-02	2.74E-04
36	44	5.70E-03	1.37E-02	2.66E-04
36	44	4.38E-03	1.43E-02	2.60E-04
36	44	4.31E-03	1.41E-02	2.53E-04
36	44	2.94E-03	1.46E-02	2.51E-04
36	44	2.89E-03	1.44E-02	2.44E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5 Ring	Element	x	y	z
36	44	1.47E-03	1.48E-02	2.45E-04
36	44	1.45E-03	1.45E-02	2.38E-04
36	44	7.91E-10	1.48E-02	2.43E-04
36	44	7.80E-10	1.46E-02	2.36E-04
37	45	1.72E-02	0.00E+00	5.29E-04
37	45	1.70E-02	0.00E+00	5.15E-04
37	45	1.72E-02	1.31E-03	5.27E-04
37	45	1.69E-02	1.30E-03	5.13E-04
37	45	1.70E-02	2.62E-03	5.21E-04
37	45	1.67E-02	2.58E-03	5.07E-04
37	45	1.66E-02	3.90E-03	5.11E-04
37	45	1.64E-02	3.85E-03	4.97E-04
37	45	1.62E-02	5.16E-03	4.97E-04
37	45	1.60E-02	5.09E-03	4.83E-04
37	45	1.56E-02	6.38E-03	4.80E-04
37	45	1.54E-02	6.29E-03	4.67E-04
37	45	1.49E-02	7.55E-03	4.60E-04
37	45	1.47E-02	7.44E-03	4.48E-04
37	46	1.49E-02	7.55E-03	4.60E-04
37	46	1.47E-02	7.44E-03	4.48E-04
37	46	1.41E-02	8.66E-03	4.39E-04
37	46	1.39E-02	8.54E-03	4.27E-04
37	46	1.32E-02	9.70E-03	4.15E-04
37	46	1.30E-02	9.57E-03	4.04E-04
37	46	1.22E-02	1.07E-02	3.91E-04
37	46	1.20E-02	1.05E-02	3.81E-04
37	47	1.22E-02	1.07E-02	3.91E-04
37	47	1.20E-02	1.05E-02	3.81E-04
37	47	1.11E-02	1.16E-02	3.67E-04
37	47	1.09E-02	1.14E-02	3.57E-04
37	47	9.89E-03	1.24E-02	3.44E-04
37	47	9.75E-03	1.22E-02	3.34E-04
37	47	8.62E-03	1.31E-02	3.22E-04
37	47	8.50E-03	1.29E-02	3.13E-04
37	48	8.62E-03	1.31E-02	3.22E-04
37	48	8.50E-03	1.29E-02	3.13E-04
37	48	7.29E-03	1.37E-02	3.02E-04
37	48	7.19E-03	1.35E-02	2.94E-04
37	48	5.90E-03	1.42E-02	2.85E-04
37	48	5.82E-03	1.40E-02	2.77E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 5				
Ring	Element	x	y	z
37	48	4.47E-03	1.46E-02	2.71E-04
37	48	4.40E-03	1.44E-02	2.64E-04
37	48	3.00E-03	1.49E-02	2.61E-04
37	48	2.95E-03	1.47E-02	2.54E-04
37	48	1.50E-03	1.51E-02	2.55E-04
37	48	1.48E-03	1.48E-02	2.48E-04
37	48	8.07E-10	1.51E-02	2.53E-04
37	48	7.96E-10	1.49E-02	2.46E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
38	1	1.77E-02	0.00E+00	5.62E-04
38	1	1.73E-02	0.00E+00	5.36E-04
38	1	1.77E-02	1.35E-03	5.60E-04
38	1	1.73E-02	1.32E-03	5.34E-04
38	1	1.75E-02	2.70E-03	5.53E-04
38	1	1.71E-02	2.64E-03	5.28E-04
38	1	1.71E-02	4.02E-03	5.42E-04
38	1	1.67E-02	3.93E-03	5.17E-04
38	1	1.67E-02	5.32E-03	5.28E-04
38	1	1.63E-02	5.19E-03	5.03E-04
38	1	1.61E-02	6.57E-03	5.10E-04
38	1	1.57E-02	6.42E-03	4.86E-04
38	1	1.54E-02	7.77E-03	4.89E-04
38	1	1.50E-02	7.59E-03	4.66E-04
38	2	1.54E-02	7.77E-03	4.89E-04
38	2	1.50E-02	7.59E-03	4.66E-04
38	2	1.45E-02	8.92E-03	4.66E-04
38	2	1.42E-02	8.71E-03	4.44E-04
38	2	1.36E-02	1.00E-02	4.41E-04
38	2	1.33E-02	9.77E-03	4.21E-04
38	2	1.26E-02	1.10E-02	4.15E-04
38	2	1.23E-02	1.07E-02	3.96E-04
38	3	1.26E-02	1.10E-02	4.15E-04
38	3	1.23E-02	1.07E-02	3.96E-04
38	3	1.14E-02	1.19E-02	3.90E-04
38	3	1.12E-02	1.16E-02	3.72E-04
38	3	1.02E-02	1.27E-02	3.65E-04
38	3	9.95E-03	1.25E-02	3.48E-04
38	3	8.89E-03	1.35E-02	3.42E-04
38	3	8.68E-03	1.32E-02	3.26E-04
38	4	8.89E-03	1.35E-02	3.42E-04
38	4	8.68E-03	1.32E-02	3.26E-04
38	4	7.51E-03	1.41E-02	3.21E-04
38	4	7.34E-03	1.38E-02	3.06E-04
38	4	6.08E-03	1.46E-02	3.03E-04
38	4	5.94E-03	1.43E-02	2.89E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
38	4	4.60E-03	1.50E-02	2.88E-04
38	4	4.49E-03	1.47E-02	2.75E-04
38	4	3.09E-03	1.53E-02	2.77E-04
38	4	3.02E-03	1.50E-02	2.64E-04
38	4	1.55E-03	1.55E-02	2.70E-04
38	4	1.51E-03	1.52E-02	2.58E-04
38	4	8.32E-10	1.56E-02	2.68E-04
38	4	8.13E-10	1.52E-02	2.56E-04
39	5	1.83E-02	0.00E+00	5.95E-04
39	5	1.78E-02	0.00E+00	5.69E-04
39	5	1.82E-02	1.39E-03	5.92E-04
39	5	1.78E-02	1.36E-03	5.67E-04
39	5	1.80E-02	2.78E-03	5.85E-04
39	5	1.76E-02	2.72E-03	5.60E-04
39	5	1.76E-02	4.14E-03	5.74E-04
39	5	1.72E-02	4.05E-03	5.49E-04
39	5	1.72E-02	5.47E-03	5.59E-04
39	5	1.68E-02	5.35E-03	5.34E-04
39	5	1.65E-02	6.76E-03	5.40E-04
39	5	1.62E-02	6.61E-03	5.16E-04
39	5	1.58E-02	8.00E-03	5.17E-04
39	5	1.55E-02	7.82E-03	4.95E-04
39	6	1.58E-02	8.00E-03	5.17E-04
39	6	1.55E-02	7.82E-03	4.95E-04
39	6	1.50E-02	9.18E-03	4.93E-04
39	6	1.46E-02	8.98E-03	4.71E-04
39	6	1.40E-02	1.03E-02	4.67E-04
39	6	1.37E-02	1.01E-02	4.46E-04
39	6	1.29E-02	1.13E-02	4.40E-04
39	6	1.26E-02	1.11E-02	4.21E-04
39	7	1.29E-02	1.13E-02	4.40E-04
39	7	1.26E-02	1.11E-02	4.21E-04
39	7	1.17E-02	1.23E-02	4.13E-04
39	7	1.15E-02	1.20E-02	3.95E-04
39	7	1.05E-02	1.31E-02	3.87E-04
39	7	1.03E-02	1.28E-02	3.70E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
39	7	9.14E-03	1.39E-02	3.62E-04
39	7	8.94E-03	1.36E-02	3.46E-04
39	8	9.14E-03	1.39E-02	3.62E-04
39	8	8.94E-03	1.36E-02	3.46E-04
39	8	7.73E-03	1.45E-02	3.40E-04
39	8	7.56E-03	1.42E-02	3.25E-04
39	8	6.26E-03	1.51E-02	3.20E-04
39	8	6.12E-03	1.47E-02	3.06E-04
39	8	4.73E-03	1.55E-02	3.05E-04
39	8	4.63E-03	1.51E-02	2.92E-04
39	8	3.18E-03	1.58E-02	2.93E-04
39	8	3.11E-03	1.54E-02	2.81E-04
39	8	1.59E-03	1.60E-02	2.86E-04
39	8	1.56E-03	1.56E-02	2.74E-04
39	8	8.56E-10	1.60E-02	2.84E-04
39	8	8.37E-10	1.57E-02	2.72E-04
40	9	1.88E-02	0.00E+00	6.28E-04
40	9	1.84E-02	0.00E+00	6.02E-04
40	9	1.87E-02	1.43E-03	6.25E-04
40	9	1.83E-02	1.40E-03	6.00E-04
40	9	1.85E-02	2.85E-03	6.18E-04
40	9	1.81E-02	2.79E-03	5.92E-04
40	9	1.81E-02	4.25E-03	6.06E-04
40	9	1.77E-02	4.16E-03	5.81E-04
40	9	1.76E-02	5.62E-03	5.90E-04
40	9	1.73E-02	5.50E-03	5.65E-04
40	9	1.70E-02	6.95E-03	5.70E-04
40	9	1.66E-02	6.80E-03	5.46E-04
40	9	1.63E-02	8.22E-03	5.46E-04
40	9	1.59E-02	8.05E-03	5.24E-04
40	10	1.63E-02	8.22E-03	5.46E-04
40	10	1.59E-02	8.05E-03	5.24E-04
40	10	1.54E-02	9.43E-03	5.20E-04
40	10	1.51E-02	9.23E-03	4.99E-04
40	10	1.44E-02	1.06E-02	4.93E-04
40	10	1.41E-02	1.03E-02	4.72E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
40	10	1.33E-02	1.16E-02	4.64E-04
40	10	1.30E-02	1.14E-02	4.45E-04
40	11	1.33E-02	1.16E-02	4.64E-04
40	11	1.30E-02	1.14E-02	4.45E-04
40	11	1.21E-02	1.26E-02	4.36E-04
40	11	1.18E-02	1.23E-02	4.18E-04
40	11	1.08E-02	1.35E-02	4.08E-04
40	11	1.05E-02	1.32E-02	3.91E-04
40	11	9.39E-03	1.43E-02	3.82E-04
40	11	9.20E-03	1.40E-02	3.66E-04
40	12	9.39E-03	1.43E-02	3.82E-04
40	12	9.20E-03	1.40E-02	3.66E-04
40	12	7.94E-03	1.49E-02	3.59E-04
40	12	7.78E-03	1.46E-02	3.44E-04
40	12	6.43E-03	1.55E-02	3.38E-04
40	12	6.29E-03	1.51E-02	3.24E-04
40	12	4.87E-03	1.59E-02	3.22E-04
40	12	4.76E-03	1.56E-02	3.08E-04
40	12	3.26E-03	1.62E-02	3.10E-04
40	12	3.20E-03	1.59E-02	2.97E-04
40	12	1.64E-03	1.64E-02	3.02E-04
40	12	1.60E-03	1.61E-02	2.90E-04
40	12	8.80E-10	1.65E-02	3.00E-04
40	12	8.61E-10	1.61E-02	2.87E-04
41	13	1.92E-02	0.00E+00	6.61E-04
41	13	1.89E-02	0.00E+00	6.35E-04
41	13	1.92E-02	1.47E-03	6.59E-04
41	13	1.88E-02	1.44E-03	6.33E-04
41	13	1.90E-02	2.93E-03	6.51E-04
41	13	1.86E-02	2.87E-03	6.25E-04
41	13	1.86E-02	4.36E-03	6.38E-04
41	13	1.82E-02	4.28E-03	6.13E-04
41	13	1.81E-02	5.77E-03	6.21E-04
41	13	1.77E-02	5.65E-03	5.97E-04
41	13	1.74E-02	7.13E-03	6.00E-04
41	13	1.71E-02	6.99E-03	5.76E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
41	13	1.67E-02	8.43E-03	5.75E-04
41	13	1.63E-02	8.27E-03	5.53E-04
41	14	1.67E-02	8.43E-03	5.75E-04
41	14	1.63E-02	8.27E-03	5.53E-04
41	14	1.58E-02	9.68E-03	5.48E-04
41	14	1.55E-02	9.48E-03	5.26E-04
41	14	1.48E-02	1.08E-02	5.19E-04
41	14	1.45E-02	1.06E-02	4.98E-04
41	14	1.36E-02	1.19E-02	4.89E-04
41	14	1.34E-02	1.17E-02	4.70E-04
41	15	1.36E-02	1.19E-02	4.89E-04
41	15	1.34E-02	1.17E-02	4.70E-04
41	15	1.24E-02	1.29E-02	4.59E-04
41	15	1.21E-02	1.27E-02	4.41E-04
41	15	1.11E-02	1.38E-02	4.30E-04
41	15	1.08E-02	1.36E-02	4.13E-04
41	15	9.64E-03	1.46E-02	4.02E-04
41	15	9.45E-03	1.43E-02	3.87E-04
41	16	9.64E-03	1.46E-02	4.02E-04
41	16	9.45E-03	1.43E-02	3.87E-04
41	16	8.15E-03	1.53E-02	3.78E-04
41	16	7.99E-03	1.50E-02	3.63E-04
41	16	6.60E-03	1.59E-02	3.56E-04
41	16	6.47E-03	1.56E-02	3.42E-04
41	16	4.99E-03	1.63E-02	3.39E-04
41	16	4.89E-03	1.60E-02	3.26E-04
41	16	3.35E-03	1.66E-02	3.26E-04
41	16	3.28E-03	1.63E-02	3.13E-04
41	16	1.68E-03	1.68E-02	3.18E-04
41	16	1.65E-03	1.65E-02	3.06E-04
41	16	9.03E-10	1.69E-02	3.16E-04
41	16	8.85E-10	1.66E-02	3.03E-04
42	17	1.97E-02	0.00E+00	6.94E-04
42	17	1.94E-02	0.00E+00	6.69E-04
42	17	1.96E-02	1.51E-03	6.92E-04
42	17	1.93E-02	1.48E-03	6.66E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
42	17	1.94E-02	3.00E-03	6.84E-04
42	17	1.91E-02	2.94E-03	6.58E-04
42	17	1.91E-02	4.47E-03	6.70E-04
42	17	1.87E-02	4.39E-03	6.45E-04
42	17	1.85E-02	5.91E-03	6.52E-04
42	17	1.82E-02	5.80E-03	6.28E-04
42	17	1.79E-02	7.30E-03	6.30E-04
42	17	1.75E-02	7.17E-03	6.06E-04
42	17	1.71E-02	8.64E-03	6.04E-04
42	17	1.68E-02	8.48E-03	5.82E-04
42	18	1.71E-02	8.64E-03	6.04E-04
42	18	1.68E-02	8.48E-03	5.82E-04
42	18	1.62E-02	9.92E-03	5.75E-04
42	18	1.59E-02	9.73E-03	5.54E-04
42	18	1.51E-02	1.11E-02	5.45E-04
42	18	1.48E-02	1.09E-02	5.25E-04
42	18	1.40E-02	1.22E-02	5.13E-04
42	18	1.37E-02	1.20E-02	4.94E-04
42	19	1.40E-02	1.22E-02	5.13E-04
42	19	1.37E-02	1.20E-02	4.94E-04
42	19	1.27E-02	1.33E-02	4.82E-04
42	19	1.25E-02	1.30E-02	4.64E-04
42	19	1.13E-02	1.42E-02	4.51E-04
42	19	1.11E-02	1.39E-02	4.35E-04
42	19	9.88E-03	1.50E-02	4.23E-04
42	19	9.70E-03	1.47E-02	4.07E-04
42	20	9.88E-03	1.50E-02	4.23E-04
42	20	9.70E-03	1.47E-02	4.07E-04
42	20	8.35E-03	1.57E-02	3.97E-04
42	20	8.20E-03	1.54E-02	3.82E-04
42	20	6.76E-03	1.63E-02	3.74E-04
42	20	6.63E-03	1.60E-02	3.60E-04
42	20	5.12E-03	1.67E-02	3.56E-04
42	20	5.02E-03	1.64E-02	3.43E-04
42	20	3.43E-03	1.71E-02	3.42E-04
42	20	3.37E-03	1.67E-02	3.30E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
42	20	1.72E-03	1.73E-02	3.34E-04
42	20	1.69E-03	1.69E-02	3.22E-04
42	20	9.25E-10	1.73E-02	3.31E-04
42	20	9.08E-10	1.70E-02	3.19E-04
43	21	2.02E-02	0.00E+00	7.29E-04
43	21	1.98E-02	0.00E+00	7.02E-04
43	21	2.01E-02	1.54E-03	7.26E-04
43	21	1.98E-02	1.51E-03	6.99E-04
43	21	1.99E-02	3.07E-03	7.17E-04
43	21	1.95E-02	3.02E-03	6.91E-04
43	21	1.95E-02	4.58E-03	7.03E-04
43	21	1.92E-02	4.50E-03	6.78E-04
43	21	1.90E-02	6.05E-03	6.84E-04
43	21	1.86E-02	5.94E-03	6.59E-04
43	21	1.83E-02	7.48E-03	6.61E-04
43	21	1.80E-02	7.35E-03	6.37E-04
43	21	1.75E-02	8.85E-03	6.34E-04
43	21	1.72E-02	8.69E-03	6.11E-04
43	22	1.75E-02	8.85E-03	6.34E-04
43	22	1.72E-02	8.69E-03	6.11E-04
43	22	1.66E-02	1.02E-02	6.04E-04
43	22	1.63E-02	9.97E-03	5.82E-04
43	22	1.55E-02	1.14E-02	5.72E-04
43	22	1.52E-02	1.12E-02	5.51E-04
43	22	1.43E-02	1.25E-02	5.39E-04
43	22	1.40E-02	1.23E-02	5.19E-04
43	23	1.43E-02	1.25E-02	5.39E-04
43	23	1.40E-02	1.23E-02	5.19E-04
43	23	1.30E-02	1.36E-02	5.06E-04
43	23	1.28E-02	1.33E-02	4.87E-04
43	23	1.16E-02	1.45E-02	4.74E-04
43	23	1.14E-02	1.43E-02	4.56E-04
43	23	1.01E-02	1.54E-02	4.43E-04
43	23	9.94E-03	1.51E-02	4.27E-04
43	24	1.01E-02	1.54E-02	4.43E-04
43	24	9.94E-03	1.51E-02	4.27E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
43	24	8.56E-03	1.61E-02	4.16E-04
43	24	8.40E-03	1.58E-02	4.01E-04
43	24	6.93E-03	1.67E-02	3.93E-04
43	24	6.80E-03	1.64E-02	3.78E-04
43	24	5.24E-03	1.71E-02	3.73E-04
43	24	5.15E-03	1.68E-02	3.60E-04
43	24	3.52E-03	1.75E-02	3.59E-04
43	24	3.45E-03	1.72E-02	3.46E-04
43	24	1.77E-03	1.77E-02	3.51E-04
43	24	1.73E-03	1.74E-02	3.38E-04
43	24	9.48E-10	1.77E-02	3.48E-04
43	24	9.31E-10	1.74E-02	3.35E-04
44	25	2.07E-02	0.00E+00	7.63E-04
44	25	2.03E-02	0.00E+00	7.37E-04
44	25	2.06E-02	1.58E-03	7.60E-04
44	25	2.02E-02	1.55E-03	7.34E-04
44	25	2.04E-02	3.14E-03	7.51E-04
44	25	2.00E-02	3.09E-03	7.25E-04
44	25	2.00E-02	4.69E-03	7.36E-04
44	25	1.96E-02	4.61E-03	7.11E-04
44	25	1.94E-02	6.19E-03	7.16E-04
44	25	1.91E-02	6.09E-03	6.92E-04
44	25	1.87E-02	7.66E-03	6.92E-04
44	25	1.84E-02	7.52E-03	6.68E-04
44	25	1.79E-02	9.06E-03	6.64E-04
44	25	1.76E-02	8.90E-03	6.41E-04
44	26	1.79E-02	9.06E-03	6.64E-04
44	26	1.76E-02	8.90E-03	6.41E-04
44	26	1.69E-02	1.04E-02	6.32E-04
44	26	1.67E-02	1.02E-02	6.10E-04
44	26	1.59E-02	1.17E-02	5.99E-04
44	26	1.56E-02	1.14E-02	5.78E-04
44	26	1.46E-02	1.28E-02	5.64E-04
44	26	1.44E-02	1.26E-02	5.45E-04
44	27	1.46E-02	1.28E-02	5.64E-04
44	27	1.44E-02	1.26E-02	5.45E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
44	27	1.33E-02	1.39E-02	5.29E-04
44	27	1.31E-02	1.37E-02	5.11E-04
44	27	1.19E-02	1.49E-02	4.96E-04
44	27	1.17E-02	1.46E-02	4.79E-04
44	27	1.04E-02	1.57E-02	4.64E-04
44	27	1.02E-02	1.54E-02	4.48E-04
44	28	1.04E-02	1.57E-02	4.64E-04
44	28	1.02E-02	1.54E-02	4.48E-04
44	28	8.76E-03	1.64E-02	4.36E-04
44	28	8.60E-03	1.62E-02	4.21E-04
44	28	7.09E-03	1.71E-02	4.11E-04
44	28	6.96E-03	1.68E-02	3.97E-04
44	28	5.37E-03	1.75E-02	3.91E-04
44	28	5.27E-03	1.72E-02	3.77E-04
44	28	3.60E-03	1.79E-02	3.76E-04
44	28	3.54E-03	1.76E-02	3.63E-04
44	28	1.81E-03	1.81E-02	3.67E-04
44	28	1.78E-03	1.78E-02	3.55E-04
44	28	9.70E-10	1.82E-02	3.64E-04
44	28	9.53E-10	1.78E-02	3.52E-04
45	29	2.11E-02	0.00E+00	7.97E-04
45	29	2.08E-02	0.00E+00	7.71E-04
45	29	2.10E-02	1.61E-03	7.94E-04
45	29	2.07E-02	1.59E-03	7.68E-04
45	29	2.08E-02	3.21E-03	7.85E-04
45	29	2.05E-02	3.16E-03	7.59E-04
45	29	2.04E-02	4.79E-03	7.69E-04
45	29	2.01E-02	4.71E-03	7.44E-04
45	29	1.99E-02	6.33E-03	7.49E-04
45	29	1.95E-02	6.23E-03	7.24E-04
45	29	1.92E-02	7.83E-03	7.23E-04
45	29	1.88E-02	7.70E-03	6.99E-04
45	29	1.83E-02	9.26E-03	6.93E-04
45	29	1.80E-02	9.11E-03	6.71E-04
45	30	1.83E-02	9.26E-03	6.93E-04
45	30	1.80E-02	9.11E-03	6.71E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
45	30	1.73E-02	1.06E-02	6.61E-04
45	30	1.70E-02	1.05E-02	6.39E-04
45	30	1.62E-02	1.19E-02	6.26E-04
45	30	1.59E-02	1.17E-02	6.05E-04
45	30	1.50E-02	1.31E-02	5.89E-04
45	30	1.47E-02	1.29E-02	5.70E-04
45	31	1.50E-02	1.31E-02	5.89E-04
45	31	1.47E-02	1.29E-02	5.70E-04
45	31	1.36E-02	1.42E-02	5.53E-04
45	31	1.34E-02	1.40E-02	5.35E-04
45	31	1.21E-02	1.52E-02	5.18E-04
45	31	1.19E-02	1.49E-02	5.01E-04
45	31	1.06E-02	1.61E-02	4.85E-04
45	31	1.04E-02	1.58E-02	4.69E-04
45	32	1.06E-02	1.61E-02	4.85E-04
45	32	1.04E-02	1.58E-02	4.69E-04
45	32	8.95E-03	1.68E-02	4.55E-04
45	32	8.80E-03	1.65E-02	4.40E-04
45	32	7.25E-03	1.74E-02	4.29E-04
45	32	7.13E-03	1.71E-02	4.15E-04
45	32	5.48E-03	1.79E-02	4.09E-04
45	32	5.39E-03	1.76E-02	3.95E-04
45	32	3.68E-03	1.83E-02	3.93E-04
45	32	3.62E-03	1.80E-02	3.80E-04
45	32	1.85E-03	1.85E-02	3.84E-04
45	32	1.82E-03	1.82E-02	3.71E-04
45	32	9.92E-10	1.86E-02	3.80E-04
45	32	9.75E-10	1.83E-02	3.68E-04
46	33	2.16E-02	0.00E+00	8.31E-04
46	33	2.12E-02	0.00E+00	8.05E-04
46	33	2.15E-02	1.65E-03	8.28E-04
46	33	2.12E-02	1.62E-03	8.02E-04
46	33	2.13E-02	3.28E-03	8.18E-04
46	33	2.09E-02	3.23E-03	7.93E-04
46	33	2.08E-02	4.89E-03	8.02E-04
46	33	2.05E-02	4.82E-03	7.77E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 6 Ring	Element	x	y	z
46	33	2.03E-02	6.47E-03	7.81E-04
46	33	2.00E-02	6.36E-03	7.56E-04
46	33	1.96E-02	7.99E-03	7.54E-04
46	33	1.93E-02	7.87E-03	7.31E-04
46	33	1.87E-02	9.46E-03	7.23E-04
46	33	1.84E-02	9.31E-03	7.01E-04
46	34	1.87E-02	9.46E-03	7.23E-04
46	34	1.84E-02	9.31E-03	7.01E-04
46	34	1.77E-02	1.09E-02	6.89E-04
46	34	1.74E-02	1.07E-02	6.67E-04
46	34	1.66E-02	1.22E-02	6.52E-04
46	34	1.63E-02	1.20E-02	6.32E-04
46	34	1.53E-02	1.34E-02	6.15E-04
46	34	1.50E-02	1.32E-02	5.96E-04
46	35	1.53E-02	1.34E-02	6.15E-04
46	35	1.50E-02	1.32E-02	5.96E-04
46	35	1.39E-02	1.45E-02	5.77E-04
46	35	1.37E-02	1.43E-02	5.59E-04
46	35	1.24E-02	1.55E-02	5.40E-04
46	35	1.22E-02	1.53E-02	5.23E-04
46	35	1.08E-02	1.64E-02	5.06E-04
46	35	1.06E-02	1.61E-02	4.90E-04
46	36	1.08E-02	1.64E-02	5.06E-04
46	36	1.06E-02	1.61E-02	4.90E-04
46	36	9.14E-03	1.72E-02	4.75E-04
46	36	9.00E-03	1.69E-02	4.60E-04
46	36	7.40E-03	1.78E-02	4.48E-04
46	36	7.28E-03	1.75E-02	4.34E-04
46	36	5.60E-03	1.83E-02	4.26E-04
46	36	5.51E-03	1.80E-02	4.13E-04
46	36	3.76E-03	1.87E-02	4.10E-04
46	36	3.70E-03	1.84E-02	3.97E-04
46	36	1.89E-03	1.89E-02	4.00E-04
46	36	1.86E-03	1.86E-02	3.88E-04
46	36	1.01E-09	1.90E-02	3.97E-04
46	36	9.97E-10	1.87E-02	3.84E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
47	1	2.21E-02	0.00E+00	8.75E-04
47	1	2.17E-02	0.00E+00	8.40E-04
47	1	2.21E-02	1.69E-03	8.72E-04
47	1	2.16E-02	1.66E-03	8.36E-04
47	1	2.18E-02	3.37E-03	8.62E-04
47	1	2.14E-02	3.30E-03	8.26E-04
47	1	2.14E-02	5.02E-03	8.45E-04
47	1	2.10E-02	4.92E-03	8.10E-04
47	1	2.08E-02	6.64E-03	8.22E-04
47	1	2.04E-02	6.50E-03	7.89E-04
47	1	2.01E-02	8.20E-03	7.94E-04
47	1	1.97E-02	8.03E-03	7.62E-04
47	1	1.92E-02	9.71E-03	7.62E-04
47	1	1.88E-02	9.51E-03	7.30E-04
47	2	1.92E-02	9.71E-03	7.62E-04
47	2	1.88E-02	9.51E-03	7.30E-04
47	2	1.82E-02	1.11E-02	7.26E-04
47	2	1.78E-02	1.09E-02	6.96E-04
47	2	1.70E-02	1.25E-02	6.87E-04
47	2	1.66E-02	1.22E-02	6.59E-04
47	2	1.57E-02	1.37E-02	6.48E-04
47	2	1.54E-02	1.35E-02	6.21E-04
47	3	1.57E-02	1.37E-02	6.48E-04
47	3	1.54E-02	1.35E-02	6.21E-04
47	3	1.43E-02	1.49E-02	6.08E-04
47	3	1.40E-02	1.46E-02	5.83E-04
47	3	1.27E-02	1.59E-02	5.69E-04
47	3	1.25E-02	1.56E-02	5.46E-04
47	3	1.11E-02	1.68E-02	5.33E-04
47	3	1.09E-02	1.65E-02	5.11E-04
47	4	1.11E-02	1.68E-02	5.33E-04
47	4	1.09E-02	1.65E-02	5.11E-04
47	4	9.39E-03	1.76E-02	5.00E-04
47	4	9.19E-03	1.73E-02	4.80E-04
47	4	7.60E-03	1.83E-02	4.72E-04
47	4	7.44E-03	1.79E-02	4.52E-04
47	4	5.75E-03	1.88E-02	4.49E-04
47	4	5.63E-03	1.84E-02	4.30E-04
47	4	3.86E-03	1.92E-02	4.32E-04
47	4	3.78E-03	1.88E-02	4.14E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
47	4	1.94E-03	1.94E-02	4.21E-04
47	4	1.90E-03	1.90E-02	4.04E-04
47	4	1.04E-09	1.95E-02	4.18E-04
47	4	1.02E-09	1.91E-02	4.01E-04
48	5	2.27E-02	0.00E+00	9.20E-04
48	5	2.23E-02	0.00E+00	8.84E-04
48	5	2.26E-02	1.73E-03	9.16E-04
48	5	2.22E-02	1.70E-03	8.81E-04
48	5	2.24E-02	3.45E-03	9.06E-04
48	5	2.19E-02	3.39E-03	8.70E-04
48	5	2.19E-02	5.15E-03	8.88E-04
48	5	2.15E-02	5.05E-03	8.53E-04
48	5	2.13E-02	6.80E-03	8.64E-04
48	5	2.09E-02	6.67E-03	8.30E-04
48	5	2.06E-02	8.41E-03	8.35E-04
48	5	2.02E-02	8.24E-03	8.02E-04
48	5	1.97E-02	9.95E-03	8.01E-04
48	5	1.93E-02	9.75E-03	7.69E-04
48	6	1.97E-02	9.95E-03	8.01E-04
48	6	1.93E-02	9.75E-03	7.69E-04
48	6	1.86E-02	1.14E-02	7.63E-04
48	6	1.82E-02	1.12E-02	7.33E-04
48	6	1.74E-02	1.28E-02	7.22E-04
48	6	1.71E-02	1.25E-02	6.94E-04
48	6	1.61E-02	1.41E-02	6.81E-04
48	6	1.58E-02	1.38E-02	6.54E-04
48	7	1.61E-02	1.41E-02	6.81E-04
48	7	1.58E-02	1.38E-02	6.54E-04
48	7	1.46E-02	1.53E-02	6.39E-04
48	7	1.43E-02	1.50E-02	6.14E-04
48	7	1.31E-02	1.63E-02	5.98E-04
48	7	1.28E-02	1.60E-02	5.75E-04
48	7	1.14E-02	1.73E-02	5.60E-04
48	7	1.12E-02	1.69E-02	5.38E-04
48	8	1.14E-02	1.73E-02	5.60E-04
48	8	1.12E-02	1.69E-02	5.38E-04
48	8	9.62E-03	1.81E-02	5.26E-04
48	8	9.43E-03	1.77E-02	5.05E-04
48	8	7.79E-03	1.87E-02	4.96E-04
48	8	7.63E-03	1.84E-02	4.76E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
48	8	5.90E-03	1.93E-02	4.72E-04
48	8	5.78E-03	1.89E-02	4.53E-04
48	8	3.96E-03	1.96E-02	4.54E-04
48	8	3.88E-03	1.93E-02	4.36E-04
48	8	1.99E-03	1.99E-02	4.43E-04
48	8	1.95E-03	1.95E-02	4.26E-04
48	8	1.07E-09	2.00E-02	4.39E-04
48	8	1.05E-09	1.96E-02	4.22E-04
49	9	2.32E-02	0.00E+00	9.65E-04
49	9	2.28E-02	0.00E+00	9.29E-04
49	9	2.32E-02	1.77E-03	9.61E-04
49	9	2.27E-02	1.74E-03	9.25E-04
49	9	2.29E-02	3.54E-03	9.50E-04
49	9	2.25E-02	3.47E-03	9.14E-04
49	9	2.25E-02	5.27E-03	9.31E-04
49	9	2.20E-02	5.17E-03	8.97E-04
49	9	2.19E-02	6.97E-03	9.06E-04
49	9	2.14E-02	6.84E-03	8.73E-04
49	9	2.11E-02	8.61E-03	8.75E-04
49	9	2.07E-02	8.45E-03	8.43E-04
49	9	2.02E-02	1.02E-02	8.40E-04
49	9	1.98E-02	1.00E-02	8.08E-04
49	10	2.02E-02	1.02E-02	8.40E-04
49	10	1.98E-02	1.00E-02	8.08E-04
49	10	1.91E-02	1.17E-02	8.00E-04
49	10	1.87E-02	1.15E-02	7.70E-04
49	10	1.78E-02	1.31E-02	7.58E-04
49	10	1.75E-02	1.29E-02	7.29E-04
49	10	1.65E-02	1.44E-02	7.14E-04
49	10	1.62E-02	1.42E-02	6.87E-04
49	11	1.65E-02	1.44E-02	7.14E-04
49	11	1.62E-02	1.42E-02	6.87E-04
49	11	1.50E-02	1.56E-02	6.70E-04
49	11	1.47E-02	1.53E-02	6.45E-04
49	11	1.34E-02	1.67E-02	6.27E-04
49	11	1.31E-02	1.64E-02	6.04E-04
49	11	1.17E-02	1.77E-02	5.87E-04
49	11	1.14E-02	1.73E-02	5.66E-04
49	12	1.17E-02	1.77E-02	5.87E-04
49	12	1.14E-02	1.73E-02	5.66E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
49	12	9.86E-03	1.85E-02	5.51E-04
49	12	9.67E-03	1.82E-02	5.31E-04
49	12	7.98E-03	1.92E-02	5.20E-04
49	12	7.83E-03	1.88E-02	5.01E-04
49	12	6.04E-03	1.97E-02	4.95E-04
49	12	5.92E-03	1.94E-02	4.76E-04
49	12	4.05E-03	2.01E-02	4.76E-04
49	12	3.98E-03	1.97E-02	4.58E-04
49	12	2.03E-03	2.04E-02	4.65E-04
49	12	2.00E-03	2.00E-02	4.47E-04
49	12	1.09E-09	2.04E-02	4.61E-04
49	12	1.07E-09	2.01E-02	4.43E-04
50	13	2.38E-02	0.00E+00	1.01E-03
50	13	2.34E-02	0.00E+00	9.74E-04
50	13	2.37E-02	1.82E-03	1.01E-03
50	13	2.33E-02	1.78E-03	9.70E-04
50	13	2.34E-02	3.62E-03	9.94E-04
50	13	2.30E-02	3.55E-03	9.59E-04
50	13	2.30E-02	5.39E-03	9.75E-04
50	13	2.26E-02	5.30E-03	9.40E-04
50	13	2.24E-02	7.13E-03	9.49E-04
50	13	2.20E-02	7.00E-03	9.15E-04
50	13	2.16E-02	8.81E-03	9.16E-04
50	13	2.12E-02	8.65E-03	8.84E-04
50	13	2.06E-02	1.04E-02	8.79E-04
50	13	2.02E-02	1.02E-02	8.48E-04
50	14	2.06E-02	1.04E-02	8.79E-04
50	14	2.02E-02	1.02E-02	8.48E-04
50	14	1.95E-02	1.20E-02	8.37E-04
50	14	1.92E-02	1.17E-02	8.07E-04
50	14	1.82E-02	1.34E-02	7.93E-04
50	14	1.79E-02	1.32E-02	7.65E-04
50	14	1.69E-02	1.48E-02	7.47E-04
50	14	1.65E-02	1.45E-02	7.21E-04
50	15	1.69E-02	1.48E-02	7.47E-04
50	15	1.65E-02	1.45E-02	7.21E-04
50	15	1.53E-02	1.60E-02	7.01E-04
50	15	1.50E-02	1.57E-02	6.76E-04
50	15	1.37E-02	1.71E-02	6.57E-04
50	15	1.34E-02	1.68E-02	6.33E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
50	15	1.19E-02	1.81E-02	6.15E-04
50	15	1.17E-02	1.78E-02	5.93E-04
50	16	1.19E-02	1.81E-02	6.15E-04
50	16	1.17E-02	1.78E-02	5.93E-04
50	16	1.01E-02	1.89E-02	5.77E-04
50	16	9.90E-03	1.86E-02	5.57E-04
50	16	8.16E-03	1.96E-02	5.44E-04
50	16	8.02E-03	1.93E-02	5.25E-04
50	16	6.18E-03	2.02E-02	5.18E-04
50	16	6.07E-03	1.98E-02	4.99E-04
50	16	4.15E-03	2.06E-02	4.98E-04
50	16	4.07E-03	2.02E-02	4.80E-04
50	16	2.08E-03	2.08E-02	4.86E-04
50	16	2.04E-03	2.05E-02	4.69E-04
50	16	1.12E-09	2.09E-02	4.82E-04
50	16	1.10E-09	2.05E-02	4.65E-04
51	17	2.43E-02	0.00E+00	1.06E-03
51	17	2.39E-02	0.00E+00	1.02E-03
51	17	2.42E-02	1.86E-03	1.05E-03
51	17	2.38E-02	1.82E-03	1.02E-03
51	17	2.39E-02	3.70E-03	1.04E-03
51	17	2.35E-02	3.63E-03	1.00E-03
51	17	2.35E-02	5.51E-03	1.02E-03
51	17	2.31E-02	5.42E-03	9.84E-04
51	17	2.29E-02	7.29E-03	9.91E-04
51	17	2.25E-02	7.16E-03	9.57E-04
51	17	2.20E-02	9.01E-03	9.57E-04
51	17	2.17E-02	8.85E-03	9.25E-04
51	17	2.11E-02	1.07E-02	9.18E-04
51	17	2.07E-02	1.05E-02	8.87E-04
51	18	2.11E-02	1.07E-02	9.18E-04
51	18	2.07E-02	1.05E-02	8.87E-04
51	18	1.99E-02	1.22E-02	8.75E-04
51	18	1.96E-02	1.20E-02	8.45E-04
51	18	1.87E-02	1.37E-02	8.28E-04
51	18	1.83E-02	1.35E-02	8.00E-04
51	18	1.72E-02	1.51E-02	7.81E-04
51	18	1.69E-02	1.48E-02	7.54E-04
51	19	1.72E-02	1.51E-02	7.81E-04
51	19	1.69E-02	1.48E-02	7.54E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
51	19	1.57E-02	1.63E-02	7.33E-04
51	19	1.54E-02	1.61E-02	7.08E-04
51	19	1.40E-02	1.75E-02	6.86E-04
51	19	1.37E-02	1.72E-02	6.63E-04
51	19	1.22E-02	1.85E-02	6.42E-04
51	19	1.20E-02	1.82E-02	6.21E-04
51	20	1.22E-02	1.85E-02	6.42E-04
51	20	1.20E-02	1.82E-02	6.21E-04
51	20	1.03E-02	1.94E-02	6.03E-04
51	20	1.01E-02	1.90E-02	5.82E-04
51	20	8.35E-03	2.01E-02	5.69E-04
51	20	8.20E-03	1.97E-02	5.49E-04
51	20	6.32E-03	2.06E-02	5.41E-04
51	20	6.21E-03	2.03E-02	5.23E-04
51	20	4.24E-03	2.11E-02	5.20E-04
51	20	4.17E-03	2.07E-02	5.03E-04
51	20	2.13E-03	2.13E-02	5.08E-04
51	20	2.09E-03	2.09E-02	4.91E-04
51	20	1.14E-09	2.14E-02	5.04E-04
51	20	1.12E-09	2.10E-02	4.87E-04
52	21	2.48E-02	0.00E+00	1.10E-03
52	21	2.44E-02	0.00E+00	1.06E-03
52	21	2.47E-02	1.90E-03	1.10E-03
52	21	2.43E-02	1.86E-03	1.06E-03
52	21	2.44E-02	3.78E-03	1.08E-03
52	21	2.41E-02	3.71E-03	1.05E-03
52	21	2.40E-02	5.63E-03	1.06E-03
52	21	2.36E-02	5.54E-03	1.03E-03
52	21	2.33E-02	7.44E-03	1.03E-03
52	21	2.30E-02	7.32E-03	1.00E-03
52	21	2.25E-02	9.20E-03	9.98E-04
52	21	2.21E-02	9.05E-03	9.66E-04
52	21	2.15E-02	1.09E-02	9.57E-04
52	21	2.12E-02	1.07E-02	9.26E-04
52	22	2.15E-02	1.09E-02	9.57E-04
52	22	2.12E-02	1.07E-02	9.26E-04
52	22	2.04E-02	1.25E-02	9.12E-04
52	22	2.00E-02	1.23E-02	8.83E-04
52	22	1.91E-02	1.40E-02	8.64E-04
52	22	1.87E-02	1.38E-02	8.36E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
52	22	1.76E-02	1.54E-02	8.14E-04
52	22	1.73E-02	1.52E-02	7.88E-04
52	23	1.76E-02	1.54E-02	8.14E-04
52	23	1.73E-02	1.52E-02	7.88E-04
52	23	1.60E-02	1.67E-02	7.64E-04
52	23	1.57E-02	1.64E-02	7.39E-04
52	23	1.43E-02	1.79E-02	7.16E-04
52	23	1.40E-02	1.76E-02	6.92E-04
52	23	1.25E-02	1.89E-02	6.70E-04
52	23	1.22E-02	1.86E-02	6.48E-04
52	24	1.25E-02	1.89E-02	6.70E-04
52	24	1.22E-02	1.86E-02	6.48E-04
52	24	1.05E-02	1.98E-02	6.29E-04
52	24	1.04E-02	1.94E-02	6.08E-04
52	24	8.52E-03	2.05E-02	5.93E-04
52	24	8.38E-03	2.02E-02	5.74E-04
52	24	6.45E-03	2.11E-02	5.64E-04
52	24	6.35E-03	2.07E-02	5.46E-04
52	24	4.33E-03	2.15E-02	5.43E-04
52	24	4.26E-03	2.11E-02	5.25E-04
52	24	2.17E-03	2.18E-02	5.30E-04
52	24	2.14E-03	2.14E-02	5.13E-04
52	24	1.17E-09	2.18E-02	5.25E-04
52	24	1.15E-09	2.15E-02	5.08E-04
53	25	2.53E-02	0.00E+00	1.15E-03
53	25	2.49E-02	0.00E+00	1.11E-03
53	25	2.52E-02	1.93E-03	1.14E-03
53	25	2.48E-02	1.90E-03	1.11E-03
53	25	2.49E-02	3.85E-03	1.13E-03
53	25	2.46E-02	3.79E-03	1.09E-03
53	25	2.45E-02	5.74E-03	1.11E-03
53	25	2.41E-02	5.65E-03	1.07E-03
53	25	2.38E-02	7.59E-03	1.08E-03
53	25	2.34E-02	7.47E-03	1.04E-03
53	25	2.30E-02	9.38E-03	1.04E-03
53	25	2.26E-02	9.24E-03	1.01E-03
53	25	2.20E-02	1.11E-02	9.97E-04
53	25	2.16E-02	1.09E-02	9.66E-04
53	26	2.20E-02	1.11E-02	9.97E-04
53	26	2.16E-02	1.09E-02	9.66E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
53	26	2.08E-02	1.27E-02	9.50E-04
53	26	2.05E-02	1.25E-02	9.20E-04
53	26	1.94E-02	1.43E-02	8.99E-04
53	26	1.91E-02	1.41E-02	8.72E-04
53	26	1.80E-02	1.57E-02	8.47E-04
53	26	1.77E-02	1.55E-02	8.21E-04
53	27	1.80E-02	1.57E-02	8.47E-04
53	27	1.77E-02	1.55E-02	8.21E-04
53	27	1.63E-02	1.70E-02	7.95E-04
53	27	1.61E-02	1.68E-02	7.71E-04
53	27	1.46E-02	1.82E-02	7.45E-04
53	27	1.43E-02	1.79E-02	7.22E-04
53	27	1.27E-02	1.93E-02	6.98E-04
53	27	1.25E-02	1.90E-02	6.76E-04
53	28	1.27E-02	1.93E-02	6.98E-04
53	28	1.25E-02	1.90E-02	6.76E-04
53	28	1.07E-02	2.02E-02	6.55E-04
53	28	1.06E-02	1.99E-02	6.34E-04
53	28	8.70E-03	2.09E-02	6.17E-04
53	28	8.56E-03	2.06E-02	5.98E-04
53	28	6.58E-03	2.15E-02	5.87E-04
53	28	6.48E-03	2.12E-02	5.69E-04
53	28	4.42E-03	2.19E-02	5.65E-04
53	28	4.35E-03	2.16E-02	5.48E-04
53	28	2.22E-03	2.22E-02	5.51E-04
53	28	2.18E-03	2.18E-02	5.34E-04
53	28	1.19E-09	2.23E-02	5.47E-04
53	28	1.17E-09	2.19E-02	5.30E-04
