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INSTRUCTION MANUAL
FOR
ULTRASONIC TRANSDUCER EQUIPMENT
FOR
UNDER SODIUM SCANNING

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DESCRIPTION

The ultrasonic transducer consists of a piezoelectric disk mounted against the inner face at one end of a leak-tight cylindrical shell. The outer surface of the active end of the transducer is spherically concave, which directs the emitted ultrasonic waves to a focal point near the transducer. A useful but seldom noticed feature of such a transducer is that the ultrasonic energy beyond the focal point is located in a small diameter beam which has a very small angle of divergence. The transducer is capable of converting an electrical pulse into an emitted ultrasonic beam, and also of converting an incoming ultrasonic signal into an electrical pulse. The individual elements of the transducer will be described in detail below. The detail numbers correspond with those on the design drawings (5XN-8855E, 5XN-8869C, and 5XN-8870B).

Lens (Detail 1) - The lens is a cylindrical element of 304 stainless steel having the outer surface of its closed end ground and polished to a 2.29 inch spherical radius, and having internal threads at its open end and a precisely ground perpendicular seal surface at its open end. An internal groove is provided at the closed end to minimize unwanted sound transmission along the cylindrical walls. Four wrench holes are provided in the cylindrical exterior for tightening the threaded connection as described below.

Cap (Detail 2) - The cap is a cylindrical element of 304 stainless steel having external threads and also, on its closed end, a projecting lug or yoke for attachment to a manipulator. Four wrench holes are provided for tightening the threaded connection. The cap and the lens, together with the seal ring (Detail 13, see below) comprise the leak tight enclosure for the piezoelectric disk and related elements. Two pins (Detail 9) are pressed into the inner face to provide proper alignment of a slot in the insulator disk (Detail 10) in relation to the MI cable conductor (Detail 8).

Seal Ring (Detail 13) - The seal ring is an expendable gasket of Nickel 270 (International Nickel Company) located between the seal surfaces of the lens and the cap. The seal ring has three sharp-edged ridges contacting the seal surfaces. After machining, the rings are annealed to a dead soft condition. To seal the enclosure for sodium service, the threaded connection is torqued to 105 foot pounds, which deforms the sharp ridges of the seal rings approximately 0.007 inch.

Piezoelectric Disk (Detail 3) - The piezoelectric element is a disk of lead-zirconate-titanate marketed as PZT-5 (formerly called PZT-5A) by Vernitron Piezoelectric Division, Bedford, Ohio. The element is 1.00 inch diameter and sized to 2.25 MHz (about 0.035 inch thick). Both sides are silver coated to ensure electrical conductivity. The piezoelectric disk is located against the inner end surface of the lens, and is acoustically coupled to the lens by a thin film of Royco 13D Ball and Roller Bearing Aircraft Grease (Royal Lubricants Company).

Backing Block (Detail 6) - The backing block is a cylindrical piece of high purity zinc (melting temperature >780 F) which, together with a spring (Detail 12), holds the piezoelectric disk in position against the lens. The material is selected for its low modulus of elasticity to act as an absorber for ultrasound transmitted back into the transducer. The conical back end of the block avoids direct reflection of such sound energy.

Mica Disk (Detail 4) - The mica disk is a 0.0015 inch thickness of clear mica (dielectric grade) located between the back face of the piezoelectric disk and the backing block. Its function is to decouple from the piezoelectric disk the capacitance of the MI cable, and to raise the breakdown voltage of the piezoelectric disk. It also reduces ultrasound transmission into the backing block.

Spring (Detail 12) - The spring, a commercially available item of 302 stainless steel, provides a 24-pound force holding the piezoelectric disk against the lens. A jumper wire is attached (Detail 17) which provides an inductance-free conductive path between the backing block and the conductor disk (Detail 11).

Conductor Disk (Detail 11) - The conductor disk is a flat plate of electrolytic copper which provides the electrical junction between the conductor wire in the mineral insulated (MI) cable (Detail 8) and the spring (Detail 12). Connection of the MI cable conductor to the conductor disk is made by means of a screw (Detail 16). The disk has two axial pins, also electrolytic copper, which engage holes in the insulator disk (Detail 10) to align a clearance slot with the MI cable conductor.

Insulator Disk (Detail 10) and Insulator Tube (Detail 5) - The insulator disk and insulator tube are elements of unfired lava (Grade A) which provide electrical insulation of the inner elements from the lens and cap. The electrical path from the MI cable then becomes: through the conductor disk, the spring jumper, the backing block, and the mica disk into the piezoelectric disk; thence into the lens and through the cap into the sheath of the MI cable.

Wave Spring Washer (Detail 7) - The wave spring washer, a commercially available item of SAE 1095 carbon steel, holds the insulator tube against the inner face of the lens, to provide secure positioning of the piezoelectric disk.

MI Cable (Detail 8) - The conductor used to connect the transducer to the electronic driving and receiving components consists of standard mineral insulated cable having the following specifications:

- a. Nominal size: 1/16 inch outside diameter.
- b. Sheath and conductor material: Inconel 600.
- c. Sheath thickness and conductor diameter: nominal 0.010 inch Reuter-Stokes (R-S) standard.

- d. Electrical insulation: MgO.
- e. Seal, on both ends: R-S No. SP-176 (Gold/Nickel; M.P. approximately 1000° C).
- f. Sheath surface finish: standard R-S quality.
- g. Maximum operating temperature: 600 F.
- h. Test voltage, without breakdown: 1000 v, dc.
- i. Cable length required: 34 feet nominal (before end seal installation).
- j. For the customer's records, the manufacturer shall furnish leakage resistance data obtained on the cables after bake-out and sealing.
- k. The end seal region of the cable shall be free of excess brazing material so that the maximum diameter dimension does not exceed by more than 0.020 inch the nominal seal diameter of 0.125 inch.
- l. Install one welding ring (Detail 14) on the MI cable in position shown on APDA Drawing 5XN-8855B. Installation is to be by Microbrazo No. 30 as noted.

The completed MI cable assembly is electron beam welded to the cap as shown on Drawing 5XN-8855E. (This type of joint can be disassembled by grinding out the weld, allowing the joint to be subsequently rewelded.) The instrumentation end of the MI cable is provided with a UHF type panel connector (Amphenol No. SO-239 or equivalent), equipped with a type UG-177/U backside hood.

Alternate Seal Ring (Detail 15) - A rubber O-ring seal is provided as an economical substitute for the nickel gasket, when testing in water. To achieve complete leak tightness, it is recommended that a coating of sealant such as Glyptal be applied over the rubber seal ring. (This is easily removed with acetone.)

Holder (Drawing 5XN-8887) - A holder is provided for the transducer, consisting of an "L" shaped bracket of carbon steel. The bracket attaches by means of set screws to the yoke on the cap, and also provides attaching lugs to hold the first three or four turns of the rolled MI cable bundle. This bracket should be used at all times when the transducer is not installed in a special manipulator, to protect the MI cable from damage--particularly at the point where it enters the transducer. The holder has a threaded boss conveniently located for attaching the transducer to a simple manipulator for water testing.

