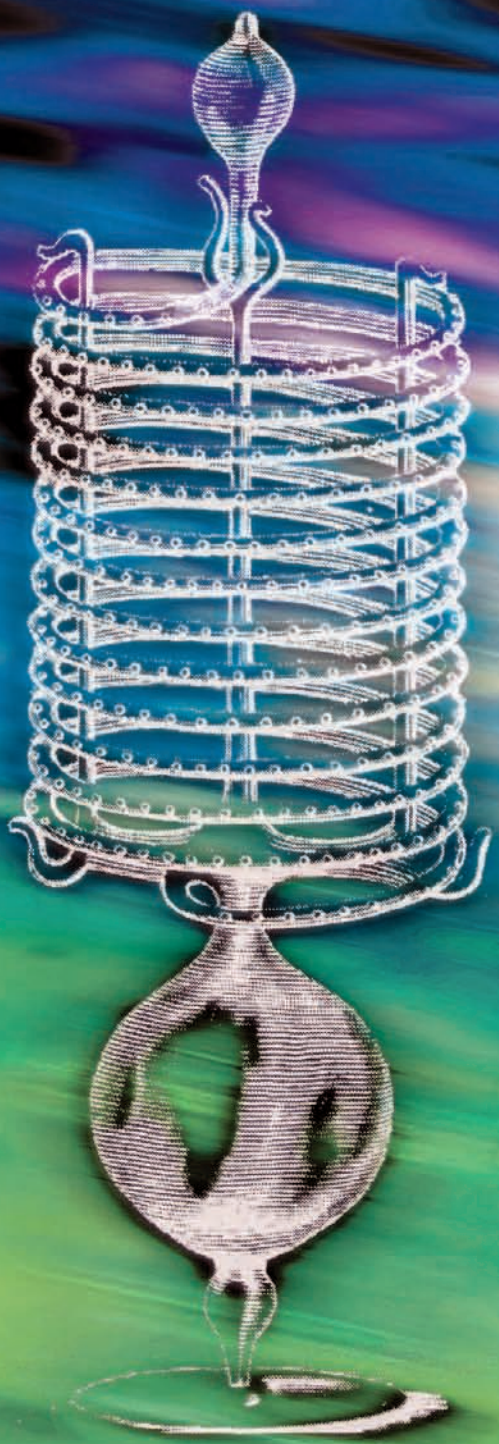


1 databookone

realizing ITS-90

Isotech's Millennium Collection of Products for the Primary Temperature Laboratory

2007-8 Edition

temperature calibration equipment & services

ISOTECH

The company is always willing to give technical advice and assistance where appropriate.

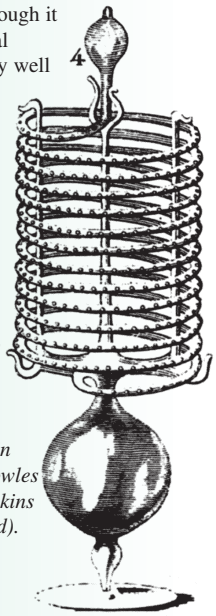
Equally because of the program of continual development and improvement, we reserve the right to amend or alter characteristics and design without prior notice.

This publication is for information only.

The thermometer with a helical scale

The sealed liquid-in-glass thermometer was invented by none less than the Grand Duke of Tuscany around 1654.

The Duke's glass blower, Mariani, was apparently a consummate workman. Some of the things he left behind were of unimaginable perfection. We can concur when we look at the beautiful instrument with a helical scale, still preserved at Florence, although it is scarcely a meteorological instrument, as the Academy well knew, saying that it was made rather "for a caprice (per una bizarria)...than to deduce the just and infallible proportions of heat and cold."



For more information on the history of the thermometers the reader is referred to:-

'A History of the Thermometer and Its Use in Meteorology' by W. E. Knowles Middleton (The Johns Hopkins Press, Baltimore, Maryland).

CONTENTS

Products in this catalogue are all CE Compliant

Introduction: for the Primary Laboratory

Benefit from Isotech's Latest range of products for the Primary Laboratory.

