INDIAN POINT UNIT 2

REACTOR VESSEL IN-SERVICE

INSPECTION PROGRAM

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1.0 INTRODUCTION

Plant Technical Specification provisions Section 4.2, Item 7.2, Reactor Vessel Special Inspection, specify that a reactor vessel in-service inspection program be forwarded to the Nuclear Regulatory Commission (NRC) 180 days prior to plant shutdown during which the inspection is scheduled to be accomplished.

In response to those provisions the reactor vessel in-service inspection program is delineated herein. This program identifies the special ultrasonic examinations that are planned to be accomplished during a 1987 refueling outage in the area of an ultrasonic indication which was previously detected during a 1984 refueling outage. The examinations will encompass an area on the order of 6 x 6 inches centered on the ultrasonic indication. The indication is in a vertical weld seam located at vessel azimuth 345 degrees. It is near the intersection of the vertical weld seam and a horizontal girth weld. The horizontal girth weld is located 236 inches below the reactor vessel flange. The indication is located lower, at about 239 inches below the flange.

2.0 GENERAL

The planned vessel ultrasonic examination program shall encompass the following activities:

2.1 Standard ASME Code Section XI ultrasonic examination and sizing techniques shall be used for the vessel examination. These techniques were utilized during previous ultrasonic examinations of the vessel in 1984.

2.2 Special ultrasonic examinations in addition to those specified in the ASME Code XI shall be also utilized. These examinations shall use techniques known as delta and pitch-catch. These techniques were also previously utilized during the 1984 examinations.

2.3 The combination of the ASME Code Section XI ultrasonic examinations and the special techniques previously utilized will form the primary basis for determining whether or not the ultrasonic indication previously detected has remained essentially unchanged.

2.0 **GENERAL** (continued)

2.4 Additional current state-of-the-art examination techniques and equipment shall be utilized in an attempt to better characterize the indication. Focused immersion transducers will be utilized to enhance the data collected with conventional transducers. Focused transducers were not used during previous vessel examinations.

2.5 The previously utilized and the additional techniques and equipment that will be utilized for the field examinations will be demonstrated offsite prior to field use. The demonstration shall be accomplished on both the normal calibration block used for vessel examinations and an additional special demonstration block containing simulated flaws.

2.6 A state-of-the-art multi channel high speed digitizing, recording and display system will be utilized to record and map ultrasonic examination results. This additional data analysis system will be used to supplement data collected with conventional recording mechanisms.

3.0 **EXAMINATION EQUIPMENT AND TECHNIQUES**

The 1987 Examination Plan will include all examinations performed during the 1984 outage as well as additional investigations with focused transducers in order to improve resolution and enhance the ability to characterize the reflector. These examinations will be supplemented by automated data recording and analysis capabilities, see Section 5. Scan increments for each individual examination technique will be 0.1 inch maximum. Techniques applied for the vessel indication evaluation will be demonstrated in accordance with the provisions of Section 4.

The planned sequence of examination is listed herein.

3.1 **ASME Section XI Ultrasonic Examinations**

The 1984 Section XI ultrasonic examinations will be repeated during the 1987 investigation. These examinations include 45 degree and 60 degree shear wave interrogation in the clockwise and counterclockwise directions and a 0 degree longitudinal wave scan. Transducers used for this phase of testing will be 2.25 MHz, 1.5 inch diameter search units mounted on the

3.0 **EXAMINATION EQUIPMENT AND TECHNIQUES** (continued)

3.1 **ASME Section XI Ultrasonic Examinations** (continued)

standard "Ten-Year Array Plate" as illustrated in Figure 3-1. Transducers identified as TR20, TR22, TR24, TR25, and TR27 will be mounted for this analysis. Every effort will be made to use the identical transducers as were used for the 1984 examinations. The examinations will be conducted in both circumferential directions on increments of 0.1 inch maximum. Each examination will be repeated a minimum of three times. Data will be digitized and recorded for off-line analysis. This will allow for archival storage of all raw data, a capability for subsequent review, and accurate comparison with any future examinations of this area. These results will be compared with those collected during the 1984 vessel examinations in terms of dB drop sizing. The data recording system also allows the capability for signal processing and conditioning which supports the potential for identifying features of the recorded signals which might otherwise go unnoticed, e.g. tip diffraction, satellite pulse.

3.2 **Special Ultrasonic Examinations**

During the 1984 evaluation, alternative ultrasonic techniques were developed and applied to aid in analysis of the vessel indication. The alternative techniques utilize a transducer array, as illustrated in Figure 3-2, containing two opposing 45 degree, 2.25 MHz, 1.5 inch diameter transducers one skip distance apart, and a 0 degree, 2.25 MHz, 1.5 inch diameter transducer located midway between the two 45 degree transducers. The 45 degree and 0 degree transducers are configured in such a way that the projected sound beams intersect at the outside surface of the vessel. A high resolution, 5.0 MHz, 1/2" x 1" rectangular transducer is also placed on the array. With this transducer configuration, the following examinations will again be performed:

- o a delta technique in two opposing directions using the 45 degree transducers as transmitters and the 2.25 MHz, 1.5 inch diameter, 0 degree transducer as a receiver.
- o the pitch-catch technique using the 45 degree transducers to respectively transmit and receive the sound beam, a diminishing echo technique.
- o the pulse echo technique for each transducer

3.0 EXAMINATION EQUIPMENT AND TECHNIQUES (continued)

3.2 Special Ultrasonic Examinations (continued)

All scans will be performed on increments of 0.1 inch maximum. Each examination will be repeated a minimum of three times. Data will be digitized and recorded for off-line analysis. This will allow for archival storage of all raw data, a capability for subsequent review, and accurate comparison with any future examinations of this area. These results will be compared with those collected during the 1984 vessel examination in terms of diminishing echo, total delta time of flight and interval between delta signals from the "tip" and the base. The data recording system also allows the capability for signal processing and conditioning which supports the potential for identifying features of the recorded signals which may reveal some evidence regarding the nature of the reflector.

3.3 State-of-the-Art Examinations

The use of focused transducers has been successfully demonstrated as able to retain satisfactory signal-to-noise ratios with good flaw detection and sizing capabilities. The transducers proposed for use in this evaluation will be 2.0 MHz, 0 degree, 45 degree and 60 degree focused units with focal lengths representative of the vessel wall thickness. Other angles may be added or substituted based upon offsite evaluations. These transducers will have permanent lenses affixed with compound curvature in order to minimize the effects of abberations due to the curvature of the vessel inside diameter surface.

These transducers will be characterized in terms of their focal spot size and focal lengths. Use of these transducers will minimize the effect of beam spreading and beam distortion on the ability to size and characterize the reflector.

The focused transducer array will be developed based upon the physical size of the transducers required to achieve the proper focal depths. Our intent is to use the focused search units in the pulse-echo mode and in a delta arrangement. The reflector will be interrogated in both circumferential directions. All scans will be performed on increments of 0.1 inch maximum. Each examination will be repeated a minimum of three times. Data will be digitized and recorded for off-line analysis. This will allow for archival storage of

3.0 EXAMINATION EQUIPMENT AND TECHNIQUES (continued)

3.3 State-of-the-Art Examinations (continued)

all raw data, a capability for subsequent review, and accurate comparison with any future examinations in this area. The data recording system also allows the capability for signal processing and conditioning which potentially could allow for the analyst to identify features of the recorded signals which could otherwise go unnoticed, e.g., tip diffraction, satellite pulse.

4.0 DEMONSTRATION AND CALIBRATION OF EQUIPMENT AND TECHNIQUES

This part of the program will provide a quantitative assessment of system repeatability and a statistical verification of sizing techniques for the three series of examinations - (1) Standard ASME Code Section XI examinations, (2) Special examinations - delta and pitch-catch techniques, and (3) State-of-the-art examinations employing focused transducers. The program will encompass the following activities:

4.1 Acoustic Similarity Evaluations

The acoustical properties of the calibration block used for the vessel examinations (Figure 4-1), the special demonstration block (Figure 4-2) containing simulated flaws, and the actual vessel material will be determined. The purpose of these tests is to determine the relative attenuation between the various components. The side-drilled holes in the calibration block and the special demonstration block will be used to measure the relative attenuation between these blocks. To determine the difference between the special demonstration block and the vessel material, a 45 degree shear wave pitch-catch transducer arrangement will be used. Since the cladding surface, the cladding base metal interface, and the local geometry will cause fluctuations in the amplitude of the received response from point to point, the gain will be set such that the amplitude fluctuation will be between 15 and 90% full screen height (FSH) as displayed on the CRT screen. This relative gain will be recorded and documented. In addition to this dynamic test, a number of random static

4.0 DEMONSTRATION AND CALIBRATION OF EQUIPMENT AND TECHNIQUES (continued)

4.1 Acoustic Similarity Evaluations (continued)

measurements will be taken using the same pitch-catch arrangement. The received response will be set at approximately 80% full screen height (FSH) and the relative gain will be recorded and documented. The results obtained will also be compared to the results obtained during the acoustic comparison of these specimens in 1984.

4.2 System Repeatability and Statistical Verification of Sizing Techniques

The system repeatability and statistical verification of the sizing techniques will be demonstrated by repetitive calibrations on the side-drilled holes in the calibration block used in the vessel examinations and examinations of the machined (artificial) flaws in the special demonstration block. The UT system includes a transducer array plate, ultrasonic test instrumentation, and the new state-ofthe-art multi-channel, high speed, digitizing, recording, and display system.

The statistical verification of sizing techniques will be performed on a sample matrix that includes the flaw sizes given in Table 4-1 and graphically displayed on Figure 4-3. A primary sample matrix has been chosen in the region encompassed by a flaw depth of 0.11" to 1.0" and a flaw length of 0.75" to 1.50". A clustering of flaws with a flaw depth of 0.11" to 0.5" and a flaw length of 0.75" to 1.0" was chosen to increase the amount of data points around the 1984 estimated reflector size of 0.26" depth by 0.85" length.

The data for each sizing technique will be evaluated through linear regression analysis performed on each depth measurement (as a function of depth and corresponding length) and each length measurement (as a function of length and corresponding depth). This analysis will result in a quantitative evaluation of each sizing technique such that the data obtained during the examination is accurately assessed within a 95% confidence level.

4.0 DEMONSTRATION AND CALIBRATION OF EQUIPMENT AND TECHNIQUES (continued)

4.2.1 Statistical Verification of Standard ASME Code Section XI Examinations

The standard ASME Code Section XI examinations consist of the techniques described in paragraph 3.1. The flaw sizing matrix is described in Table 4-2. Each of the twelve flaws will be scanned ten times with each transducer. To differentiate between transducer and cladding effects the flaws will be examined from both directions with each transducer, where appropriate. The total targeted number of scans will be 480 with a scan increment of 0.1". Figures 4-4 and 4-5 describe where the scans fall with respect to flaw depth and flaw length.

