SODIUM IMMERSIBLE HIGH TEMPERATURE MICROPHONE
DESIGN DESCRIPTION

by

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I. INTRODUCTION

Argonne National Laboratory has developed a rugged high-temperature (HT) microphone for use as a sodium-immersed acoustic monitor in Liquid Metal Fast Breeder Reactors (LMFBRs). Microphones of this design have been extensively tested in room temperature water, in air up to 1200°F, and in sodium up to 1200°F. They have been successfully installed and employed as acoustic monitors in several operating liquid metal systems.^(1,2,3,4)

This report describes the design, construction sequence, calibration, and testing of these microphones in a manner such that any or all of the technology can be used by industrial instrument suppliers in the production of similar high-temperature microphones or related devices.

The body of the report describes the principle of operation, purpose of various parts, reasons for pertinent design and material requirements, and the construction sequence, with emphasis on steps which are critical to successful operation of the completed microphones. Also described in detail is a conditioning procedure requiring exposure at high temperature with controlled - internal gas composition, which is vital to successful operation at design conditions. Material and fabrication quality assurance requirements essential for production of consistently reliable microphones and for safety of the systems into which the units are to be installed are discussed, emphasizing their importance in production of components whose major use is expected to be in nuclear reactor safety systems.

Physical dimensions and materials of construction are completely defined by drawings in Appendix 1, and in detailed materials specifications for nonstandard components in Appendix 2. Detailed, step-by-step procedures are included as Appendix 3.

During the development which preceded the establishment of the basic design and procedures documented here problems were encountered such as: crystal breakage; poor response characteristics; leakage in welds; shorting of internal parts to case; loss of electrical contact between internal parts; break down of cable resistance; and misalignment of parts. Using the design and procedures about 30 microphones have been manufactured without a single defective unit.

II. DESCRIPTION

A. Design Configuration

1. Operating Characteristics

The microphone is illustrated in Figs. 1 to 5 as a disc $7/8$ in. in diameter by $3/8$ in. thick to which two leads are attached. The signal lead is a $1/8$ in. o.d., stainless steel clad, mineral insulated, co-axial cable. The gas lead is a $1/16$ in. o.d. by 0.020 in. i.d. stainless steel tube, which is required to supply oxygen to the interior of the sensor housing for reasons discussed below. The signal lead is terminated by a BNC connector which is removable to allow the lead to pass through a $1/8$ in. hole in a fitting for installation. The operating characteristics of these microphones are listed in Table 1.

Fig. 1. ANL High-temperature Microphone Assembly

Fig. 2. Closeup of High-Temperature Microphone

Fig. 3. Microphone Signal Lead Connector

Fig. 4. Oxygen Reservoir for High-temperature Microphone

Fig. 5. ANL HT Microphone Outline Dimensions

Table 1. Operating Characteristics of ANL High-Temperature Microphone

*Temperature:	1200°F
Charge Sensitivity:	1200 - 1400 pC/bar
Frequency Range:	10 Hz to 100 kHz
Typical Resistance at 1200°F:	25 kOhms

*Higher temperatures (up to at least 1300°F) cause no damage to microphone, but above 1200°F microphone resistance decreases to less than that required for operation of available charge amplifiers.

Figure 6 is a signal vs frequency curve for a typical microphone.

Figure 7 shows the directivity of response at several excitation frequencies for typical microphone.

2. Principle of Operation

The piezoelectric material upon which the operation of the microphone is dependent is lithium niobate. The physical design of the sensor (Fig. 8) is based on the symmetric drive concept in which two circular plates of this material are arranged with surfaces of like polarity facing a central electrode in a housing between flexible diaphragms. A change of pressure in the liquid in which the unit is immersed produces an electric charge at the surfaces of the plates which is transmitted to the read out instrumentation via the high temperature coaxial cable attached to the sensor housing.

This configuration results in a microphone which is sensitive to changes in pressure at the sensor faces, but which is relatively insensitive to acceleration forces transmitted to the unit by the support structure.

One difficulty with using lithium niobate at high temperature is that at low partial pressures of oxygen (below 1/300 atm), the material partially reduces to an equilibrium level at a given temperature, and its electrical conductivity increases by orders of magnitude.^{5,6} These effects are particularly important during transducer operation when oxygen is gettered by metallic components.

In order to maintain sufficient electrical resistivity in the lithium niobate crystals, all microphones intended for operation at temperatures in excess of 1000°F for periods of more than one month require a case vent consisting of a small diameter tube (1/16 in. o.d. x 0.020 in. i.d.)

Fig. 6. Frequency Response of Typical ANL HT Microphone

The signal projector located in a horizontal plane perpendicular to flat faces of microphone. When microphone is rotated at 0 and 180°, projector is on a line perpendicular to faces.

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Fig. 7. Directivity of Typical ANL HT Microphone

Fig. 8. Sectional Views of ANL HT Microphone

connected to an external source of oxygen maintained at less than one atmosphere absolute pressure.

In order for the unit to function properly the surfaces of the piezoelectric plates must be maintained in intimate contact with the diaphragm faces and with the central platinum foil electrode. This is accomplished by a combination of three measures: (1) The surfaces of the lithium niobate plates and the central portion of the stainless steel diaphragms are maintained to very close flatness tolerances and are highly polished, (2) annealed platinum foil cushions are placed between the plates and the diaphragms surfaces, and (3) a constant static force is produced between the surfaces by welding the diaphragms in place while they are held in a deformed condition by a special fixture.

3. Components

The 16 parts which comprise the microphone assembly are pictured in Fig. 9, and the exact dimensions and configuration of each of the parts are detailed in drawings included as Appendix 1. Tolerances indicated have been specified after careful consideration of functional requirements and must be adhered to rigidly. Variation in dimensions could cause uneven clamping pressure when the unit is placed in the welding fixture, resulting in breakage of the piezoelectric discs or in insufficient residual clamping force between the discs and diaphragms in the completed unit.

B. Materials

1. Bill of Materials

The bill of materials (Table 2), includes a listing of each part re-

Fig. 9. Components of ANL HT Microphone

Table 2. Parts List for ANL High-Temperature Microphone

Part No.	Drawing No.*	Part Name or Description	Material	Quantity
	2	HIGH TEMPERATURE MICROPHONE ASSEMBLY		
1	4	DIAPHRAGM	304 Stainless Steel ASTM-A-182-71 OR A-479-63	2
2	5	CUSHION	PLATINUM FOIL 99.95 PURE	2
3	6	PIEZOELECTRIC DISC	LITHIUM NIOBATE ANL T0009-0054-SC	2
4	7	CENTRAL ELECTRODE	PLATINUM FOIL 99.96 PURE	1
5	8	ALIGNMENT RING	HARD FIRED ALUMINA RDT C18-1T	1
6	9	BODY RING	304 Stainless Steel ASTM A-182-71 OR A-479-63	1
7	10	CABLE COUPLING	304 Stainless Steel ASTM A 182-71 A-479-63 OR A-213-71	1
8		COAXIAL CABLE	RDT C-17 5T AND ANL SPECS	
9	11	CLIP	304 Stainless Steel ASTM A-177-69	1
10		INSULATOR TUBE - .075 $\pm$.003 O.D. X .025 $\pm$.003 I.D., .250 $\pm$.030 LNG	HARD FIRED ALUM- INA RDT C18-IT	2
11	27	TUBE COUPLING	304 Stainless Steel ASTM A-182-71 A-479-63 OR A-213-71	1
12		TUBING - .062 O.D. X .020 I.D.	304 Stainless Steel ANL-T0009-0022-SC	
13	28	TERMINAL PIN	BRASS ASTM B-134 ALLOY #6	1
14	29	TERMINAL (ALTERED)	MFG STD. BRASS	1

Table 2. Parts List for ANL High-Temperature Microphone (Contd.)

Part No.	Drawing No.*	Part Name or Description	Material	Quantity
15	30	CABLE PLUG (ALTERED)	MFG STD	1
16	31	TERMINAL COUPLING	BRASS ASTM B-16-71	1
17		#6-32 UNC-2A X 3/16 LG SLOTTED SET SCREW	Stainless Steel	

*Complete ANL document control numbers are composed as follows

T0009-	---	-D	-
Program	serial	drawing	latest
Identifier	number	size	revision

Drawing numbers used in this report refer to the serial number portion only

quired and indicates the material of construction and specification to which it conforms. Copies of ANL specifications are included in Appendix 2. The following discussion presents reasons for those requirements of the material specifications which are considered critical to production of microphones of uniform high quality.

2. Lithium Niobate Plates

The specification used to procure lithium niobate plates for our microphones (see Appendix 2) requires the material to be premium grade; single domain. The plates are 36° Y cut ($\bar{Y}ZT$) 36° in accordance with terminology defined in ANSI Standard C 83.3-1951). The 36° Y cut has a higher sensitivity in the compression mode than other available cuts.

The plates must be uniformly poled. This requirement is extremely important, as is the ability to check plates received to determine conformance with it. The equipment and procedure used at ANL is described in Appendix 3. Briefly, this procedure uses a "D" tester (Aerotech Laboratories) to measure the sensitivity of each plate at five specified points on each surface. At the same time, the polarity of the faces are determined so that they can be properly oriented when assembled into the microphone.

The flatness, parallelism, and polish of the plate surfaces are important to assure good physical contact with the diaphragm faces and to assure uniform loading to prevent cracking when they are clamped in place between the diaphragms during assembly.

We have produced microphones with uniform sensitivity and with no difficulty with crystal breakage from plates purchased to this specification.

3. Signal Cable

The signal cable is purchased to RDT Standard C-17-5T. A copy of ordering data used in conjunction with the RDT standard is included in Appendix 2.

The most important requirement of cable for high temperature microphones is the insulation resistance at operating temperature. Specific installation requirements may call for 25 or more feet of cable to operate at temperatures from 700°F to 1200°F. At the latter temperature, 25 feet of cable with the specified minimum resistance of 8 megohm-ft would have a leakage resistance of about 320 kohms. A leakage resistance below this could cause serious problems with electrical noise in the signal.

Either aluminum oxide or magnesium oxide cable insulation is acceptable for use in these microphones as long as specific attention is given to keeping exposed ends from picking up moisture from the atmosphere. In this respect, we find Al_2O_3 to be less of a problem, but cable manufacturers seem to have less difficulty in fabricating cable to the required specifications when MgO is specified.

4. Vent Tubing

A copy of ANL specification #T0009-0022-SC for small-diameter tubing is included in Appendix 2. This specification supplements ASTM specification A632-69 seamless and welded austenitic stainless steel tubing (small diameter). The major concern in obtaining tubing for vent lines is internal cleanliness. While it is impossible to apply the "swatch" test described in the ASTM

"Thermocouple Clean" specification, the absence of drawing compound or other contamination can be spot checked by filing away half of the tube to expose the interior for microscopic examination, and for oxide check by picking, as specified the ASTM "Thermocouple clean requirement".

One reason for paying particular attention to cleanliness of all parts is that organic compounds are readily oxidized and consume oxygen, thus adding to the problem of conditioning the microphone for operation at high temperature, as discussed later.

5. Stainless Steel Bar Stock

Stainless steel bar stock purchased to either of the ASTM specifications indicated on the bill of materials is suitable for machining parts for the microphones. However, special caution must be exercised in selecting stock for the diaphragms. In several instances the stock has been found to contain longitudinal porosity which resulted in very small leaks through the diaphragms. In these cases we have been able to identify the porosity by subjecting the pieces to standard dye penetrant and developer check as used in examining welds and then carefully examining the diaphragm surface under a low power binocular microscope for the appearance of very small red spots in the white dye check developer. It is now our standard procedure to remove a 1/32-in.-thick slice from each end of the bar to be used for machining diaphragms and checking it in this manner before proceeding with machining of parts.

C. Procedures

1. Parts Fabrication

With the exception of preparation of diaphragm surfaces, normal machining methods and adherence to the tolerance specified on the drawings are sufficient for production of all stainless steel parts.

As mentioned above the face of the thick center portion of the diaphragm which bears against the piezoelectric disc must be as flat and smooth as possible in order to prevent crystal breakage and to assure uniform intimate contact for transmission of acoustic pressure from the outer surface of the diaphragm to the crystal. The diaphragm construction drawing No. 4 (App. 1) includes dimensions of a lapping ring which is required to maintain flatness and avoid fracture of edges during grinding and lapping operations. Construction procedure No. 2 (App. 3) describes in detail the procedure developed for hand lapping these faces to the specified surface requirements. Other lapping processes may be employed provided the specified flatness and surface smoothness is achieved. The effect of surface smoothness on microphone performance has not been investigated.

Special attention must be given to assure that accumulation of slight errors in thickness of components does not result in improper clamping forces during final assembly. For this reason, a check on dimension of specific parts selected for each sensor is recommended. With reference to Fig. 8 and the sketches below this dimensional check is as follows:

Central Thickness	<u>inches</u>
Three Thickness of pt foil	-----
Thickness of #1 LiNbO_3 plate	-----
Thickness of #2 LiNbO_3 plate	-----
Dim. A of #1 diaphragm	-----
Dim. A. of #2 diaphragm	-----
<u>*Total "Central Thickness"</u>	-----

*Dimension "B" of body ring must be .010 to .020 in. less than the central thickness.

The platinum foil parts, i.e., central electrode and cushions, are die cut from .001 in. thick platinum foil. After cutting they are annealed by heating in an air furnace to about 2000°F for a short time and allowing them to cool in air to room temperature.

