MODEL 909F
WORKING STANDARD
PLATINUM RESISTANCE
THERMOMETER

ISOTECH

Isotech North America
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Drawing Number: 909F-20-01
Packing Instructions for Return of 909F

GUARANTEE

This instrument has been manufactured to exacting standards and is guaranteed for twelve months against electrical break-down or mechanical failure caused through defective material or workmanship. Failure as a result of misuse is not covered. In the event of failure covered by this guarantee, the instrument must be returned, carriage paid, to the supplier for examination, and will be replaced or repaired at our option.

FRAGILE CERAMIC AND/OR GLASS PARTS ARE NOT COVERED BY THIS GUARANTEE

INTERFERENCE WITH, OR FAILURE PROPERLY TO MAINTAIN THIS INSTRUMENT MAY INVALIDATE THIS GUARANTEE

RECOMMENDATION

The life of your **ISOTECH** Instrument will be prolonged if regular maintenance and cleaning to remove general dust and debris is carried out.

We recommend this instrument to be calibrated annually

Serial No:..

Date:..

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STANDARD THERMOMETER

Various producers of standard platinum resistance thermometers quote the performance of their product in various ways:

Tinsley say of their 5187SA 25.5Ω thermometer	Reproducibility ±0.001°C Accuracy ±0.001°C over 0 to 100°C
Y.S.I.	**DO NOT SAY ANYTHING**
Chino quote various drift rates	From 0.001K/year for the 25.5Ω up to 630 to 0.01°C/100 hours when a thermometer is used above 850°C. Their reproducibility is 0.001K.
CLAL drift	10 cycles - 500 hours at 660°C = 0.01Ω

The following definitions from the International Vocabulary of Metrological terms show that "Accuracy", "Reproducibility" and "Drift" do not define the performance of an S.P.R.T.

The real criteria is how accurately can an S.P.R.T. measure temperature and with what uncertainty.

Using a "Measurements International" bridge it is possible to resolve the signal from an S.P.R.T. to ±0.00005K.

In a fixed point cell it is possible to realise the ITS-90 values from about .15mK for the Triple Point of Water and Melting Point of Gallium to between 2 & 4mK at the Silver Point.

With a fixed resistor and the best calibration 0.05ppm uncertainty is possible.

In addition is the reproducibility of the S.P.R.T. and various other small uncertainties; from all this the overall uncertainty can be estimated.

Uncertainties also vary depending on the temperature range of calibration.

Isotech's 909 and 962 thermometers are sufficiently stable to conform to uncertainties translated overleaf Models 670 and 96178 can be calibrated as tabulated overleaf or at extra cost to the uncertainties of issue 26 of our schedule tabulated on page 6.

The annual drift, although of interest is of little importance to the calibration process. Certainly 1mK per year drift is an impossibility if the thermometer is used regularly from 90K to 661°C and Chino have refused to replace a thermometer with higher drift rates than their literature states.

United Kingdom Accreditation Service

CALIBRATION LABORATORY
No. 0175

NAMAS
National Accreditation of Measurement And Sampling

SCHEDULE

Address of permanent laboratory	Category 0 — Permanent Laboratory
Isothermal Technology Ltd Pine Grove Southport Merseyside PR9 9AG Telephone : Southport (01704) 543830/544611 Fax : 01704 544799	Calibration performed on permanent laboratory premises APPROVED SIGNATORIES Head of Laboratory: Mr J P Tavener Deputy: Mr D J Ayres Mrs A S Blundell, Mr D Southworth, Mr N Davies, Mr A Orme Issue No: 13 — Date: 24 February 1997

Measured Quantities for which UKAS has granted NAMAS Accreditation

Item	Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty (±)*
	TEMPERATURE		
1	Platinum thermocouples	0 to 1100 °C	1 K
		Above 1100 to 1300 °C	2 K
2	Other thermocouples	-196 °C	0.5 K
		-80 to 250 °C	0.3 K
		Above 250 to 660 °C	1 K
		Above 660 to 900 °C	2 K
		Above 900 to 1100 °C	3 K
		Above 1100 to 1300 °C	4 K
3	Compensating and extension cables	-25 to 200 °C	1 K
4	4-wire platinum resistance thermometer		