4.2.2 Statistical Verification of Special Examinations

The special examinations will consist of the techniques described in paragraph 3.2. The flaw sizing matrix for the delta technique and for the pitch-catch technique is described in Table 4-3 and Table 4-4, respectively. For the delta technique, each of the twelve flaws will be scanned ten times with each transducer combination (five times from each direction, where appropriate) for a total of 240 targeted scans with a scan increment of 0.1". For the pitch-catch technique, ten of twelve flaws will be scanned ten times (five times from each setup) for a total of 100 targeted scans. Figures 4-6, 4-7, and 4-8 describe where the scans fall with respect to the flaw depth and flaw length.

4.2.3 Statistical Verification of State-of-the-Art Examinations

The state-of-the-art examinations will consist of the techniques described in paragraph 3.3. The flaw sizing matrix for the ASME Section XI techniques is described in Table 4-5. Each of the twelve flaws will be scanned ten times with each transducer. To differentiate between transducer and cladding effects the flaws will be examined from both directions with each transducer, where appropriate. The total targeted number of scans will be 480 with a scan increment of 0.1". In addition

4.0 DEMONSTRATION AND CALIBRATION OF EQUIPMENT AND TECHNIQUES (continued)

4.2.3 Statistical Verification of State-of-the-Art Examinations (continued)

to using the focused transducers for amplitude based sizing of the indication per normal ASME Code Section XI techniques special emphasis will be placed on detecting and distinguishing diffraction tips to improve sizing capabilities. In effect this will improve on normal ASME Code Section XI techniques. Figures 4-4 and 4-5 describe where the scans fall with respect to flaw depth and flaw length. The flaw sizing matrix for the delta technique is described in Table 4-6. Each of the twelve flaws will be scanned ten times with each transducer combination (five times from each direction, where appropriate) for a total of 240 targeted scans with a scan increment of 0.1". Figures 4-6 and 4-7 describe where the scans fall with respect to flaw depth and flaw length.

5.0 ULTRASONIC EXAMINATION DATA RECORDING AND DISPLAY SYSTEM

5.1 Background

Traditional ultrasonic nondestructive examination techniques have tended to emphasize single channel analog displays which rely upon considerable subjective interpretation for analysis of ultrasonic signals.

The advent of high frequency analog to digital conversion, high speed processing, and digital data displays have provided advantages over traditional ultrasonic techniques. Westinghouse is currently developing a multi-channel, high speed system capable of digitizing, recording and displaying ultrasonic data acquired by a UT system. Such a system is suitable for recording and mapping complex flaw patterns. A slower two channel prototype of this system has already been built and was successfully utilized in the field during 1985 for a vessel inspection. Over 100,000 digital A-Scans were recorded during this inspection and the color displays generated by the system were useful in mapping plan views of IGSCC (Intergranular Stress Corrosion Cracking) and in flaw sizing.

5.0 ULTRASONIC EXAMINATION DATA RECORDING AND DISPLAY SYSTEM (continued)

5.1 Background (continued)

The field experience gained from the prototype system has been incorporated into the design of the multi-channel high speed system. It is this system, called ARES II (A-Scan Recording and Enhancement System), with suitable modifications that is planned to be used for the Indian Point Unit 2 Vessel ultrasonic inspection.

5.2 System Overview

5.2.1 Major Components

The block diagram in Figure 5-1 illustrates the major components of ARES II. The components and a brief description of each are as follows:

1. **Front End**

   This unit is composed of high frequency A/D converters, memory modules for data storage and real-time D/A playback modules. The input to the unit consists of analog RF or rectified signals along with corresponding trigger signals for time base establishment. The front end is capable of digitizing at rates up to 100 MHz with 8 bit resolution. The analog signals are multiplexed to reduce the number of A/D converter modules and the addition of extra memory allows signals of up to several thousand microseconds in length to be digitized and stored. The unit is programmable and is controlled by the I/O computer via prescan operator input. The front end also has the capability of providing a user specified pretrigger which allows a non-zero start time for the gate.

2. **I/O Computer**

   This component is a multi-microprocessor computer and its purpose is to control the flow of digital data in ARES II. The I/O computer performs this function by utilizing parallel microprocessors sharing a common memory via a high speed bus with a capacity up to 24 mB/sec for data transfer.

5.0 ULTRASONIC EXAMINATION DATA RECORDING AND DISPLAY SYSTEM (continued)

5.2 System Overview (continued)

2. **I/O Computer** (continued)

   The microprocessors are connected to outside devices via special processor boards installed in a backplane (see Figure 5-1). The components which are connected to the I/O computer include the front end, mass storage, the array processor and the host minicomputer. The I/O computer is programmable and is controlled via software which is downloaded from the host computer.

3. **Mass Storage**

   This component is used to store large quantities of digital data, primarily digitized A-Scans and associated data. The devices are of two types: magnetic disk drives for fast temporary storage and optical laser drives with each drive holding one cartridge with a large storage capacity of 1 gigabyte per side. This represents, for example, the capability of storing approximately 100,000 digitized A-Scans, each with a time duration of 1000 usec. Each cartridge is two sided and thus the storage capability is doubled.

4. **Array Processor**

   This is a special computer for performing vectorized operations on the digital ultrasonic data. ARES II uses an array processor which has a rated speed of 30 million floating point operations per second. The array processor receives the digital data via a special high speed interface connected to a microprocessor on the I/O computer. The array processor then executes algorithms to filter general background signals and detect peaks above a user defined threshold. The peak amplitudes and actual spatial location of the detected peaks (after conversion to depth using the refraction angle in the material) are returned by the array processor to the I/O computer mass memory. The array processor is programmable and is controlled from software downloaded from the host through the I/O computer. In addition, the array processor is used to color code the A-Scan amplitude data for display.

5.0 **ULTRASONIC EXAMINATION DATA RECORDING AND DISPLAY SYSTEM** (continued)

5.2 **System Overview** (continued)

5. **Host Minicomputer**

The host minicomputer performs the necessary control functions. A microprocessor on the I/O computer is dedicated to the host and all control parameters are passed via this interface. The host utilizes a 71 WB disk for temporary data storage and for source file storage. A tape cartridge system is supplied for downloading operating system upgrades and ARES II application software upgrades.

6. **Color Graphics Workstation**

This system displays all the relevant data in color and is composed of several components, the primary one being the Color Graphics Workstation. This terminal is capable of drawing 50,000 vectors/sec and is connected to the host minicomputer via a high speed data transfer bus utilizing Direct Memory Access. The terminal can display up to 16 different colors on the screen at once. The color copies system contains multiplexed rasterizer units for temporary image storage during plotting. This speeds up the generation of color copies. All operator input to ARES II is via the color graphics terminal.

5.2.2 **Modes of Operation**

ARES II has been designed to operate in three basic modes: Detection, Recording and Analysis. The use of these different modes during different aspects of the inspection allow the analyst a great deal of flexibility to cope with changing conditions, such as, noise level variation. Each of these modes of operation is described in more detail as follows:

1. **Detection**

A typical ultrasonic inspection problem, particularly noticeable at high sensitivity levels, is the appearance of numerous indications which upon subsequent examination turn out to be either electronic noise, metal grain noise, cladding interference, non-relevant indications or certain types of geometrical reflections. Mode conversion may also be apparent in some cases. In the detection mode of operation ARES II detects and stores on disk only those indications above a user-defined threshold level, which is adjustable by operator command

5.0 ULTRASONIC EXAMINATION DATA RECORDING AND DISPLAY SYSTEM (continued)

5.2 System Overview (continued)

1. **Detection** (continued)

   at anytime during the inspection. Prior to actual detection, ARES II applies spatial and temporal averaging to the data to increase the signal-to-noise ratio. The parameters controlling these processes are adjustable by operator input. Thus the operator can specify more averaging if a particularly noisy part of the vessel is being inspected.

2. **Recording**

   This mode of operation is used to store the entire digital A-Scan on optical disk. Due to the use of optical disks, which have a storage capacity of 1 gigabyte per side, ARES II is capable of storing an enormous amount of data around a zone where an indication is to be examined in more detail. Furthermore, the speed of ARES II allows the data to be recorded very rapidly so that the detection process can continue. Only the unprocessed digital A-Scans are stored on disks in this mode.

3. **Analysis**

   Once the detection and/or recording phase of inspecting a particular zone has occurred, the analyst can then enter the analysis mode and display the stored data in various ways. All displays are in color and various signal processing options can be employed on the digital A-Scan data at this point. The displays which are produced in this mode are discussed under the section, below. The high speed data buses utilized by ARES II allow the analyst to review a large amount of data in a relatively short time span.

5.2.3 Data Displays and Analysis

Two basic types of data displays are provided by ARES II: real-time and off-line displays. The first display plots peak threshold amplitudes in real-time when the system is operating in the detection mode. The second display actually consists of a number of displays which plot data that has been acquired in either the detection mode or the recording mode. These two types of displays will now be described in more detail.

5.0 ULTRASONIC EXAMINATION DATA RECORDING AND DISPLAY SYSTEM (continued)

5.2 System Overview (continued)

1. **Real-Time Display**

   Figure 5-2 shows the type of display produced by ARES II during the detection mode. The large rectangle in the figure is the Projected Digital C-Scan or plan view of the material. The coordinates are in inches for the vertical axis and degrees for the horizontal. The area represented is approximately 10 inches by 90 inches, but the area displayed can be changed by operator input. The horizontal scale in degrees is useful for examining large quantities of data. Note the small circle in the lower right-hand corner of the figure which displays that section of the vessel geometry (as seen in cross-section) which is being examined via the data displays. Other scales for the display can be chosen as considered appropriate. The two smaller rectangular plots in Figure 5-2 are the Projected Digital B-Scans with views of cross-sections of the material at right angles to each other. The scales for the B-Scan displays are in degrees or inches (to correspond to the scales on the C-Scan) and inches for depth. All the data in Figure 5-2 has been converted to depth using the appropriate material refraction angle and velocity. In addition, the data has been projected back to its true spatial location by refraction angle correction. The C-Scan data is projected onto the geometrical surface of the vessel.

   As shown in Figure 5-2 a code has been established showing data from each channel or transducer. As many channels can be displayed at once as desired but interpretation will become difficult if too many are displayed at once. The operator can change the channels which are displayed at anytime during the inspection.

