NANMAC

Foremost in Temperature Measurement™

# NANMAC

# Quality

# Performance

# Solutions

www.nanmac.com info@nanmac.com Tel: 001.508.872.4811 Fax: 001.508.879.5450

**This presentation will consist of six sections:**

- Nanmac history and Corporate overview
- General thermocouple & RTD theory
- High Temperature Thermocouples
- Ultra High Temperature Thermocouples
- High Performance Thermocouples
- Nanmac Quality Program

# NANMAC

## History and Corporate overview

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# NANMAC
## History

- Nanmac was established in 1956 by a group of scientists to develop high performance temperature sensors
- Initial focus was on Government research & Military applications
- Many of these have become commercial applications – plastics, material evaluation, heat transfer studies, incineration
- Nanmac holds various patents on temperature sensors, erosion gages, and multi-function sensors.
- Nanmac is a Veteran owned company

# NANMAC
## Corporate

**Nanmac**
**1657 Washington St, Bldg. 3**
**Holliston, MA 01746**
**United States**

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**Toll Free: 1-800-786-4669**
**Fax: 1-508-879-5450**
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**Nanmac – Asia**
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**Fahuazhen Road Changning District**
**Shanghai, P.R. China 200052**

**Tel: 021-51186096**
**Fax: 021-62801021**
**www.nanmac.com/cn**
**asia.support@nanmac.com**
**Primary Contact: Vivian Wu**

# Corporate - Center of Excellence

## Facility Overview

- 12,000 square-foot facility
- Company leased building
- 30 employees
- Calibration Lab
- Pressure and Vacuum Testing

## Key Operations

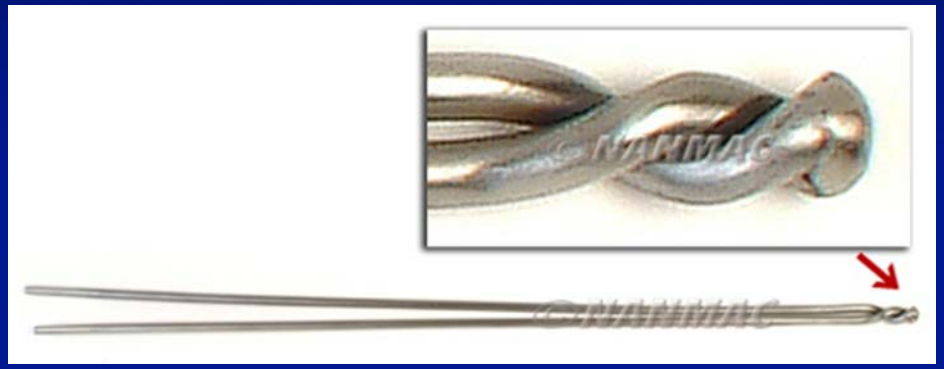
- Executive Management
- Research and Development
- Assembly and Testing
- Sales and Marketing
- Finance and Administration

# NANMAC

## General Thermocouple & RTD Theory

# General Thermocouple Theory

- Thermocouple circuit is made from two metals of different materials being electrically connected. This connection is called the thermocouple junction.




- The output of a thermocouple is a millivolt signal. The higher the temperature, the higher the millivolt output, this is called Electro Motive Force (EMF).

# General Thermocouple Theory

- The type of metals used to make the thermocouple element determines the temperature range of the thermocouple.
- Each thermocouple “Type”, has a specific accuracy as determined by the US National Institute of Standards (NIST). Accuracy is based on a percentage of the temperature being measured.

# General Thermocouple Theory

| ANSI Code | Alloy Materials | Range |
|---|---|---|
| Type J | Iron/Constantan | 0 to 750 C |
| Type K | Chromel/Alumel | 0 to 1250 C |
| Type T | Copper/Constantan | 0 to 350 C |
| Type E | Chromel/Constantan | 0 to 900 C |
| Type N | Nicrosil/Nisil | 0 to 1300 C |
| Type R | Pt-13%Rh/Pt | 0 to 1450 C |
| Type S | Pt-10%Rh/Pt | 0 to 1450 C |
| Type B | Pt-30%Rh/Pt-6%Rh | 870 to 1820 C |
| Type C | W-5%Re/W-26%Re | 426 to 2320 C |
| Type D | W-3%Re/W-25%Re | 426 to 2320 C |

# General Thermocouple Theory

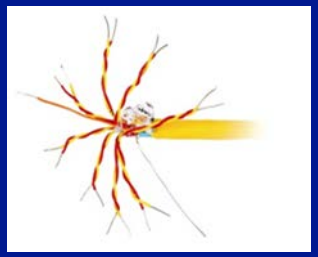
## American Limits of Error

| ANSI Code | Standard | Special |
|---|---|---|
| Type J | 2.2 C or 0.75 % | 1.1 or 0.4% |
| Type K | 2.2 C or 0.75 % | 1.1 or 0.4% |
| Type T | 1.0 C or 0.75 % | 0.5 or 0.4% |
| Type E | 1.7 C or 0.5 % | 1.0 or 0.4% |
| Type N | 2.2 C or 0.75 % | 1.1 or 0.4% |
| Type R S | 1.5 C or 0.25 % | 1.1 or 0.4% |
| Type B | 0.5 % | Not Established |
| Type C D | 4.5 C or 1.0 % | Not Established |

# General Thermocouple Theory

## ANSI Color codes for Thermocouple, Wire and Connectors

| TYPE | COLOR |
|---|---|
| B | GRAY |
| C | BROWN |
| D | BROWN |
| E | PURPLE |
| G | BROWN |
| J | BLACK |
| K | YELLOW |
| N | ORANGE |
| R | GREEN |
| S | GREEN |
| T | BLUE |



# General Thermocouple Theory

- The design of the thermocouple determines how the thermocouple will react to the temperature it is measuring.
- The larger the thermocouple junction is, the slower the thermocouple response time is.
- The smaller the thermocouple junction is, the faster is it is, and the more delicate it is.
- Protection tubes such as stainless steel, alumina or molybdenum prolong the life of the thermocouple, and slow down the response time.