2. Microphone Assembly

The construction sequence for each microphone consists of the steps listed in Table 3.

Table 3. ANL High-Temperature Microphone

CONSTRUCTION SEQUENCE

<u>Step No.</u>	<u>Activity</u>	<u>Procedure* No.</u>
1.	Examine lithium niobate plates and record results on data sheet	1
2.	Machine parts according to drawings listed on parts list for microphone to be fabricated.	
3.	Scribe body ring and diaphragms with distinctive markings for identification.	
4.	Lap diaphragms.	2
5.	Record part numbers and measurements of selected parts on microphone data sheet. Check measurements for proper fit.	
6.	Check and cut cable and vent tube according to requirements of microphone to be assembled. Label each piece and record original identity on data sheet.	
7.	Trim ends of cable so that 1/4 in. of lead extends beyond sheath and place temporary seals on ends of cable.	3
8.	Using assembly drawing as a guide check that thickness through center of assembled parts will be .010 to .020 in. greater than corresponding dimension on body ring.	
9.	Weld couplings to vent tube and cable and check integrity of welds.	5
10.	Tack weld cable coupling to body ring.	3 & 5
11.	Attach central electrode to cable conductor.	3
12.	Weld bottom diaphragm in place.	5
13.	Install internal parts, position top diaphragm and install assembled unit in welding fixture.	4
14.	Weld top diaphragm, tube coupling, and cable coupling to body ring and check weld integrity.	5
15.	Attach signal lead connector to cable.	6
16.	Check response of assembled microphone to acoustic excitation in water.	7
17.	Season microphone in air furnace.	
18.	Perform final calibration in water.	7

*See Appendix 3.

Steps 1, 2, 4 and 8 have been discussed in the preceding section. Steps 3, 5, and 6 are required to assure proper verification of dimensions and materials, and to provide a record for positive identification of all parts incorporated into the assembly.

Since several microphones will probably be at various stages of assembly at one time, it is important that each be assigned a distinctive serial number and that all parts intended for that unit be labeled accordingly.

All of the welding required for production of these microphones is accomplished by a manual Gas Tungsten Arc Welding (GTAW) process as specified in an ANL Central Shops procedure developed for these units (Procedure No. 5, App. 3). Any welding process which results in welds which fulfill the criteria stated in the weld procedure would be acceptable.

Step 9 is the first step in welding the assembly. It involves welding the couplings to the thin walls of the cable and vent tube, respectively. To avoid subsequent rejection of an entire unit due to a defective weld at one of these joints, both are nondestructively tested to assure compliance with design requirements before being attached to the microphone body. Nondestructive testing of each joint includes radiography, vacuum leak check, and dye penetrant examination. The inside of the vent tube is also checked for any obstruction at the location of the weld.

In Step 10 the end of the signal lead is tack welded to the body ring preparatory to positioning the central electrode. The weld is not completed at this point to avoid distortion of the body ring.

Installation of the central electrode (Step 11) requires the use of an alignment fixture which is inserted through the bottom of the body ring while working from the top. The location and attachment of this electrode are

important to assure good electrical continuity, uniform contact with crystal surfaces, and proper clearances to prevent shorting of the lead wire to the microphone case.

For diaphragm welding (Step 12) a special welding fixture (see Drawing 85, Appendix 1) is used to hold the welding chill in place, and to minimize strain on the cable-to-body ring tack welds. To assure sufficient weld thickness, the edges of the diaphragm and body ring are beveled and filler wire is used to fill the resulting groove during welding. In early models, the closure was effected by a simple fusion weld between square edges. However, the procedure was discontinued since the position of the weld was difficult to radiograph and verify minimum weld thickness. Steps 1 through 10 of Procedure No. 4 detail the procedure followed in installation of the bottom diaphragm.

Detailed assembly of internal parts (Step 13) is described in Steps 11 through 35 of Procedure No. 4. The cleanliness stressed in the procedure is vital to production of acceptable microphones. Dust or metal filings between the surfaces of the piezoelectric plates and the diaphragms can result in poor physical contact or breakage of the crystals. Organic material inside the sensor housing will oxidize at elevated temperatures and thus lengthen the period required to reduce the oxygen consumption to acceptable limits, as described in the seasoning procedure below.

Dimensions have been selected to assure that the required deflection (0.010-0.020 in.) of the diaphragms will occur when the clamping screw of the welding fixture is tightened to seat the edges of diaphragms on the mating surfaces of the body ring. A confirmation of diaphragm deflection during

this process is provided by incorporating a dial thickness gauge through linkages to register exact deflection of the lower diaphragm (see Fig. 10). This rules out any possibility of burrs or undetected variances from specified measurements causing interference with proper seating of the diaphragm edges on the step on the body ring resulting in insufficient clamping pressure on the sensor parts.

After completion of all welds, integrity of the assembly is checked by radiography, by helium leak check, and by dye penetrant examination of all weld surfaces. The vent tube provides an excellent access to the sensor housing to allow a reliable helium leak check of each unit.

In attaching the signal lead connector to the signal cable it is essential that special care be exercised to provide a seal which will prevent moisture from entering the cable insulation and decreasing its electrical resistance. Magnesium oxide insulated cable is hygroscopic and special care must be observed to prevent moisture pick up from the time the manufacturers end seal is removed, until the final epoxy end seal is completed. The problem is much more prominent when units are assembled in a humid atmosphere. Measures which are taken to prevent moisture pickup include, minimizing the time which the bare end of cable is exposed during fabrication of microphone, and covering bare ends by inserting them through a rubber stopper into a small bottle containing dry silica jell at all times when they must be unsealed. Before leads are connected inside the microphone housing a resistance check of the cable will verify its resistivity but after the microphone is assembled this check is limited to cable resistances of the same magnitude or lower than that of the resistance of the lithium niobate crystals which is generally an order of magnitude lower than the cable.

The material used to form the seal must be carefully selected. We have found that very few candidate compounds provide the seal required over long periods

Fig. 10. Apparatus Used for Checking Diaphragm Deflection

of time in humid atmospheres. The "Torr Seal" specified in Procedure No. 6 provides the required seal, and is hard and durable. Since soldering flux is corrosive and extremely detrimental to the electrical resistance of the cable insulation, the attachment of the connector pin to the cable conductor by silver soldering must receive special attention to prevent solder or flux from entering the cable sheath.

The method of attaching the modified BNC connector allows removal of all but the central pin by simply loosening the Allen set screw which secures it to the cable sheath. This feature allows the lead to pass through any standard tube fitting to allow sealing through a containment boundary without welding or brazing and without disturbing the cable end seal.

The test of acoustic response in water (Step 16) and equipment described in Procedure No. 7 provide a simple check of sensor performance. Although not a check of response to a wide range of frequencies or of performance at ultimate operating conditions it is indicative of response relative to similar units produced in the past which have been exhaustively calibrated by methods described in Section III. We find little variation in response characteristics from one microphone to the next. The purpose of this initial check of performance of a new unit is to identify defective units before proceeding with the conditioning process.

3. Microphone Conditioning

The electrical resistance of the lithium niobate surface is reduced when exposed to a high temperature oxygen deficient atmosphere; hence, it is necessary to reduce the oxygen consumption caused by oxidation of interior stainless steel surfaces and traces of oxidizable contaminants to as low a level as possible before a microphone is ready for ultimate use. This "conditioning" process is accomplished by placing the microphone and as much of the

cable and vent tube as possible in an inert atmosphere tube furnace and heating it to a temperature at least equivalent to the maximum expected service temperature while periodically evacuating and refilling the sensor housing with pure dry oxygen through the vent tube. Our furnaces are capable of heating several microphones and up to nine feet of the leads to temperatures of at least 1300°F. Normally new microphones are conditioned at 1200°F for periods of from a week to a month. The progress of the passivation process is determined by monitoring the electrical resistance of the microphone being conditioned. Early experience with this process showed that a dc voltage applied to a microphone for continuously measuring electrical resistance can induce electro-chemical effects. In this case it caused sticking at the crystal diaphragm interface and eventual cracking of the crystal. A temporary-polarizing effect is also detectable by making a resistance measurement with one dc polarity and then reversing the polarity. Resistance indicated by the meter may be quite different and may drift with application of as little as 10 volts for a short period of time. We have developed an ac resistance bridge which causes no detectable crystal degradation when used for continuous resistance monitoring. This bridge coupled with a log rms voltmeter as a readout device covers a four decade resistance range. This wide range of resistance measuring capability is required to monitor the resistance of our microphones which ranges from about 1×10^8 ohms at room temperature to 2.5×10^4 ohms at 1200°F. The bridge applies 10V rms at 10 Hz to the sensor.

The seasoning process consists of the following steps:

- (1) The new microphone is placed in the tube furnace and the leads are passed through the furnace end seal.

- (2) The vent tube is connected to a gas manifold system (Fig. 11), which, in turn, is connected through appropriate valving to a mechanical vacuum pump, a source of filtered dry oxygen, and a bourdon tube vacuum gauge (0 - 760 mm mercury absolute pressure).
- (3) The signal lead is connected to the ac resistance bridge for continuous monitoring of microphone electrical resistance. If more than one microphone is to be conditioned a simple switching arrangement which allows checking of each microphone under treatment is usually employed.
- (4) The furnace blanket gas flow is adjusted to maintain about one half inch of water positive gas pressure within the furnace. Either argon or helium is satisfactory for use as a blanket gas to prevent oxidation of microphone and lead surfaces.
- (5) The furnace temperature controller is set to the desired conditioning temperature. Since a high rate of temperature rise does not damage the microphones we place no limit on rate of furnace heat up. Our furnace temperature rises from room temperature to 1200°F in about four hours.
- (6) While the temperature is rising the resistance of each microphone is monitored. If at any time it drops below the value indicated on Fig. 12 for the microphone temperature at the time of the measurement the internal gas volume of the unit is "purged" by first evacuating and then back filling with oxygen to about 700 mm of mercury absolute pressure. This is accomplished by manipulating appropriate valves on the gas manifold. Evacuation of microphones with long vent

Fig. 11. Oxygen Filling Manifold

Fig. 12. Internal Resistance vs Temperature for Typical
ANL HT Microphone

tubes requires several minutes due to the small inside diameter of the tube. For a microphone being heated for the first time, resistance may drop below the typical (oxygen saturated) value indicated by Fig. 12; at temperatures as low as 600°F. If the unit is purged soon after the resistance drop occurs the resistance is recovered very rapidly, i.e., in a few seconds, after oxygen reaches the crystals. On the other hand, as is usually the case, if the furnace reaches temperature late in the day and the new microphones are left at high temperature over night and purged on the following morning, the resistance is regained more slowly, i.e., in from a few minutes to half an hour. This seems to have no permanent effect on microphone performance. Microphones left for long periods of time, i.e., many days, with insufficient oxygen have been rejuvenated, but the recovery of resistance in this case is usually very slow. Even when the outer end of the vent tube is open to a large-volume (100 cc or more) oxygen reservoir, the small inside diameter of the vent tube prevents effective interchange of gaseous oxidation products from the microphone housing with oxygen in reservoir. This is especially true in a new unit in which carbon from the stainless steel surfaces and organic contamination in the microphone housing are oxidizing more rapidly to form CO_2 , CO or H_2O . To enhance this interchange at times when no one is present to perform the purging procedure described above, we have developed a simple means of varying the pressure difference between the sensor housing and the reservoir to force the exchange of gases through the vent tube. We do this by wrapping a few turns of insulated resistance wire around

the stainless steel oxygen reservoir and attaching the ends through a Variac to a time-controlled switch. We adjust the Variac so that the temperature in the reservoir rises to about 400°F in about 10 minutes. This results in a system pressure rise of about 50% as long as the volume of the unheated section of the manifold is small compared to that of the oxygen reservoir. We set the time switch to actuate the heater for about 10 minutes out of every hour to allow time for the reservoir to cool to room temperature between heating cycles. The oxygen interchange produced by this simple arrangement shortens the time required to complete the conditioning process by several days.

- (7) As the conditioning process continues a week or two, the time during which the resistance remains stable at a value near that indicated on Fig. 7 increases from less than an hour to several days. The exact time required and ultimate operating time without purging depend on small differences in the composition of the stainless steel of the case, the vent tube, the cable sheath, and on the cable insulation purity since the interior of the microphone is directly connected to the unsealed end of the insulation. Our observations of gas consumption rate during long-term tests of microphones in air furnaces indicate that a well-conditioned microphone with a vent tube connected to a 100 cc volume reservoir initially filled to 600 - 700 mm mercury absolute pressure with oxygen and then sealed should survive several years of operation at temperatures up to 1200°F.
- (8) For some applications which require short-term, i.e., a few months, operation at temperatures below 1100°F and in which incorporation

of the vent tube is difficult or impossible, well-seasoned units have been supplied with vent tubes cut off near the microphones case and sealed by welding after the seasoning process is completed. Production of these sealed units requires careful filling and sealing procedures to assure a high-purity gas fill and a gastight seal on the end of the vent tube stub. To assist in leak checking of this seal weld, we incorporate a few percent of helium in the final oxygen fill gas. This allows a check with a helium leak detector.

Quality Assurance

1. General Discussion

Because of the hostile environment in which these units are required to operate and since their primary end use is expected to be in nuclear reactor safety systems, it is imperative that both materials and fabrication be of the best quality available. This high standard of quality must be documented to assure that each part and each manufacturing step meets the specifications as indicated below.