2. **Off-Line Displays (Analysis Mode)**

   Once data has been collected and stored in the detection and/or recording modes the analyst can then utilize ARES II in the analysis mode and produce a number of off-line displays. These displays include the following:

5.0 **ULTRASONIC EXAMINATION DATA RECORDING AND DISPLAY SYSTEM** (continued)

5.2 **System Overview** (continued)

2. **Off-Line Displays (Analysis Mode)** (continued)

A. Projected Digital B- and C-Scans

This data is from any area previously inspected. This is the same display as shown in the detection mode (Figure 5-2).

B. Projected Digital B-Scans/Geometry Displayed

In this display the actual geometry is shown along with the data to define the corresponding spatial relationship. This display is useful in zones of significant curvature with respect to distance along the surface.

C. Digital A-Scan Displays

Figure 5-3 illustrates a type of A-Scan display called successive digital A-Scans. The vertical axis is in degrees and the horizontal axis is in time (microseconds). Single digital A-scans with an expanded time scale can also be generated. This allows the analyst to examine the data in more detail.

D. Projected Digital B-Scans

This display is similar to the B-Scan displays in Figure 5-2 except that the display is for one channel only and occupies the entire screen. An example is shown in Figure 5-4.

E. Digital Amplitude B- and C-Scans

These displays require ARES II to be operated in the Recording Mode to collect the complete digital A-Scans in a zone. In these displays the actual A-Scan amplitudes are color coded and displayed.

6.0 SUMMARY

The planned vessel inservice inspection program as described herein utilizes a combination of standard ASME Code examinations and special examinations, both of which were accomplished previously. In addition new examination techniques with best available equipment and instrumentation will be used. All of the examination techniques and equipment will be extensively demonstrated over a statistically relevant range of flaw sizes on material which represents the geometry, size and composition of the installed reactor vessel. The data resulting from field examinations and offsite demonstrations will be recorded and displayed using a state-of-the-art data acquisition and analysis system.

The use of multi-examination techniques, the demonstration on representative vessel material over a range of flaw sizes and use of new data processing techniques together represent an extensive and technically advanced plan for inspecting the reactor vessel indication area.

TABLE 4-1

ARTIFICIAL FLAWS IN SPECIAL DEMONSTRATION BLOCK IPP-2T

Notch Identification	Depth	Length
A	0.112"	1.00"
B	0.305"	1.00"
C	0.501"	1.00"
D	1.499"	2.00"
E	1.849"	2.00"
G	0.180"	0.50"
H	0.181"	1.00"
O	0.180" *	0.75" *
P	0.500" *	0.75" *
Q	1.000" *	1.00" *
R	0.180" *	1.50" *
S	0.500" *	1.50" *

* Planned sizes, as built sizes not yet available

TABLE 4-2

ARTIFICIAL FLAW SIZING MATRIX FOR STANDARD ASME CODE SECTION XI EXAMINATIONS

TRANSDUCER ARRANGEMENT	NOTCHES (Number of Measurements, Target)											
	A	B	C	D	E	G	H	O	P	Q	R	S
45 degree Shear, 2.25 MHz (TR22)												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
45 degree Shear, 2.25 MHz (TR24)												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
60 degree Shear, 2.25 MHz (TR25)												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
60 degree Shear, 2.25 MHz (TR27)												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5

Total number of measurements (target) = 480

TABLE 4-3

ARTIFICIAL FLAW SIZING MATRIX FOR SPECIAL ULTRASONIC EXAMINATIONS, DELTA TECHNIQUE

TRANSDUCER ARRANGEMENT	NOTCHES A	B	C	D	E	G	H	O	P	Q	R	S
	(Number of Measurements, Target)											
45 degree Shear, 2.25 MHz (TR22) & 0 degrees Longitudinal, 2.25 MHz												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
45 degree Shear, 2.25 MHz (TR24) & 0 degrees Longitudinal, 2.25 MHz												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5

Total number of measurements (target) = 240

TABLE 4-4

ARTIFICIAL FLAW SIZING MATRIX FOR SPECIAL ULTRASONIC EXAMINATIONS, PITCH-CATCH TECHNIQUE

TRANSDUCER ARRANGEMENT	NOTCHES (Number of Measurements, Target)											
	A	B	C	D	E	G	H	O	P	Q	R	S
45 degree Shear, 2.25 MHz (TR22) & 45 degree Shear, 2.25 MHz (TR24)												
Direction A	5	5	5	5	5	0	0	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5

Total number of measurements (target) = 100

TABLE 4-5

ARTIFICIAL FLAW SIZING MATRIX FOR STATE-OF-THE-ART EXAMINATIONS, ASME SECTION XI TECHNIQUES

TRANSDUCER ARRANGEMENT	NOTCHES (Number of Measurements, Target)											
	A	B	C	D	E	G	H	O	P	Q	R	S
1st 45 degree Shear, 2.25 MHz focused												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
2nd 45 degree Shear, 2.25 MHz focused												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
1st 60 degree Shear, 2.25 MHz focused												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
2nd 60 degree Shear, 2.25 MHz focused												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5

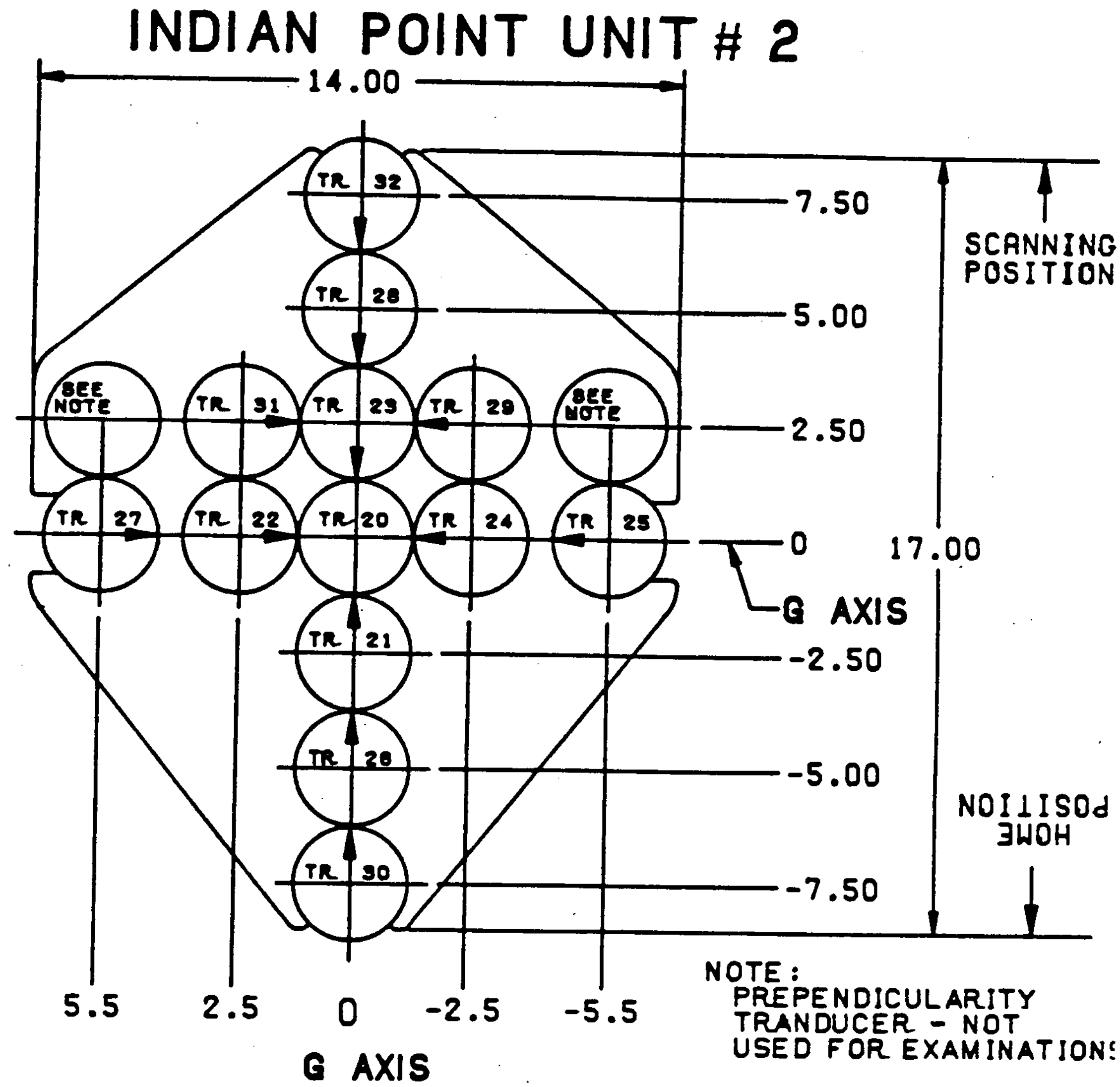
Total number of measurements (target) = 480

TABLE 4-6

ARTIFICIAL FLAW SIZING MATRIX FOR STATE-OF-THE-ART EXAMINATIONS, DELTA TECHNIQUE

TRANSDUCER ARRANGEMENT	NOTCHES (Number of Measurements, Target)											
	A	B	C	D	E	G	H	O	P	Q	R	S
1st 45 degree Shear, 2.25 MHz focused & 0 degree Longitudinal, 2.25 MHz												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5
2nd 45 degree Shear, 2.25 MHz, focused & 0 degree Longitudinal, 2.25 MHz												
Direction A	5	5	5	5	5	10	10	5	5	5	5	5
Direction B	5	5	5	5	5	0	0	5	5	5	5	5

Total number of measurements (target) = 240



TRANSDUCER I.D.	NOMINAL INCIDENT ANGLE	NOMINAL REFRACTED ANGLE	TRANSDUCER MOUNT ANGLE FOR CALIBRATION	TRANSDUCER MOUNT ANGLE FOR EXAMINATION
TR 20	0	0	0	0
TR 21	19	45 S	19.00	19.00
TR 22	19	45 S	19.00	21.62
TR 23	19	45 S	19.00	19.00
TR 24	19	45 S	19.00	21.62
TR 25	23.5	60 S	23.50	24.87
TR 26	23.5	60 S	23.50	23.50
TR 27	23.5	60 S	23.50	24.87
TR 28	23.5	60 S	23.50	23.50
TR 29	19	45 S	19.00	21.62
TR 30	19	45 S	19.00	19.00
TR 31	19	45 S	19.00	21.62
TR 32	19	45 S	19.00	19.00