# General Thermocouple Theory

- Several factors must be accounted for when designing a Thermocouple.
  - What is the expected temperature: Highest and Lowest?
  - Is it a long-term measurement; i.e. furnace or short term test?
  - What is the response time requirement?
  - What is the environment; i.e. air, neutral, vacuum, or flame?
  - How will the thermocouple be mounted?
  - What is the size and shape of the thermocouple?

# General Thermocouple Theory

- Several factors must be accounted for when designing a Thermocouple, continued
  - In the situation of special tests:
    - What is the material being tested?
    - What is the specific temperature of interest?
      - Surface temperature of an object; i.e. exhaust nozzle, gun barrel
      - Gas temperature of a flame or explosion
      - Interface temperature of two solid materials, i.e. automotive brake pads

# General RTD theory

- Resistive Temperature Detectors (RTDs) are temperature sensors that change resistance as temperature changes.
- Temperature range is from –200 to 600 Degree C. Accuracy is +/- ½ % of the temperature being measured, and can be even better for high accuracy RTD.
- More delicate and sometimes more expensive than thermocouple.
- RTDs are usually either Platinum or Nickel and have several different resistances, such as:
  - 100 Ohm Pt or 1000 Ohm Pt
  - 100 Ohm Nickel or 200 Ohm Nickel
- The same design questions must be asked for RTDs.

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## *High Temperature and Ultra High Temperature thermocouples*

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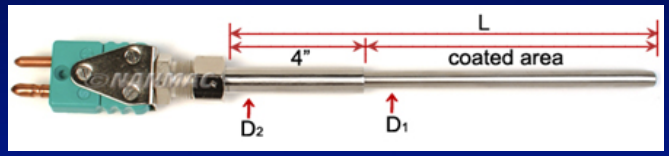
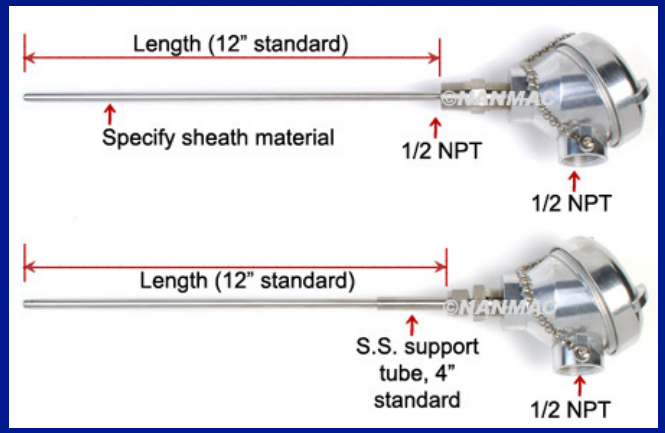
# *High Temperature* Thermocouples

- Available in Thermocouple Types… C, D, S, R & B

- Designed for temperatures to over 1500˚C
- 24 or 30 gage wire
- Sheath material to suit application
- Optional support tube
- Variety of termination styles



# *High Temperature* Thermocouples

- Protection tube materials:
  - Tantalum (metal)
    - Melts at 3000° C
    - Good for neutral environment
    - Good for thermal cycling; high to low temperatures
    - Fair in graphite furnaces
    - Bad in oxygen
  - Molybdenum (metal)
    - Melts at 2600° C
    - Good for neutral environment
    - Good for thermal cycling; high to low temperatures
    - Fair in graphite furnaces
    - Bad in oxygen

- Protection tube materials:
  - Zirconia (ceramic)
    - Melts at > 2425° C
    - Good in oxygen
    - Poor for thermal cycling
  - Alumina (ceramic)
    - Melts at 2030° C
    - Good in oxygen
    - Poor for thermal cycling
  - Nanmac NC-12 (ceramic)
    - Useful up to 1200° C in air
    - 1000° C in Molten aluminum – months of continuous use
    - 900° C in Zinc – Months of continuous use
    - Bad in molten steel or iron

# *Ultra-High Temperature* Thermocouples

- Industrial applications include:
  - Vacuum furnaces
  - Graphite lined furnaces or furnaces with graphite heaters
  - Petrochemical cracking furnace
  - Heat treating and sintering
  - Calibration, drift and uniformity & profile studies

- Unique performance characteristics
  - Temperatures to 2300° C
  - Accurate to +/- 1 % of reading, even at 2000° C
  - Prolonged life in harsh environments – 10 times the life of standard sensors
  - Up to 70 inches long

A12D Series – Ultra High Temp

- Available in all thermocouple calibrations, including Platinum and Tungsten
- Made to order in less than 3 weeks

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## High Performance Thermocouples

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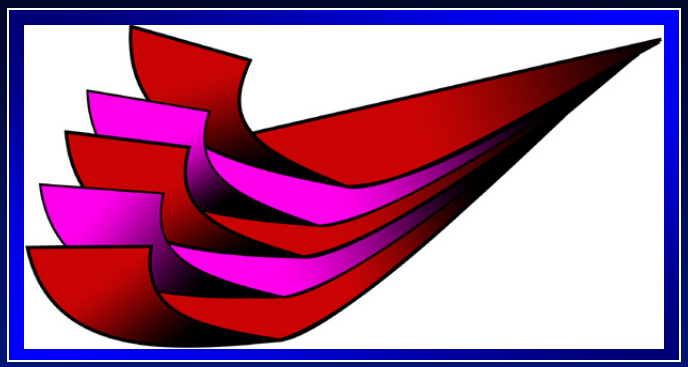
# *"Self Renewing"* Thermocouple



- 5 Layer construction
- 3 layers are very thin electrical insulators
- 2 layers are thermocouple alloy ribbon

