HIGH TEMPERATURE
(2000°F AND UP)
THERMOCOUPLES

PRODUCT INFORMATION
REPORT No. 8.1
(REVISION A)

Aero Research
INSTRUMENT DEPARTMENT

AMERICAN-Standard

ARi

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Aero Research
INSTRUMENT COMPANY, INC.

PRODUCT INFORMATION REPORT NO. 8.1

INTRODUCTION

With the advent of high temperature applications for solid, liquid and gaseous processes, it has become necessary to measure and/or control these elevated temperature processes. With the advance of materials research, thermocouples can now be used in many applications which heretofore have not been amenable to accurate or convenient temperature measurement. Some specific applications are:

a. Industrial	- Measure molten glass temperatures - Control high speed batch processes - Measurement and control of ultra-high temperature furnaces
b. Missile & Aircraft	- Measure temperature of rocket exhausts and other gas generators such as afterburners - Measurement of nose cones entering atmosphere - Measurement of nozzle surface temperatures
c. Nuclear	- Measure coolant gas and fuel pin temperatures. (Materials can be chosen for low neutron capture cross section).
d. Laboratory	- Measure and control temperature of pilot-process prototypes of full-scale processes - Measure and control temperatures of crystal growing ovens

Other applications, as well as suggested methods of attachment, are given at the end of this report. The data presented herein is conservative. It is the belief of ARi that the conservative approach must be taken until more complete data on high temperature materials becomes available.

Aero Research has developed a line of standard application thermocouples using many new materials specifically applicable for high temperature thermocouples. These are presented herein along with a group of special application high temperature thermocouples, some of which are water cooled.

STANDARD APPLICATION THERMOCOUPLES

BASIC MATERIALS

All standard application thermocouples are comprised of four basic components. Sheath, insulators, thermo-elements and connectors or terminations. It is not the purpose of this report to present a technical dissertation on these components, as this has been treated by this company in a paper at the SAE meeting in April 1960. (Reprints of this paper are available from ARi upon request - Form 158B). Materials for use in these thermocouples are:

a. Thermo-elements	- Platinum, pure and alloyed with Rhodium - Iridium, pure and alloyed with Rhodium - Tungsten, pure and alloyed with Rhenium
b. Insulators	- Magnesia (MgO) - Beryllia (BeO)
c. Sheath Materials	- Platinum Rhodium Alloy - Tantalum - Molybdenum - Molybdenum with CR coating for oxidation resistance
d. Terminations	- Quick disconnect, ARi Type B - Ceramic, ARi Type F - Industrial, ARi Types H & G - Transition, with compensating material lead wire - Transition with thermocouple material lead wire

Items a, b and c are limited by the elevated temperature atomosphere to which they may be subjected, i.e., some are suitable for use in oxidizing and some are usable in reducing atmospheres. Most of these materials may be used in inert or vacuum conditions.

In Table I are listed the standard combinations of sheath, wire and insulator which, when combined, will permit temperature measurement to that indicated in the noted atmospheres. Symbols are listed to denote different materials. Styles of standard application thermocouples are discussed in the following pages.

Some high temperature sheath materials are sufficiently ductile to lend themselves to swaging or drawing processes. Such is the case with platinum and tantalum. With these materials, the sheath can be swaged or drawn upon crushable ceramic insulators containing the thermo-elements which, even though they may not be very ductile, are not affected by such processing. High temperature thermocouples made in this manner (AerOpak compacted ceramic construction) can be bent to desired configuration and welded or silver-soldered in place. Platinum sheathed thermocouples can be bent on a mandrel of approximately five times the diameter of sheath. Tantalum sheathed thermocouples can be bent on a mandrel of about ten times the sheath diameter, providing the sheath has been thoroughly and properly annealed in the region of the bend. Molybdenum sheathed thermocouples cannot be readily bent.

TABLE I

MATERIALS & APPLICATION DATA

Sheath	Sheath Symbol	Insulation [2]	Thermocouple [3]	Diameters "D" in inches & Symbols	Length, "L" inches	Permiss. Atmos. [4]	Maximum Temp. °F (Note 2)
Platinum-Rhodium Alloy [1]	(AA)	M	S	.040 A	Up to 80	O, I	2900
		M	R	.063 B		O, I	2900
				.125 D			
Molybdenum with CR Coating	(OCR)	M	V	.125 D	5 & 17*	O, R, I, V	3000
Molybdenum	(O)	M	S		Up to 30	I, V, R	2900
		M	R	.063 B		I, V, R	2900
		M	V	.125 D		I, V, R	3500
		M	AA	.250 F		I, V, R	3700
		B	AA			I, V, R	4000
Tantalum [1]	(N)	M	S		Up to 84	I, V	2900
		M	R	.040 A		I, V	2900
		M	V	.063 B		I, V	3500
		M	AA	.125 D		I, V	3700
		B	AA			I, V	4000

*T-14 lengths are 6" and 18".

SUPERSCRIPTS

1. Can be readily bent.
2. Insulation Symbols:
   M - MgO - Magnesia
   B - BeO - Beryllia
3. Thermocouple Symbols:
   V - Iridium-60% Rhodium/Iridium
   R - Platinum-13% Rhodium/Platinum
   S - Platinum-10% Rhodium/Platinum
   AA - Tungsten/Tungsten-26% Rhenium
4. Atmosphere Symbols:
   O - Oxidizing (more than 0.5% free oxygen)
   I - Inert (Helium, Argon, Neon, etc.)
   V - Vacuum (less than 10^{-4} in. Hg abs.)
   R - Reducing (less than 0.5% O_2)

NOTES

1. The specific combinations of materials shown above are ARi recommended for atmosphere and maximum temperature usage and are standard for the thermocouples presented herein.
2. Although a maximum temperature is noted, these materials or other combinations of material (available on special order) may be used at higher temperatures for short duration or "one shot" applications. Consult an ARi Sales Engineer about your specific problem.

THERMO-ELEMENTS

The thermo-element combinations noted in Table I are receiving considerable attention in the search for materials for high temperature measurement. Notable in this is Tungsten/Tungsten 26% Rhenium, but its usage is restricted to either vacuum or reducing and inert atmospheres. However, it has been found that Tungsten/Tungsten 26% Rhenium can be used in oxidizing atmospheres for short, intermittent periods of time, utilizing to good advantage the finite time required for oxidation of these elements. Platinum-Rhodium/Platinum can be used continuously in oxidizing atmospheres to temperatures slightly greater than 2900°F Above this temperature, Iridium-Rhodium/Iridium is recommended.

INSULATORS

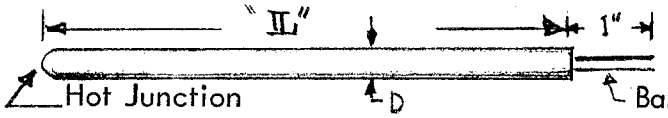
The function of the insulator is to provide electrical isolation between the wires and the sheath and between the wires themselves. Yet, the insulator should be a good thermal conductor. The two insulators recommended are chosen for their respective dielectric and thermal conductivity characteristics. Magnesia is a better insulator than alumina at the higher temperatures and possesses a high thermal conductivity, permitting its usage to temperatures of 3700°F. Beryllia exhibits approximately the same electrical properties as Magnesia and has an extremely high coefficient of thermal conductivity. Beryllia is recommended for usage not exceeding 4000°F, as above that temperature toxic gases are generated. Thoria is generally used above the toxic range of Beryllia and has the highest resistivity of available insulation materials at 4500°F.

SHEATHS AND OXIDATION-RESISTANT COATING

All the sheath materials listed above are generally known with, perhaps, the exception of Molybdenum with CR coating. ARi has participated in the development of this new coating, which is applied by gas plating to the molybdenum. This coating is required on Molybdenum when used in an oxidizing atmosphere, as molybdenum oxidizes extremely fast at elevated temperatures. Hence the strength of Molybdenum can be put to useful purposes in oxidizing atmospheres by using CR coating over Molybdenum. This coating has the advantage of being extremely hard and will withstand thermal shock and most mechanical shocks. It will not peel or spall due to the diffusion of the coating material into the parent molybdenum. It is also chemically inert and will withstand almost all environments at high temperatures.

THERMOCOUPLE CONFIGURATIONS

With extensive experience in the high temperature measurement field, ARi is now in position to offer a line of standard application high temperature sensors. The designs shown are those which have seen application in specific industries. Basically, the design of these thermocouples is similar to those of ARi Catalog 3.8.A, the alternate being for high temperature service. At the back of this brochure are engineering drawings showing the pertinent details of construction. Methods of formulating a specific part number for a thermocouple that will satisfy your requirements are shown in "How to Order", Page 9.



BASIC THERMOCOUPLES

The basic thermocouple element is the T-14 style shown above. This sensor is furnished with bared thermocouple wires at the termination (cold end) of the thermocouple, and is available in all the sheath, insulator and thermo-element combinations shown in Table I. The closed end (hot junction) of the thermocouple is welded shut permitting temperature sensing in both high pressure or vacuum media. The thermo-element is electrically grounded to sheath for fast time response. This thermocouple is sold without any formal termination for those wishing to connect to their own extension leads.

THERMOCOUPLES WITH ADJUSTABLE ADAPTOR FOR INSTALLATION (T-Series)

Variations of the basic thermocouple are shown that are accomplished by different connectors and terminations. One set of thermocouples is presented that require an adjustable adaptor to permit installation into the high temperature region. These are used where the depth of immersion is not too readily known or can vary.

THERMOCOUPLE WITH PERMANENT ADAPTORS (TX-SERIES)

These are similar to the above, except that the adaptor position is fixed. This type of adaptor permits the use of small diameter sheaths and still provides a rugged thermocouple protruding from the vessel.

THERMOCOUPLE CALIBRATION

Most of the thermo-elements discussed above are not covered by applicable ISA or NBS calibration data. The exception is, of course, Platinum/Rhodium-Platinum (Calibration R or S). ARi supplies calibration information on the wire used in each probe for all element combinations other than Calibration R or S. Figure 1 shows comparative calibrations (Page 6).

TIME RESPONSE CHARACTERISTICS

The time required for a thermocouple to respond to a sudden change in environment temperature is characterized by a comparison value called "Time Constant." It is the time required for a thermocouple to reach 63.2% of the step change in gas temperature at a given media mass velocity, and is proportional to the mass of the thermocouple and the mass velocity of the media. Typical values are shown below for grounded junction (as per the design of the thermocouples herein) at a mass velocity (G_o) of 6 lb/sec-ft.^{2} in a gaseous media.

Diameter D, inches	.04	1/16	1/8	1/4
Time Constant, τ_o sec.	2.5	5.0	14.0	39.0

For other values of mass velocity, the time constant is computed from $\tau = \tau_o(2.4/\sqrt{G})$ where τ_o is the time constant from the table above, and G is the new mass velocity in lb/sec-ft.^{2}.