FIGURE 3-1: 10 YEAR EXAMINATION ARRAY PLATE

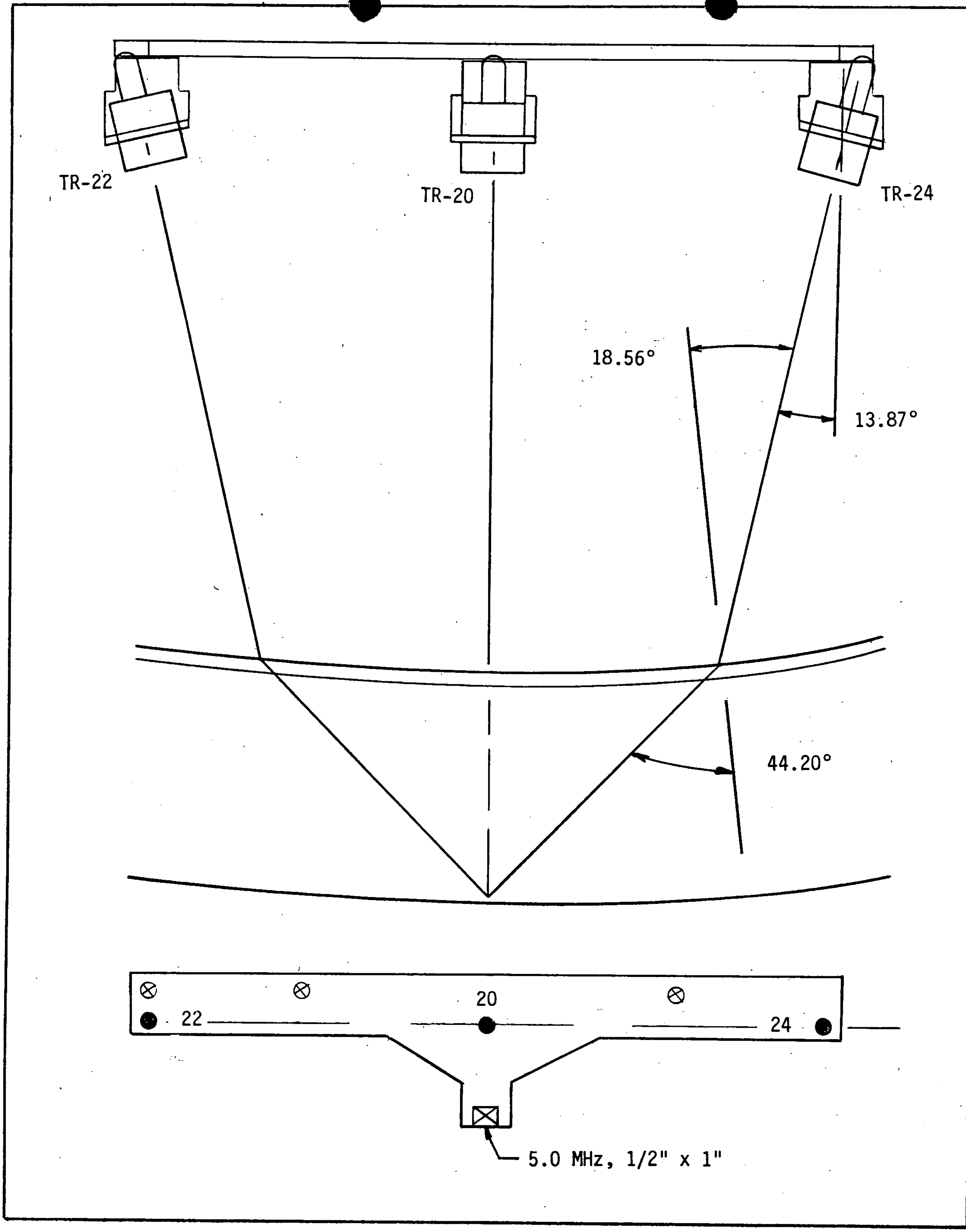


FIGURE 3-2: DELTA PLATE

ILLUSTRATIVE ONLY

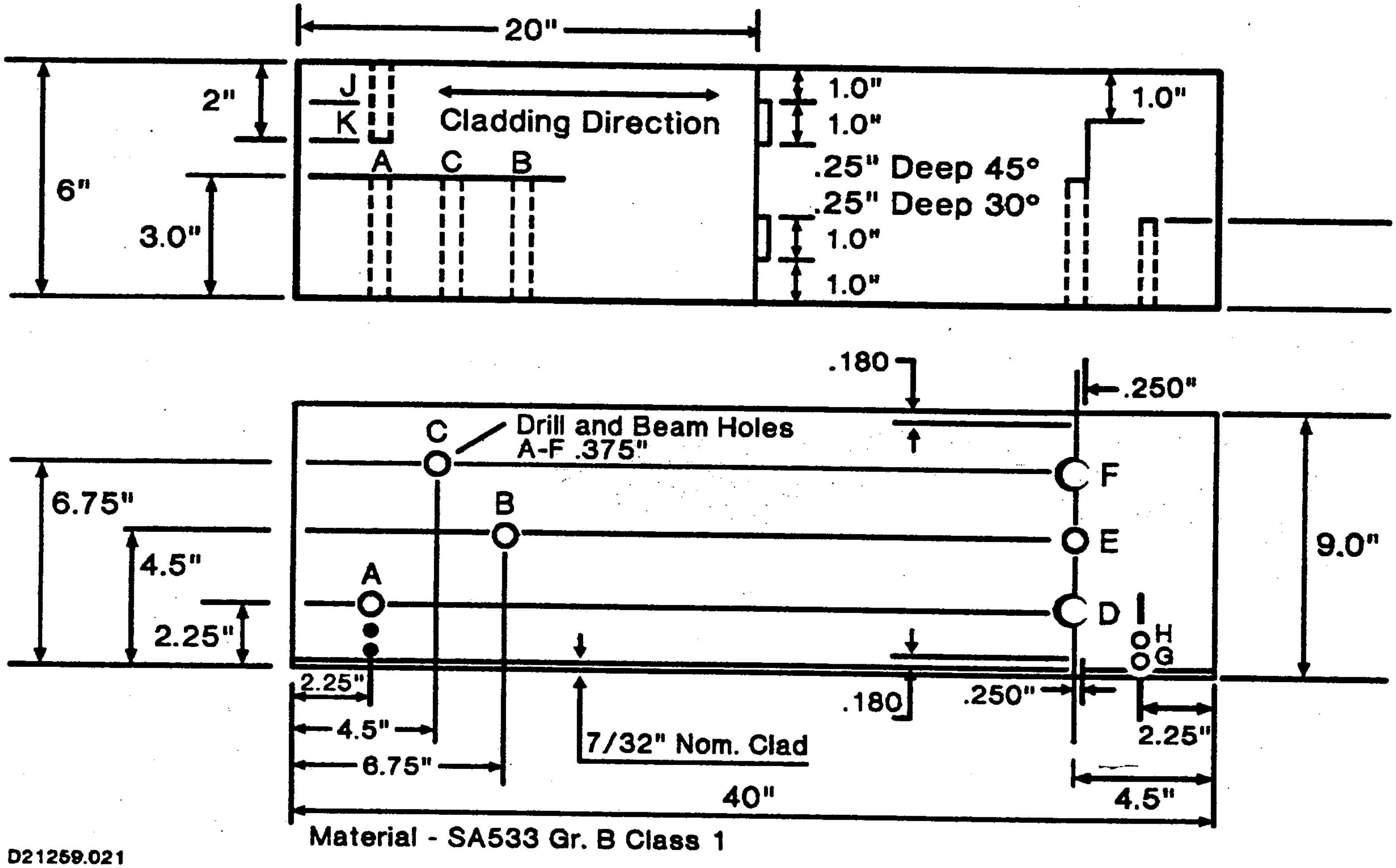
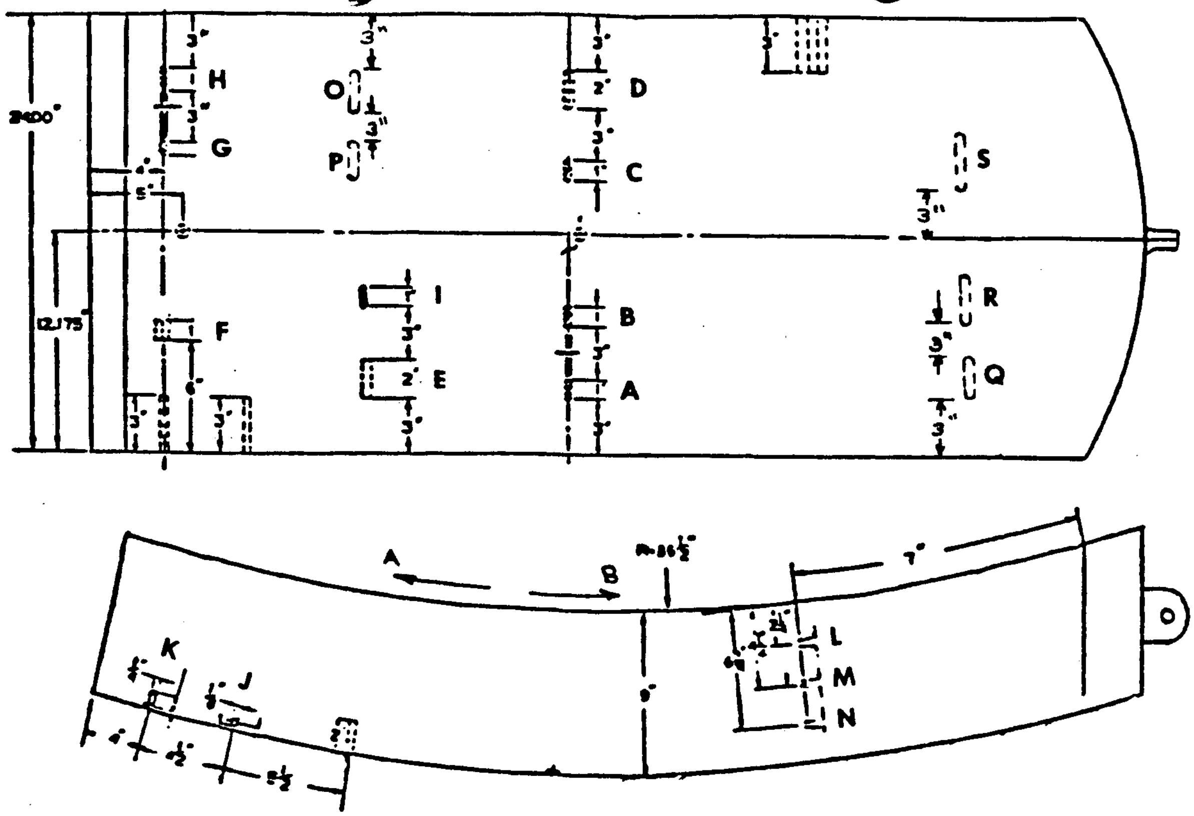