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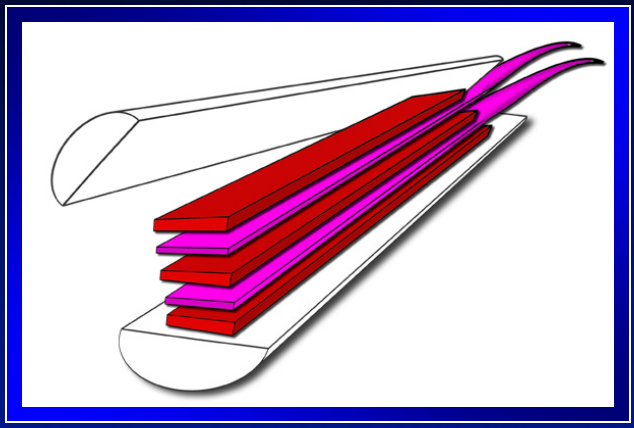

- All 5 layers are pressed between a split insert

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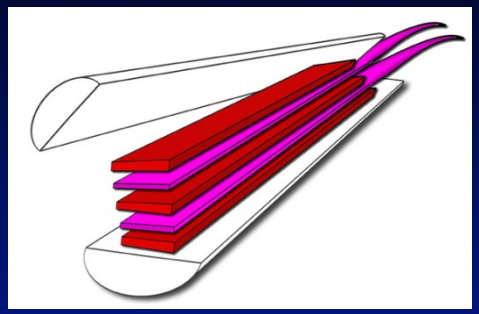

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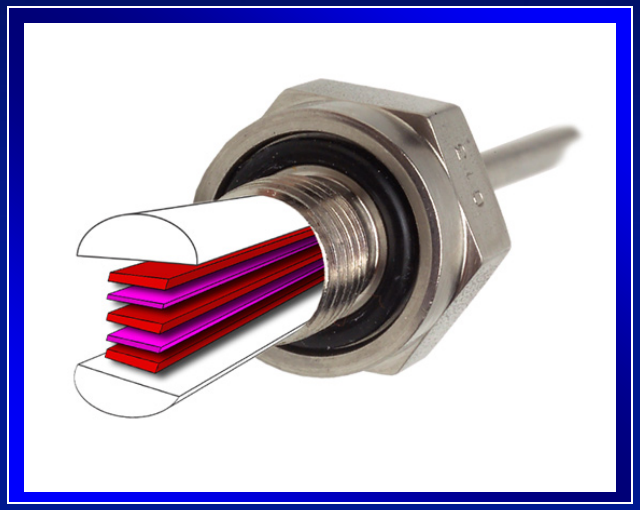

- Entire assembly is then inserted into the required housing

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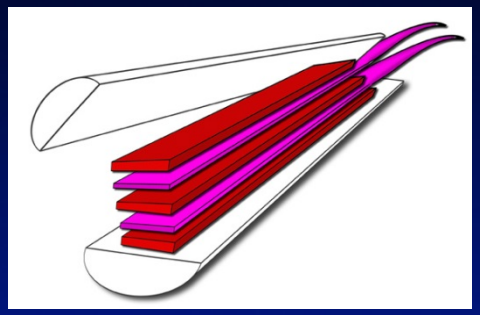

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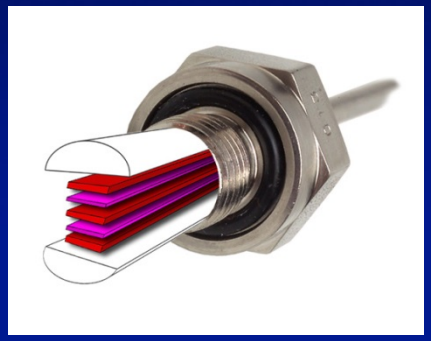

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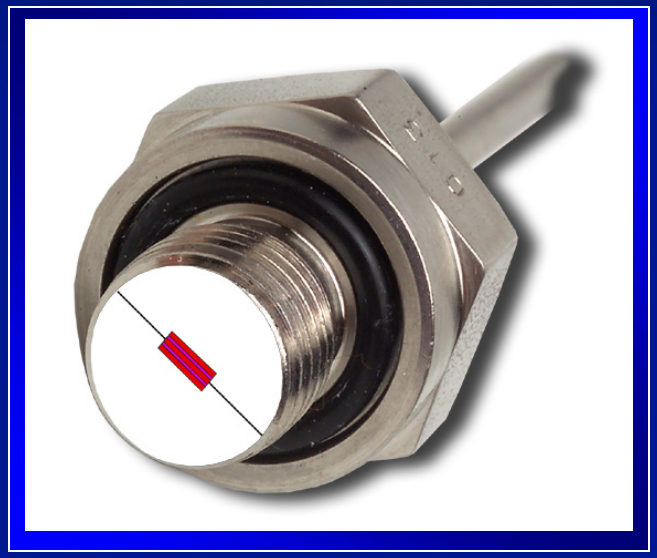

- Housing can be made from any material to match the thermal properties of the test material – in almost any shape

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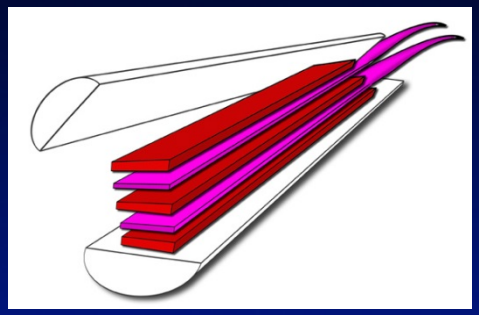

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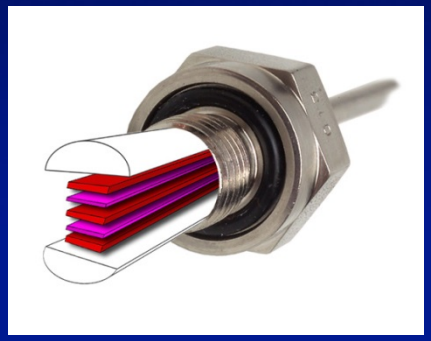