54	29	2.58E-02	0.00E+00	1.19E-03
54	29	2.54E-02	0.00E+00	1.16E-03
54	29	2.57E-02	1.97E-03	1.19E-03
54	29	2.53E-02	1.94E-03	1.15E-03
54	29	2.54E-02	3.93E-03	1.17E-03
54	29	2.51E-02	3.87E-03	1.14E-03
54	29	2.50E-02	5.86E-03	1.15E-03
54	29	2.46E-02	5.77E-03	1.12E-03
54	29	2.43E-02	7.74E-03	1.12E-03
54	29	2.39E-02	7.62E-03	1.09E-03
54	29	2.34E-02	9.57E-03	1.08E-03
54	29	2.31E-02	9.42E-03	1.05E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
54	29	2.24E-02	1.13E-02	1.04E-03
54	29	2.21E-02	1.12E-02	1.01E-03
54	30	2.24E-02	1.13E-02	1.04E-03
54	30	2.21E-02	1.12E-02	1.01E-03
54	30	2.12E-02	1.30E-02	9.88E-04
54	30	2.09E-02	1.28E-02	9.58E-04
54	30	1.98E-02	1.46E-02	9.36E-04
54	30	1.95E-02	1.43E-02	9.07E-04
54	30	1.83E-02	1.60E-02	8.82E-04
54	30	1.80E-02	1.58E-02	8.55E-04
54	31	1.83E-02	1.60E-02	8.82E-04
54	31	1.80E-02	1.58E-02	8.55E-04
54	31	1.67E-02	1.74E-02	8.28E-04
54	31	1.64E-02	1.71E-02	8.02E-04
54	31	1.49E-02	1.86E-02	7.75E-04
54	31	1.46E-02	1.83E-02	7.51E-04
54	31	1.30E-02	1.97E-02	7.26E-04
54	31	1.28E-02	1.94E-02	7.04E-04
54	32	1.30E-02	1.97E-02	7.26E-04
54	32	1.28E-02	1.94E-02	7.04E-04
54	32	1.10E-02	2.06E-02	6.81E-04
54	32	1.08E-02	2.03E-02	6.60E-04
54	32	8.87E-03	2.13E-02	6.42E-04
54	32	8.74E-03	2.10E-02	6.23E-04
54	32	6.72E-03	2.19E-02	6.11E-04
54	32	6.61E-03	2.16E-02	5.92E-04
54	32	4.51E-03	2.24E-02	5.88E-04
54	32	4.44E-03	2.20E-02	5.70E-04
54	32	2.26E-03	2.26E-02	5.74E-04
54	32	2.23E-03	2.23E-02	5.56E-04
54	32	1.21E-09	2.27E-02	5.69E-04
54	32	1.20E-09	2.24E-02	5.52E-04
55	33	2.63E-02	0.00E+00	1.24E-03
55	33	2.59E-02	0.00E+00	1.20E-03
55	33	2.62E-02	2.01E-03	1.23E-03
55	33	2.58E-02	1.98E-03	1.20E-03
55	33	2.59E-02	4.00E-03	1.22E-03
55	33	2.56E-02	3.95E-03	1.18E-03
55	33	2.54E-02	5.97E-03	1.19E-03
55	33	2.51E-02	5.88E-03	1.16E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 7 Ring	Element	x	y	z
55	33	2.48E-02	7.89E-03	1.16E-03
55	33	2.44E-02	7.78E-03	1.13E-03
55	33	2.39E-02	9.75E-03	1.12E-03
55	33	2.35E-02	9.61E-03	1.09E-03
55	33	2.28E-02	1.15E-02	1.08E-03
55	33	2.25E-02	1.14E-02	1.05E-03
55	34	2.28E-02	1.15E-02	1.08E-03
55	34	2.25E-02	1.14E-02	1.05E-03
55	34	2.16E-02	1.32E-02	1.03E-03
55	34	2.13E-02	1.31E-02	9.96E-04
55	34	2.02E-02	1.49E-02	9.72E-04
55	34	1.99E-02	1.46E-02	9.44E-04
55	34	1.87E-02	1.63E-02	9.16E-04
55	34	1.84E-02	1.61E-02	8.89E-04
55	35	1.87E-02	1.63E-02	9.16E-04
55	35	1.84E-02	1.61E-02	8.89E-04
55	35	1.70E-02	1.77E-02	8.60E-04
55	35	1.67E-02	1.75E-02	8.35E-04
55	35	1.52E-02	1.89E-02	8.05E-04
55	35	1.49E-02	1.87E-02	7.82E-04
55	35	1.32E-02	2.00E-02	7.54E-04
55	35	1.30E-02	1.97E-02	7.32E-04
55	36	1.32E-02	2.00E-02	7.54E-04
55	36	1.30E-02	1.97E-02	7.32E-04
55	36	1.12E-02	2.10E-02	7.07E-04
55	36	1.10E-02	2.07E-02	6.87E-04
55	36	9.04E-03	2.18E-02	6.67E-04
55	36	8.91E-03	2.14E-02	6.48E-04
55	36	6.85E-03	2.24E-02	6.35E-04
55	36	6.74E-03	2.20E-02	6.16E-04
55	36	4.59E-03	2.28E-02	6.11E-04
55	36	4.53E-03	2.25E-02	5.93E-04
55	36	2.31E-03	2.31E-02	5.96E-04
55	36	2.27E-03	2.27E-02	5.79E-04
55	36	1.24E-09	2.32E-02	5.91E-04
55	36	1.22E-09	2.28E-02	5.74E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
56	1	2.69E-02	0.00E+00	1.29E-03
56	1	2.64E-02	0.00E+00	1.25E-03
56	1	2.68E-02	2.05E-03	1.28E-03
56	1	2.63E-02	2.02E-03	1.24E-03
56	1	2.65E-02	4.09E-03	1.27E-03
56	1	2.60E-02	4.02E-03	1.23E-03
56	1	2.60E-02	6.09E-03	1.24E-03
56	1	2.55E-02	5.99E-03	1.20E-03
56	1	2.53E-02	8.06E-03	1.21E-03
56	1	2.49E-02	7.92E-03	1.17E-03
56	1	2.44E-02	9.96E-03	1.17E-03
56	1	2.40E-02	9.79E-03	1.13E-03
56	2	2.44E-02	9.96E-03	1.17E-03
56	2	2.40E-02	9.79E-03	1.13E-03
56	2	2.33E-02	1.18E-02	1.12E-03
56	2	2.29E-02	1.16E-02	1.09E-03
56	2	2.21E-02	1.35E-02	1.07E-03
56	2	2.17E-02	1.33E-02	1.03E-03
56	3	2.21E-02	1.35E-02	1.07E-03
56	3	2.17E-02	1.33E-02	1.03E-03
56	3	2.06E-02	1.52E-02	1.01E-03
56	3	2.03E-02	1.49E-02	9.80E-04
56	3	1.91E-02	1.67E-02	9.54E-04
56	3	1.87E-02	1.64E-02	9.23E-04
56	4	1.91E-02	1.67E-02	9.54E-04
56	4	1.87E-02	1.64E-02	9.23E-04
56	4	1.73E-02	1.81E-02	8.96E-04
56	4	1.70E-02	1.78E-02	8.67E-04
56	4	1.55E-02	1.93E-02	8.39E-04
56	4	1.52E-02	1.90E-02	8.12E-04
56	5	1.55E-02	1.93E-02	8.39E-04
56	5	1.52E-02	1.90E-02	8.12E-04
56	5	1.35E-02	2.05E-02	7.86E-04
56	5	1.33E-02	2.01E-02	7.60E-04
56	5	1.14E-02	2.14E-02	7.37E-04
56	5	1.12E-02	2.11E-02	7.13E-04
56	6	1.14E-02	2.14E-02	7.37E-04
56	6	1.12E-02	2.11E-02	7.13E-04
56	6	9.23E-03	2.22E-02	6.95E-04
56	6	9.08E-03	2.19E-02	6.73E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
56	6	6.99E-03	2.28E-02	6.61E-04
56	6	6.87E-03	2.25E-02	6.40E-04
56	6	4.69E-03	2.33E-02	6.36E-04
56	6	4.61E-03	2.29E-02	6.16E-04
56	6	2.35E-03	2.36E-02	6.21E-04
56	6	2.32E-03	2.32E-02	6.01E-04
56	6	1.26E-09	2.37E-02	6.16E-04
56	6	1.24E-09	2.33E-02	5.96E-04
57	7	2.74E-02	0.00E+00	1.34E-03
57	7	2.70E-02	0.00E+00	1.30E-03
57	7	2.73E-02	2.09E-03	1.34E-03
57	7	2.69E-02	2.06E-03	1.29E-03
57	7	2.70E-02	4.17E-03	1.32E-03
57	7	2.66E-02	4.10E-03	1.28E-03
57	7	2.65E-02	6.22E-03	1.30E-03
57	7	2.61E-02	6.12E-03	1.26E-03
57	7	2.58E-02	8.22E-03	1.26E-03
57	7	2.54E-02	8.09E-03	1.22E-03
57	7	2.49E-02	1.02E-02	1.22E-03
57	7	2.45E-02	1.00E-02	1.18E-03
57	8	2.49E-02	1.02E-02	1.22E-03
57	8	2.45E-02	1.00E-02	1.18E-03
57	8	2.38E-02	1.20E-02	1.17E-03
57	8	2.34E-02	1.18E-02	1.13E-03
57	8	2.25E-02	1.38E-02	1.11E-03
57	8	2.21E-02	1.36E-02	1.08E-03
57	9	2.25E-02	1.38E-02	1.11E-03
57	9	2.21E-02	1.36E-02	1.08E-03
57	9	2.11E-02	1.55E-02	1.05E-03
57	9	2.07E-02	1.52E-02	1.02E-03
57	9	1.94E-02	1.70E-02	9.94E-04
57	9	1.91E-02	1.68E-02	9.62E-04
57	10	1.94E-02	1.70E-02	9.94E-04
57	10	1.91E-02	1.68E-02	9.62E-04
57	10	1.77E-02	1.85E-02	9.33E-04
57	10	1.74E-02	1.82E-02	9.03E-04
57	10	1.58E-02	1.97E-02	8.74E-04
57	10	1.55E-02	1.94E-02	8.46E-04
57	11	1.58E-02	1.97E-02	8.74E-04
57	11	1.55E-02	1.94E-02	8.46E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
57	11	1.38E-02	2.09E-02	8.18E-04
57	11	1.35E-02	2.05E-02	7.92E-04
57	11	1.16E-02	2.19E-02	7.68E-04
57	11	1.15E-02	2.15E-02	7.43E-04
57	12	1.16E-02	2.19E-02	7.68E-04
57	12	1.15E-02	2.15E-02	7.43E-04
57	12	9.42E-03	2.27E-02	7.24E-04
57	12	9.27E-03	2.23E-02	7.01E-04
57	12	7.13E-03	2.33E-02	6.89E-04
57	12	7.02E-03	2.29E-02	6.67E-04
57	12	4.79E-03	2.38E-02	6.63E-04
57	12	4.71E-03	2.34E-02	6.42E-04
57	12	2.40E-03	2.41E-02	6.47E-04
57	12	2.36E-03	2.37E-02	6.26E-04
57	12	1.29E-09	2.41E-02	6.41E-04
57	12	1.27E-09	2.38E-02	6.21E-04
58	13	2.80E-02	0.00E+00	1.40E-03
58	13	2.75E-02	0.00E+00	1.35E-03
58	13	2.79E-02	2.13E-03	1.39E-03
58	13	2.74E-02	2.10E-03	1.35E-03
58	13	2.75E-02	4.25E-03	1.37E-03
58	13	2.71E-02	4.19E-03	1.33E-03
58	13	2.70E-02	6.34E-03	1.35E-03
58	13	2.66E-02	6.24E-03	1.31E-03
58	13	2.63E-02	8.38E-03	1.31E-03
58	13	2.59E-02	8.25E-03	1.27E-03
58	13	2.54E-02	1.04E-02	1.27E-03
58	13	2.50E-02	1.02E-02	1.23E-03
58	14	2.54E-02	1.04E-02	1.27E-03
58	14	2.50E-02	1.02E-02	1.23E-03
58	14	2.43E-02	1.23E-02	1.22E-03
58	14	2.39E-02	1.21E-02	1.18E-03
58	14	2.29E-02	1.41E-02	1.16E-03
58	14	2.26E-02	1.39E-02	1.12E-03
58	15	2.29E-02	1.41E-02	1.16E-03
58	15	2.26E-02	1.39E-02	1.12E-03
58	15	2.15E-02	1.58E-02	1.10E-03
58	15	2.11E-02	1.55E-02	1.06E-03
58	15	1.98E-02	1.74E-02	1.03E-03
58	15	1.95E-02	1.71E-02	1.00E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
58	16	1.98E-02	1.74E-02	1.03E-03
58	16	1.95E-02	1.71E-02	1.00E-03
58	16	1.80E-02	1.88E-02	9.70E-04
58	16	1.78E-02	1.85E-02	9.40E-04
58	16	1.61E-02	2.01E-02	9.08E-04
58	16	1.59E-02	1.98E-02	8.81E-04
58	17	1.61E-02	2.01E-02	9.08E-04
58	17	1.59E-02	1.98E-02	8.81E-04
58	17	1.40E-02	2.13E-02	8.51E-04
58	17	1.38E-02	2.10E-02	8.25E-04
58	17	1.19E-02	2.23E-02	7.98E-04
58	17	1.17E-02	2.20E-02	7.74E-04
58	18	1.19E-02	2.23E-02	7.98E-04
58	18	1.17E-02	2.20E-02	7.74E-04
58	18	9.61E-03	2.31E-02	7.53E-04
58	18	9.46E-03	2.28E-02	7.30E-04
58	18	7.28E-03	2.38E-02	7.16E-04
58	18	7.16E-03	2.34E-02	6.94E-04
58	18	4.88E-03	2.42E-02	6.89E-04
58	18	4.81E-03	2.39E-02	6.68E-04
58	18	2.45E-03	2.45E-02	6.72E-04
58	18	2.41E-03	2.41E-02	6.52E-04
58	18	1.32E-09	2.46E-02	6.67E-04
58	18	1.30E-09	2.42E-02	6.46E-04
59	19	2.85E-02	0.00E+00	1.45E-03
59	19	2.81E-02	0.00E+00	1.41E-03
59	19	2.84E-02	2.17E-03	1.44E-03
59	19	2.80E-02	2.14E-03	1.40E-03
59	19	2.81E-02	4.33E-03	1.43E-03
59	19	2.77E-02	4.27E-03	1.39E-03
59	19	2.75E-02	6.46E-03	1.40E-03
59	19	2.71E-02	6.37E-03	1.36E-03
59	19	2.68E-02	8.54E-03	1.36E-03
59	19	2.64E-02	8.41E-03	1.32E-03
59	19	2.58E-02	1.06E-02	1.32E-03
59	19	2.55E-02	1.04E-02	1.28E-03
59	20	2.58E-02	1.06E-02	1.32E-03
59	20	2.55E-02	1.04E-02	1.28E-03
59	20	2.47E-02	1.25E-02	1.26E-03
59	20	2.43E-02	1.23E-02	1.22E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
59	20	2.34E-02	1.43E-02	1.20E-03
59	20	2.30E-02	1.41E-02	1.17E-03
59	21	2.34E-02	1.43E-02	1.20E-03
59	21	2.30E-02	1.41E-02	1.17E-03
59	21	2.19E-02	1.61E-02	1.14E-03
59	21	2.16E-02	1.58E-02	1.11E-03
59	21	2.02E-02	1.77E-02	1.07E-03
59	21	1.99E-02	1.74E-02	1.04E-03
59	22	2.02E-02	1.77E-02	1.07E-03
59	22	1.99E-02	1.74E-02	1.04E-03
59	22	1.84E-02	1.92E-02	1.01E-03
59	22	1.81E-02	1.89E-02	9.78E-04
59	22	1.64E-02	2.05E-02	9.43E-04
59	22	1.62E-02	2.02E-02	9.16E-04
59	23	1.64E-02	2.05E-02	9.43E-04
59	23	1.62E-02	2.02E-02	9.16E-04
59	23	1.43E-02	2.17E-02	8.83E-04
59	23	1.41E-02	2.14E-02	8.57E-04
59	23	1.21E-02	2.27E-02	8.29E-04
59	23	1.19E-02	2.24E-02	8.05E-04
59	24	1.21E-02	2.27E-02	8.29E-04
59	24	1.19E-02	2.24E-02	8.05E-04
59	24	9.80E-03	2.36E-02	7.82E-04
59	24	9.65E-03	2.32E-02	7.59E-04
59	24	7.41E-03	2.42E-02	7.43E-04
59	24	7.30E-03	2.39E-02	7.22E-04
59	24	4.98E-03	2.47E-02	7.15E-04
59	24	4.90E-03	2.43E-02	6.94E-04
59	24	2.50E-03	2.50E-02	6.98E-04
59	24	2.46E-03	2.46E-02	6.78E-04
59	24	1.34E-09	2.51E-02	6.92E-04
59	24	1.32E-09	2.47E-02	6.72E-04
60	25	2.90E-02	0.00E+00	1.50E-03
60	25	2.86E-02	0.00E+00	1.46E-03
60	25	2.89E-02	2.21E-03	1.50E-03
60	25	2.85E-02	2.18E-03	1.45E-03
60	25	2.86E-02	4.41E-03	1.48E-03
60	25	2.82E-02	4.35E-03	1.44E-03
60	25	2.80E-02	6.58E-03	1.45E-03
60	25	2.76E-02	6.49E-03	1.41E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
60	25	2.73E-02	8.70E-03	1.41E-03
60	25	2.69E-02	8.57E-03	1.37E-03
60	25	2.63E-02	1.07E-02	1.36E-03
60	25	2.59E-02	1.06E-02	1.33E-03
60	26	2.63E-02	1.07E-02	1.36E-03
60	26	2.59E-02	1.06E-02	1.33E-03
60	26	2.52E-02	1.27E-02	1.31E-03
60	26	2.48E-02	1.25E-02	1.27E-03
60	26	2.38E-02	1.46E-02	1.25E-03
60	26	2.35E-02	1.44E-02	1.21E-03
60	27	2.38E-02	1.46E-02	1.25E-03
60	27	2.35E-02	1.44E-02	1.21E-03
60	27	2.23E-02	1.64E-02	1.18E-03
60	27	2.20E-02	1.61E-02	1.15E-03
60	27	2.06E-02	1.80E-02	1.11E-03
60	27	2.03E-02	1.78E-02	1.08E-03
60	28	2.06E-02	1.80E-02	1.11E-03
60	28	2.03E-02	1.78E-02	1.08E-03
60	28	1.87E-02	1.95E-02	1.04E-03
60	28	1.84E-02	1.93E-02	1.01E-03
60	28	1.67E-02	2.09E-02	9.78E-04
60	28	1.65E-02	2.06E-02	9.51E-04
60	29	1.67E-02	2.09E-02	9.78E-04
60	29	1.65E-02	2.06E-02	9.51E-04
60	29	1.46E-02	2.21E-02	9.16E-04
60	29	1.44E-02	2.18E-02	8.90E-04
60	29	1.23E-02	2.31E-02	8.59E-04
60	29	1.21E-02	2.28E-02	8.35E-04
60	30	1.23E-02	2.31E-02	8.59E-04
60	30	1.21E-02	2.28E-02	8.35E-04
60	30	9.97E-03	2.40E-02	8.10E-04
60	30	9.83E-03	2.37E-02	7.88E-04
60	30	7.55E-03	2.47E-02	7.71E-04
60	30	7.44E-03	2.43E-02	7.49E-04
60	30	5.07E-03	2.52E-02	7.42E-04
60	30	5.00E-03	2.48E-02	7.21E-04
60	30	2.54E-03	2.55E-02	7.24E-04
60	30	2.51E-03	2.51E-02	7.03E-04
60	30	1.37E-09	2.56E-02	7.18E-04
60	30	1.35E-09	2.52E-02	6.98E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
61	31	2.95E-02	0.00E+00	1.56E-03
61	31	2.91E-02	0.00E+00	1.51E-03
61	31	2.94E-02	2.25E-03	1.55E-03
61	31	2.90E-02	2.22E-03	1.51E-03
61	31	2.91E-02	4.49E-03	1.53E-03
61	31	2.87E-02	4.43E-03	1.49E-03
61	31	2.85E-02	6.70E-03	1.50E-03
61	31	2.81E-02	6.60E-03	1.46E-03
61	31	2.78E-02	8.85E-03	1.46E-03
61	31	2.74E-02	8.73E-03	1.42E-03
61	31	2.68E-02	1.09E-02	1.41E-03
61	31	2.64E-02	1.08E-02	1.37E-03
61	32	2.68E-02	1.09E-02	1.41E-03
61	32	2.64E-02	1.08E-02	1.37E-03
61	32	2.56E-02	1.29E-02	1.36E-03
61	32	2.53E-02	1.28E-02	1.32E-03
61	32	2.42E-02	1.49E-02	1.29E-03
61	32	2.39E-02	1.47E-02	1.26E-03
61	33	2.42E-02	1.49E-02	1.29E-03
61	33	2.39E-02	1.47E-02	1.26E-03
61	33	2.27E-02	1.67E-02	1.22E-03
61	33	2.24E-02	1.64E-02	1.19E-03
61	33	2.09E-02	1.83E-02	1.15E-03
61	33	2.07E-02	1.81E-02	1.12E-03
61	34	2.09E-02	1.83E-02	1.15E-03
61	34	2.07E-02	1.81E-02	1.12E-03
61	34	1.90E-02	1.99E-02	1.08E-03
61	34	1.88E-02	1.96E-02	1.05E-03
61	34	1.70E-02	2.13E-02	1.01E-03
61	34	1.68E-02	2.10E-02	9.85E-04
61	35	1.70E-02	2.13E-02	1.01E-03
61	35	1.68E-02	2.10E-02	9.85E-04
61	35	1.48E-02	2.25E-02	9.49E-04
61	35	1.46E-02	2.22E-02	9.23E-04
61	35	1.25E-02	2.36E-02	8.90E-04
61	35	1.24E-02	2.32E-02	8.66E-04
61	36	1.25E-02	2.36E-02	8.90E-04
61	36	1.24E-02	2.32E-02	8.66E-04
61	36	1.02E-02	2.44E-02	8.40E-04
61	36	1.00E-02	2.41E-02	8.17E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
61	36	7.69E-03	2.51E-02	7.99E-04
61	36	7.58E-03	2.48E-02	7.77E-04
61	36	5.16E-03	2.56E-02	7.68E-04
61	36	5.09E-03	2.53E-02	7.47E-04
61	36	2.59E-03	2.59E-02	7.50E-04
61	36	2.55E-03	2.56E-02	7.29E-04
61	36	1.39E-09	2.60E-02	7.43E-04
61	36	1.37E-09	2.57E-02	7.23E-04
62	37	3.00E-02	0.00E+00	1.61E-03
62	37	2.96E-02	0.00E+00	1.57E-03
62	37	2.99E-02	2.29E-03	1.60E-03
62	37	2.95E-02	2.26E-03	1.56E-03
62	37	2.96E-02	4.57E-03	1.59E-03
62	37	2.92E-02	4.51E-03	1.54E-03
62	37	2.90E-02	6.81E-03	1.55E-03
62	37	2.86E-02	6.72E-03	1.51E-03
62	37	2.82E-02	9.00E-03	1.51E-03
62	37	2.79E-02	8.88E-03	1.47E-03
62	37	2.73E-02	1.11E-02	1.46E-03
62	37	2.69E-02	1.10E-02	1.42E-03
62	38	2.73E-02	1.11E-02	1.46E-03
62	38	2.69E-02	1.10E-02	1.42E-03
62	38	2.61E-02	1.32E-02	1.40E-03
62	38	2.57E-02	1.30E-02	1.37E-03
62	38	2.47E-02	1.51E-02	1.34E-03
62	38	2.43E-02	1.49E-02	1.30E-03
62	39	2.47E-02	1.51E-02	1.34E-03
62	39	2.43E-02	1.49E-02	1.30E-03
62	39	2.31E-02	1.70E-02	1.27E-03
62	39	2.28E-02	1.67E-02	1.23E-03
62	39	2.13E-02	1.87E-02	1.19E-03
62	39	2.10E-02	1.84E-02	1.16E-03
62	40	2.13E-02	1.87E-02	1.19E-03
62	40	2.10E-02	1.84E-02	1.16E-03
62	40	1.94E-02	2.02E-02	1.12E-03
62	40	1.91E-02	2.00E-02	1.09E-03
62	40	1.73E-02	2.16E-02	1.05E-03
62	40	1.71E-02	2.13E-02	1.02E-03
62	41	1.73E-02	2.16E-02	1.05E-03
62	41	1.71E-02	2.13E-02	1.02E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
62	41	1.51E-02	2.29E-02	9.82E-04
62	41	1.49E-02	2.26E-02	9.56E-04
62	41	1.28E-02	2.40E-02	9.21E-04
62	41	1.26E-02	2.36E-02	8.97E-04
62	42	1.28E-02	2.40E-02	9.21E-04
62	42	1.26E-02	2.36E-02	8.97E-04
62	42	1.03E-02	2.49E-02	8.69E-04
62	42	1.02E-02	2.45E-02	8.46E-04
62	42	7.82E-03	2.56E-02	8.26E-04
62	42	7.72E-03	2.52E-02	8.05E-04
62	42	5.25E-03	2.61E-02	7.95E-04
62	42	5.18E-03	2.57E-02	7.74E-04
62	42	2.63E-03	2.64E-02	7.76E-04
62	42	2.60E-03	2.60E-02	7.55E-04
62	42	1.41E-09	2.65E-02	7.69E-04
62	42	1.40E-09	2.61E-02	7.49E-04
63	43	3.05E-02	0.00E+00	1.66E-03
63	43	3.01E-02	0.00E+00	1.62E-03
63	43	3.04E-02	2.33E-03	1.66E-03
63	43	3.00E-02	2.30E-03	1.62E-03
63	43	3.01E-02	4.64E-03	1.64E-03
63	43	2.97E-02	4.59E-03	1.60E-03
63	43	2.95E-02	6.92E-03	1.61E-03
63	43	2.91E-02	6.84E-03	1.57E-03
63	43	2.87E-02	9.15E-03	1.56E-03
63	43	2.83E-02	9.04E-03	1.52E-03
63	43	2.77E-02	1.13E-02	1.51E-03
63	43	2.74E-02	1.12E-02	1.47E-03
63	44	2.77E-02	1.13E-02	1.51E-03
63	44	2.74E-02	1.12E-02	1.47E-03
63	44	2.65E-02	1.34E-02	1.45E-03
63	44	2.61E-02	1.32E-02	1.41E-03
63	44	2.51E-02	1.54E-02	1.38E-03
63	44	2.47E-02	1.52E-02	1.35E-03
63	45	2.51E-02	1.54E-02	1.38E-03
63	45	2.47E-02	1.52E-02	1.35E-03
63	45	2.35E-02	1.72E-02	1.31E-03
63	45	2.32E-02	1.70E-02	1.27E-03
63	45	2.17E-02	1.90E-02	1.23E-03
63	45	2.14E-02	1.87E-02	1.20E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
63	46	2.17E-02	1.90E-02	1.23E-03
63	46	2.14E-02	1.87E-02	1.20E-03
63	46	1.97E-02	2.06E-02	1.16E-03
63	46	1.95E-02	2.03E-02	1.13E-03
63	46	1.76E-02	2.20E-02	1.08E-03
63	46	1.74E-02	2.17E-02	1.06E-03
63	47	1.76E-02	2.20E-02	1.08E-03
63	47	1.74E-02	2.17E-02	1.06E-03
63	47	1.53E-02	2.33E-02	1.01E-03
63	47	1.51E-02	2.30E-02	9.89E-04
63	47	1.30E-02	2.44E-02	9.52E-04
63	47	1.28E-02	2.41E-02	9.28E-04
63	48	1.30E-02	2.44E-02	9.52E-04
63	48	1.28E-02	2.41E-02	9.28E-04
63	48	1.05E-02	2.53E-02	8.98E-04
63	48	1.04E-02	2.49E-02	8.75E-04
63	48	7.95E-03	2.60E-02	8.54E-04
63	48	7.85E-03	2.57E-02	8.32E-04
63	48	5.34E-03	2.65E-02	8.22E-04
63	48	5.27E-03	2.62E-02	8.01E-04
63	48	2.68E-03	2.68E-02	8.02E-04
63	48	2.64E-03	2.65E-02	7.81E-04
63	48	1.44E-09	2.69E-02	7.95E-04
63	48	1.42E-09	2.66E-02	7.75E-04
64	49	3.10E-02	0.00E+00	1.72E-03
64	49	3.06E-02	0.00E+00	1.68E-03
64	49	3.09E-02	2.37E-03	1.71E-03
64	49	3.05E-02	2.34E-03	1.67E-03
64	49	3.06E-02	4.72E-03	1.69E-03
64	49	3.02E-02	4.66E-03	1.65E-03
64	49	3.00E-02	7.04E-03	1.66E-03
64	49	2.96E-02	6.95E-03	1.62E-03
64	49	2.92E-02	9.30E-03	1.62E-03
64	49	2.88E-02	9.19E-03	1.58E-03
64	49	2.82E-02	1.15E-02	1.56E-03
64	49	2.78E-02	1.14E-02	1.52E-03
64	50	2.82E-02	1.15E-02	1.56E-03
64	50	2.78E-02	1.14E-02	1.52E-03
64	50	2.69E-02	1.36E-02	1.50E-03
64	50	2.66E-02	1.34E-02	1.46E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 8 Ring	Element	x	y	z
64	50	2.55E-02	1.56E-02	1.43E-03
64	50	2.52E-02	1.54E-02	1.39E-03
64	51	2.55E-02	1.56E-02	1.43E-03
64	51	2.52E-02	1.54E-02	1.39E-03
64	51	2.38E-02	1.75E-02	1.35E-03
64	51	2.35E-02	1.73E-02	1.32E-03
64	51	2.20E-02	1.93E-02	1.27E-03
64	51	2.17E-02	1.90E-02	1.24E-03
64	52	2.20E-02	1.93E-02	1.27E-03
64	52	2.17E-02	1.90E-02	1.24E-03
64	52	2.00E-02	2.09E-02	1.20E-03
64	52	1.98E-02	2.06E-02	1.17E-03
64	52	1.79E-02	2.24E-02	1.12E-03
64	52	1.77E-02	2.21E-02	1.09E-03
64	53	1.79E-02	2.24E-02	1.12E-03
64	53	1.77E-02	2.21E-02	1.09E-03
64	53	1.56E-02	2.37E-02	1.05E-03
64	53	1.54E-02	2.34E-02	1.02E-03
64	53	1.32E-02	2.48E-02	9.83E-04
64	53	1.30E-02	2.45E-02	9.59E-04
64	54	1.32E-02	2.48E-02	9.83E-04
64	54	1.30E-02	2.45E-02	9.59E-04
64	54	1.07E-02	2.57E-02	9.27E-04
64	54	1.05E-02	2.54E-02	9.04E-04
64	54	8.08E-03	2.64E-02	8.82E-04
64	54	7.98E-03	2.61E-02	8.60E-04
64	54	5.42E-03	2.69E-02	8.49E-04
64	54	5.36E-03	2.66E-02	8.27E-04
64	54	2.72E-03	2.73E-02	8.28E-04
64	54	2.69E-03	2.69E-02	8.07E-04
64	54	1.46E-09	2.74E-02	8.21E-04
64	54	1.44E-09	2.70E-02	8.01E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
65	1	3.16E-02	0.00E+00	1.78E-03
65	1	3.11E-02	0.00E+00	1.73E-03
65	1	3.15E-02	2.41E-03	1.78E-03
65	1	3.10E-02	2.38E-03	1.72E-03
65	1	3.11E-02	4.81E-03	1.76E-03
65	1	3.07E-02	4.74E-03	1.70E-03
65	1	3.05E-02	7.17E-03	1.72E-03
65	1	3.01E-02	7.06E-03	1.67E-03
65	1	2.97E-02	9.47E-03	1.68E-03
65	1	2.93E-02	9.33E-03	1.63E-03
65	1	2.87E-02	1.17E-02	1.62E-03
65	1	2.83E-02	1.15E-02	1.57E-03
65	2	2.87E-02	1.17E-02	1.62E-03
65	2	2.83E-02	1.15E-02	1.57E-03
65	2	2.74E-02	1.39E-02	1.55E-03
65	2	2.70E-02	1.37E-02	1.51E-03
65	2	2.59E-02	1.59E-02	1.48E-03
65	2	2.56E-02	1.57E-02	1.44E-03
65	3	2.59E-02	1.59E-02	1.48E-03
65	3	2.56E-02	1.57E-02	1.44E-03
65	3	2.43E-02	1.78E-02	1.40E-03
65	3	2.39E-02	1.76E-02	1.36E-03
65	3	2.24E-02	1.96E-02	1.32E-03
65	3	2.21E-02	1.93E-02	1.28E-03
65	4	2.24E-02	1.96E-02	1.32E-03
65	4	2.21E-02	1.93E-02	1.28E-03
65	4	2.04E-02	2.13E-02	1.24E-03
65	4	2.01E-02	2.10E-02	1.20E-03
65	4	1.82E-02	2.28E-02	1.16E-03
65	4	1.79E-02	2.24E-02	1.13E-03
65	5	1.82E-02	2.28E-02	1.16E-03
65	5	1.79E-02	2.24E-02	1.13E-03
65	5	1.59E-02	2.41E-02	1.09E-03
65	5	1.57E-02	2.37E-02	1.06E-03
65	5	1.34E-02	2.52E-02	1.02E-03
65	5	1.32E-02	2.49E-02	9.90E-04
65	6	1.34E-02	2.52E-02	1.02E-03
65	6	1.32E-02	2.49E-02	9.90E-04
65	6	1.09E-02	2.62E-02	9.62E-04
65	6	1.07E-02	2.58E-02	9.34E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
65	6	8.23E-03	2.69E-02	9.15E-04
65	6	8.11E-03	2.65E-02	8.88E-04
65	6	5.53E-03	2.74E-02	8.80E-04
65	6	5.44E-03	2.70E-02	8.55E-04
65	6	2.77E-03	2.78E-02	8.59E-04
65	6	2.73E-03	2.73E-02	8.34E-04
65	6	1.49E-09	2.79E-02	8.52E-04
65	6	1.47E-09	2.75E-02	8.27E-04
66	7	3.22E-02	0.00E+00	1.85E-03
66	7	3.17E-02	0.00E+00	1.80E-03
66	7	3.20E-02	2.46E-03	1.84E-03
66	7	3.16E-02	2.42E-03	1.79E-03
66	7	3.17E-02	4.89E-03	1.82E-03
66	7	3.12E-02	4.82E-03	1.77E-03
66	7	3.11E-02	7.29E-03	1.78E-03
66	7	3.06E-02	7.19E-03	1.73E-03
66	7	3.03E-02	9.64E-03	1.74E-03
66	7	2.98E-02	9.51E-03	1.69E-03
66	7	2.92E-02	1.19E-02	1.68E-03
66	7	2.88E-02	1.18E-02	1.63E-03
66	8	2.92E-02	1.19E-02	1.68E-03
66	8	2.88E-02	1.18E-02	1.63E-03
66	8	2.79E-02	1.41E-02	1.61E-03
66	8	2.75E-02	1.39E-02	1.56E-03
66	8	2.64E-02	1.62E-02	1.53E-03
66	8	2.60E-02	1.60E-02	1.49E-03
66	9	2.64E-02	1.62E-02	1.53E-03
66	9	2.60E-02	1.60E-02	1.49E-03
66	9	2.47E-02	1.82E-02	1.45E-03
66	9	2.44E-02	1.79E-02	1.41E-03
66	9	2.28E-02	2.00E-02	1.37E-03
66	9	2.25E-02	1.97E-02	1.33E-03
66	10	2.28E-02	2.00E-02	1.37E-03
66	10	2.25E-02	1.97E-02	1.33E-03
66	10	2.08E-02	2.17E-02	1.28E-03
66	10	2.05E-02	2.14E-02	1.25E-03
66	10	1.85E-02	2.32E-02	1.20E-03
66	10	1.83E-02	2.29E-02	1.17E-03
66	11	1.85E-02	2.32E-02	1.20E-03
66	11	1.83E-02	2.29E-02	1.17E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
66	11	1.62E-02	2.45E-02	1.13E-03
66	11	1.59E-02	2.42E-02	1.09E-03
66	11	1.37E-02	2.57E-02	1.06E-03
66	11	1.35E-02	2.53E-02	1.03E-03
66	12	1.37E-02	2.57E-02	1.06E-03
66	12	1.35E-02	2.53E-02	1.03E-03
66	12	1.11E-02	2.66E-02	9.97E-04
66	12	1.09E-02	2.63E-02	9.69E-04
66	12	8.38E-03	2.74E-02	9.48E-04
66	12	8.26E-03	2.70E-02	9.22E-04
66	12	5.63E-03	2.79E-02	9.12E-04
66	12	5.55E-03	2.75E-02	8.87E-04
66	12	2.82E-03	2.83E-02	8.90E-04
66	12	2.78E-03	2.79E-02	8.65E-04
66	12	1.52E-09	2.84E-02	8.83E-04
66	12	1.49E-09	2.80E-02	8.58E-04
67	13	3.27E-02	0.00E+00	1.91E-03
67	13	3.23E-02	0.00E+00	1.86E-03
67	13	3.26E-02	2.50E-03	1.90E-03
67	13	3.22E-02	2.46E-03	1.85E-03
67	13	3.22E-02	4.98E-03	1.88E-03
67	13	3.18E-02	4.91E-03	1.83E-03
67	13	3.16E-02	7.42E-03	1.85E-03
67	13	3.12E-02	7.32E-03	1.80E-03
67	13	3.08E-02	9.81E-03	1.80E-03
67	13	3.04E-02	9.68E-03	1.75E-03
67	13	2.97E-02	1.21E-02	1.74E-03
67	13	2.93E-02	1.20E-02	1.69E-03
67	14	2.97E-02	1.21E-02	1.74E-03
67	14	2.93E-02	1.20E-02	1.69E-03
67	14	2.84E-02	1.44E-02	1.66E-03
67	14	2.80E-02	1.42E-02	1.62E-03
67	14	2.69E-02	1.65E-02	1.59E-03
67	14	2.65E-02	1.63E-02	1.54E-03
67	15	2.69E-02	1.65E-02	1.59E-03
67	15	2.65E-02	1.63E-02	1.54E-03
67	15	2.51E-02	1.85E-02	1.50E-03
67	15	2.48E-02	1.82E-02	1.46E-03
67	15	2.32E-02	2.03E-02	1.42E-03
67	15	2.29E-02	2.01E-02	1.38E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
67	16	2.32E-02	2.03E-02	1.42E-03
67	16	2.29E-02	2.01E-02	1.38E-03
67	16	2.11E-02	2.20E-02	1.33E-03
67	16	2.08E-02	2.17E-02	1.29E-03
67	16	1.89E-02	2.36E-02	1.25E-03
67	16	1.86E-02	2.33E-02	1.21E-03
67	17	1.89E-02	2.36E-02	1.25E-03
67	17	1.86E-02	2.33E-02	1.21E-03
67	17	1.65E-02	2.50E-02	1.17E-03
67	17	1.62E-02	2.46E-02	1.13E-03
67	17	1.39E-02	2.61E-02	1.09E-03
67	17	1.37E-02	2.58E-02	1.06E-03
67	18	1.39E-02	2.61E-02	1.09E-03
67	18	1.37E-02	2.58E-02	1.06E-03
67	18	1.13E-02	2.71E-02	1.03E-03
67	18	1.11E-02	2.67E-02	1.00E-03
67	18	8.53E-03	2.79E-02	9.81E-04
67	18	8.41E-03	2.75E-02	9.55E-04
67	18	5.72E-03	2.84E-02	9.44E-04
67	18	5.65E-03	2.80E-02	9.18E-04
67	18	2.87E-03	2.88E-02	9.21E-04
67	18	2.83E-03	2.84E-02	8.96E-04
67	18	1.54E-09	2.89E-02	9.13E-04
67	18	1.52E-09	2.85E-02	8.89E-04
68	19	3.33E-02	0.00E+00	1.98E-03
68	19	3.28E-02	0.00E+00	1.92E-03
68	19	3.31E-02	2.54E-03	1.97E-03
68	19	3.27E-02	2.51E-03	1.92E-03
68	19	3.28E-02	5.06E-03	1.95E-03
68	19	3.23E-02	4.99E-03	1.89E-03
68	19	3.22E-02	7.55E-03	1.91E-03
68	19	3.17E-02	7.45E-03	1.86E-03
68	19	3.13E-02	9.98E-03	1.86E-03
68	19	3.09E-02	9.84E-03	1.81E-03
68	19	3.02E-02	1.23E-02	1.79E-03
68	19	2.98E-02	1.22E-02	1.75E-03
68	20	3.02E-02	1.23E-02	1.79E-03
68	20	2.98E-02	1.22E-02	1.75E-03
68	20	2.89E-02	1.46E-02	1.72E-03
68	20	2.85E-02	1.44E-02	1.68E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
68	20	2.73E-02	1.68E-02	1.64E-03
68	20	2.70E-02	1.65E-02	1.60E-03
68	21	2.73E-02	1.68E-02	1.64E-03
68	21	2.70E-02	1.65E-02	1.60E-03
68	21	2.56E-02	1.88E-02	1.55E-03
68	21	2.52E-02	1.85E-02	1.51E-03
68	21	2.36E-02	2.07E-02	1.46E-03
68	21	2.33E-02	2.04E-02	1.43E-03
68	22	2.36E-02	2.07E-02	1.46E-03
68	22	2.33E-02	2.04E-02	1.43E-03
68	22	2.15E-02	2.24E-02	1.38E-03
68	22	2.12E-02	2.21E-02	1.34E-03
68	22	1.92E-02	2.40E-02	1.29E-03
68	22	1.89E-02	2.37E-02	1.25E-03
68	23	1.92E-02	2.40E-02	1.29E-03
68	23	1.89E-02	2.37E-02	1.25E-03
68	23	1.67E-02	2.54E-02	1.21E-03
68	23	1.65E-02	2.50E-02	1.17E-03
68	23	1.42E-02	2.66E-02	1.13E-03
68	23	1.40E-02	2.62E-02	1.10E-03
68	24	1.42E-02	2.66E-02	1.13E-03
68	24	1.40E-02	2.62E-02	1.10E-03
68	24	1.15E-02	2.76E-02	1.07E-03
68	24	1.13E-02	2.72E-02	1.04E-03
68	24	8.68E-03	2.84E-02	1.01E-03
68	24	8.56E-03	2.80E-02	9.88E-04
68	24	5.82E-03	2.89E-02	9.76E-04
68	24	5.74E-03	2.85E-02	9.50E-04
68	24	2.92E-03	2.93E-02	9.53E-04
68	24	2.88E-03	2.89E-02	9.27E-04
68	24	1.57E-09	2.94E-02	9.45E-04
68	24	1.55E-09	2.90E-02	9.19E-04
69	25	3.38E-02	0.00E+00	2.04E-03
69	25	3.34E-02	0.00E+00	1.99E-03
69	25	3.37E-02	2.58E-03	2.03E-03
69	25	3.33E-02	2.55E-03	1.98E-03
69	25	3.33E-02	5.14E-03	2.01E-03
69	25	3.29E-02	5.08E-03	1.96E-03
69	25	3.27E-02	7.67E-03	1.97E-03
69	25	3.23E-02	7.57E-03	1.92E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
69	25	3.18E-02	1.01E-02	1.92E-03
69	25	3.14E-02	1.00E-02	1.87E-03
69	25	3.07E-02	1.25E-02	1.85E-03
69	25	3.03E-02	1.24E-02	1.81E-03
69	26	3.07E-02	1.25E-02	1.85E-03
69	26	3.03E-02	1.24E-02	1.81E-03
69	26	2.93E-02	1.48E-02	1.78E-03
69	26	2.90E-02	1.46E-02	1.73E-03
69	26	2.78E-02	1.70E-02	1.70E-03
69	26	2.74E-02	1.68E-02	1.65E-03
69	27	2.78E-02	1.70E-02	1.70E-03
69	27	2.74E-02	1.68E-02	1.65E-03
69	27	2.60E-02	1.91E-02	1.61E-03
69	27	2.57E-02	1.89E-02	1.56E-03
69	27	2.40E-02	2.10E-02	1.51E-03
69	27	2.37E-02	2.08E-02	1.47E-03
69	28	2.40E-02	2.10E-02	1.51E-03
69	28	2.37E-02	2.08E-02	1.47E-03
69	28	2.18E-02	2.28E-02	1.42E-03
69	28	2.16E-02	2.25E-02	1.38E-03
69	28	1.95E-02	2.44E-02	1.33E-03
69	28	1.93E-02	2.41E-02	1.30E-03
69	29	1.95E-02	2.44E-02	1.33E-03
69	29	1.93E-02	2.41E-02	1.30E-03
69	29	1.70E-02	2.58E-02	1.25E-03
69	29	1.68E-02	2.55E-02	1.21E-03
69	29	1.44E-02	2.70E-02	1.17E-03
69	29	1.42E-02	2.67E-02	1.14E-03
69	30	1.44E-02	2.70E-02	1.17E-03
69	30	1.42E-02	2.67E-02	1.14E-03
69	30	1.17E-02	2.80E-02	1.10E-03
69	30	1.15E-02	2.77E-02	1.07E-03
69	30	8.82E-03	2.88E-02	1.05E-03
69	30	8.71E-03	2.84E-02	1.02E-03
69	30	5.92E-03	2.94E-02	1.01E-03
69	30	5.84E-03	2.90E-02	9.83E-04
69	30	2.97E-03	2.97E-02	9.84E-04
69	30	2.93E-03	2.94E-02	9.59E-04
69	30	1.60E-09	2.99E-02	9.76E-04
69	30	1.57E-09	2.95E-02	9.51E-04