Since 1954 Metrology products now made by Isothermal Technology Limited have been satisfying the highest demands of science, research and industry.

From the water triple point cells of Jarrett Instrument Company (now Jarrett-Isotech) to the sealed fixed point cells designed and developed by Henry Sostmann in the 1970's (now Isotech products) they have given the very best results available and have a well deserved enviable reputation.

Benefit from our commitment to the highest standards of supervision by UKAS (United Kingdom Accreditation Service).

Isotech's Primary Laboratory realize the International Temperature Scale of 1990 (ITS-90) but we are still subject to the discipline imposed by UKAS, one of the world's leading accreditation authorities.

We can therefore completely endorse all the items shown in this manual as being the very best available, and meeting the rigorous scrutiny of the best accreditation authorities.

Benefit from our wide choice of products.

To realize all, or part of ITS-90 one needs to measure ratios and resistances to sub-millikelvin level (1mK can be equated to 1ppm accuracy) and select from ITS-90 the range of temperatures to be realized. To help, we have prepared a chart which details the fixed points and the ITS-90 calibration ranges.

This, Databook 1, details the products required to establish a Primary Temperature Calibration Laboratory to the highest standards available. Beginning with the apparatus and ITS-90 fixed points the databook continues with the reference thermometers and thermocouples needed, followed by the instruments and fixed resistors.

Benefit from our Journal of Thermometry

To provide knowledge of how to organize a Primary Laboratory and use the products purchased a set of Isotech Journals of Thermometry provides all the information needed. Details can be found in Databook 5.

Primary or Fixed Point Laboratories

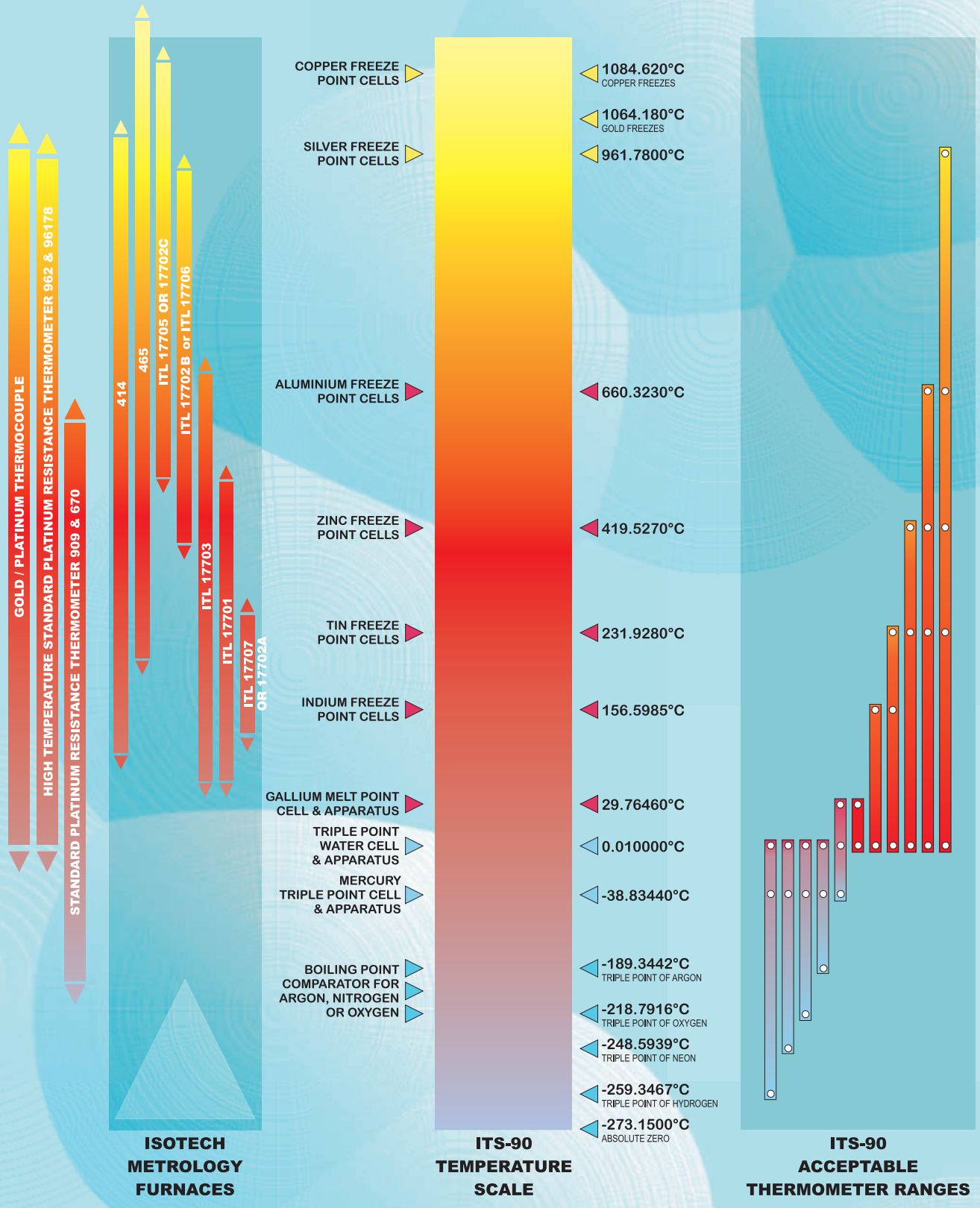
The Primary Laboratory requires the finest equipment available (to claim to have the cheapest Primary Laboratory is an unworthy boast and self-condemnation).