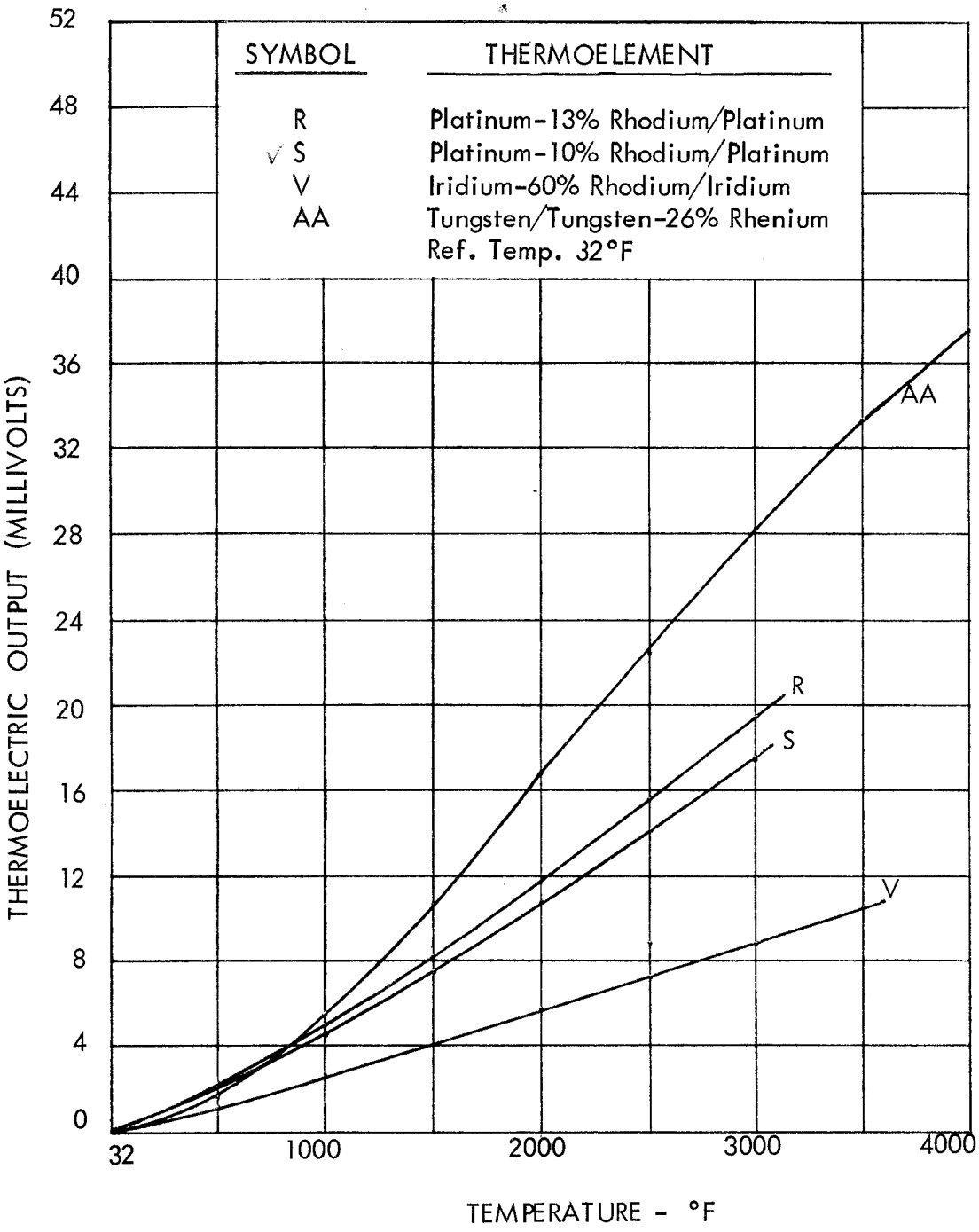


Figure 1 - THERMOELECTRIC OUTPUT OF ELEMENTS NOTED IN THIS REPORT

LEAD WIRE

Lead wires have been developed for the newer high temperature thermocouple elements. Specific compensating wire is available for Iridium/Iridium Rhodium, Tungsten/Tungsten 26% Rhenium and the ISA designated SX wire for Platinum Rhodium/Platinum combinations.

Compensating insulated lead wire is available from ARi and may be ordered as follows:

Thermocouple Calibration	ARi Lead Wire Designation	Wire Gauge	Thermocouple Calibration	ARi Lead Wire Designation	Wire Gauge
R	SX	20	AA	AAL	24
S	SX	20	V	VL	24

Thermocouple Style T-107, Page 13, uses a transition termination with lead wire of the compensating type. For this thermocouple, the junction temperature at the transition between the thermocouple and the lead wire should be kept below 450°F to avoid introducing thermocouple error. For applications where higher transition temperatures will be experienced, lead wires of the same composition as the thermo-elements can be supplied using flexible insulated, solid wire. Thermocouples of this design are stocked as Style T-106. The thermocouple to lead wire transition temperature in this case may be safely operated up to 800°F with negligible error. Metal sheathed, ceramic insulated AerOpak (Catalog 4) is available on special order for applications where either conditions or service require a higher temperature insulation over the wires. In this case the conductors should be of the same material as the thermocouple wire. If compensating wire is used, the maximum temperature is 450°F. Using thermocouple wire the maximum temperature is limited by the sheath material. The AerOpak would replace the flexible insulated lead wires shown on the catalog items.

CONNECTORS

A series of connectors is presented that have distinct advantages for the many possible applications. Details of the connectors are shown on Page 12.

TYPE B CONNECTOR

This connector has contacts made of compensating metals for Calibration S and R. For AA and V, the contact material is copper. It is a quick disconnect with the mating connector supplied as an extra.

TYPE F CONNECTOR

This is an ARi patented connector capable of operating to 1000°F. It has the distinct feature of permitting direct contact between lead wire and thermocouple wire and thus eliminating third metal problems. This connector is usable with any thermocouple material.

TYPE G CONNECTOR

This is a new lightweight connector suitable for industrial use. The cap is weatherproof and could be made waterproof. This connector is usable with any thermocouple material. It is made of aluminum with rubber seals.

TYPE H CONNECTOR

This is also a new lightweight connector, very similar to the conventional thermocouple heads commonly used. It is made of aluminum with a ceramic insert that is firmly attached to the housing. The 1/2 inch IPT exit is suitable for conduit or cable attachment. The lock cap is gasketed, making the unit water tight. This connector is usable with any thermocouple material.

SPECIAL APPLICATION THERMOCOUPLES

In addition to the "standard application" line of thermocouples presented herein, ARi has developed additional thermocouple sensors for high temperature application. These are described as follows:

STYLE T-110
Developed for usage in applications where walls are thick and to reduce the over all cost of the part that does not require high temperature material. Available in all sheath materials and wire calibrations as per Table I.

STYLE T-1058M
A high temperature modification of the basic T-1058 thermocouple described in ARi PIR 3.13. It is used in moving gas streams with negligible corrections for radiation, conduction and recovery factor errors. Available in sheath and wire materials as per the drawing for T-1058M.

STYLE T-1006
This is a high temperature adaptation of the aspirating thermocouple described in ARi PIR 3.13 with the same performance characteristics. It is available in a non-cooled (T-1006-2 and T-1006-11) support shaft and a water cooled (T-1006-6 and T-1006-9) support shaft. Performance characteristics depicted in ARi PIR 3.13 can be used for determining the accuracy. These thermocouples are used where very high accuracy in measuring gas temperature is required. The accuracy of these thermocouples is better than that of the T-1058M, but their installation is somewhat more complex.

STYLE T-1105
This is an unique development of a thermocouple sensor to measure very high gas temperature. It has a water cooled shaft permitting the use of less expensive materials. It is the only known thermocouple to operate at 4000°F in an oxidizing atmosphere.

The designs shown in this brochure have been standardized by ARi so that reliable thermocouples can be offered at both price and delivery normally associated with large quantity production. Deviations and/or modifications to these standards may be accomplished but it should be understood that, due to special handling, additional design engineering and small lot material procurement, both the price and delivery advantage may be sacrificed.

INSTALLATION INSTRUCTIONS

FITTINGS
Installation of these thermocouples is very readily accomplished through the use of adjustable adaptors (compression fittings Cat. No. PTM) or through the permanently attached fitting of the TX Series. These adaptors are available in either stainless steel or brass, depending upon temperature or environmental conditions. The adjustable adaptor is more fully described in ARi Catalog 3.8.A, Page 3.8.3.

ACCURACY
The thermo-element wire supplied by ARi is accurate to the following:

a. Cal. R or S - Standard ISA tolerances
   ±5°F from 0 to 1000°F
   ±1/2% from 1000° to 2700°F

b. Cal. V - +40°F to 3600°F

c. Cal. AA - ±30°F to 3200°F
   ±1% to 4200°F

Corrections for radiation and conduction cannot be given due to the multiplicity of factors affecting these corrections. Please refer to NASA TN 2599, Experimental Determination of Time Constants and Nusselt Numbers for Bare-Wire Thermocouples in High-Velocity Air Streams and Analytic Approximation of Conduction and Radiation Errors, by Marvin D. Scadron and Isidore Warshawsky. Corrections associated with conduction in a liquid or solid require their own analysis and as such you are invited to contact ARi for assistance.

HOW TO ORDER

The basic premise in ordering is that the maximum operating temperature as well as the environment be known. Thus:

1. Refer to Table 1: Knowing the atmosphere and maximum temperature, the proper combination of sheath, insulator and thermo-elements can be determined.
2. Establish Length and Diameter for your Installation: Add 2 inches to the thermocouple length if adjustable adaptor, Cat. No. PTM is required. The diameter is determined by the static or dynamic conditions imposed upon the sensor in the media of measurement. If you have a problem concerning this, consult ARi.
3. Refer to the Drawings of Thermocouple Configurations: At the back of this report, you will find the style of thermocouple required to fit your application.
4. Catalog Number: Having selected the materials from Table I in the style of thermocouple you need, complete the catalog number as follows:

STYLE	Insul. Symbol	-	Length L	Dia. D	Wire Cal.	Junct. 8	Sheath Matl.

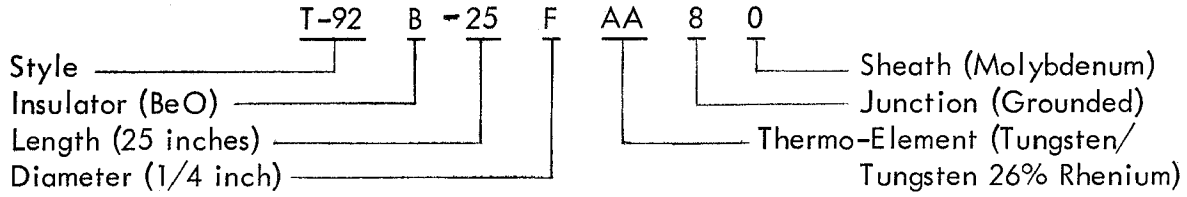
EXAMPLE

Requirement: To measure the temperature in a vessel wherein the maximum temperature is 3800°F, the atmosphere is inert, the insertion depth must be 12 inches through an 8-inch wall. The ambient temperature is 150°F at the termination. The diameter must be 1/4 inch.