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
70	31	3.43E-02	0.00E+00	2.11E-03
70	31	3.39E-02	0.00E+00	2.06E-03
70	31	3.42E-02	2.62E-03	2.10E-03
70	31	3.38E-02	2.59E-03	2.05E-03
70	31	3.38E-02	5.23E-03	2.07E-03
70	31	3.34E-02	5.16E-03	2.02E-03
70	31	3.32E-02	7.79E-03	2.03E-03
70	31	3.28E-02	7.69E-03	1.98E-03
70	31	3.23E-02	1.03E-02	1.98E-03
70	31	3.19E-02	1.02E-02	1.93E-03
70	31	3.12E-02	1.27E-02	1.91E-03
70	31	3.08E-02	1.26E-02	1.87E-03
70	32	3.12E-02	1.27E-02	1.91E-03
70	32	3.08E-02	1.26E-02	1.87E-03
70	32	2.98E-02	1.51E-02	1.84E-03
70	32	2.94E-02	1.49E-02	1.79E-03
70	32	2.82E-02	1.73E-02	1.75E-03
70	32	2.79E-02	1.71E-02	1.71E-03
70	33	2.82E-02	1.73E-02	1.75E-03
70	33	2.79E-02	1.71E-02	1.71E-03
70	33	2.64E-02	1.94E-02	1.66E-03
70	33	2.61E-02	1.92E-02	1.62E-03
70	33	2.44E-02	2.14E-02	1.56E-03
70	33	2.41E-02	2.11E-02	1.52E-03
70	34	2.44E-02	2.14E-02	1.56E-03
70	34	2.41E-02	2.11E-02	1.52E-03
70	34	2.22E-02	2.32E-02	1.47E-03
70	34	2.19E-02	2.29E-02	1.43E-03
70	34	1.98E-02	2.48E-02	1.37E-03
70	34	1.96E-02	2.45E-02	1.34E-03
70	35	1.98E-02	2.48E-02	1.37E-03
70	35	1.96E-02	2.45E-02	1.34E-03
70	35	1.73E-02	2.62E-02	1.29E-03
70	35	1.71E-02	2.59E-02	1.25E-03
70	35	1.46E-02	2.74E-02	1.21E-03
70	35	1.44E-02	2.71E-02	1.18E-03
70	36	1.46E-02	2.74E-02	1.21E-03
70	36	1.44E-02	2.71E-02	1.18E-03
70	36	1.18E-02	2.85E-02	1.14E-03
70	36	1.17E-02	2.81E-02	1.11E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
70	36	8.96E-03	2.93E-02	1.08E-03
70	36	8.85E-03	2.89E-02	1.06E-03
70	36	6.01E-03	2.99E-02	1.04E-03
70	36	5.94E-03	2.95E-02	1.02E-03
70	36	3.02E-03	3.02E-02	1.02E-03
70	36	2.98E-03	2.98E-02	9.90E-04
70	36	1.62E-09	3.03E-02	1.01E-03
70	36	1.60E-09	3.00E-02	9.82E-04
71	37	3.49E-02	0.00E+00	2.17E-03
71	37	3.45E-02	0.00E+00	2.12E-03
71	37	3.48E-02	2.66E-03	2.16E-03
71	37	3.43E-02	2.63E-03	2.11E-03
71	37	3.44E-02	5.31E-03	2.14E-03
71	37	3.39E-02	5.24E-03	2.09E-03
71	37	3.37E-02	7.91E-03	2.10E-03
71	37	3.33E-02	7.82E-03	2.05E-03
71	37	3.28E-02	1.05E-02	2.04E-03
71	37	3.24E-02	1.03E-02	1.99E-03
71	37	3.17E-02	1.29E-02	1.97E-03
71	37	3.13E-02	1.28E-02	1.93E-03
71	38	3.17E-02	1.29E-02	1.97E-03
71	38	3.13E-02	1.28E-02	1.93E-03
71	38	3.03E-02	1.53E-02	1.89E-03
71	38	2.99E-02	1.51E-02	1.85E-03
71	38	2.87E-02	1.76E-02	1.80E-03
71	38	2.83E-02	1.74E-02	1.76E-03
71	39	2.87E-02	1.76E-02	1.80E-03
71	39	2.83E-02	1.74E-02	1.76E-03
71	39	2.68E-02	1.97E-02	1.71E-03
71	39	2.65E-02	1.95E-02	1.67E-03
71	39	2.48E-02	2.17E-02	1.61E-03
71	39	2.45E-02	2.14E-02	1.57E-03
71	40	2.48E-02	2.17E-02	1.61E-03
71	40	2.45E-02	2.14E-02	1.57E-03
71	40	2.25E-02	2.35E-02	1.51E-03
71	40	2.23E-02	2.32E-02	1.48E-03
71	40	2.01E-02	2.52E-02	1.42E-03
71	40	1.99E-02	2.49E-02	1.38E-03
71	41	2.01E-02	2.52E-02	1.42E-03
71	41	1.99E-02	2.49E-02	1.38E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
71	41	1.76E-02	2.66E-02	1.33E-03
71	41	1.73E-02	2.63E-02	1.29E-03
71	41	1.48E-02	2.79E-02	1.24E-03
71	41	1.47E-02	2.75E-02	1.21E-03
71	42	1.48E-02	2.79E-02	1.24E-03
71	42	1.47E-02	2.75E-02	1.21E-03
71	42	1.20E-02	2.89E-02	1.17E-03
71	42	1.19E-02	2.86E-02	1.14E-03
71	42	9.10E-03	2.97E-02	1.12E-03
71	42	8.99E-03	2.94E-02	1.09E-03
71	42	6.11E-03	3.03E-02	1.07E-03
71	42	6.03E-03	3.00E-02	1.05E-03
71	42	3.07E-03	3.07E-02	1.05E-03
71	42	3.03E-03	3.03E-02	1.02E-03
71	42	1.65E-09	3.08E-02	1.04E-03
71	42	1.63E-09	3.04E-02	1.01E-03
72	43	3.54E-02	0.00E+00	2.24E-03
72	43	3.50E-02	0.00E+00	2.19E-03
72	43	3.53E-02	2.70E-03	2.23E-03
72	43	3.49E-02	2.67E-03	2.18E-03
72	43	3.49E-02	5.38E-03	2.20E-03
72	43	3.45E-02	5.32E-03	2.15E-03
72	43	3.42E-02	8.03E-03	2.16E-03
72	43	3.38E-02	7.93E-03	2.11E-03
72	43	3.33E-02	1.06E-02	2.10E-03
72	43	3.29E-02	1.05E-02	2.05E-03
72	43	3.21E-02	1.31E-02	2.03E-03
72	43	3.18E-02	1.30E-02	1.98E-03
72	44	3.21E-02	1.31E-02	2.03E-03
72	44	3.18E-02	1.30E-02	1.98E-03
72	44	3.07E-02	1.55E-02	1.95E-03
72	44	3.04E-02	1.54E-02	1.90E-03
72	44	2.91E-02	1.78E-02	1.86E-03
72	44	2.87E-02	1.76E-02	1.81E-03
72	45	2.91E-02	1.78E-02	1.86E-03
72	45	2.87E-02	1.76E-02	1.81E-03
72	45	2.72E-02	2.00E-02	1.76E-03
72	45	2.69E-02	1.98E-02	1.72E-03
72	45	2.51E-02	2.20E-02	1.66E-03
72	45	2.48E-02	2.18E-02	1.62E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 9 Ring	Element	x	y	z
72	46	2.51E-02	2.20E-02	1.66E-03
72	46	2.48E-02	2.18E-02	1.62E-03
72	46	2.29E-02	2.39E-02	1.56E-03
72	46	2.26E-02	2.36E-02	1.52E-03
72	46	2.04E-02	2.55E-02	1.46E-03
72	46	2.02E-02	2.52E-02	1.42E-03
72	47	2.04E-02	2.55E-02	1.46E-03
72	47	2.02E-02	2.52E-02	1.42E-03
72	47	1.78E-02	2.70E-02	1.37E-03
72	47	1.76E-02	2.67E-02	1.33E-03
72	47	1.51E-02	2.83E-02	1.28E-03
72	47	1.49E-02	2.80E-02	1.25E-03
72	48	1.51E-02	2.83E-02	1.28E-03
72	48	1.49E-02	2.80E-02	1.25E-03
72	48	1.22E-02	2.94E-02	1.21E-03
72	48	1.21E-02	2.90E-02	1.18E-03
72	48	9.24E-03	3.02E-02	1.15E-03
72	48	9.13E-03	2.98E-02	1.12E-03
72	48	6.20E-03	3.08E-02	1.10E-03
72	48	6.13E-03	3.04E-02	1.08E-03
72	48	3.11E-03	3.11E-02	1.08E-03
72	48	3.08E-03	3.08E-02	1.05E-03
72	48	1.67E-09	3.13E-02	1.07E-03
72	48	1.65E-09	3.09E-02	1.04E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
73	1	3.60E-02	0.00E+00	2.31E-03
73	1	3.55E-02	0.00E+00	2.25E-03
73	1	3.58E-02	2.74E-03	2.30E-03
73	1	3.54E-02	2.71E-03	2.24E-03
73	1	3.54E-02	5.47E-03	2.27E-03
73	1	3.50E-02	5.40E-03	2.21E-03
73	1	3.47E-02	8.15E-03	2.23E-03
73	1	3.43E-02	8.05E-03	2.17E-03
73	1	3.38E-02	1.08E-02	2.17E-03
73	1	3.34E-02	1.06E-02	2.11E-03
73	1	3.26E-02	1.33E-02	2.10E-03
73	1	3.22E-02	1.32E-02	2.04E-03
73	2	3.26E-02	1.33E-02	2.10E-03
73	2	3.22E-02	1.32E-02	2.04E-03
73	2	3.12E-02	1.58E-02	2.01E-03
73	2	3.08E-02	1.56E-02	1.96E-03
73	2	2.95E-02	1.81E-02	1.92E-03
73	2	2.92E-02	1.79E-02	1.87E-03
73	3	2.95E-02	1.81E-02	1.92E-03
73	3	2.92E-02	1.79E-02	1.87E-03
73	3	2.76E-02	2.03E-02	1.82E-03
73	3	2.73E-02	2.01E-02	1.77E-03
73	3	2.55E-02	2.24E-02	1.71E-03
73	3	2.52E-02	2.21E-02	1.67E-03
73	4	2.55E-02	2.24E-02	1.71E-03
73	4	2.52E-02	2.21E-02	1.67E-03
73	4	2.32E-02	2.42E-02	1.61E-03
73	4	2.29E-02	2.39E-02	1.57E-03
73	4	2.08E-02	2.59E-02	1.50E-03
73	4	2.05E-02	2.56E-02	1.47E-03
73	5	2.08E-02	2.59E-02	1.50E-03
73	5	2.05E-02	2.56E-02	1.47E-03
73	5	1.81E-02	2.75E-02	1.41E-03
73	5	1.79E-02	2.71E-02	1.37E-03
73	5	1.53E-02	2.87E-02	1.32E-03
73	5	1.51E-02	2.84E-02	1.29E-03
73	6	1.53E-02	2.87E-02	1.32E-03
73	6	1.51E-02	2.84E-02	1.29E-03
73	6	1.24E-02	2.98E-02	1.25E-03
73	6	1.22E-02	2.94E-02	1.21E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
73	6	9.39E-03	3.07E-02	1.19E-03
73	6	9.27E-03	3.03E-02	1.16E-03
73	6	6.30E-03	3.13E-02	1.14E-03
73	6	6.22E-03	3.09E-02	1.11E-03
73	6	3.16E-03	3.16E-02	1.11E-03
73	6	3.12E-03	3.12E-02	1.08E-03
73	6	1.70E-09	3.18E-02	1.10E-03
73	6	1.68E-09	3.14E-02	1.08E-03
74	7	3.65E-02	0.00E+00	2.38E-03
74	7	3.61E-02	0.00E+00	2.32E-03
74	7	3.64E-02	2.79E-03	2.37E-03
74	7	3.59E-02	2.75E-03	2.31E-03
74	7	3.60E-02	5.55E-03	2.34E-03
74	7	3.55E-02	5.48E-03	2.28E-03
74	7	3.53E-02	8.28E-03	2.30E-03
74	7	3.48E-02	8.18E-03	2.24E-03
74	7	3.43E-02	1.09E-02	2.24E-03
74	7	3.39E-02	1.08E-02	2.18E-03
74	7	3.31E-02	1.35E-02	2.16E-03
74	7	3.27E-02	1.34E-02	2.11E-03
74	8	3.31E-02	1.35E-02	2.16E-03
74	8	3.27E-02	1.34E-02	2.11E-03
74	8	3.17E-02	1.60E-02	2.07E-03
74	8	3.13E-02	1.58E-02	2.02E-03
74	8	3.00E-02	1.84E-02	1.98E-03
74	8	2.96E-02	1.82E-02	1.93E-03
74	9	3.00E-02	1.84E-02	1.98E-03
74	9	2.96E-02	1.82E-02	1.93E-03
74	9	2.81E-02	2.06E-02	1.87E-03
74	9	2.77E-02	2.04E-02	1.83E-03
74	9	2.59E-02	2.27E-02	1.76E-03
74	9	2.56E-02	2.24E-02	1.72E-03
74	10	2.59E-02	2.27E-02	1.76E-03
74	10	2.56E-02	2.24E-02	1.72E-03
74	10	2.36E-02	2.46E-02	1.66E-03
74	10	2.33E-02	2.43E-02	1.62E-03
74	10	2.11E-02	2.63E-02	1.55E-03
74	10	2.08E-02	2.60E-02	1.51E-03
74	11	2.11E-02	2.63E-02	1.55E-03
74	11	2.08E-02	2.60E-02	1.51E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
74	11	1.84E-02	2.79E-02	1.45E-03
74	11	1.82E-02	2.75E-02	1.42E-03
74	11	1.55E-02	2.92E-02	1.36E-03
74	11	1.54E-02	2.88E-02	1.33E-03
74	12	1.55E-02	2.92E-02	1.36E-03
74	12	1.54E-02	2.88E-02	1.33E-03
74	12	1.26E-02	3.03E-02	1.28E-03
74	12	1.24E-02	2.99E-02	1.25E-03
74	12	9.53E-03	3.11E-02	1.22E-03
74	12	9.41E-03	3.08E-02	1.19E-03
74	12	6.40E-03	3.18E-02	1.18E-03
74	12	6.32E-03	3.14E-02	1.15E-03
74	12	3.21E-03	3.21E-02	1.15E-03
74	12	3.17E-03	3.17E-02	1.12E-03
74	12	1.72E-09	3.23E-02	1.14E-03
74	12	1.70E-09	3.19E-02	1.11E-03
75	13	3.70E-02	0.00E+00	2.45E-03
75	13	3.66E-02	0.00E+00	2.39E-03
75	13	3.69E-02	2.83E-03	2.44E-03
75	13	3.65E-02	2.79E-03	2.38E-03
75	13	3.65E-02	5.63E-03	2.41E-03
75	13	3.61E-02	5.57E-03	2.35E-03
75	13	3.58E-02	8.40E-03	2.37E-03
75	13	3.54E-02	8.30E-03	2.31E-03
75	13	3.48E-02	1.11E-02	2.30E-03
75	13	3.44E-02	1.10E-02	2.25E-03
75	13	3.36E-02	1.37E-02	2.23E-03
75	13	3.32E-02	1.36E-02	2.17E-03
75	14	3.36E-02	1.37E-02	2.23E-03
75	14	3.32E-02	1.36E-02	2.17E-03
75	14	3.22E-02	1.63E-02	2.14E-03
75	14	3.18E-02	1.61E-02	2.08E-03
75	14	3.04E-02	1.87E-02	2.04E-03
75	14	3.01E-02	1.84E-02	1.99E-03
75	15	3.04E-02	1.87E-02	2.04E-03
75	15	3.01E-02	1.84E-02	1.99E-03
75	15	2.85E-02	2.09E-02	1.93E-03
75	15	2.81E-02	2.07E-02	1.88E-03
75	15	2.63E-02	2.30E-02	1.82E-03
75	15	2.60E-02	2.28E-02	1.77E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
75	16	2.63E-02	2.30E-02	1.82E-03
75	16	2.60E-02	2.28E-02	1.77E-03
75	16	2.40E-02	2.50E-02	1.71E-03
75	16	2.37E-02	2.47E-02	1.66E-03
75	16	2.14E-02	2.67E-02	1.60E-03
75	16	2.11E-02	2.64E-02	1.56E-03
75	17	2.14E-02	2.67E-02	1.60E-03
75	17	2.11E-02	2.64E-02	1.56E-03
75	17	1.87E-02	2.83E-02	1.50E-03
75	17	1.84E-02	2.80E-02	1.46E-03
75	17	1.58E-02	2.96E-02	1.40E-03
75	17	1.56E-02	2.93E-02	1.37E-03
75	18	1.58E-02	2.96E-02	1.40E-03
75	18	1.56E-02	2.93E-02	1.37E-03
75	18	1.28E-02	3.07E-02	1.32E-03
75	18	1.26E-02	3.04E-02	1.29E-03
75	18	9.68E-03	3.16E-02	1.26E-03
75	18	9.56E-03	3.12E-02	1.23E-03
75	18	6.50E-03	3.22E-02	1.21E-03
75	18	6.42E-03	3.19E-02	1.18E-03
75	18	3.26E-03	3.26E-02	1.18E-03
75	18	3.22E-03	3.22E-02	1.15E-03
75	18	1.75E-09	3.28E-02	1.17E-03
75	18	1.73E-09	3.24E-02	1.14E-03
76	19	3.76E-02	0.00E+00	2.52E-03
76	19	3.71E-02	0.00E+00	2.46E-03
76	19	3.74E-02	2.87E-03	2.51E-03
76	19	3.70E-02	2.84E-03	2.45E-03
76	19	3.70E-02	5.72E-03	2.48E-03
76	19	3.66E-02	5.65E-03	2.43E-03
76	19	3.63E-02	8.52E-03	2.44E-03
76	19	3.59E-02	8.42E-03	2.38E-03
76	19	3.54E-02	1.13E-02	2.37E-03
76	19	3.49E-02	1.11E-02	2.32E-03
76	19	3.41E-02	1.39E-02	2.29E-03
76	19	3.37E-02	1.38E-02	2.24E-03
76	20	3.41E-02	1.39E-02	2.29E-03
76	20	3.37E-02	1.38E-02	2.24E-03
76	20	3.26E-02	1.65E-02	2.20E-03
76	20	3.22E-02	1.63E-02	2.15E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
76	20	3.09E-02	1.89E-02	2.09E-03
76	20	3.05E-02	1.87E-02	2.05E-03
76	21	3.09E-02	1.89E-02	2.09E-03
76	21	3.05E-02	1.87E-02	2.05E-03
76	21	2.89E-02	2.12E-02	1.98E-03
76	21	2.86E-02	2.10E-02	1.94E-03
76	21	2.67E-02	2.34E-02	1.87E-03
76	21	2.64E-02	2.31E-02	1.83E-03
76	22	2.67E-02	2.34E-02	1.87E-03
76	22	2.64E-02	2.31E-02	1.83E-03
76	22	2.43E-02	2.54E-02	1.76E-03
76	22	2.40E-02	2.51E-02	1.72E-03
76	22	2.17E-02	2.71E-02	1.64E-03
76	22	2.14E-02	2.68E-02	1.61E-03
76	23	2.17E-02	2.71E-02	1.64E-03
76	23	2.14E-02	2.68E-02	1.61E-03
76	23	1.89E-02	2.87E-02	1.54E-03
76	23	1.87E-02	2.84E-02	1.50E-03
76	23	1.60E-02	3.01E-02	1.44E-03
76	23	1.58E-02	2.97E-02	1.41E-03
76	24	1.60E-02	3.01E-02	1.44E-03
76	24	1.58E-02	2.97E-02	1.41E-03
76	24	1.30E-02	3.12E-02	1.36E-03
76	24	1.28E-02	3.08E-02	1.33E-03
76	24	9.82E-03	3.21E-02	1.30E-03
76	24	9.70E-03	3.17E-02	1.27E-03
76	24	6.59E-03	3.27E-02	1.25E-03
76	24	6.51E-03	3.23E-02	1.22E-03
76	24	3.31E-03	3.31E-02	1.22E-03
76	24	3.27E-03	3.27E-02	1.19E-03
76	24	1.78E-09	3.32E-02	1.21E-03
76	24	1.76E-09	3.28E-02	1.18E-03
77	25	3.81E-02	0.00E+00	2.59E-03
77	25	3.77E-02	0.00E+00	2.54E-03
77	25	3.80E-02	2.91E-03	2.58E-03
77	25	3.75E-02	2.88E-03	2.53E-03
77	25	3.75E-02	5.80E-03	2.55E-03
77	25	3.71E-02	5.73E-03	2.50E-03
77	25	3.68E-02	8.64E-03	2.50E-03
77	25	3.64E-02	8.55E-03	2.45E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
77	25	3.59E-02	1.14E-02	2.44E-03
77	25	3.54E-02	1.13E-02	2.38E-03
77	25	3.46E-02	1.41E-02	2.36E-03
77	25	3.42E-02	1.40E-02	2.30E-03
77	26	3.46E-02	1.41E-02	2.36E-03
77	26	3.42E-02	1.40E-02	2.30E-03
77	26	3.31E-02	1.67E-02	2.26E-03
77	26	3.27E-02	1.65E-02	2.21E-03
77	26	3.13E-02	1.92E-02	2.15E-03
77	26	3.10E-02	1.90E-02	2.11E-03
77	27	3.13E-02	1.92E-02	2.15E-03
77	27	3.10E-02	1.90E-02	2.11E-03
77	27	2.93E-02	2.15E-02	2.04E-03
77	27	2.90E-02	2.13E-02	2.00E-03
77	27	2.71E-02	2.37E-02	1.92E-03
77	27	2.68E-02	2.34E-02	1.88E-03
77	28	2.71E-02	2.37E-02	1.92E-03
77	28	2.68E-02	2.34E-02	1.88E-03
77	28	2.46E-02	2.57E-02	1.81E-03
77	28	2.44E-02	2.54E-02	1.77E-03
77	28	2.20E-02	2.75E-02	1.69E-03
77	28	2.18E-02	2.72E-02	1.65E-03
77	29	2.20E-02	2.75E-02	1.69E-03
77	29	2.18E-02	2.72E-02	1.65E-03
77	29	1.92E-02	2.91E-02	1.58E-03
77	29	1.90E-02	2.88E-02	1.55E-03
77	29	1.62E-02	3.05E-02	1.49E-03
77	29	1.61E-02	3.01E-02	1.45E-03
77	30	1.62E-02	3.05E-02	1.49E-03
77	30	1.61E-02	3.01E-02	1.45E-03
77	30	1.32E-02	3.16E-02	1.40E-03
77	30	1.30E-02	3.13E-02	1.37E-03
77	30	9.96E-03	3.25E-02	1.33E-03
77	30	9.85E-03	3.22E-02	1.30E-03
77	30	6.69E-03	3.32E-02	1.28E-03
77	30	6.61E-03	3.28E-02	1.25E-03
77	30	3.36E-03	3.36E-02	1.25E-03
77	30	3.32E-03	3.32E-02	1.22E-03
77	30	1.80E-09	3.37E-02	1.24E-03
77	30	1.78E-09	3.33E-02	1.21E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
78	31	3.86E-02	0.00E+00	2.66E-03
78	31	3.82E-02	0.00E+00	2.61E-03
78	31	3.85E-02	2.95E-03	2.65E-03
78	31	3.81E-02	2.92E-03	2.60E-03
78	31	3.81E-02	5.88E-03	2.62E-03
78	31	3.76E-02	5.81E-03	2.57E-03
78	31	3.73E-02	8.76E-03	2.57E-03
78	31	3.69E-02	8.67E-03	2.52E-03
78	31	3.63E-02	1.16E-02	2.51E-03
78	31	3.59E-02	1.15E-02	2.45E-03
78	31	3.51E-02	1.43E-02	2.42E-03
78	31	3.47E-02	1.42E-02	2.37E-03
78	32	3.51E-02	1.43E-02	2.42E-03
78	32	3.47E-02	1.42E-02	2.37E-03
78	32	3.35E-02	1.70E-02	2.32E-03
78	32	3.32E-02	1.68E-02	2.27E-03
78	32	3.18E-02	1.95E-02	2.21E-03
78	32	3.14E-02	1.93E-02	2.17E-03
78	33	3.18E-02	1.95E-02	2.21E-03
78	33	3.14E-02	1.93E-02	2.17E-03
78	33	2.97E-02	2.18E-02	2.10E-03
78	33	2.94E-02	2.16E-02	2.05E-03
78	33	2.75E-02	2.40E-02	1.98E-03
78	33	2.72E-02	2.38E-02	1.93E-03
78	34	2.75E-02	2.40E-02	1.98E-03
78	34	2.72E-02	2.38E-02	1.93E-03
78	34	2.50E-02	2.61E-02	1.86E-03
78	34	2.47E-02	2.58E-02	1.82E-03
78	34	2.23E-02	2.79E-02	1.74E-03
78	34	2.21E-02	2.76E-02	1.70E-03
78	35	2.23E-02	2.79E-02	1.74E-03
78	35	2.21E-02	2.76E-02	1.70E-03
78	35	1.95E-02	2.95E-02	1.63E-03
78	35	1.93E-02	2.92E-02	1.59E-03
78	35	1.65E-02	3.09E-02	1.53E-03
78	35	1.63E-02	3.06E-02	1.49E-03
78	36	1.65E-02	3.09E-02	1.53E-03
78	36	1.63E-02	3.06E-02	1.49E-03
78	36	1.33E-02	3.21E-02	1.44E-03
78	36	1.32E-02	3.17E-02	1.41E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
78	36	1.01E-02	3.30E-02	1.37E-03
78	36	9.99E-03	3.26E-02	1.34E-03
78	36	6.78E-03	3.37E-02	1.32E-03
78	36	6.70E-03	3.33E-02	1.29E-03
78	36	3.40E-03	3.41E-02	1.28E-03
78	36	3.37E-03	3.37E-02	1.26E-03
78	36	1.83E-09	3.42E-02	1.27E-03
78	36	1.81E-09	3.38E-02	1.25E-03
79	37	3.91E-02	0.00E+00	2.74E-03
79	37	3.87E-02	0.00E+00	2.68E-03
79	37	3.90E-02	2.99E-03	2.73E-03
79	37	3.86E-02	2.96E-03	2.67E-03
79	37	3.86E-02	5.95E-03	2.69E-03
79	37	3.82E-02	5.89E-03	2.64E-03
79	37	3.78E-02	8.88E-03	2.64E-03
79	37	3.74E-02	8.78E-03	2.59E-03
79	37	3.68E-02	1.17E-02	2.57E-03
79	37	3.64E-02	1.16E-02	2.52E-03
79	37	3.55E-02	1.45E-02	2.49E-03
79	37	3.52E-02	1.44E-02	2.43E-03
79	38	3.55E-02	1.45E-02	2.49E-03
79	38	3.52E-02	1.44E-02	2.43E-03
79	38	3.40E-02	1.72E-02	2.39E-03
79	38	3.36E-02	1.70E-02	2.33E-03
79	38	3.22E-02	1.97E-02	2.27E-03
79	38	3.18E-02	1.95E-02	2.23E-03
79	39	3.22E-02	1.97E-02	2.27E-03
79	39	3.18E-02	1.95E-02	2.23E-03
79	39	3.01E-02	2.21E-02	2.15E-03
79	39	2.98E-02	2.19E-02	2.11E-03
79	39	2.78E-02	2.44E-02	2.03E-03
79	39	2.75E-02	2.41E-02	1.99E-03
79	40	2.78E-02	2.44E-02	2.03E-03
79	40	2.75E-02	2.41E-02	1.99E-03
79	40	2.53E-02	2.64E-02	1.91E-03
79	40	2.51E-02	2.61E-02	1.87E-03
79	40	2.26E-02	2.83E-02	1.79E-03
79	40	2.24E-02	2.80E-02	1.75E-03
79	41	2.26E-02	2.83E-02	1.79E-03
79	41	2.24E-02	2.80E-02	1.75E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
79	41	1.97E-02	2.99E-02	1.67E-03
79	41	1.95E-02	2.96E-02	1.64E-03
79	41	1.67E-02	3.13E-02	1.57E-03
79	41	1.65E-02	3.10E-02	1.53E-03
79	42	1.67E-02	3.13E-02	1.57E-03
79	42	1.65E-02	3.10E-02	1.53E-03
79	42	1.35E-02	3.25E-02	1.48E-03
79	42	1.34E-02	3.22E-02	1.45E-03
79	42	1.02E-02	3.34E-02	1.41E-03
79	42	1.01E-02	3.31E-02	1.38E-03
79	42	6.87E-03	3.41E-02	1.35E-03
79	42	6.80E-03	3.37E-02	1.32E-03
79	42	3.45E-03	3.45E-02	1.32E-03
79	42	3.41E-03	3.41E-02	1.29E-03
79	42	1.85E-09	3.46E-02	1.31E-03
79	42	1.83E-09	3.43E-02	1.28E-03
80	43	3.97E-02	0.00E+00	2.81E-03
80	43	3.92E-02	0.00E+00	2.75E-03
80	43	3.95E-02	3.03E-03	2.80E-03
80	43	3.91E-02	3.00E-03	2.74E-03
80	43	3.91E-02	6.03E-03	2.77E-03
80	43	3.87E-02	5.97E-03	2.71E-03
80	43	3.83E-02	9.00E-03	2.71E-03
80	43	3.79E-02	8.90E-03	2.66E-03
80	43	3.73E-02	1.19E-02	2.64E-03
80	43	3.69E-02	1.18E-02	2.59E-03
80	43	3.60E-02	1.47E-02	2.55E-03
80	43	3.56E-02	1.46E-02	2.50E-03
80	44	3.60E-02	1.47E-02	2.55E-03
80	44	3.56E-02	1.46E-02	2.50E-03
80	44	3.44E-02	1.74E-02	2.45E-03
80	44	3.41E-02	1.72E-02	2.40E-03
80	44	3.26E-02	2.00E-02	2.33E-03
80	44	3.23E-02	1.98E-02	2.29E-03
80	45	3.26E-02	2.00E-02	2.33E-03
80	45	3.23E-02	1.98E-02	2.29E-03
80	45	3.05E-02	2.24E-02	2.21E-03
80	45	3.02E-02	2.22E-02	2.17E-03
80	45	2.82E-02	2.47E-02	2.08E-03
80	45	2.79E-02	2.44E-02	2.04E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 10 Ring	Element	x	y	z
80	46	2.82E-02	2.47E-02	2.08E-03
80	46	2.79E-02	2.44E-02	2.04E-03
80	46	2.57E-02	2.68E-02	1.96E-03
80	46	2.54E-02	2.65E-02	1.92E-03
80	46	2.29E-02	2.87E-02	1.83E-03
80	46	2.27E-02	2.84E-02	1.79E-03
80	47	2.29E-02	2.87E-02	1.83E-03
80	47	2.27E-02	2.84E-02	1.79E-03
80	47	2.00E-02	3.03E-02	1.72E-03
80	47	1.98E-02	3.00E-02	1.68E-03
80	47	1.69E-02	3.18E-02	1.61E-03
80	47	1.67E-02	3.14E-02	1.58E-03
80	48	1.69E-02	3.18E-02	1.61E-03
80	48	1.67E-02	3.14E-02	1.58E-03
80	48	1.37E-02	3.30E-02	1.52E-03
80	48	1.36E-02	3.26E-02	1.49E-03
80	48	1.04E-02	3.39E-02	1.44E-03
80	48	1.03E-02	3.35E-02	1.41E-03
80	48	6.96E-03	3.46E-02	1.39E-03
80	48	6.89E-03	3.42E-02	1.36E-03
80	48	3.50E-03	3.50E-02	1.35E-03
80	48	3.46E-03	3.46E-02	1.33E-03
80	48	1.88E-09	3.51E-02	1.34E-03
80	48	1.86E-09	3.47E-02	1.32E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
81	1	4.03E-02	0.00E+00	2.89E-03
81	1	3.98E-02	0.00E+00	2.82E-03
81	1	4.01E-02	3.07E-03	2.88E-03
81	1	3.96E-02	3.03E-03	2.81E-03
81	1	3.97E-02	6.12E-03	2.85E-03
81	1	3.92E-02	6.05E-03	2.78E-03
81	1	3.89E-02	9.13E-03	2.79E-03
81	1	3.84E-02	9.02E-03	2.73E-03
81	1	3.79E-02	1.21E-02	2.72E-03
81	1	3.74E-02	1.19E-02	2.65E-03
81	1	3.66E-02	1.49E-02	2.63E-03
81	1	3.61E-02	1.47E-02	2.56E-03
81	2	3.66E-02	1.49E-02	2.63E-03
81	2	3.61E-02	1.47E-02	2.56E-03
81	2	3.50E-02	1.77E-02	2.52E-03
81	2	3.45E-02	1.75E-02	2.46E-03
81	2	3.31E-02	2.03E-02	2.40E-03
81	2	3.27E-02	2.00E-02	2.35E-03
81	3	3.31E-02	2.03E-02	2.40E-03
81	3	3.27E-02	2.00E-02	2.35E-03
81	3	3.10E-02	2.28E-02	2.28E-03
81	3	3.06E-02	2.25E-02	2.22E-03
81	3	2.86E-02	2.51E-02	2.15E-03
81	3	2.83E-02	2.48E-02	2.10E-03
81	4	2.86E-02	2.51E-02	2.15E-03
81	4	2.83E-02	2.48E-02	2.10E-03
81	4	2.61E-02	2.72E-02	2.02E-03
81	4	2.57E-02	2.68E-02	1.97E-03
81	4	2.33E-02	2.91E-02	1.89E-03
81	4	2.30E-02	2.87E-02	1.84E-03
81	5	2.33E-02	2.91E-02	1.89E-03
81	5	2.30E-02	2.87E-02	1.84E-03
81	5	2.03E-02	3.08E-02	1.77E-03
81	5	2.01E-02	3.04E-02	1.72E-03
81	5	1.72E-02	3.22E-02	1.66E-03
81	5	1.70E-02	3.18E-02	1.62E-03
81	6	1.72E-02	3.22E-02	1.66E-03
81	6	1.70E-02	3.18E-02	1.62E-03
81	6	1.39E-02	3.35E-02	1.56E-03
81	6	1.37E-02	3.30E-02	1.53E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
81	6	1.05E-02	3.44E-02	1.49E-03
81	6	1.04E-02	3.40E-02	1.45E-03
81	6	7.07E-03	3.51E-02	1.43E-03
81	6	6.98E-03	3.47E-02	1.40E-03
81	6	3.55E-03	3.55E-02	1.40E-03
81	6	3.51E-03	3.51E-02	1.36E-03
81	6	1.91E-09	3.57E-02	1.38E-03
81	6	1.88E-09	3.52E-02	1.35E-03
82	7	4.08E-02	0.00E+00	2.98E-03
82	7	4.04E-02	0.00E+00	2.91E-03
82	7	4.07E-02	3.12E-03	2.97E-03
82	7	4.02E-02	3.08E-03	2.90E-03
82	7	4.02E-02	6.21E-03	2.93E-03
82	7	3.98E-02	6.14E-03	2.86E-03
82	7	3.95E-02	9.26E-03	2.88E-03
82	7	3.90E-02	9.15E-03	2.81E-03
82	7	3.84E-02	1.22E-02	2.80E-03
82	7	3.80E-02	1.21E-02	2.73E-03
82	7	3.71E-02	1.51E-02	2.71E-03
82	7	3.67E-02	1.50E-02	2.64E-03
82	8	3.71E-02	1.51E-02	2.71E-03
82	8	3.67E-02	1.50E-02	2.64E-03
82	8	3.55E-02	1.79E-02	2.60E-03
82	8	3.51E-02	1.77E-02	2.54E-03
82	8	3.36E-02	2.06E-02	2.48E-03
82	8	3.32E-02	2.03E-02	2.42E-03
82	9	3.36E-02	2.06E-02	2.48E-03
82	9	3.32E-02	2.03E-02	2.42E-03
82	9	3.14E-02	2.31E-02	2.35E-03
82	9	3.11E-02	2.28E-02	2.29E-03
82	9	2.91E-02	2.54E-02	2.21E-03
82	9	2.87E-02	2.51E-02	2.16E-03
82	10	2.91E-02	2.54E-02	2.21E-03
82	10	2.87E-02	2.51E-02	2.16E-03
82	10	2.64E-02	2.76E-02	2.08E-03
82	10	2.61E-02	2.73E-02	2.03E-03
82	10	2.36E-02	2.95E-02	1.94E-03
82	10	2.33E-02	2.92E-02	1.90E-03
82	11	2.36E-02	2.95E-02	1.94E-03
82	11	2.33E-02	2.92E-02	1.90E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
82	11	2.06E-02	3.12E-02	1.82E-03
82	11	2.04E-02	3.09E-02	1.78E-03
82	11	1.74E-02	3.27E-02	1.71E-03
82	11	1.72E-02	3.23E-02	1.67E-03
82	12	1.74E-02	3.27E-02	1.71E-03
82	12	1.72E-02	3.23E-02	1.67E-03
82	12	1.41E-02	3.40E-02	1.61E-03
82	12	1.39E-02	3.35E-02	1.57E-03
82	12	1.07E-02	3.49E-02	1.53E-03
82	12	1.06E-02	3.45E-02	1.49E-03
82	12	7.18E-03	3.56E-02	1.47E-03
82	12	7.09E-03	3.52E-02	1.44E-03
82	12	3.60E-03	3.60E-02	1.44E-03
82	12	3.56E-03	3.56E-02	1.40E-03
82	12	1.93E-09	3.62E-02	1.42E-03
82	12	1.91E-09	3.57E-02	1.39E-03
83	13	4.14E-02	0.00E+00	3.06E-03
83	13	4.09E-02	0.00E+00	2.99E-03
83	13	4.13E-02	3.16E-03	3.05E-03
83	13	4.08E-02	3.12E-03	2.98E-03
83	13	4.08E-02	6.30E-03	3.02E-03
83	13	4.03E-02	6.23E-03	2.95E-03
83	13	4.00E-02	9.40E-03	2.96E-03
83	13	3.96E-02	9.29E-03	2.89E-03
83	13	3.90E-02	1.24E-02	2.88E-03
83	13	3.85E-02	1.23E-02	2.81E-03
83	13	3.76E-02	1.54E-02	2.78E-03
83	13	3.72E-02	1.52E-02	2.72E-03
83	14	3.76E-02	1.54E-02	2.78E-03
83	14	3.72E-02	1.52E-02	2.72E-03
83	14	3.60E-02	1.82E-02	2.67E-03
83	14	3.56E-02	1.80E-02	2.61E-03
83	14	3.41E-02	2.09E-02	2.55E-03
83	14	3.37E-02	2.06E-02	2.49E-03
83	15	3.41E-02	2.09E-02	2.55E-03
83	15	3.37E-02	2.06E-02	2.49E-03
83	15	3.19E-02	2.34E-02	2.41E-03
83	15	3.15E-02	2.32E-02	2.36E-03
83	15	2.95E-02	2.58E-02	2.27E-03
83	15	2.91E-02	2.55E-02	2.22E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
83	16	2.95E-02	2.58E-02	2.27E-03
83	16	2.91E-02	2.55E-02	2.22E-03
83	16	2.68E-02	2.80E-02	2.14E-03
83	16	2.65E-02	2.77E-02	2.09E-03
83	16	2.40E-02	3.00E-02	2.00E-03
83	16	2.37E-02	2.96E-02	1.95E-03
83	17	2.40E-02	3.00E-02	2.00E-03
83	17	2.37E-02	2.96E-02	1.95E-03
83	17	2.09E-02	3.17E-02	1.87E-03
83	17	2.07E-02	3.13E-02	1.83E-03
83	17	1.77E-02	3.32E-02	1.76E-03
83	17	1.75E-02	3.28E-02	1.72E-03
83	18	1.77E-02	3.32E-02	1.76E-03
83	18	1.75E-02	3.28E-02	1.72E-03
83	18	1.43E-02	3.45E-02	1.66E-03
83	18	1.42E-02	3.40E-02	1.62E-03
83	18	1.08E-02	3.54E-02	1.58E-03
83	18	1.07E-02	3.50E-02	1.54E-03
83	18	7.28E-03	3.61E-02	1.52E-03
83	18	7.19E-03	3.57E-02	1.48E-03
83	18	3.66E-03	3.66E-02	1.48E-03
83	18	3.61E-03	3.61E-02	1.44E-03
83	18	1.96E-09	3.67E-02	1.47E-03
83	18	1.94E-09	3.63E-02	1.43E-03
84	19	4.20E-02	0.00E+00	3.15E-03
84	19	4.15E-02	0.00E+00	3.08E-03
84	19	4.18E-02	3.21E-03	3.14E-03
84	19	4.14E-02	3.17E-03	3.07E-03
84	19	4.14E-02	6.39E-03	3.10E-03
84	19	4.09E-02	6.32E-03	3.03E-03
84	19	4.06E-02	9.53E-03	3.04E-03
84	19	4.01E-02	9.42E-03	2.97E-03
84	19	3.95E-02	1.26E-02	2.96E-03
84	19	3.91E-02	1.25E-02	2.90E-03
84	19	3.81E-02	1.56E-02	2.86E-03
84	19	3.77E-02	1.54E-02	2.80E-03
84	20	3.81E-02	1.56E-02	2.86E-03
84	20	3.77E-02	1.54E-02	2.80E-03
84	20	3.65E-02	1.84E-02	2.75E-03
84	20	3.61E-02	1.82E-02	2.69E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
84	20	3.45E-02	2.12E-02	2.62E-03
84	20	3.42E-02	2.09E-02	2.56E-03
84	21	3.45E-02	2.12E-02	2.62E-03
84	21	3.42E-02	2.09E-02	2.56E-03
84	21	3.23E-02	2.38E-02	2.48E-03
84	21	3.20E-02	2.35E-02	2.43E-03
84	21	2.99E-02	2.62E-02	2.34E-03
84	21	2.95E-02	2.59E-02	2.29E-03
84	22	2.99E-02	2.62E-02	2.34E-03
84	22	2.95E-02	2.59E-02	2.29E-03
84	22	2.72E-02	2.84E-02	2.20E-03
84	22	2.69E-02	2.81E-02	2.15E-03
84	22	2.43E-02	3.04E-02	2.06E-03
84	22	2.40E-02	3.00E-02	2.01E-03
84	23	2.43E-02	3.04E-02	2.06E-03
84	23	2.40E-02	3.00E-02	2.01E-03
84	23	2.12E-02	3.21E-02	1.93E-03
84	23	2.10E-02	3.18E-02	1.88E-03
84	23	1.79E-02	3.37E-02	1.81E-03
84	23	1.77E-02	3.33E-02	1.77E-03
84	24	1.79E-02	3.37E-02	1.81E-03
84	24	1.77E-02	3.33E-02	1.77E-03
84	24	1.45E-02	3.49E-02	1.70E-03
84	24	1.44E-02	3.45E-02	1.67E-03
84	24	1.10E-02	3.59E-02	1.62E-03
84	24	1.09E-02	3.55E-02	1.58E-03
84	24	7.39E-03	3.67E-02	1.56E-03
84	24	7.30E-03	3.62E-02	1.52E-03
84	24	3.71E-03	3.71E-02	1.52E-03
84	24	3.67E-03	3.67E-02	1.49E-03
84	24	1.99E-09	3.72E-02	1.51E-03
84	24	1.97E-09	3.68E-02	1.47E-03
85	25	4.26E-02	0.00E+00	3.23E-03
85	25	4.21E-02	0.00E+00	3.16E-03
85	25	4.24E-02	3.25E-03	3.22E-03
85	25	4.19E-02	3.21E-03	3.15E-03
85	25	4.19E-02	6.47E-03	3.19E-03
85	25	4.15E-02	6.40E-03	3.12E-03
85	25	4.11E-02	9.65E-03	3.12E-03
85	25	4.07E-02	9.55E-03	3.06E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
85	25	4.01E-02	1.28E-02	3.04E-03
85	25	3.96E-02	1.26E-02	2.98E-03
85	25	3.87E-02	1.58E-02	2.94E-03
85	25	3.82E-02	1.56E-02	2.88E-03
85	26	3.87E-02	1.58E-02	2.94E-03
85	26	3.82E-02	1.56E-02	2.88E-03
85	26	3.70E-02	1.87E-02	2.82E-03
85	26	3.66E-02	1.85E-02	2.76E-03
85	26	3.50E-02	2.15E-02	2.69E-03
85	26	3.46E-02	2.12E-02	2.63E-03
85	27	3.50E-02	2.15E-02	2.69E-03
85	27	3.46E-02	2.12E-02	2.63E-03
85	27	3.28E-02	2.41E-02	2.55E-03
85	27	3.24E-02	2.38E-02	2.49E-03
85	27	3.03E-02	2.65E-02	2.40E-03
85	27	3.00E-02	2.62E-02	2.35E-03
85	28	3.03E-02	2.65E-02	2.40E-03
85	28	3.00E-02	2.62E-02	2.35E-03
85	28	2.76E-02	2.88E-02	2.26E-03
85	28	2.73E-02	2.84E-02	2.21E-03
85	28	2.46E-02	3.08E-02	2.11E-03
85	28	2.44E-02	3.04E-02	2.07E-03
85	29	2.46E-02	3.08E-02	2.11E-03
85	29	2.44E-02	3.04E-02	2.07E-03
85	29	2.15E-02	3.26E-02	1.98E-03
85	29	2.13E-02	3.22E-02	1.93E-03
85	29	1.82E-02	3.41E-02	1.86E-03
85	29	1.80E-02	3.38E-02	1.82E-03
85	30	1.82E-02	3.41E-02	1.86E-03
85	30	1.80E-02	3.38E-02	1.82E-03
85	30	1.47E-02	3.54E-02	1.75E-03
85	30	1.46E-02	3.50E-02	1.71E-03
85	30	1.12E-02	3.64E-02	1.66E-03
85	30	1.10E-02	3.60E-02	1.63E-03
85	30	7.49E-03	3.72E-02	1.60E-03
85	30	7.40E-03	3.67E-02	1.57E-03
85	30	3.76E-03	3.76E-02	1.56E-03
85	30	3.72E-03	3.72E-02	1.53E-03
85	30	2.02E-09	3.77E-02	1.55E-03
85	30	2.00E-09	3.73E-02	1.51E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
86	31	4.31E-02	0.00E+00	3.32E-03
86	31	4.27E-02	0.00E+00	3.25E-03
86	31	4.30E-02	3.29E-03	3.31E-03
86	31	4.25E-02	3.26E-03	3.24E-03
86	31	4.25E-02	6.56E-03	3.27E-03
86	31	4.20E-02	6.49E-03	3.20E-03
86	31	4.17E-02	9.78E-03	3.21E-03
86	31	4.12E-02	9.68E-03	3.14E-03
86	31	4.06E-02	1.29E-02	3.12E-03
86	31	4.02E-02	1.28E-02	3.06E-03
86	31	3.92E-02	1.60E-02	3.02E-03
86	31	3.88E-02	1.58E-02	2.95E-03
86	32	3.92E-02	1.60E-02	3.02E-03
86	32	3.88E-02	1.58E-02	2.95E-03
86	32	3.75E-02	1.89E-02	2.90E-03
86	32	3.71E-02	1.87E-02	2.83E-03
86	32	3.55E-02	2.18E-02	2.76E-03
86	32	3.51E-02	2.15E-02	2.70E-03
86	33	3.55E-02	2.18E-02	2.76E-03
86	33	3.51E-02	2.15E-02	2.70E-03
86	33	3.32E-02	2.44E-02	2.62E-03
86	33	3.29E-02	2.41E-02	2.56E-03
86	33	3.07E-02	2.69E-02	2.47E-03
86	33	3.04E-02	2.66E-02	2.41E-03
86	34	3.07E-02	2.69E-02	2.47E-03
86	34	3.04E-02	2.66E-02	2.41E-03
86	34	2.79E-02	2.91E-02	2.32E-03
86	34	2.76E-02	2.88E-02	2.27E-03
86	34	2.50E-02	3.12E-02	2.17E-03
86	34	2.47E-02	3.09E-02	2.12E-03
86	35	2.50E-02	3.12E-02	2.17E-03
86	35	2.47E-02	3.09E-02	2.12E-03
86	35	2.18E-02	3.30E-02	2.03E-03
86	35	2.15E-02	3.27E-02	1.99E-03
86	35	1.84E-02	3.46E-02	1.91E-03
86	35	1.82E-02	3.42E-02	1.86E-03
86	36	1.84E-02	3.46E-02	1.91E-03
86	36	1.82E-02	3.42E-02	1.86E-03
86	36	1.49E-02	3.59E-02	1.80E-03
86	36	1.48E-02	3.55E-02	1.76E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
86	36	1.13E-02	3.69E-02	1.71E-03
86	36	1.12E-02	3.65E-02	1.67E-03
86	36	7.59E-03	3.77E-02	1.64E-03
86	36	7.51E-03	3.73E-02	1.61E-03
86	36	3.81E-03	3.81E-02	1.60E-03
86	36	3.77E-03	3.77E-02	1.57E-03
86	36	2.05E-09	3.83E-02	1.59E-03
86	36	2.02E-09	3.78E-02	1.56E-03
87	37	4.37E-02	0.00E+00	3.41E-03
87	37	4.32E-02	0.00E+00	3.34E-03
87	37	4.35E-02	3.33E-03	3.39E-03
87	37	4.31E-02	3.30E-03	3.32E-03
87	37	4.30E-02	6.64E-03	3.35E-03
87	37	4.26E-02	6.58E-03	3.29E-03
87	37	4.22E-02	9.91E-03	3.29E-03
87	37	4.18E-02	9.81E-03	3.22E-03
87	37	4.11E-02	1.31E-02	3.20E-03
87	37	4.07E-02	1.30E-02	3.14E-03
87	37	3.97E-02	1.62E-02	3.10E-03
87	37	3.93E-02	1.60E-02	3.03E-03
87	38	3.97E-02	1.62E-02	3.10E-03
87	38	3.93E-02	1.60E-02	3.03E-03
87	38	3.80E-02	1.92E-02	2.97E-03
87	38	3.76E-02	1.90E-02	2.91E-03
87	38	3.59E-02	2.20E-02	2.83E-03
87	38	3.56E-02	2.18E-02	2.77E-03
87	39	3.59E-02	2.20E-02	2.83E-03
87	39	3.56E-02	2.18E-02	2.77E-03
87	39	3.37E-02	2.47E-02	2.68E-03
87	39	3.33E-02	2.45E-02	2.63E-03
87	39	3.11E-02	2.72E-02	2.53E-03
87	39	3.08E-02	2.69E-02	2.48E-03
87	40	3.11E-02	2.72E-02	2.53E-03
87	40	3.08E-02	2.69E-02	2.48E-03
87	40	2.83E-02	2.95E-02	2.38E-03
87	40	2.80E-02	2.92E-02	2.33E-03
87	40	2.53E-02	3.16E-02	2.23E-03
87	40	2.50E-02	3.13E-02	2.18E-03
87	41	2.53E-02	3.16E-02	2.23E-03
87	41	2.50E-02	3.13E-02	2.18E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
87	41	2.21E-02	3.35E-02	2.08E-03
87	41	2.18E-02	3.31E-02	2.04E-03
87	41	1.87E-02	3.50E-02	1.95E-03
87	41	1.85E-02	3.47E-02	1.91E-03
87	42	1.87E-02	3.50E-02	1.95E-03
87	42	1.85E-02	3.47E-02	1.91E-03
87	42	1.51E-02	3.64E-02	1.84E-03
87	42	1.50E-02	3.60E-02	1.81E-03
87	42	1.15E-02	3.74E-02	1.75E-03
87	42	1.13E-02	3.70E-02	1.72E-03
87	42	7.69E-03	3.82E-02	1.69E-03
87	42	7.61E-03	3.78E-02	1.65E-03
87	42	3.86E-03	3.86E-02	1.64E-03
87	42	3.82E-03	3.82E-02	1.61E-03
87	42	2.07E-09	3.88E-02	1.63E-03
87	42	2.05E-09	3.84E-02	1.60E-03
88	43	4.42E-02	0.00E+00	3.49E-03
88	43	4.38E-02	0.00E+00	3.42E-03
88	43	4.41E-02	3.38E-03	3.48E-03
88	43	4.36E-02	3.34E-03	3.41E-03
88	43	4.36E-02	6.73E-03	3.44E-03
88	43	4.31E-02	6.66E-03	3.37E-03
88	43	4.28E-02	1.00E-02	3.38E-03
88	43	4.23E-02	9.93E-03	3.31E-03
88	43	4.16E-02	1.33E-02	3.29E-03
88	43	4.12E-02	1.31E-02	3.22E-03
88	43	4.02E-02	1.64E-02	3.18E-03
88	43	3.98E-02	1.62E-02	3.11E-03
88	44	4.02E-02	1.64E-02	3.18E-03
88	44	3.98E-02	1.62E-02	3.11E-03
88	44	3.84E-02	1.94E-02	3.05E-03
88	44	3.80E-02	1.92E-02	2.99E-03
88	44	3.64E-02	2.23E-02	2.91E-03
88	44	3.60E-02	2.21E-02	2.85E-03
88	45	3.64E-02	2.23E-02	2.91E-03
88	45	3.60E-02	2.21E-02	2.85E-03
88	45	3.41E-02	2.50E-02	2.75E-03
88	45	3.37E-02	2.48E-02	2.70E-03
88	45	3.15E-02	2.76E-02	2.60E-03
88	45	3.12E-02	2.73E-02	2.54E-03