The International Temperature Scale of 1990 (ITS-90) splits the temperature range from -200°C to +1000°C into as many as 7 ranges. A free ITS-90 wall chart is available by contacting Isotech. (also see overleaf)

Standard thermometers for the Primary Laboratory are specially selected to be used within individual narrow temperature spans and to have optimised stability over their working ranges. After 5 years of continuous research, and by adopting the very latest materials, we have developed a new generation of thermometers designed to give stabilities and reproducibilities better than ever before.

The indicating instrument must also be the best available, and after considerable research, we have selected an outstanding automatic instrument. It is the most modern version of a bridge designed at the National Research Council in Canada; and has a resolution of 0.1nanodegrees Celsius. This bridge lies at the cutting edge of technology. The T. T. I. 3 as we call it is described fully in the text which follows.

www.isotech.co.uk/primary



ISOTECH METROLOGY INSTRUMENTS

for the MILLENNIUM

FOR FULL DETAILS CONTACT ISOTHERMAL TECHNOLOGY LIMITED, PINE GROVE, SOUTHPORT, MERSEYSIDE, PR9 9AG, ENGLAND
TELEPHONE NUMBER +44 (0) 1704 543830 FAX NUMBER +44 (0) 1704 544799 EMAIL INFO@ISOTECH.CO.UK HTTP://WWW.ISOTECH.CO.UK

Isotech Metrology Instruments for the Millennium

The Jarrett-Isotech Range of Water Triple Point Cells

Why the Jarrett-Isotech Cell is the best standard.

The Jarrett-Isotech range of Water Triple Point Cells is unique.

Unique in being in production for over 45 years. Unique in having 12 steps in the water purification process.

Unique in having the most comprehensive evaluations ever made on Water Triple Point Cells performed on it.

One assumes that every Water Triple Point Cell, no matter from which source will be the same.

This is not so. Each manufacturer employs his own design of distillation plant to produce the pure water that goes into the Cell, and cleans the Cell in different ways.

The Jarrett Instrument Company and in particular its proprietor James L. Cross devoted 45 years with no other product in his range, to the understanding and perfection of the Water Triple Point Cell.

As improvements became possible, or research showed that additional precautions were necessary, additional steps were placed in the distillation process until, for the past 20 or more years the design as it is currently produced has been available as the World's Temperature Standard.

In 1980 a full evaluation of over 20 Jarrett Cells was undertaken and the results showed the high reproducibility of the Jarrett production over a very long period of time.

It will keep its value for between 10 and 20 years, no other manufacture has sufficient data to justify this claim.