Instrument Package - The instrumentation consists of the electronic components required to operate the transducer in either the A-scan or C-scan modes, with an oscilloscope for A-scan presentation and a recorder for C-scan presentation. The basic components of the instrumentation are: timing pulse generator, pulse transmitter/receiver, oscilloscope, gate (with alarm relay), recording amplifier, and recorder. The instrument package and its requirements are defined in APDA Specification No. 121-1 (Appendix 1). All of the components are combined into a package known as the Automation Industries Reflectoscope, except for the recorder, which is an Alden recorder. Each of these units is fully described in the manufacturer's instruction books furnished with the package.

QUALITY ASSURANCE

An informal program of quality assurance was used to assure that the transducers and the electronic instrumentation complied in all respects with the design drawings and specifications. The elements of this program are summarized below. Copies of supporting documents are compiled in Appendix 2.

Materials Identification - Materials certifications were furnished by the fabricator on the following raw materials: 1-1/2" dia. x 18" long 304 stainless steel, 1/4" dia. x 12' long 304 stainless steel, 1" dia. x 6" long copper. APDA obtained certification on 1-1/4" dia. x 24" long zinc, and furnished nickel 270 with a photograph record of the identification as recorded on the actual material. Identification was established by vendors' packing slips for Grade A lava, PZT-5 piezoelectric disks, and Royco 13D grease.

Fabricator's Inspection - The transducer fabricator conducted a dimensional inspection of all fabricated items. The results of that inspection, demonstrating dimensional compliance with the drawings, was recorded on a set of prints transmitted to APDA for review. These prints are maintained on file at APDA. The MI cable manufacturer tested each cable after fabrication and furnished certification of compliance with purchase specifications. (These certificates were packaged with the assembled transducers).

Receiving Inspection - The transducers were inspected by APDA for proper fits and configuration following receipt by APDA. The electronic components were inspected by APDA for absence of in-transit damage, upon arrival at APDA.

Compliance with Specification - Automation Industries furnished a letter certifying that the Reflectoscope furnished does comply with APDA Specification No. 121-1. Similarly, Alden Electronic and Impulse Recording Equipment Company certified by letter the compliance of the recorder they furnished with the pertinent sections of that specification.

Manufacturers' Warranties - Both Automation and Alden extended a one-year warranty against defects in materials or workmanship. The Automation warranty is incorporated in their instruction book. The Alden warranty is included in Appendix 2.

5.2.1 Nominal Operating Frequency

The transmitter shall operate at the nominal frequency of 2.25 MHz (same as the natural frequency of the transducer piezo-electric element to be used).

5.2.2 Tuning Range

The transmitter shall be tunable approximately ± 1 MHz, or greater, about the nominal center frequency of 2.25 MHz.

5.2.3 Output Pulse Amplitude Adjustment

A front panel control shall be provided allowing a continuous range of adjustment of the output pulse amplitude, from the maximum level of approximately 900 volts down to the lowest practicable level.

5.2.4 Pulse Length

The transmitted pulse length shall be adjustable over the range of approximately 3 to 10 cycles @ 2.25 MHz, equivalent to 1.3 to 4.5 μ sec.

5.2.5 Pulse Repetition Rate

See under Section 5.1 Timing Pulse Generator

5.2.6 Tolerance of Capacitive Loading

The transmitter shall be capable of exciting the transducer as required at the nominal frequency of 2.25 MHz with capacitive loading present on the transmitter output up to 5000 pf.

5.3 Receiver

The nominal parameters desired of this unit are those offered by the Automation Industries Model 10N module, which also contains the circuit of the pulse transmitter.

5.3.1 Gain

The receiver shall have a gain of at least 75 db.

5.3.2 Range of Gain Adjustment

The receiver gain shall be adjustable over the range of 1000 to 1.

5.3.3 Dynamic Range

The amplitude range over which a signal can be discernible for a fixed setting of gain control shall be at least 64 to 1.

5.3.4 Modes of Operation

Capability shall be provided for operating in the pulse echo mode (as with a single transducer), or transmit-and-receive mode (as with two transducers).

5.4 A-Scan Oscilloscope

The nominal parameters desired of this unit are those offered by the Automation Industries, Inc., Model UM 771 display chassis.

5.4.1 Vertical Axis Bandwidth

Shall be 25 MHz or greater.

5.4.2 Full Scale Signal

Shall be 7.65 cm (3 inches) vertical, and 10.2 cm (4 inches) horizontal.

5.4.3 Vertical Linearity

Shall be within $\pm 2\%$ of full vertical scale.

5.4.4 Horizontal Linearity

Shall be within $\pm 2\%$ of full horizontal scale.

5.4.5 Cathode Ray Tube

Face shall be 12.7 cm (5 inches) in diameter with green phosphor, having bonded nonreflective face plate equipped with a green filter.

5.4.6 Graticule

A graticule shall be provided for the front of the cathode ray tube face which is vertically calibrated in both inches and percent, and horizontally calibrated in 10 major and 100 minor divisions.

5.5 Gate

The nominal parameters desired of the gate are those offered by the Automation Industries, Inc., Graphigate unit.

5.5.1 Gate Length

The gate length shall be adjustable over the range $0.25 \mu\text{sec}$ to $1700 \mu\text{sec}$.

5.5.2 Start Delay

Delay of the start of the gate shall be adjustable over the range $0.25 \mu\text{sec}$ to $300 \mu\text{sec}$.

5.5.3 Synchronization

Flexibility shall be provided to allow synchronizing the gate start with the first signal arriving after the transmitted pulse, or with start of the transmitted pulse itself.

5.5.4 Input Signal

The gate shall be capable of handling the normal full range of signal to be supplied by the receiver.

5.5.5 Output Signal

The range of output signal shall be as required for full range of operation of the recorder amplifier; see Section 5.6, Recording Amplifier.

5.5.6 Setup/Operation

A setup switch shall be provided for introducing a calibrated signal to which front panel controls can be preset for anticipated recording conditions.

5.5.7 Intensity

An intensity control shall be provided for adjusting the darkness of the recorded traces.

5.5.8 Lower Limit Adjustment

A control shall be provided for selecting the signal height (as viewed on the A-scan oscilloscope) at which recording will start.

5.5.9 Upper Limit Adjustment

A control shall be provided for selecting the signal height (as viewed on the A-scan oscilloscope) at which recording will stop.

5.5.10 Signal Level Meter

A panel meter shall be provided which indicates the amplitude of the gate output signal being supplied to the input of the recording amplifier.

5.5.11 Alarm Relay

An alarm relay, actuated on presence of a signal within the gate, shall be provided which has a normally-open and normally-closed arrangement of contacts for remote circuit operation. Contact rating shall be 10 amperes.

5.6 Recording Amplifier

The operating characteristics desired of the C-scan recording amplifier are those offered by the Automation Industries, Inc., Model 1/2 S. This amplifier provides output characteristics typical of those required for C-scan recorders such as the Alden Model 11.

5.6.1 Input Signal

Shall be capable of accepting an input signal of 0 to 6 volts.

5.6.2 Output Signal

Shall be capable of supplying an output signal of 0 to -60 volts.