Table F-1. Listing of Element Coordinates (Continued)

Belt 11 Ring	Element	x	y	z
88	46	3.15E-02	2.76E-02	2.60E-03
88	46	3.12E-02	2.73E-02	2.54E-03
88	46	2.87E-02	2.99E-02	2.44E-03
88	46	2.84E-02	2.96E-02	2.39E-03
88	46	2.56E-02	3.20E-02	2.28E-03
88	46	2.53E-02	3.17E-02	2.24E-03
88	47	2.56E-02	3.20E-02	2.28E-03
88	47	2.53E-02	3.17E-02	2.24E-03
88	47	2.24E-02	3.39E-02	2.14E-03
88	47	2.21E-02	3.35E-02	2.09E-03
88	47	1.89E-02	3.55E-02	2.01E-03
88	47	1.87E-02	3.51E-02	1.96E-03
88	48	1.89E-02	3.55E-02	2.01E-03
88	48	1.87E-02	3.51E-02	1.96E-03
88	48	1.53E-02	3.68E-02	1.89E-03
88	48	1.52E-02	3.65E-02	1.85E-03
88	48	1.16E-02	3.79E-02	1.80E-03
88	48	1.15E-02	3.75E-02	1.76E-03
88	48	7.79E-03	3.87E-02	1.73E-03
88	48	7.71E-03	3.83E-02	1.69E-03
88	48	3.91E-03	3.91E-02	1.69E-03
88	48	3.87E-03	3.87E-02	1.65E-03
88	48	2.10E-09	3.93E-02	1.67E-03
88	48	2.08E-09	3.89E-02	1.64E-03

APPENDIX G—BEAM SHAPES AND ELEMENT GEOMETRIES FOR THE SUPPLIER E TRANSDUCER DESIGN (CONCAVE SURFACES)

Supplier E produced a phased array transducer design for inspection through concave surfaces and a design for inspection through convex surfaces. This appendix presents details of the transducer designed for the concave entry surface. The first half of the appendix provides the supplier's calculation of beam shapes at various depths below two concave surfaces, and the second half of the appendix shows the details of the element geometry for the phased array transducer.

A summary of the ultrasonic modeling results for the phased array transducer designed by supplier E for the concave curved entry surface of radii of curvature of -11.82″ and -14.7″, respectively, at different depths is shown in figures G-1 through G-30. The model results in this appendix were produced by supplier E.

All results for concave radius = -11.82″.

Results for concave radius = -11.82″, depth = 0.2″.

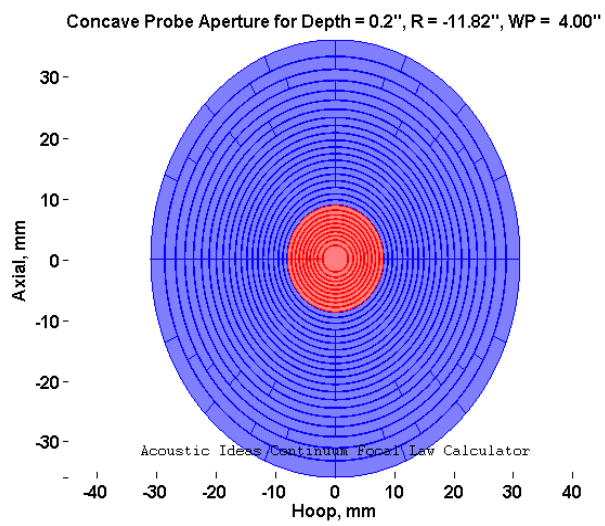


Figure G-1. Active Aperture for Concave Radius = -11.82″, depth = 0.2″

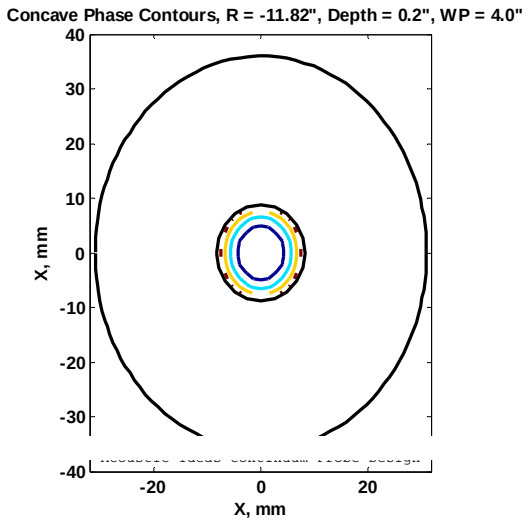


Figure G-2. Phase Variation for Concave Radius = -11.82″, depth = 0.2″

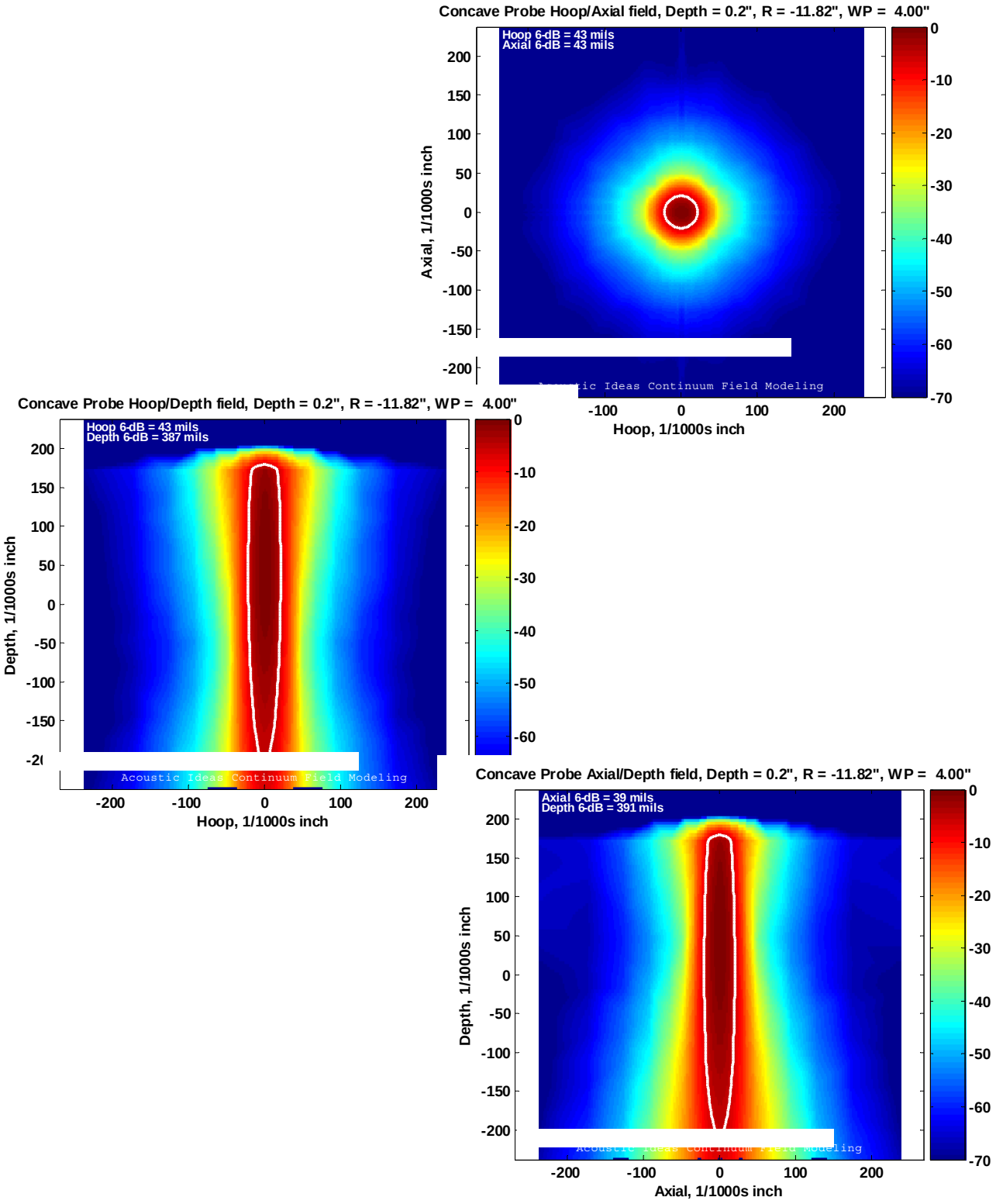


Figure G-3. Ultrasonic Field Modeling and Beam Width Measurement for Concave Radius = -11.82″, depth = 0.2″

Results for concave radius = -11.82″, depth = 1.0″.

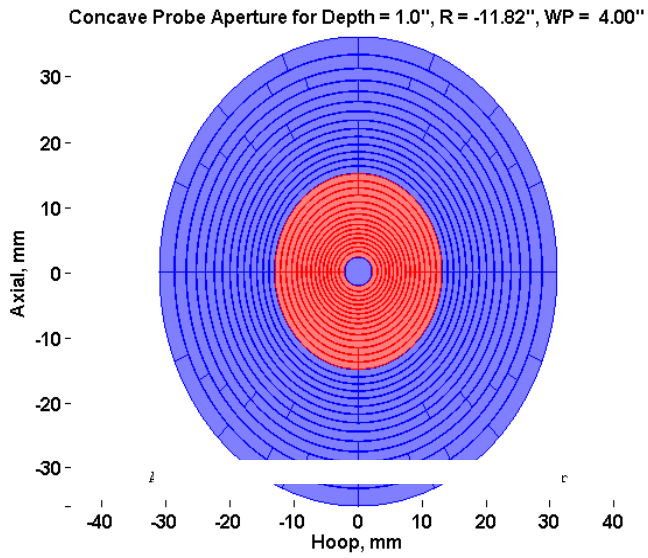


Figure G-4. Active Aperture for Concave Radius = -11.82″, Depth = 1.0″

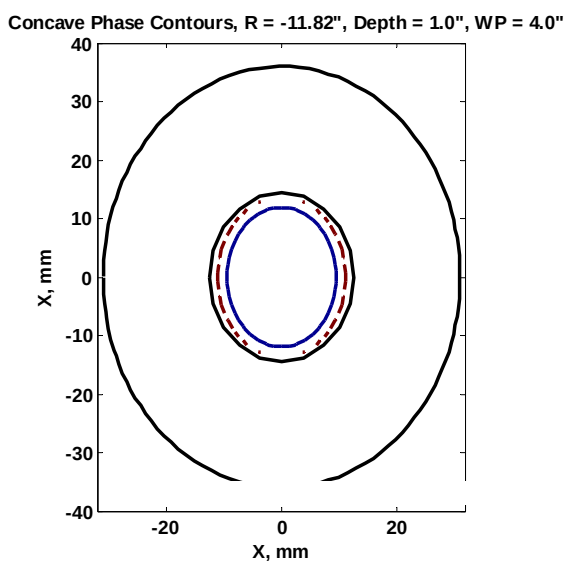


Figure G-5. Phase Variation for Concave Radius = -11.82″, depth = 1.0″

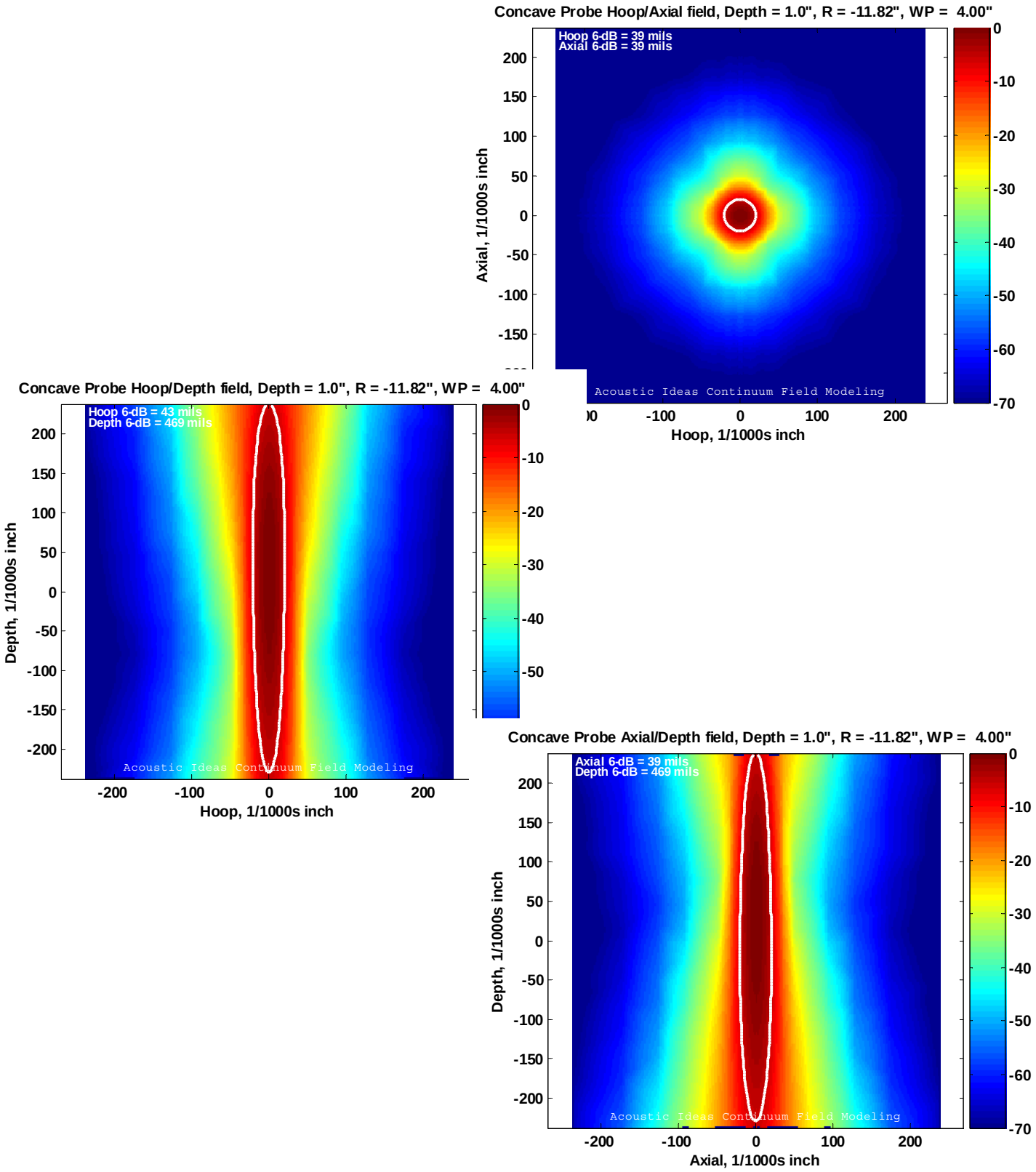


Figure G-6. Ultrasonic Field Modeling and Beam Width Measurement for Concave Radius = -11.82″, Depth = 1.0″

Results for concave radius = -11.82″, depth = 2.0″.

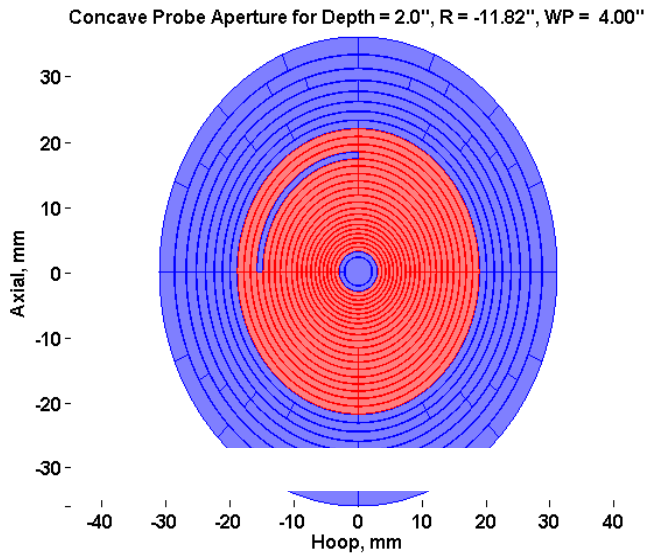


Figure G-7. Active Aperture for Concave Radius = -11.82″, Depth = 2.0″

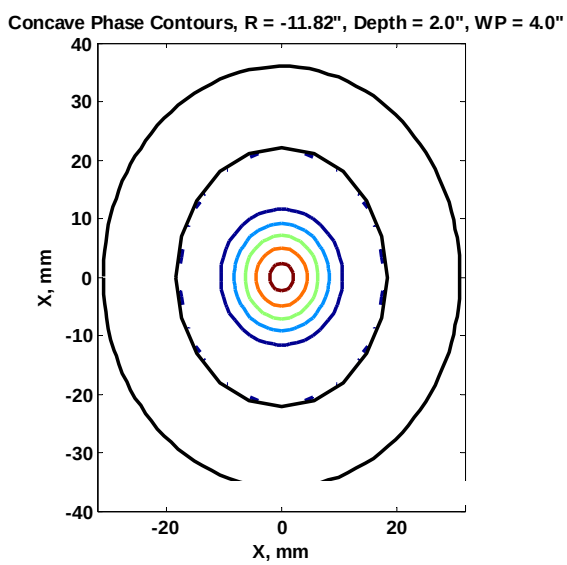


Figure G-8. Phase Variation for Concave Radius = -11.82″, Depth = 2.0″

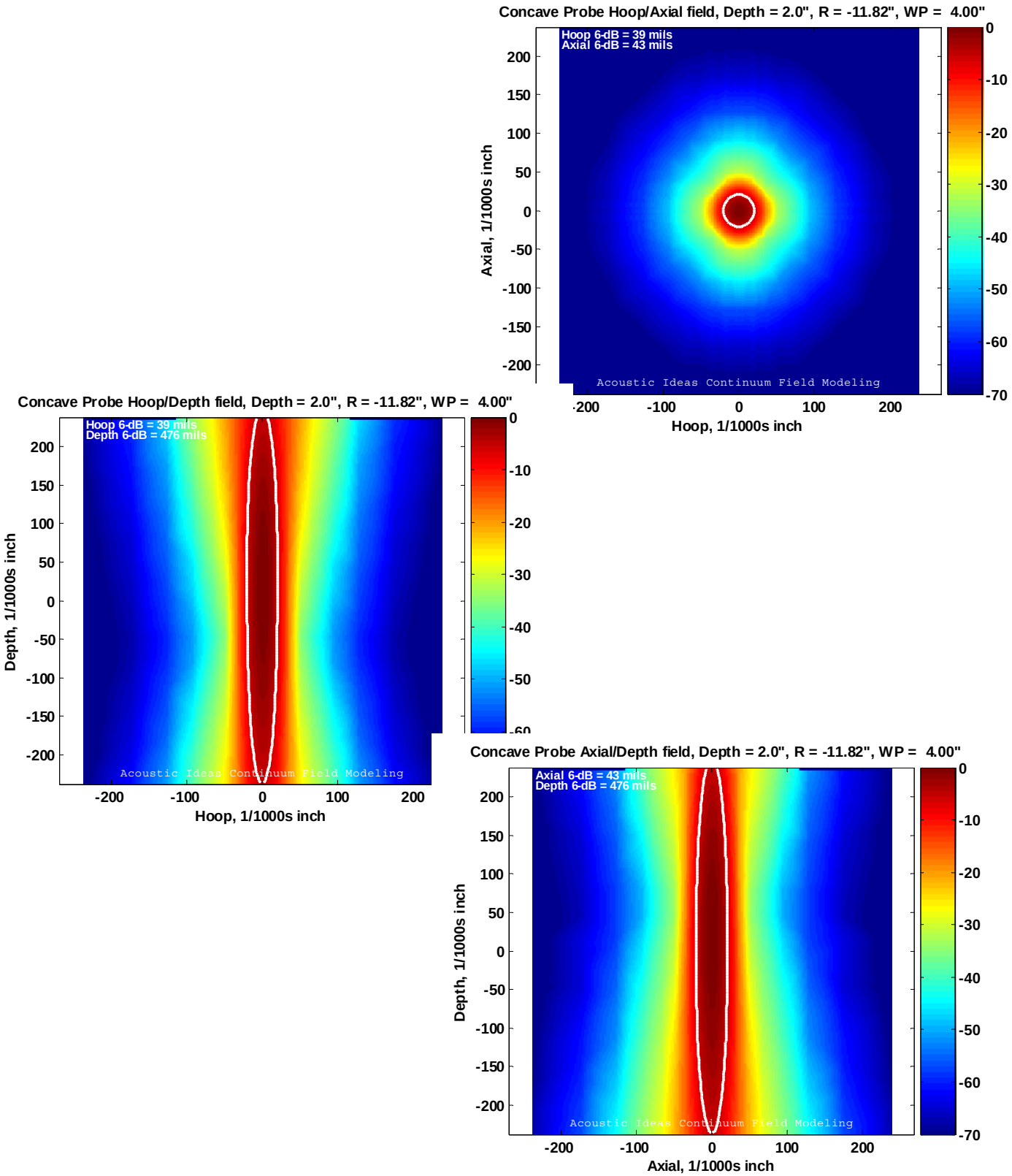


Figure G-9. Ultrasonic Field Modeling and Beamwidth Measurement for Concave Radius = -11.82″, Depth = 2.0″

Results for concave radius = -11.82″, depth = 3.0″.

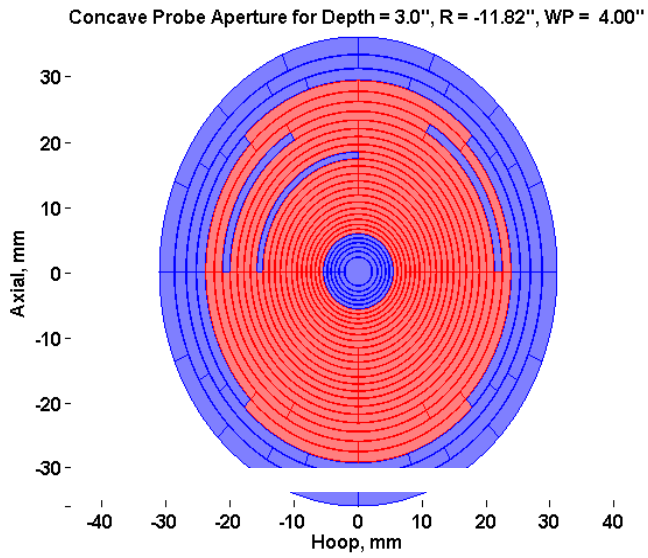


Figure G-10. Active Aperture for Concave Radius = -11.82″ Depth = 3.0″

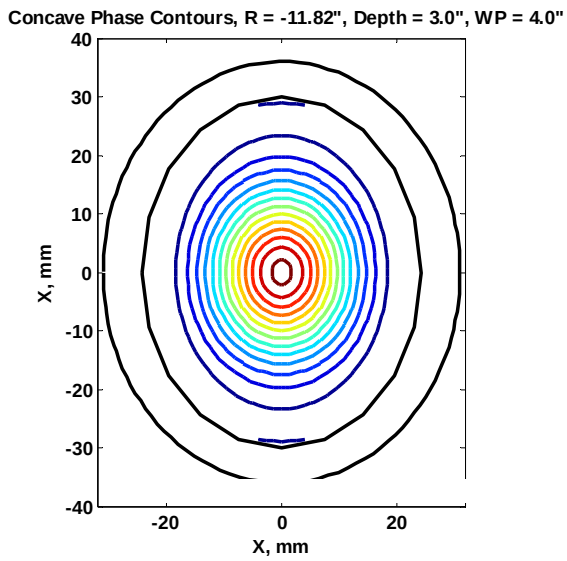


Figure G-11. Phase Variation for Concave Radius = -11.82″, Depth = 3.0″

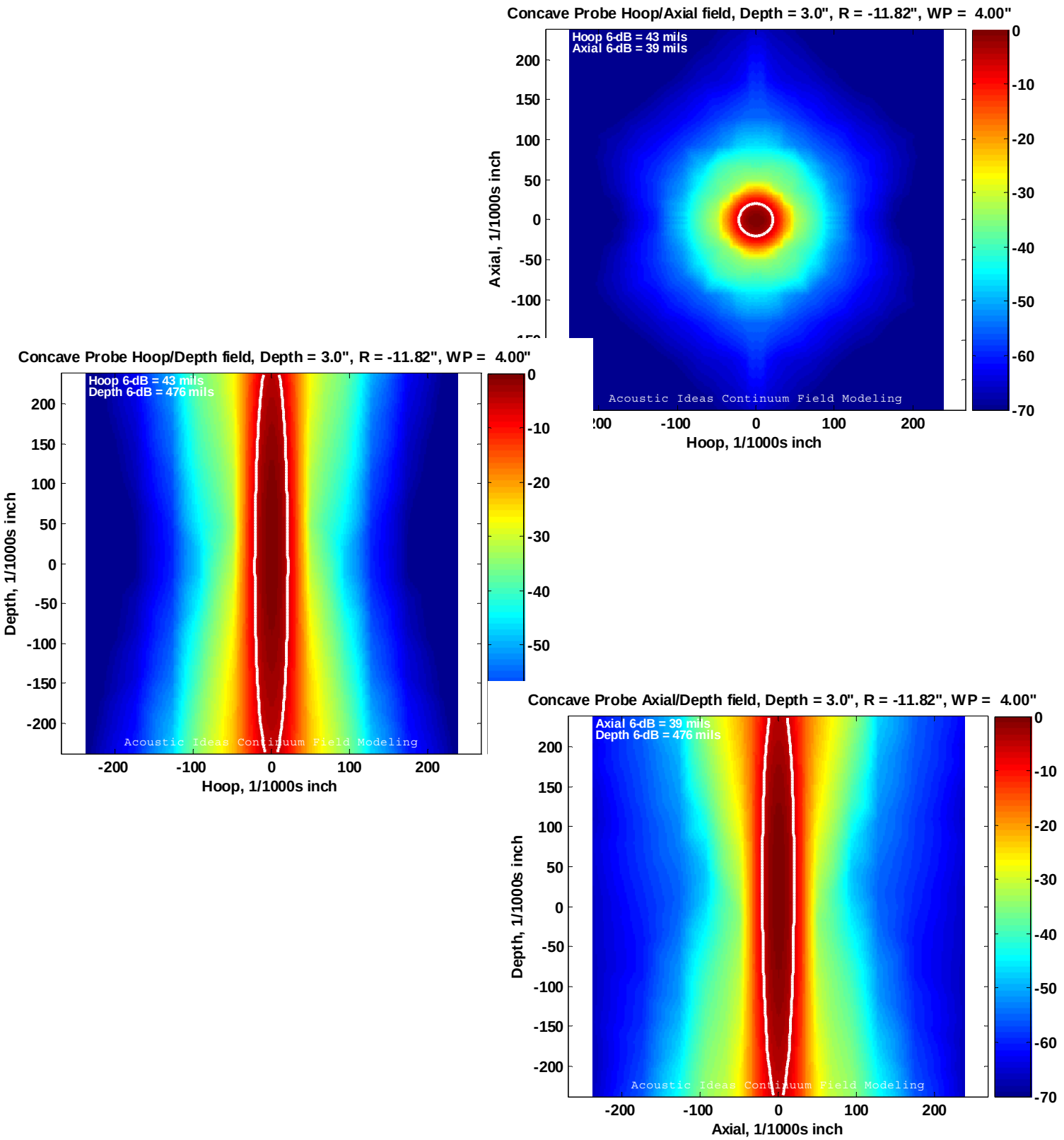


Figure G-12. Ultrasonic Field Modeling and Beam Width Measurement for Concave Radius = -11.82″, Depth = 3.0″

Results for concave radius = -11.82″, depth = 4.0″.