Uncertainty (±)

Temperature	(°C)	Range 1	Range 2	Range 3	Range 4	Range 5
BP Nitrogen	-196		10 mK	10 mK	10 mK	
TP Mercury	-38.8344	2 mK	2 mK	2 mK	5 mK	
TP Water	0.01	1mK	1 mK	2 mK	5 mK	10 mK
MP Gallium	29.7646	2 mK				
FP Indium	156.5985		3 mK			
FP Tin	231.928		3.5 mK	3.5 mK	5 mK	10 mK
FP Zinc	419.527			3.5 mK	5 mK	10 mK
FP Aluminium	660.323				10 mK	25 mK
FP Silver	961.78					40 mK

Note: TP = Triple Point, MP = Melting Point,
FP = Freezing Point, BP = Boiling Point

*The Expanded Uncertainty is given for k=2, providing a level of confidence of approximately 95%

Issued by the United Kingdom Accreditation Service — Sheet 1 of 3

[illegible]

UKAS
0175
Calibration performed on permanent laboratory premises

Schedule of Accreditation (DRAFT)
issued by
United Kingdom Accreditation Service
21 - 47 High Street, Feltham, Middlesex, TW13 4UN, UK

Isothermal Technology Ltd

Issue No: 028 **Issue date:** January 2002

DETAIL OF ACCREDITATION

Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty (k=2)	Remarks
TEMPERATURE			
Platinum thermocouples Calibration by comparisons	-50°C to 660°C above 660°C to 1100°C above 1100°C to 1300°C	0.5°C 0.8°C 2.2°C	
Calibrations at fixed points	232°C up to 962°C	0.4°C	
Gold/Platinum thermocouples Calibration at fixed points	0°C to 1000°C 420, 660, 962°C	0.1°C 0.06°C	
Other thermocouples	-196°C below 0°C to -80°C 0°C up to 50°C above 50°C up to 300°C above 300°C up to 420°C above 420°C to 660°C above 660°C to 1100°C above 1100°C to 1300°C	0.2°C 0.25°C 0.1°C 0.25°C 0.30°C 0.4°C 0.8°C 2.2°C	
Compensating and extension cables	-25°C to 200°C	1°C	
4-wire platinum resistance thermometer Fixed point calibrations			

Uncertainty (±)

Temperature	(°C)	Range 1	Range 2	Range 3	Range 4	Range 5
BP Nitrogen	-196		5 mK	5 mK	6 mK	
TP Mercury	-38.8344	0.6 mK	1 mK	1 mK	2 mK	
TP Water	0.01	0.5 mK	1 mK	1 mK	2 mK	4 mK
MP Gallium	29.7646	0.5 mK				
FP Indium	156.5985		1 mK			
FP Tin	231.928		1 mK	1 mK	2 mK	4 mK
FP Zinc	419.527			1.2 mK	2.5 mK	5 mK
FP Aluminium	660.323				4 mK	7 mK
FP Silver	961.78					11 mK

Note: TP = Triple Point MP = Melting Point
MP = Melting Point BP = Boiling Point

Measured Quantity Instrument or Gauge	Range	Best Measurement Capability Expressed as an Expanded Uncertainty (k=2)	Remarks
Calibration by comparisons	Below -40°C down to -80°C -40°C up to +50°C above 50°C up to 156°C above 156°C up to 300°C above 300°C up to 420°C above 420°C up to 660°C	7.0 mK 4.0 mK 5.0 mK 6.5 mK 20 mK 35 mK	
Fixed point cells	Mercury triple point (-38.834°C)	0.5 mK	The degree Celsius (°C) is equal to the Kelvin (K) temperature interval
	Water triple point (0.01°C)	0.15 mK	

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The enclosed uncertainties apply on condition that the measurements of resistance at the triple point of water are reproducible within the uncertainty given at that temperature. Uncertainties for thermometers which do not meet this requirement will be increased by a factor of 3 or 10, as appropriate. For the time being, metal-sheathed thermometers will be calibrated by comparison with standard thermometers at the requested points. Calibrations at the triple point of argon are obtained from comparisons with standard thermometers in a bath of liquid nitrogen.

Calibration below 0°C is optional. Ranges of calibration using combinations of fixed points other than those given above, may be accommodated on request.