1. Refer to Table 1. All the materials shown can be used in an inert atmosphere, but not to this temperature. For temperature of 3800°F, the following holds true:
   a. The thermo-element which can be used is AA.
   b. The only insulator which can be used is BeO.
   c. The only sheath materials which can be used are molybdenum or tantalum.
2. The length of the thermocouple should be:

a. Insertion depth	12 inches
b. Wall Thickness	8 inches
c. Adjustable Adaptor	2 inches
d. Working Space between Adaptor and Type F Head (assumed)	3 inches
Total	25 inches

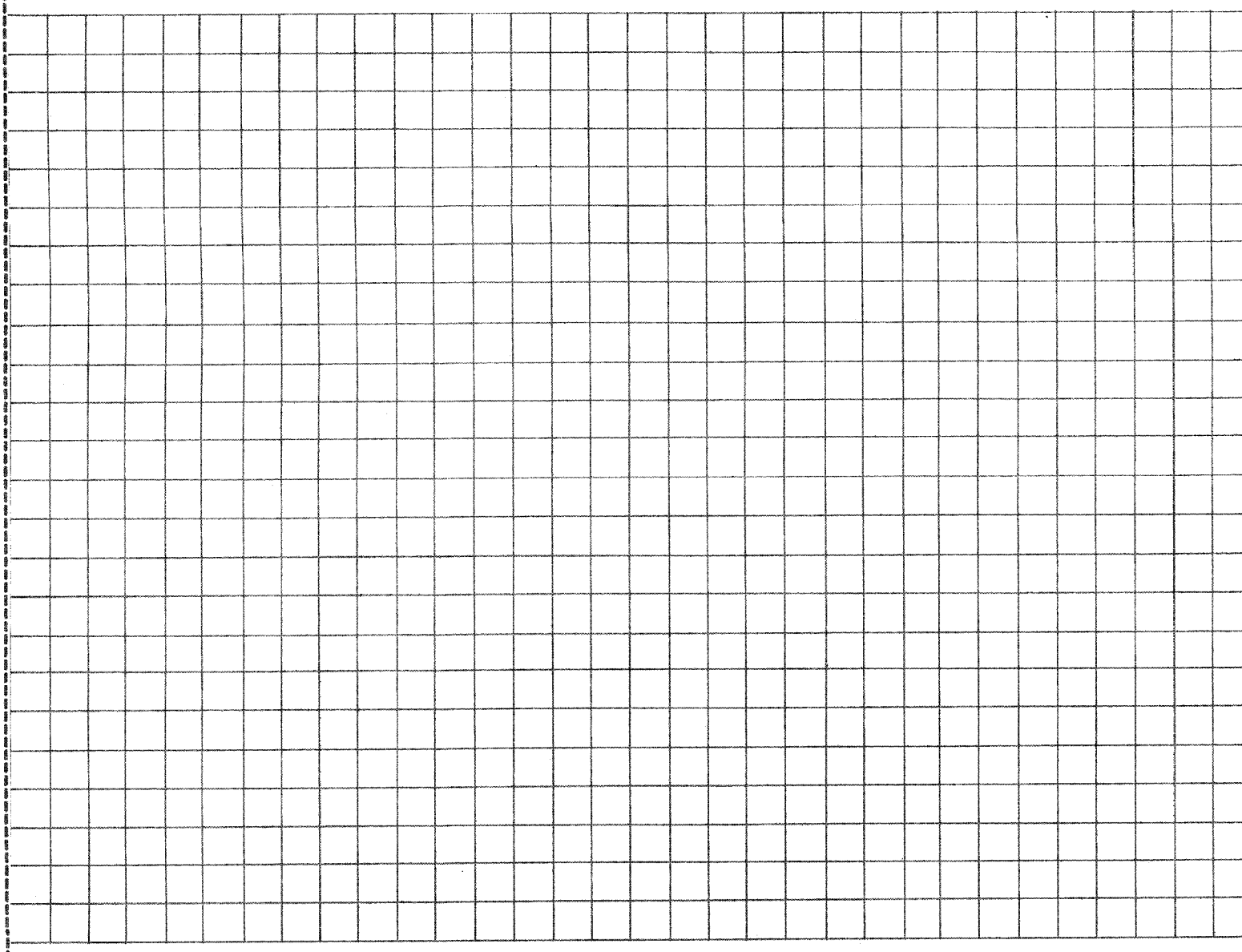
   The diameter previously required was 1/4 inch.
3. Refer to Thermocouple Configuration Drawings: Since the ambient temperature is only 150°F and a rugged termination is needed, Type F head is decided upon. Hence a Style T-92 thermocouple is chosen.
4. Complete the Catalog Number: Since the required 1/4 inch diameter thermocouple is readily available in molybdenum only, this sheath is decided upon. Calibration AA thermo-elements are used. Thus, the catalog Style is T-92B-(L) (Dia.)AA80.



HIGH TEMPERATURE THERMOCOUPLE APPLICATION DATA SHEET

1. Application (please sketch below)
2. Temperature at Termination _____ °F
3. Maximum Temperature _____ °F
4. Adjustable Adaptor
   Yes ☐ No ☐
5. Gas Velocity _____
6. Maximum Pressure _____ psia
7. Probe Length _____ inches
8. Atmosphere _____
9. Sheath Diameter _____ inches
10. Anticipated Qty. next 6 mos. _____
11. Quantity to be Ordered _____

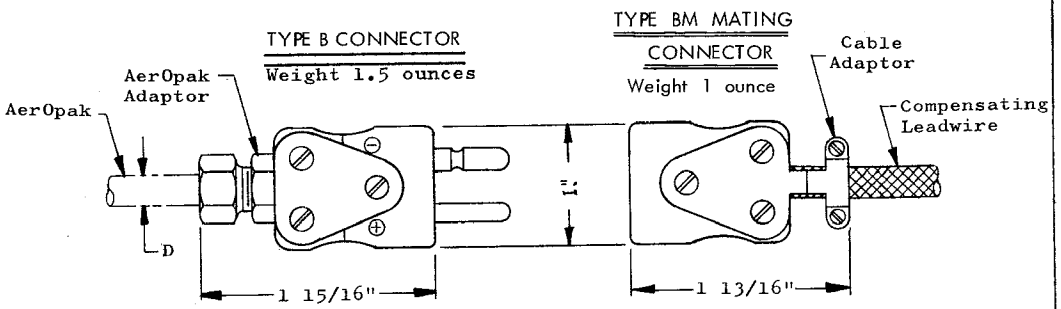
(S k e t c h)



Print your name and address on reverse side - Fold on dotted lines and staple if used as a postage Free mailer.

TYPE B CONNECTOR

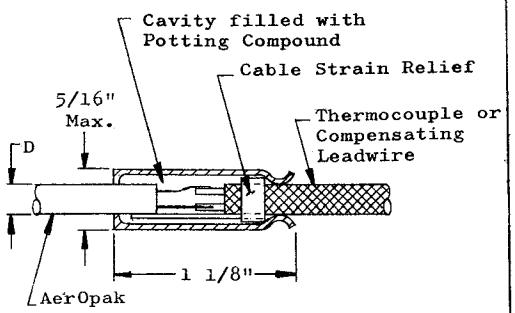
Weight 1.5 ounces



Used on T-91, TX-91 and T-1058M Styles
For operation to 500°F max. Available with thermocouple material for calibration S and R. Use copper contacts for calibration AA and V. When ordering separately, specify by catalog number, specify "D" (1/16", 1/8", 1/4") and specify if AerOpak or cable adaptor should be supplied.

Calibration	AerOpak Connector	Cable Connector
S	BS	BMS
R	BS	BMS
AA	BCU	BMCU
V	BCU	BMCU

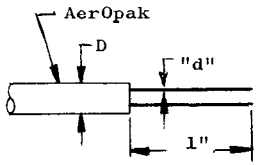
TYPE 5004 TERMINATION



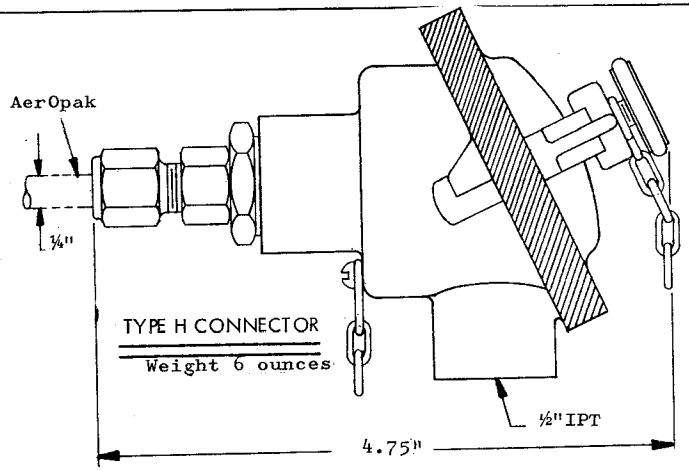
Used on T-106 & T-107 Styles
For operation to 500°F. A transition from AerOpak to more flexible insulated wire. Not sold separately.

BARE WIRE

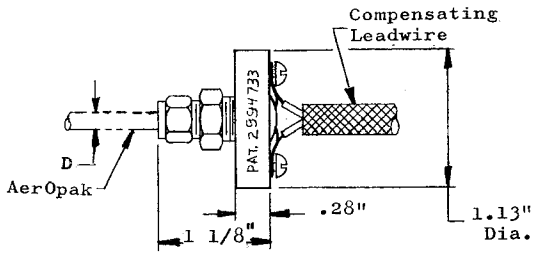
Used For T-14 Style



Basic termination upon which all connectors and lead wires are attached. Wire diameter "d" is same as wire diameter in sheath.



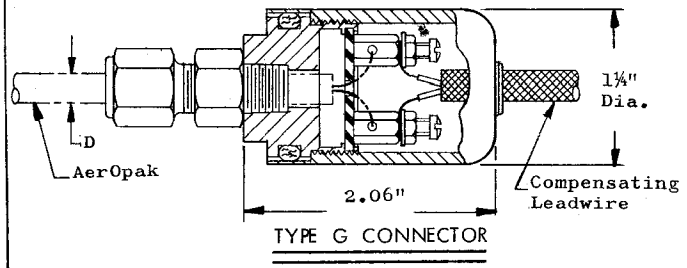
For operation to 400°F. For use with calibration S, R, AA & V. When ordering separately, specify Type H connector.
Used on T-110, T-117 and TX-117 Styles



TYPE F CONNECTOR

Weight 1.5 ounces

For operation to 1000°F. For use with calibration S, R, AA & V. This connector permits direct contact of lead wire to thermocouple wire. When ordering separately, specify (1) Type F connector & (2) Diameter "D" (1/16, 1/8 and 1/4 ")
Used on T-92 and TX-92 Styles.