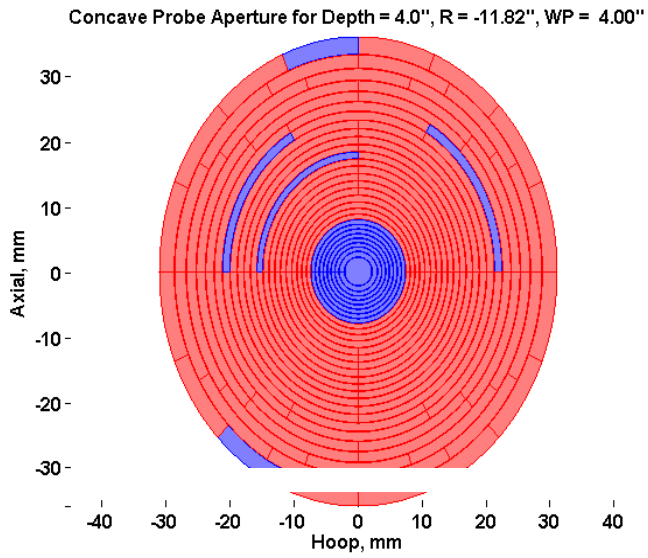


Figure G-13. Active Aperture for Concave Radius = -11.82″, Depth = 4.0″

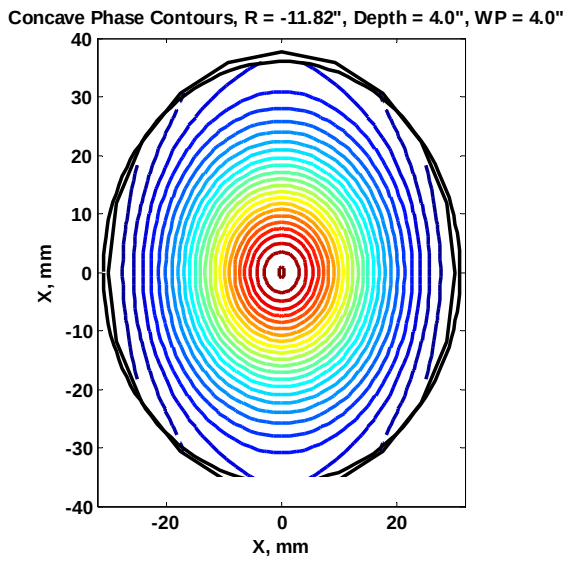


Figure G-14. Phase Variation for Concave Radius = -11.82″, Depth = 4.0″

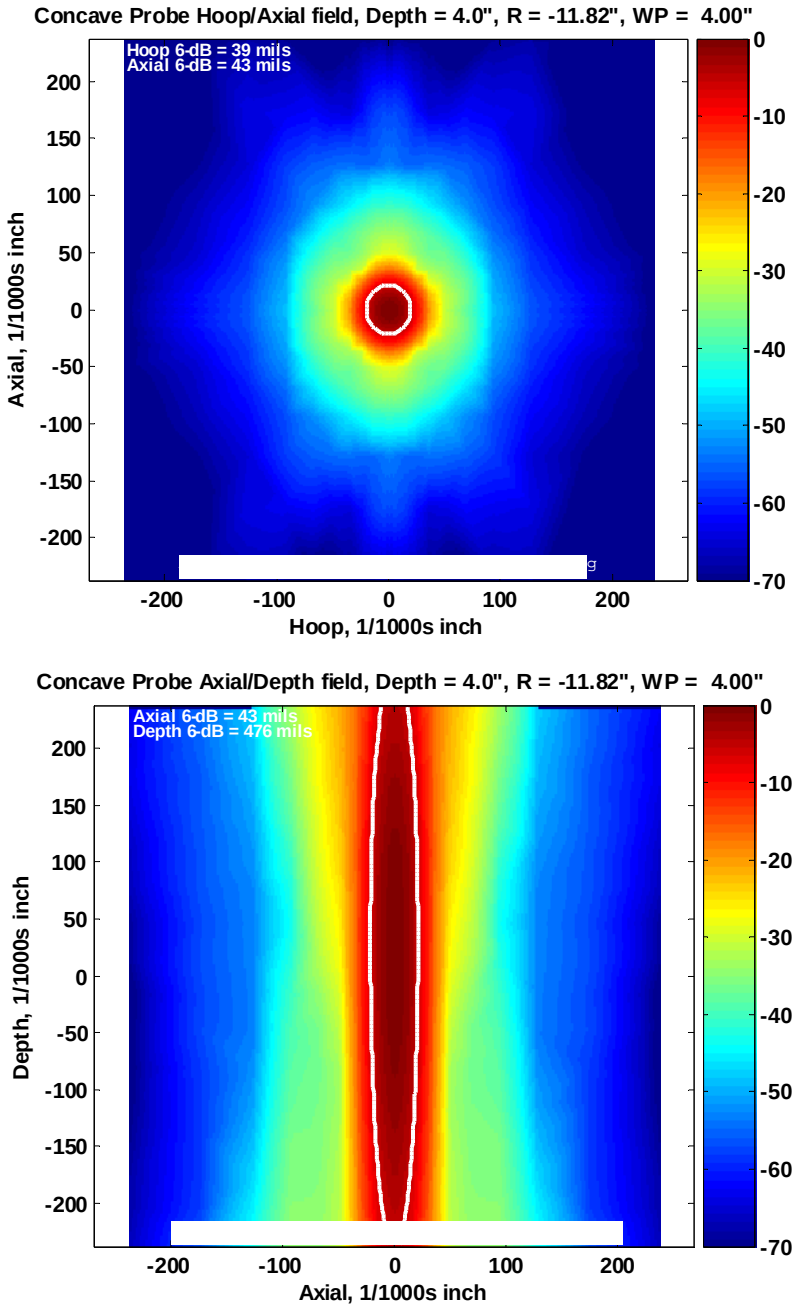


Figure G-15. Ultrasonic Field Modeling and Beamwidth Measurement for Concave Radius = -11.82″, Depth = 4.0″

All results for concave radius = -14.70″.
Results for concave radius = -14.70″, depth = 0.2″.

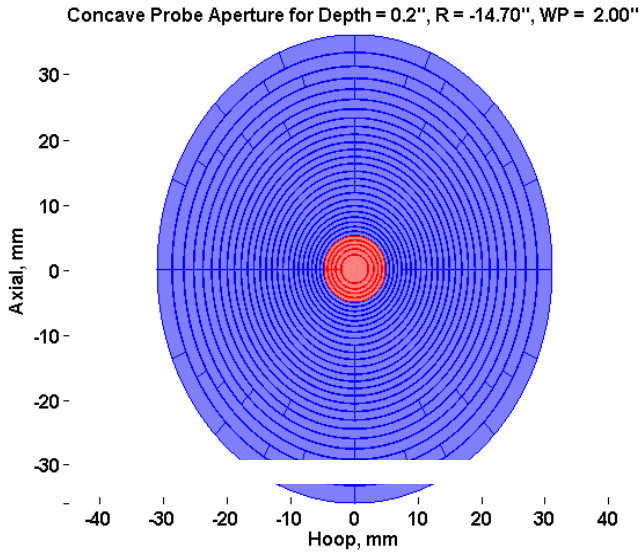


Figure G-16. Active Aperture for Concave Radius = -14.70″, Depth = 0.2″

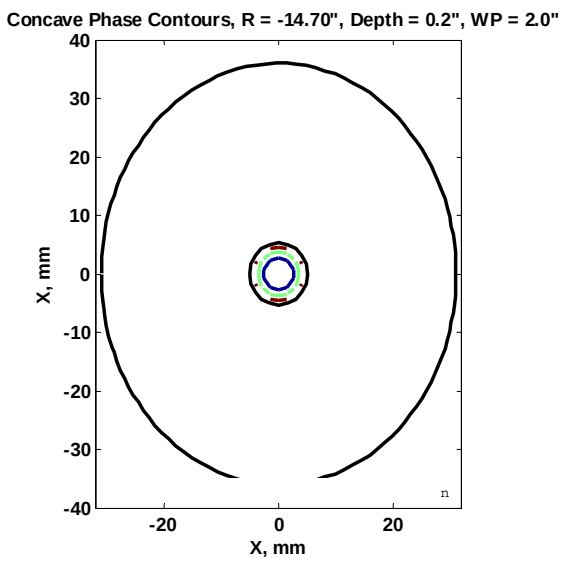


Figure G-17. Phase Variation for Concave Radius = -14.70″, Depth = 0.2″

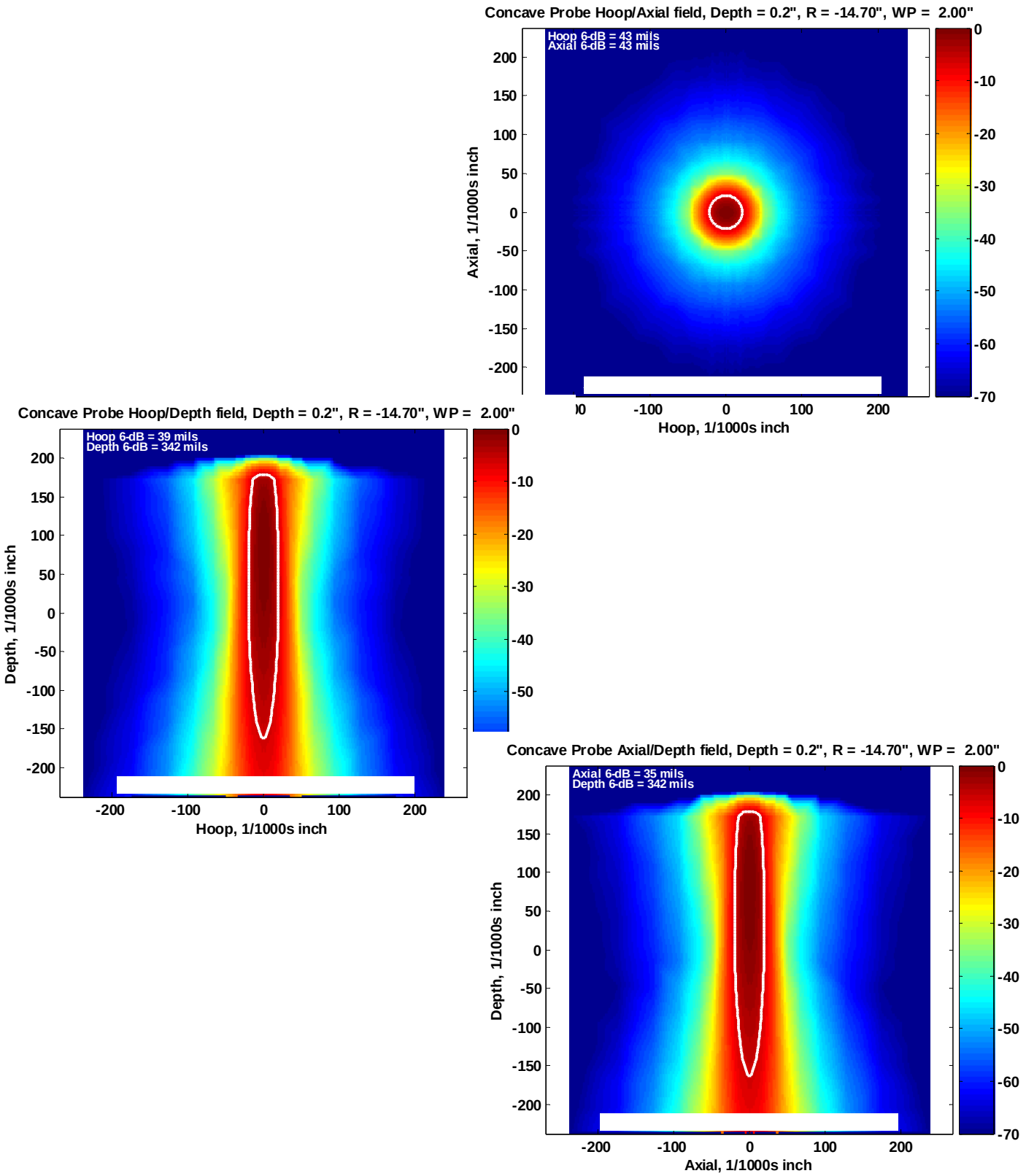


Figure G-18. Ultrasonic Field Modeling and Beamwidth Measurement for Concave Radius = -14.70″, Depth = 0.2″

Results for concave radius = -14.70″, depth = 1.0″.

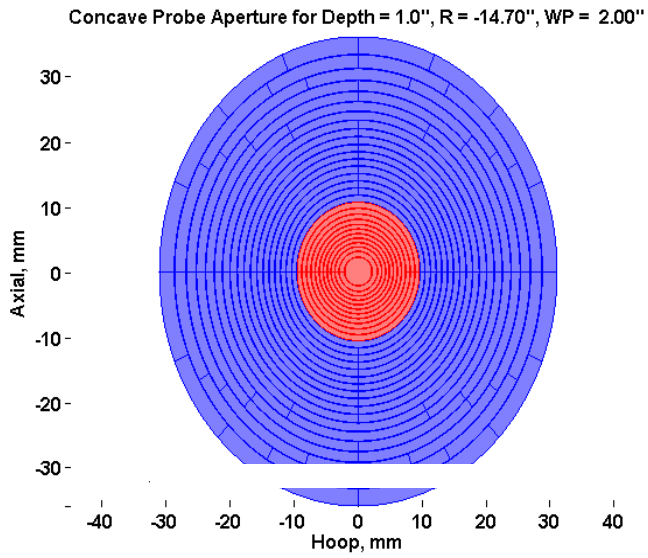


Figure G-19. Active Aperture for Concave Radius = -14.70″, Depth = 1.0″

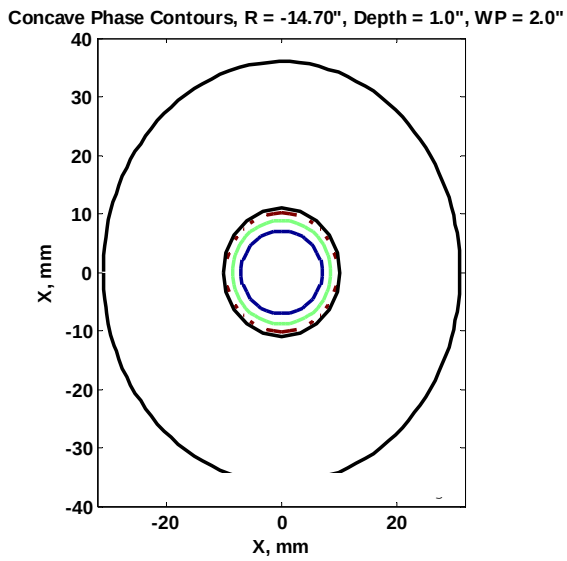


Figure G-20. Phase Variation for Concave Radius = -14.70″, Depth = 1.0″

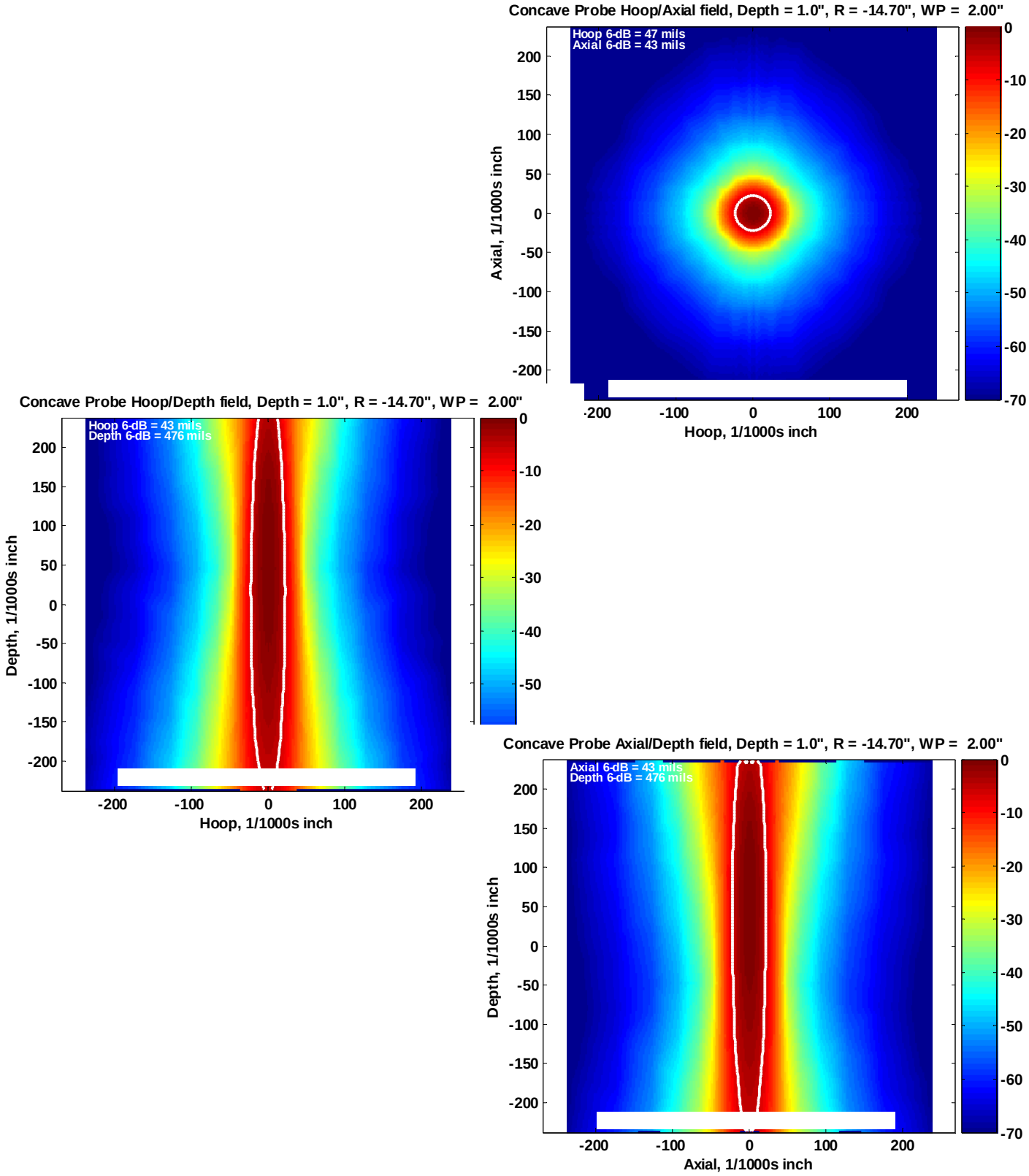


Figure G-21. Ultrasonic Field Modeling and Beamwidth Measurement for Concave Radius = -14.70″, Depth = 1.0″

Results for concave radius = -14.70″, depth = 2.0″.

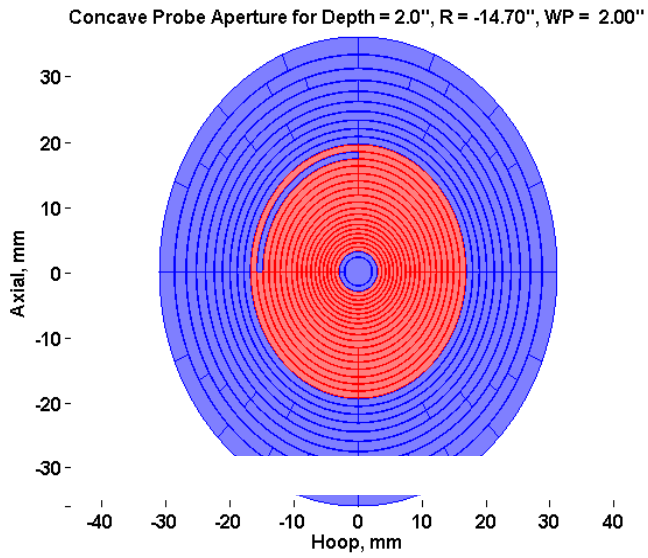


Figure G-22. Active Aperture for Concave Radius = -14.70″, Depth = 2.0″

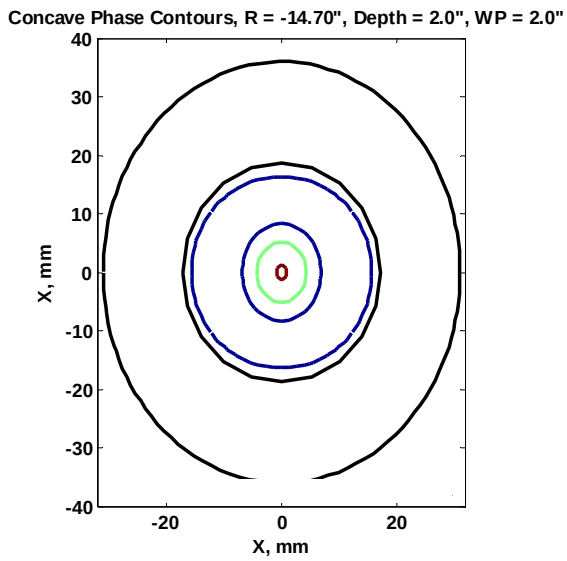


Figure G-23. Phase Variation for Concave Radius = -14.70″, Depth = 2.0″

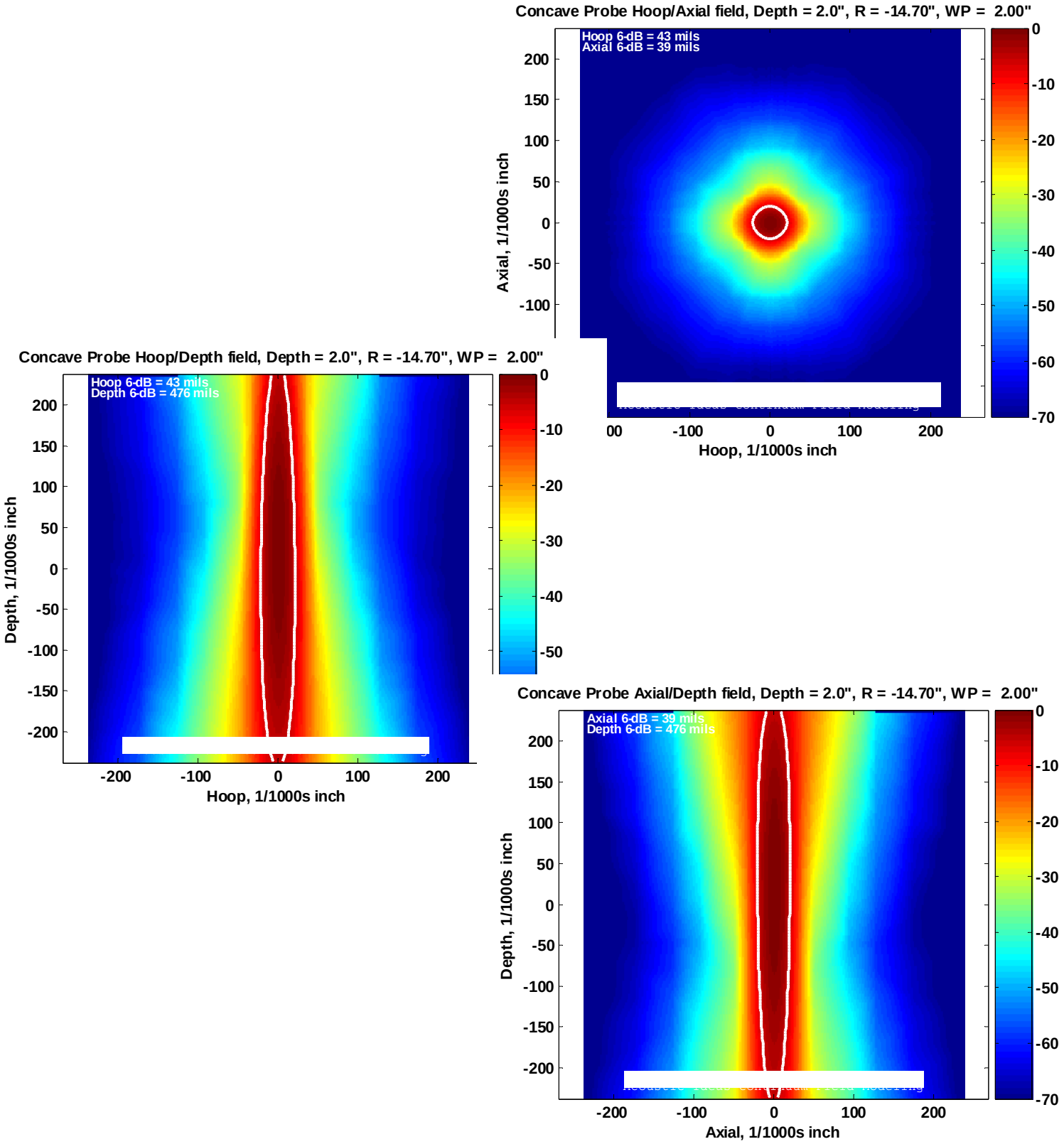


Figure G-24. Ultrasonic Field Modeling and Beamwidth Measurement for Concave Radius = -14.70″, Depth = 2.0″

Results for concave radius = -14.70″, depth = 3.0″.

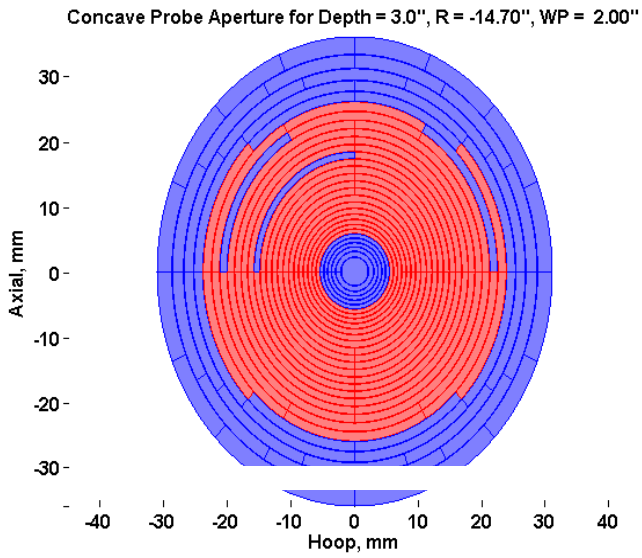


Figure G-25. Active Aperture for Concave Radius = -14.70″, Depth = 3.0″

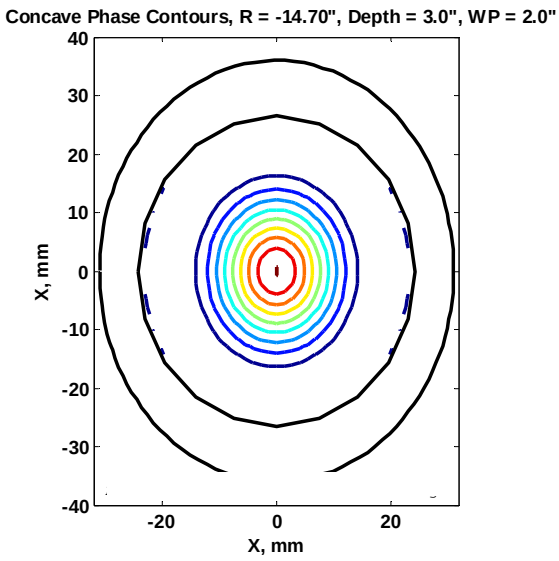


Figure G-26. Phase Variation for Concave Radius = -14.70″, Depth = 3.0″

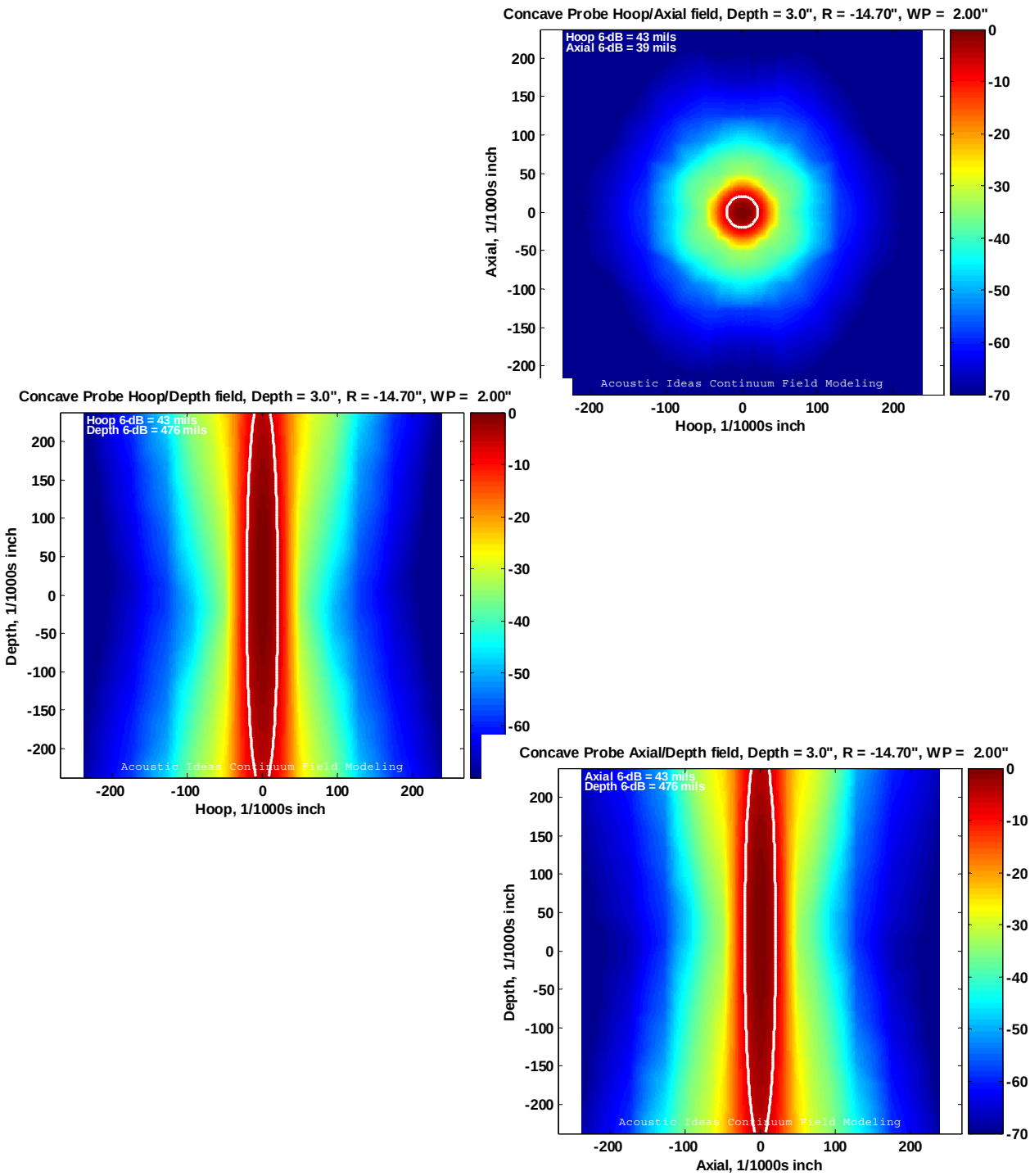


Figure G-27. Ultrasonic Field Modeling and Beamwidth Measurement for Concave Radius = -14.70″, Depth = 3.0″

Results for concave radius = -14.70″, depth = 4.0″.

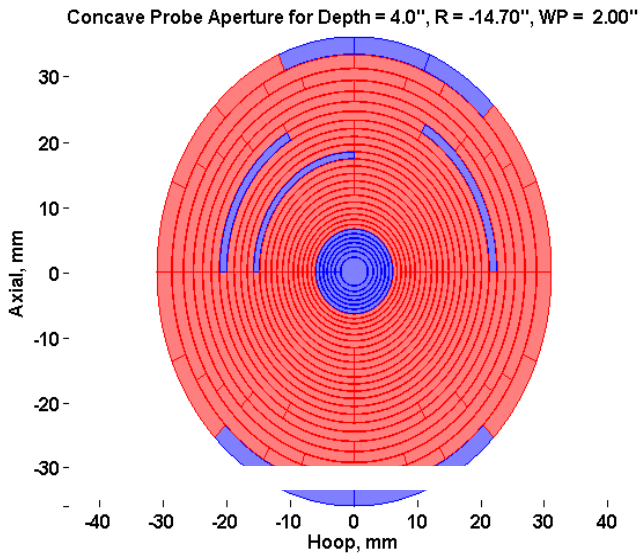


Figure G-28. Active Aperture for Concave Radius = -14.70″, Depth = 4.0″

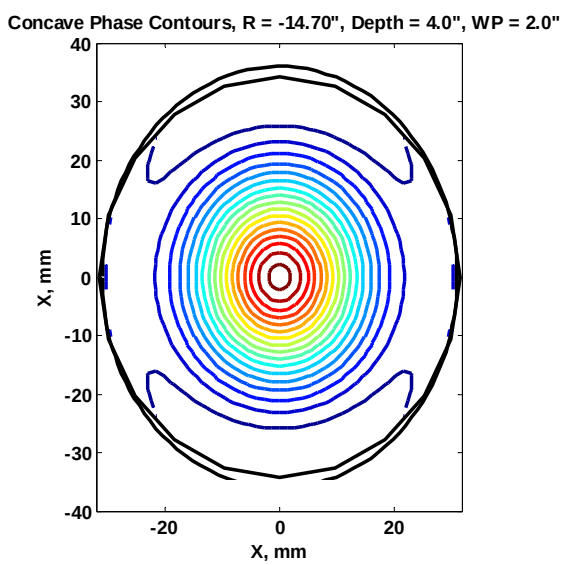


Figure G-29. Phase Variation for Concave Radius = -14.70″, Depth = 4.0″

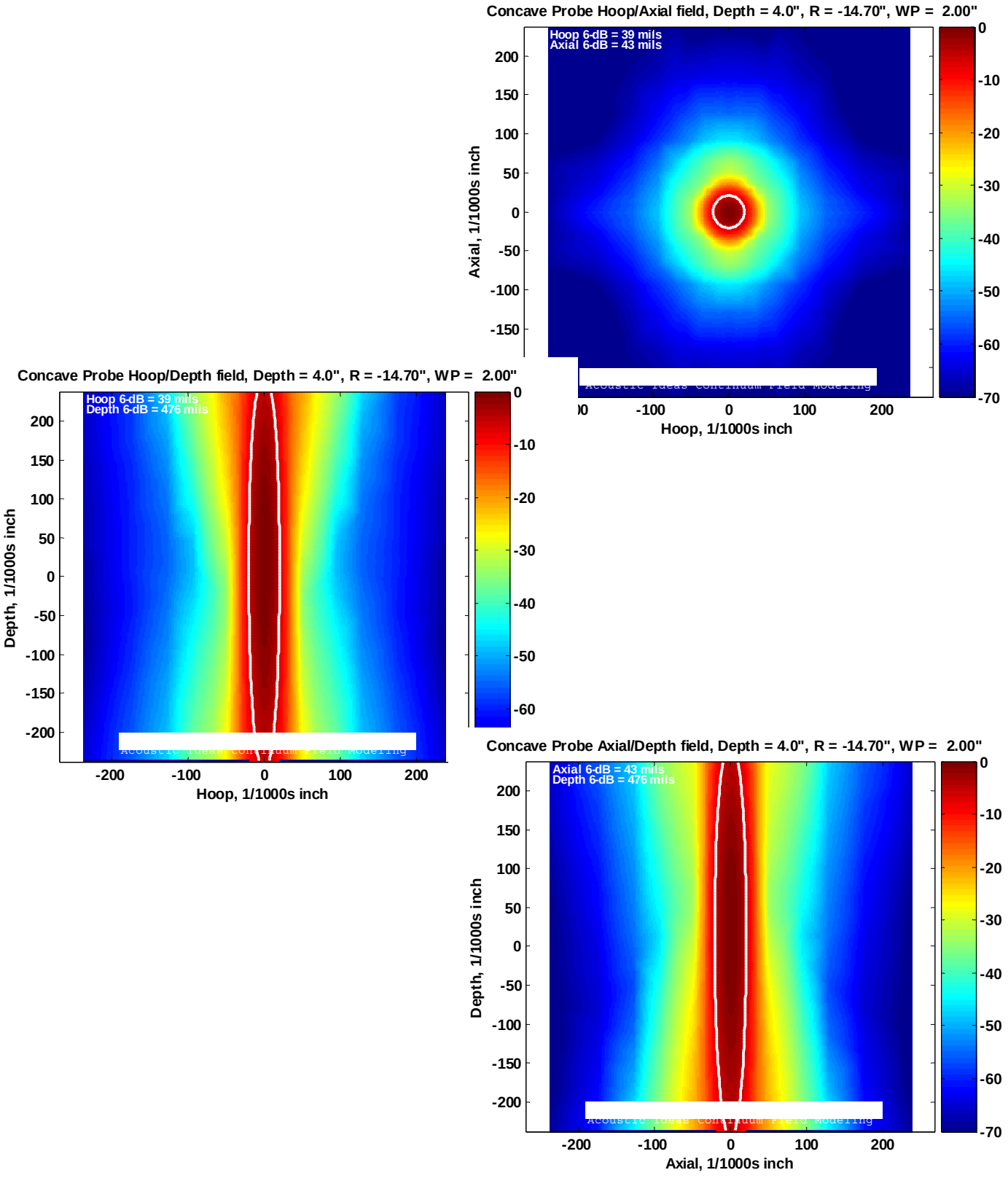


Figure G-30. Ultrasonic Field Modeling and Beamwidth Measurement for Concave Radius = -14.70″, Depth = 4.0″

The following detailed element listing is for the 10-MHz phased array transducer designed for a concave curved entry surface of radius of curvature of 13.26″ and a target beam spot size of approximately 45 mil.

Ring Number 1: Inner a = 0.00 mm, outer a = 2.09 mm, innber b = 0.00 mm, outer b = 2.14 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 14.0 square mm, element number = 1
Corners and middle: [0.00 0.00 2.09 2.09 -1.05
0.00 0.00 0.00 -0.00 -0.00
-0.00 -0.00 -0.01 -0.01 -0.00];

Ring Number 2: Inner a = 2.19 mm, outer a = 2.94 mm, innber b = 2.24 mm, outer b = 3.01 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 12.4 square mm, element number = 2
Corners and middle: [2.19 2.19 2.94 2.94 -2.56
0.00 -0.00 0.00 0.00 -0.00
-0.01 -0.01 -0.02 -0.02 -0.02];

Ring Number 3: Inner a = 3.04 mm, outer a = 3.60 mm, innber b = 3.11 mm, outer b = 3.72 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 12.4 square mm, element number = 3
Corners and middle: [3.04 3.04 3.60 3.60 -3.32
0.00 -0.00 0.00 -0.00 -0.00
-0.03 -0.03 -0.04 -0.04 -0.03];

Ring Number 4: Inner a = 3.70 mm, outer a = 4.21 mm, innber b = 3.82 mm, outer b = 4.38 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 13.5 square mm, element number = 4
Corners and middle: [3.70 3.70 4.21 4.21 -3.96
0.00 -0.00 0.00 -0.00 -0.00
-0.04 -0.04 -0.05 -0.05 -0.04];

Ring Number 5: Inner a = 4.31 mm, outer a = 4.82 mm, innber b = 4.48 mm, outer b = 5.06 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 15.8 square mm, element number = 5
Corners and middle: [4.31 4.31 4.82 4.82 -4.56
0.00 -0.00 0.00 -0.00 -0.00
-0.05 -0.05 -0.06 -0.06 -0.05];

Ring Number 6: Inner a = 4.92 mm, outer a = 5.42 mm, innber b = 5.16 mm, outer b = 5.75 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 18.3 square mm, element number = 6
Corners and middle: [4.92 4.92 5.42 5.42 -5.17
0.00 -0.00 0.00 -0.00 -0.00
-0.06 -0.06 -0.07 -0.07 -0.07];

Ring Number 7: Inner a = 5.52 mm, outer a = 6.04 mm, innber b = 5.85 mm, outer b = 6.46 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 0.0 deg, sector area = 21.0 sqmm, element number = 7
Corners and middle: [5.52 5.52 6.04 6.04 -5.78
0.00 0.00 0.00 -0.00 -0.00
-0.07 -0.07 -0.09 -0.09 -0.08];

Ring Number 8: Inner a = 6.14 mm, outer a = 6.68 mm, innber b = 6.56 mm, outer b = 7.18 mm, number of sectors = 1
Sector number 1: theta start = 360.0 deg, theta end = 0.0 deg, sector area = 24.2 square mm, element number = 8
Corners and middle: [6.14 6.14 6.68 6.68 -6.41
-0.00 0.00 0.00 -0.00 -0.00
-0.09 -0.09 -0.10 -0.10 -0.10];

Ring Number 9: Inner a = 6.78 mm, outer a = 7.34 mm, innber b = 7.28 mm, outer b = 7.94 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 28.2 square mm, element number = 9
Corners and middle: [6.78 6.78 7.34 7.34 -7.06
0.00 -0.00 0.00 -0.00 -0.00
-0.10 -0.10 -0.12 -0.12 -0.11];

Ring Number 10: Inner a = 7.44 mm, outer a = 8.04 mm, innber b = 8.04 mm, outer b = 8.75 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 16.6 square mm, element number = 10
Corners and middle: [7.44 -7.44 8.04 -8.04 -0.00
0.00 -0.00 0.00 -0.00 8.40
-0.12 -0.12 -0.14 -0.14 -0.19];
Sector number 2: theta start = 180.0 deg, theta end = 360.0 deg, sector area = 16.6 square mm, element number = 42
Corners and middle: [-7.44 7.44 -8.04 8.04 0.00
-0.00 -0.00 -0.00 -0.00 -8.40
-0.12 -0.12 -0.14 -0.14 -0.19];

Ring Number 11: Inner a = 8.14 mm, outer a = 8.78 mm, innber b = 8.85 mm, outer b = 9.65 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 19.8 square mm, element number = 11
Corners and middle: [8.14 -8.14 8.78 -8.78 -0.00
0.00 -0.00 0.00 -0.00 9.25
-0.14 -0.14 -0.16 -0.16 -0.22];
Sector number 2: theta start = 180.0 deg, theta end = 360.0 deg, sector area = 19.8 square mm, element number = 43
Corners and middle: [-8.14 8.14 -8.78 8.78 0.00
-0.00 -0.00 -0.00 -0.00 -9.25
-0.14 -0.14 -0.16 -0.16 -0.22];

Ring Number 12: Inner a = 8.88 mm, outer a = 9.54 mm, innber b = 9.75 mm, outer b = 10.62 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 23.1 square mm, element number = 12
Corners and middle: [8.88 -8.88 9.54 -9.54 -0.00
0.00 -0.00 0.00 -0.00 10.18
-0.16 -0.16 -0.18 -0.18 -0.26];
Sector number 2: theta start = 180.0 deg, theta end = 0.0 deg, sector area = 23.1 square mm, element number = 44
Corners and middle: [-8.88 8.88 -9.54 9.54 0.00
-0.00 0.00 -0.00 0.00 -10.18
-0.16 -0.16 -0.18 -0.18 -0.26];

Ring Number 13: Inner a = 9.64 mm, outer a = 10.34 mm, innber b = 10.72 mm, outer b = 11.66 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 27.2 square mm, element number = 13
Corners and middle: [9.64 -9.64 10.34 -10.34 -0.00
0.00 -0.00 0.00 -0.00 11.19
-0.18 -0.18 -0.20 -0.20 -0.30];
Sector number 2: theta start = 180.0 deg, theta end = 0.0 deg, sector area = 27.2 square mm, element number = 45
Corners and middle: [-9.64 9.64 -10.34 10.34 0.00
-0.00 0.00 -0.00 -0.00 -11.19
-0.18 -0.18 -0.20 -0.20 -0.30];

Ring Number 14: Inner a = 10.44 mm, outer a = 11.21 mm, innber b = 11.76 mm, outer b = 12.77 mm, number of sectors = 4
Sector number 1: theta start = 360.0 deg, theta end = 90.0 deg, sector area = 16.0 square mm, element number = 14
Corners and middle: [10.44 -0.00 11.21 -0.00 8.33
-0.00 11.76 -0.00 12.77 7.83
-0.20 -0.33 -0.22 -0.37 -0.27];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 16.0 square mm, element number = 46
Corners and middle: [-0.00 -10.44 -0.00 -11.21 -8.33
11.76 -0.00 12.77 -0.00 7.83
-0.33 -0.20 -0.37 -0.22 -0.27];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 16.0 square mm, element number = 78
Corners and middle: [-10.44 0.00 -11.21 0.00 -8.33
-0.00 -11.76 -0.00 -12.77 -7.83
-0.20 -0.33 -0.22 -0.37 -0.27];
Sector number 4: theta start = 270.0 deg, theta end = 0.0 deg, sector area = 16.0 square mm, element number = 110
Corners and middle: [0.00 10.44 0.00 11.21 8.33
-11.76 0.00 -12.77 0.00 -7.83
-0.33 -0.20 -0.37 -0.22 -0.27];

Ring Number 15: Inner a = 11.31 mm, outer a = 12.10 mm, innber b = 12.87 mm, outer b = 13.85 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 17.3 square mm, element number = 33
Corners and middle: [11.31 -0.00 12.10 -0.00 9.05
0.00 12.87 -0.00 13.85 8.47
-0.22 -0.38 -0.24 -0.43 -0.30];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 17.3 square mm, element number = 65
Corners and middle: [-0.00 -11.31 -0.00 -12.10 -9.05
12.87 -0.00 13.85 -0.00 8.47
-0.38 -0.22 -0.43 -0.24 -0.30];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 17.3 square mm, element number = 97
Corners and middle: [-11.31 0.00 -12.10 0.00 -9.05
-0.00 -12.87 -0.00 -13.85 -8.47
-0.22 -0.38 -0.24 -0.43 -0.30];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 17.3 square mm, element number = 251
Corners and middle: [0.00 11.31 0.00 12.10 9.05
-12.87 -0.00 -13.85 0.00 -8.47
-0.38 -0.22 -0.43 -0.24 -0.30];