5.6.3 Frequency Response

Shall be capable of operating on signals within the range dc to 5 KHz.

5.6.4 Output Impedance

Shall not exceed 200 ohms.

5.6.5 Output Current

Shall be capable of supplying currents up to 0.30 ampere.

5.7 Module Assembly Enclosure

The component instrument modules and associated power supply, excluding the facsimile recorder, which will be a separate instrument, will be housed in a bench top cabinet enclosure equipped with carrying handles. The Automation Industries, Inc., Type UM 771 Reflectoscope comprises an assembly of such configuration. Overall dimensions of the UM 771 Reflectoscope are as shown in the outline sketch in Figure 2.

5.7.1 Frame Construction

Shall have a welded steel chassis.

5.7.2 Grounding

A grounding terminal shall be provided at the rear of the main frame.

5.8 Servicability and Test Points

The timing pulse generator, gate, pulser/receiver, and recording amplifier shall be of plug-in modular construction, with circuit adjustments and test points clearly marked. All assemblies shall be changeable with a screwdriver.

5.9 Transistor Circuits

The circuits of the instrument package shall be transistorized to the maximum practical extent to insure ruggedness of the equipment, and to obtain long, trouble-free operating life.

6. C-SCAN FACSIMILE RECORDER REQUIREMENTS

The performance characteristics desired of the C-scan recorder are those offered by the Alden Model 11 unit, catalog No. 311/1100. The outline dimensions of this recorder are given in Figure 3.

6.1 Recording Paper and Color

The recording paper shall be Alfax A, current sensitive type, providing facsimile recordings in sepia tones.

6.2 Paper Width

Shall be 28 cm (11 inches).

6.3 Paper Storage

The recording paper shall have a virtually unlimited shelf life in the storage temperature range of -56°C (-70°F) to 82.5°C (180°F).

6.4 Recording Permanence

Recordings shall be smudge proof, and shall not fade or darken.

7. OPERATING AND SERVICE INSTRUCTIONS

Three (3) copies of instruction manuals on operation and servicing of all instrument package components are required; parts lists shall be included.

8. WARRANTY

The equipment procured in accordance with this specification shall be covered by warranty against defects in material and workmanship under normal use and service for a period of at least one (1) year.

FIGURE 1- BLOCK DIAGRAM OF UNDER SODIUM SCANNER INSTRUMENT PACKAGE

FIGURE 2 OVERALL DIMENSIONS OF AUTOMATION INDUSTRIES, INC. REFLECTOSCOPE

APPENDIX NO. 1

APDA SPECIFICATION NO. 121-1

SPECIFICATION FOR
UNDER SODIUM SCANNER INSTRUMENT PACKAGE
May 1, 1972

SPECIFICATION
FOR
UNDER SODIUM SCANNER
INSTRUMENT PACKAGE

PNC/APDA Contract, December 24, 1971
APDA Project 293

SPECIFICATION NO. 121-1

May 1, 1972

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Specification
for
Under Sodium Scanner
Instrument Package

1. PURPOSE AND SCOPE

This specification forms the basis for procurement of the instrument package required for the under sodium scanner system and lists the principal operational parameters required of the component modules which will comprise this equipment. The instrument package will consist of equipment such as is commonly employed in ultrasonic nondestructive testing in which A-scan presentation and C-scan recording are employed, because the functional principles of the under sodium scanner are basically the same as those of a nondestructive test scanner operating in water. The Reflectoscope instrument unit made by Automation Industries, Inc., and furnished in several arrangements of module types, is an example of such an instrument package for an ultrasonic scanner. Although this specification is based on Automation Industries and Alden Company equipment, equivalent instrumentation is available from other manufacturers, with the possible exception of the C-scan recorder. Except for statement of its ultrasonic operating frequency and mention in areas of the document where necessary, the transducer is not a part of this specification. A block diagram is presented which illustrates the functional relationship of the instrument circuits by their signal flows. Also presented are outline diagrams of the module cabinet enclosure, which also contains an A-scan oscilloscope, and of the C-scan recorder, giving their overall dimensions.

2. INSTRUMENT PACKAGE COMPONENTS

Figure 1 presents a block diagram defining the major components which will comprise the instrument package for the under sodium scanner. Except for the C-scan recorder, which will be a separate instrument of a type such as the Alden Model 11 unit, the component blocks represent modules which are assembled in a main frame enclosure designated the Type UM771 Reflectoscope. Physically, the circuitry of both the pulse transmitter and the receiver are contained in a single Model 10N module unit, while the alarm relay is located in the gate module unit. The timing pulse generator module contains the "clock" pulse circuit which triggers both the pulse transmitter and the A-scan oscilloscope for synchronized operation.

3. INPUT POWER REQUIREMENTS

3.1 Module Assembly (Reflectoscope)

3.1.1 Line Voltage

Internal power supplies are to be regulated for satisfactory operation on 90 to 130 volts a-c; or to be operable on 220V a-c upon a simple wiring change made at the rear of the cabinet enclosure.

3.1.2 Frequency

50 to 60 Hz.

3.2 C-Scan Recorder

The C-scan recorder does not require an external power supply, since the recorder drive motors will be energized and controlled by a stepping motor control unit to be recommended under the APDA/PNC contract, but not included in this instrument package.

4. TEMPERATURE TOLERANCE REQUIREMENTS

4.1 Module Assembly (Reflectoscope):

Reliable operation shall be obtained in the temperature range 0° to 120°F (-18°C to 49°C)

4.2 C-Scan Recorder

Reliable operation in the temperature range 0° to 120°F (-18°C to +49°C).

5. COMPONENT MODULE REQUIREMENTS (REFLECTOSCOPE)

This section gives the requirements for all instrument package modules except the C-scan recorder, which is covered in Section 6.

5.1 Timing Pulse Generator

The nominal parameters desired of this unit are those offered by the Automation Industries Model AG-IF Timer unit.

5.1.1 Pulse Repetition Rate

The pulse repetition rate shall be adjustable over the range 100 to 2000 pulses per second. Sweep control provisions shall be included whereby the repetition rate will automatically adjust to the sweep length of the A-scan display.

5.1.2 Sweep Length

The sweep length shall be adjustable over the range 0.87 μ sec to 2200 μ sec.

5.1.3 Sweep Delay

The sweep delay shall be adjustable from 0 to 500 μ sec.

5.2 Pulse Transmitter

The nominal parameters desired of this unit are those offered by the Automation Industries Model 10N module.

DESIGN REQUIREMENTS

The design requirements for the transducer and instrumentation were set forth in the PNC/APDA Contract, December 24, 1971. These are summarized below:

Functional Requirements

The transducer must be suitable for mounting on a remotely operated manipulator for use in a sodium-cooled reactor as a sweep device (using A-scan mode), and as a viewing device at short range (using C-scan) for such purposes as reading engraved marks.

Environmental Requirements

The transducer must be able to withstand:

- a. Radiation field typical of a shutdown reactor.
- b. Liquid sodium or an inert gas atmosphere containing sodium vapors.
- c. Temperature--in either liquid sodium or an inert gas-sodium vapor atmosphere--up to 315°C (600°F).
- d. External pressure up to 2 kg/cm^2 (28.44 psi).