FIGURE 4-1: BASIC 9" REACTOR VESSEL CALIBRATION BLOCK, IPP-RV-70

ILLUSTRATIVE ONLY



TARGET	DEPTH	TYPE	AS BUILT
A	.100"	1/8" X 1.00"	.112"
B	.300"	1/8" X 1.00"	.305"
C	.500"	1/8" X 2.00"	.501"
D	1.5"	3/16" X 2.00"	1.499"
E	2.0"	3/16" X 2.00"	1.849"
F		V-Notch 90°	
G	.180"	1/8" X 0.50"	.180"
H	.180"	1/8" X 1.00"	.181"
I	.250"	Tack Weld (Fillet) 1.0" Lg.	
J	3.00"	1/8" Dia. Hole	1.8"
K	3.00"	1/4" x 3/4" Slot	3.00"
L	3.00"	3/8" Dia. Hole	3.00"
M	3.00"	3/8" Dia. Hole	3.00"
N	3.00"	3/8" Dia. Hole	3.00"
O	.180"	1/8" X 0.75"	
P	.500"	1/8" X 0.75"	
Q	1.00"	1/8" X 1.00"	
R	.180"	1/8" X 1.50"	
S	.500"	1/8" X 1.50"	

IPP-2T-REV-1

FIGURE 4-2: SPECIAL DEMONSTRATION BLOCK, IPP-2T-REV. 1

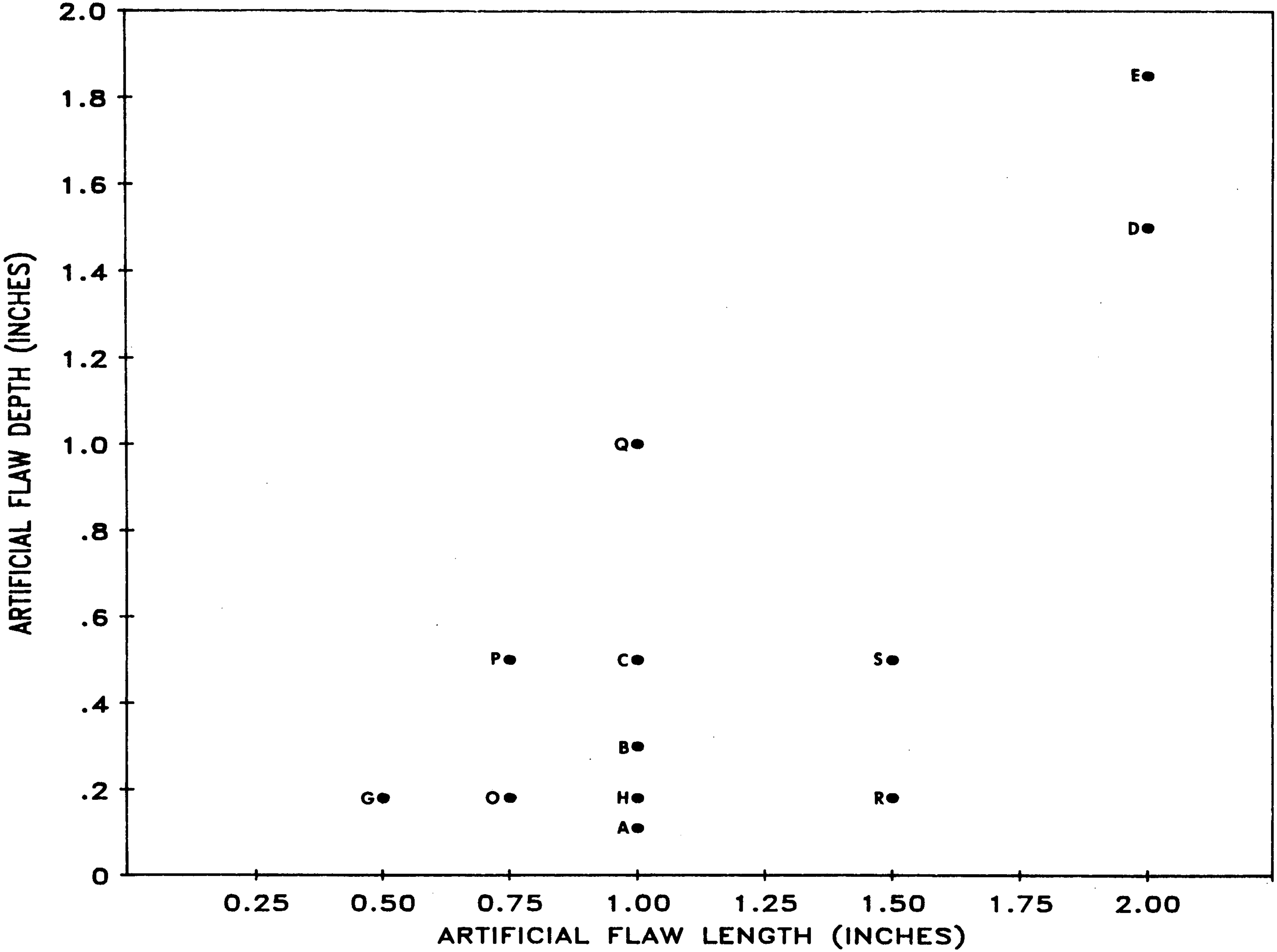


FIGURE 4-3: ARTIFICIAL FLAWS IN THE DEMONSTRATION CALIBRATION BLOCK (IPP-2T)

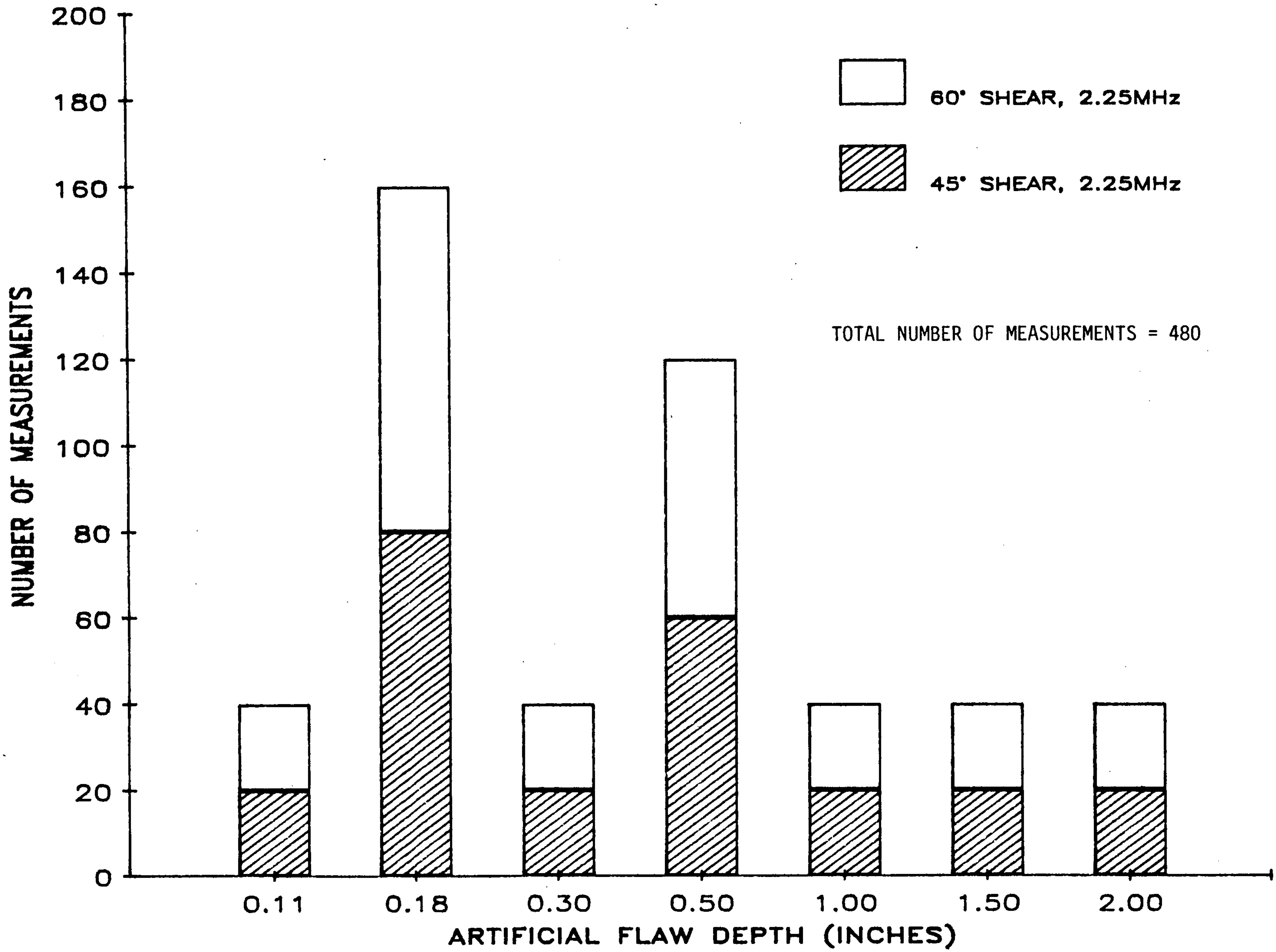


FIGURE 4-4: DATA POINT BREAKDOWN, ARTIFICIAL FLAW DEPTH FOR STANDARD ASME CODE SECTION XI ULTRASONIC EXAMINATIONS AND STATE-OF-THE-ART EXAMINATIONS, ASME CODE TECHNIQUES