Ring Number 16: Inner a = 12.20 mm, outer a = 13.00 mm, innber b = 13.95 mm, outer b = 14.98 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 19.3 square mm, element number = 15
Corners and middle: [12.20 -0.00 13.00 -0.00 9.78
0.00 13.95 0.00 14.98 9.12
-0.25 -0.43 -0.27 -0.48 -0.34];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 19.3 square mm, element number = 47
Corners and middle: [-0.00 -12.20 -0.00 -13.00 -9.78
13.95 -0.00 14.98 -0.00 9.12
-0.43 -0.25 -0.48 -0.27 -0.34];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 19.3 square mm, element number = 79
Corners and middle: [-12.20 0.00 -13.00 0.00 -9.78
-0.00 -13.95 -0.00 -14.98 -9.12
-0.25 -0.43 -0.27 -0.48 -0.34];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 19.3 square mm, element number = 111
Corners and middle: [0.00 12.20 0.00 13.00 9.78
-13.95 -0.00 -14.98 -0.00 -9.12
-0.43 -0.25 -0.48 -0.27 -0.34];

Ring Number 17: Inner a = 13.10 mm, outer a = 13.89 mm, innber b = 15.08 mm, outer b = 16.14 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 21.0 square mm, element number = 16
Corners and middle: [13.10 -0.00 13.89 -0.00 10.52
0.00 15.08 0.00 16.14 9.78
-0.27 -0.49 -0.29 -0.54 -0.37];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 21.0 square mm, element number = 48
Corners and middle: [-0.00 -13.10 -0.00 -13.89 -10.52
15.08 -0.00 16.14 -0.00 9.78
-0.49 -0.27 -0.54 -0.29 -0.37];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 21.0 square mm, element number = 80
Corners and middle: [-13.10 0.00 -13.89 0.00 -10.52
-0.00 -15.08 -0.00 -16.14 -9.78
-0.27 -0.49 -0.29 -0.54 -0.37];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 21.0 square mm, element number = 112
Corners and middle: [0.00 13.10 0.00 13.89 10.52
-15.08 -0.00 -16.14 -0.00 -9.78
-0.49 -0.27 -0.54 -0.29 -0.37];

Ring Number 18: Inner a = 13.99 mm, outer a = 14.82 mm, innber b = 16.24 mm, outer b = 17.22 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 21.9 square mm, element number = 17
Corners and middle: [13.99 -0.00 14.82 -0.00 11.25
0.00 16.24 0.00 17.22 10.44
-0.29 -0.55 -0.31 -0.60 -0.41];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 21.9 square mm, element number = 49
Corners and middle: [-0.00 -13.99 -0.00 -14.82 -11.26
16.24 -0.00 17.22 -0.00 10.44
-0.55 -0.29 -0.60 -0.31 -0.41];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 21.9 square mm, element number = 81
Corners and middle: [-13.99 0.00 -14.82 0.00 -11.25
-0.00 -16.24 -0.00 -17.22 -10.45
-0.29 -0.55 -0.31 -0.60 -0.41];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 21.9 square mm, element number = 113
Corners and middle: [0.00 13.99 0.00 14.82 11.26
-16.24 -0.00 -17.22 -0.00 -10.44
-0.55 -0.29 -0.60 -0.31 -0.41];

Ring Number 19: Inner a = 14.92 mm, outer a = 15.77 mm, innber b = 17.32 mm, outer b = 18.32 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 23.9 square mm, element number = 34
Corners and middle: [14.92 -0.00 15.77 -0.00 11.99
0.00 17.32 0.00 18.32 11.12
-0.31 -0.60 -0.33 -0.66 -0.44];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 23.9 square mm, element number = 252
Corners and middle: [-0.00 -14.92 -0.00 -15.77 -11.99
17.32 -0.00 18.32 -0.00 11.12
-0.60 -0.31 -0.66 -0.33 -0.44];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 23.9 square mm, element number = 66
Corners and middle: [-14.92 0.00 -15.77 0.00 -11.99
-0.00 -17.32 -0.00 -18.32 -11.13
-0.31 -0.60 -0.33 -0.66 -0.44];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 23.9 square mm, element number = 98
Corners and middle: [0.00 14.92 0.00 15.77 11.99
-17.32 -0.00 -18.32 -0.00 -11.12
-0.60 -0.31 -0.66 -0.33 -0.44];

Ring Number 20: Inner a = 15.87 mm, outer a = 16.75 mm, innber b = 18.42 mm, outer b = 19.46 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 26.4 square mm, element number = 18
Corners and middle: [15.87 -0.00 16.75 -0.00 12.74
0.00 18.42 0.00 19.46 11.82
-0.33 -0.66 -0.35 -0.72 -0.48];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 26.4 square mm, element number = 50
Corners and middle: [-0.00 -15.87 -0.00 -16.75 -12.74
18.42 -0.00 19.46 -0.00 11.82
-0.66 -0.33 -0.72 -0.35 -0.48];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 26.4 square mm, element number = 82
Corners and middle: [-15.87 0.00 -16.75 0.00 -12.74
-0.00 -18.42 -0.00 -19.46 -11.82
-0.33 -0.66 -0.35 -0.72 -0.48];
Sector number 4: theta start = 270.0 deg, theta end = 0.0 deg, sector area = 26.4 square mm, element number = 114
Corners and middle: [0.00 15.87 0.00 16.75 12.74
-18.42 0.00 -19.46 -0.00 -11.82
-0.66 -0.33 -0.72 -0.35 -0.48];

Ring Number 21: Inner a = 16.85 mm, outer a = 17.77 mm, innber b = 19.56 mm, outer b = 20.64 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 29.3 square mm, element number = 19
Corners and middle: [16.85 -0.00 17.77 -0.00 13.52
0.00 19.56 0.00 20.64 12.55
-0.35 -0.73 -0.37 -0.79 -0.52];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 29.3 square mm, element number = 51
Corners and middle: [-0.00 -16.85 -0.00 -17.77 -13.52
19.56 -0.00 20.64 -0.00 12.55
-0.73 -0.35 -0.79 -0.37 -0.52];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 29.3 square mm, element number = 83
Corners and middle: [-16.85 0.00 -17.77 0.00 -13.52
-0.00 -19.56 -0.00 -20.64 -12.55
-0.35 -0.73 -0.37 -0.79 -0.52];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 29.3 square mm, element number = 115
Corners and middle: [0.00 16.85 0.00 17.77 13.52
-19.56 -0.00 -20.64 -0.00 -12.54
-0.73 -0.35 -0.79 -0.37 -0.52];

Ring Number 22: Inner a = 17.87 mm, outer a = 18.82 mm, innber b = 20.74 mm, outer b = 21.87 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 32.2 square mm, element number = 20
Corners and middle: [17.87 -0.00 18.82 -0.00 14.33
0.00 20.74 0.00 21.87 13.30
-0.37 -0.79 -0.39 -0.86 -0.55];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 32.2 square mm, element number = 52
Corners and middle: [-0.00 -17.87 -0.00 -18.82 -14.33
20.74 -0.00 21.87 -0.00 13.30
-0.79 -0.37 -0.86 -0.39 -0.55];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 32.2 square mm, element number = 84
Corners and middle: [-17.87 0.00 -18.82 0.00 -14.33
-0.00 -20.74 -0.00 -21.87 -13.30
-0.37 -0.79 -0.39 -0.86 -0.55];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 32.2 square mm, element number = 116
Corners and middle: [0.00 17.87 0.00 18.82 14.33
-20.74 -0.00 -21.87 -0.00 -13.30
-0.79 -0.37 -0.86 -0.39 -0.55];

Ring Number 23: Inner a = 18.92 mm, outer a = 19.95 mm, innber b = 21.97 mm, outer b = 23.17 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 36.6 square mm, element number = 21
Corners and middle: [18.92 -0.00 19.95 -0.00 15.18
0.00 21.97 0.00 23.17 14.09
-0.39 -0.86 -0.41 -0.93 -0.59];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 36.6 square mm, element number = 53
Corners and middle: [-0.00 -18.92 -0.00 -19.95 -15.18
21.97 -0.00 23.17 -0.00 14.09
-0.86 -0.39 -0.93 -0.41 -0.59];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 36.6 square mm, element number = 85
Corners and middle: [-18.92 0.00 -19.95 0.00 -15.18
-0.00 -21.97 -0.00 -23.17 -14.09
-0.39 -0.86 -0.41 -0.93 -0.59];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 36.6 square mm, element number = 117
Corners and middle: [0.00 18.92 0.00 19.95 15.19
-21.97 -0.00 -23.17 -0.00 -14.09
-0.86 -0.39 -0.93 -0.41 -0.59];

Ring Number 24: Inner a = 20.05 mm, outer a = 21.13 mm, innber b = 23.27 mm, outer b = 24.55 mm, number of sectors = 6
Sector number 1: theta start = 0.0 deg, theta end = 63.7 deg, sector area = 27.3 square mm, element number = 35
Corners and middle: [20.05 9.97 21.13 10.52 18.32
0.00 20.19 0.00 21.29 10.90
-0.41 -0.81 -0.42 -0.87 -0.53];

Sector number 2: theta start = 63.7 deg, theta end = 116.3 deg, sector area = 27.3 square mm, element number = 36
Corners and middle: [9.97 -9.98 10.52 -10.52 -0.01
20.19 20.19 21.29 21.29 23.91
-0.81 -0.81 -0.87 -0.87 -0.97];
Sector number 3: theta start = 116.3 deg, theta end = 180.0 deg, sector area = 27.3 square mm, element number = 253
Corners and middle: [-9.98 -20.05 -10.52 -21.13 -18.33
20.19 -0.00 21.29 -0.00 10.90
-0.81 -0.41 -0.87 -0.42 -0.53];
Sector number 4: theta start = 180.0 deg, theta end = 243.7 deg, sector area = 27.3 square mm, element number = 67
Corners and middle: [-20.05 -9.97 -21.13 -10.52 -18.32
-0.00 -20.19 -0.00 -21.29 -10.90
-0.41 -0.81 -0.42 -0.87 -0.53];
Sector number 5: theta start = 243.7 deg, theta end = 296.3 deg, sector area = 27.3 square mm, element number = 100
Corners and middle: [-9.97 9.97 -10.52 10.52 0.00
-20.19 -20.19 -21.29 -21.29 -23.91
-0.81 -0.81 -0.87 -0.87 -0.97];
Sector number 6: theta start = 296.3 deg, theta end = 360.0 deg, sector area = 27.3 square mm, element number = 99
Corners and middle: [9.97 20.05 10.52 21.13 18.33
-20.19 -0.00 -21.29 -0.00 -10.90
-0.81 -0.41 -0.87 -0.42 -0.53];

Ring Number 25: Inner a = 21.23 mm, outer a = 22.40 mm, innber b = 24.65 mm, outer b = 26.02 mm, number of sectors = 6
Sector number 1: theta start = 0.0 deg, theta end = 63.7 deg, sector area = 31.2 square mm, element number = 254
Corners and middle: [21.23 10.56 22.40 11.15 19.42
0.00 21.38 0.00 22.57 11.55
-0.43 -0.87 -0.44 -0.94 -0.56];
Sector number 2: theta start = 63.7 deg, theta end = 116.3 deg, sector area = 31.2 square mm, element number = 38
Corners and middle: [10.56 -10.57 11.15 -11.16 -0.01
21.38 21.38 22.57 22.56 25.33
-0.87 -0.87 -0.94 -0.94 -1.06];
Sector number 3: theta start = 116.3 deg, theta end = 180.0 deg, sector area = 31.2 square mm, element number = 37
Corners and middle: [-10.57 -21.23 -11.16 -22.40 -19.42
21.38 -0.00 22.56 -0.00 11.54
-0.87 -0.43 -0.94 -0.44 -0.56];
Sector number 4: theta start = 180.0 deg, theta end = 243.7 deg, sector area = 31.2 square mm, element number = 69
Corners and middle: [-21.23 -10.56 -22.40 -11.15 -19.42

-0.00 -21.38 -0.00 -22.57 -11.55
-0.43 -0.87 -0.44 -0.94 -0.56];
Sector number 5: theta start = 243.7 deg, theta end = 296.3 deg, sector area = 31.2 square mm, element number = 102
Corners and middle: [-10.56 10.57 -11.15 11.16 0.00
-21.38 -21.38 -22.57 -22.56 -25.33
-0.87 -0.87 -0.94 -0.94 -1.06];
Sector number 6: theta start = 296.3 deg, theta end = 360.0 deg, sector area = 31.2 square mm, element number = 101
Corners and middle: [10.57 21.23 11.16 22.40 19.42
-21.38 -0.00 -22.56 -0.00 -11.55
-0.87 -0.43 -0.94 -0.44 -0.56];

Ring Number 26: Inner a = 22.50 mm, outer a = 23.75 mm, innber b = 26.12 mm, outer b = 27.59 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 49.4 deg, sector area = 26.6 square mm, element number = 22
Corners and middle: [22.50 15.86 23.75 16.75 21.58
0.00 18.53 0.00 19.56 9.66
-0.44 -0.78 -0.45 -0.83 -0.54];
Sector number 2: theta start = 49.4 deg, theta end = 90.0 deg, sector area = 26.6 square mm, element number = 23
Corners and middle: [15.86 -0.00 16.75 -0.00 9.25
18.53 26.12 19.56 27.59 24.62
-0.78 -1.11 -0.83 -1.20 -1.04];
Sector number 3: theta start = 90.0 deg, theta end = 130.6 deg, sector area = 26.6 square mm, element number = 55
Corners and middle: [-0.00 -15.86 -0.00 -16.76 -9.25
26.12 18.52 27.59 19.56 24.61
-1.11 -0.78 -1.20 -0.83 -1.04];
Sector number 4: theta start = 130.6 deg, theta end = 180.0 deg, sector area = 26.6 square mm, element number = 54
Corners and middle: [-15.86 -22.50 -16.76 -23.75 -21.58
18.52 -0.00 19.56 -0.00 9.65
-0.78 -0.44 -0.83 -0.45 -0.54];
Sector number 5: theta start = 180.0 deg, theta end = 229.4 deg, sector area = 26.6 square mm, element number = 86
Corners and middle: [-22.50 -15.86 -23.75 -16.75 -21.58
-0.00 -18.53 -0.00 -19.56 -9.66
-0.44 -0.78 -0.45 -0.83 -0.54];
Sector number 6: theta start = 229.4 deg, theta end = 270.0 deg, sector area = 26.6 square mm, element number = 87
Corners and middle: [-15.86 0.00 -16.75 0.00 -9.24
-18.53 -26.12 -19.56 -27.59 -24.62
-0.78 -1.11 -0.83 -1.20 -1.04];

Sector number 7: theta start = 270.0 deg, theta end = 310.6 deg, sector area = 26.6 square mm, element number = 119
Corners and middle: [0.00 15.86 0.00 16.75 9.25
-26.12 -18.53 -27.59 -19.56 -24.62
-1.11 -0.78 -1.20 -0.83 -1.04];
Sector number 8: theta start = 310.6 deg, theta end = 0.0 deg, sector area = 26.6 square mm, element number = 118
Corners and middle: [15.86 22.50 16.75 23.75 21.58
-18.53 0.00 -19.56 -0.00 -9.65
-0.78 -0.44 -0.83 -0.45 -0.54];

Ring Number 27: Inner a = 23.85 mm, outer a = 25.20 mm, innber b = 27.69 mm, outer b = 29.28 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 49.4 deg, sector area = 30.3 square mm, element number = 24
Corners and middle: [23.85 16.82 25.20 17.78 22.89
0.00 19.64 -0.00 20.75 10.24
-0.45 -0.83 -0.46 -0.88 -0.56];
Sector number 2: theta start = 49.4 deg, theta end = 90.0 deg, sector area = 30.3 square mm, element number = 25
Corners and middle: [16.82 -0.00 17.78 -0.00 9.81
19.64 27.69 20.75 29.28 26.11
-0.83 -1.20 -0.88 -1.30 -1.12];
Sector number 3: theta start = 90.0 deg, theta end = 130.6 deg, sector area = 30.3 square mm, element number = 57
Corners and middle: [-0.00 -16.82 -0.00 -17.78 -9.81
27.69 19.63 29.28 20.75 26.11
-1.20 -0.83 -1.30 -0.88 -1.12];
Sector number 4: theta start = 130.6 deg, theta end = 180.0 deg, sector area = 30.3 square mm, element number = 56
Corners and middle: [-16.82 -23.85 -17.78 -25.20 -22.89
19.63 -0.00 20.75 -0.00 10.24
-0.83 -0.45 -0.88 -0.46 -0.56];
Sector number 5: theta start = 180.0 deg, theta end = 229.4 deg, sector area = 30.3 square mm, element number = 88
Corners and middle: [-23.85 -16.82 -25.20 -17.78 -22.89
-0.00 -19.64 -0.00 -20.75 -10.24
-0.45 -0.83 -0.46 -0.88 -0.56];
Sector number 6: theta start = 229.4 deg, theta end = 270.0 deg, sector area = 30.3 square mm, element number = 89
Corners and middle: [-16.82 0.00 -17.78 0.00 -9.81
-19.64 -27.69 -20.75 -29.28 -26.11
-0.83 -1.20 -0.88 -1.30 -1.12];
Sector number 7: theta start = 270.0 deg, theta end = 310.6 deg, sector area = 30.3 square mm, element number = 121
Corners and middle: [0.00 16.82 0.00 17.78 9.82

-27.69 -19.64 -29.28 -20.75 -26.10
-1.20 -0.83 -1.30 -0.88 -1.12];
Sector number 8: theta start = 310.6 deg, theta end = 360.0 deg, sector area = 30.3 square mm, element number = 120
Corners and middle: [16.82 23.85 17.78 25.20 22.89
-19.64 -0.00 -20.75 0.00 -10.24
-0.83 -0.45 -0.88 -0.46 -0.56];

Ring Number 28: Inner a = 25.30 mm, outer a = 26.78 mm, innber b = 29.38 mm, outer b = 31.10 mm, number of sectors = 10
Sector number 1: theta start = 0.0 deg, theta end = 40.3 deg, sector area = 28.1 square mm, element number = 26
Corners and middle: [25.30 20.43 26.78 21.63 24.87
0.00 17.33 0.00 18.33 8.95
-0.46 -0.76 -0.47 -0.80 -0.55];
Sector number 2: theta start = 40.3 deg, theta end = 74.4 deg, sector area = 28.1 square mm, element number = 27
Corners and middle: [20.43 7.78 21.63 8.24 15.66
17.33 27.95 18.33 29.59 24.16
-0.76 -1.23 -0.80 -1.33 -1.04];
Sector number 3: theta start = 74.4 deg, theta end = 105.6 deg, sector area = 28.1 square mm, element number = 39
Corners and middle: [7.78 -7.79 8.24 -8.25 -0.01
27.95 27.95 29.59 29.59 30.24
-1.23 -1.23 -1.33 -1.33 -1.36];
Sector number 4: theta start = 105.6 deg, theta end = 139.7 deg, sector area = 28.1 square mm, element number = 59
Corners and middle: [-7.79 -20.43 -8.25 -21.63 -15.66
27.95 17.32 29.59 18.33 24.16
-1.23 -0.76 -1.33 -0.80 -1.04];
Sector number 5: theta start = 139.7 deg, theta end = 180.0 deg, sector area = 28.1 square mm, element number = 58
Corners and middle: [-20.43 -25.30 -21.63 -26.78 -24.87
17.32 -0.00 18.33 -0.00 8.94
-0.76 -0.46 -0.80 -0.47 -0.55];
Sector number 6: theta start = 180.0 deg, theta end = 220.3 deg, sector area = 28.1 square mm, element number = 90
Corners and middle: [-25.30 -20.43 -26.78 -21.63 -24.87
-0.00 -17.33 -0.00 -18.34 -8.95
-0.46 -0.76 -0.47 -0.80 -0.55];
Sector number 7: theta start = 220.3 deg, theta end = 254.4 deg, sector area = 28.1 square mm, element number = 91
Corners and middle: [-20.43 -7.78 -21.63 -8.24 -15.66
-17.33 -27.95 -18.34 -29.59 -24.16
-0.76 -1.23 -0.80 -1.33 -1.04];

Sector number 8: theta start = 254.4 deg, theta end = 285.6 deg, sector area = 28.1 square mm, element number = 103
Corners and middle: [-7.78 7.79 -8.24 8.24 0.00
-27.95 -27.95 -29.59 -29.59 -30.24
-1.23 -1.23 -1.33 -1.33 -1.36];
Sector number 9: theta start = 285.6 deg, theta end = 319.7 deg, sector area = 28.1 square mm, element number = 123
Corners and middle: [7.79 20.44 8.24 21.63 15.67
-27.95 -17.32 -29.59 -18.33 -24.15
-1.23 -0.76 -1.33 -0.80 -1.04];
Sector number 10: theta start = 319.7 deg, theta end = 360.0 deg, sector area = 28.1 square mm, element number = 122
Corners and middle: [20.44 25.30 21.63 26.78 24.87
-17.32 -0.00 -18.33 0.00 -8.95
-0.76 -0.46 -0.80 -0.47 -0.55];

Ring Number 29: Inner a = 26.88 mm, outer a = 28.61 mm, innber b = 31.20 mm, outer b = 33.23 mm, number of sectors = 12
Sector number 1: theta start = 0.0 deg, theta end = 34.0 deg, sector area = 29.4 square mm, element number = 28
Corners and middle: [26.88 23.25 28.61 24.75 26.86
0.00 15.65 0.00 16.66 8.08
-0.47 -0.71 -0.47 -0.75 -0.54];
Sector number 2: theta start = 34.0 deg, theta end = 63.7 deg, sector area = 29.4 square mm, element number = 29
Corners and middle: [23.25 13.39 24.75 14.26 19.87
15.65 27.05 16.66 28.81 22.48
-0.71 -1.19 -0.75 -1.29 -0.97];
Sector number 3: theta start = 63.7 deg, theta end = 90.0 deg, sector area = 29.4 square mm, element number = 30
Corners and middle: [13.39 -0.00 14.26 -0.00 7.32
27.05 31.20 28.81 33.23 31.08
-1.19 -1.42 -1.29 -1.56 -1.42];
Sector number 4: theta start = 90.0 deg, theta end = 116.3 deg, sector area = 29.4 square mm, element number = 62
Corners and middle: [-0.00 -13.39 -0.00 -14.27 -7.32
31.20 27.05 33.23 28.81 31.07
-1.42 -1.19 -1.56 -1.29 -1.42];
Sector number 5: theta start = 116.3 deg, theta end = 146.1 deg, sector area = 29.4 square mm, element number = 61
Corners and middle: [-13.39 -23.25 -14.27 -24.75 -19.87
27.05 15.65 28.81 16.66 22.48
-1.19 -0.71 -1.29 -0.75 -0.97];
Sector number 6: theta start = 146.1 deg, theta end = 180.0 deg, sector area = 29.4 square mm, element number = 60
Corners and middle: [-23.25 -26.88 -24.75 -28.61 -26.86

15.65 -0.00 16.66 -0.00 8.08
-0.71 -0.47 -0.75 -0.47 -0.54];
Sector number 7: theta start = 180.0 deg, theta end = 214.0 deg, sector area = 29.4 square mm, element number = 92
Corners and middle: [-26.88 -23.25 -28.61 -24.75 -26.85
-0.00 -15.66 -0.00 -16.66 -8.08
-0.47 -0.71 -0.47 -0.75 -0.54];
Sector number 8: theta start = 214.0 deg, theta end = 243.7 deg, sector area = 29.4 square mm, element number = 93
Corners and middle: [-23.25 -13.39 -24.75 -14.26 -19.87
-15.66 -27.05 -16.66 -28.81 -22.49
-0.71 -1.19 -0.75 -1.29 -0.97];
Sector number 9: theta start = 243.7 deg, theta end = 270.0 deg, sector area = 29.4 square mm, element number = 94
Corners and middle: [-13.39 0.00 -14.26 0.01 -7.32
-27.05 -31.20 -28.81 -33.23 -31.08
-1.19 -1.42 -1.29 -1.56 -1.42];
Sector number 10: theta start = 270.0 deg, theta end = 296.3 deg, sector area = 29.4 square mm, element number = 126
Corners and middle: [0.00 13.40 0.01 14.27 7.33
-31.20 -27.05 -33.23 -28.80 -31.07
-1.42 -1.19 -1.56 -1.29 -1.42];
Sector number 11: theta start = 296.3 deg, theta end = 326.1 deg, sector area = 29.4 square mm, element number = 125
Corners and middle: [13.40 23.25 14.27 24.76 19.87
-27.05 -15.65 -28.80 -16.66 -22.48
-1.19 -0.71 -1.29 -0.75 -0.97];
Sector number 12: theta start = 326.1 deg, theta end = 360.0 deg, sector area = 29.4 square mm, element number = 124
Corners and middle: [23.25 26.88 24.76 28.61 26.86
-15.65 -0.00 -16.66 -0.00 -8.08
-0.71 -0.47 -0.75 -0.47 -0.54];

Ring Number 30: Inner a = 28.71 mm, outer a = 31.00 mm, innber b = 33.33 mm, outer b = 36.00 mm, number of sectors = 16
Sector number 1: theta start = 0.0 deg, theta end = 25.7 deg, sector area = 31.2 square mm, element number = 31
Corners and middle: [28.71 26.52 31.00 28.63 29.30
0.00 12.78 0.00 13.79 6.64
-0.47 -0.63 -0.47 -0.65 -0.51];
Sector number 2: theta start = 25.7 deg, theta end = 49.3 deg, sector area = 31.2 square mm, element number = 32
Corners and middle: [26.52 20.28 28.63 21.90 24.95
12.78 23.59 13.79 25.48 19.04
-0.63 -1.02 -0.65 -1.11 -0.83];

Sector number 3: theta start = 49.3 deg, theta end = 70.4 deg, sector area = 31.2 square mm, element number = 40
Corners and middle: [20.28 10.97 21.90 11.84 16.74
23.59 30.80 25.48 33.27 28.70
-1.02 -1.40 -1.11 -1.55 -1.28];
Sector number 4: theta start = 70.4 deg, theta end = 90.0 deg, sector area = 31.2 square mm, element number = 41
Corners and middle: [10.97 -0.00 11.84 -0.00 5.89
30.80 33.33 33.27 36.00 33.98
-1.40 -1.56 -1.55 -1.74 -1.60];
Sector number 5: theta start = 90.0 deg, theta end = 109.6 deg, sector area = 31.2 square mm, element number = 255
Corners and middle: [-0.00 -10.97 -0.00 -11.85 -5.90
33.33 30.80 36.00 33.26 33.98
-1.56 -1.40 -1.74 -1.55 -1.60];
Sector number 6: theta start = 109.6 deg, theta end = 130.7 deg, sector area = 31.2 square mm, element number = 72
Corners and middle: [-10.97 -20.28 -11.85 -21.91 -16.75
30.80 23.59 33.26 25.47 28.70
-1.40 -1.02 -1.55 -1.11 -1.28];
Sector number 7: theta start = 130.7 deg, theta end = 154.3 deg, sector area = 31.2 square mm, element number = 64
Corners and middle: [-20.28 -26.52 -21.91 -28.63 -24.95
23.59 12.77 25.47 13.79 19.03
-1.02 -0.63 -1.11 -0.65 -0.83];
Sector number 8: theta start = 154.3 deg, theta end = 180.0 deg, sector area = 31.2 square mm, element number = 63
Corners and middle: [-26.52 -28.71 -28.63 -31.00 -29.30
12.77 -0.00 13.79 -0.00 6.63
-0.63 -0.47 -0.65 -0.47 -0.51];
Sector number 9: theta start = 180.0 deg, theta end = 205.7 deg, sector area = 31.2 square mm, element number = 95
Corners and middle: [-28.71 -26.52 -31.00 -28.63 -29.30
-0.00 -12.78 -0.00 -13.80 -6.64
-0.47 -0.63 -0.47 -0.65 -0.51];
Sector number 10: theta start = 205.7 deg, theta end = 229.3 deg, sector area = 31.2 square mm, element number = 96
Corners and middle: [-26.52 -20.28 -28.63 -21.90 -24.95
-12.78 -23.59 -13.80 -25.48 -19.04
-0.63 -1.02 -0.65 -1.11 -0.83];
Sector number 11: theta start = 229.3 deg, theta end = 250.4 deg, sector area = 31.2 square mm, element number = 256
Corners and middle: [-20.28 -10.97 -21.90 -11.85 -16.74
-23.59 -30.80 -25.48 -33.27 -28.70
-1.02 -1.40 -1.11 -1.55 -1.28]

Sector number 12: theta start = 250.4 deg, theta end = 270.0 deg, sector area = 31.2 square mm, element number = 73
Corners and middle: [-10.97 0.01 -11.85 0.01 -5.89
-30.80 -33.33 -33.27 -36.00 -33.99
-1.40 -1.56 -1.55 -1.74 -1.61];
Sector number 13: theta start = 270.0 deg, theta end = 289.6 deg, sector area = 31.2 square mm, element number = 105
Corners and middle: [0.01 10.97 0.01 11.85 5.90
-33.33 -30.80 -36.00 -33.27 -33.98
-1.56 -1.40 -1.74 -1.55 -1.60];
Sector number 14: theta start = 289.6 deg, theta end = 310.7 deg, sector area = 31.2 square mm, element number = 104
Corners and middle: [10.97 20.29 11.85 21.91 16.75
-30.80 -23.59 -33.27 -25.47 -28.70
-1.40 -1.02 -1.55 -1.11 -1.28];
Sector number 15: theta start = 310.7 deg, theta end = 334.3 deg, sector area = 31.2 square mm, element number = 128
Corners and middle: [20.29 26.52 21.91 28.64 24.95
-23.59 -12.77 -25.47 -13.79 -19.03
-1.02 -0.63 -1.11 -0.65 -0.83];
Sector number 16: theta start = 334.3 deg, theta end = 360.0 deg, sector area = 31.2 square mm, element number = 127
Corners and middle: [26.52 28.71 28.64 31.00 29.30
-12.77 -0.00 -13.79 -0.00 -6.63
-0.63 -0.47 -0.65 -0.47 -0.51];

APPENDIX H—BEAM SHAPES AND ELEMENT GEOMETRIES FOR THE SUPPLIER E TRANSDUCER DESIGN (CONVEX SURFACES)

Supplier E produced a phased array transducer design for inspection through concave surfaces and a design for inspection through convex surfaces. Appendix H presents details of the transducer designed for the convex entry surface. The first half of the appendix provides the supplier's calculation of beam shapes at various depths below two convex surfaces, and the second half of the appendix shows the details of the element geometry for the phased array transducer.

A summary of ultrasonic modeling results for the phased array transducer designed by supplier E for the case of convex curved entry surface of radii of curvature of 11.33″ and 15.62″, respectively, at different depths is shown in figures H-1 through H-30. The model results presented in this appendix were produced by the supplier.

All results for concave radius 11.33″.

Results for convex radius = 11.33″, depth = 0.2″.

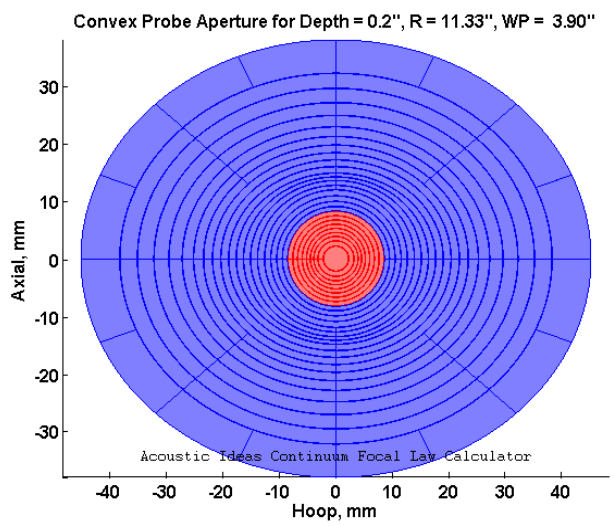


Figure H-1. Active Aperture for Convex Radius = 11.33″, Depth = 0.2″

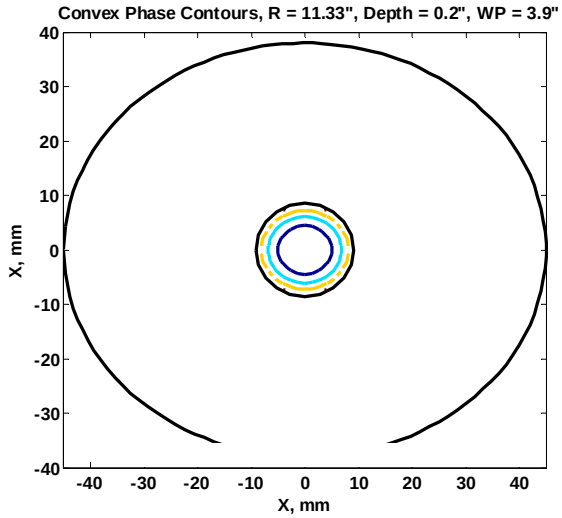


Figure H-2. Phase Variation for Convex Radius = 11.33″, Depth = 0.2″

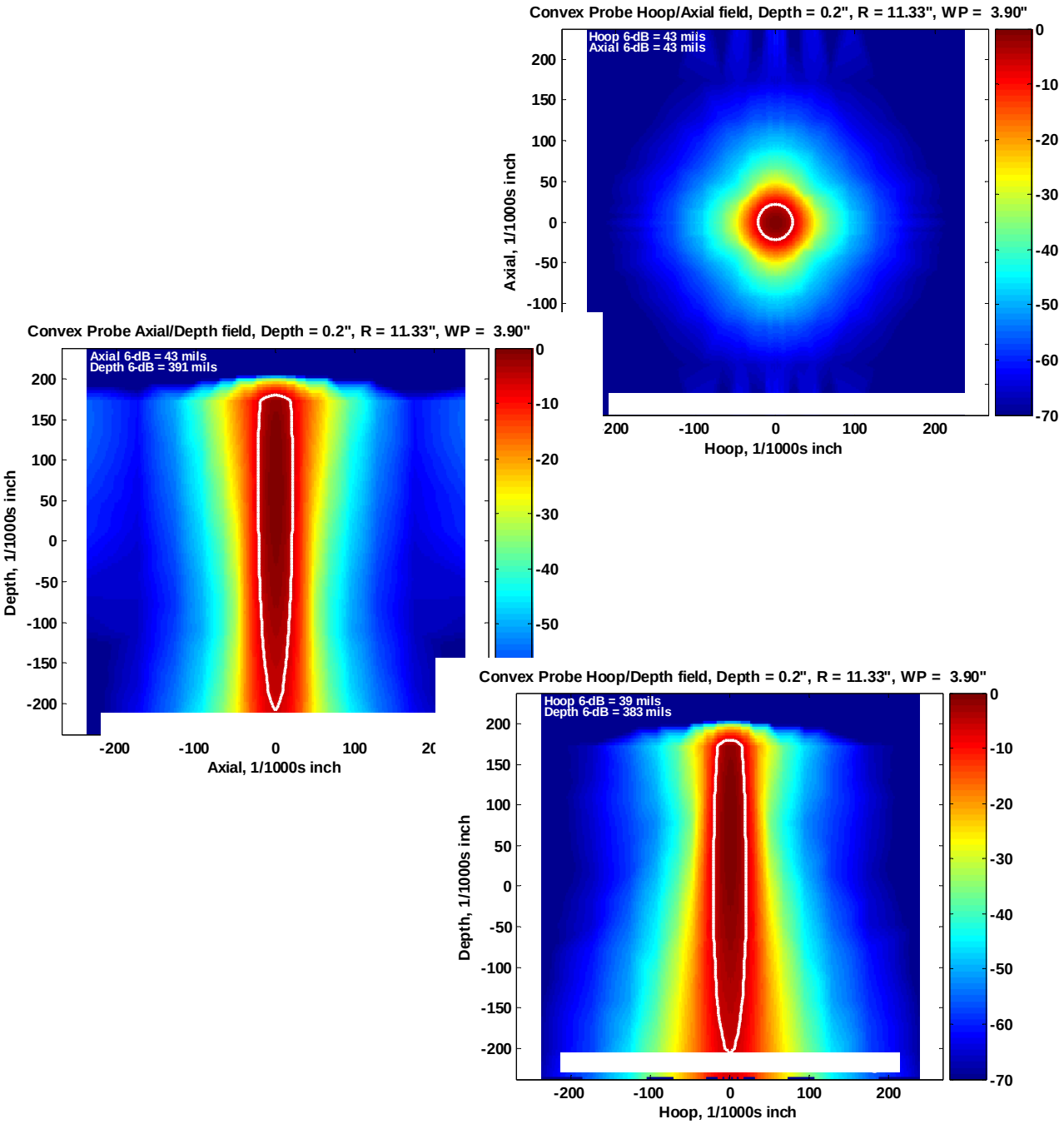


Figure H-3. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 11.33″, Depth = 0.2″

Results for convex radius = 11.33″, depth = 1.0″.

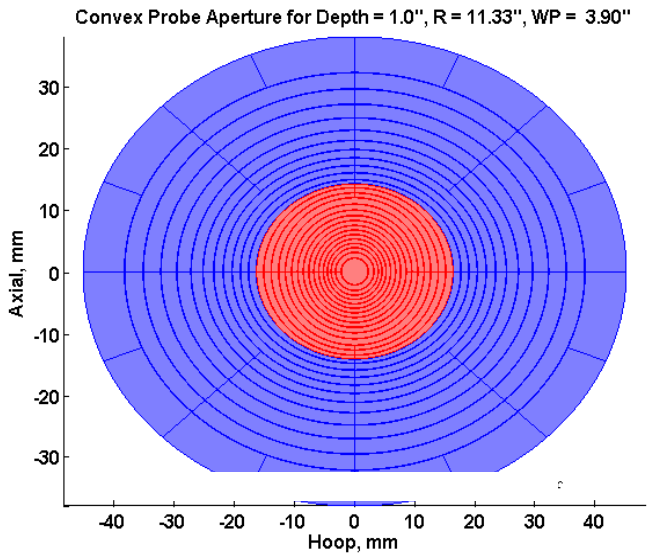


Figure H-4. Active Aperture for Convex Radius = 11.33″, Depth = 1.0″

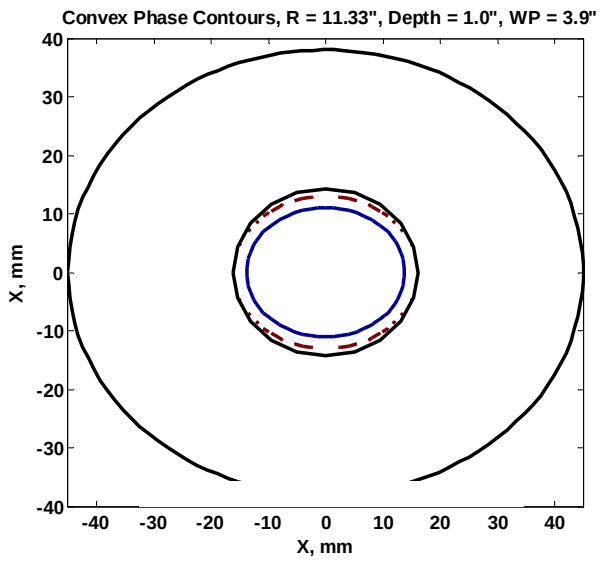


Figure H-5. Phase Variation for Convex Radius = 11.33″, Depth = 1.0″

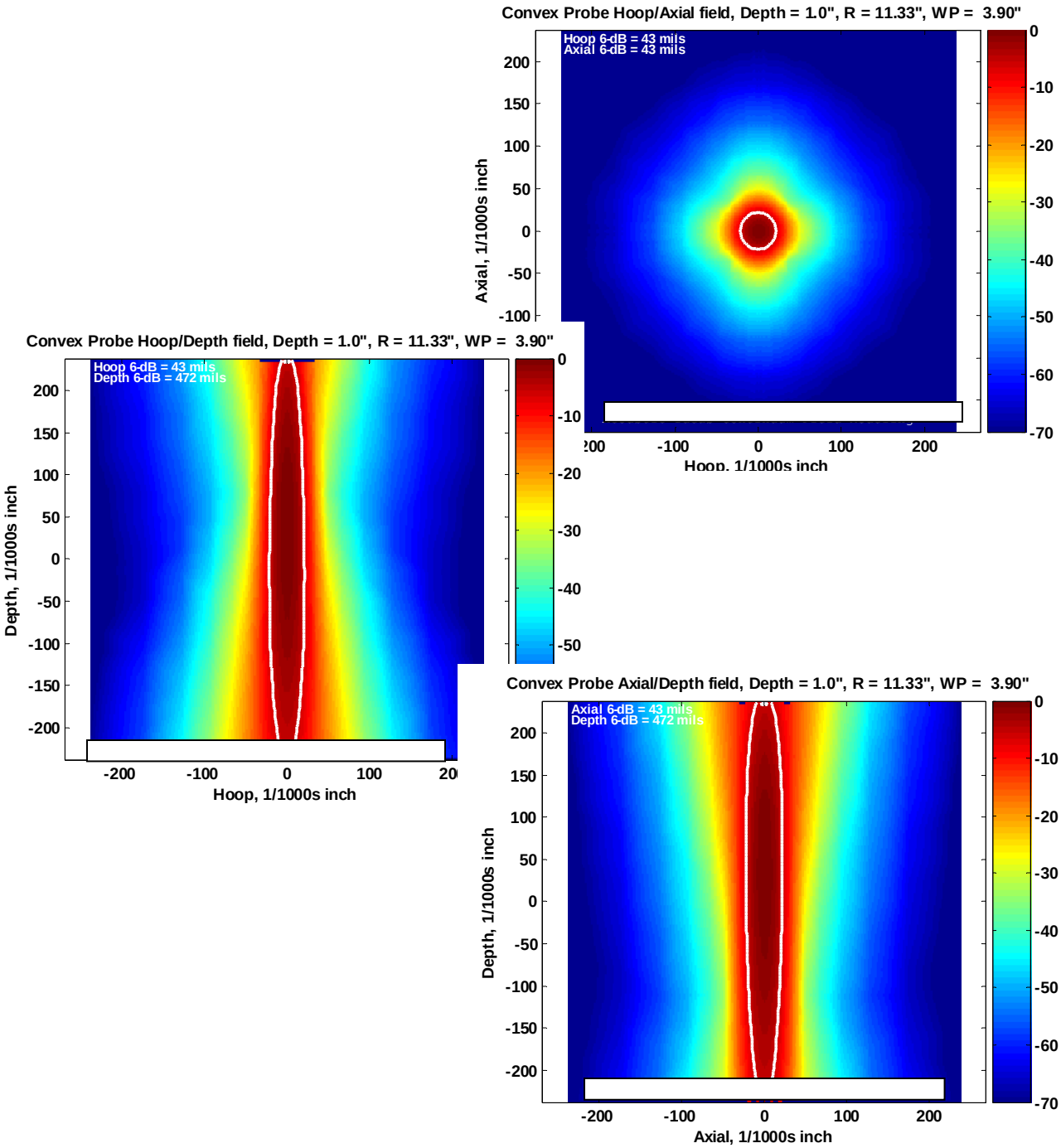


Figure H-6. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 11.33″, Depth = 1.0″

Results for convex radius = 11.33″, depth = 2.0″.