3.05 accuracy of measurement

The closeness of the agreement between the result of a measurement and the (conventional) true value of the measurand.

3.07 reproducibility of measurements

The closeness of the agreement between the results of measurements of the same measurand, where the individual measurements are carried out changing conditions such as:

- method of measurement
- observer,
- measuring instrument,
- location,
- conditions of use,
- time.

Notes:

1. A valid statement of reproducibility requires specification of the conditions changed.

2. Reproducibility may be expressed quantitively in terms of the dispersion of the results

3.09 uncertainty of measurement

An estimate characterising the range of values within which the true value of a measurand lies.

Note:

Uncertainty of measurement comprises, in general, many components. Some of these components may be estimated on the basis of the statistical distribution of the results of series of measurements and can be characterised by experimental standard deviations. Estimates of other components can only be based on experience or other information.

5.16 stability

The ability of a measuring instrument to maintain constant its metrological characteristics

5.18 drift

The slow variation with time of a metrological characteristic of a measuring instrument

This instrument has taken many hours to prepare, manufacture and calibrate. To get the best results from such an instrument it is necessary to treat it with care, love and understanding.

Treat it as you would a piece of Dresden, Capo-di-Monte or Minton China.

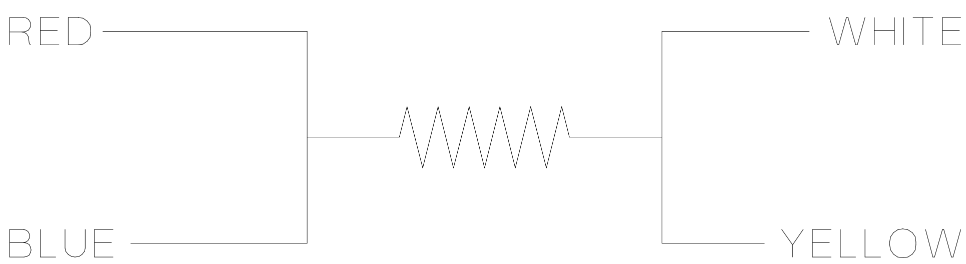
i. Have a special place in which it can be stored
ii. Do not drop or knock
iii. Do not put lateral pressure on the stem; it is rigid and will break, not bend
iv. Support by clamping the PTFE handle between soft jaws
v. The handle and top 40mm of stem should not be heated over 50°C
vi. The cable will withstand 200°C
vii Always pre-clean the quartz sheath before use with alcohol and dry thoroughly.

To keep the original characteristics:

1. Do not use the standard in conditions where there is vibration or mechanical shock.
2. Avoid thermal shock - allow the standard to warm-up and cool-down slowly.
3. Do not exceed the temperature limits (-200°C to +670°C) for 25Ω 909F's or -200°C to 550°C for 100Ω versions.

To obtain best results, the immersion recommendations given in Appendix I should be observed.

The cable is connected as follows:



<u>RETURNING YOUR 909F TO ISOTECH</u>

REPACKING INSTRUCTIONS:

Place a small foam spacer under the end of the sheath and one under the handle.

Then place two larger pieces over the end of the sheath.

Preparing the boxes

Place the two foam blocks over the closed case and lower into inner box. Pad out ends with polystyrene chips to stop the unit from moving - seal the box, lower it into the outer box and fill with chips, then lift the inner box slightly so the polystyrene chips completely surround it. Place the protective sheath on top of the chips and seal the box.

Always remember to label the box thoroughly with fragile and this way up labels.

Your unit should now be ready to send safely.

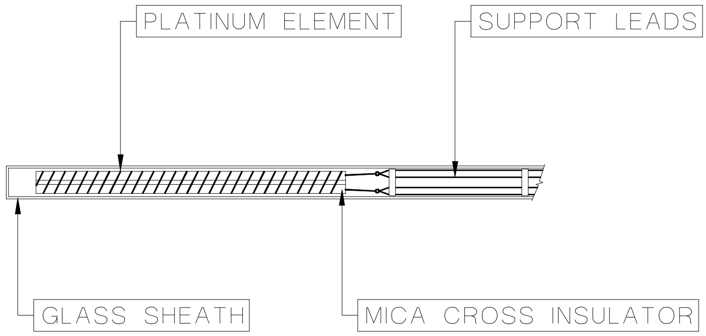
APPENDIX I

One of the principal difficulties encountered in making high precision measurements with long stem thermometers is that resulting from poor immersion characteristics of the thermometer.