In 1997 the late Henry Sostmann wrote a report summarising a number of important International and National Comparisons on Water Triple Point Cells. The Jarrett-Isotech Cells in many cases formed the reference to which other cells were compared, and in the other intercomparisons our cells were always the best. Before you choose a water triple point cell ask for a copy of Henry's summary report.

Three fundamentally different designs of Cells are available from Isotech, the type A Cell design with a McLeod gauge which enables the vacuum to be assessed, or the type B in which the reentrant tube is longer and hence sticks out of the apparatus and our unique K. T. cell.

For optimal realisations we use, and recommend the type A11.

Isotech offers the following range of Cells, the A11 and B11 are the preferred models. You can purchase the cells with a certificate of conformity, or preferably UKAS certification.

Isotech's unique K.T. Water triple point cell.

Reverting to the very first designs of water triple point cells, Isotech produce a cell with Isotopic Analysis, a McLeod guage to assess any trapped air and an attached flask where the cell's water can be transferred and redistilled.

By accounting for these sources of uncertainty we claim that this cell represents the ultimate reference for those requiring cells as close to ITS-90 as possible.

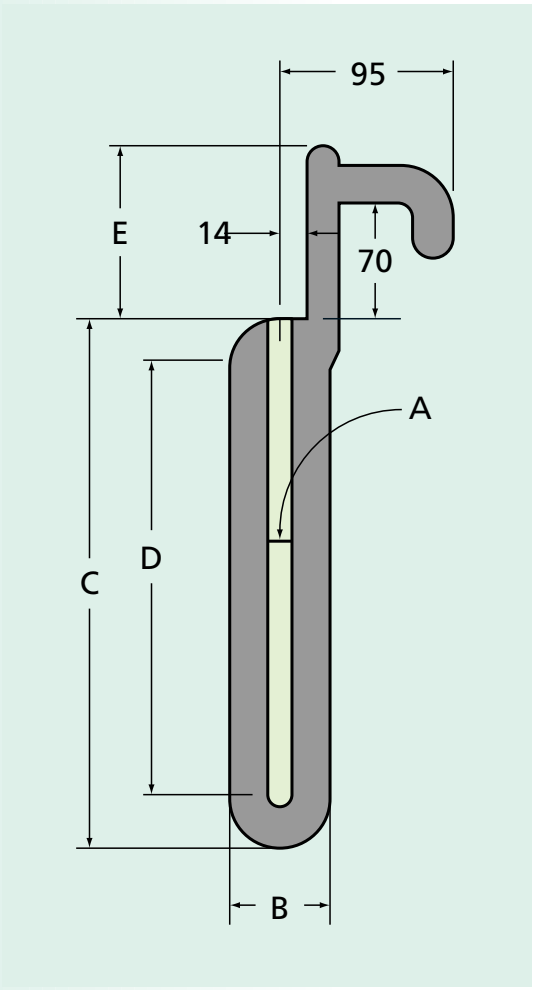
Please ask for a copy of a comprehensive report describing the cell, its operation and performance.