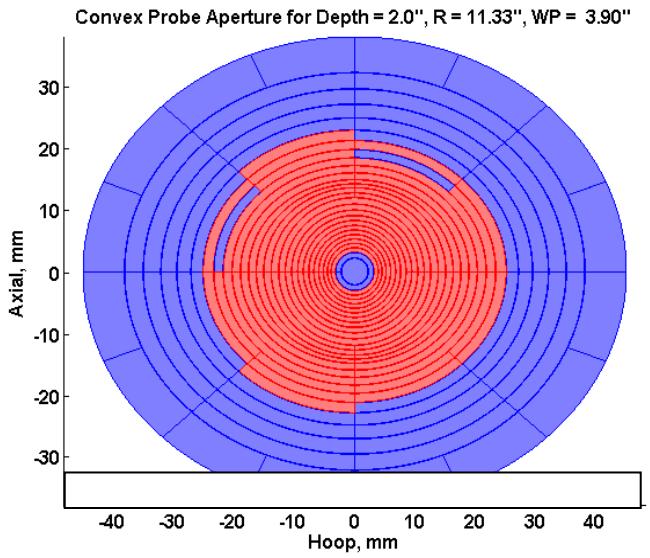


Figure H-7. Active Aperture for Convex Radius = 11.33″, Depth = 2.0″

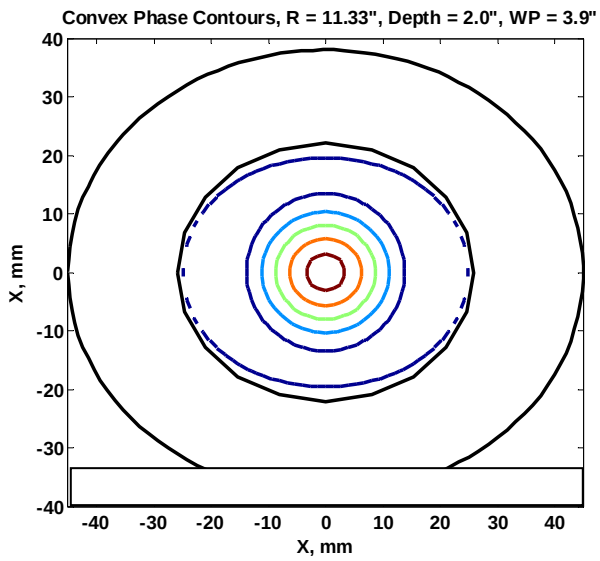


Figure H-8. Phase Variation for Convex Radius = 11.33″, Depth = 2.0″

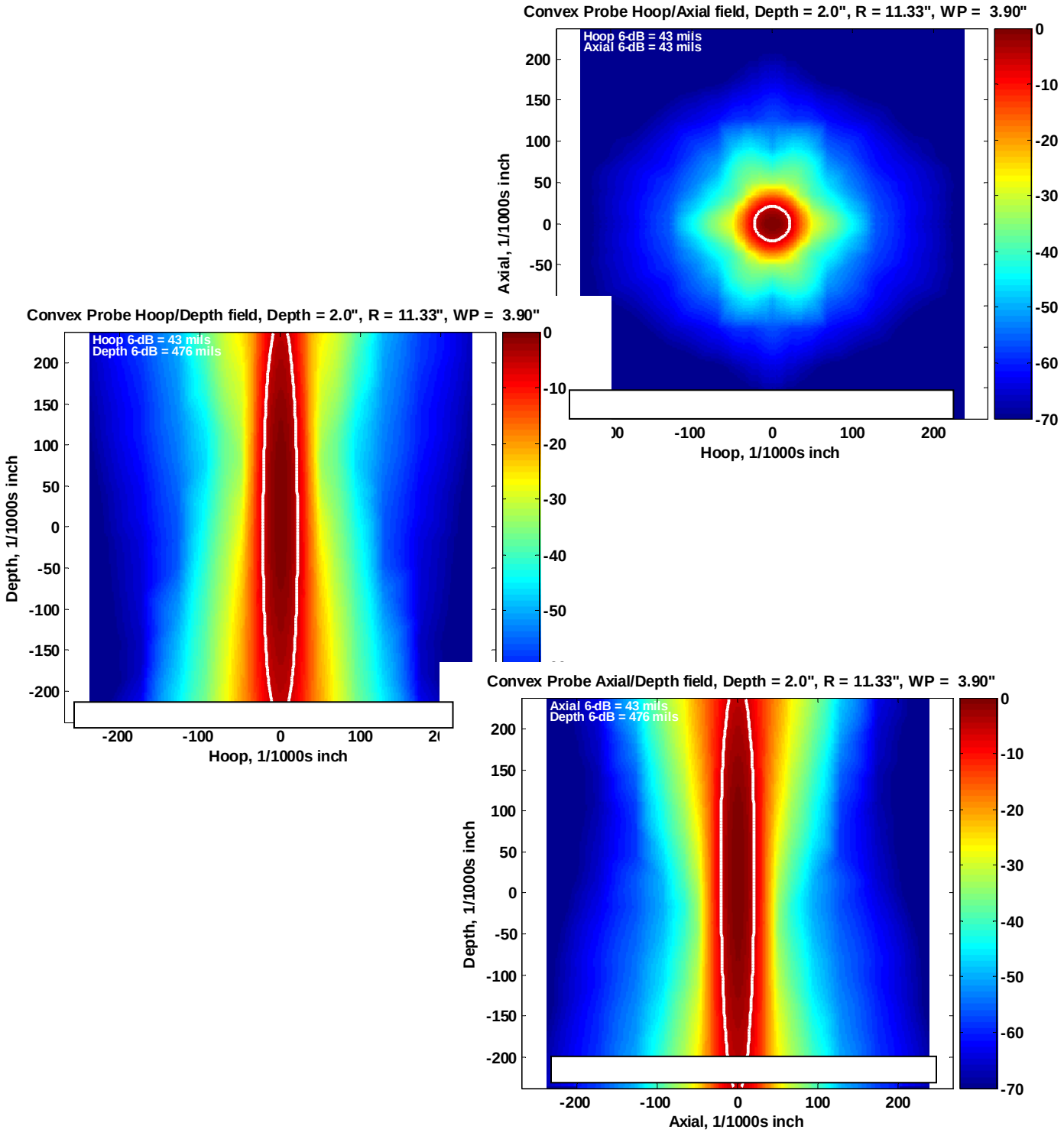


Figure H-9. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 11.33″, Depth = 2.0″

Results for convex radius = 11.33″, depth = 3.0″.

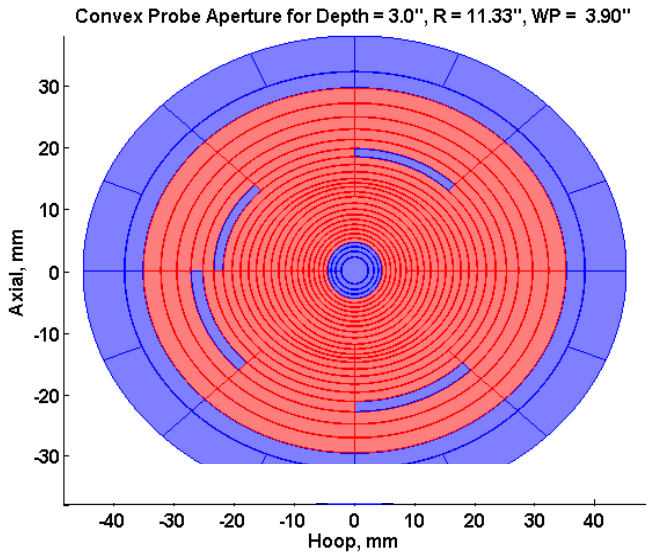


Figure H-10. Active Aperture for Convex Radius = 11.33″, Depth = 3.0″

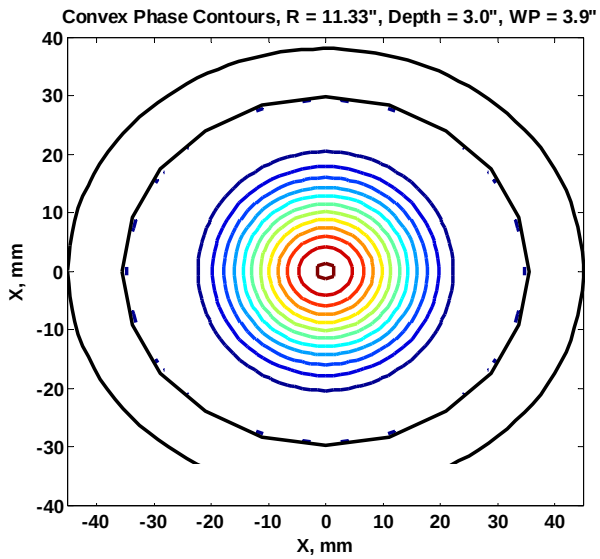


Figure H-11. Phase Variation for Convex Radius = 11.33″, Depth = 3.0″

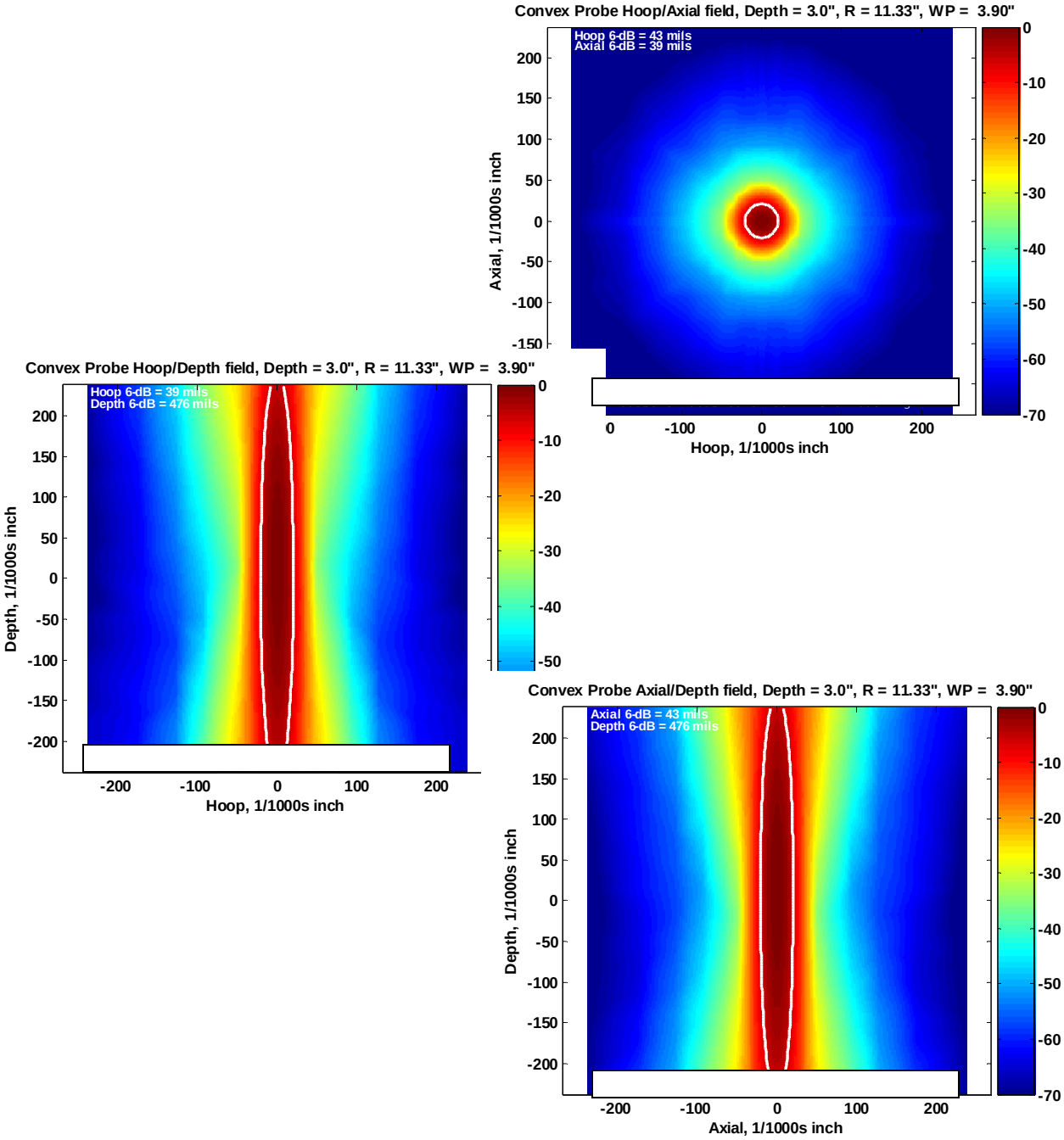


Figure H-12. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 11.33″, Depth = 3.0″

Results for convex radius = 11.33″, depth = 3.9″.

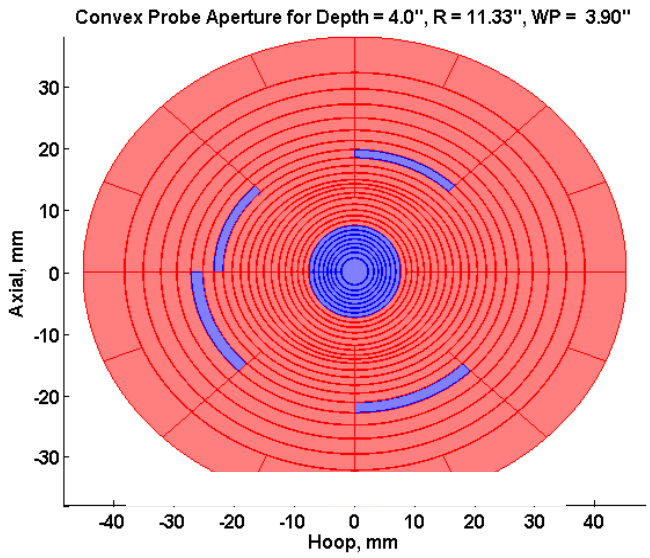


Figure H-13. Active Aperture for Convex Radius = 11.33″, Depth = 3.9″

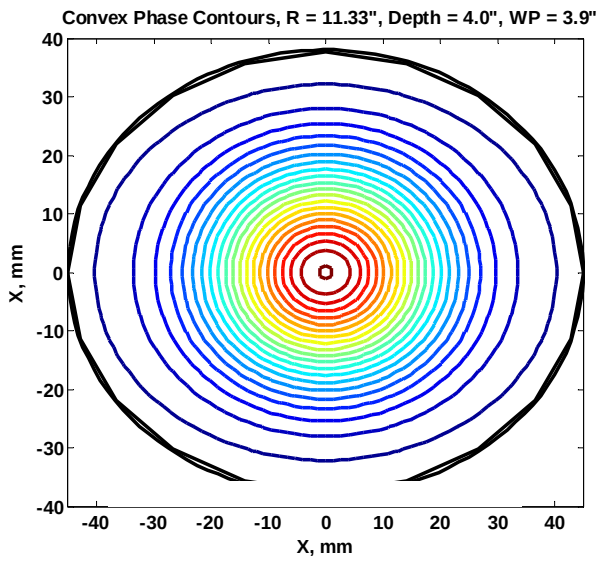


Figure H-14. Phase Variation for Convex Radius = 11.33″, Depth = 3.9″

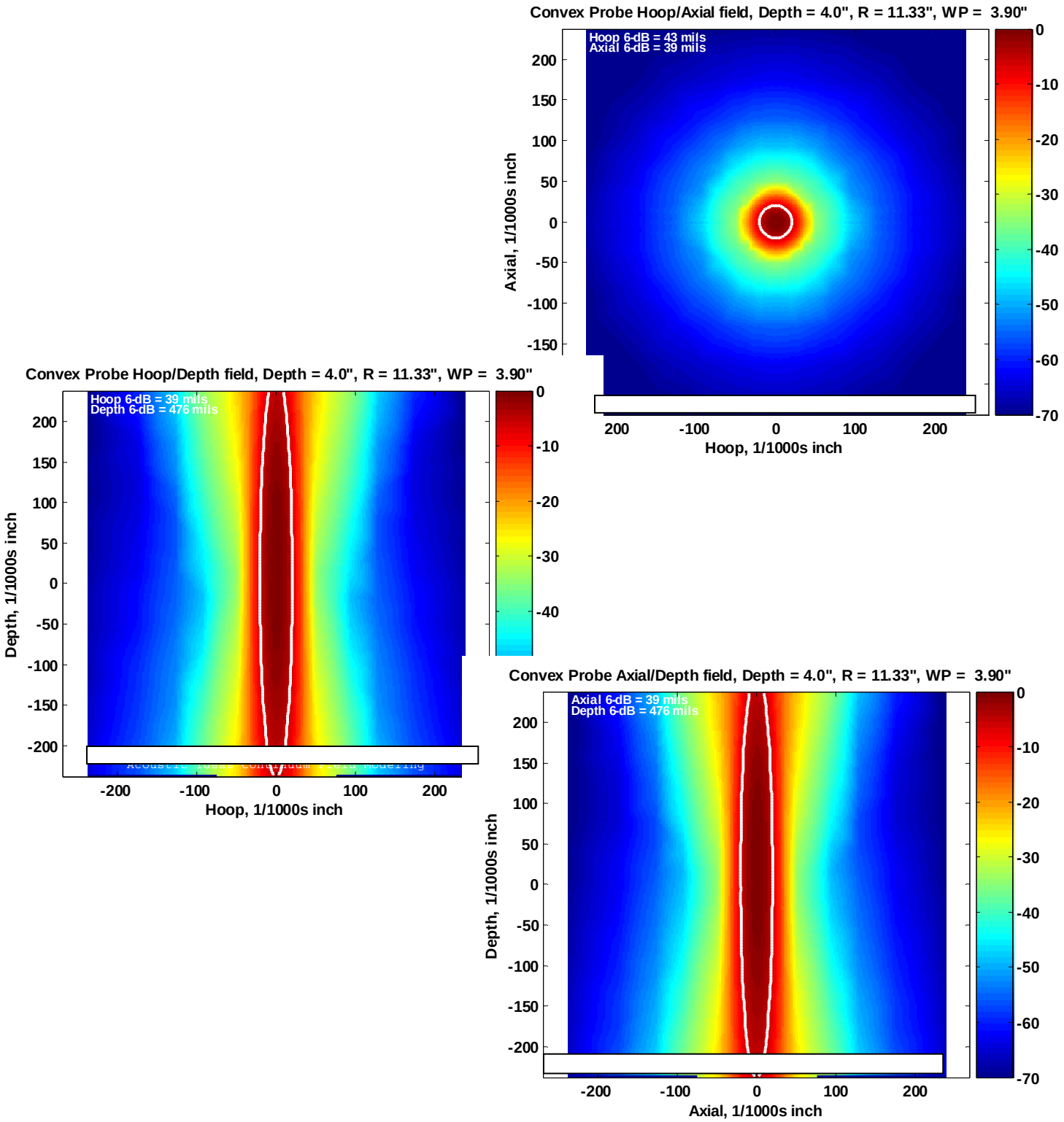


Figure H-15. Ultrasonic Field modeling and Beamwidth Measurement for Convex Radius = 11.33″, Depth = 3.9″

All results for convex radius 15.62″.

Results for convex radius = 15.62″, depth = 0.2″.

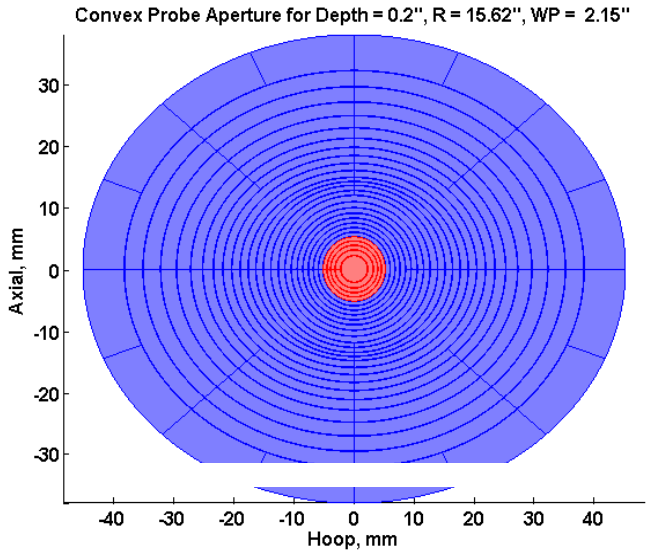


Figure H-16. Active Aperture for Convex Radius = 15.62″, Depth = 0.2″

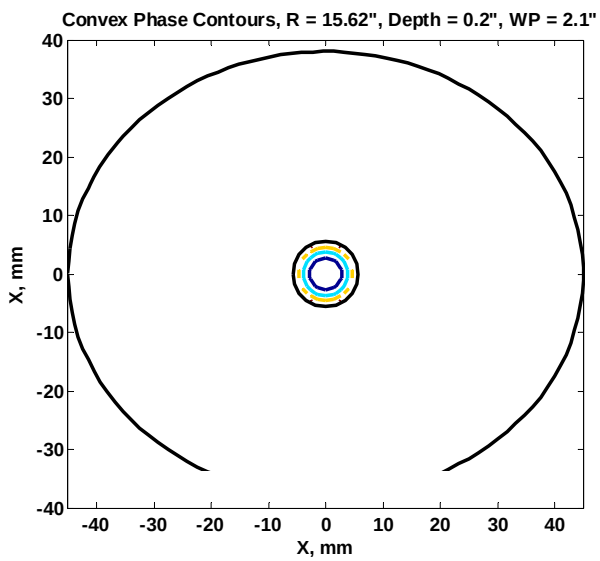


Figure H-17. Phase Variation for Convex Radius = 15.62″, Depth = 0.2″

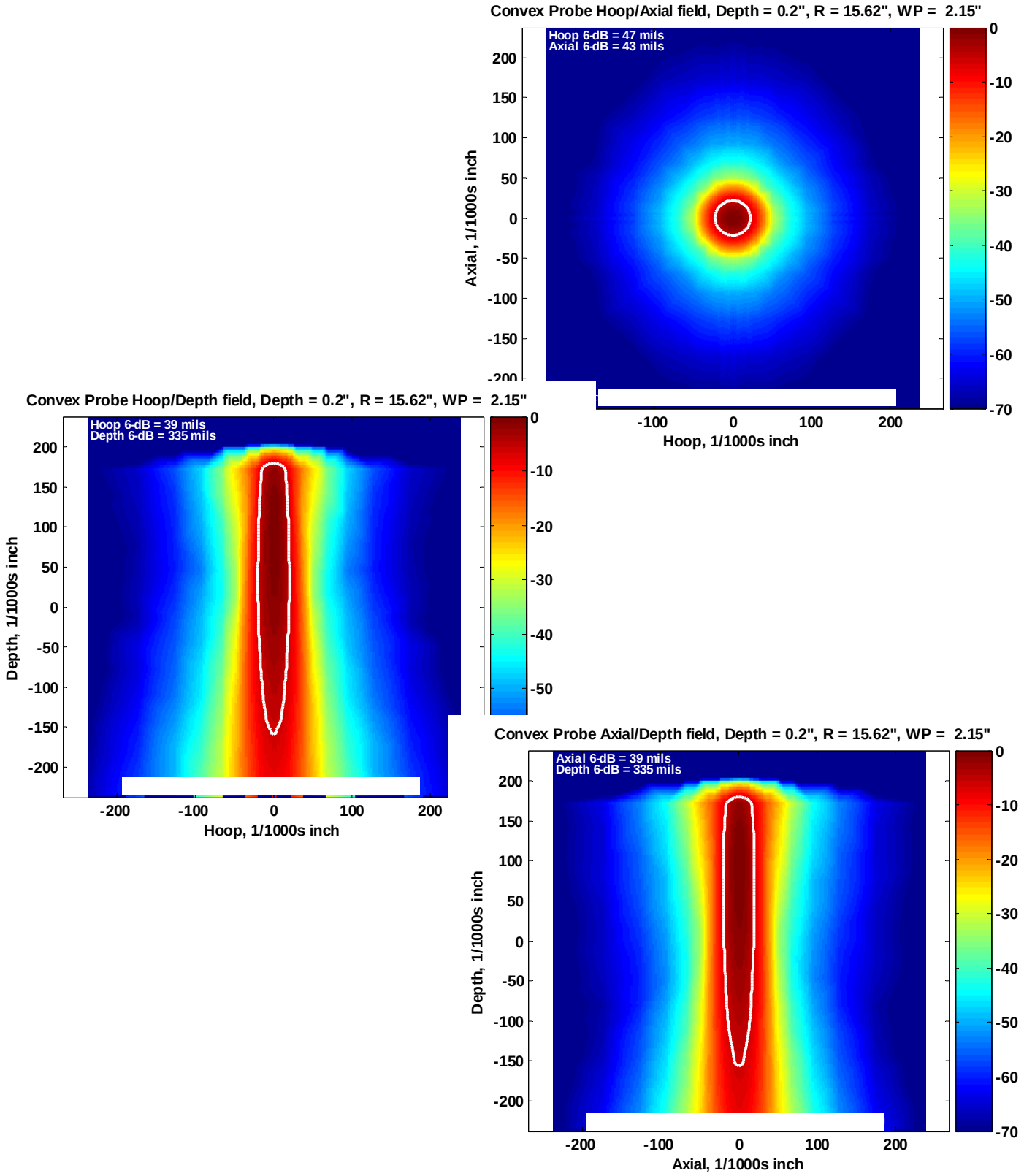


Figure H-18. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 15.62″, Depth = 0.2″

Results for convex radius = 15.62″, depth = 1.0″.

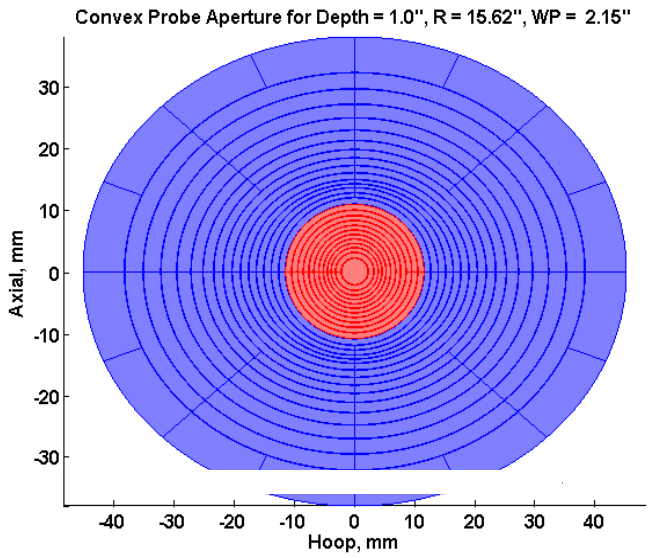


Figure H-19. Active Aperture for Convex Radius = 15.62″, Depth = 1.0″

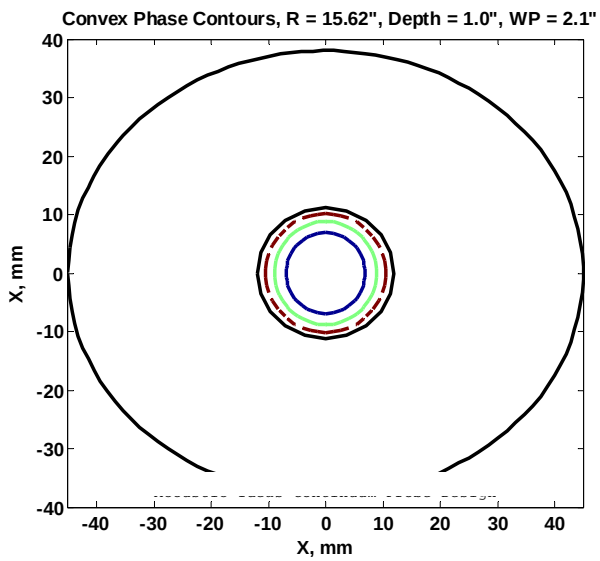


Figure H-20. Phase Variation for Convex Radius = 15.62″, Depth = 1.0″

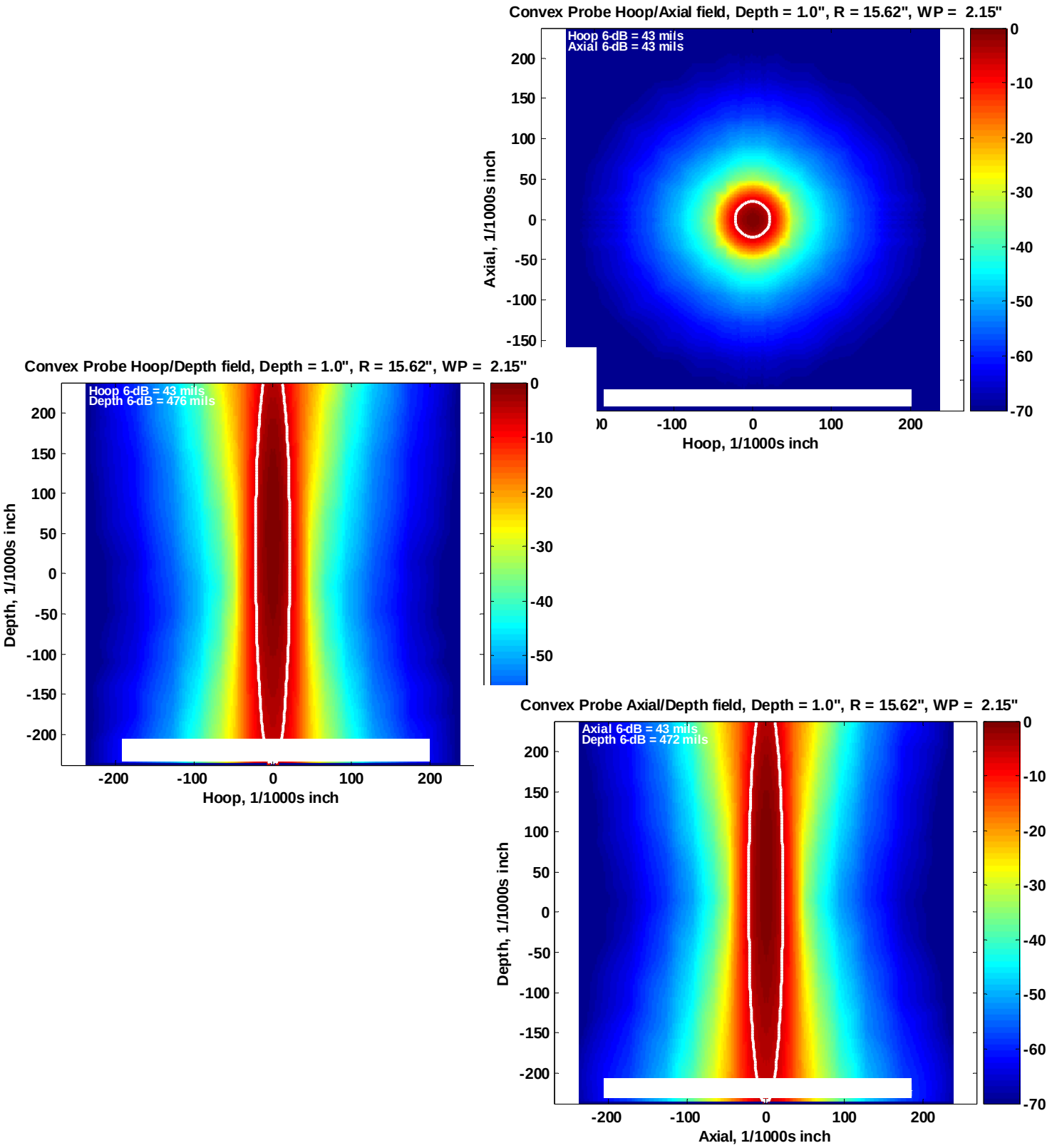


Figure H-21. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 15.62″, Depth = 1.0″

Results for convex radius = 15.62″, depth = 2.0″.

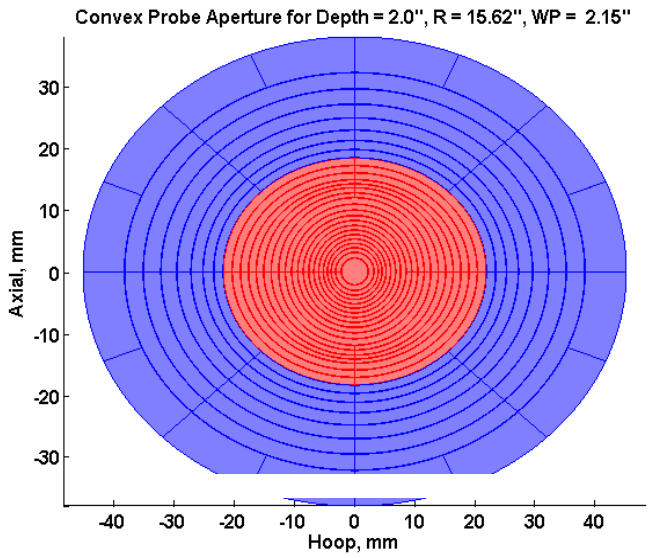


Figure H-22. Active Aperture for Convex Radius = 15.62″, Depth = 2.0″

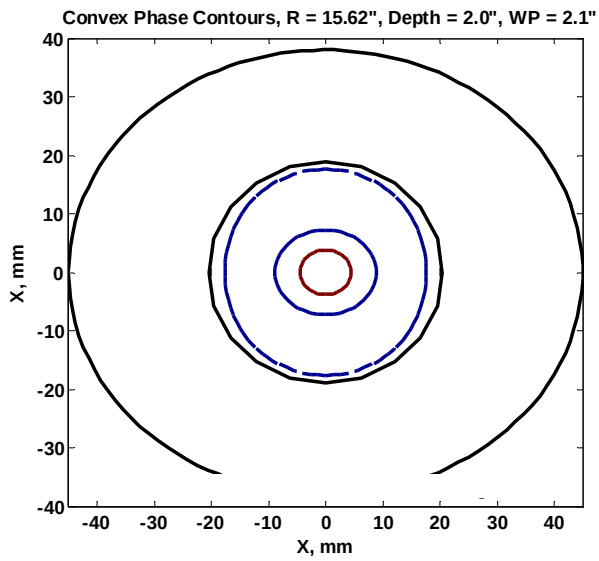


Figure H-23. Phase Variation for Convex Radius = 15.62″, Depth = 2.0″

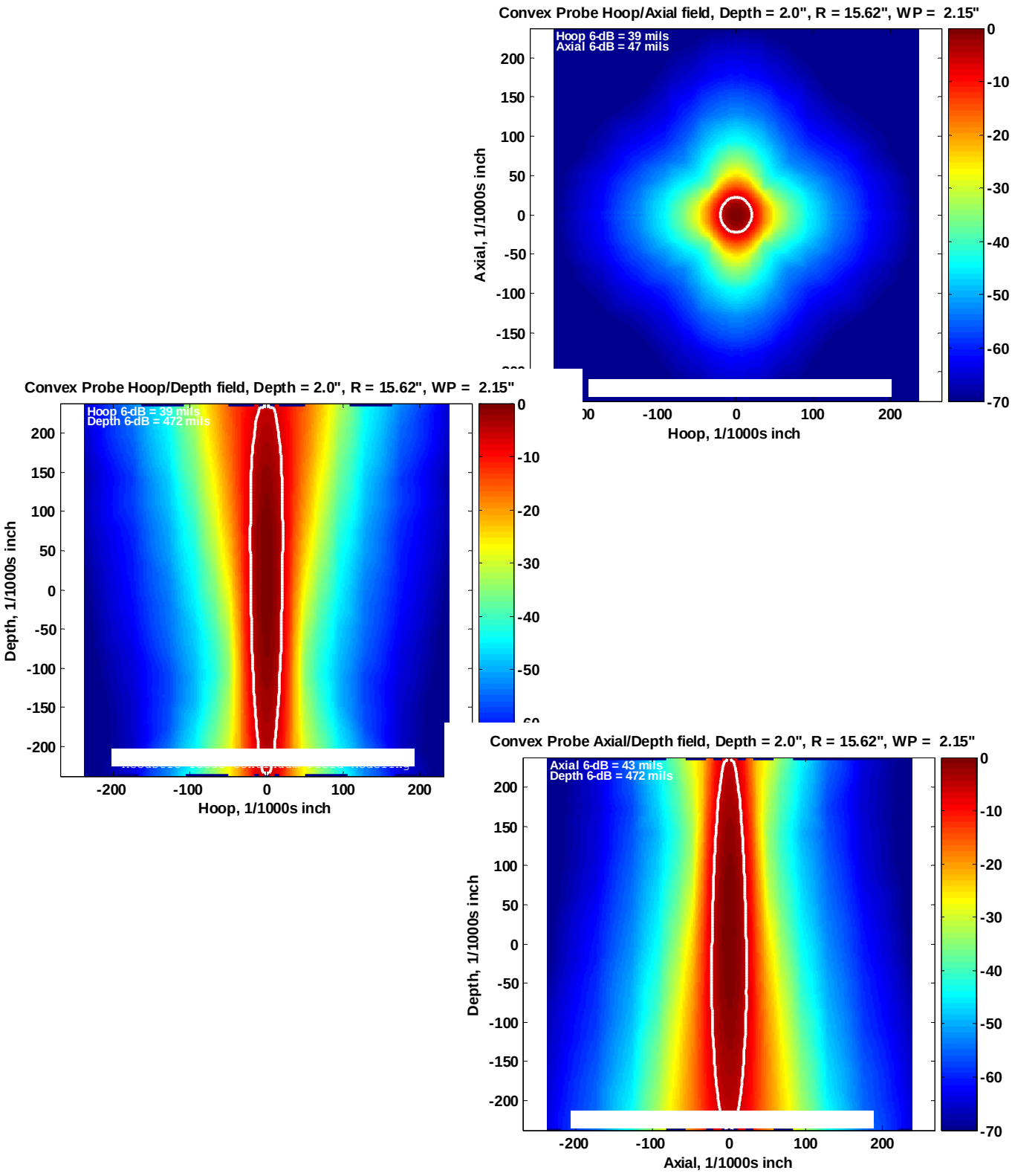


Figure H-24. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 15.62″, Depth = 2.0″

Results for convex radius = 15.62″, depth = 3.0″.

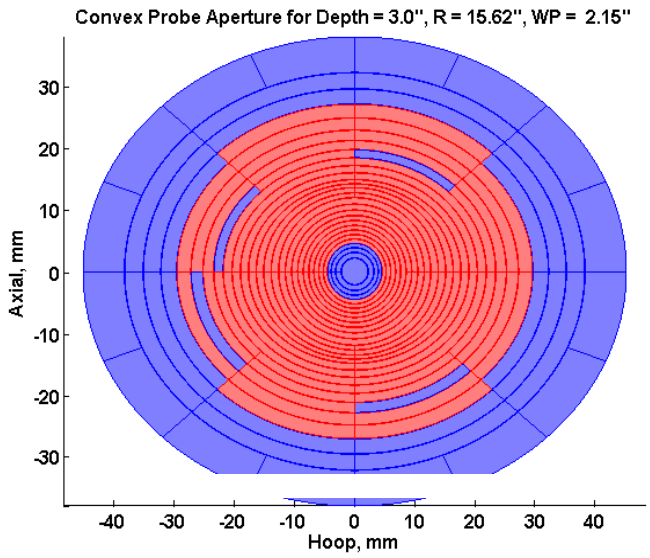


Figure H-25. Active Aperture for Convex Radius = 15.62″, Depth = 3.0″

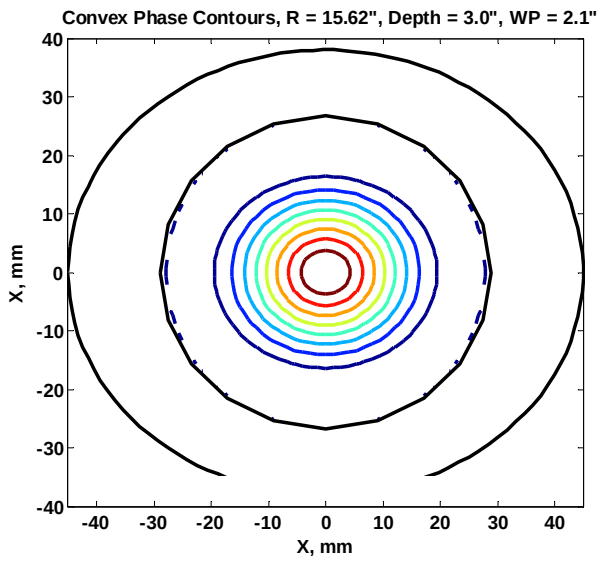


Figure H-26. Phase Variation for Convex Radius = 15.62″, Depth = 3.0″

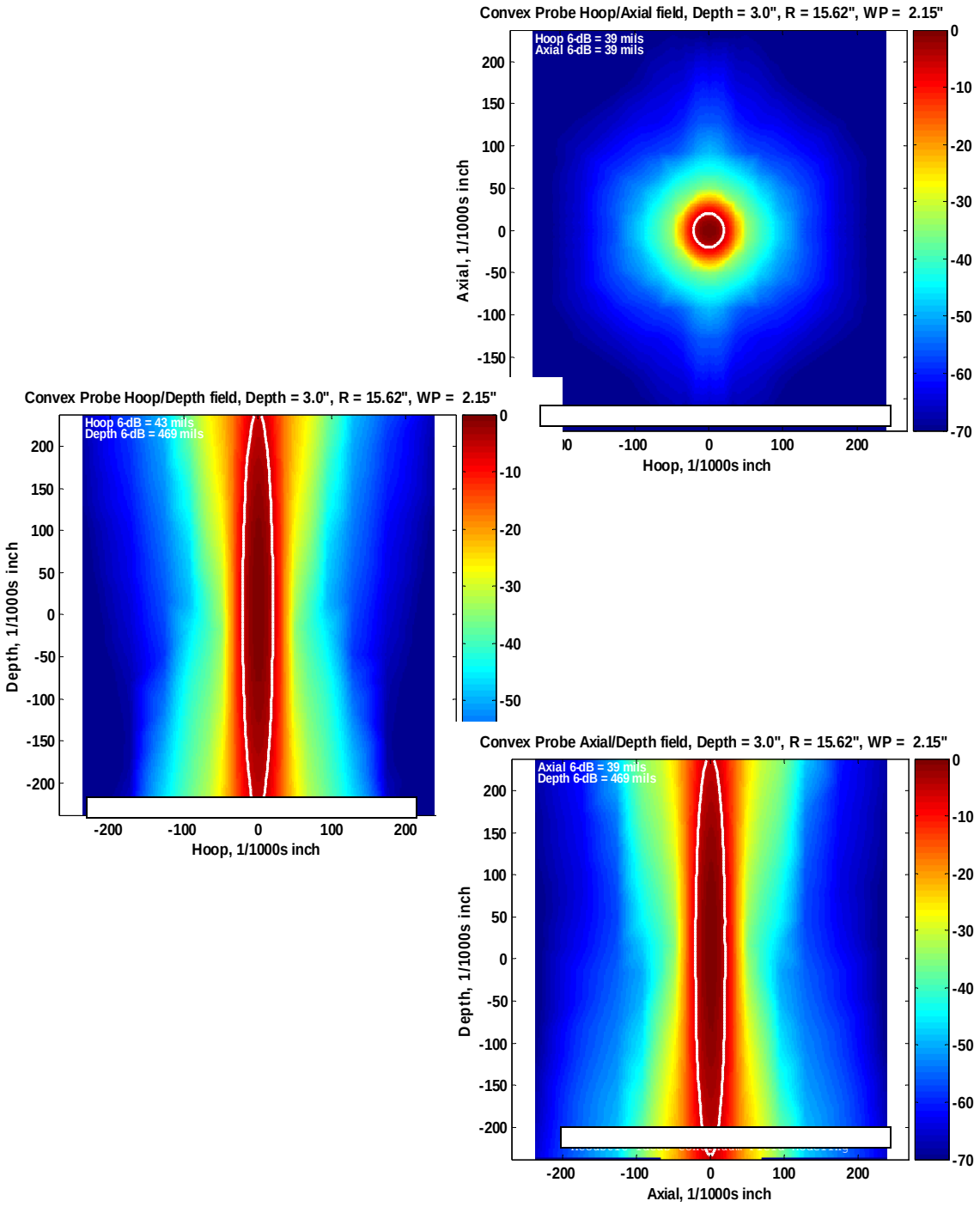


Figure H-27. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 15.62″, Depth = 3.0″

Results for convex radius = 15.62″, depth = 4.0″.