2. Materials

All materials used are purchased to the specifications indicated on the bill of materials (Table 2) and certified by the manufacturer to be in compliance with those specifications. In addition, check analysis of samples taken from the as-received material is required in most cases. Materials control numbers for material of each part are recorded together with serial numbers scribed on each major component of the assembly.

3. Fabrication

An ANL Central Shops Job Control Plan is used to document all steps

of the assembly process. A separate document is used for each microphone produced and describes each step in the assembly process and provides appropriate spaces for responsible persons to verify compliance with state requirements for each step. A copy of a typical ANL Central Shops Job Control Plan is included in Appendix 4.

E. Modified Designs

Although the major portion of our development effort has been devoted to the basic configuration described, we have constructed several microphones in which this design was modified for various reasons. Each modified design has been identified with "HT-" serial number prefix. The configuration discussed previously in this report is designated HT-9 (Fig. 13). Three modifications of the configuration are illustrated in Figs. 14, 16, and 17.

The HT-10 series depicted in Fig. 14 uses a twin-lead signal cable in which the second lead wire is grounded to the inside of the microphone housing. The system used to isolate the second lead from the cable sheath at the connector end is shown in Fig. 15. There were three reasons for using this configuration: (1) unavailability of single lead cable; (2) the hope that this grounding system might help reduce background electrical noise; and (3) the development of a configuration that could be used later in a completely ungrounded sensor. The second lead grounded inside the case did not prove advantageous in reducing the electrical noise in any of the instances where we employed this design.

While the isolation of the second lead complicates the installation of the signal lead connector slightly, it is still possible to completely remove

Fig. 13. ANL HT Microphone: HT-9 Series

Fig. 14. ANL HT Microphone: HT-10 Series

Fig. 15. Signal Lead Connector Detail for Twin-Lead Cable

the connector for ease of insertion of the lead through a tube fitting in a containment vessel without breaking the cable end seal.

The HT-11 series illustrated in Fig. 16 employs two sapphire discs to electrically isolate the outer surface of the lithium niobate discs from the housing. Two additional platinum foil electrodes sandwiched between sapphire and lithium niobate discs are connected to the second conductor of twin lead cable. A microphone manufactured to this design was calibrated in the water facility and found to have the same sensitivity as our standard design units without the sapphire insulators. This unit has also been tested in the furnace facility and again it's response to low frequency excitation is equivalent to our standard HT-9 microphones. The effect of the complete electrical insulation of the crystals on noise pick-up has not been investigated nor has a calibration over a wide frequency range been conducted. A thorough evaluation of this design is contemplated if signal to noise problems become serious in future applications.

In an effort to reduce the size of access penetration required and the actual space occupied by a microphone we have developed the HT-12 series illustrated in Fig. 17. The configuration utilizes the same lithium niobate plates, platinum foil electrodes and cushion and signal cable, and vent tubes as the HT-9 series. By eliminating the ceramic alignment ring and modifying the diaphragms as illustrated, a reduction in size to .720 in. o.d. by .270 in. thick has been achieved. Change in the angle of attachment of the signal cable and vent tube makes it possible to pass the entire unit through a 0.770-in. diameter hole. By carefully matching the corners of the assembled unit, the hole diameter could be reduced to 3/4 in. A unit of this design has been assembled and tested for response to acoustic excitation in the water and in the air furnace calibration facilities. Its sensitivity

Fig. 16. ANL HT Microphone: HT-11 Series

Fig. 17. ANL HT Microphone: HT-12 Series

at low frequency is about eighty percent of that of our full size microphones. Since no urgent requirement for a microphone of this size has been defined, further evaluation of this miniature design has not been pursued.

III. Evaluation

A. Calibration

1. In Water

After final furnace seasoning, each microphone is calibrated using the water calibration facility described in Fig. 18 and Procedure No. 7 in Appendix 3. This procedure provides a low frequency (up to 500 Hz) comparison against a secondary standard hydrophone in water at room temperature.

Representative microphones have been calibrated over the range 0.1 to 150 kHz by Underwater Sound Reference Division of the Naval Research Laboratory, Orlando, Florida. These calibrations were performed in water in their "Lake Facility". Figure 6 is a plot of the results of this calibration for a typical microphone. The directivity of these units as measured by the Underwater Sound Reference Laboratory is shown in Fig. 3.

2. In Air

We have developed a facility for calibrating microphones in air at temperatures up to 1200°F. This facility (Fig. 19) consists of a cylindrical electrically heated furnace 2-3/4 in. in diameter by 6 in. high. The bottom of this furnace is a stainless steel piston which is attached to the driver of an electromagnetic shaker by means of a 3/8 in. stainless steel rod. This piston is a few thousandths of an inch smaller than the inside diameter

Fig. 18. Water Calibration Facility

Fig. 19. Furnace Calibration Facility

of the furnace and is carefully centered to avoid contact with the furnace wall which has a split center section with two holes to accommodate the signal lead and vent tube of the microphone. These top parts are sized to minimize air leakage, but no gas tight seal is employed. The electromagnetic shaker is driven with a signal oscillator and amplifier at frequencies from 100 to 500 Hz to produce acoustic pressure in the furnace. We find that a good reproducible signal level can be maintained in this frequency range but due to the poor efficiency of air as a sound transmission medium, compared to water or sodium, the use of the apparatus at higher frequencies is not practical.

The power supply to the shaker is regulated by an electronic level controller which maintains a set acceleration on the shaker driver element. An accelerometer mounted on the shaker element is used to sense the acceleration of the drive piston. Since no standard acoustic pressure measuring transducers are available which can operate at the temperatures of interest we have no reference measurement of the acoustic pressure in the furnace chamber at temperature. Instead, a reproducible signal is maintained which provides a reference point to establish effects of high temperature exposure on high temperature microphones.

3. In Sodium

Figure 20 shows a third calibration facility which is capable of determining acoustic response of a microphone immersed in sodium at temperatures up to 1200°F. This apparatus consists of a cylindrical stainless steel vessel (6 in. i.d., 12 in. high) which is heated by a metal clad electric resistance heater wound around the outside of the vessel. The sodium vessel is surrounded by a steel box which is filled with expanded vermiculite.

Fig. 20. Sodium Calibration Facility

This material serves as thermal insulation and as an absorbant for liquid sodium in case of a leak in the sodium vessel.

The microphone is inserted through a large gate valve and a flange attached to the top of this vessel. This arrangement allows the microphone to be installed with the leads passing through tube fittings on the upper flange while the sodium in the vessel is isolated by the closed gate valve. After the flange is bolted in place, but before the tube fittings are tightened, the valve is opened and the microphone is lowered into the sodium by sliding the leads through the tube fittings in top flange. When the microphone is at the desired level the tube fittings are tightened to position the microphone.

The acoustic signal is introduced by means of 1/2-in. dia. rod which is welded to the center of the 1/16-in.-thick bottom of the vessel. This rod passes through a seal in the bottom of the containment vessel. At the lower end of this rod a specially designed piezoelectric driver consisting of stack of PZT elements is attached. This driver is excited through a power amplifier by a signal from a white noise generator. Here again, no standard microphone exists which can withstand the exposure conditions, so our calibrations are related to an arbitrary sound pressure level produced by the piezoelectric driver when driven by a set rms voltage white noise signal. This apparatus allows us to determine the effect of long term exposure of our microphones to high temperature sodium.

B. Applications

1. Laboratory Tests

Two microphones have accumulated 15 months exposure to 1200°F air in the furnace calibration facility without change in electrical resistance or response to a standard 500-Hz acoustic signal. The vent tubes of these units are open to the laboratory atmosphere.

2. Installations in Operating Liquid Metal Systems

The following is a brief description of tests in which ANL microphones have been employed as acoustic monitors. In each case, the microphone signal(s) together with signals from other acoustic sensors and from transducers monitoring other system parameters have been tape recorded. In all tests listed, the microphones produced good signals indicative of the acoustic pressure which is developed as a result of loop operating conditions. Analysis of data recorded and correlation of this acoustic information with other recorded information will be the subject of individual reports on the various tests cited.

a. Core Components Test Loop (CCTL) at ANL

A microphone places just under the surface of the sodium in the test vessel of the CCTL operated satisfactorily for 120 days at 1100°F. During a series of tests to determine the limits of detection of gas bubbles in the system, the sound produced by argon gas injected at 2 cc/min into the 525-gpm CCTL flow were readily audible when the amplified signal from the microphone was monitored by means of a loud speaker. The vent tube of this

unit was connected to an oxygen reservoir which was periodically evacuated and refilled with oxygen. There was no evidence of degradation of the sensor signal due to this exposure.

b. LMFBR Heat Transfer Simulation Loop (HTSL) at ANL

A microphone placed in the plenum of the HTSL provided an audible indication of the onset of boiling during a series of sodium superheat tests. Signals from the microphone and from a waveguide were recorded for future analysis. The vent tube of this microphone was connected to an oxygen reservoir (~200 cc volume) which was evacuated and filled with oxygen to 400 mm of mercury absolute pressure at the start of the test series with no further manipulation throughout the test series. The loop operated for a total of about 400 hr at temperatures above 900°F with an additional 100 hr between 400 and 900°F. The microphone was still in good operating condition at the conclusion of the test series.

c. EBR-II Acoustic Monitoring Test (MT3)

For the MT 3 test, a microphone was immersed about 12 in. under the surface of the sodium in the EBR-II Primary Tank. The sodium temperature in the EBR-II tank is maintained at 700°F at all times regardless of reactor operating conditions. Laboratory tests had indicated that at this low temperature the microphone should operate almost indefinitely with no additional oxygen supply required. Consequently, at the time of installation the MT3 microphone was filled with oxygen to 400 mm of mercury absolute pressure and the vent tube was sealed at a point which made it accessible above the EBR-II tank cover. After about six months of operation in the

EBR-II tank the signal from the microphone became erratic. The resistance of the unit had dropped to a few ohms. Evacuating the microphone housing and backfilling with dry oxygen succeeded, after several purge cycles, in raising the resistance to 35 kohms. While this resistance is sufficient for operation of the signal amplifier, it was still far below the typical microphone resistance of 2 megohms at 700°F. Within two months, the microphone resistance again dropped to a very low level and was again raised to about 35 kohms by the purging procedure described above. When the resistance again dropped in a period of about a month, it was decided to incorporate a oxygen reservoir (100 cc volume) on the end of the vent tube. At the time of this installation the same purging procedure as used previously was performed with a resulting sensor resistance of about 30 kohms. Readings taken after installation of the oxygen reservoir indicated a slowly increasing resistance, resulting in a value of 100 kohms three weeks later.

No completely satisfactory explanation of the abnormal behavior of this microphone has been found.

d. Failed Fuel Mockup (FFM) ORNL

A total of four microphones have been supplied to ORNL for inclusion in experimental assemblies for the FFM. Signals produced by these microphones during two test series have been monitored and recorded for further analysis. They correlate well with other ORNL acoustic monitors. Satisfactory operation was obtained.

e. Transient Reactor Test (TREAT) R7 Tests

A microphone with a sealed vent tube was installed in the R7 test. The output signal together with the signals from other sensors was recorded during a test in which a TREAT reactor power burst was used to induce sodium boiling on the surface of a seven pin fuel bundle contained in

the loop. The engineers responsible for the "R" Series tests consider the microphone signal to be a valuable addition to information obtained during the test.

3. Future Applications

Microphones are being constructed for use in several planned tests; these include:

- (1) EBR-II upper Plenum Acoustic Probe
- (2) Sodium Loop Safety Facility Loops
- (3) Steam detector leak detection experiment in CCTL
- (4) Future TREAT "R" Series Tests
- (5) FFTF pump cavitation tests
- (6) Out and In pile tests in cooperation with INTERATOM
- (7) TREAT IRT - 10 test

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A. Libal - for design development and production of engineering drawings;

and to the many Argonne personnel responsible for procurement of materials, matching, welding, and inspection, whose specific abilities are essential to the successful production of these microphones.