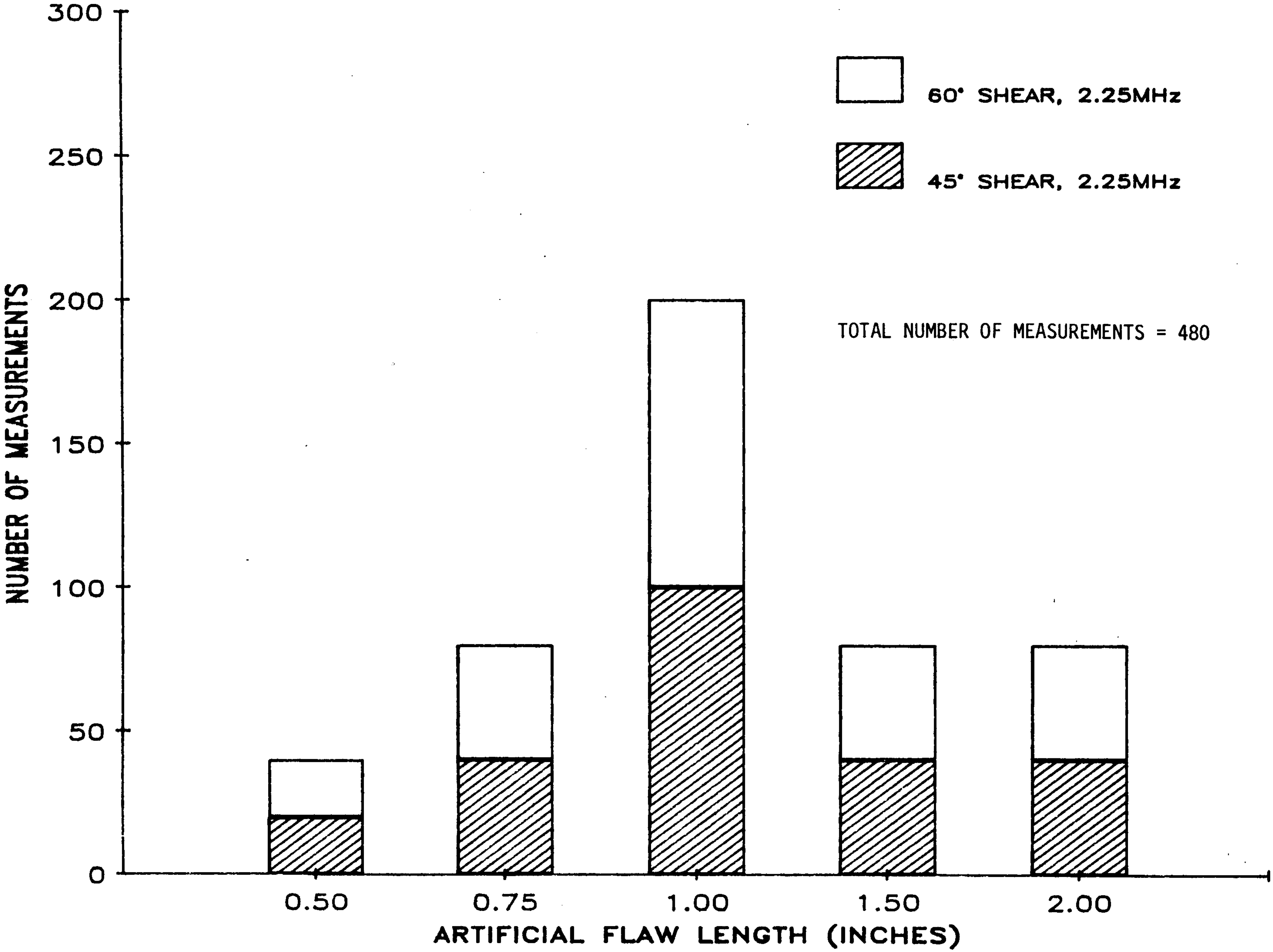


FIGURE 4-5: DATA POINT BREAKDOWN, ARTIFICIAL FLAW LENGTH FOR STANDARD ASME CODE SECTION XI ULTRASONIC EXAMINATIONS AND STATE-OF-THE-ART EXAMINATIONS, ASME CODE TECHNIQUES

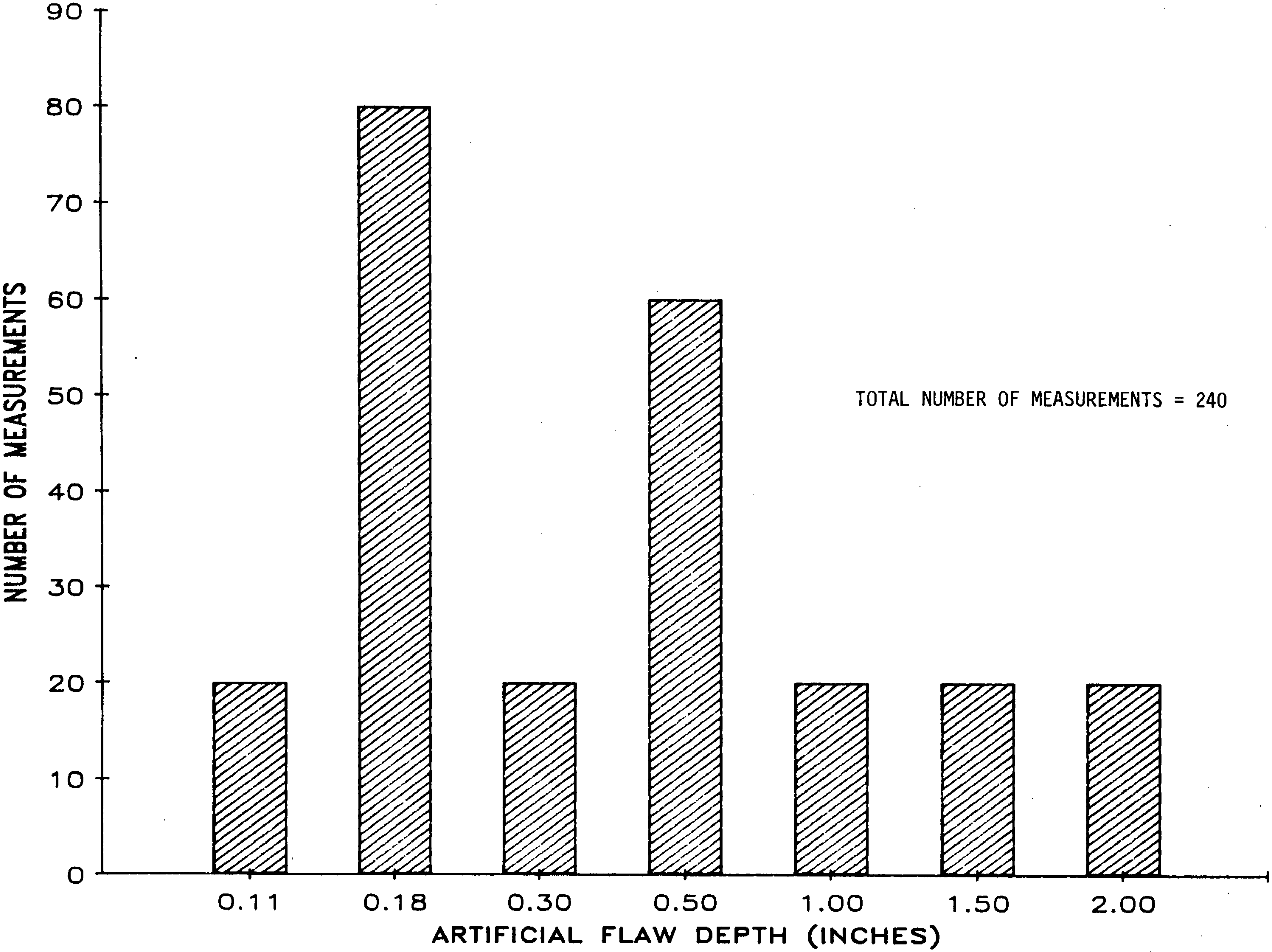


FIGURE 4-6: DATA POINT BREAKDOWN, ARTIFICIAL FLAW DEPTH FOR SPECIAL EXAMINATIONS, DELTA TECHNIQUE AND STATE-OF-THE-ART EXAMINATIONS, DELTA TECHNIQUE

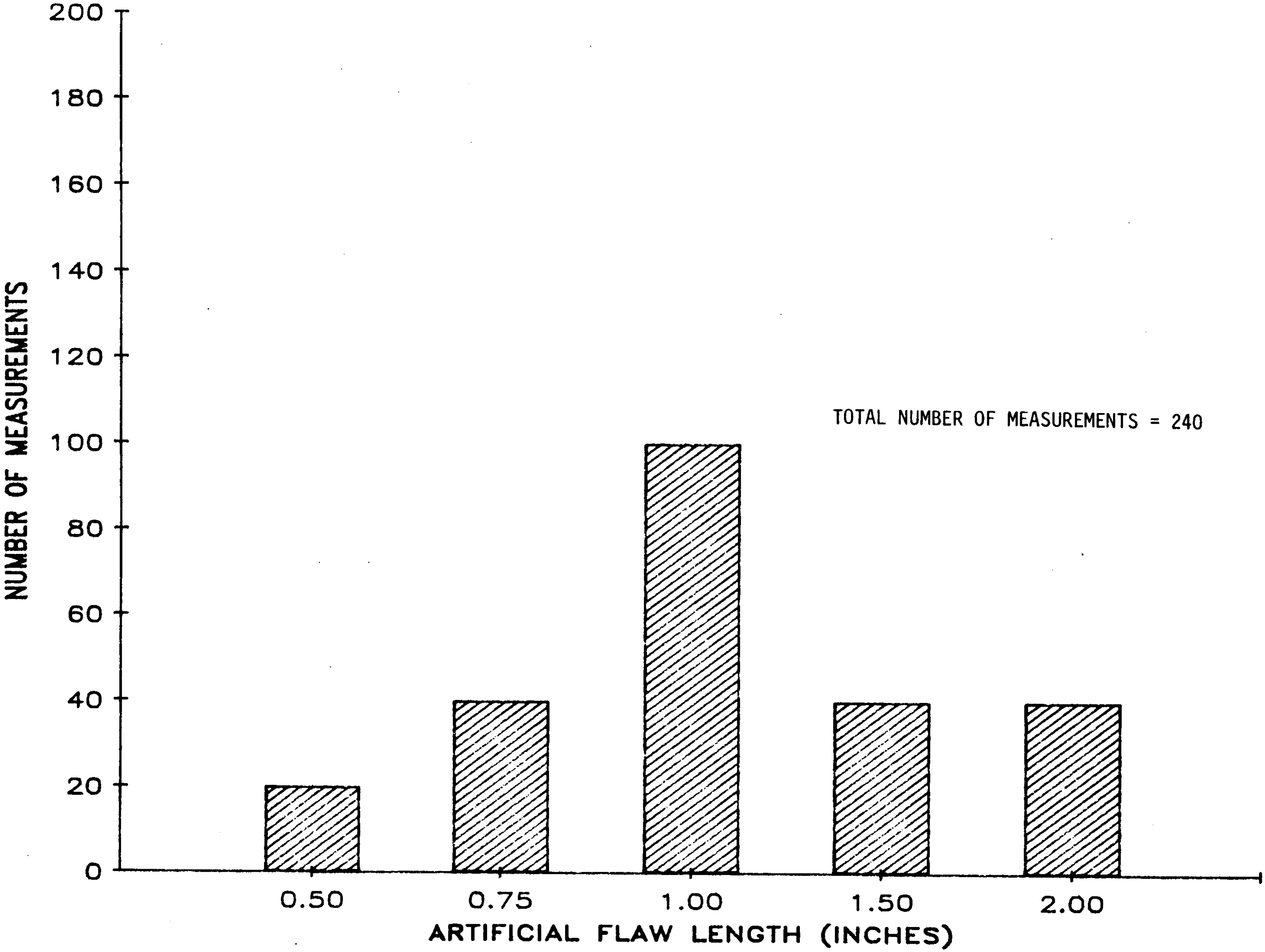


FIGURE 4-7: DATA POINT BREAKDOWN, ARTIFICIAL FLAW LENGTH FOR SPECIAL EXAMINATIONS, DELTA TECHNIQUE AND STATE-OF-THE-ART EXAMINATIONS, DELTA TECHNIQUE