TYPE G CONNECTOR

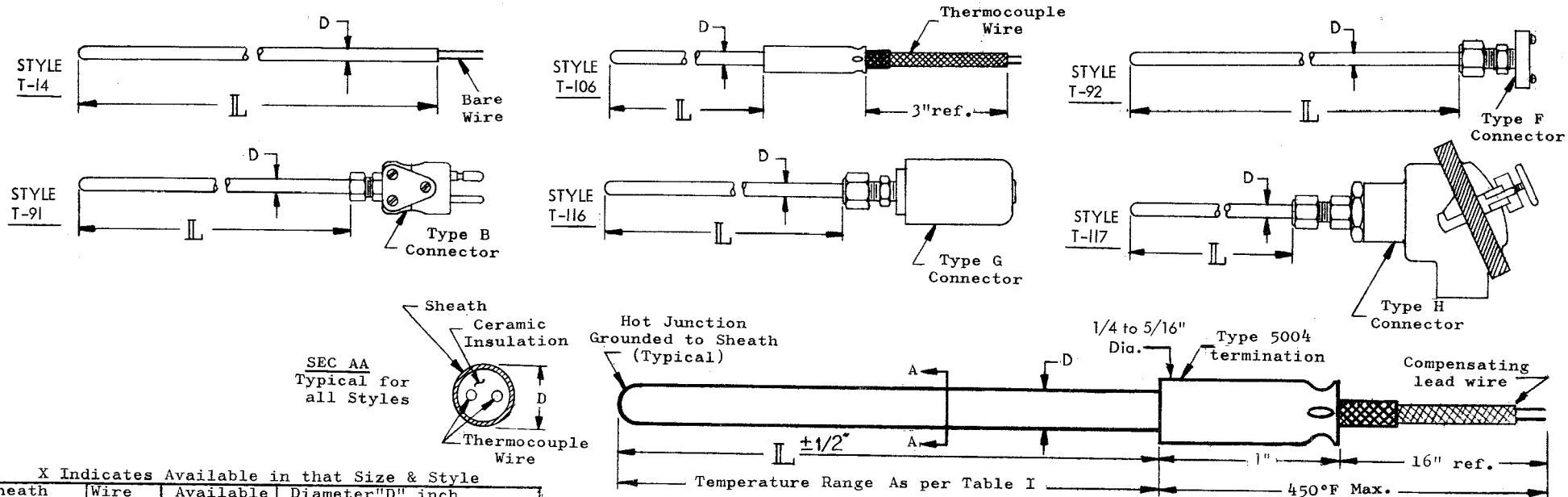
Weight 3 ounces.

For operation to 300°F max. For use with calibration S, R, AA & V. When ordering separately, specify (1) Type G connector & (2) Diameter "D" (1/8" and 1/4")
Used on T-116 and TX-116 Styles.

TITLE
CONNECTORS & TERMINATIONS for ARi Hi-Temperature Thermocouples.

AERO RESEARCH INSTRUMENT CO.
315 N. ABERDEEN AVE.
CHICAGO, ILL.

DRAWN BY	DATE	CHK. BY DESIGN ENG.	DATE
R.F	1 DEC 61	MS	4 Dec 61

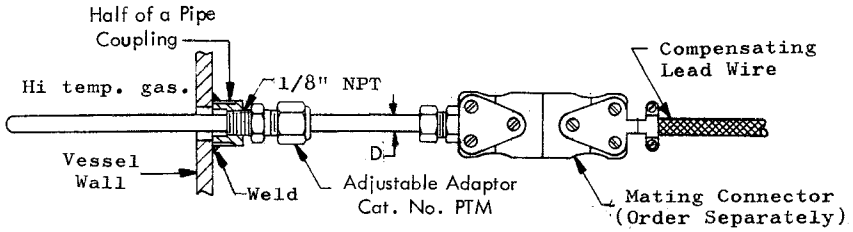


STYLE T-107

Alternate Connectors & Terminations can be Supplied in Place of T-107. Order by Style Number.

X Indicates Available in that Size & Style

Sheath Material	Wire Calib.	Available Style	Diameter "D" inch .040	.063	.125	.250
Plat.Rhod. Alloy Symbol(AA)	S,R	T-14	X	X	X	
		T-91		X	X	
		T-92		X	X	
		T-106	X	X	X	
		T-107	X	X	X	
Molybdenum Symbol (O)	S,R, AA,V	T-14		X	X	X
		T-91		X	X	X
		T-92		X	X	X
		T-106		X	X	X
		T-107		X	X	X
		T-116				X
		T-117				X
C R Coated Molybdenum Symbol(OCR)	V	T-14			X	
		T-91			X	
		T-92			X	
		T-106			X	
		T-107			X	
Tantalum Symbol (N)	S,R, AA,V	T-14	X	X	X	X
		T-91		X	X	X
		T-92		X	X	X
		T-106	X	X	X	X
		T-107	X	X	X	X
		T-116			X	X
		T-117				X



TYPICAL INSTALLATION

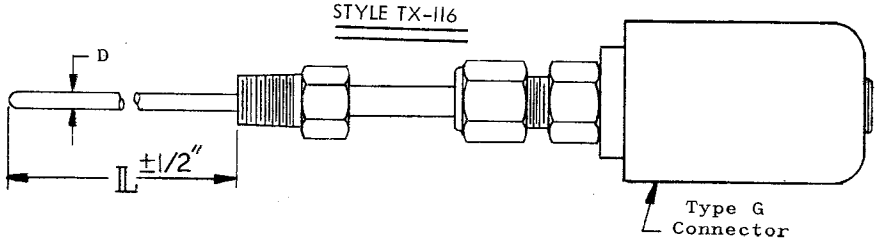
"D" inches	Stainless Steel ADJUSTABLE ADAPTOR
.040	Not Available
.063	PTM-B2A
.125	PTM-D2A
.250	PTM-F2A

Max. pressure rating is 500 psi at operating temperature

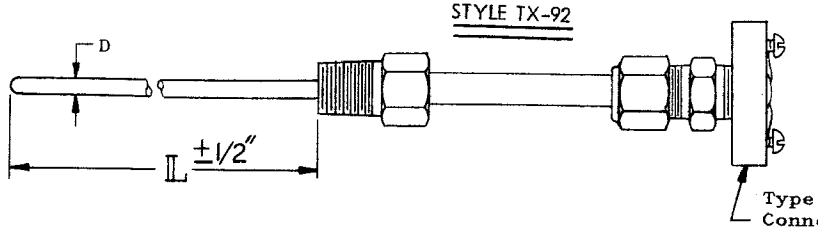
TITLE	HI-TEMPERATURE THERMOCOUPLES USING ADJUSTABLE ADAPTOR INSTALLATION
	AERO RESEARCH INSTRUMENT CO. 315 N. ABERDEEN AVE. CHICAGO, ILL.
DRAWN BY	RF
DATE	12-4-56
CHK. BY DESIGN ENG.	MS
DATE	8 DEC 61
CHK'D BY PROD. ENG.	
DATE	
NO.	T-SERIES
REV.	ORIG.

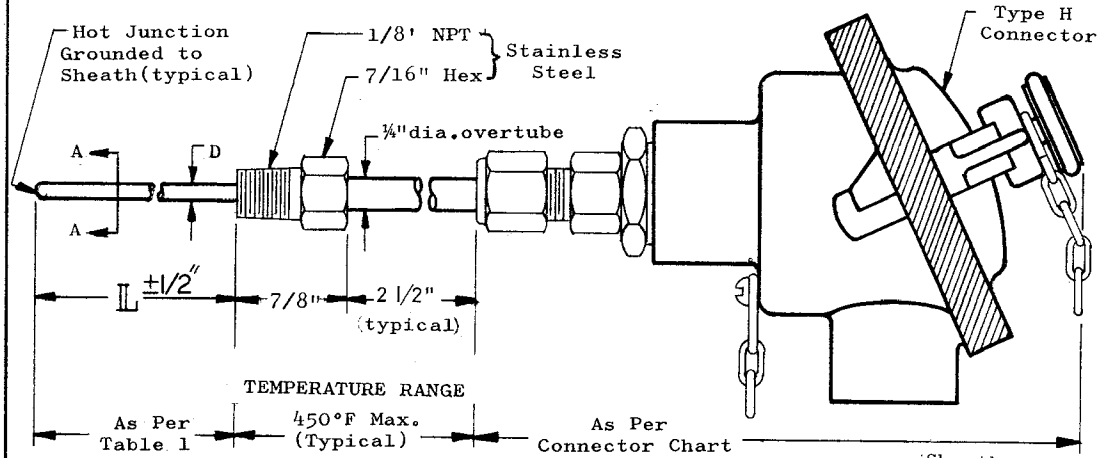
NO. T-SERIES REV. ORIG.

STYLE TX-116

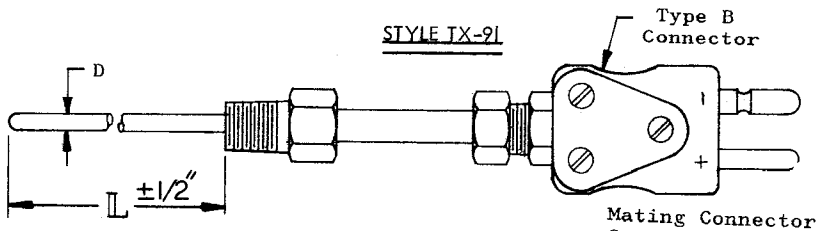


STYLE TX-92

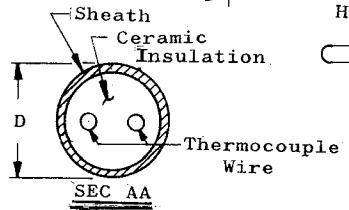




STYLE TX-91

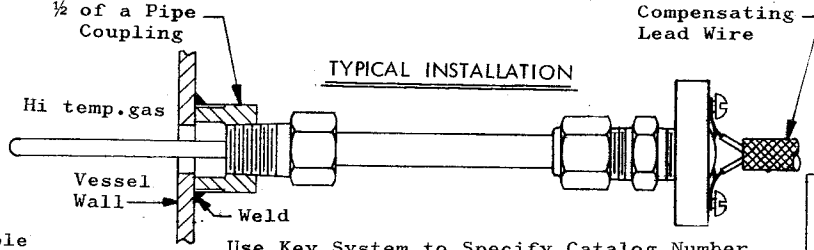


STYLE TX-117



Typical for all Styles

TYPICAL INSTALLATION



Sheath Material	Wire Calibration	Sheath Dia.Inch	Style Available
Plat.Rhod. Alloy Symbol(AA)	S,R	.04 (A) .063 (B) .125 (D)	TX-91,TX-92 TX-116,TX-117
Molybdenum Symbol(O)	S,R,AA,V	.063 (B) .125 (D)	TX-91,TX-92 TX-116,TX-117
C R Coated Molybdenum Symbol(OCR)	V	.125 (D)	TX-91,TX-92 TX-116,TX-117
Tantalum Symbol (N)	S,R,AA,V	.04 (A) .063 (B) .125 (D)	TX-91,TX-92 TX-116,TX-117

Use Key System to Specify Catalog Number

TX- [Style] [Insul. Mat.] - [Length L] [Diam. D] [Wire Cal.] [Junction 8] [Sheath Mat.]

See Table I

REVISIONS

ZONE	DATE	C.O.NO.	REV.	CHANGE

MADE FROM

TOL.

MAT.

SCALE

UNLESS OTHERWISE SPECIFIED
FRACT. DIMENSIONS MAY VARY ±
HUNDREDTH DIMENSIONS MAY VARY ±
THOUSANTH DIMENSIONS MAY VARY ±
ANGULAR DIMENSIONS MAY VARY ±
DIMENSIONS MAY VARY ±
BREAK SHARP EDGES
ALLOWABLE SURFACE ROUGHNESS ON FINISHED SURFACES TO BE MICROINCHES R.M.S.

REQ. | USED ON

TITLE
HI-TEMPERATURE THERMOCOUPLE WITH PERMANENT ADAPTOR.