Transducer Performance Requirements

- a. The acoustic beam collimation or angle of divergence must not exceed 4 degrees in water.
- b. The signal-to-noise ratio of the echo from a plane target in water at a distance of one meter must be not less than 40 db.

Instrumentation Performance Requirements

- a. As utilized in this transducer system, the A-scope on the instrumentation must be able to measure distance with a resolution of not greater than one cm up to a range of 300 cm.
- b. In the C-scan mode, the instrumentation must be able to resolve a lateral distance of not less than 5 mm at range of 3 to 10 cm.

DESIGN BASIS

Since the design requirements describe generally the demonstrated capabilities of under-sodium transducers previously operated successfully in sodium, as described in APDA-210, compliance with the design requirements is obtained by minimizing the departure from the earlier APDA transducers. The principal change incorporated in the present design is the use of metal sheathed mineral insulated (MI) cable, rather than a conventional conductor strung within a rigid tube. This change was made to permit use of a remotely operated scanning manipulator of the type proposed in APDA-220. Detailed compliance with the requirements is obtained as described below.

Functional Requirements

The transducer is capable of being mounted in a mounting ring at the lower end of an in-reactor type of manipulator, as shown on drawing 5XN-8868. The transducer can be locked into such a ring by set screws or other suitable means. The transducer is provided with a projecting lug on its back face for attachment to the actuating element of a manipulator. The MI cable can be formed into a helical coil arranged to accommodate elastically a 90° range of transducer elevation angles, as shown on 5XN-8868.

The focal length (10 cm in sodium) was selected so that the same transducer can be used for either A-scan sweeping at distances up to several meters or for C-scan viewing at close-in ranges. This is possible because of the very narrow beam beyond the focal point, a characteristic of this transducer configuration. This narrow beam provides good resolution at distances much greater than the focal distance.

Environmental Requirements

All transducer components having surfaces exposed to sodium are made of metals which are compatible with sodium up to temperatures much higher than the 600° F specified. All of the internal components can withstand temperatures of 770° F or higher.* The nickel seal between the cap and the lens was selected because it has previously been proved successful in a sodium centrifuge application in which the seal remained leaktight against liquid sodium at a pressure of 62,000 times "g" (the gravitational acceleration constant).

Transducer Performance Requirements

The characteristics of the acoustic beam, and also the reception of an adequate echo, were obtained by retaining the essential configuration features and materials selection that had been employed in earlier APDA transducers.

Instrumentation Performance Requirements

The instrumentation employed with these transducers consisted of components either identical or substantially improved as compared with the components which had been previously found satisfactory by APDA.

* The Royco 13D grease, used as a couplant between the piezoelectric disk and the lens, has a limited (but useful) life above 500° F (260° C). It was selected as the best couplant presently available, and because a nearly identical product has previously been successfully used. Royco 13D has very low volatility, and, in the thin film configuration used in this transducer, is almost completely isolated from the internal atmosphere of the transducer.

Design Calculations

Calculation of radius of curvature for stainless steel lens in sodium.

Focal length, $f = 10$ cm

Index of refraction, $n = 2.39$

R = spherical radius of lens

$$f = \frac{R}{1 - \frac{1}{n}}$$

$$R = f \left(1 - \frac{1}{n}\right) = 10 \left(1 - \frac{1}{2.39}\right) \\ = 10 (0.582)$$

$$R = \underline{5.82 \text{ cm}} \text{ or } \underline{2.29 \text{ inch}}$$

Calculation of wave length, λ , in stainless steel at 2.25 MHz.

v = velocity of sound in S.S.

f = ultrasonic frequency

$$\lambda = \frac{581000 \text{ cm/sec}}{2.25 \times 10^6 \text{ cycles/sec}}$$

$$\lambda = \underline{0.259 \text{ cm}} \text{ or } \underline{0.102 \text{ inch}}$$

Calculation of lens thickness

Purpose of the calculation:

Calculate $T = t_0 + t$, where T is the "average" thickness, defined as the thickness which the largest possible lens area should approach. I.e., the "averaging" is to be done on a per-area basis. To fulfill this definition,

$$T \times A = T \left(\frac{\pi}{4} D^2\right) = \text{Vol. of the lens, } V.$$

Thus,

t is to be determined geometrically;

t_0 will be set so that $T = \lambda$ for the specific lens in sodium.

Calculation of lens thickness - Continued

Consider a cylinder of diameter D and height h, intersected by a sphere of radius R, the intersection of cylinder and sphere occurring at upper end of h (as shown). Further, h is such that sphere is tangent to base of the cylinder. The volume of cylinder below the sphere, V_B , is then equal to the volume of the cylinder, V_C , minus the portion of the sphere below the top of the cylinder.

$$V_C = A \cdot h$$

$$V_B = A \cdot h - \pi h \left(\frac{D^2}{8} + \frac{h^2}{6} \right), \text{ where } h = R - \frac{1}{2} \sqrt{4R^2 - D^2}$$

$$h = 2.28 - \frac{1}{2} \sqrt{4(2.28)^2 - 1.31^2} = .096 \text{ inch}$$

$$\text{or } V_B = (.096) \frac{\pi}{4} (1.31)^2 - \pi (.096) \left(\frac{(1.31)^2}{8} + \frac{(.096)^2}{6} \right)$$

$$V_B = 0.129 - .065 = .064 \text{ in}^3$$

Then,

$$t = \frac{V_B}{A} = \frac{0.064}{\frac{\pi}{4} (1.31)^2} = 0.0475 \text{ inch}$$

For best transparency,

$$T = \lambda = 0.102 \text{ inch}$$

$$\text{Then } t_o = T - t = 0.102 - 0.0475 = 0.0545 \text{ inch}$$

Process Tests

Several design features of the transducer design were tested to ensure their suitability or adequacy for the intended application of these transducers. These features are discussed below.

Thread Coating - The threaded joint between the cap and lens cannot employ untreated threads, since both details are made of Type 304 stainless steel. Three different types of thread coating were tested and examined, including extended submersion in liquid sodium, using the test specimens shown on drawing 4XN-8856. On the basis of this test, the male thread on the cap was specified to be treated with a metal spray of molybdenum.

Effect of Nickel Seal on Type 304 Steel - Although the nickel seal had been proven in a sodium centrifuge application, that case employed the soft nickel against a surface of Inconel. Therefore, a test was performed to ensure that use of the nickel seal against a surface of Type 304 stainless steel would not damage the 304. This test was performed using test specimens shown on drawing 5XN-8874.

Electron Beam Weld Demonstration - Before the MI cables were welded to the caps by the electron beam process, several demonstration runs were made on specially prepared specimens. The post-weld specimens were sectioned longitudinally to demonstrate the quality of the weld and the absence of damage to the welded details.

A. ASSEMBLY PROCEDURE FOR TRANSDUCER

This assembly procedure is to be used with APDA Drawings 5XN-8855E, 6XN-8872, 5XN-8873, and 5XN-8887.