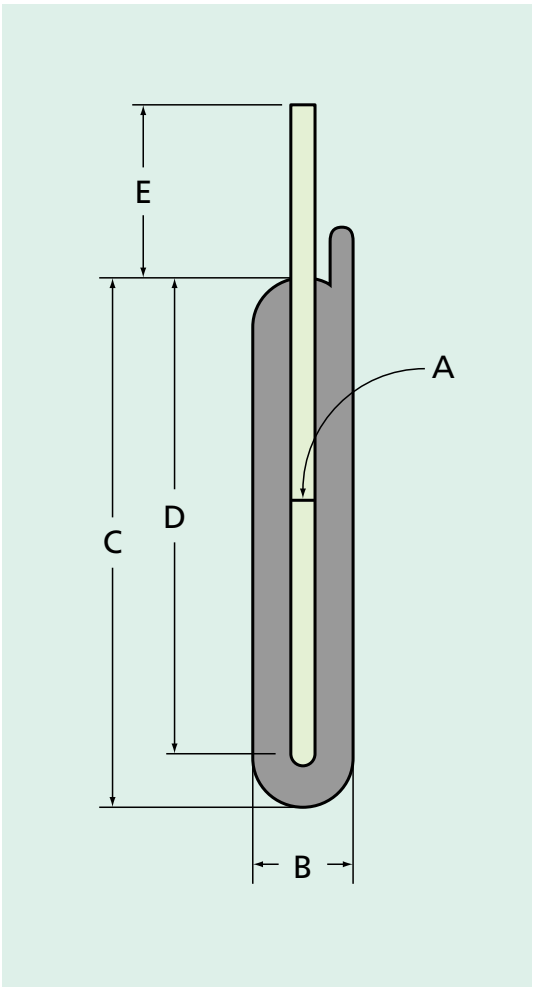
The Jarrett-Isotech

Triple Point of Water Cells: Physical Features

Type A cells (fig 1) were designed by Dr. H. F. Stimson at NBS. A tubular glass extension at the top of the cell serves as a convenient handle for lifting and carrying the cell, as a hook for supporting it in an ice bath, and as an indicator of partial pressure of air in the cell.

Type B cells (fig 2) were designed at NRC of Canada. The thermometer well extends 100mm above the top of the cell. Heat transfer to the ice mantle may be essentially eliminated by keeping these cells packed in ice to the top of the well extension, or by immersing them sufficiently in a Water Triple Point Maintenance bath.





Nominal Dimensions in mm

Model	A	B	C	D	E	Comments
A11-50-270	11	50	350	270	100	Highly recommended (1) (2)
A13-50-270	13	50	350	270	100	Large re-entrant tube
B8-30-130	8	30	160	130	0	Was D8, Ideal for Isocal-6, NPL type 16
B1-40-210	12	40	290	210	75	Replacement NPL type 32
B12-46-210	12	46	290	210	75	Fits Oceanus, Hydra, was C12
B11-50-270	11	50	350	270	100	Highly recommended (1) (2)
B11-65-270	11	65	350	270	100	NRCC's favourite Cell (2)
B13-65-270	13	65	350	270	100	Large re-entrant tube
B16-65-270	16	65	350	270	100	Larger re-entrant tube

452 Water Triple Point

Ice Mantle Maker

INTRODUCTION

Are you fed up with cold wet hands, and hours of frustration when you produce an ice mantle in your Triple Point Cell?

Change your life and try the Isotech Ice Mantle Maker.

We developed it, like so many of our products, for our own use in our UKAS facility. It is so easy that we actually want to make more mantles. The days of dreading making ice mantles are gone with the Ice Mantle Maker.

It works by using a specially designed anti-gravity heat-pipe. The heat-pipe exits the cell and exchanges the heat in a small container filled with carbon dioxide or preferably liquid nitrogen.

Because of the low temperature gradient along the heat-pipe the ice mantle is formed close to 0°C, and so beautiful strain free mantles are formed.

The mantle maker works equally well when you wish to increase the thickness of ice at the bottom of the cell. By keeping only a cc of alcohol in the cell the heat transfer is focused around the bottom of the cell.

BACKGROUND

In 1969 John Evans of N.B.S. America described a method of heat removal and ice mantle growth in a water triple point cell. His materials, liquids, etc. were adequate at the time and the idea has been considered as a novelty since.

Now, Isotech have brought the liquids and technology right up to date to effectively solve the problem of trouble free and strain free fast ice mantle manufacture.

ICE BRIDGE PREVENTION COLLAR

In developing the heat pipe Ice Mantle Maker we worried that an ice bridge can form across the top of the cell.

We therefore developed a clever collar that sits around the cell and prevents ice formation at the water/vapour interface.

We include this free with the Mantle Maker provided you inform us of the cell diameter with the order.

Weight	250g
Typical time to create a mantle	20 to 30 minutes using a Jarrett-Isotech A11 Water Triple Point Cell.*

* Longer or shorter times for larger or smaller cells.