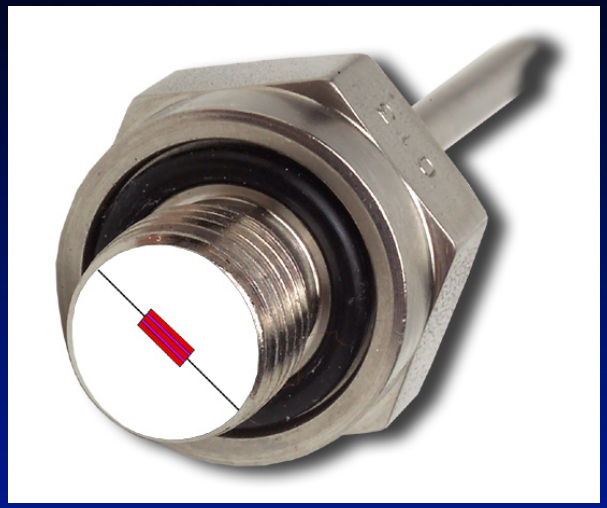
- Entire assembly is then inserted into the required housing

- Housing can be made from any material to match the thermal properties of the test material – in almost any shape

*Thermocouple junction is formed by grinding motion across the layers*
*Junction is microscopic, continued grinding forms new junctions*
*Grinding motion can be from shaping, ablation, wear, etc…*

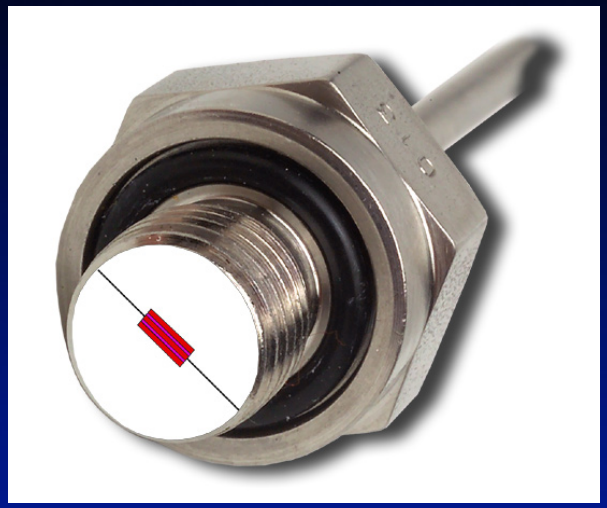
# *"Self Renewing"* Thermocouple

- Patented design



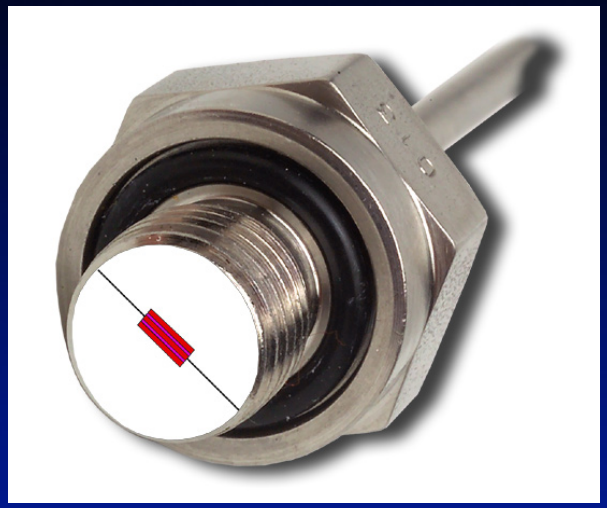
# *"Self Renewing"* Thermocouple

- Patented design
- Millisecond response time



# *"Self Renewing"* Thermocouple

- Patented design
- Millisecond response time
- Thermal device can be made from most any material, in most any shape: Graphite, steel, plastic, phenolic, rubber, wood



# *"Self Renewing"* Thermocouple

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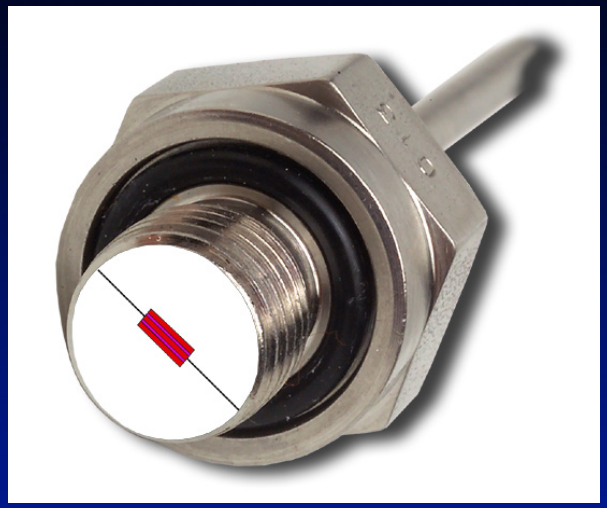
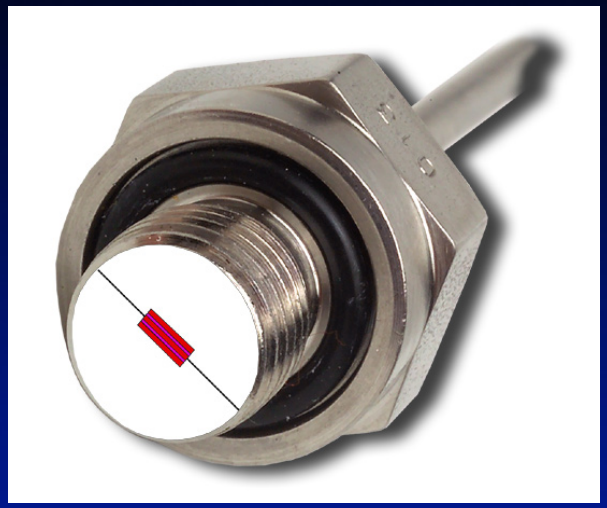
- Temperatures to over 2300˚C