Procedure

1. Clean the transducer parts, with the exception of the transducer cap (Detail 2), with a Freon solvent or acetone. The parts should then be wiped dry with a lint free absorbent paper. The cap can be carefully wiped with a moist (with Freon or acetone) paper. Care should be taken not to contaminate the end seal with the Freon or acetone. Contamination of the conductor end seal will reduce the resistance of the end seal ceramic insulator.
2. Remove any soft nickel (from the seal ring) from the sealing surfaces of the lens (Detail 1) and the cap (Detail 2), scraping gently. Care must be taken not to scratch the sealing surfaces of either the lens or cap.
3. Mount the cap of the transducer (Detail 2, APDA Drawing 5XN-8855E) onto the holder (APDA Drawing 5XN-8887) as shown on APDA Drawing 5XN-8873.
4. Clamp the holder into a smooth jawed vise so that the transducer cap cavity is upward.
5. Place the lava insulator disk (Detail 10) into the cap by fitting it onto the pins in the cap cavity.
6. Install the wavy spring washer (Detail 7) around the lava insulator disk.
7. Place the copper conductor disk (Detail 11) on top of the lava insulator disk by fitting the pins of conductor disk into the holes of the insulator disk.
8. Attach the wire of the conductor to the conductor disk by means of the screw (Detail 16). This operation should be done very carefully because of the fragile nature of the conductor end seal.
9. Place the spring (Detail 12) onto the conductor disk.
10. Place the zinc backing block (Detail 6) onto the spring.
11. Holding the insulator tube (Detail 5), with the inner lip uppermost, slip the insulator tube over the zinc backing block and spring until the insulator tube rests on the backing block.

12. Place the mica disk (Detail 4) on top of the zinc backing block.
13. Using a small quantity of the Royco 13D grease, apply a thin layer to one side of the piezoelectric disk (Detail 3).
14. Place the ungreased side of the piezoelectric disk onto the mica disk.
15. Place the nickel seal ring (Detail 31) onto the transducer cap. (This must be an un-used ring.)
16. Carefully place the lens (Detail 1) over the insulator tube. (The assembly will now be in the configuration shown on Drawing 5XN-8873.) Push down on the lens so that the threads of lens can engage the threads of the cap. Screw together finger-tight.
17. Bolt the lower portion of the wrench fixture (APDA Drawing 6XN-8872) onto a stout bench or table. Install upper portion over the lower portion.
18. Retract the eight pins in the wrench fixture (APDA Drawing 6XN-8872) so that they do not interfere or scratch the transducer when it is inserted into the wrench fixture.
19. Remove one pin from the top and bottom parts of the wrench fixture.
20. Remove the assembled transducer and holder from the vise.
21. Insert the transducer into the wrench fixture and rotate the transducer until the holes in the transducer are aligned with the holes (where the two pins have been removed) of the wrench fixture.
22. Carefully screw in the eight pins in the wrench fixture until they bottom in the holes of the transducer. DO NOT TIGHTEN THE PINS ANY MORE.
23. Place a torque wrench of 150 ft-lbs capacity into the 1/2 inch square hole of the wrench fixture in the position shown on Drawing 6XN-8872.
24. Turn the torque wrench clockwise to a torque of 97 ft-lbs.
25. Remove the torque wrench from the square hole in the wrench fixture.
26. Retract the eight pins in the wrench fixture and then remove the transducer from the wrench fixture.

B. DISASSEMBLY PROCEDURE FOR TRANSDUCER

This disassembly procedure is to be used with APDA Drawings 5XN-8855E, 6XN-8872, 5XN-8873, and 5XN-8887.

Procedure

1. If the transducer has been used in a special manipulator, install it into the holder (drawing 5XN-8887) as shown on drawing 5XN-8873.
2. Clean the transducer of sodium by first wiping and then by washing in butyl cellosolve or ethyl alcohol.
3. Retract the 8 pins in the wrench fixture (drawing 6XN-8872) so that they do not interfere or scratch the transducer when it is inserted into the wrench fixture.
4. Remove one pin from the top and bottom parts of the wrench fixture.
5. Insert the transducer into the wrench fixture and rotate the transducer until the holes in the transducer are aligned with holes (where the two pins have been removed) of the wrench fixture.
6. Screw inward the eight pins in the wrench fixture until they bottom in the holes of the transducer. DO NOT TIGHTEN THE PINS ANY MORE.
7. Place a socket wrench into the 1/2 inch square hole of the wrench fixture. Turn the wrench in a counter-clockwise direction to unscrew the transducer lens from the cap.
8. Unscrew the transducer approximately two turns.
9. Retract the eight pins in the wrench fixture and then remove the transducer from the wrench fixture.
10. Clamp the holder into a smooth jawed vise so that the transducer lens is upward.
11. Manually unscrew the lens (Detail 1) from the cap (Detail 2) and carefully remove the lens. The piezoelectric disk (Detail 3) will probably be stuck to the inside front of the lens. A suggested method of removing the disk is given below (step 17).
12. Carefully remove the insulator tube (Detail 5).
13. Remove the loose parts in this order: the mica disk (Detail 4), the backing block (Detail 6), the spring (Detail 12).
14. Remove the nickel seal ring (Detail 13) from the cap. (This seal ring is not re-usable.)

15. Unscrew the screw (Detail 16) to remove the conductor wire. This should be done very carefully because of the fragile nature of the conductor end seal.
16. Remove the remaining parts in this order: the copper conductor disk (Detail 11), the wavy spring washer (Detail 7), and the lava insulator disk.
17. Fill the lens with acetone and allow the piezoelectric disk to soak for a period of time until the disk becomes free of the lens. Another method is to soak the disk in hot water until it becomes free.

C. IN-WATER TEST OPERATION

In general, ultrasonic scanning tests in water can be patterned after practices that are conventional in the field of water immersion nondestructive testing. It is advisable to employ a tank setup in which water is circulated through a filter to maintain system cleanness and promote constancy of test conditions.

Avoidance of Air Bubbles, Rust, and Dirt

Accumulation of air bubbles on the transducer acoustic lens or the scanned surface will cause echo signal attenuation which can be considerable. Rust or dirt on these surfaces will also result in signal attenuation.

Agitation of the water from flow circulation will help prevent bubble accumulation on critical surfaces. Addition of a wetting agent to the water will also be beneficial toward reducing bubble accumulation.

During scanning operations it will be advisable to wipe the lens surface of the submerged transducer to insure absence of bubbles from these surfaces. This should be done somewhat frequently at the outset of operations and periodically as they are conducted.

A rust preventive should be added to the water if surfaces in contact with the water are of a material which will become rusted.

The transducer, particularly the lens surface, as well as the surface of the object scanned, should be cleansed of foreign matter before use.

Transducer and Target Support Fixture

It is essential that the transducer and the scan target be held rigidly in their respective holding fixtures. A small shift in beam orientation from looseness in either fixture can cause a large fluctuation in echo signal, and even its loss.