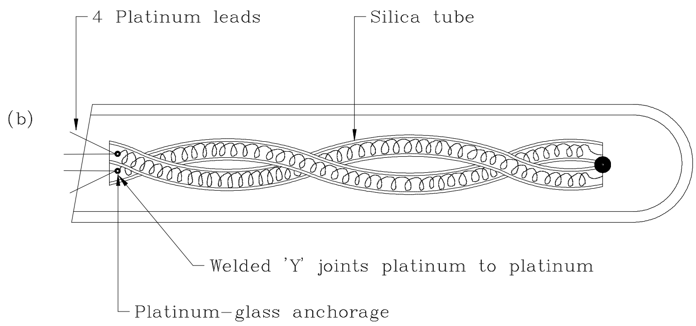
The relatively poor thermal contact between the thermometer element and the surroundings, together with the conduction and radiation down the stem, call for a very deep immersion. figure 1 shows how the measured temperature for this particular design of thermometer depends upon immersion in a triple-point-of-water cell. The immersion characteristics are noticeably different for the different types of thermometer and as we would expect, depend upon how close the platinum wire is to the wall of the stem. The heating effects found in the three types of thermometer shown in Figure 1 (a, b + c) in a triple-point-of-water cell are 1mK, 3mK and 1mK respectively for a 1mA measuring current.

It is worth remarking here that if the ultimate in reproducibility is being sought, better than 20uK for example, it is the stability of the heating effect that is likely to be the limiting factor. This arises because it becomes increasingly difficult to maintain the constancy of thermal contact between the resistance wire and the surrounding medium as the temperature resolution increases.

a.



b.



c.

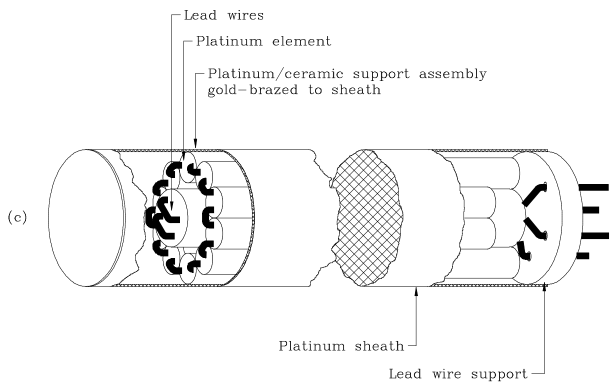


FIGURE 1 - Design of resistance element found in long-stem platinum resistance thermometers:

a. bifilar winding on a mica former
b. coil inside silica tubes
c. wires in alumina tubes; this type of element is usually mounted in a PTFE tube (Curtis 1972)

An immersion of 15cm in a triple-point-of-water cell (which is demanded for measurements of the highest accuracy) is not difficult to achieve, but at higher temperatures, it becomes difficult to produce regions of uniform temperature which are sufficiently long. The immersion required for a given accuracy does not depend strongly upon temperature because of the logarithmic nature of the dependence. For example, in Figure 2 the temperature difference between thermometer G and the triple point decreases by a factor of 10 for an increase in immersion of just over 3cm. Thus, if the outside temperature differs by 250°C rather than 25°C from that of the medium being measured, an additional 3cm immersion is all that is required. Conversely, if the outside temperature differs by only 2.5°C, only 3cm less immersion is required. Thus, if the temperature of a water or oil bath at 20°C is being measured in a room at 22.5°C, an immersion of 9cm would be required for an accuracy of 0.1mK, compared with an immersion of 12cm in the triple-point-of-water cell. This also explains why it is so difficult to make accurate measurements of high temperatures. The uniformity of temperature demanded is much greater than might be expected. On the basis of a 3cm immersion being required for each factor of 10 in temperature difference, it is obvious that a temperature difference of 0.01°C at a distance of 6cm from the element will produce the same error as a difference of 1°C at a distance of 12cm.

FIGURE 2