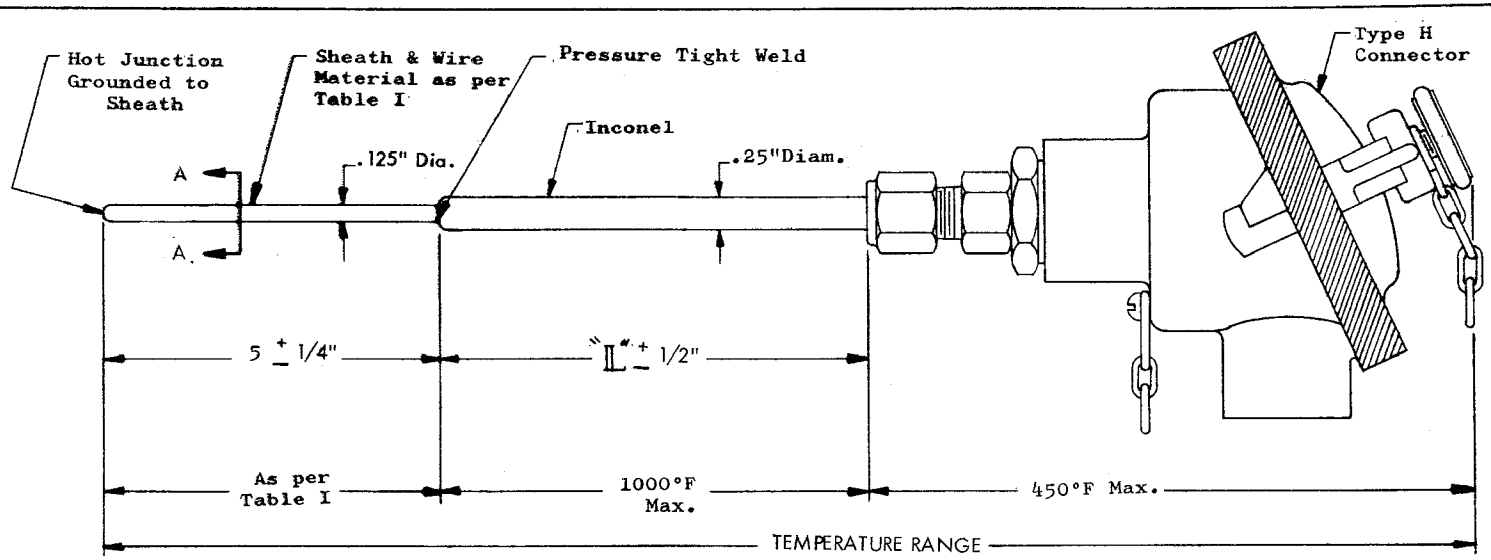
AERO RESEARCH INSTRUMENT CO.
315 N. ABERDEEN AVE.
CHICAGO, ILL.

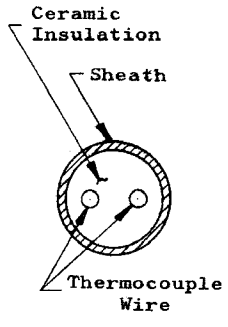
DRAWN BY	DATE	CHK. BY DESIGN ENG.	DATE
R.F.	12-4-61	[signature]	9 Dec 61
CHK'D BY PROD. ENG.			DATE

NO. TX SERIES REV. ORIG.

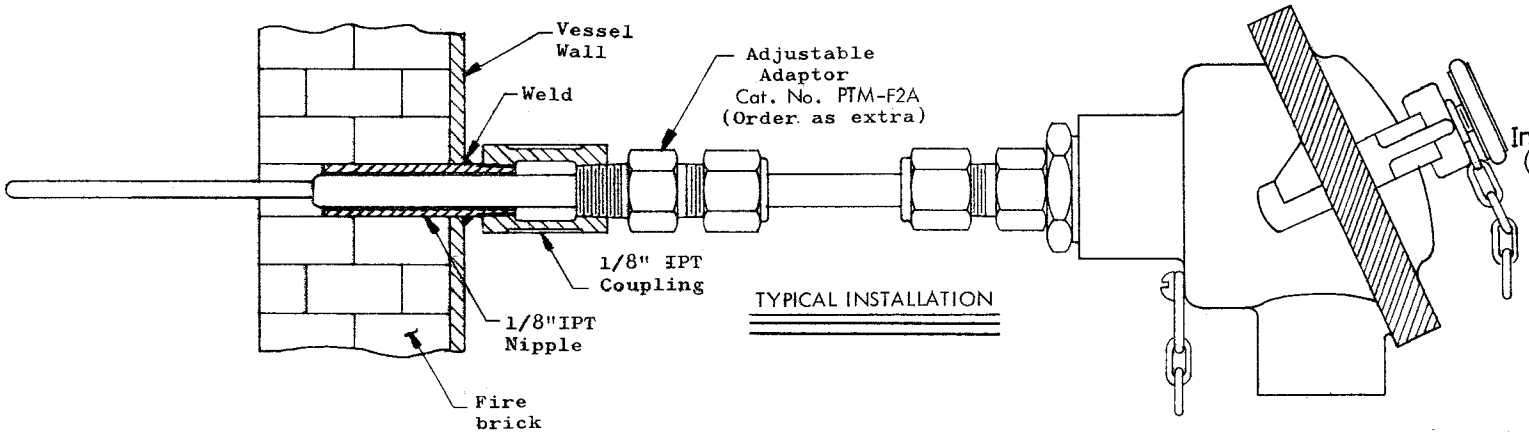
NO. TX SERIES REV. ORIG.

CROFOOT NIELSEN & CO. 1000 H CLEARPRINT





SEC AA



TYPICAL INSTALLATION

Cat. No.

T-110 □-"L"-D □ 8 □

- Style
- Insulation Mat. (see table 1)
- Length "L" in inches
- Diameter 1/8"
- Wire Calibration (see table 1)
- Sheath Material (see table 1)
- Hot junction (grounded)

NO. T-110 REV. A

REVISIONS

ZONE	DATE	C.O.NO.	REV.	CHANGE

MADE FROM

TOL.

MAT.

SCALE

UNLESS OTHERWISE SPECIFIED
FRACT. DIMENSIONS MAY VARY ± 1/32
HUNDREDTH DIMENSIONS MAY VARY ± .01
THOUSANTH DIMENSIONS MAY VARY ±
ANGULAR DIMENSIONS MAY VARY ±
DIMENSIONS MAY VARY ±
BREAK SHARP EDGES
ALLOWABLE SURFACE ROUGHNESS ON FINISHED SURFACES TO BE MICROINCHES R.M.S.

REQ.	USED ON

TITLE

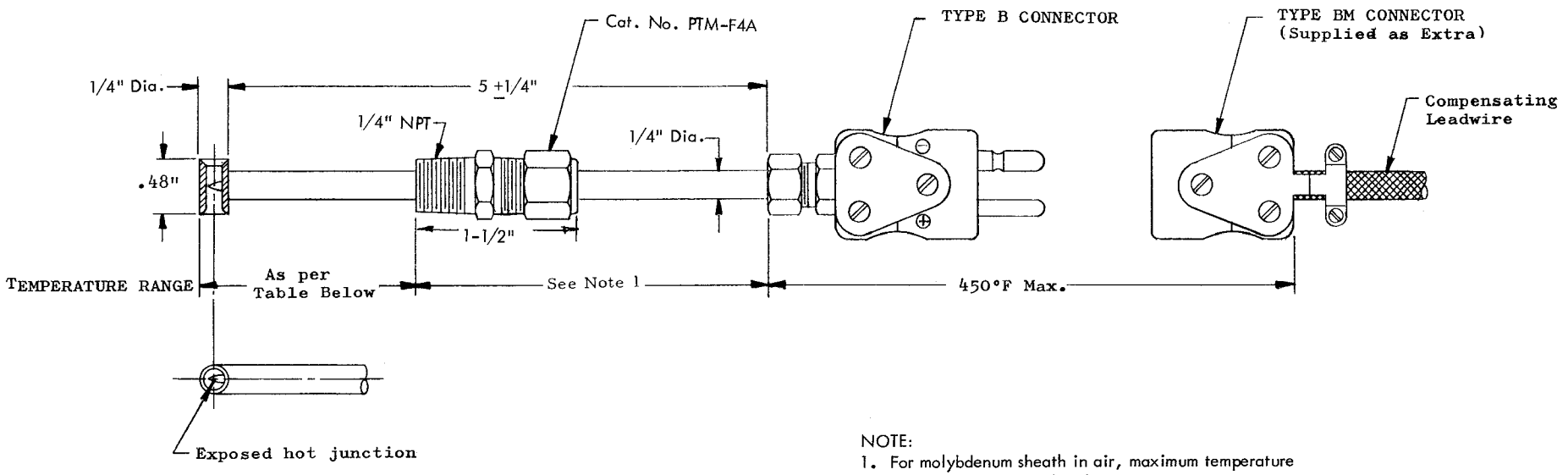
HI-TEMPERATURE EXTENSION THERMOCOUPLE

AERO RESEARCH INSTRUMENT CO.
315 N. ABERDEEN AVE.
CHICAGO, ILL.

DRAWN BY	DATE	CHK. BY DESIGN. ENG.	DATE
R.F	11-29-61		12/3 12/6/61
CHK'D BY PROD. ENG.		DATE	

NO. T-110 REV. A

CROFOOT NIELSEN & CO. 1000 H CLEARPRINT



NOTE:

1. For molybdenum sheath in air, maximum temperature is 600°F. For OCR sheath in air, maximum temperature is 1800°F. In this case, the adjustable adaptor is the limiting factor.

Sheath Material	Wire Calib.	Permissable Atmosphere	Maximum Temp.°F	Catalog Number
Molybdenum Symbol (O)	S	I	2900	T-1058M-6S70
	R		2900	T-1058M-6R70
	AA		4000	T-1058M-6V70
	V		3500	T-1058M-6AA70
C R Coated Molybdenum Symbol(OCR)	V	O,R,I	3000	T-1058M-6V70CR

SPECIFICATIONS:

1. Mach Range: 0 to Supersonic
2. Flow Angle Range: ±50°
3. Time Constant: 0.5 sec at 6 lb/sec-ft^2

REVISIONS

ZONE	DATE	C.O.NO.	REV.	CHANGE

MADE FROM

TOL.

MAT.

SCALE

UNLESS OTHERWISE SPECIFIED
FRACT. DIMENSIONS MAY VARY ±
HUNDREDTH DIMENSIONS MAY VARY ±.01
THOUSANTH DIMENSIONS MAY VARY ±
ANGULAR DIMENSIONS MAY VARY ±
DIMENSIONS MAY VARY ±
BREAK SHARP EDGES
ALLOWABLE SURFACE ROUGHNESS ON FINISHED SURFACES TO BE MICROINCHES R.M.S.

REQ. | USED ON

TITLE
HIGH TEMPERATURE
THERMOCOUPLE WITH VENTURI
SHIELD

AERO RESEARCH INSTRUMENT CO.
315 N. ABERDEEN AVE.
CHICAGO, ILL.