Appendix 1

CONSTRUCTION DRAWINGS

Notes

1. All dimensions are in inches unless otherwise noted
2. Materials specifications are listed on parts list
3. Numbers of drawings are serial number portion of ANL

Document Control number i.e., T0009-00-- -DX-XX

Serial
Number

PART NO.	DRAWING NO.	PART NAME OR DESCRIPTION	REMARKS	FOR PURCH. PARTS ONLY	
				MATERIAL	QTY.
	T0009-0002-DD-03	HT MICROPHONE ASSEMBLY	ET-D-3761		
1	T0009-0004-DB-06	DIAPHRAGM	ET-B-3761-1	304 SST ASTM A-182-71 OR A-479-63	2
2	T0009-0005-DB-01	CUSHION	ET-B-3761-2	PLATINUM FOIL 99.95 PURE	2
3	T0009-0006-DB-01	PIEZOELECTRIC DISC	ET-B-3761-3	LITHIUM NIOBATE	2
4	T0009-0007-DB-01	CENTRAL ELECTRODE	ET-B-3761-4	PLATINUM FOIL 99.95 PURE	1
5	T0009-0008-DB-01	ALIGNMENT RING	ET-B-3761-5	HARD FIRED ALUMINA RST C18-IT	1
6	T0009-0009-DB-03	BODY RING	ET-B-3761-6	304 SST ASTM A-182-71 OR A-479-63	1
7	T0009-0010-DB-02	CABLE COUPLING	ET-B-3761-7	304 SST ASTM A-182-71 OR A-479-63 OR A-213-71	1
8		COAXIAL CABLE	LENGTH AS REQ'D	ANL SPEC.	
9	T0009-0011-DB-01	CLIP	ET-B-3761-8	304 SST ASTM A-177-69	1
10		INSULATOR TUBE - .075 ± .003 O.D. x .025 ± .003 I.D., .250 ± .030 LRG		HARD FIRED ALUMINA RST C18-IT	2
11	T0009-0027-DB-00	TUBE COUPLING	ET-B-3761-9	304 SST ASTM A-182-71, A-479-63 OR A-213-71	1
12		TUBING - .062 O.D. x .020 I.D.	LENGTH AS REQ'D	304 SST ANL-T0009-0022-SC	
13	T0009-0028-DB-00	TERMINAL PIN	ET-B-3761-10	BRASS ASTM B-134 ALLOY #6	1
14	T0009-0029-DB-00	TERMINAL (ALTERED)	ET-B-3761-11	MFG STD. BRASS	1
15	T0009-0030-DB-00	CABLE PLUG (ALTERED)	ET-B-3761-12	MFG STD	1
16	T0009-0031-DB-00	TERMINAL COUPLING	ET-B-3761-13	BRASS ASTM B-16-71	1
17		#6-32 UNC-2A x 3/16 LG SLOTTED SET SCREW		SST	

PARTS LIST FOR ANL HT MICROPHONE (HT-9 SERIES)

NOTES

1-VACUUM LEAK CHECK RDT-F3-GT, PROBE METHOD.
MAX. LEAK RATE 1×10^{-8} CC/SEC.

2-AFTER REMOVING INSULATION FROM COAXIAL CABLE AND
INSERTING ITEM (10) FILL WITH VARIAN ASSOCIATES
MODEL NO. 953-0001 TORR SEAL APPROX. AS SHOWN

SEE NOTE 1

SEE NOTE 1

SEE NOTE 1 J_2
 $\frac{1}{6}$ MIN. V SEE NOTE 1

NOTE:
DIM. IN MILLIMETERS

Drawing Number 6 PIEZOELECTRIC DISC

Drawing Number 8

ALIGNMENT RING

Drawing Number 9 BODY RING

DIA'S CONCENTRIC WITHIN .003

Drawing Number 10

CABLE COUPLING

Drawing Number 11 CLIP

Drawing Number 27

TUBE COUPLING

Drawing Number 28

TERMINAL PIN

NOTE:-

ALTER AS SHOWN

COMPONENT OF BENDIX #4876-1 CABLE PLUG - BNC SERIES

Drawing Number 29 TERMINAL (ALTERED)

NOTE:-

ALTER AS SHOWN
COMPONENT OF BENDIX #4876-1
CABLE PLUG.-BNC SERIES

Drawing Number 30

CABLE PLUG (ALTERED)

NOTE:-

FURNISH (1) $\#5-40$ UNC. X $3/32$ LONG
SOC. HD. SET SCREW 304 SST.

Drawing Number 31

TERMINAL COUPLING

APPENDIX 2

MATERIAL SPECIFICATIONS

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1. Specification for Small Diameter Tubing	2-2
2. Specification for Lithium Niobate Plates for Piezoelectric Microphones	2-6
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Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

SPECIFICATION NO. T0009-0022-SC-01

SPECIFICATION FOR SMALL DIAMETER TUBING

Signature	Organization	Date
<i>J. D. Minkley</i>	ETD	12/7/71
<i>J. M. Stansel</i>	ETD-QA	12/21/71
<i>D. E. Lutz</i>	OQA	12/22/71

U of C-AIA-USAEC	ARGONNE NATIONAL LABORATORY		T0009-0022-SC-01		
	Title: SPECIFICATION FOR SMALL DIAMETER TUBING		Rev. 1	Approved	Date 12/6/71
	ENGINEERING AND TECHNOLOGY DIVISION		Page <u>1</u> of <u>2</u>		

1.0 Scope

The seller shall supply stainless steel tubing fabricated, inspected, tested, packaged, and delivered in accordance with this specification.

2.0 Applicable Documents

A 632-69 Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Service.

3.0 Technical Requirements

3.1 The tubing supplied shall meet all of the requirements of ASTM A 632 and the specific requirements listed below.

3.2 The tubing shall be manufactured from grade TP 304 Stainless Steel with chemical analysis as listed in Table 1 of ASTM A 632 and the additional requirement that carbon content be at least .04%.

3.3 The tubing shall be seamless.

3.4 Dimensions and tolerances shall be as tabulated below

Outside Diameter 0.062 in. plus 0.002 in. minus 0.000 in.

Inside Diameter 0.020 in. plus 0.000 in. minus 0.002 in.

Length Per Purchase Order

3.5 Tube shall be nondestructively tested while in the drawing range of 0.500 in. to 0.125 in. in outside diameter with a method capable of detecting defects with a depth exceeding 10 percent of wall thickness.

3.6 Tube shall be as clean and free from foreign material as possible.

3.7 Tube shall be supplied in annealed temper.

U of C-ALA-USAC	ARGONNE NATIONAL LABORATORY		T0009-0022-SC-01		
	Title: SPECIFICATION FOR SMALL DIAMETER TUBING		Rev. 0	Approved	Date 12/6/71
	ENGINEERING AND TECHNOLOGY DIVISION		Page <u>2</u> of <u>2</u>		

4.0 Quality Assurance

Manufacturer shall supply the following.

4.1 A certified analysis of the material from which the tube is manufactured.

4.2 A certified report of nondestructive test specified in Section 3.5 of this specification.

4.3 A certification that tubing was manufactured to all requirements of ASTM A 632.

5.0 Delivery

Tube shall be shipped in a coil not less than 20 in. in inside diameter wound in such a manner that at least six in. of each end are accessible for inspection and testing without unwinding remainder of tube.

6.0 Supplementary Information

None

Acceptance Criteria for Small Diameter
Tube Specification #T0009-0022-SC-01

Receiving inspection will be made by recipient and will consist of

1. Having check analysis run on sample of tube cut from coil when received.
2. Sectioning samples cut from each end of tube to inspect for cleanliness.
3. Check on approximate length of tube (π x ave. coil diameter x number of turns)
4. Dimensional check - OD in at least 10 places along length - ID on sectioned pieces from both ends.
5. Check documents as required in Section 4.0 of specification.

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

Components Technology Division

SPECIFICATION NO: T0009-0054-SC-00

DEVELOPMENTAL
SPECIFICATION FOR LITHIUM NIOBATE PLATES FOR
PIEZOELECTRIC MICROPHONES

May, 1973

Prepared by: A. R. Gavin Project Engineer

Authorized for Release: E. D. Mulcahy Project Manager

D. N. Bonnell QAD, 6-11-73

U of C-AIA-URAC	ARGONNE NATIONAL LABORATORY		T0009-0054-SC-00		
	Title: DEVELOPMENTAL SPECIFICATION FOR LITHIUM NIOBATE PLATES FOR PIEZOELECTRIC MICROPHONES		Rev. 0	Approved	Date 5/73
	COMPONENTS TECHNOLOGY		Page <u>1</u> of <u>2</u>		

1.0 Scope

The seller shall supply developmental lithium niobate (LiNbO_3) plates for use in piezoelectric microphones and analysis and test data as specified below.

2.0 Applicable Documents

2.1 American Society for Testing Materials Standards

2.1.1 E 135-72 Definition of Terms and Symbols Relating to Emission Spectroscopy

2.1.2 E 158-66 Recommended Practices for Spectrochemical Computations

2.2 American National Standards Institute Standard

ANSI C 83.3-1951 American Standard Terminology for Piezoelectric Crystals

2.3 Drawing

T0009-0006-DB-02 Piezoelectric Disc

3.0 Technical Requirements

3.1 Material shall be premium grade lithium niobate

3.2 Material shall be single domain

3.3 Material shall contain less than 1000 dislocations per square centimeter

3.4 Plates shall be 36°Y cut - i.e. (yzt) 36° in accordance with the terminology defined in ANSI standard C 83.3-1951

3.5 Material shall be uniformly poled

3.6 Plates shall be annealed after fabrication

3.7 Dimensions of plates shall be in conformance with the dimensions and tolerances specified on Argonne National Laboratory drawing T0009-0006-DB-02

3.8 Plate faces shall be polished flat to within $1/2$ wavelength

3.9 Plate faces shall be parallel to within 1 minute of angle

4.0 Quality Assurance and Control

In order to assure traceability and reproducibility of material supplied the seller shall furnish the following information

4.1 Identification of manufacturers boule or boule from which discs were fabricated

U of C-ALMA-USAEC	ARGONNE NATIONAL LABORATORY		T0009-0054-SC-00	
	Title: DEVELOPMENTAL SPECIFICATION FOR LITHIUM NIOBATE PLATES FOR PIEZOELECTRIC MICROPHONES		Rev. 0	Approved Date 5/73
	COMPONENTS TECHNOLOGY		Page <u>2</u> of <u>2</u>	

4.2 Curie temperature of material

4.3 Coupling coefficient of materials together with method of determining

4.4 Spectrographic analysis of material from each boule from which plates were fabricated according to ASTM Standards E158 and E135

4.5 Description of annealing procedure used

5.0 Delivery

5.1 Packaging

5.1.1 Each plate shall be individually boxed

5.1.2 Individual boxes shall be contained within a second box

5.2 Marking

Outer box is to be marked to the effect that it is to be opened only by persons familiar with the nature of its contents.

6.0 Notes

The material to be supplied will be used in a developmental program for piezoelectric microphones. The reproducibility and traceability of the material must be assured, however. If the material cannot be supplied as specified, the supplier shall detail exceptions to this specification in the proposals submitted for buyer consideration.

ORDERING DATA USED IN CONJUNCTION WITH RDT STANDARD
SPECIFICATION - RDT C-17-5T, METAL-SHEATHED, MINERAL-
INSULATED CABLE BULK MATERIAL

FOR

ANL - HT MICROPHONES

Note:

Paragraph numbers in data correspond to those sections of
RDT C-17-5T to which they apply.

Cable bulk material shall be manufactured in according with RDT Standard C 17-5T as supplemented and amended by the following ordering data.

Ordering Data

3. TECHNICAL REQUIREMENTS

3.1.2 Environment

3.1.2.1 Temperature. The cable bulk material shall be capable of continuous operation at 1200°F.

3.1.2.3 Vibration. No specific requirements for vibration resistance are imposed.

3.2 Mechanical Requirements

3.2.1 Configuration. The cable bulk material shall contain one or two conductors and shall conform to the following dimensional requirements

Sheath:	Outside Diameter	0.125 in. ± 0.001 in.
	Wall Thickness	0.022 in. ± 0.001 in.
Conductor:	Diameter	0.020 in. ± 0.002 in.
Length:		400 ft. in 40 ft. lengths

3.2.2.1 Conductor Material. Center conductor shall be 304 SS according to ASTM A 478-70 "Chromium-Nickel Stainless and Heat Resisting Steel Wire".

3.2.2.2 Insulation. Insulating material shall be alumina (Al_2O_3) or magnesia (MgO).

3.2.2.3 Sheath. Sheath tubing shall be seamless.

3.3.2 Fabrication Procedures. Two copies of the fabrication procedures shall be submitted to and approved by the purchaser prior to start of fabrication.

3.4.1 End Seals. Each end of each cable sheath shall be finished square and smooth with a 1 in. cleaned section of conductor protruding. Each end shall be sealed with a durable, moisture-proof material which, after setting will maintain its moisture-proof seal during and after exposure in air at 100°C. The

end seal material shall fill the sheath I.D. for a distance of between one and two cable diameters from the end of the sheath. The insulation resistance of the end seal material shall be at least as good as that specified for the cable insulation.

3.4.2 Insulation Resistance. At 25°C - Shall exceed 5000 megohm-feet

At 675°C - Shall exceed 8 megohm-feet

The insulation resistances shall be measured between conductors and between each conductor and the sheath at 25°C and 675°C as indicated below and with both direct and reversed polarity. The resistance values shall be read 30 seconds after the measuring potential is applied. The accuracy of the measuring instrument shall be better than 10%.

Insulation Resistance at 25°C ± 5°C of each finished cable shall be measured after each cable has been exposed to atmospheric humidity for at least 2 days after end seals have been installed and shall exceed the value specified with 100 VDC applied.

Insulation Resistance at 675°C ± 25°C of at least a 5 foot length of each lot of bulk material shall be measured and shall exceed the value specified with 10 VDC applied. The temperature at the time of measurement shall be reported.

3.4.5 Length. The cable bulk material shall be supplied in lengths of 40 feet minimum.

4. QUALITY ASSURANCE REQUIREMENTS

4.3.2 Radiographic Examination. Each finished length of cable shall be examined radiographically over at least a four inch section of each end and of the center of the cable length. For the 2 conductor cable 2 views taken at 90° of each other shall be provided in each location.

4.3.3 Liquid Penetrant Examination. The entire surface of the finished cable shall be inspected by liquid penetrant examination. No indications shall be allowed.

4.6 Documentation. All documents required shall be submitted to the buyer in duplicate as indicated below.

4.6.1 Material Identification. Copies of mill reports and check analysis reports covering all materials shall be submitted to and approved by the buyer prior to start of fabrication of the cable.