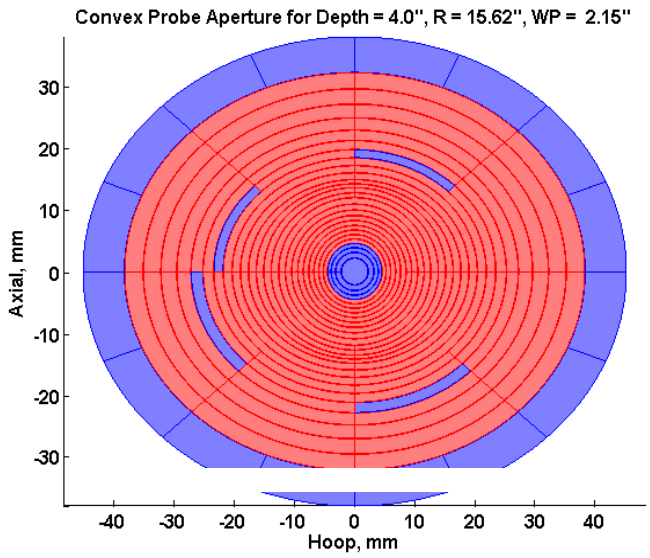


Figure H-28. Active Aperture for Convex Radius = 15.62″, Depth = 4.0″

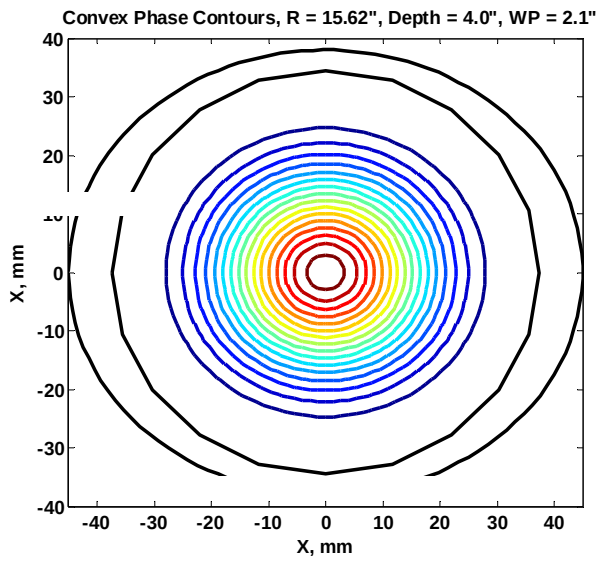


Figure H-29. Phase Variation for Convex Radius = 15.62″, Depth = 4.0″

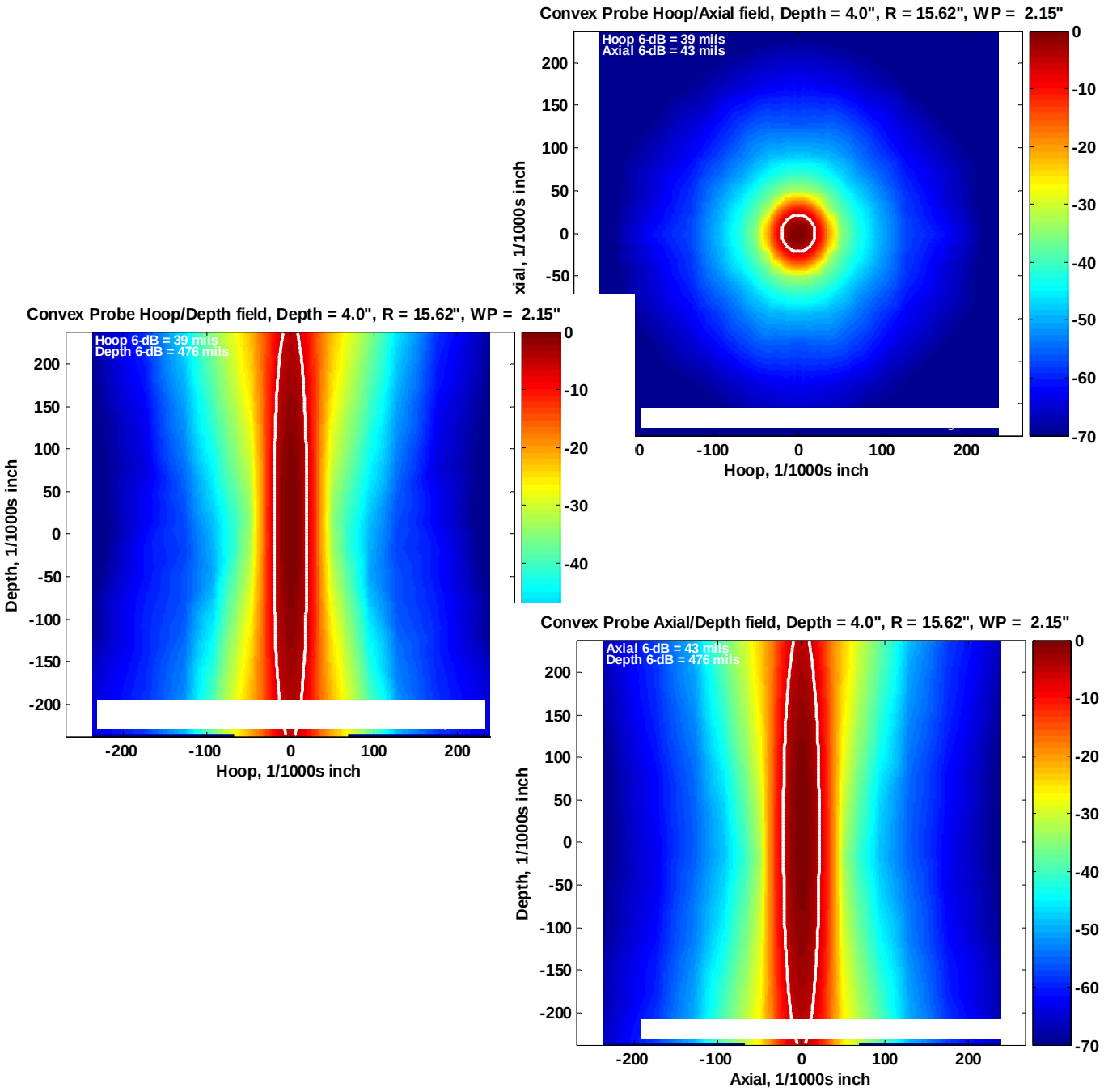


Figure H-30. Ultrasonic Field Modeling and Beamwidth Measurement for Convex Radius = 15.62″, Depth = 4.0″

The following detailed element listing is for the 10-MHz phased array transducer designed for a convex curved entry surface of radius of curvature of 13.475″ and a target beam spot size of approximately 45 mil.

Ring Number 1: Inner a = 0.00 mm, outer a = 2.20 mm, innber b = 0.00 mm, outer b = 2.13 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 14.7 square mm, element number = 1
Corners and middle: [0.00 0.00 2.20 2.20 -1.10
0.00 0.00 0.00 0.00 -0.00
0.00 0.00 -0.02 -0.02 -0.00];

Ring Number 2: Inner a = 2.30 mm, outer a = 3.14 mm, innber b = 2.23 mm, outer b = 3.05 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 14.0 square mm, element number = 2
Corners and middle: [2.30 2.30 3.14 3.14 -2.72
0.00 0.00 0.00 0.00 -0.00
-0.02 -0.02 -0.03 -0.03 -0.02];

Ring Number 3: Inner a = 3.24 mm, outer a = 3.85 mm, innber b = 3.15 mm, outer b = 3.80 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 13.8 square mm, element number = 3
Corners and middle: [3.24 3.24 3.85 3.85 -3.55
0.00 0.00 0.00 0.00 -0.00
-0.03 -0.03 -0.05 -0.05 -0.04];

Ring Number 4: Inner a = 3.95 mm, outer a = 4.49 mm, innber b = 3.90 mm, outer b = 4.50 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 15.1 square mm, element number = 4
Corners and middle: [3.95 3.95 4.49 4.49 -4.22
0.00 0.00 0.00 -0.00 -0.00
-0.05 -0.05 -0.06 -0.06 -0.06];

Ring Number 5: Inner a = 4.59 mm, outer a = 5.14 mm, innber b = 4.60 mm, outer b = 5.21 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 17.8 square mm, element number = 5
Corners and middle: [4.59 4.59 5.14 5.14 -4.87
0.00 -0.00 0.00 -0.00 -0.00
-0.07 -0.07 -0.08 -0.08 -0.07];

Ring Number 6: Inner a = 5.24 mm, outer a = 5.92 mm, innber b = 5.31 mm, outer b = 5.92 mm, number of sectors = 1
Sector number 1: theta start = 360.0 deg, theta end = 0.0 deg, sector area = 22.6 square mm, element number = 6
Corners and middle: [5.24 5.24 5.92 5.92 -5.58
-0.00 0.00 0.00 0.00 -0.00
-0.09 -0.09 -0.11 -0.11 -0.10];

Ring Number 7: Inner a = 6.02 mm, outer a = 6.73 mm, innber b = 6.02 mm, outer b = 6.65 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 26.8 square mm, element number = 7
Corners and middle: [6.02 6.02 6.73 6.73 -6.37
0.00 0.00 0.00 0.00 -0.00
-0.11 -0.11 -0.14 -0.14 -0.12];

Ring Number 8: Inner a = 6.83 mm, outer a = 7.58 mm, innber b = 6.75 mm, outer b = 7.41 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 31.5 square mm, element number = 8
Corners and middle: [6.83 6.83 7.58 7.58 -7.20
0.00 0.00 0.00 0.00 -0.00
-0.14 -0.14 -0.17 -0.17 -0.16];

Ring Number 9: Inner a = 7.68 mm, outer a = 8.47 mm, innber b = 7.51 mm, outer b = 8.20 mm, number of sectors = 1
Sector number 1: theta start = 0.0 deg, theta end = 360.0 deg, sector area = 36.9 square mm, element number = 9
Corners and middle: [7.68 7.68 8.47 8.47 -8.07
0.00 0.00 0.00 0.00 -0.00
-0.18 -0.18 -0.21 -0.21 -0.19];

Ring Number 10: Inner a = 8.57 mm, outer a = 9.41 mm, innber b = 8.30 mm, outer b = 9.02 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 21.6 square mm, element number = 10
Corners and middle: [8.57 -8.57 9.41 -9.41 -0.00
0.00 -0.00 0.00 -0.00 8.66
-0.22 -0.22 -0.26 -0.26 -0.19];
Sector number 2: theta start = 180.0 deg, theta end = 360.0 deg, sector area = 21.6 square mm, element number = 42
Corners and middle: [-8.57 8.57 -9.41 9.41 0.00
-0.00 0.00 -0.00 0.00 -8.66
-0.22 -0.22 -0.26 -0.26 -0.19];

Ring Number 11: Inner a = 9.51 mm, outer a = 10.40 mm, innber b = 9.12 mm, outer b = 9.89 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 25.5 square mm, element number = 11
Corners and middle: [9.51 -9.51 10.40 -10.40 -0.00
0.00 -0.00 0.00 -0.00 9.51
-0.26 -0.26 -0.31 -0.31 -0.22];
Sector number 2: theta start = 180.0 deg, theta end = 360.0 deg, sector area = 25.5 square mm, element number = 43
Corners and middle: [-9.51 9.51 -10.40 10.40 0.00
-0.00 0.00 -0.00 0.00 -9.51
-0.26 -0.26 -0.31 -0.31 -0.22];

Ring Number 12: Inner a = 10.50 mm, outer a = 11.45 mm, innber b = 9.99 mm, outer b = 10.85 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 30.3 square mm, element number = 12
Corners and middle: [10.50 -10.50 11.45 -11.45 -0.00
0.00 -0.00 0.00 -0.00 10.42
-0.31 -0.31 -0.37 -0.37 -0.26];
Sector number 2: theta start = 180.0 deg, theta end = 360.0 deg, sector area = 30.3 square mm, element number = 44
Corners and middle: [-10.50 10.50 -11.45 11.45 0.00
-0.00 0.00 -0.00 0.00 -10.42
-0.31 -0.31 -0.37 -0.37 -0.26];

Ring Number 13: Inner a = 11.55 mm, outer a = 12.56 mm, innber b = 10.95 mm, outer b = 11.91 mm, number of sectors = 2
Sector number 1: theta start = 0.0 deg, theta end = 180.0 deg, sector area = 36.2 square mm, element number = 13
Corners and middle: [11.55 -11.55 12.56 -12.56 -0.00
0.00 -0.00 0.00 -0.00 11.43
-0.37 -0.37 -0.44 -0.44 -0.30];
Sector number 2: theta start = 180.0 deg, theta end = 360.0 deg, sector area = 36.2 square mm, element number = 45
Corners and middle: [-11.55 11.55 -12.56 12.56 0.00
-0.00 0.00 -0.00 0.00 -11.43
-0.37 -0.37 -0.44 -0.44 -0.30];

Ring Number 14: Inner a = 12.66 mm, outer a = 13.79 mm, innber b = 12.01 mm, outer b = 12.69 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 18.0 square mm, element number = 14
Corners and middle: [12.66 -0.00 13.79 -0.00 8.86
0.00 12.01 0.00 12.69 9.17
-0.44 -0.33 -0.51 -0.36 -0.41];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 18.0 square mm, element number = 46
Corners and middle: [-0.00 -12.66 -0.00 -13.79 -8.86
12.01 -0.00 12.69 -0.00 9.17
-0.33 -0.44 -0.36 -0.51 -0.41];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 18.0 square mm, element number = 78
Corners and middle: [-12.66 0.00 -13.79 0.00 -8.86
-0.00 -12.01 -0.00 -12.69 -9.17
-0.44 -0.33 -0.51 -0.36 -0.41];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 18.0 square mm, element number = 110
Corners and middle: [0.00 12.66 0.00 13.79 8.86
-12.01 0.00 -12.69 0.00 -9.17
-0.33 -0.44 -0.36 -0.51 -0.41];

Ring Number 15: Inner a = 13.89 mm, outer a = 15.01 mm, innber b = 12.79 mm, outer b = 13.51 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 19.7 square mm, element number = 15
Corners and middle: [13.89 -0.00 15.01 -0.00 9.47
0.00 12.79 0.00 13.51 9.93
-0.52 -0.37 -0.60 -0.40 -0.46];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 19.7 square mm, element number = 47
Corners and middle: [-0.00 -13.89 -0.00 -15.01 -9.47
12.79 -0.00 13.51 -0.00 9.93
-0.37 -0.52 -0.40 -0.60 -0.46];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 19.7 square mm, element number = 79
Corners and middle: [-13.89 0.00 -15.01 0.00 -9.47
-0.00 -12.79 -0.00 -13.51 -9.93
-0.52 -0.37 -0.60 -0.40 -0.46];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 19.7 square mm, element number = 111
Corners and middle: [0.00 13.89 0.00 15.01 9.47
-12.79 0.00 -13.51 0.00 -9.93
-0.37 -0.52 -0.40 -0.60 -0.46];

Ring Number 16: Inner a = 15.11 mm, outer a = 16.26 mm, innber b = 13.61 mm, outer b = 14.14 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 19.0 square mm, element number = 16
Corners and middle: [15.11 -0.00 16.26 -0.00 10.03
0.00 13.61 0.00 14.14 10.66
-0.61 -0.41 -0.69 -0.43 -0.51];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 19.0 square mm, element number = 48
Corners and middle: [-0.00 -15.11 -0.00 -16.26 -10.03
13.61 -0.00 14.14 -0.00 10.66
-0.41 -0.61 -0.43 -0.69 -0.51];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 19.0 square mm, element number = 80
Corners and middle: [-15.11 0.00 -16.26 0.00 -10.03
-0.00 -13.61 -0.00 -14.14 -10.66
-0.61 -0.41 -0.69 -0.43 -0.51];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 19.0 square mm, element number = 112
Corners and middle: [0.00 15.11 0.00 16.26 10.03
-13.61 0.00 -14.14 0.00 -10.66
-0.41 -0.61 -0.43 -0.69 -0.51];

Ring Number 17: Inner a = 16.36 mm, outer a = 17.55 mm, innber b = 14.24 mm, outer b = 14.82 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 21.3 square mm, element number = 17
Corners and middle: [16.36 -0.00 17.55 -0.00 10.53
0.00 14.24 0.00 14.82 11.38
-0.70 -0.44 -0.79 -0.47 -0.56];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 21.3 square mm, element number = 49
Corners and middle: [-0.00 -16.36 -0.00 -17.55 -10.53
14.24 -0.00 14.82 -0.00 11.38
-0.44 -0.70 -0.47 -0.79 -0.56];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 21.3 square mm, element number = 81
Corners and middle: [-16.36 0.00 -17.55 0.00 -10.53
-0.00 -14.24 -0.00 -14.82 -11.38
-0.70 -0.44 -0.79 -0.47 -0.56];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 21.3 square mm, element number = 113
Corners and middle: [0.00 16.36 0.00 17.55 10.54
-14.24 0.00 -14.82 0.00 -11.38
-0.44 -0.70 -0.47 -0.79 -0.56];

Ring Number 18: Inner a = 17.65 mm, outer a = 18.88 mm, innber b = 14.92 mm, outer b = 15.93 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 29.4 square mm, element number = 18
Corners and middle: [17.65 -0.00 18.88 -0.00 11.20
0.00 14.92 0.00 15.93 12.19
-0.79 -0.47 -0.89 -0.52 -0.63];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 29.4 square mm, element number = 50
Corners and middle: [-0.00 -17.65 -0.00 -18.88 -11.20
14.92 -0.00 15.93 -0.00 12.18
-0.47 -0.79 -0.52 -0.89 -0.63];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 29.4 square mm, element number = 82
Corners and middle: [-17.65 0.00 -18.88 0.00 -11.20
-0.00 -14.92 -0.00 -15.93 -12.19
-0.79 -0.47 -0.89 -0.52 -0.63];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 29.4 square mm, element number = 114
Corners and middle: [0.00 17.65 0.00 18.88 11.20
-14.92 0.00 -15.93 0.00 -12.18
-0.47 -0.79 -0.52 -0.89 -0.63];

Ring Number 19: Inner a = 18.98 mm, outer a = 20.26 mm, innber b = 16.03 mm, outer b = 17.10 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 33.2 square mm, element number = 19
Corners and middle: [18.98 -0.00 20.26 -0.00 12.03
0.00 16.03 0.00 17.10 13.09
-0.90 -0.53 -1.01 -0.59 -0.71];
Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 33.2 square mm, element number = 51
Corners and middle: [-0.00 -18.98 -0.00 -20.26 -12.03
16.03 -0.00 17.10 -0.00 13.09
-0.53 -0.90 -0.59 -1.01 -0.71];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 33.2 square mm, element number = 83
Corners and middle: [-18.98 0.00 -20.26 0.00 -12.03
-0.00 -16.03 -0.00 -17.10 -13.09
-0.90 -0.53 -1.01 -0.59 -0.71];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 33.2 square mm, element number = 115
Corners and middle: [0.00 18.98 0.00 20.26 12.03
-16.03 0.00 -17.10 0.00 -13.09
-0.53 -0.90 -0.59 -1.01 -0.71];

Ring Number 20: Inner a = 20.36 mm, outer a = 21.73 mm, innber b = 17.20 mm, outer b = 18.34 mm, number of sectors = 4
Sector number 1: theta start = 0.0 deg, theta end = 90.0 deg, sector area = 37.9 square mm, element number = 20
Corners and middle: [20.36 -0.00 21.73 -0.00 12.90
0.00 17.20 0.00 18.34 14.04
-1.02 -0.59 -1.13 -0.65 -0.79];

Sector number 2: theta start = 90.0 deg, theta end = 180.0 deg, sector area = 37.9 square mm, element number = 52
Corners and middle: [-0.00 -20.36 -0.00 -21.73 -12.90
17.20 -0.00 18.34 -0.00 14.04
-0.59 -1.02 -0.65 -1.13 -0.79];
Sector number 3: theta start = 180.0 deg, theta end = 270.0 deg, sector area = 37.9 square mm, element number = 84
Corners and middle: [-20.36 0.00 -21.73 0.00 -12.90
-0.00 -17.20 -0.00 -18.34 -14.04
-1.02 -0.59 -1.13 -0.65 -0.79];
Sector number 4: theta start = 270.0 deg, theta end = 360.0 deg, sector area = 37.9 square mm, element number = 116
Corners and middle: [0.00 20.36 0.00 21.73 12.90
-17.20 0.00 -18.34 0.00 -14.04
-0.59 -1.02 -0.65 -1.13 -0.79];

Ring Number 21: Inner a = 21.83 mm, outer a = 23.32 mm, innber b = 18.44 mm, outer b = 19.68 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 40.0 deg, sector area = 22.2 square mm, element number = 33
Corners and middle: [21.83 15.49 23.32 16.53 20.67
0.00 12.99 0.00 13.88 7.66
-1.14 -0.90 -1.28 -1.00 -1.13];
Sector number 2: theta start = 40.0 deg, theta end = 90.0 deg, sector area = 22.2 square mm, element number = 254
Corners and middle: [15.49 -0.00 16.53 -0.00 8.03
12.99 18.44 13.88 19.68 17.81
-0.90 -0.66 -1.00 -0.72 -0.76];
Sector number 3: theta start = 90.0 deg, theta end = 140.0 deg, sector area = 22.2 square mm, element number = 34
Corners and middle: [-0.00 -15.49 -0.00 -16.53 -8.04
18.44 12.99 19.68 13.88 17.81
-0.66 -0.90 -0.72 -1.00 -0.76];
Sector number 4: theta start = 140.0 deg, theta end = 180.0 deg, sector area = 22.2 square mm, element number = 253
Corners and middle: [-15.49 -21.83 -16.53 -23.32 -20.67
12.99 -0.00 13.88 -0.00 7.65
-0.90 -1.14 -1.00 -1.28 -1.13];
Sector number 5: theta start = 180.0 deg, theta end = 220.0 deg, sector area = 22.2 square mm, element number = 65
Corners and middle: [-21.83 -15.48 -23.32 -16.53 -20.67
-0.00 -12.99 -0.00 -13.88 -7.66
-1.14 -0.90 -1.28 -1.00 -1.13];
Sector number 6: theta start = 220.0 deg, theta end = 270.0 deg, sector area = 22.2 square mm, element number = 66
Corners and middle: [-15.48 0.00 -16.53 0.00 -8.03

-12.99 -18.44 -13.88 -19.68 -17.81
-0.90 -0.66 -1.00 -0.72 -0.76];
Sector number 7: theta start = 270.0 deg, theta end = 320.0 deg, sector area = 22.2 square mm, element number = 98
Corners and middle: [0.00 15.49 0.00 16.54 8.04
-18.44 -12.99 -19.68 -13.87 -17.81
-0.66 -0.90 -0.72 -1.00 -0.76];
Sector number 8: theta start = 320.0 deg, theta end = 360.0 deg, sector area = 22.2 square mm, element number = 97
Corners and middle: [15.49 21.83 16.54 23.32 20.67
-12.99 0.00 -13.87 0.00 -7.66
-0.90 -1.14 -1.00 -1.28 -1.13];

Ring Number 22: Inner a = 23.42 mm, outer a = 25.07 mm, innber b = 19.78 mm, outer b = 21.16 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 40.0 deg, sector area = 26.4 square mm, element number = 21
Corners and middle: [23.42 16.61 25.07 17.77 22.20
0.00 13.94 0.00 14.93 8.23
-1.29 -1.01 -1.44 -1.13 -1.27];
Sector number 2: theta start = 40.0 deg, theta end = 90.0 deg, sector area = 26.4 square mm, element number = 22
Corners and middle: [16.61 -0.00 17.77 -0.00 8.62
13.94 19.78 14.93 21.16 19.13
-1.01 -0.73 -1.13 -0.81 -0.84];
Sector number 3: theta start = 90.0 deg, theta end = 140.0 deg, sector area = 26.4 square mm, element number = 54
Corners and middle: [-0.00 -16.61 -0.00 -17.77 -8.63
19.78 13.94 21.16 14.92 19.13
-0.73 -1.01 -0.81 -1.13 -0.84];
Sector number 4: theta start = 140.0 deg, theta end = 180.0 deg, sector area = 26.4 square mm, element number = 53
Corners and middle: [-16.61 -23.42 -17.77 -25.07 -22.20
13.94 -0.00 14.92 -0.00 8.22
-1.01 -1.29 -1.13 -1.44 -1.27];
Sector number 5: theta start = 180.0 deg, theta end = 220.0 deg, sector area = 26.4 square mm, element number = 85
Corners and middle: [-23.42 -16.61 -25.07 -17.77 -22.19
-0.00 -13.95 -0.00 -14.93 -8.23
-1.29 -1.01 -1.44 -1.13 -1.27];
Sector number 6: theta start = 220.0 deg, theta end = 270.0 deg, sector area = 26.4 square mm, element number = 86
Corners and middle: [-16.61 0.00 -17.77 0.00 -8.62
-13.95 -19.78 -14.93 -21.16 -19.13
-1.01 -0.73 -1.13 -0.81 -0.84];

Sector number 7: theta start = 270.0 deg, theta end = 320.0 deg, sector area = 26.4 square mm, element number = 118
Corners and middle: [0.00 16.61 0.00 17.77 8.63
-19.78 -13.94 -21.16 -14.92 -19.13
-0.73 -1.01 -0.81 -1.13 -0.84];
Sector number 8: theta start = 320.0 deg, theta end = 360.0 deg, sector area = 26.4 square mm, element number = 117
Corners and middle: [16.61 23.42 17.77 25.07 22.20
-13.94 0.00 -14.92 0.00 -8.23
-1.01 -1.29 -1.13 -1.44 -1.27];

Ring Number 23: Inner a = 25.17 mm, outer a = 27.07 mm, innber b = 21.26 mm, outer b = 22.85 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 40.0 deg, sector area = 32.7 square mm, element number = 35
Corners and middle: [25.17 17.84 27.07 19.18 23.91
0.00 14.99 0.00 16.12 8.87
-1.45 -1.13 -1.64 -1.27 -1.44];
Sector number 2: theta start = 40.0 deg, theta end = 90.0 deg, sector area = 32.7 square mm, element number = 36
Corners and middle: [17.84 -0.00 19.18 -0.00 9.29
14.99 21.26 16.12 22.85 20.61
-1.13 -0.81 -1.27 -0.90 -0.94];
Sector number 3: theta start = 90.0 deg, theta end = 140.0 deg, sector area = 32.7 square mm, element number = 68
Corners and middle: [-0.00 -17.85 -0.00 -19.18 -9.29
21.26 14.99 22.85 16.12 20.61
-0.81 -1.13 -0.90 -1.27 -0.94];
Sector number 4: theta start = 140.0 deg, theta end = 180.0 deg, sector area = 32.7 square mm, element number = 67
Corners and middle: [-17.85 -25.17 -19.18 -27.07 -23.91
14.99 -0.00 16.12 -0.00 8.87
-1.13 -1.45 -1.27 -1.64 -1.44];
Sector number 5: theta start = 180.0 deg, theta end = 220.0 deg, sector area = 32.7 square mm, element number = 256
Corners and middle: [-25.17 -17.84 -27.07 -19.18 -23.91
-0.00 -14.99 -0.00 -16.12 -8.87
-1.45 -1.13 -1.64 -1.27 -1.44];
Sector number 6: theta start = 220.0 deg, theta end = 270.0 deg, sector area = 32.7 square mm, element number = 99
Corners and middle: [-17.84 0.00 -19.18 0.00 -9.29
-14.99 -21.26 -16.12 -22.85 -20.61
-1.13 -0.81 -1.27 -0.90 -0.94];
Sector number 7: theta start = 270.0 deg, theta end = 320.0 deg, sector area = 32.7 square mm, element number = 255
Corners and middle: [0.00 17.85 0.00 19.18 9.30

-21.26 -14.99 -22.85 -16.12 -20.61
-0.81 -1.13 -0.90 -1.27 -0.94];
Sector number 8: theta start = 320.0 deg, theta end = 360.0 deg, sector area = 32.7 square mm, element number = 100
Corners and middle: [17.85 25.17 19.18 27.07 23.91
-14.99 0.00 -16.12 0.00 -8.87
-1.13 -1.45 -1.27 -1.64 -1.44];

Ring Number 24: Inner a = 27.17 mm, outer a = 29.42 mm, innber b = 22.95 mm, outer b = 24.83 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 40.1 deg, sector area = 42.0 square mm, element number = 23
Corners and middle: [27.17 19.25 29.42 20.84 25.90
0.00 16.19 0.00 17.53 9.62
-1.65 -1.28 -1.89 -1.45 -1.64];
Sector number 2: theta start = 40.1 deg, theta end = 90.0 deg, sector area = 42.0 square mm, element number = 24
Corners and middle: [19.25 -0.00 20.84 -0.00 10.06
16.19 22.95 17.53 24.83 22.33
-1.28 -0.91 -1.45 -1.02 -1.06];
Sector number 3: theta start = 90.0 deg, theta end = 140.0 deg, sector area = 42.0 square mm, element number = 56
Corners and middle: [-0.00 -19.26 -0.00 -20.84 -10.06
22.95 16.19 24.83 17.52 22.33
-0.91 -1.28 -1.02 -1.45 -1.06];
Sector number 4: theta start = 140.0 deg, theta end = 180.0 deg, sector area = 42.0 square mm, element number = 55
Corners and middle: [-19.26 -27.17 -20.84 -29.42 -25.90
16.19 -0.00 17.52 -0.00 9.61
-1.28 -1.65 -1.45 -1.89 -1.64];
Sector number 5: theta start = 180.0 deg, theta end = 220.1 deg, sector area = 42.0 square mm, element number = 87
Corners and middle: [-27.17 -19.25 -29.42 -20.84 -25.90
-0.00 -16.19 -0.00 -17.53 -9.61
-1.65 -1.28 -1.89 -1.45 -1.64];
Sector number 6: theta start = 220.1 deg, theta end = 270.0 deg, sector area = 42.0 square mm, element number = 88
Corners and middle: [-19.25 0.00 -20.84 0.00 -10.06
-16.19 -22.95 -17.53 -24.83 -22.33
-1.28 -0.91 -1.45 -1.02 -1.06];
Sector number 7: theta start = 270.0 deg, theta end = 319.9 deg, sector area = 42.0 square mm, element number = 120
Corners and middle: [0.00 19.26 0.00 20.84 10.07
-22.95 -16.19 -24.83 -17.53 -22.33
-0.91 -1.28 -1.02 -1.45 -1.06];

Sector number 8: theta start = 319.9 deg, theta end = 360.0 deg, sector area = 42.0 square mm, element number = 119
Corners and middle: [19.26 27.17 20.84 29.42 25.90
-16.19 0.00 -17.53 0.00 -9.61
-1.28 -1.65 -1.45 -1.89 -1.64];

Ring Number 25: Inner a = 29.52 mm, outer a = 32.06 mm, innber b = 24.93 mm, outer b = 27.06 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 40.1 deg, sector area = 51.7 square mm, element number = 25
Corners and middle: [29.52 20.91 32.06 22.70 28.18
0.00 17.60 0.00 19.11 10.46
-1.90 -1.46 -2.18 -1.66 -1.88];
Sector number 2: theta start = 40.1 deg, theta end = 90.0 deg, sector area = 51.7 square mm, element number = 26
Corners and middle: [20.91 -0.00 22.70 -0.00 10.94
17.60 24.93 19.11 27.06 24.30
-1.46 -1.02 -1.66 -1.15 -1.20];
Sector number 3: theta start = 90.0 deg, theta end = 139.9 deg, sector area = 51.7 square mm, element number = 58
Corners and middle: [-0.00 -20.92 -0.00 -22.71 -10.95
24.93 17.59 27.06 19.10 24.30
-1.02 -1.46 -1.15 -1.66 -1.20];
Sector number 4: theta start = 139.9 deg, theta end = 180.0 deg, sector area = 51.7 square mm, element number = 57
Corners and middle: [-20.92 -29.52 -22.71 -32.06 -28.19
17.59 -0.00 19.10 -0.00 10.46
-1.46 -1.90 -1.66 -2.18 -1.88];
Sector number 5: theta start = 180.0 deg, theta end = 220.1 deg, sector area = 51.7 square mm, element number = 89
Corners and middle: [-29.52 -20.91 -32.06 -22.70 -28.18
-0.00 -17.59 -0.00 -19.11 -10.47
-1.90 -1.46 -2.18 -1.66 -1.88];
Sector number 6: theta start = 220.1 deg, theta end = 270.0 deg, sector area = 51.7 square mm, element number = 90
Corners and middle: [-20.91 0.00 -22.70 0.00 -10.94
-17.59 -24.93 -19.11 -27.06 -24.30
-1.46 -1.02 -1.66 -1.15 -1.20];
Sector number 7: theta start = 270.0 deg, theta end = 319.9 deg, sector area = 51.7 square mm, element number = 122
Corners and middle: [0.00 20.92 0.00 22.71 10.95
-24.93 -17.59 -27.06 -19.10 -24.30
-1.02 -1.46 -1.15 -1.66 -1.20];
Sector number 8: theta start = 319.9 deg, theta end = 360.0 deg, sector area = 51.7 square mm, element number = 121
Corners and middle: [20.92 29.52 22.71 32.06 28.19

-17.59 0.00 -19.10 0.00 -10.46
-1.46 -1.90 -1.66 -2.18 -1.88];

Ring Number 26: Inner a = 32.16 mm, outer a = 34.97 mm, innber b = 27.16 mm, outer b = 29.52 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 40.1 deg, sector area = 62.5 square mm, element number = 27
Corners and middle: [32.16 22.78 34.97 24.76 30.72
0.00 19.17 0.00 20.85 11.41
-2.19 -1.67 -2.52 -1.91 -2.17];
Sector number 2: theta start = 40.1 deg, theta end = 90.0 deg, sector area = 62.5 square mm, element number = 28
Corners and middle: [22.78 -0.00 24.76 -0.00 11.93
19.17 27.16 20.85 29.52 26.49
-1.67 -1.15 -1.91 -1.29 -1.36];
Sector number 3: theta start = 90.0 deg, theta end = 139.9 deg, sector area = 62.5 square mm, element number = 60
Corners and middle: [-0.00 -22.78 -0.00 -24.77 -11.93
27.16 19.17 29.52 20.84 26.49
-1.15 -1.67 -1.29 -1.91 -1.36];
Sector number 4: theta start = 139.9 deg, theta end = 180.0 deg, sector area = 62.5 square mm, element number = 59
Corners and middle: [-22.78 -32.16 -24.77 -34.97 -30.73
19.17 -0.00 20.84 -0.00 11.41
-1.67 -2.19 -1.91 -2.52 -2.17];
Sector number 5: theta start = 180.0 deg, theta end = 220.1 deg, sector area = 62.5 square mm, element number = 91
Corners and middle: [-32.16 -22.78 -34.97 -24.76 -30.72
-0.00 -19.17 -0.00 -20.85 -11.41
-2.19 -1.67 -2.52 -1.91 -2.17];
Sector number 6: theta start = 220.1 deg, theta end = 270.0 deg, sector area = 62.5 square mm, element number = 92
Corners and middle: [-22.78 0.00 -24.76 0.00 -11.93
-19.17 -27.16 -20.85 -29.52 -26.49
-1.67 -1.15 -1.91 -1.29 -1.36];
Sector number 7: theta start = 270.0 deg, theta end = 319.9 deg, sector area = 62.5 square mm, element number = 124
Corners and middle: [0.00 22.78 0.00 24.77 11.94
-27.16 -19.17 -29.52 -20.85 -26.49
-1.15 -1.67 -1.29 -1.91 -1.36];
Sector number 8: theta start = 319.9 deg, theta end = 360.0 deg, sector area = 62.5 square mm, element number = 123
Corners and middle: [22.78 32.16 24.77 34.97 30.73
-19.17 0.00 -20.85 0.00 -11.41
-1.67 -2.19 -1.91 -2.52 -2.17];

Ring Number 27: Inner a = 35.07 mm, outer a = 38.08 mm, innber b = 29.62 mm, outer b = 32.15 mm, number of sectors = 8
Sector number 1: theta start = 0.0 deg, theta end = 40.1 deg, sector area = 72.7 square mm, element number = 29
Corners and middle: [35.07 24.84 38.08 26.96 33.48
0.00 20.91 0.00 22.70 12.44
-2.53 -1.92 -2.91 -2.18 -2.50];
Sector number 2: theta start = 40.1 deg, theta end = 90.0 deg, sector area = 72.7 square mm, element number = 30
Corners and middle: [24.84 -0.00 26.96 -0.00 13.00
20.91 29.62 22.70 32.15 28.87
-1.92 -1.30 -2.18 -1.46 -1.55];
Sector number 3: theta start = 90.0 deg, theta end = 139.9 deg, sector area = 72.7 square mm, element number = 62
Corners and middle: [-0.00 -24.84 -0.00 -26.96 -13.00
29.62 20.91 32.15 22.70 28.87
-1.30 -1.92 -1.46 -2.18 -1.55];
Sector number 4: theta start = 139.9 deg, theta end = 180.0 deg, sector area = 72.7 square mm, element number = 61
Corners and middle: [-24.84 -35.07 -26.96 -38.08 -33.48
20.91 -0.00 22.70 -0.00 12.43
-1.92 -2.53 -2.18 -2.91 -2.50];
Sector number 5: theta start = 180.0 deg, theta end = 220.1 deg, sector area = 72.7 square mm, element number = 93
Corners and middle: [-35.07 -24.84 -38.08 -26.96 -33.48
-0.00 -20.91 -0.00 -22.70 -12.44
-2.53 -1.92 -2.91 -2.18 -2.50];
Sector number 6: theta start = 220.1 deg, theta end = 270.0 deg, sector area = 72.7 square mm, element number = 94
Corners and middle: [-24.84 0.00 -26.96 0.00 -12.99
-20.91 -29.62 -22.70 -32.15 -28.87
-1.92 -1.30 -2.18 -1.46 -1.55];
Sector number 7: theta start = 270.0 deg, theta end = 319.9 deg, sector area = 72.7 square mm, element number = 126
Corners and middle: [0.00 24.85 0.00 26.97 13.01
-29.62 -20.91 -32.15 -22.70 -28.87
-1.30 -1.92 -1.46 -2.19 -1.55];
Sector number 8: theta start = 319.9 deg, theta end = 360.0 deg, sector area = 72.7 square mm, element number = 125
Corners and middle: [24.85 35.07 26.97 38.08 33.48
-20.91 0.00 -22.70 0.00 -12.43
-1.92 -2.53 -2.19 -2.91 -2.50];

Ring Number 28: Inner a = 38.18 mm, outer a = 45.00 mm, innber b = 32.25 mm, outer b = 38.00 mm, number of sectors = 16

Sector number 1: theta start = 0.0 deg, theta end = 19.3 deg, sector area = 94.1 square mm, element number = 31
Corners and middle: [38.18 35.28 45.00 41.57 40.77
0.00 12.34 0.00 14.54 6.95
-2.92 -2.71 -3.91 -3.61 -3.32];
Sector number 2: theta start = 19.3 deg, theta end = 40.2 deg, sector area = 94.0 square mm, element number = 32
Corners and middle: [35.28 27.01 41.57 31.82 34.40
12.34 22.80 14.54 26.87 19.74
-2.71 -2.19 -3.61 -2.88 -2.84];
Sector number 3: theta start = 40.2 deg, theta end = 63.9 deg, sector area = 94.0 square mm, element number = 37
Corners and middle: [27.01 14.62 31.82 17.22 22.78
22.80 29.79 26.87 35.11 29.39
-2.19 -1.68 -2.88 -2.16 -2.18];
Sector number 4: theta start = 63.9 deg, theta end = 90.0 deg, sector area = 94.0 square mm, element number = 38
Corners and middle: [14.62 -0.00 17.22 -0.00 7.92
29.79 32.25 35.11 38.00 34.48
-1.68 -1.46 -2.16 -1.86 -1.72];
Sector number 5: theta start = 90.0 deg, theta end = 116.2 deg, sector area = 94.0 square mm, element number = 39
Corners and middle: [-0.00 -14.63 -0.00 -17.24 -7.93
32.25 29.79 38.00 35.10 34.48
-1.46 -1.68 -1.86 -2.16 -1.72];
Sector number 6: theta start = 116.2 deg, theta end = 139.8 deg, sector area = 94.0 square mm, element number = 40
Corners and middle: [-14.63 -27.01 -17.24 -31.83 -22.79
29.79 22.79 35.10 26.86 29.38
-1.68 -2.19 -2.16 -2.88 -2.18];
Sector number 7: theta start = 139.8 deg, theta end = 160.7 deg, sector area = 94.0 square mm, element number = 64
Corners and middle: [-27.01 -35.28 -31.83 -41.58 -34.41
22.79 12.33 26.86 14.53 19.73
-2.19 -2.71 -2.88 -3.61 -2.84];
Sector number 8: theta start = 160.7 deg, theta end = 180.0 deg, sector area = 94.0 square mm, element number = 63
Corners and middle: [-35.28 -38.18 -41.58 -45.00 -40.77
12.33 -0.00 14.53 -0.00 6.94
-2.71 -2.92 -3.61 -3.91 -3.32];
Sector number 9: theta start = 180.0 deg, theta end = 199.3 deg, sector area = 94.0 square mm, element number = 95
Corners and middle: [-38.18 -35.28 -45.00 -41.58 -40.77
-0.00 -12.33 -0.00 -14.54 -6.96
-2.92 -2.71 -3.91 -3.61 -3.32];

Sector number 10: theta start = 199.3 deg, theta end = 220.2 deg, sector area = 94.0 square mm, element number = 96
Corners and middle: [-35.28 -27.01 -41.58 -31.83 -34.40
-12.33 -22.79 -14.54 -26.86 -19.74
-2.71 -2.19 -3.61 -2.88 -2.84];
Sector number 11: theta start = 220.2 deg, theta end = 243.9 deg, sector area = 94.0 square mm, element number = 101
Corners and middle: [-27.01 -14.62 -31.83 -17.23 -22.78
-22.79 -29.79 -26.86 -35.10 -29.39
-2.19 -1.68 -2.88 -2.16 -2.18];
Sector number 12: theta start = 243.9 deg, theta end = 270.0 deg, sector area = 94.0 square mm, element number = 102
Corners and middle: [-14.62 0.00 -17.23 0.01 -7.92
-29.79 -32.25 -35.10 -38.00 -34.48
-1.68 -1.46 -2.16 -1.86 -1.72];
Sector number 13: theta start = 270.0 deg, theta end = 296.1 deg, sector area = 94.0 square mm, element number = 103
Corners and middle: [0.00 14.62 0.01 17.23 7.93
-32.25 -29.79 -38.00 -35.10 -34.48
-1.46 -1.68 -1.86 -2.16 -1.72];
Sector number 14: theta start = 296.1 deg, theta end = 319.8 deg, sector area = 94.0 square mm, element number = 104
Corners and middle: [14.62 27.01 17.23 31.83 22.78
-29.79 -22.79 -35.10 -26.86 -29.38
-1.68 -2.19 -2.16 -2.88 -2.18];
Sector number 15: theta start = 319.8 deg, theta end = 340.7 deg, sector area = 94.0 square mm, element number = 128
Corners and middle: [27.01 35.28 31.83 41.58 34.40
-22.79 -12.33 -26.86 -14.53 -19.73
-2.19 -2.71 -2.88 -3.61 -2.84];
Sector number 16: theta start = 340.7 deg, theta end = 360.0 deg, sector area = 94.0 square mm, element number = 127
Corners and middle: [35.28 38.18 41.58 45.00 40.77
-12.33 0.00 -14.53 0.00 -6.94
-2.71 -2.92 -3.61 -3.91 -3.32];