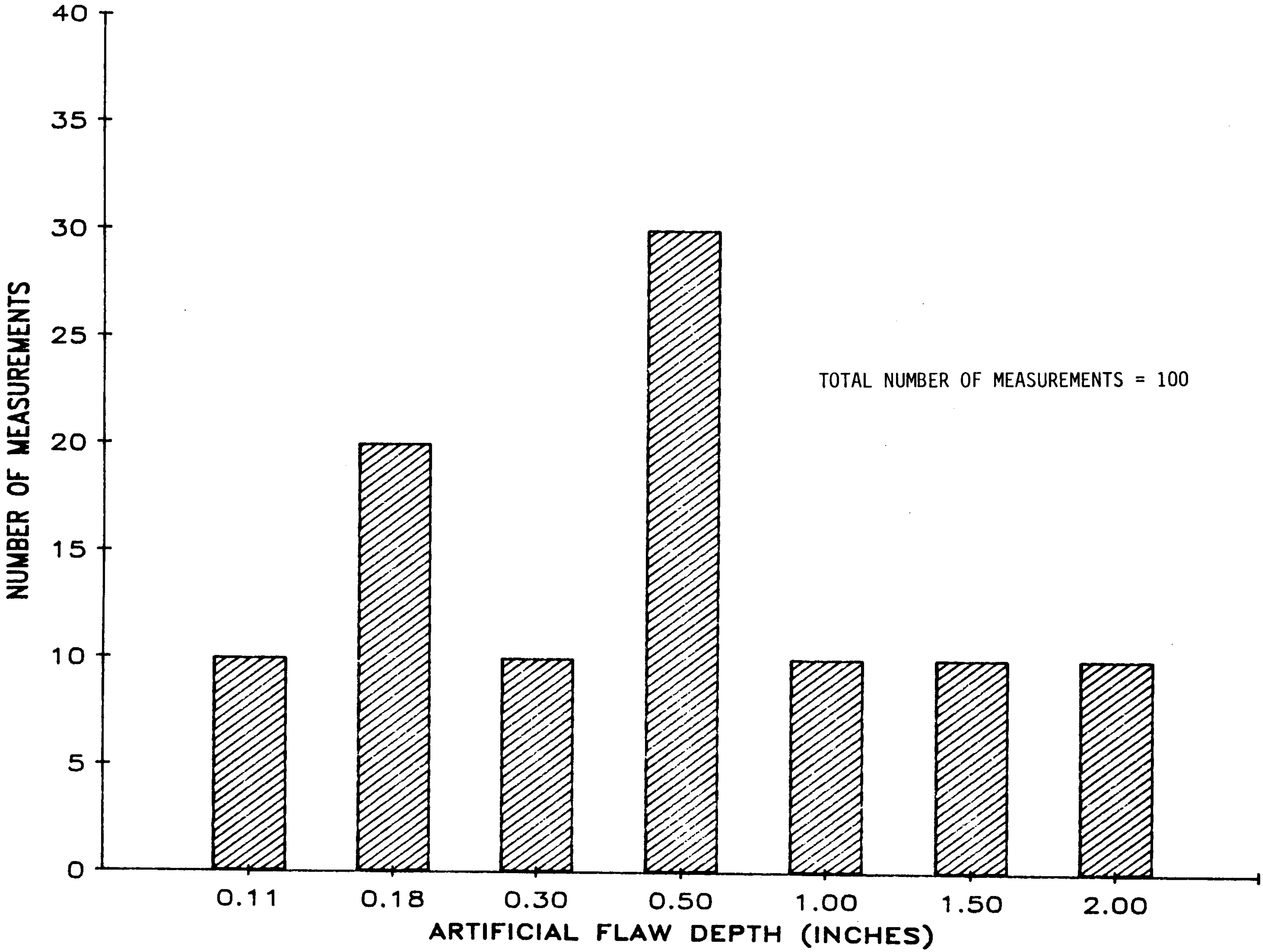


FIGURE 4-8: DATA POINT BREAKDOWN, ARTIFICIAL FLAW DEPTH FOR SPECIAL EXAMINATIONS, PITCH-CATCH TECHNIQUE

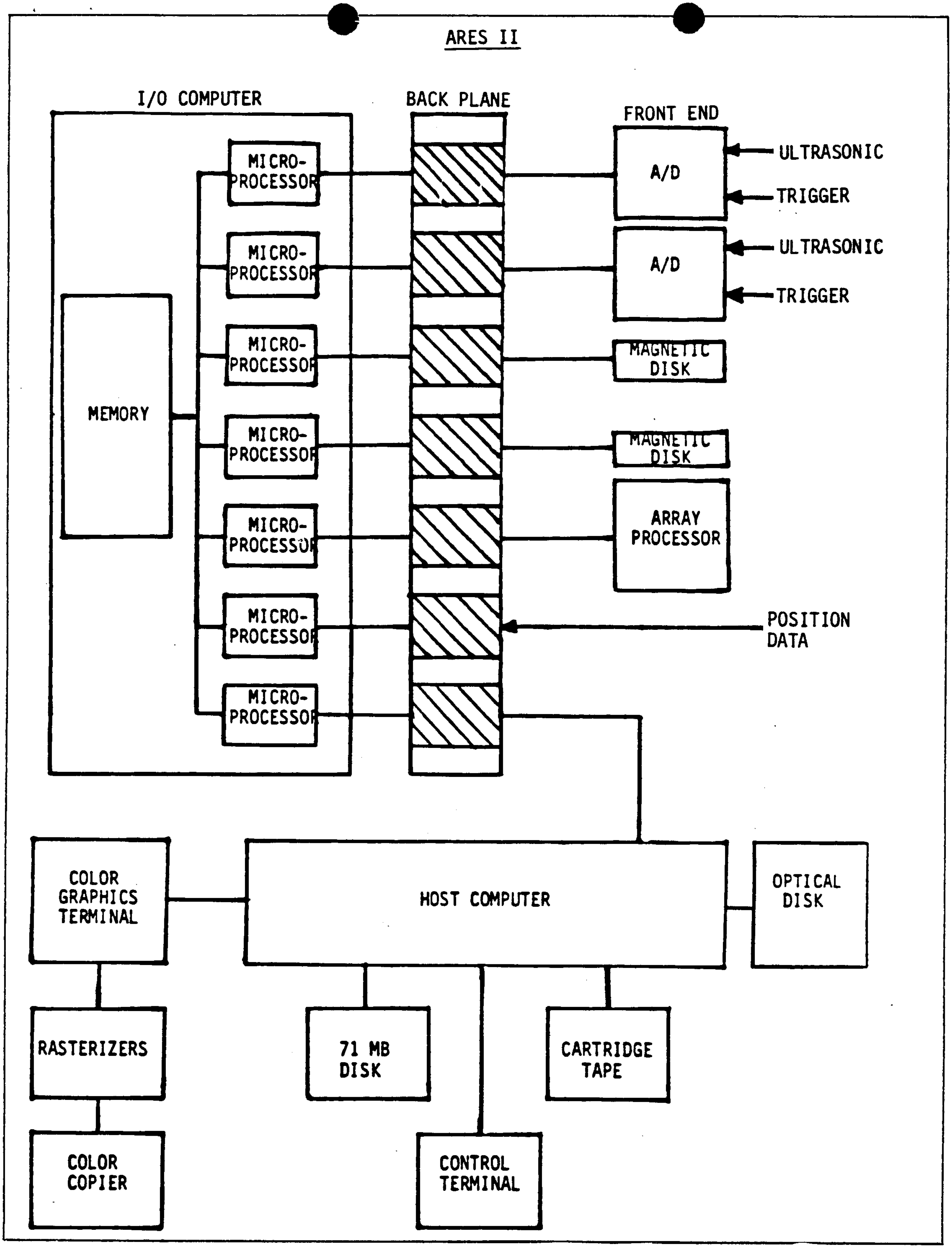


FIGURE 5-1: SYSTEM BLOCK DIAGRAM

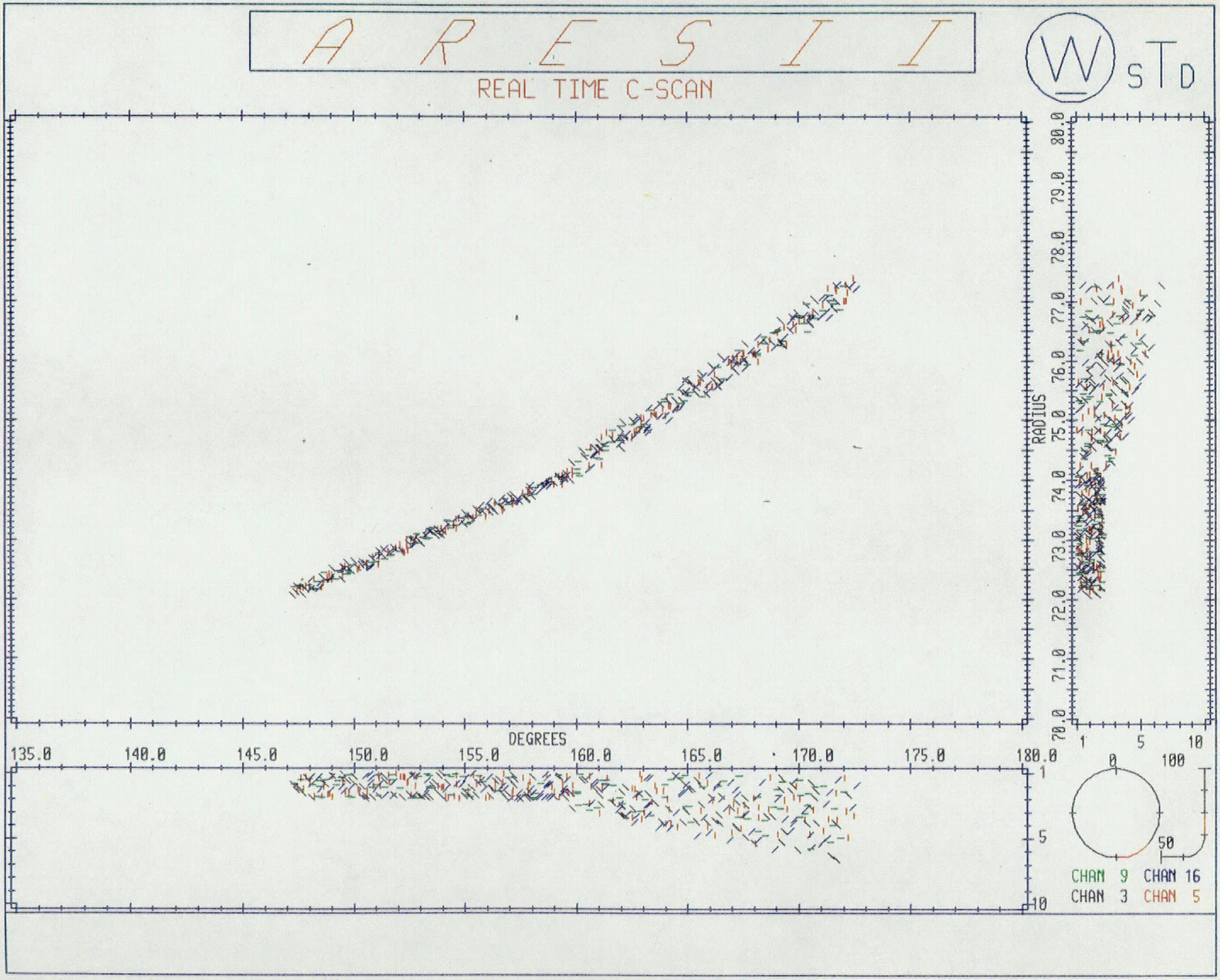

A R E S I I
REAL TIME C-SCAN
W STD
RADIUS
70.0
71.0
72.0
73.0
74.0
75.0
76.0
77.0
78.0
79.0
80.0
DEGREES
135.0
140.0
145.0
150.0
155.0
160.0
165.0
170.0
175.0
180.0
1
5
10
0
100
50
CHAN 9
CHAN 16
CHAN 3
CHAN 5