4.6.2 Inspection and Test Results. Copies of all inspection and test results shall be submitted to the buyer with the finished material.

5. PREPARATION FOR DELIVERY

5.1 Sealing, Packaging, Packing, and Marking. Material shall be shipped in straight lengths or in coils of a diameter not less than 48 inches inside diameter.

APPENDIX 3

CONSTRUCTION PROCEDURES

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ANL HT MICROPHONE FABRICATION

PROCEDURE NO. 1INSPECTION OF LITHIUM NIOBATE DISCSPurpose

The purpose of this procedure is to establish the physical dimensions and piezoelectric sensitivity of lithium niobate discs received from a supplier.

Equipment

1. Dial type thickness gauge .250 in. range with .001 divisions
2. Micrometer caliper 0 - 1 inch
3. Binocular microscope 5 to 10 power
4. "D" tester - Acrotech Laboratories
5. Oscilloscope
6. Voltmeter 0 - 100 mV RMS range
7. Small forceps for handling crystals
8. Sharp pointed scribing tool
9. Felt tipped pen

Materials

1. Disposable wiping tissues
2. Ethyl alcohol (c.p.)

1. Record purchase order number, date received, and quantity received in lab notebook. Attach copy of PO, spectrographic analysis report, and any other information received from vendor with shipment to notebook page.
2. Each crystal should be contained separately in a small envelope within an individual plastic or cardboard box. If crystals are not so packaged when received they should be separated and so packaged before proceeding.
3. Mark each individual envelope and the top and bottom of each individual box with a serial number which is different for each crystal and indicative of the lot from which it was taken.
4. After marking packaging as above, no more than one crystal is to be out of its protective envelope at any given time until permanently marked.
5. Connect "D" tester and other instruments as indicated in diagram below.

6. Using reference standard crystal set tester control to obtain a reading of 80 mV on DVM.
7. With numbered side of standard crystal up, set trace on oscilloscope so that a positive peak is displayed above the center line of screen.

8. Remove standard crystal and place crystal to be checked in position in tester being sure that point of contact probe does not scratch surface of crystal.
9. If oscilloscope has a positive trace at center of screen leave crystal as is, if negative remove crystal, turn over, replace in holder and recheck for a positive trace display.
10. With felt tipped pen place a small dot on the top surface of the crystal at front edge of the crystal (edge toward operator) to establish a polarity and index mark for engraving a permanent code number on each crystal.
11. Using locating shield and guide measure "D" coefficient in five places on crystal surface as indicated below. Record readings in table in data book (see sample data sheet attached).

12. Replace crystal in its numbered protective envelope.
13. Proceed to mark and measure remaining crystals rechecking tester output with standard crystal after every five crystals measured. If setting is off more than .5 mV reset and recheck previous five crystals. (Use same location on surface of standard for all checks.)
14. Check polarity and measure "D" values for all crystals in lot.
15. Each crystal is to be permanently marked on the surface whose polarity matches that of the numbered side of the "D" tester standard. The marking is to be placed on the edge nearest the operator when the "D" values were measured. (This position was temporarily marked with ink in Step 10 above.)

16. Using binocular microscope and a needle sharp scribe of the hardest material available scribe a serial number and lot letter on each disc. Care should be taken to make markings as light as possible and still legible.
17. With dial micrometer check thickness of each disc in five places. Record average on data sheet. Note any discernable deviation from average.
18. With micrometer caliper measure diameter of each disc on two diameters approximately 90° apart and record average on data sheet.
19. Check flatness of each side of each disc and record maximum number of light bands deviation from flatness.

INFORMATION TO BE RECORDED IN DATA BOOK

P.O. #	Name of Manufacturer
--------	----------------------

Manufacturer's Identification No. for lot _____

[illegible]

Crystal No.	"D" Value					*Thickness	Diameter	Flatness	Comments
	1	2	3	4	5	Ave.	Inches	Inches	
(Attach copy of PO and spectrographic analysis to data book page)									
* Ave. 5 places									

(Attach copy of PO and spectrographic analysis to data book page)

* Ave. 5 places

ANL HT MICROPHONE FABRICATION
PROCEDURE NO. 2
POLISHING DIAPHRAGM FACES

Equipment

1. Cast iron lapping plate (not grooved)
2. Optical flat
3. Monochromatic light source
4. Diaphragm lapping ring removal fixture Fig. 2-1.
5. Small sharpening stone (1/2 x 1/2 x 2 in.)

Materials

1. Polishing grit - aluminum oxide in the following grades
 - #400 grit
 - #500 grit
 - #600 grit
 - 200 micron
 - 95 micron
2. Lapping film ("Imperial" Brand - Minnesota Mining and Manufacturing Company) aluminum oxide on 1 mil milar backing
 - 12 micron
 - 3 micron
 - .3 micron
3. Liquid soap and scrub brush
4. Disposable tissue
5. Ethyl alcohol

Parts

1. Diaphragms with lapping rings machined and ground as indicated
on Drawing Number T0009

Procedure

1. Clean lapping plate by scrubbing with soap and water. Rinse with running water. If water does not wet surface after this step dry and wash with perchlorethylene or other solvent to remove grease and oil. Dry and scrub with soap and water as before.
2. With plate surface wet but with no standing water place about 1 teaspoon of #400 grit polishing abrasive in the center of the plate, and add a few drops of water. With diaphragm and lapping ring in holder held between fingers spread compound and water over center part of plate using a circular motion. When compound is spread evenly continue circular motion but increase pressure. Lap in this manner for about 50 strokes.
3. Rinse plate and diaphragm with running water.
4. Recharge plate with #400 grit abrasive and repeat above for 50 more strokes. Unless deep scratches or other imperfections are evident in diaphragm surface proceed to next step. Light scratches are allowable and will be removed by the following steps.
5. Remove all traces of #400 grit abrasive from diaphragm, lapping plate, and hands by scrubbing with soap and water. Rinse with running water.
6. Charge plate with #500 grit abrasive as in step number 2 and lap for 50 strokes. Rinse diaphragm, hands and plate.
7. Diaphragm surface should have a uniform grey appearance without scratches or other imperfections. If surface is not uniform in appearance repeat steps 4 and 5. If imperfections still exist repeat entire procedure from step 1.

8. When uniform surface has been achieved with 500 grit abrasive carefully remove all 500 grit abrasive from diaphragm, surface plate and hands by scrubbing with soap and water.
9. Charge plate with 600 grit abrasive as in step number 2 and lap for 50 strokes. Wash diaphragm, plate and hands.
10. Check surface for uniform appearance and proceed to step 11 if uniform or repeat step 9 if imperfections exist.
11. Charge plate with 200 micron abrasive as in step number 2 and lap for 50 strokes. Wash diaphragm, plate and hands.
12. Check surface for imperfections and proceed to step 13 if uniform or repeat step 11 if imperfections exist.
13. Charge plate with 95 micron abrasive as in step number 2 and lap 50 strokes. Wash diaphragm, plate, and hands.
14. Check surface for imperfections and proceed to step 15 if uniform or repeat step 13 if imperfections exist.
15. Rinse surface of lapping plate with running water and while still wet place a sheet of 12 micron lapping film on surface and work water out from between plate and film with hands. Allow a slow stream of water to run on surface of film. Place diaphragm on surface of film and lap 50 strokes as in previous operations. Rinse diaphragm with running water.
16. Repeat step 15 using 3 micron lapping film.
17. Repeat step 15 using .3 micron lapping film.
18. Rinse diaphragm thoroughly and dry with soft tissue.

19. Wash diaphragm face and face of optical flat with ethyl alcohol and dry. Be sure that no lint particles are present on surfaces.
20. With a sliding motion force face of polished diaphragm (with lapping ring still in place) against face of optical flat.
21. Examine under monochromatic light for presence of color rings.
Existence of circular color bands indicates surface of diaphragm is not perfectly flat. No more than two complete bands should be present. More than this are unacceptable and part must be reworked or discarded. Record flatness in number of light bands present in lab notebook.
22. With ring removal fixture (Fig. 2-2) remove lapping ring from diaphragm.
23. Examine face of finished diaphragm under the low power microscope.
If a slight burr appears on the edges of the raised portion it is to be removed by careful use of a small sharpening stone.

ANL HT MICROPHONE FABRICATION

PROCEDURE NO. 3ATTACHMENT OF LEAD WIRE TO CENTRAL ELECTRODEEquipment

Spot welder with 1/8 in. dia. sharp pointed copper electrode and foot operated trigger (15 watt second capacity)

Die makers files

Electrode alignment fixture - Fig 3-1

Scissors

1/2 in. dia. 1/8 in. thick stainless steel anvil

1/8 in. dia. chisel

1/4 in. dia. x 3 in. long steel rod

1/2 in. x 1/2 in. sharpening stone

Hammer and heavy back up plate

"Handy tool" hand grinder with 1/32 x 1 in. abrasive wheel or small three cornered file for stripping stainless steel sheath from coaxial cable

1 in. micrometer

*Binocular microscope 5 to 10 power

Polishing cloth

Sensor assembly fixture drawing no.

Assorted tweezers - stainless steel

Machinists scale - 6 in.

Dissecting needles with wooden handles - modified

Materials

1. Sheathed cable-specification and length as required for sensor under construction
2. Body ring - drawing no. T0009-0009

*Special Note:

Proper surveillance of this procedure can only be maintained through the use of a low power binocular microscope. Imperfections in parts, improper alignment of parts, or the presence of foreign particles cannot be ascertained by the unaided eye or by low power viewers.

3. Cable Coupling - drawing no. T0009-0010-
4. Central electrode - drawing no. T0009-0007-
5. Attachment clip - drawing no. T0009-0011-
6. Hard fired alumina bead .025 ID x .075 OD x .250 long
(part #10 on parts list)

Procedures

1. Trim one end of cable sheath to allow 1/4 in. of lead wire to extend beyond the sheath. Clean burrs from 1.00 OD of tubing and clean lead wire.
2. Check and record cable resistance.
3. Have cable coupling welded to cable allowing cable sheath to extend 1/16 in. beyond end of adapter. Record name of welder on data sheet.
4. Leak check cable to coupling weld per leak check procedure no. 7. Have weld repaired if any indication of leak.
5. Check and record cable resistance. If resistance has dropped to less than 10 K ohms cut cable at cable-to-coupling weld and start over from Step #1.
6. Remove aluminum oxide insulation to 1/4 in. back from adapter end of sheath.
7. Position cable and cable adapter in housing ring, clamp in sensor assembly fixture and have cable adapter tack welded to housing ring in two places being sure that tacks do not cause deformation of ring.
8. Slip 1/4 in. fired alumina sleeve over end of lead wire and push into place inside cable sheath. The end of the sleeve should be flush with the inside of the housing ring.
9. With small needle nose pliers bend lead sharply close to the inside of the body ring so that bent end of wire is parallel to internal face of ring.
10. Insert electrode alignment fixture and adjust bend of lead wire to fit groove in fixture so that it does not move when fixture is removed.
11. Slip end of shim stock attachment clip over end of lead wire and fit clip into slot in alignment fixture.

12. Make sure attachment clip fits snugly around lead wire and is at least .020 in. from body ring.
13. Place brass plate under assembly and attach ground electrode of spot welder to it.
14. Set welder at 7 ampere-seconds.
15. Using pointed electrode apply pressure to attachment clip at a point over the lead wire. Weld in two places using foot switch to trigger welder discharge.
16. Remove alignment jig and insert 1/2 in. dia x 1/8 in. thick anvil under attachment clip as close to lead wire as possible. Place assembly on heavy backup plate.
17. Using 1/8 in. dia chisel and hammer cut ends of attachment clip to leave 1/16 in. overall length of clip.
18. Reposition electrode alignment fixture inside housing ring so that lead wire is in groove and attachment clip is in its proper slot. With pointed tool separate ends of attachment clip to allow easy insertion of tab from platinum electrode.
19. Position platinum central electrode in circular cavity of alignment fixture being careful to fit tab between ends of attachment clip.
20. Place assembly on heavy brass plate and connect ground of spot welder to plate. Adjust welder to 7 ampere seconds.
21. Firmly press ends of attachment clip together with pointed electrode of spot welder. Be certain that tab of platinum electrode is sandwiched between sides of attachment clip. Spot weld in two places.
22. Remove assembly from alignment fixture and examine both sides of weld to assure adequate spot welds and proper positioning of electrode tab.
23. Platinum electrode should remain centered in the housing ring when alignment fixture is removed. Check to be sure this is the case.

② CHILL BLOCK (COPPER) BOTTOM HT-6

Figure 3-2 MICROPHONE

ANL HT MICROPHONE FABRICATION

PROCEDURE NO. 4ASSEMBLY OF INTERNAL PARTSEquipment

1. Binocular microscope 5 to 10 power
2. Assorted tweezers - stainless steel
3. Plastic squeeze bottle with small tube (for blowing or sucking dust from parts)
4. Welding fixture - Drawing No. T0009-0085-DC-01
5. Dissecting needles with wooden handles - modified

Materials

Plastic squeeze bottles containing

1. C.P. Acetone
2. C.P. Ethyl alcohol
3. Wiping tissue

Parts

1. Cable - body ring - central electrode assembly from Procedure #4
2. Piezoelectric disc - Drawing No. T0009-0006-DB-01 (Two required)
3. Cushion - Drawing No. T0009-0005-DB-01 (Two required)
4. Alignment Ring - Drawing No. T0009-0008-DB-01
5. 1/16" OD x .021 ID stainless steel vent tube same length as cable
6. Tube coupling - Drawing No. T0009-0027-DB-01

Procedures

1. Wash internal surfaces of the body ring, platinum electrode, lead wire and lead wire clip with acetone being careful not to wet ceramic insulator or inside of cable.
2. Dry all internal parts thoroughly.