DRAWN BY RF DATE 7Dec61 | CHK. BY DESIGN ENG. DATE 7Dec61
CHK'D BY PROD. ENG. DATE

NO. T-1058M REV. A

NO. T-1058M REV. A

CROFOOT NIELSEN & CO. 1000 H CLEARPRINT

HIGH GAS TEMPERATURE THERMOCOUPLE
WATER COOLED

APPLICATION:

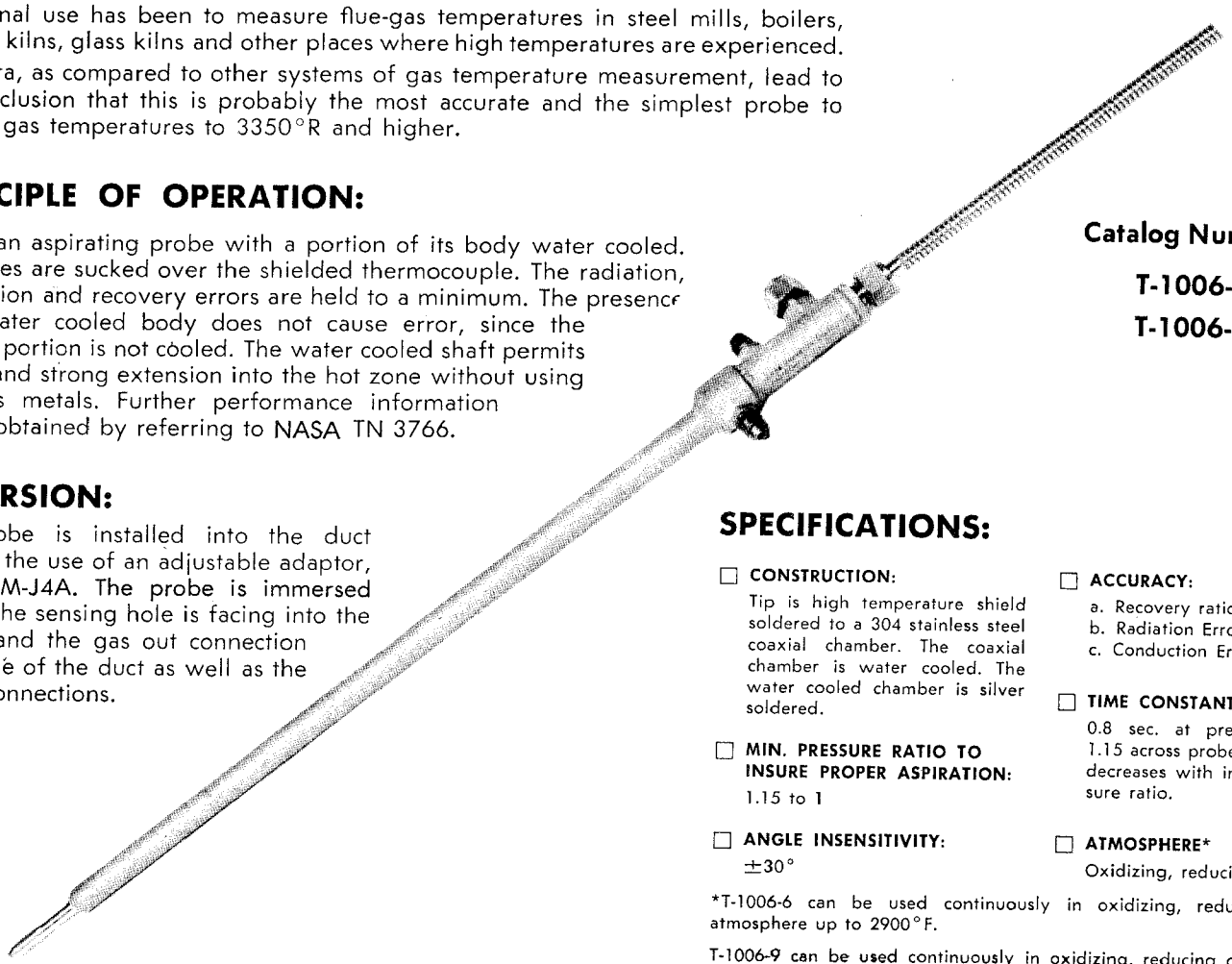
This ARi high gas temperature probe has been developed to measure the gas total temperature in an afterburning turbo-jet or ram-jet engine. This design is the result of many hours of development and testing at ARi and at Government jet engine research laboratories such as the NASA.

Additional use has been to measure flue-gas temperatures in steel mills, boilers, ceramic kilns, glass kilns and other places where high temperatures are experienced.

Test data, as compared to other systems of gas temperature measurement, lead to the conclusion that this is probably the most accurate and the simplest probe to use for gas temperatures to 3350°R and higher.

PRINCIPLE OF OPERATION:

This is an aspirating probe with a portion of its body water cooled. The gases are sucked over the shielded thermocouple. The radiation, conduction and recovery errors are held to a minimum. The presence of a water cooled body does not cause error, since the sensing portion is not cooled. The water cooled shaft permits a long and strong extension into the hot zone without using precious metals. Further performance information can be obtained by referring to NASA TN 3766.



Catalog Numbers

T-1006-6

T-1006-9

IMMERSION:

The probe is installed into the duct through the use of an adjustable adaptor, P/N PTM-J4A. The probe is immersed so that the sensing hole is facing into the stream and the gas out connection is outside of the duct as well as the water connections.

SPECIFICATIONS:

☐ **CONSTRUCTION:**
Tip is high temperature shield soldered to a 304 stainless steel coaxial chamber. The coaxial chamber is water cooled. The water cooled chamber is silver soldered.

☐ **MIN. PRESSURE RATIO TO INSURE PROPER ASPIRATION:**
1.15 to 1

☐ **ANGLE INSENSITIVITY:**
±30°

☐ **ACCURACY:**
a. Recovery ratio — 1.0
b. Radiation Error — 0
c. Conduction Error — 0

☐ **TIME CONSTANT:**
0.8 sec. at pressure ratio of 1.15 across probe. Time constant decreases with increase in pressure ratio.

☐ **ATMOSPHERE***
Oxidizing, reducing, or inert

*T-1006-6 can be used continuously in oxidizing, reducing or inert atmosphere up to 2900°F.

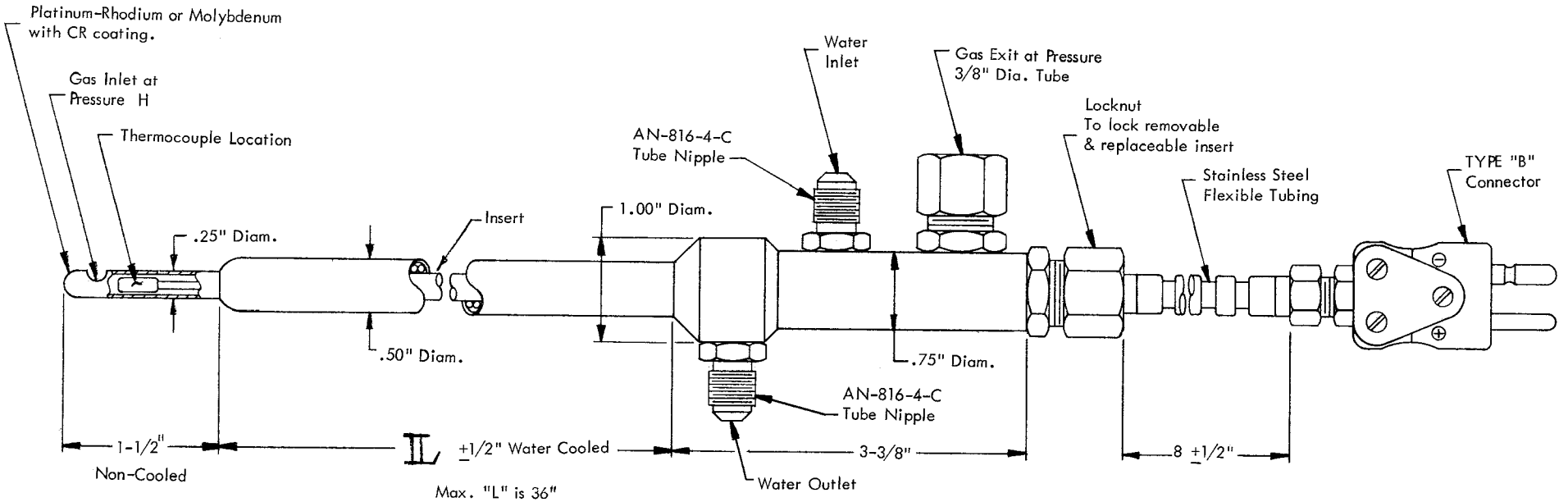
T-1006-9 can be used continuously in oxidizing, reducing or inert atmosphere to 3100°F.

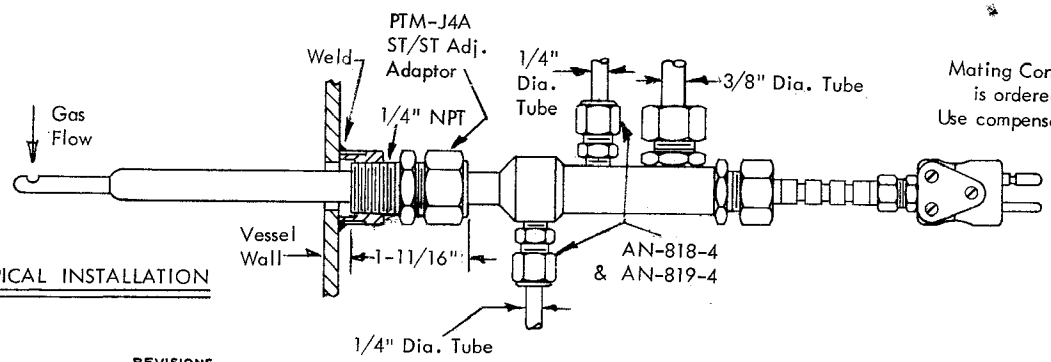
STANDARD PROBE DESIGNS:

CATALOGUE NUMBER	THERMOELEMENT	SHIELDS	MAXIMUM TEMPERATURE AT VELOCITY MACH 0-0.6	MAXIMUM TEMPERATURE AT VELOCITY MACH 0-1.0
T-1006-6(L)R	R-Platinum-13% Rhodium/Platinum	Two (Platinum-Rhodium Alloy)	2900°F	2800°F
T-1006-6(L)S	S-Platinum-10% Rhodium/Platinum	Two (Platinum-Rhodium Alloy)	2900°F	2800°F
T-1006-9(L)V	V-Iridium-60% Rhodium/Iridium	Two ("CR" coated Molybdenum)	3100°F	3100°F

HOW TO ORDER:

Specify catalogue number. Standard probe has a length "L" of 18 in.
Complete installation and operating procedures are supplied with each probe.





Mating Connector Type BM is ordered separately. Use compensating lead wire

TYPICAL INSTALLATION

Thermocouple Material	Catalog Number
S	T-1006-6(L)S
R	T-1006-6(L)R
V	T-1006-9(L)V

Fill in required length "L" in inches, in place of the Symbol "L"

REVISIONS

ZONE	DATE	C.O.NO.	REV.	CHANGE
			B	REDRAWN

MADE FROM

TOL.

MAT.

SCALE

UNLESS OTHERWISE SPECIFIED
FRACT. DIMENSIONS MAY VARY ±1/16
HUNDREDTH DIMENSIONS MAY VARY ±.01
THOUSANTH DIMENSIONS MAY VARY ±
ANGULAR DIMENSIONS MAY VARY ±
DIMENSIONS MAY VARY ±
BREAK SHARP EDGES
ALLOWABLE SURFACE ROUGHNESS ON FINISHED SURFACES TO BE MICROINCHES R.M.S.