FIGURE 5-2

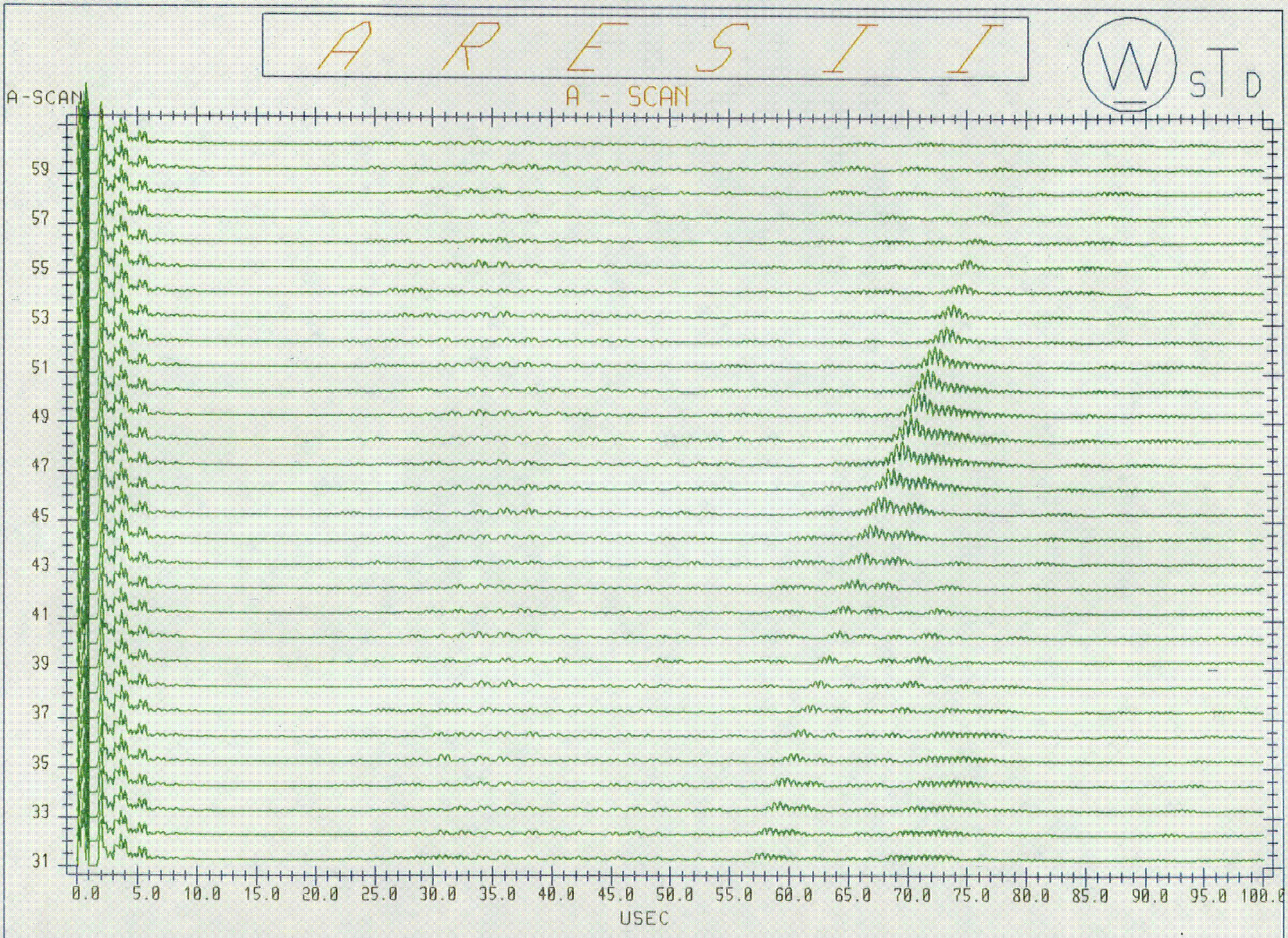

A R E S I I
A - SCAN
STD
A-SCAN
59
57
55
53
51
49
47
45
43
41
39
37
35
33
31
0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0 55.0 60.0 65.0 70.0 75.0 80.0 85.0 90.0 95.0 100.0
USEC

FIGURE 5-3

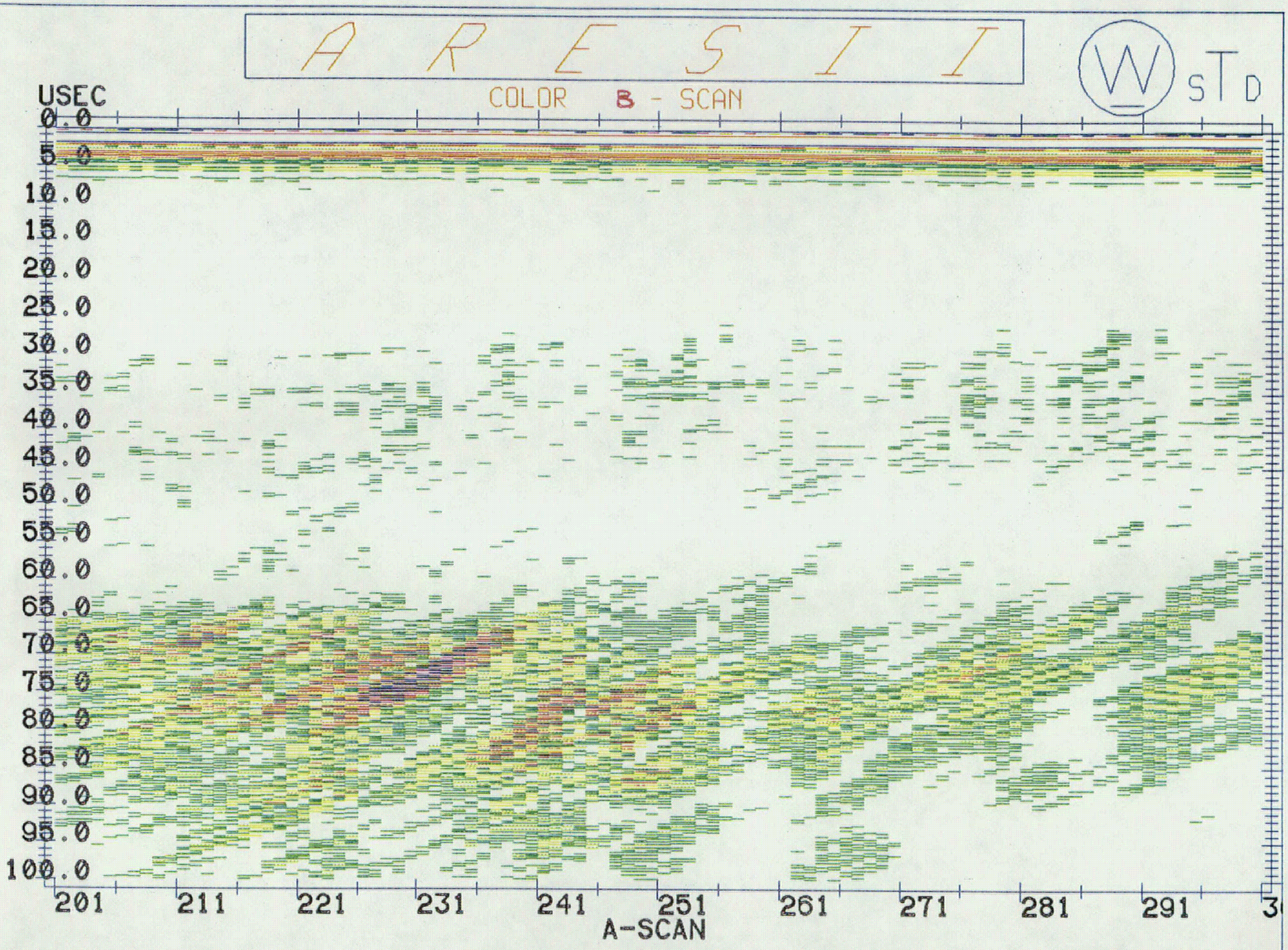

A R E S I I
COLOR B - SCAN
W STD
USEC
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
80.0
85.0
90.0
95.0
100.0
201
211
221
231
241
251
261
271
281
291
3
A-SCAN

FIGURE 5-4