3. Repeat Steps 1 and 2 using ethyl alcohol instead of acetone and cover assembly to keep it clean.
4. Wash all component parts of sensor (diaphragms, discs, platinum pads and ceramic alignment ring) using acetone first then alcohol. Dry thoroughly after washings. Cover parts to keep clean.
5. Clean diaphragm welding fixture Drawing No. T0009-0085 with acetone.
6. Install one diaphragm in bottom of body ring. (Top determined by position of bent lead wire in a counterclockwise position when viewed from an open side).
7. Install assembly (Step 6) in welding fixture with diaphragm up. Position fixture chill in center of diaphragm and tighten chill clamping screw to exert moderate clamping pressure on diaphragm.
8. Install and tighten cable clamp on side of fixture to support cable during welding operation.
9. Clean weld area on diaphragm and body ring with acetone.
10. Weld diaphragm - per Procedure #5.
11. Remove partial sensor assembly from fixture after welding.
12. Clean parts of assembly as in steps 1-2-3. Be sure that foreign materials (lint, dust or grit) are removed from cavity.
13. Position sensor under microscope open side (top) up.
14. With tweezers, bend center electrode up (90° to diaphragm) to facilitate installation of lower cushion and disc.
15. Position washed parts (diaphragm, cushion, discs, and ceramic alignment ring) near assembly on clean paper to permit microscope inspection before final assembly.
16. Using plastic squeeze bottle blow dust or lint (if any) from cavity of sensor.
17. Lift platinum cushion with tweezers, inspect for damage and/or foreign materials on its surface. If clean and undamaged, place in sensor cavity on top and in alignment with the lower diaphragm electrode surface.
18. Lift disc (lithium niobate) with tweezers, inspect and place code number (on one face of disc) down, on top of and aligned with the platinum cushion (Step 17).

19. Using tweezers bend center electrode down to contact top surface of disc.
20. With tweezers, make any final adjustments necessary to bring all three parts in perfect alignment with raised portion of diaphragm to permit easy installation of ceramic alignment ring.
21. Lift ceramic alignment ring with tweezers, and inspect (as in Step 17). If clean and undamaged, install it in sensor cavity with the electrode wire clip in the ring slot, alignment ring fully seated against bottom diaphragm, and the previously installed parts (cushion, disc, and electrode) in original alignment position.
22. Lift remaining disc (lithium niobate) with tweezers, inspect, and place code number up inside of alignment ring and on top of center electrode.
23. Lift remaining platinum cushion with tweezers, inspect, and place inside of alignment ring on top of disc.
24. Make final inspection of internal assembly for foreign materials and remove if present.
25. Inspect top diaphragm, if clean install it in body ring to complete the assembly procedure.
26. Install dial gage and probe assembly on lower anvil of welding fixture to provide an accurate method of indicating lower diaphragm preload and deflection preceding final welding. See Sketch (4-1)
27. Place assembled sensor in welding fixture with welded diaphragm (bottom) down.
28. Place chill block on top, and in the center, of the top diaphragm and tighten clamping screw to hold sensor in place.
29. Install and tighten cable clamp on side of fixture to support cable during the final welding operation.
30. Advance clamping screw while observing reading on dial gage. The diaphragm will be properly seated in the body ring when there is no further advance in the dial gage reading. Do not tighten beyond this point as sensor damage will result.
31. Remove dial indicator and support rods.
32. Weld vent tube to tube coupling per Procedure #5.
33. Leak check vent tube to tube coupling weld per Procedure #6.
34. Position tube coupling with attached vent tube in sensor body ring and tack weld in place.
35. Weld top diaphragm tube coupling and cable coupling per Procedure #5.

Figure 4-1

APPARATUS USED FOR CHECKING DIAPHRAGM DEFLECTION

U.S. ATOM. ENERGY COM.

3-21

ARGONNE NATIONAL LABORATORY

HIGH TEMPERATURE MICROPHONE FABRICATION

PROCEDURE NO. 5
Central Shops Department

Weld Procedure and Welder Qualification
Specification for Manual GTA Welding of
Acoustic Sensor Assembly (HT-9 Series)

Specification No. ANL-CS-5047

February 22, 1974

This weld procedure and operator qualification is certified to conform to the requirements set forth in the ASME Boiler and Pressure Vessel Code, Sections III and IX, and RDT Standard F 6-5T, Welding Qualifications.

Revision 1 Date 3-7-75

Approved By: _____

Prepared By: C. J. [Signature] 2/22/74

Checked By: [Signature]

Approved By: [Signature] 2/22/74

CENTRAL SHOPS DEPARTMENT
WELD PROCEDURE AMENDMENT LISTING

ANL PROCEDURE NO. ANL-CS-5047

AMENDMENT NO./ DATE	DESCRIPTION	APPROVED
1. March 1975	<p><u>Add:</u></p> <ul style="list-style-type: none"> (a) Job No. 114-12246, Microphone Assembly (b) Job Control Plan No. 2981-1 thru required number (c) Drawing T0009-0041-DD-02, Microphone Assembly, HT-10 Series <p><u>Revised:</u></p> <ul style="list-style-type: none"> (a) Page 4, Paragraph 8.2(e) & (f) (b) Page 6, Paragraphs 14.1 (Visual) and 14.4 (Radiographic Examination) (c) Page 9, Schedule 3 (d) Page 11, Sketch 	<p><i>10/10/75</i> <i>5/1/75</i></p>

U of C-AUA-USAC	ARGONNE NATIONAL LABORATORY CENTRAL SHOPS DEPARTMENT		Specification No. ANL-CS-5047		
	Title:	WELD PROCEDURE AND WELDER QUALIFICATION SPECIFICATION FOR MANUAL GTA WELDING OF ACOUSTIC SENSOR ASSEMBLY (HP-9 SERIES)		Rev. 0	Approved
				Date 2-22-7	
		Page <u>1</u> of <u>11</u>			

<u>Section</u>	<u>Title</u>
1.0	Scope
2.0	Applicable Documents
3.0	Welder Prequalifications
4.0	Base Metal
5.0	Weld Filler Metal
6.0	Material Certification
7.0	Weld Position
8.0	Preparation of Base Metal
9.0	Electrical Characteristics
10.0	Appearance of Welds
11.0	Defects
12.0	Welding Procedure and Sequence
13.0	Base Metal Thickness
14.0	Inspection Acceptance Criteria

Schedules 1, 2 and 3

U of C-ANL-USAE	ARGONNE NATIONAL LABORATORY CENTRAL SHOPS DEPARTMENT		Specification No. ANL-CS-5047		
	Title: WELD PROCEDURE AND WELDER QUALIFICATION SPECIFICATION FOR MANUAL GTA WELDING OF ACCUSTIC SENSOR ASSEMBLY (RT-9 SERIES)	Rev.	Approved	Date	
		0		2-22-	
		Page <u>2</u> of <u>11</u>			

1.0 SCOPE

This is a specification for welding and testing of miniature thin wall stainless steel instrumented high-temperature microphone components and their assemblies.

1.1 Application

This specification defines the requirements for:

- 1.1.1 Weld procedure qualification and performance qualification for welders, weld operators, weld equipment and fixturing for the welding of microphone components.
- 1.1.2 Application of qualified procedures and personnel for welding of microphone components.
- 1.1.3 Destructive and nondestructive testing and examination for qualification of procedures and for job welding.

2.0 APPLICABLE DOCUMENTS

The following documents are a part of this specification when specified.

2.1 Specifications

- (a) ASME Boiler and Pressure Vessel Code, Section IX, Welding Qualifications
- (b) Weld Procedure ANL-CS-1012, Fusion Welding and Thin Sheet and Thin Wall Tubing
- (c) Weld Procedure ANL-CS-1007, Welding Procedure Specification for Gas Tungsten Arc Welding (GTAW) Stainless Steel
- (d) RDT Standard F 6-5T, Welding Qualifications
- (e) RDT Standard F 3-6T, Nondestructive Examination
- (f) RDT Standard F 5-1T, Cleaning and Cleanliness Requirement for Nuclear Components

U of C-AUA-USAC	ARGONNE NATIONAL LABORATORY CENTRAL SHEPS DEPARTMENT		Specification No. ANL-CS-5047	
	Title: WELD PROCEDURE AND WELDER QUALIFICATION SPECIFICATION FOR MANUAL GTA WELDING OF ACOUSTIC SENSOR ASSEMBLY (HT-9 SERIES)		Rev. 0	Approved
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2.2 Drawing

- (a) Drawing T0009-0002-DD-03, Acoustic Sensor Assembly
(HT-9 Series), March 19, 1973

3.0 WELDER PREQUALIFICATIONS

In order to fulfill the requirements of this specification, the welder must be prequalified to Weld Procedures ANL-CS-1001 or ANL-CS-1007 and ANL-CS-1012.

4.0 BASE METAL

The base metal shall conform to the specifications listed in the ASME Boiler and Pressure Vessel Code, Section IX, Table Q-11.1, Materials Group No. P-8, Type 304 Stainless Steel.

5.0 WELD FILLER METAL

Weld filler metal requirements shall conform to RDT Standard M 1-2T and ASME Boiler and Pressure Vessel Code, Section IX.

- (a) ASME SFA-5.9 (AISI), Table Q-11.2, Group No. F-7, Type 308 for Ferrous Filler Metal.
- (b) The chemical composition of the weld deposit shall fall within the limits of ASME SFA-5.9, Table Q-11.3, Group No. A-7, Type 308 Weld Metal Analysis.

6.0 MATERIAL CERTIFICATION

Weld filler metal used in this qualification have met the applicable RDT Standard Certification and Documentation and are on file.

- (a) 1/32 diameter, AWS ER-308, CS ID #102902
- (b) 1/16 diameter, AWS ER-308, CS ID #102903

7.0 WELD POSITION

Welding shall be performed in the flat 1G position.

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8.0 PREPARATION OF BASE METAL

8.1 All weld joints shall be prepared by machining and cleaned per RDT Standard F 5-1T.

8.2 Weld joints shown on Drawing T0009-0041-DD-02 shall be of the following geometries:

- (a) Weld J1, 1/64 minimum to 1/32 maximum fillet
- (b) Weld J2, 1/64 minimum to 1/32 maximum fillet
- (c) Weld J3, 1/32 minimum to 3/64 maximum fillet
- (d) Weld J4, 1/32 minimum to 3/64 maximum fillet
- (e) Weld J5, .015 minimum penetration, 75° included angle
- (f) Weld J6, .015 minimum penetration, 75° included angle

9.0 ELECTRICAL CHARACTERISTICS

Electrical characteristics for welding shall be direct current - straight polarity (DC-SP).

10.0 APPEARANCE OF WELDS

The welding current and manner of depositing the weld metal shall be such that there shall be no undercutting on the side walls of the butt weld and face and sides of the fillets. The weld color shall be no less than dark blue upon completion with no oxidation scaling. The weld can be stainless steel wire brushed.

11.0 DEFECTS

Any visual evidence of surface weld defects, porosity, tungsten inclusion or fissuring shall be removed by grinding prior to completion of the weld.

U of C-AUA-USAEC	ARGONNE NATIONAL LABORATORY CENTRAL SHOPS DEPARTMENT		Specification No. ANL-CS-5047		
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12.0 WELDING PROCEDURE AND SEQUENCE

12.1 Weld joints J1 and J2 shall be set up, positioned and welded per parameters of Schedule 1.

12.1.1 Weld inspection of weld joints J1 and J2:

- (a) Visual examination (optical magnifier, 7X minimum)
- (b) Helium vacuum leak test
- (c) Dye penetrant examination
- (d) Radiographic examination
- (e) Metallographic (25X maximum, weld procedure only)

12.2 Weld joint J4 shall be set up, positioned and tack welded (two 1/32 tacks, 180° apart, at 90° from weld joints J5 and J6 on cylindrical section of vessel).

12.3 Return to customer for installation of central electrode.

12.4 Weld joint J6 shall be assembled and welded per parameters of Schedule 3.

12.5 Assembly shall be transferred to customer for installation of internal parts.

12.6 Weld joint J3 shall be tack welded per parameters of Schedule 2.

12.7 Weld joint J5 shall be welded per parameters of Schedule 3.

12.8 Weld joints J3 and J4 shall be welded per parameters of Schedule 2.

12.9 Weld inspection of weld joints J3 thru J6:

- (a) Visual examination (optical magnifier, 7X minimum)
- (b) Helium vacuum leak test
- (c) Dye penetrant examination

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(d) Radiographic examination

(e) Metallographic (25X maximum, weld procedure only)

13.0 BASE METAL THICKNESS

The procedure shall qualify only the welding of material geometries and thicknesses of the actual job/drawing requirements.

14.0 INSPECTION ACCEPTANCE CRITERIA

14.1 Visual (optical magnifier, 7X min.)

All weld surfaces and adjacent base metal shall be free of fissures, incomplete fusion, craters, surface inclusions, arc strikes, porosity, concavity, splatter and black or gray flaking oxidation.