REQ.	USED ON

TITLE
THERMOCOUPLE, ASPIRATING GAS, WATER COOLED

AERO RESEARCH INSTRUMENT CO.
315 N. ABERDEEN AVE.
CHICAGO, ILL.

DRAWN BY	DATE	CHK. BY DESIGN ENG.	DATE
R.F	12-6-61		
CHK'D BY PROD. ENG.		DATE	

NO. T-1006 REV. B

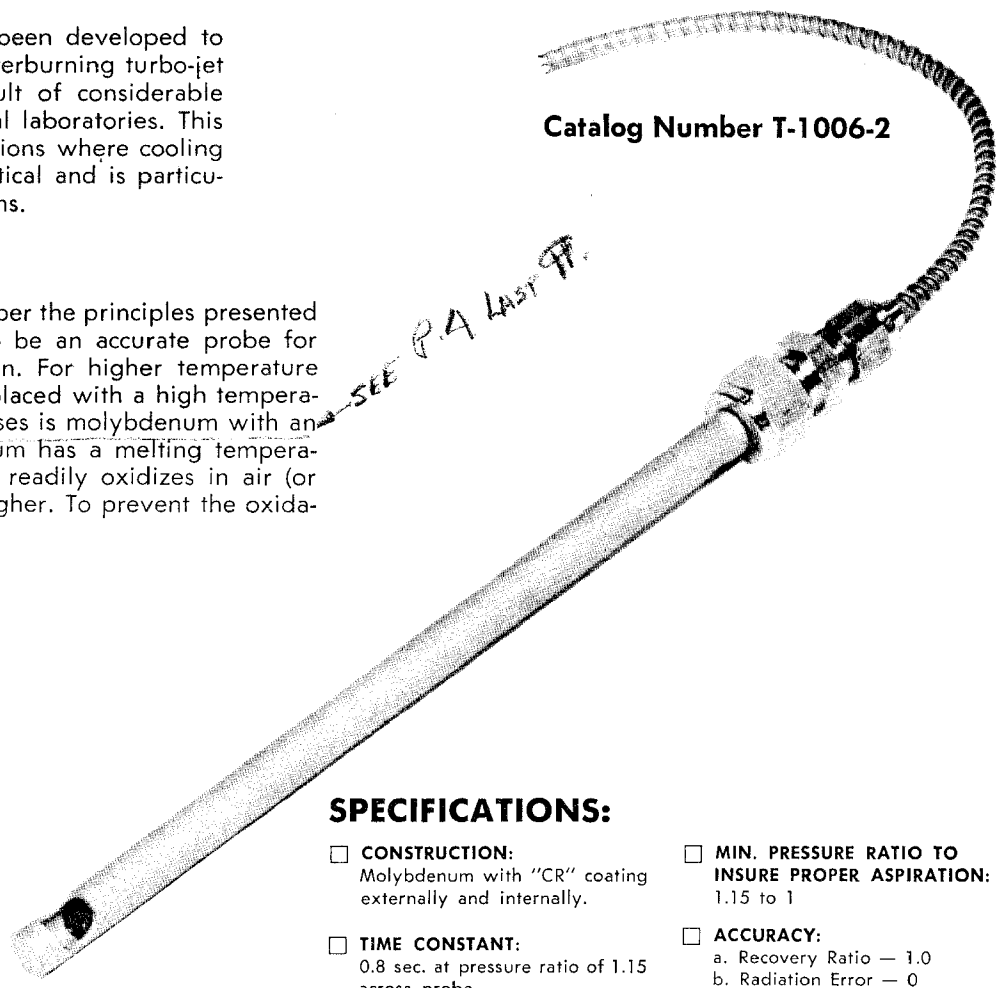
SPEC. CONT. DWG. NO. T-1006 REV. B

SPEC. CONTROL DWG.

HIGH GAS TEMPERATURE THERMOCOUPLE TYPE
NON-COOLED

APPLICATION:

This ARi high gas temperature probe has been developed to measure the gas total temperature in an afterburning turbo-jet or ram-jet engine. This design is the result of considerable development and testing at ARi and several laboratories. This is a non-cooled probe designed for applications where cooling of all or a portion of the probe is not practical and is particularly suited for missile and flight applications.



Catalog Number T-1006-2

PRINCIPLE OF OPERATION:

This is an aspirating type probe designed as per the principles presented in NASA TN 3755. Data has shown this to be an accurate probe for use up to 2300°F with inconel construction. For higher temperature applications the inconel tubing has been replaced with a high temperature metal. The metal exposed to the hot gases is molybdenum with an oxidation-resistant "CR" coating. Molybdenum has a melting temperature of approximately 5000°F. However, it readily oxidizes in air (or exhaust gas) at temperatures of 800°F or higher. To prevent the oxidation, the molybdenum parts are coated with "CR" coating. This new material has an operating temperature of 3100°F in still air and about 2900°F in moving air. Probes coated with this new material have successfully withstood short-time excursions to 4000°F in oxidizing atmospheres. This coating process has opened up a whole new field of metals for use at 2700°F and higher. In order to use the process to its fullest advantage, the design of the parts are extremely critical. Hundreds of hours at temperatures above 2700°F have been obtained with the metal with good success.

SPECIFICATIONS:

- ☐ **CONSTRUCTION:** Molybdenum with "CR" coating externally and internally.
- ☐ **TIME CONSTANT:** 0.8 sec. at pressure ratio of 1.15 across probe.
- ☐ **ANGLE INSENSITIVITY:** ±30°
- ☐ **MIN. PRESSURE RATIO TO INSURE PROPER ASPIRATION:** 1.15 to 1
- ☐ **ACCURACY:**
  a. Recovery Ratio — 1.0
  b. Radiation Error — 0
  c. Conduction Error — 0
- ☐ **ATMOSPHERE:*** Oxidizing, reducing, or inert

*T-1006-2 can be used continuously in oxidizing, reducing or inert atmosphere to 3000°F depending upon aerodynamic loading.

IMMERSION:

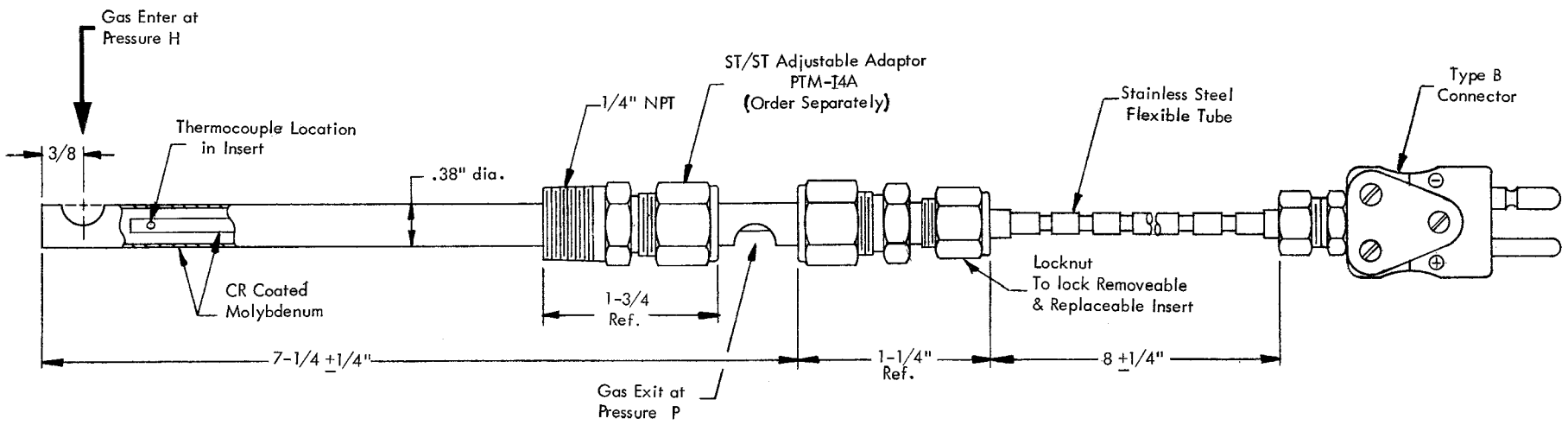
The probe is installed into the duct through the use of an adjustable adaptor, P/N PTM-I4A. The probe is immersed so that the sensing hole is facing into the stream and the hole nearest the connector is outside of the duct.

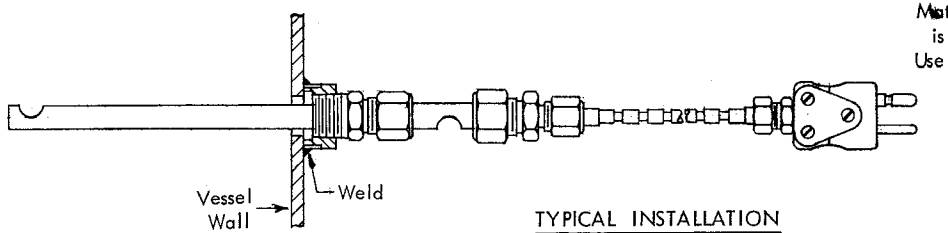
STANDARD PROBE DESIGNS:

CATALOGUE NUMBER	THERMOELEMENT	MAXIMUM OPERATING TEMPERATURE AT VELOCITY MACH 0-0.3	MACH 0-0.6	MACH 0-1.0
T-1006-2R	R-Platinum-13% Rhodium/Platinum	3000°F	2800°F	2600°F
T-1006-2S	S-Platinum-10% Rhodium/Platinum	3000°F	2800°F	2600°F
T-1006-2V	V-Iridium-60% Rhodium/Iridium	3100°F	3100°F	3100°F

HOW TO ORDER:

Specify catalogue number. The length and diameter are fixed, at $7\frac{5}{16}$" and 3/8", respectively.





TYPICAL INSTALLATION

Thermocouple Material	Catalog No.
S	T-1006-2S
R	T-1006-2R
V	T-1006-2V

REVISIONS

ZONE	DATE	C.O.NO.	REV.	CHANGE
			H	REDRAWN

MADE FROM

TOL.

MAT.

SCALE

UNLESS OTHERWISE SPECIFIED
FRACT. DIMENSIONS MAY VARY ± 1/16
HUNDREDTH DIMENSIONS MAY VARY ± .01
THOUSANTH DIMENSIONS MAY VARY ±
ANGULAR DIMENSIONS MAY VARY ±
DIMENSIONS MAY VARY ±
BREAK SHARP EDGES
ALLOWABLE SURFACE ROUGHNESS ON FINISHED SURFACES TO BE MICROINCHES R.M.S.

REQ.	USED ON

TITLE
THERMOCOUPLE, ASPIRATING, GAS
NON COOLED

AERO RESEARCH INSTRUMENT CO.
315 N. ABERDEEN AVE.
CHICAGO, ILL.