# *"Self Renewing"* Thermocouple

- Patented design
- Millisecond response time
- Thermal device can be made from most any material, in most any shape: Graphite, steel, plastic, phenolic, rubber, wood
- Temperatures to over 2300ºC
  Pressures to over 25,000 psi



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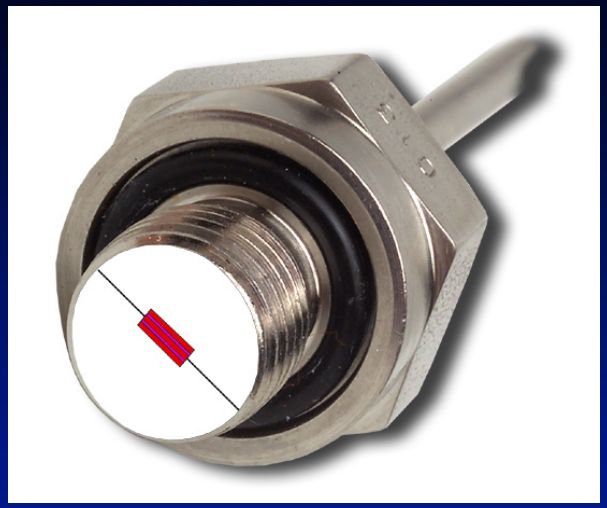
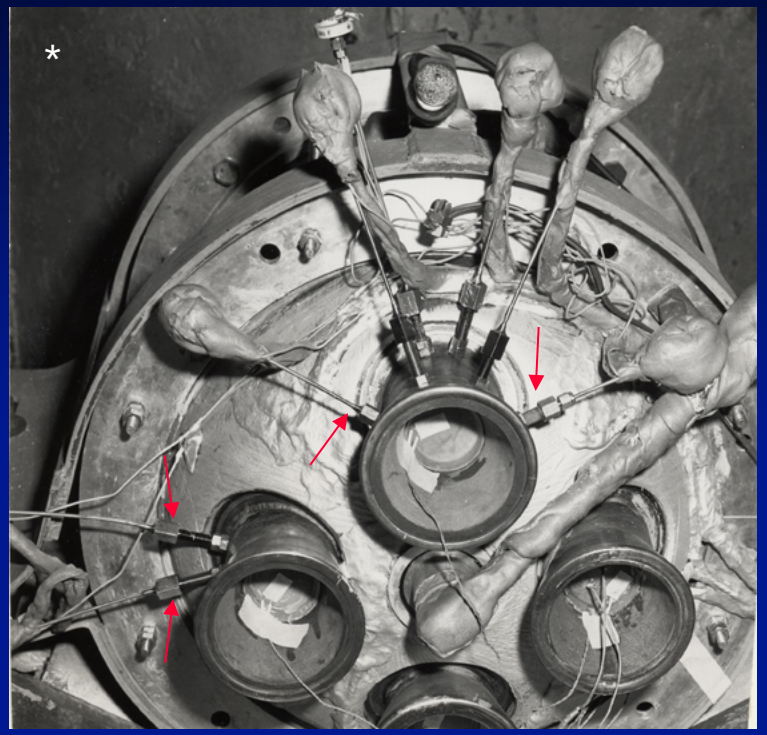
- Millisecond response time
- Thermal device can be made from most any material, in most any shape: Graphite, steel, plastic, phenolic, rubber, wood
- Temperatures to over 2300ºC
  Pressures to over 25,000 psi
- Available in all thermocouple calibrations, including Type B & C



# *"Self Renewing"* Thermocouples for Research

- Research applications include:
  - Rocket nozzle blast temperatures *
  - Interface measurements between moving surfaces – brake pads, piston walls, bearings
  - Ablation studies
- Unique performance characteristics
  - Millisecond response time
  - 2 dimension thermal junction, exact location placement
  - Sensing device can wear or "erode" up to 0.375" and continue to measure – even during erosion

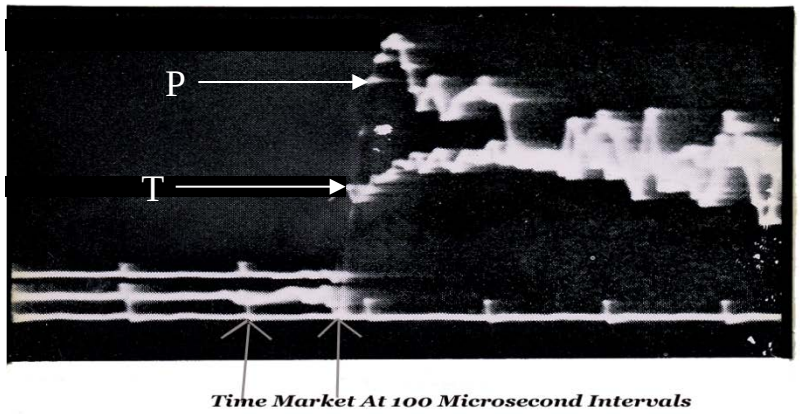



**4 of 7 "Eroding" thermocouples – all 7 mounted flush to inside of nozzle**

# *"Self Renewing"* Thermocouples for Research

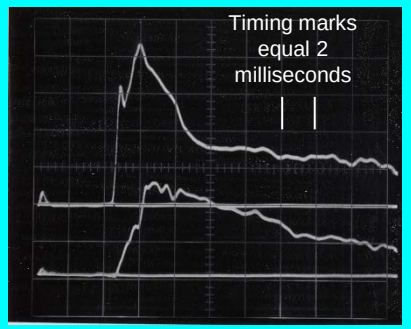
- Additional research applications include:
  - Shockwave measurements **
  - Projectiles and Gun barrel breaches
  - Explosions
  - Squibs and Igniters
- Unique performance characteristics
  - Sensing device can be machined to match wall contours
  - Distinct temperature of interest can be provided: the wall surface temperature (thermally grounded), or the interface {gas, flame, friction} temperature at the wall surface (thermally isolated)