The deposited weld metal shall be such that there be no undercutting on the side walls of the butt weld and face and sides of the fillets. The weld color shall be no less than dark blue upon completion with no oxidation scaling. The welds may be stainless steel wire brushed.

14.2 Helium Vacuum Leak Test

All welds shall be helium leak tested. Leakage shall not exceed 1×10^{-8} std. cc/sec. of helium.

14.3 Dye Penetrant

All welds shall be dye penetrant examined. Any penetrant indication shall be cause for rejection and evaluation for reweld.

14.4 Radiographic Examination

All welds shall be radiographed. Weld defects, fissures, porosity, inclusions exceeding 20% of the actual weld thickness (in any direction) shall be cause for rejection and evaluation for reweld.

On welds J5 and J6 the radiography consists of two shots with the body of the microphone in the flat position. A third shot is taken on edge using stainless steel powder as a shape correction form. This third shot provides a positive check on the depth of the weld penetration at two points on each weld. The film from the flat position is examined for uniformity in contrast of the weld thereby verifying acceptable penetration.

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14.5 Metallographic Examination (weld procedure only)

All weld joints shall be cross-sectioned mounted and polished for examination. Twenty (20) X macrographs of each cross section shall be examined for fissuring, porosity, inclusions and minimum weld penetration.

Issued:

By C. T. Szymko Rev. 0

Date 2-22-74 Rev. 0

Central Shops Department

MANUFACTURING PROCEDURE

PROCESS - WELDING

CS Job Control Plan No. 2887

Drawing No. TC009-2002-DD-03

Page 7 of 11 Pages

SCHEDULE 1

Job No. 114-11303

Job Name EP-9 Microphone Assembly Welding

Customer A. P. Gavin

Planner A. J. Rogers

Foreman L. Lach

QUALIFICATION PROCEDURES ANL-CS-5047

Base Metal: ASTM A-162, Type 304

Welded To: ASTM A-162, Type 304

ASME Sect. IX P₈ To P₈

Spec. ASTM A-162, Type 304 To ASTM A-177

Welding Matl. ASME SFA-5.9, Type 308

.04 carbon minimum

ASME Sect. IX P₈ 7

ASME Sect. IX A₇ 7

Specification:

Shield Gas: Argon

Purge Gas: Argon

Consumable Insert: N/A

Flux: N/A

Preheat (°F) N/A

Interpass Temperature (°F) 350 maximum

Postweld Heat Treat: N/A

Thickness: Per Drawing

Backing Strip N/A

Welding: Per Procedure

Additional Requirements:

JOB IDENTIFICATION:

Weld Joint No. J1 & J2

Weld Joint Geometry

Applicable Gen. Weld Proc. ANL-CS-1012
ANL-CS-1007

Number of passes is approximate

Welding Process	GTAW		
Position	1G		
Pass No.	1	Weld Machine	
Filler Metal Diameter	1/32	Hobart 300 Amps.	
Current (Amps)	5/40	Model M-300	
Arc Length (Volts)	14	Top Range 0	
Electrode Polarity	Straight		
Torch Gas (CFH)	Argon 150 CFH		
Purge Gas (CFH)	Argon 5 CFH		
Trailing Shield (CFH)	N/A		
Cup Size	#6 gas lens		
Electrode Ext.	3/8"		
Tungsten Diameter	.040 tapered		
Travel Speed	Manual		
Weld Inspection Requirements:	Per Weld Procedure ANL-CS-5047		
Visual Inspection:	Yes, per Weld Procedure ANL-CS-5047		
Dimensional Inspection:	Yes, per Weld Procedure ANL-CS-5047		
Magnetic Particle Inspection:	N/A		
Radiographic Inspection:	Yes, per Weld Procedure ANL-CS-5047		
Ultrasonic Inspection:	N/A		
Notes: None noted above, except to provide proper fit-up for weld.			
Qualification Procedures:	ANL-CS-5047		

Issued:

By C. T. Szyzko Rev. 0

Date 2-22-74 Rev. 0

ARGONNE NATIONAL LABORATORY
Central Shops Department

MANUFACTURING PROCEDURE

PROCESS - WELDING

CS Job Control Plan No. 2287

Drawing No. T0009-0002-DD-03

Page 8 of 11 Pages

SCHEDULE 2

Job No. 114-11303

Job Name HT-9 Microphone Assembly Welding

Customer A. P. Gavin

Planner A. J. Rogers

Foreman L. Lach

QUALIFICATION PROCEDURES ANL-CS-5047

Base Metal: ASTM A-182, Type 304

Welded To: ASTM A-182, Type 304

ASME Sect. IX P¹ 8 To P¹ 8

Spec. ASTM A-182, Type 304 To ASTM A-177

Welding Matl. ASME BFA-5.9, Type 308

.04 carbon minimum

ASME Sect. IX P¹ 7

ASME Sect. IX A¹ 7

Specification:

Shield Gas: Argon

Purge Gas: Argon

Consumable Insert: N/A

Flux: N/A

Preheat (°F) N/A

Interpass Temperature (°F) 350 maximum

Postweld Heat Treat: N/A

Thickness: Per Drawing

Br ing Strips N/A

Welding: Per procedure

Additional Requirements:

JOB IDENTIFICATION:

Weld Joint No. J3 & J4

Weld Joint Geometry

Applicable Gen. Weld Proc. ANL-CS-1012

ANL-CS-1007

Number of passes is approximate

Welding Process	GTAW		
Position	1G		
Pass No.	1	Weld Machine	
Filler Metal Diameter	1/32	Robart 300 Amps.	
Current (Amps)	20	Model M-300	
Arc Length (Volts)	14	Top Range 4	
Electrode Polarity	Straight		
Torch Gas (CFH)	Argon 15 CFH		
Purge Gas (CFH)	Argon 5 CFH		
Trailing Shield (CFH)	N/A		
Cup Size	No gas lens		
Electrode Ext.	3/8"		
Tungsten Diameter	.080 tapered		
Travel Speed	Manual		
Weld Inspection Requirements:	Per Weld Procedure ANL-CS-5047		
Visual Inspection:	Yes, per Weld Procedure ANL-CS-5047		
Penetrant Inspection:	Yes, per Weld Procedure ANL-CS-5047		
Magnetic Particle Inspection:	N/A		
Radiographic Inspection:	Yes, per Weld Procedure ANL-CS-5047		
Ultrasonic Inspection:	N/A		

Qualification Procedure: ANL-CS-5047

Issued:

By C. T. Szymko Rev.

Date 3-4-75 Rev.

ARGONNE NATIONAL LABORATORY
Central Shops Department

MANUFACTURING PROCEDURE
ANL-CS-5047
PROCESS - WELDING
Schedule 3

CS Job Control Plan No. 2987

Drawing No. T0009-0041-DD-02

Page 9 of 11 Pages

Job No. 114-12246

Job Name Microphone Assembly

Customer A. P. Gavin

Planner A. J. Rogers

Foreman L. S. Lach

QUALIFICATION PROCEDURES ANL-CS-5047

Base Metal: ASTM A-182, Type 304

Welded To: ASTM A-182, Type 304

ASME Sect. IX P# 8 To P# 8

Spec. ASTM A-182, Type 304 to ASTM A-177

Welding Matl. ASME SPA-5.9, Type 308

.04 Carbon Minimum

ASME Sect. IX P# 7

ASME Sect. IX A# 7

Specification:

Shield Gas: Argon

Purge Gas: Argon

Consumable Insert: N/A

Flux: N/A

Preheat (°F) N/A

Interpass Temperature (°F) 350°F Max.

Postweld Heat Treat: N/A

Thickness: per Drawing

Backing Strip Yes No x

Cleaning: per Procedure

Additional Requirements:

Weld Chill Fixture D

Drawing T0009-0086-DB-00 (Fixture)

Drawing T0009-0085-DC-00 (Fixture)

Applicable Gen. Weld Proc. ANL-CS-1012

ANL-CS-1007

JOB IDENTIFICATION:

Weld Joint No. J5 & J6

Weld Joint Geometry 75° Lap - Butt .025"

Number of passes is approximate

Welding Process

GTAW

Position

1G

Pass No.

1

Weld Machine

Filler Metal Diameter

1/32

Hobart 300 Amps.

Current (Amps)

5-10

Model M-300

Arc Length (Volts)

14

Top Range 0

Electrode Polarity

Straight

Torch Gas (CFH)

Argon

15 cfh

Purge Gas (CFH)

Argon

5 cfh

Trailing Shield (CFH)

N/A

Cup Size

#6 Gas Lens

Electrode Ext.

3/8

Tungsten Diameter

.040 Tapered

Travel Speed

Manual

Weld Inspection Requirements:

Weld Procedure ANL-CS-5047

Visual Inspection:

Yes, Weld Procedure ANL-CS-5047

Dye-Penetrant Inspection:

Yes, Weld Procedure ANL-CS-5047

Magnetic Particle Inspection:

N/A

Radiographic Inspection:

Yes, Weld Procedure ANL-CS-5047

Ultrasonic Inspection:

N/A

NOTE: When not specified above, refer to process sheets & drawings for nondestructive tests.

Qualification Procedure: ANL-CS-5047

Job No. 114-11303
 SOP No. 2837
 Drawing No. T0009-0002-DD-03
 Weld Procedure ANL-CS-5047

Job No. 114-12246
JCP No. 2981-1 thru required number
Drawing T0009-0041-DD-02
Weld Procedure ANL-CS-5047
Rev. 1, 3-4-75 *CAF*

ANL HIGH TEMPERATURE MICROPHONE FABRICATION

PROCEDURE NO. 6ATTACHMENT OF BNC CONNECTOR TO METAL SHEATHED CABLEEquipment

1. Die makers files
2. Small gas torch (for silver soldering terminal pin)
3. Resistance meter to measure up to 10^{14} ohms
4. Dissecting needles

Materials

1. Epoxy resin, Varian Associates "Torr Seal"
2. Silver solder and flux

Parts

1. Cable plug (altered) T0009-0030
2. Terminal (altered) T0009-0029
3. Terminal pin T0009-0028
4. Terminal coupling T0009-0031
5. Insulator tube See Parts List

Procedure

1. Trim terminal end of cable sheath to remove all material from previous seals and allow 1/4 in. of lead wire to protrude.
2. Clean burrs from inside of sheath and from end of lead wire.
Scrape wire clean.

3. Remove oxide insulation from inside of cable with a clean dissecting needie to a depth of approximately 5/16 in.
4. Insert ceramic insulator tube into cable sheath and press in firmly.
5. Wash brass terminal pin and end of lead wire with acetone.
6. Insert lead wire into hole in end of brass terminal pin.
7. Apply a small amount of flux and silver solder junction of terminal pin and lead wire. Do not allow flux to contact insulating bead or end of cable sheath.
8. Clean terminal pin and lead wire to remove all flux.
9. Mix a small amount of epoxy sealing compound and fill end of cable to seal insulation, tube, and lead wire. Make sure that epoxy does not protrude beyond O.D. of cable sheath. Allow epoxy to harden before proceeding to next step.
10. Assemble BNC connector to end of cable sheath.
11. Check and record on data sheet resistance between terminal pin and sheath.

ANL HIGH TEMPERATURE MICROPHONE FABRICATION
PROCEDURE NO. I

LOW FREQUENCY CALIBRATION OF MICROPHONES IN WATER

Purpose

The purpose of this procedure is to define a standard method for determining the sensitivity of Sodium Immersible Microphones relative to a secondary standard hydrophone. It is to be used to establish the sensitivity of sodium immersible microphones and to monitor the effects of various exposure tests on them.

Equipment

1. U.S. Navy Underwater Sound Reference Laboratory (USRL) Type G19 acoustic calibrator.
2. Calibrator drive and sensor read out equipment per drawing and description in Figure 1.

Related Documents

1. Instructions for USRL Type G19 calibrator dated February 1966.
2. Data sheet for calibration of acoustic sensors at low frequency in water.

Procedure

1. Check that instrument and calibrator connections are according to diagram (Fig. 1).
2. Check that instrument settings are as indicated in Table 1.
3. Brush inside walls of calibrator tank with stiff bristle brush to assure that no gas bubbles remain and check that water level is 1/2 in. below top of tank.
4. Record serial number of reference hydrophone and mount so that tip is $5\frac{1}{2} \pm \frac{1}{8}$ in. below top edge of tank and in the center of the tank. Connect transducer cable to pC/bar input connector on relay rack.

5. Set oscillator frequency to 300 hz and adjust drive voltage to 0.50 V RMS on drive voltmeter.
6. Select signal amplifier range to give a reading of between 1 and 10 volts on output meter. Record setting on data sheet.
7. Record output meter reading at these settings.
8. Change oscillator frequency to 400 hz and adjust drive voltage to 0.50 RMS. Record output meter reading on data sheet.
9. Repeat step 8 for 450, 500, and 550 hz settings.
10. Determine hydrophone sensitivity by adding five readings and multiplying by 200 X full scale pC setting of signal amplifier as indicated on data sheet. If sensitivity varies more than 5% from hydrophone calibration value recheck all instrument settings, hydrophone location in calibrator tank, and water level, and be sure that no bubbles exist on side walls or on hydrophone. Recheck reference hydrophone sensitivity per steps 5 through 9 above. Do not proceed until sensitivity determined for reference hydrophone agrees within $\pm 5\%$ of calibration. (For reference hydrophone LC 10 serial #1596 calibration is 35,600 pC/bar, allowable range is 33,800 to 37,400 pC/bar.)
11. Disconnect reference hydrophone and remove from calibrator tank.
12. Mount microphone to be calibrated in approximate center of tank with center of diaphragm $5\frac{1}{2} \pm \frac{1}{8}$ in. below top of tank. Connect signal lead to pC/bar input connector on relay rack.
13. Proceed with calibration as in steps 5 through 9.
14. As indicated on data sheet, add five readings for each sensor and multiply by 200 X full scale pC setting on signal amplifier. Result is sensitivity of sensor in pC/bar.
15. Remove microphone from calibrator and replace calibrator cover.