DRAWN BY	DATE	CHK. BY DESIGN ENG.	DATE
R.F.	12-7-61	MS	9/26/61
CHK'D BY PROD. ENG.			DATE

NO. T-1006-2 REV. H

SPEC. CONT. DWG NO. T-1006-2 REV. H

CROFOOT NIELSEN & CO. 1000 H CLEARPRINT

SPEC. CONTROL DRAWING

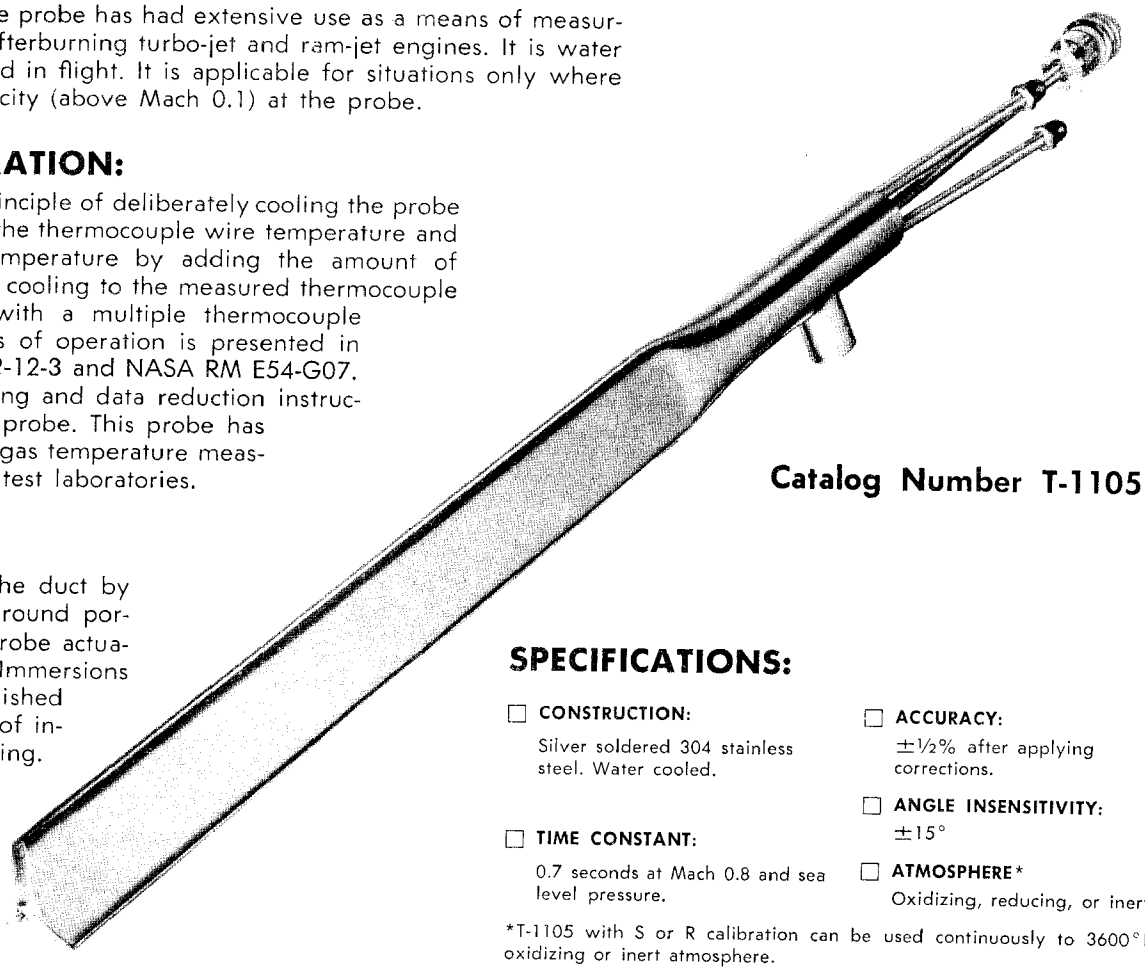
HIGH GAS TEMPERATURE THERMOCOUPLE
WATER COOLED

APPLICATION:

This ARi high gas temperature probe has had extensive use as a means of measuring the gas temperature in afterburning turbo-jet and ram-jet engines. It is water cooled and has not been used in flight. It is applicable for situations only where there is appreciable gas velocity (above Mach 0.1) at the probe.

PRINCIPLE OF OPERATION:

This probe operates on the principle of deliberately cooling the probe a known amount, measuring the thermocouple wire temperature and then calculating the total temperature by adding the amount of temperature reduction due to cooling to the measured thermocouple temperature. This is done with a multiple thermocouple junction. A complete analysis of operation is presented in NASA TN 2599, ISA Paper 52-12-3 and NASA RM E54-G07. Complete installation, operating and data reduction instructions are supplied with each probe. This probe has become the standard of high gas temperature measurements at many jet engine test laboratories.



Catalog Number T-1105

IMMERSION:

The probe is mounted into the duct by clamping and sealing at the round portion. It is often used with a probe actuator to traverse the gas stream. Immersions up to 52" have been accomplished with no failure. Send details of intended mounting when ordering.

SPECIFICATIONS:

☐ **CONSTRUCTION:**
Silver soldered 304 stainless steel. Water cooled.

☐ **ACCURACY:**
±½% after applying corrections.

☐ **ANGLE INSENSITIVITY:**
±15°

☐ **TIME CONSTANT:**
0.7 seconds at Mach 0.8 and sea level pressure.

☐ **ATMOSPHERE***
Oxidizing, reducing, or inert

*T-1105 with S or R calibration can be used continuously to 3600°F in oxidizing or inert atmosphere.

T-1105 with V calibration can be used continuously to 4000°F in oxidizing, reducing or inert atmosphere.

STANDARD PROBE DESIGNS:

CATALOGUE NUMBER	THERMOELEMENT	MAXIMUM OPERATING TEMPERATURE MACH 0 TO SUPERSONIC
T-1105-[D] R [A]	R-Platinum-13% Rhodium/Platinum	3600°F
T-1105-[D] S [A]	S-Platinum-10% Rhodium/Platinum	3600°F
T-1105-[D] V [A]	V-Iridium-60% Rhodium/Iridium	4000°F

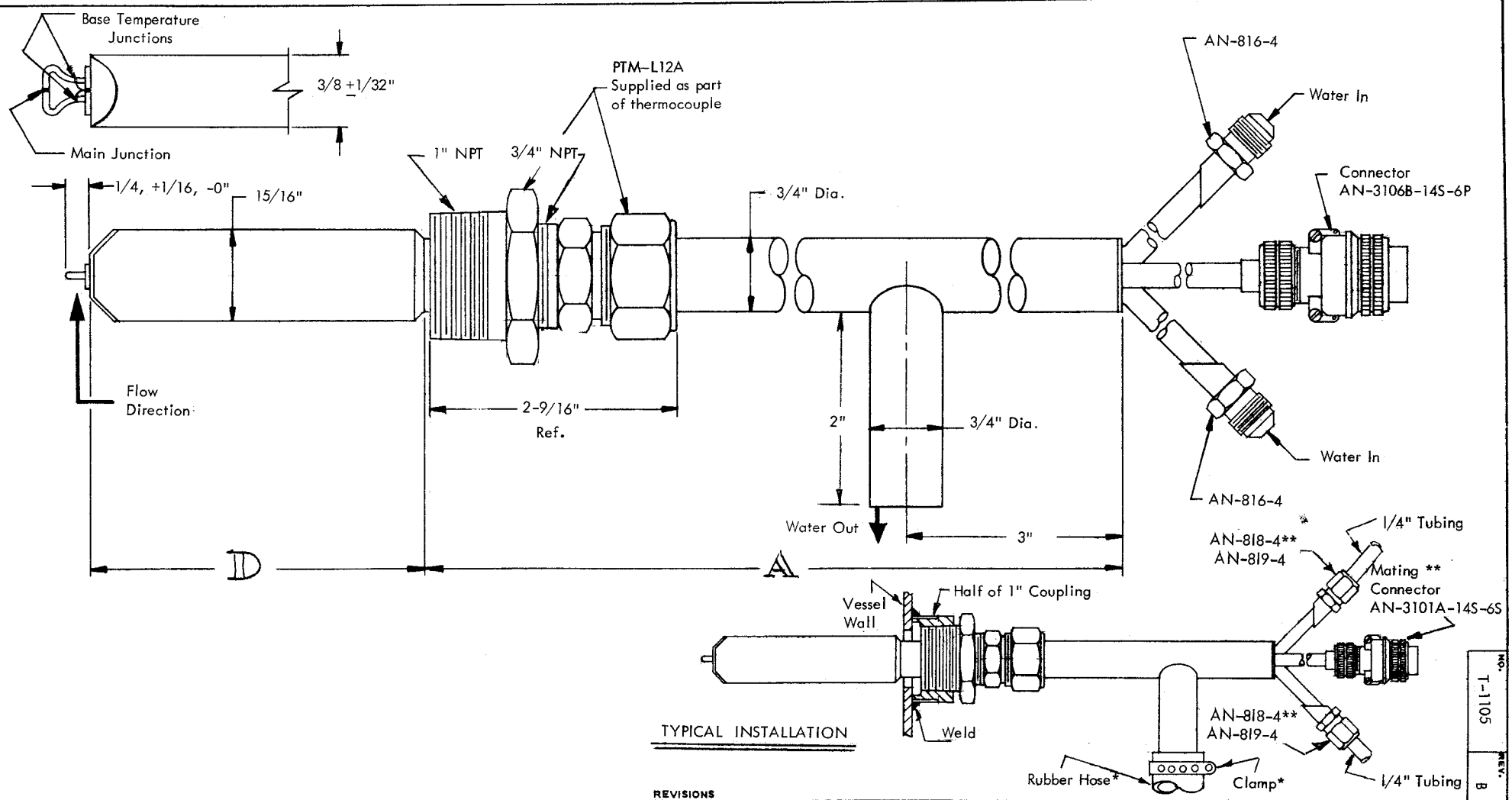
HOW TO ORDER:

Standard Length "D" is 18", 30", 42", 52".
Standard wires are ISA, R, S, or ARi calib. V(Irid-60% Rhod/Irid).

EXAMPLE: Catalog No. T-1105, ISA Cal. R wire, D= 18" and A=8" would be

T-1105 – 18 – R – 8

- T-1105: Type
- 18: Length in Inches
- R: Wire Material
- 8: Length A



TYPICAL INSTALLATION

Thermocouple Calibration	Catalog Number
S	T-1105 D S A
R	T-1105 D R A
V	T-1105 D V A

NOTE:
* Not Supplied
** Supplied as an Extra

REVISIONS

ZONE	DATE	C.O.NO.	REV.	CHANGE
			B	REDRAWN

MADE FROM
TOL.
MAT.
SCALE

UNLESS OTHERWISE SPECIFIED
FRACT. DIMENSIONS MAY VARY ± 1/64
HUNDREDTH DIMENSIONS MAY VARY ± .02
THOUSANTH DIMENSIONS MAY VARY ±
ANGULAR DIMENSIONS MAY VARY ±
DIMENSIONS MAY VARY ±
BREAK SHARP EDGES
ALLOWABLE SURFACE ROUGHNESS ON FINISHED SURFACES TO BE MICROINCHES R. M. S.

REQ. | USED ON

TITLE
Thermocouple, Multijunction
Water Cooled, Gas Temperature

AERO RESEARCH INSTRUMENT CO.
315 N. ABERDEEN AVE.
CHICAGO, ILL.

DRAWN BY	DATE	CHK. BY DESIGN ENG.	DATE
R.F.	12-8-61	MS	11 Dec 61
CHK'D BY PROD. ENG.			DATE

NO. T-1105 REV. B

NO. T-1105 REV. B

CROFOOT NIELSEN & CO. 1000 H CLEARPRINT