**




P = pressure, ~ 1000 psi

T = temperature, ~ 650 Deg F



# *"Self Renewing"* Thermocouples for Industry

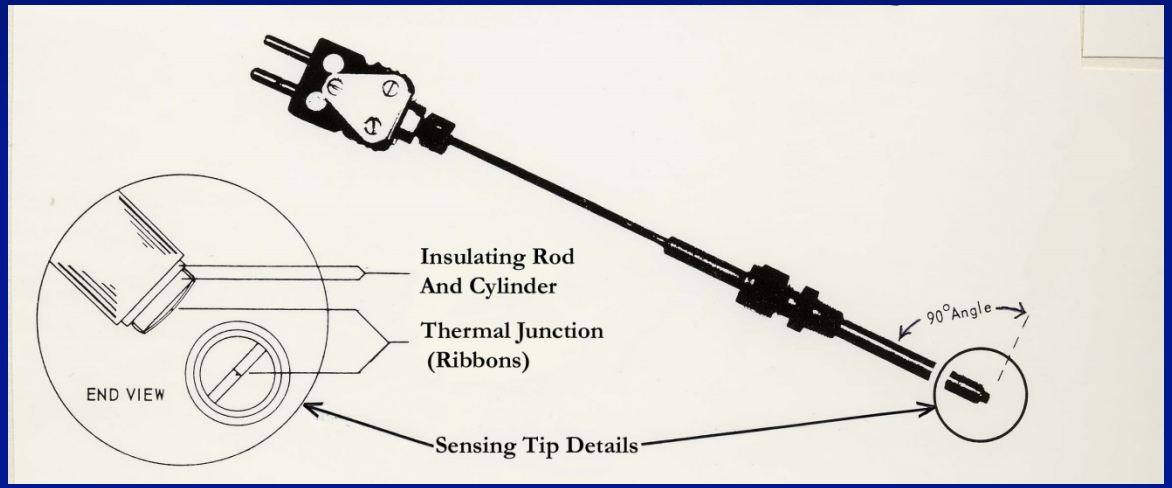
- Industrial applications include:
  - Plastic processing
  - Thermal modeling
  - Combustion gases in diesel engines
  - Moving wires or textiles
  - Brake lining interface temps



- Unique performance characteristics
  - True plastic temperatures, unaffected by mold wall heat-sink
  - Sensor can be shaped or machined to match wall surface contours – Mold walls, cylinder, manifolds, bearings
  - Multiple sensors can be located within a single housing with exact positioning