Target Material, Thickness, and Surface Smoothness

Careful attention should be given to the choice of material which is to be used to make a scan target. It will be found that echo levels from steel will be greater than from aluminum. Thick sections will provide greater signals than thin sheets. Also, echos from smooth surfaces will be greater than from rough surfaces.

Familiarization with the Reflectoscope

Prior to initial operation of the Reflectoscope, the Operating and Maintenance Manual for the instrument unit, especially chapters 1, 2, and 3, should be read by the prospective operator(s).

Transducer Connection

To avoid possible injury to operating personnel from accidental contact with high voltage at the pulser output receptacle, the transducer connection should be made to the Reflectoscope before power to the unit is turned on.

The transducer can be operated either from the T or the R connector. Output power from the T connector will be found somewhat higher than from the R connector, apparently because of a lower source impedance, and use of the T connector is preferred.

Propagation Time and Sweep Calibration

The two-way propagation time in water at 65° F (18.3° C) is 34 μ sec/in, or 13.4 μ sec/cm. The velocity of sound in steel at 68° F is approximately 228,000 in/sec. The values which appear on the timer push button switches, namely, .02, .1, .5, 2, and 10 in/division, relate to the propagation velocity in steel, not water. For relevance to water, these values are to be divided by the factor 3.9.

A-Scan Operation

Assuming for simplicity an A-scan operation in which the echo presence/absence alarm gate (located in the timer unit) is not employed, the following are the Reflectoscope control settings which would be used during scanning for echo signal acquisition.

1. Oscilloscope Panel

Power to the Reflectoscope is turned on by depressing the pushbutton switch labeled POWER. (Depressing the same switch again turns the power off.) The ASTIG (astigmatism), INTENSITY, and FOCUS controls will be set as required to obtain a sweep trace that is well focused and is sufficiently bright for comfortable viewing.

2. Pulser/Receiver

MAIN PULSE AMP: maximum
PULSE LENGTH: maximum
PULSE TUNING: set for peak signal if echo is visible;
otherwise setting will be temporarily
at an arbitrary value.
REJECT: off
FREQUENCY: 2.25 MHz

3. Timer

SWEEP DELAY: off
SWEEP RANGE: as required for signal appearance on
A-scan screen.
ALARM GATE: off
ALARM: off
IF SNYC: off

4. Graphigate

The Graphigate will not be used for normal A-scan operations.
GATE ON/OFF: off

5. Recording Amplifier

The recording amplifier will not be used in normal A-scan operations. Power to this unit will be removed when not used by disconnecting its power cord at the back of the Reflectoscope.

Transducer Beam Orientation

Acquisition of an echo signal from the scanned object will require that perpendicular orientation of the transducer beam axis relative to the object surface be made with care and patience. It will be found that a slight movement of the transducer or the target can make the difference between the presence or absence of an echo signal on the A-scan oscilloscope. The necessary technique will only be developed through operating experience. A very important benefit to be derived from water testing is the familiarization of personnel with the properties of acoustics and the characteristics of displayed signals.

Signal Optimization

Since the available gain in the receiver is high, use of the full output voltage of the pulser will generally be found to be unnecessary for close target distances, such as one focal distance, assuming that the target area is of reasonably large size. In these cases a reduced output from the pulser can be used without risk of failing to obtain a discernible target echo. If there is doubt as to whether sufficient echo signal will be obtained, the MAIN PULSE AMP and the PULSE LENGTH controls should be set at maximum to furnish full pulser output to the transducer during signal acquisition.

After an echo signal is acquisitioned, settings of the MAIN PULSE AMP and PULSE LENGTH controls can be reduced and the receiver SENSITIVITY controls reset to eliminate signal saturation, if present. PULSE TUNING should be adjusted to peak the signal, then SENSITIVITY controls can be again reset as required to bring the echo signal to a suitable display level. Settings of these controls should be further optimized to achieve the best obtainable time and amplitude resolution of the displayed signal. It will be essential in the course of these operations to also check the transducer beam orientation to make sure it is set for maximum echo signal for best signal-to-noise ratio.

C-Scan Operation

In C-scan operation the Graphigate, recording amplifier, and the Alden recorder will also be employed. Instructional information on these components of the instrument package should be thoroughly studied before attempting their use. Also studied should be information on the characteristics of the paper which is used in the Alden recorder, mainly to take full advantage of the shading resolution the manufacturer claims for his product.

D. IN-SODIUM OPERATION

Gas Bubbles, Corrosion, and Dirt

As in the case of in-water testing, accumulation of gas bubbles on the transducer lens surface or the target surface can cause considerable attenuation of the echo signal. Care should be given to avoiding target designs or operating conditions where serious problems from bubbles could be encountered.

Corrosion or dirt on the transducer lens surface or the target surface can also cause echo signal attenuation.

The transducer and associated support structure should be thoroughly cleaned of foreign matter before it is immersed in sodium.

Sodium of high purity, unless otherwise dictated for test reasons, should be employed for scanning operations.

Transducer Lens Wetting

Wetting of the transducer lens surface by the sodium is essential for efficient acoustic coupling between the transducer and the liquid sodium medium. Wetting is a function of time and temperature. Accordingly, gradual changes in signal levels from lower to higher levels should be expected early in the course of operations in sodium as lens wetting progresses. To insure uniformity of lens wetting, thorough cleansing of the lens surface before immersion in sodium, and freedom from gas bubbles, is essential.

Thermal Shock

Because of the relatively thin-wall configuration of the transducer shell and to the poor heat conduction between the shell and internal elements, no special precautions to minimize thermal shock are specified.

Scanner System Operating Proficiency

Scanner operating experience gained from tests in water will be found to be of utmost importance for sodium work, where the medium is opaque and visual backup will not be possible for target acquisition. The importance of practicing in water prior to operating in sodium cannot be overestimated.

Propagation Time and Sweep Calibration

The two-way propagation time in sodium at 600° F (315° C) is 21.3 μ sec/in, or 8.4 μ sec/cm. Since the values which appear on the push button switches of the Reflectoscope timer relate to the propagation velocity in steel, not sodium, for relevance to sodium at 600° F these values are to be divided by the factor 2.4.

- NOTES**
1. SPHERICITY OF SPHERICAL RAD. $\pm .0001$ AND THE FINISH OF THE SPHERICAL SURFACE TO BE 164 RMS.
 2. PITCH DIA. OF TH'DS. TO BE CON-CENTRIC TO 1.300 DIA WITHIN .001 T.I.R.

① LENS *
MAT'L. ~ 304 S.S.

- NOTES**
1. PITCH DIA. OF THDS. TO BE CONCENTRIC TO 1.343 DIA. WITHIN .001 T.I.R.
 2. APPLY A THIN COAT OF SPRAYBOND (MOLYBDENUM) TO THREADS ONLY.
- ② SPRAYBOND TO BE APPLIED BY THE SALERANO METAL SPRAY CO. OF WARREN, MICH.

② CAP *
WELDED CONST

- (A) BODY - ONE REQ'D.
MAT'L. - 304 S.S.
- (B) EXTENSION - ONE REQ'D.
MAT'L. - 304 S.S.