DATA SHEET

FOR

LOW FREQUENCY CALIBRATION OF HIGH TEMPERATURE MICROPHONES IN WATER*

Date _____

	Type	Serial No.	Comments
Reference Hydrophone			
Sensor #1			
Sensor #2			

	Reference Hydrophone	Sensor #1	Sensor #2
Signal Amplifier (A) Full Scale Setting, pC			

Frequency Hz	SIGNAL AMPLIFIER OUTPUT VOLTS		
300			
400			
450			
500			
550			
Sum of 5 Readings			
Sum X 200 X (A) = Sensitivity in pC/bar			

Calibrated by: _____

*To be used with instructions provided in construction procedure #9, "Low Frequency Calibration of Sodium Immersible Microphones in Water".

TABLE I

Instrument Settings for Acoustic Sensor Calibration

Endevco 2730 - Charge Amplifier

<u>Control</u>	<u>Position</u>
Function	Operate
Ground	Grounded
Convertor	Internal
Filter	Out
Sensitivity Range	1-10 pC/g
Variable Sensitivity dial	5.00
Full Scale Range	As required

Oscillator

<u>Control</u>	<u>Position</u>
Frequency Range	X100
Power	on
Load	on
Frequency dial	As per procedure
Amplitude	As per procedure

Calibrator Drive Amplifier

<u>Control</u>	<u>Position</u>
Power	on

APPENDIX 4
JOB CONTROL PLAN

ANL CENTRAL SHOPS
LIST OF FABRICATION DOCUMENTS

Page 1 of 1

Job No. <u>114-12246</u>					
Job Name <u>HT-10 Mic. Assembly Welding</u>					
Job Control Plan No. <u>2981-1</u> Date <u>12-9-74</u>					
Rev. <u>0</u> Date _____					
DOCUMENT					
No.	Name	Rev.			
<u>SERVICE REQUEST</u>					
E-4744	HT-10 Microphone Assembly Welding	0			
<u>DRAWINGS</u>					
T0009-0004-DB (REF.)	Diaphragm	07			
T0009-0009-DB (REF.)	Body Ring	04			
T0009-0010-DB (REF.)	Cable Coupling	02			
T0009-0011-DB (REF.)	Clip	01			
T0009-0027-DB (REF.)	Tube Coupling	00			
0009-0041-PL (REF.)	Parts List	01			
T0009-0041-DD	Microphone Assembly	02			
T0009-0086-DB (REF.)	Chill Blocks	01			
<u>JOB CONTROL PLAN & ATTACHMENTS</u>					
2981-1	HT-10 Mic. Assembly Welding	0			
CS-89	Certificate of Welding Compliance	0			

*Copies to be furnished to customer by QC.

CS-83 (8-74)

ANL CENTRAL SHOPS JOB CONTR PLAN

Page 1 of 7

Job No. <u>114-12246</u>	Plan No. <u>2981-1</u> Date <u>12-9-74</u>	Drwg. No. <u>T0009-0041-DD</u> Pg. <u> </u> of <u> </u>
Job Name <u>HT-10 Mic. Assembly Welding</u>	Rev. <u>0</u> Date <u> </u>	Part Name <u>Microphone Assembly</u>
Mfg. Eng. <u>A. J. Rogers</u>	QC Rep. <u>F. Simon</u>	Item <u>11 and 12</u> Qty <u>1</u>

Sequence		M - Manufacturing Operation	M-Released By: Name & Date	For QA Use Only				
M	QC	QC - Control Requirement	QC-Document Required	Resp.	Freq.	Acc.	NC	Rej.
1		Obtain customer furnished material (Items 11 and 12) per Parts List. (Reference #1)		F				
2		Verify cleanliness. Joint area to be cleaned with ethyl alcohol just prior to welding. Polyethylene wrap ends between sequences.		F				
3		Identify qualified welder for weld J1 per Weld Procedure ANL-CS-5047.	CS-89	WF				
4		Weld J1.						
	5	Radiograph J1 per NDT-500, Rev. 0	Q-740 Q-742	QAD	100%			
	6	Helium leak test per NDT-700, Rev. 0, and Drawing Note 1.	Q-780 V-File # <u> </u>	I	100%			
		(continued on next page)						

REFERENCE:

Ref. #1 - Coaxial cable will be received in polyethylene bags containing dry silica jell to minimize moisture absorption. During processing, return parts into bags when not in use. This plan and its required documentation shall reflect the S/N's assigned by the customer.

Responsibility Key:

I - Inspector	WE - Weld Eng.
IF - Insp. Foreman	WF - Weld Foreman
F - Fab. Foreman	Q - QC Rep.
ME - Mfg. Eng.	C - Customer

Drwg. No. T0009-0041-DD Pg. of

Part Name	Microphone Assembly
-----------	---------------------

Item	11 and 12	Qty	1
------	-----------	-----	---

REFERENCE:

Responsibility Key:

I - Inspector	WE - Weld Eng.
IF - Insp. Foreman	WF - Weld Foreman
F - Fab. Foreman	Q - QC Rep.
ME - Mfg. Eng.	C - Customer

ANL CENTRAL SHOPS JOB CONTROL LAN

Page 3 7

Job No. <u>114-12246</u>	Plan No. <u>2981-1</u> Date <u>12-9-74</u>	Drwg. No. <u>T0009-0041-DD</u> Pg. <u> </u> of <u> </u>
Job Name <u>HT-10 Mic. Assembly Welding</u>	Rev. <u>0</u> Date <u> </u>	Part Name <u>Microphone Assembly</u>
Mfg. Eng. <u>A. J. Rogers</u>	QC Rep. <u>F. Simon</u>	Item <u>7 and 8</u> Qty <u>1</u>

Sequence		M - Manufacturing Operation QC - Control Requirement	M-Released By: Name & Date QC-Document Required	For QA Use Only				
M	QC			Resp.	Freq.	Acc.	NC	Rej.
1		Obtain customer furnished material (Items 7 and 3) per Parts List. (Reference #1)		F				
2		Verify cleanliness. Joint area to be cleaned with ethyl alcohol just prior to welding. Polyethylene bag ends between sequences.		F				
3		Identify qualified welder for weld J2 per Weld Procedure ANL-CS-5047.	CS-89	WF				
4		Weld J2.						
	5	Radiograph J2 per NDT-500, Rev. 0	Q-740 Q-742	QAD	100%			
	6	Helium leak test per NDT-700, Rev. 0, and Drawing Note 1.	Q-780 V-File # <u> </u>	I	100%			
		(continued on next page)						

REFERENCE:

Ref. #1 - Coaxial cable will be received in polyethylene bags containing dry silica jell to minimize moisture absorption. During processing, return parts into bags when not in use. This plan and its required documentation shall reflect the S/N's assigned by the customer.

Responsibility Key:

I - Inspector	WE - Weld Eng.
IF - Insp. Foreman	WF - Weld Foreman
F - Fab. Foreman	Q - QC Rep.
ME - Mfg. Eng.	C - Customer

Page 4 of 7

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Responsibility Key:

I - Inspector	WE - Weld Eng.
IF - Insp. Foreman	WF - Weld Foreman
F - Fab. Foreman	Q - QC Rep.
ME - Mfg. Eng.	C - Customer

ANL CENTRAL SHOPS JOB CONT PLAN

Page 5 of 7

Job No. <u>114-12246</u>	Plan No. <u>2981-1</u> Date <u>12-9-74</u>	Drvg. No. <u>T0009-0041-DD</u> Pg. <u> </u> of <u> </u>
Job Name <u>UT-10 Mic. Assembly Welding</u>	Rev. <u>0</u> Date <u> </u>	Part Name <u>Microphone Assembly</u>
Mfg. Eng. <u>A. J. Rogers</u>	QC Rep. <u>F. Simon</u>	Item <u> </u> Noted <u> </u> Qty <u>1</u>

Sequence		M - Manufacturing Operation QC - Control Requirement	M-Released By: Name & Date QC-Document Required	For QA Use Only				
M	QC			Resp.	Freq.	Acc.	NC	Rej.
1		Obtain completed parts from Pages 1 thru 4 of this Job Control Plan and Items 1 and 6 per Parts List.		F				
2		Verify cleanliness. Joint area to be cleaned with ethyl alcohol just prior to welding. Polyethylene wrap ends between sequences.		F				
3		Identify qualified welder for weld J4 per Weld Procedure ANL-CS-5047.	CS-89	WF				
4		Tack weld J4.						
5		Customer is to install Items 4 and 9.		C				
6		Identify qualified welder for weld J6 per Weld Procedure ANL-CS-5047.	CS-89	WF				
7		Insert Item 1 and weld J6.						
		(continued on next page)						

REFERENCE:

Ref. #1 - Coaxial cable will be received in polyethylene bags containing dry silica jell to minimize moisture absorption. During processing, return parts into bags when not in use. This plan and its required documentation shall reflect the S/N's assigned by the customer.

Responsibility Key:

I - Inspector	WE - Weld Eng.
IF - Insp. Foreman	WF - Weld Foreman
F - Fab. Foreman	Q - QC Rep.
ME - Mfg. Eng.	C - Customer

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Job No. 114-12246	Plan No. 2981-1	Date 12-9-74	Drvg. No. T0009-0041-DD	Pg. of
Job Name HT-10 Mic. Assembly Welding	Rev. 0	Date	Part Name Microphone Assembly	
Mfg. Eng. A. J. Rogers	QC Rep. F. Simon		Item	Noted Qty 1

Sequence		M - Manufacturing Operation	M-Released By: Name & Date	For QA Use Only				
M	QC	QC - Control Requirement	QC-Documents Required	Resp.	Freq.	Acc.	NC	Rej.
8		Customer shall complete loading of sensor and return to Central Shops to complete closure testing.		C				
9		Identify qualified welder for welds J3, J4 and J5 per Weld Procedure ANL-CS-5047.	CS-89	WF				
10		When sensor assembly is returned, weld J5. Proceed with completion of welds J3 and J4 per the weld procedure.						
11		Radiograph J3, J4, J5 and J6 per NDT-500, Rev. 0	Q-740 Q-742	Q. D	100%			
12		Helium leak test per NDT-700, Rev. 0, and Drawing Note 1.	Q-780 V-File #	I	100%			
13		Dye-penetrant test J3, J4, J5 and J6 per NDT-300, Rev. 0	Q-745 D-File #	I	100%			

REFERENCE:

Ref. #1 - Coaxial cable will be received in polyethylene bags containing dry silica jell to minimize moisture absorption. During processing, return parts into bags when not in use. This plan and its required documentation shall reflect the S/N's assigned by the customer.

Responsibility Key:

I - Inspector	WE - Weld Eng.
IF - Insp. Foreman	WF - Weld Foreman
F - Fab. Foreman	Q - QC Rep.
ME - Mfg. Eng.	C - Customer

ANL CENTRAL SHOPS JOB CONTR PLAN

Page 7 of 7

Job No. <u>114-12246</u>	Plan No. <u>2981-1</u> Date <u>12-9-74</u>	Drwg. No. <u>-</u> Pg. <u>of</u>
Job Name <u>HT-10 Mic. Assembly Welding</u>	Rev. <u>0</u> Date <u></u>	Part Name <u>-</u>
Mfg. Eng. <u>A. J. Rogers</u>	QC Rep. <u>F. Simon</u>	Item <u></u> Qty <u>-</u>

Sequence		M - Manufacturing Operation QC - Control Requirement	M-Released By: Name & Date QC-Document Required	For QA Use Only				
M	QC			Resp.	Freq.	Acc.	NC	Rej.
	1	Verify welder qualification and documentation.	CS-89	I	100%			
	2	Verify plan documentation/certificate of conformance.	Q-886/Q-881	I	100%			
		APPROVAL FOR SHIPMENT _____ Inspection Foreman	DATE _____					

Responsibility Key:

I - Inspector	WE - Weld Eng.
IF - Insp. Foreman	WF - Weld Foreman
F - Fab. Foreman	Q - QC Rep.
ME - Mfg. Eng.	C - Customer

ARGONNE NATIONAL LABORATORY
Central Shops
CERTIFICATE OF WELDING COMPLIANCE
Page 1 of 1

4-10

Job Name HT-10 Mic. Assembly Welding

Job No. 114-12246 JCP No. 2981-1 Rev. 0 Date 12-9-74

Drawing No.	Joint No.	Procedure Specification	Welded By	Date
T0009-0041-DD	J1	ANL-CS-5047		
↑	J2	↑		
	Tack Weld			
	J4			
	J6			
	J5			
	J3			
↓	J4	↓		

This is to certify that Central Shops welders and/or welding procedures utilized on this job have been qualified in compliance and accordance with:

Specification _____
(Number and Name)

Specification _____
(Number and Name)

All required documents, including procedures, test records, specimens, sections and radiographs, are available for review upon request to Central Shops.

(Date)

By _____
(For Central Shops)