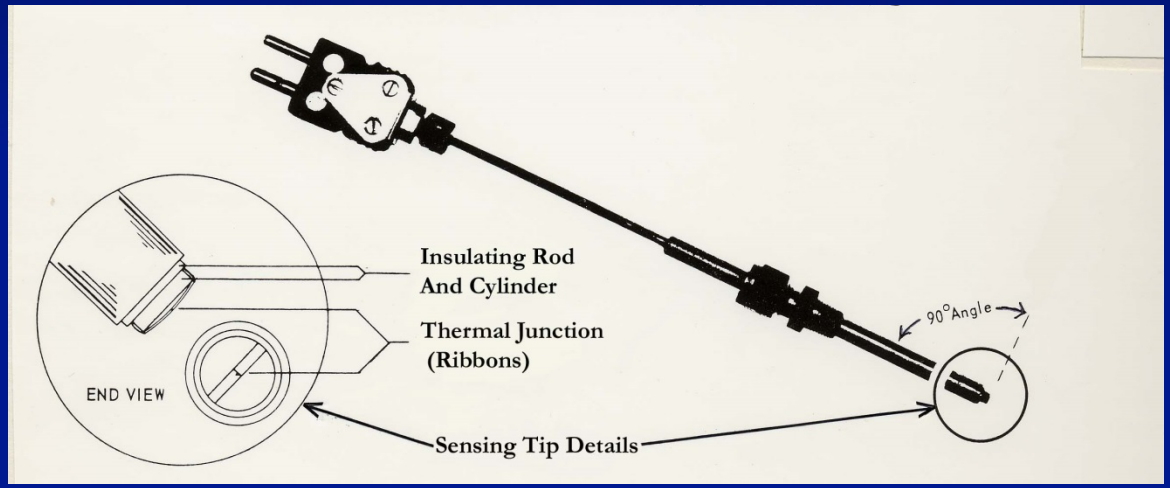
# *"Right-Angle"* Ribbon Thermocouple

- Patented design



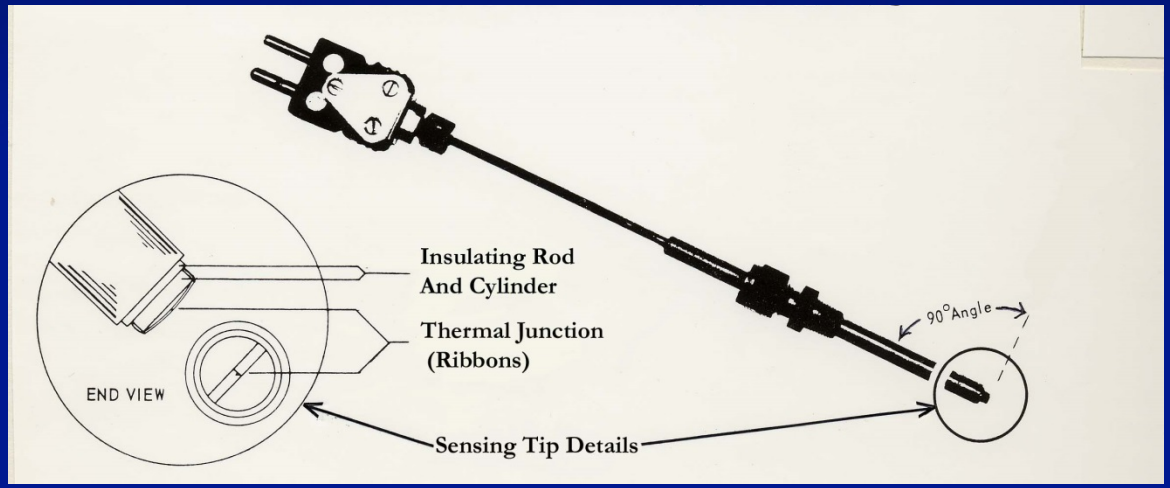
# *"Right-Angle"* Ribbon Thermocouple

- Patented design
- Millisecond Response time



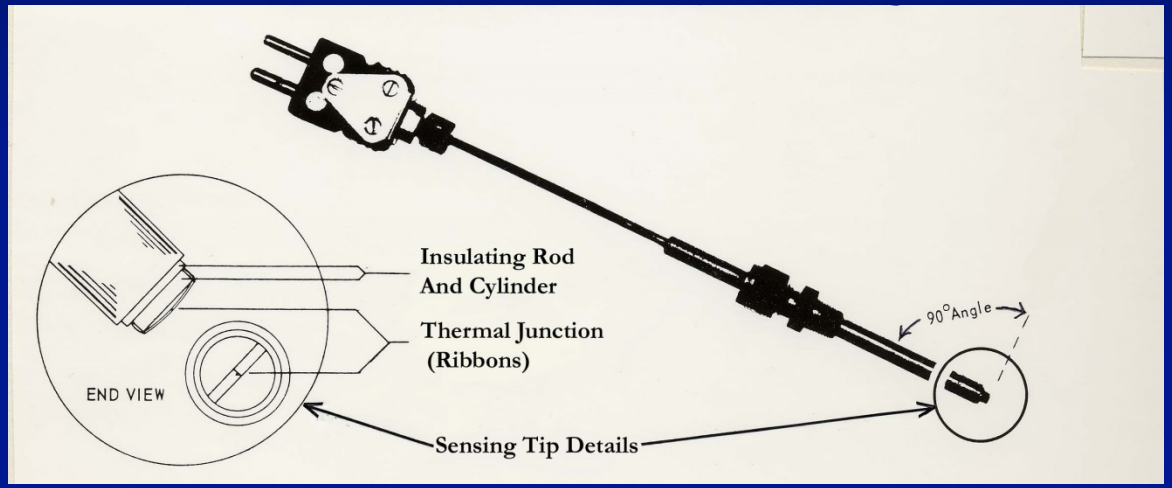
# *"Right-Angle"* Ribbon Thermocouple

- Patented design
- Millisecond Response time
- Pressures to over 50,000 psi.



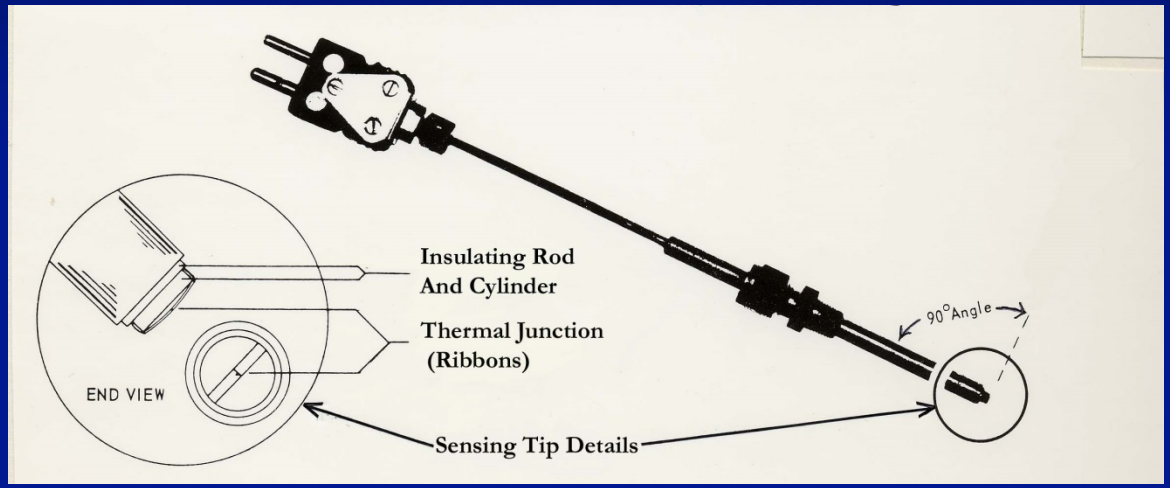
# *"Right-Angle"* Ribbon Thermocouple

- Patented design
- Millisecond Response time
- Pressures to over 50,000 psi.
- No conduction Error – provides absolute temperature



# *"Right-Angle"* Ribbon Thermocouple

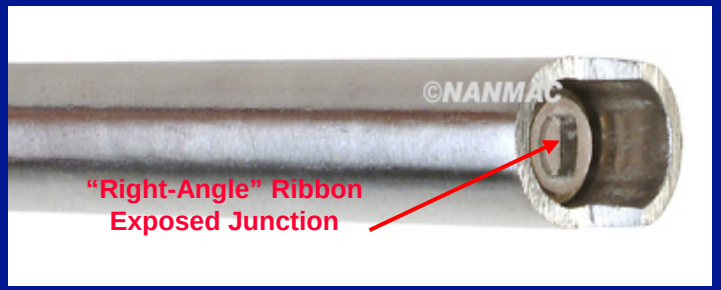
- Patented design
- Millisecond Response time
- Pressures to over 50,000 psi.
- No conduction Error – provides absolute temperature
- Temperatures > 2300˚C



# *"Right-Angle"* Thermocouples for Research

- Research applications include:
  - Rocket nozzle exhaust gases
  - Profile temperatures within chambers or pipelines
  - Flat-bottom, bored holes within walls