5 INSULATOR TUBE *
MATH. ~ UNFIRED LAVA (GRADE A)
AMERICAN LAVA CORP.
CHATTANOOGA, TENN.

16 SPACER RING (FOR WATER TESTING)
MATL. - 304 S.S.

DETAIL PARTS			LIST FOR DRAWING No 5XN-8869		
ITEM No.	SHOWN ON DWG. No.	QTY.	DESCRIPTION	MATL	USED ON DWG No
1	THIS SHEET		LENS	SEE DETAIL	5XN-8835
2	" "		CAP	" "	" "
5	" "		INSULATOR TUBE --	" "	" "

C	1-E	ADDED "SPRAY BOND" NOTE TO DETAIL N°3		CLB	7-26-72	SM	7-26-72	SM	7-26-72
B	3-D	DET. N°2 - REMOVED "SLOAN 90° OUT OF POSITION" IDENTIFIED ONE HOLES IN END VIEW 90°		CLB 5-1-72	SM	5-1-72	SM	5-1-72	SM
A		DET. N°3 - ADDED 1 037 DIA STEP - 1 010 DIA WAS 1 020 - 1 168 DIA WAS 1 01 - DET. 028 STEP - 1 077 DIA WAS 1 580 - UNIFIED LAW WAS AFRICAN WOODRUFF STONE DET. N°1 - 109 HOLES WERE SLOTS - 1 020 - 1 182 HOLE LOCATION - REMOVED 1 028 DIA - 1 300 DIA WAS 1 200 ADDED PERPENDICULARITY NOTE - 1 480 DIA WAS 1 578 1 178 DIA WAS 1 182 INCREASED TO 3 PLAT DIA'S DET. N°2 - ADDED PERPENDICULARITY NOTE - 1 208 DIA WAS 1 204 - 1 109 HOLES WERE SLOTS - REMOVED 1 08 HOLE LOCATION - ADDED 2 08 R - ADDED GRAIN RELIEF - 230 DIMS. WERE .25 - ADDED 250 DIM - ADDED 250 DIA TO LOCATE FERS. PLAT PILOT HOLES - 1 420 DIA WAS 1 578 DIA WAS 1 125 - REDIMENSIONED CAVITY DEPTH AND SHOULDER - INCREASED THREAD AND PILOT DIA'S ADDED "SEE NOTE N°3 ON DWG 54X-8855"		CLB 4/14/72	SM	4/14/72	SM	4/14/72	SM
L.T.R ZONE		CHANGE		MADE BY	DATE	APP'D	DATE		
NAME		DATE		TITLE					
MADE BY		BRADLEY 5/15/72		UNDER SODIUM SCANNER FOR PNC					
CHECKED BY		K. Rogers 4/14/72		TRANSDUCER DETAILS					
CHECKED BY		SMITH 4/14/72							
APP'D BY				ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.					
APP'D BY				SCALE		PROJECT NO.		DRAWING NUMBER	
APP'D BY				DOUBLE 1/8" = 1"		293-01-02		54X-8869 C	
USE DIMENSIONS ONLY									

Tolerances Unless Otherwise Specified
Finish 125 μ RMS
 ± 0.1 For 1 Place Decimals
 ± 0.01 For 2 Place Decimals
 ± 0.005 For 3 Place Decimals
 $\pm \frac{1}{4}^\circ$ For Angles
Break All Sharp Edges 0.10 Max Radius

⑥ BACKING BLOCK *
MAT'L. - ZINC - BALANCE
PB. - .002%
CD. - .048%
FE. - .001%
 (MAT'L. FURNISHED BY APDA)

10 INSULATOR DISK *
MAT'L ~ UNFIRED LAVA (GRADE A)
AMERICAN LAVA CORP.
CHATTANOGA, TENN.

11 CONDUCTOR DISK *
MALL - ELECTROLYTIC COPPER

- (A) DISK - ONE REQ'D
MATL - ELECTROLYTIC COPPER
- (B) PINS - TWO REQ'D
MATL - ELECTROLYTIC COPPER

* SEE NOTE N° 3 ON
DWG. N° 5XN-8855

13 SEALING *
MAT'L J# 270 NICKEL-ANNEAL DEAD SOFT AFTER MACH.
FOI SIZE - (MAT'L. FURNISHED BYAPOA)

⑦ WAVE SPRING WAS
MATH. - 302 S.S.

14 WELDING RING.
MAT'L - 304 S.S.
FOUR X SIZE

DETAIL PARTS LIST FOR DRAWING No. 5XN-8870				
ITEM No	SHOWN ON DWG. No	QTY.	DESCRIPTION	USED ON DWG No
6	THIS SHEET		BACKING BLOCK	SEE DETAIL 5XN-8855
7	" "		WAVE SPRING WASHER	" " "
10	" "		INSULATOR DISK	" " "
11	" "		CONDUCTOR DISK	" " "
13	" "		SEAL RING	" " "
14	" "		WELDING RING	" " "

B	1-C	DET #10 - ADDED 5/64 ORNICK TAPPED HOLE DET. #11 - ADDED 3/4 ORNICK TAPPED HOLE	CLB 7/21/72		DM	7/14/72
A	~	DET #2 - 1.000 DIA WAS .995 - 1.00 DIA WAS 1.00 - CHANGED ZINC SPEC. DET #7 - DELETED (BUT YES 8/4-8055) DET #12 - 47 HAS HOLE .875 DIA WAS .995 1.00 DIA WAS .010 - UNKINS LAVA WAS AFRICAN WONDER STONE DET #11 - .85 DIA WAS .86 - ADDED DIMMER .875 DIA WAS .995 - DET #18 - REVISED 0.0 2.32, TOOTH DIMMER REVISED ADDED "ANNAH" DEED 80FT ABOVE HATCH - 0.02 DIM. 2.01 CHANGE - DET #13 - 1.0 DIA WAS .87	CLB 4/14/72	DM	4/14/72	DM 4/14/72
L.T.R. ZONE		CHANGE	MADE BY	CH KD	DATE	APP D DATE
NAME		DATE	TITLE			
MADE BY		BRADLEY 5/23/72	UNDER SODIUM SCANNER FOR PNC TRANSOUCCER DETAILS			
CHECKED BY		K. Rogers 4/10/72				
CHECKED BY						
APP'D BY		SWITTE 4/4/72	ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.			
APP'D BY			DRAWING NUMBER			
SCALE		PROJECT NO	5XN-8870 B			
NOTED		253-01-02				
USE DIMENSIONS ONLY						

Tolerances Unless Otherwise Specified
Finish 125 μ RMS
 ± 0.1 For 1 Place Decimals
 ± 0.01 For 2 Place Decimals
 ± 0.005 For 3 Place Decimals
 $\pm 16^\circ$ For Angles
Break All Sharp Edges 010 Max. Radius

APPENDIX NO. 2

QUALITY ASSURANCE DOCUMENTS

FIGURE 3.- OVERALL DIMENSIONS OF ALDEN
MODEL 11 FACSIMILE RECORDER

A
B
C
D
E

Tolerances Unless Otherwise Specified
Finish 125 μ RMS
 ± 0.1 for 1 Place Decimals
 ± 0.01 for 2 Place Decimals
 ± 0.005 for 3 Place Decimals
 $\pm .14^\circ$ for Angles
Break All Sharp Edges .010 Max. Radius

LIST FOR DRAWING No. 5XN-8873				
ITEM No.	SHOWN ON DWG. No.	QTY.	DESCRIPTION	USED ON DWG. No.