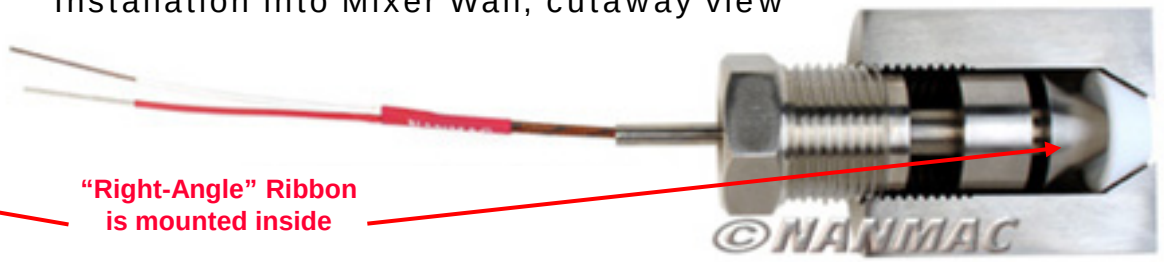
- Unique performance characteristics
  - Thermocouple junction is thermally isolated from the thermowell / mounting fixture
  - Thermowell can be designed with "radiation shield" for specific gas temperatures that are unaffected by chamber wall heating
  - Thermal junction (ribbon) is parallel to isotherm



# *"Right-Angle"* Thermocouples for Industry

- Industrial applications include:
  - Gases or liquids in pipelines
  - Mixers for food, propellant or pharmaceutical process
  - Petrochemical systems
  - Smoke stacks and exhaust pipes
- Unique performance characteristics
  - Thermal sensor can be "Isolated" for sanitary applications
  - Various mounting configurations: In-wall, in-stream, adjustable immersion
  - Cryogenic temperatures

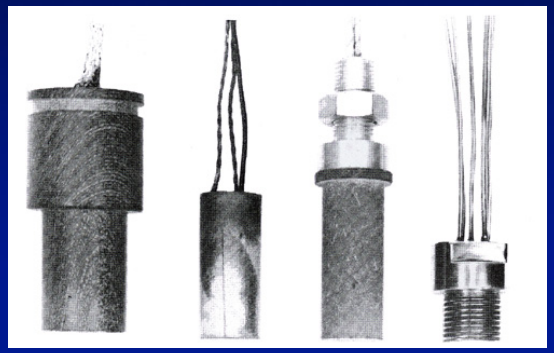

Installation into Mixer Wall, cutaway view

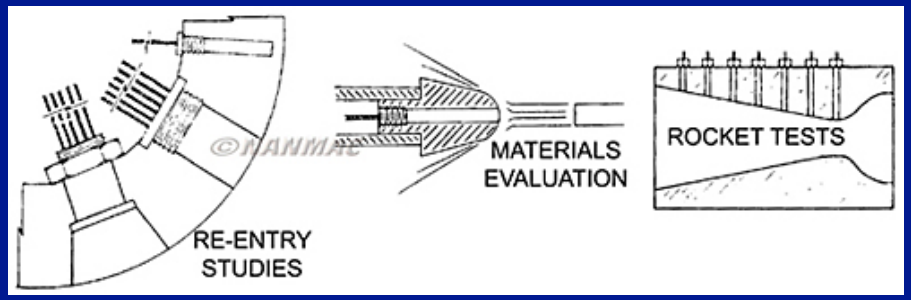


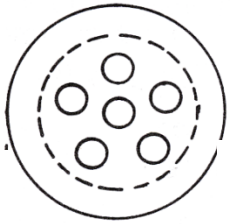
# *"Multi-Function"* Thermocouples for Research

- Combine multiple **Eroding** & **Right-Angle** thermocouples within a single housing
- Thermocouple housing made from test-wall material to replicate exact thermal properties
- Heat flux & heat transfer studies, Ablative materials research

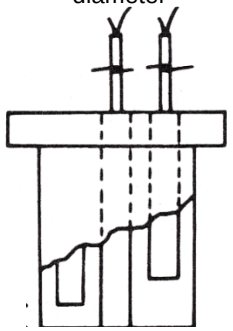
- Surface measurements and in-wall temperatures at the same time





As small as 1/2 Inch diameter



Combine Eroding & Right-Angle sensors within one housing

# NANMAC

## Quality Program

www.nanmac.com info@nanmac.com Tel: 001.508.872.4811 Fax: 001.508.879.5450

# Nanmac Quality

- Quality Management System per ISO 9001:2008 certified by TUV
- Calibration in accordance with ASTM specification E220-07, traceable to National Institute of Standards and Technology (NIST)
- Calibration process capable of up to 1500˚C
- Initial Calibration Tolerances per ASTM E230 and ANSI MC96.1
- Pressure test lab equipment to 50,000 PSI
- Vacuum leak test equipment to $10^{-7}$ Torr
- Calibration & Test records on file for minimum of five years after date of manufacture

TÜV USA
TÜV NORD GROUP

# CERTIFICATE

## TUV USA Inc.

hereby certifies that

## Nanmac Corp.
## 1657 Washington Street
## Holliston, MA 01746 USA

has established and applies a quality system for

**Manufacture of standard and custom temperature sensing assemblies and systems including calibration of thermocouples and RTDs, and distribution of temperature sensing accessories.**

Proof has been furnished that the requirements according to

**ISO 9001:2008**

are fulfilled.

Further clarifications regarding the scope of this certificate and the applicability of ISO 9001:2008 requirements may be obtained by consulting the organization.

**Certificate Registration No.**

**15-1804**

**Effective:** November 5, 2015

**Expires:** September 15, 2018

**Date of Issue:** November 5, 2015

Quality Systems Division
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DAkkS
Deutsche Akkreditierungsstelle
D-ZM-18830-01-00

NANMAC

Foremost in Temperature Measurement™

# NANMAC

# Quality

# Performance

# Solutions

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