A	~	REPLACED ASS'Y. FIXTURE WITH HOLDER	CLS				
L'IN ZONE		TITLE WAS "TRANSDUCER ASSY. FIXTURE" 8-9-72		MADE BY	CH'KD	DATE	APP'D DATE
NAME		DATE		TITLE			
MADE BY		DATE		UNDER SODIUM SCANNER FOR PNC			
CHECKED BY		DATE		TRANSDUCER ASSEMBLY METHOD			
DRAWN BY		DATE		ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.			
APP'D BY		DATE		DRAWING NUMBER			
APP'D BY		DATE		5XN-8873 A			
SCALE		NOTED		DATE PRINTED		USE DIMENSIONS ONLY	
7		293-01-02		8			

A
B
C
D
E

VIEW OF SEAL RING ASSEMBLED WITH
SCREW THREAD TEST SPECIMENS
10 X 8 SIZE

NOT
TORQUE EQUIVALENT TO
TORQUE TO BE USED FOR

NORMAL ASSEMBLY - 35 FT. LBS.
1737 - 40 FT. LBS.

ASSEMBLY TAKE-OFF LIST FOR DRAWING No. 5XN-8874.

ITEM No.	SHOWN ON DWG. No.	QTY.	DESCRIPTION	MAT'L	USED ON DWG. No.
		1	SEAL RING TEST SPECIMEN	SEE DETAIL

SEAL RING TEST SPECIMEN
MAT'L - 270 NICKEL (ANNEAL DEAD
AFTER MACHINING)
2 X 5 SIZE

NOTE
1.383 DIA. & 1.3474 DIA. TO BE CONCENTRIC
WITHIN .002 T.I.R.

Endurance Unless Otherwise Specified
Finish 125 μ RMS
 $\pm$ 0.1 For 1 Place Decimals
 $\pm$ 0.01 For 2 Place Decimals
 $\pm$ 0.005 For 3 Place Decimals
 $\pm$ 1/4° For Angles
Break All Sharp Edges .010 Max Radius

A	C6	ADDED "ANNEAL DEAD SOFT AFTER MACH."	CLB	5-12-72					
1/17	1/17	NAME	DATE	CHANGE	MADE BY	CH'KD	DATE	APP'D	DATE
MADE BY	BRADLEY	4-28-72							
CH'KD BY	J. PUGH	5-11-72							
APP'D BY	J. Malt	5-11-72							
APP'D BY									
TITLE: UNIFORM SODIUM SCANNER FOR PNC TRANSDUCER SEAL RING TEST SPECIMEN TO OBSERVE EFFECT OF RING ON SEAL SURFACES				ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.					
SCALE NOTED				DATE PRINTED		DRAWING NUMBER			
USE DIMENSIONS ONLY				293-01-02		5XN-8874 A			

A
B
C
D
E

M.O.W. 1.28

-.0361 DIA.
WIRES

10000
 1.0038

SECTION	X SIZE
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
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75	75
76	76
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78	78
79	79
80	80
81	81
82	82
83	83
84	84
85	85
86	86
87	87
88	88
89	89
90	90
91	91
92	92
93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

-1.2679- 16 N THREADS

MAJOR DIA. = 1.2679 $\frac{+0000}{-0010}$

PITCH DIA. = 1.2273 $\begin{smallmatrix} +.0000 \\ -.0038 \end{smallmatrix}$ (SEE SECT. ABOVE)

MINOR DIA. = 1.1912 $\begin{matrix} +.0000 \\ -.0083 \end{matrix}$

(SEE DWG. N° BXN-8858)

① MALE THREAD TEST SPECIMEN
MAT'L. ~ 304 STAINLESS STEEL

2 SAME AS DET. N° 1 EXCEPT APPLY
A LIGHT COATING OF DRY LUBRICANTS
CORP. N° 24-P BONDED LUBRICANT
TO THREADS - BY APDA

3 SAME AS DET. NO 1 EXCEPT APPLY A
LIGHT COATING OF SPRAYBOND (MOLYBDENUM)
TO THREADS.
SPRAYBOND TO BE APPLIED BY SALERNO
METAL SPRAY CO. WARREN, MICH.

4 SAME AS DET. NO. 1 EXCEPT TUFTRIDE
THE THREADS
TUFTRIDING TO BE PERFORMED BY
THE KOLENE CORP. DETROIT, MICH.

1. THREADS ON ABOVE
GROUND, UFTAIL, TO BE
2. SEE SCREW THRU ID CLEARANCE
STUDY - DWG. N° 4-8958

— 1.281 - 16 N THREADS

MAJOR DIA. = $1.2813 \begin{smallmatrix} +.0128 \\ -.0000 \end{smallmatrix}$

PITCH DIA. 1.2407 $\begin{smallmatrix} +.0038 \\ -.0000 \end{smallmatrix}$

MINOR DIA. 1.2136 $\pm .0015$
-0000

(SEE DWG. N° 5XN-8858)

5 FEMALE THREAD TEST SPECIMEN
MAT'L. ~ 304 STAINLESS STEEL

(6) SAME AS DET. N° 5 EXCEPT TREAT
THREADS SAME AS DET. N° 2

7 SAME AS DET. N° 5 EXCEPT TREAT
THREAD SAME AS DET. N° 3

⑧ SAME AS DET. N° 5 EXCEPT TREAT
THREADS SAME AS DET. N° 4

LIST FOR DRAWING No. 4XN -8856					
ITEM No.	SHOWN ON DWG. No.	QTY.	DESCRIPTION	MAT'L	USED ON DWG. No.
1	THIS SHEET	AS PER PURCHASE ORDER	MALE THREAD TEST SPECIMEN	SEE DETAIL	
2	" "		" " " "	"	
3	" "		" " " "	"	
4	" "		" " " "	"	
5	" "		FEMALE THREAD TEST SPECIMEN	"	
6	" "		" " " "	"	
7	" "		" " " "	"	
8	" "		" " " "	"	

L'T'R		ZONE	CHANGE		MADE BY	CH'KD	DATE	APP'D	DATE
		NAME	DATE	TITLE <u>UNDER SODIUM SCANNER FOR PNC</u> <u>TRANSDUCER SCREW THREAD TEST</u> <u>11 SPECIMENS</u>					
MADE BY	<u>WHAIRY</u>		<u>5/11/82</u>						
CHKD BY	<u>W. JOTH</u>		<u>5/26/82</u>						
CHKD BY	<u>J. Pugh</u>		<u>2/29/82</u>						
APP'D BY	<u>J. Matha</u>		<u>7/29/82</u>						
APP'D BY									
APP'D BY									
				ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.					
				SCALE FULL		PROJECT NO. 293-01-02		DRAWING NUMBER 4XN-8856	
				USE DIMENSIONS ONLY					