Options

Additional Ice Bridge Prevention Collar

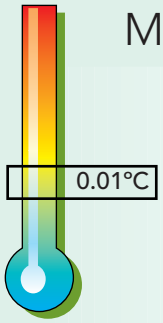
How to order

452 Ice Mantle Maker and one ice bridge prevention collar

Please specify A) Cell Type or
B) Outside diameter of Water Triple Point Cell (mm)
C) Depth from shoulder of Cell to water level (mm)

Water Triple Point

Maintenance Bath



The Isotech Model 18233 Water Triple Point Maintenance Bath is not an adaptation of general-purpose commercial equipment, but is specifically designed to maintain and safeguard 1 to 4 Water Triple Point Cells, for the calibration of thermometers on the International Temperature Scale of 1990.

It will maintain the water triple point for long periods of time (many months, with occasional attention) so that this fundamental fixed point of thermometry is continuously available.

It will ensure the integrity of the cells against catastrophic freezing, which can break the glass envelope.

1. The case of the bath is made of special-quality double-skinned laminated wood for best thermal resistance and stability.

2. Cooling is accomplished by efficient solid-state Peltier chilling modules, powered so that the rate of temperature change is very small.

3. Two safety circuits are provided to prevent cell breakage by excessive ice formation. The controls can be set to a resolution of better than 0.001°C. If control fails in such a mode that the Peltier chillers are full on, a warning light is lit to give the operator 20 minutes in which to take appropriate action. If no action is taken, the apparatus is automatically switched off and the cells are allowed to warm slowly.

4. Passive safety is provided by the physics of ice. If the Peltier chillers become too cold, the first ice which forms is on the water tank surfaces directly in contact with the chillers, effectively inhibiting further rapid transfer of freezing to the bath water.

5. A specific stirring rate of bath fluid is provided by bubble agitation which prevents the water from stratifying.

6. The bath is manufactured to the strict requirements of BS 5750 and ISO 9000. Each finished bath becomes part of the Isotech UKAS working calibration Laboratory for two weeks or more, during which use the control and alarm circuits are set and checked for optimum performance. It is released only when Isotech is entirely satisfied with its performance.

The bath has a long and successful history and is relied on by many National Laboratories throughout the world. This history of successful use is one of the most important reasons for choosing Isothermals' products.

7. Recent design changes mean that the bath will work in higher ambient temperatures and, if a chiller module fails, it can be replaced easily.

Model No	ITL-M-18233
Temperature Range	+0.01°C±0.3°C
Accuracy	±0.001°C ±0.0001°C in Cell
Ambient Limits	18°C to 28°C
Time to temperature	na
Power	150W typical, 100-130 or 208-240VAC* 50/60Hz (*field changeable)
Dimensions	Height 910mm Width 635mm Depth 710mm
Weight	66kgs

Options

Triple Point of Water Cells (see page one/6)

How to order

ITL-M-18233 Water Triple Point Maintenance Bath

Please specify which type of cells will be used so that we can supply the correct cell holder.

No Ice required, Automatic, Vibration free,
Electrical noise free, Solid state cooling, Double safety circuits

Sostmann-Isotech

Gallium Cell

INTRODUCTION

Second only to the Water Triple Point and in many ways, because of its ease of use and purity, superior to it, is the Gallium Melt Point. At 29.7646°C this is a very convenient temperature. Its existence on the ITS-90 Temperature Scale is due almost entirely to the efforts of one man, the late Henry Sostmann.

Henry, and a small team of dedicated metrologists created commercially available and user friendly versions of the fixed points required to calibrate the highest quality standard thermometers from the Triple Point of Mercury to the Silver Point. It is no exaggeration to say that modern Fixed Point thermometry would not exist as we know it without Henry.

In 1988 his adopted company Yellow Springs Incorporated decided to sell off the Metrology Division, and Isotech was fortunate enough to become the custodian of these wonderful products. Henry continued to work as a consultant for Isotech until his untimely death in 1999.

The Gallium Cell and Apparatus epitomises his efforts in metrology and in recognition of his work we asked and got his permission to call it the Sostmann-Isotech Gallium Cell.

Henry presented a paper in which he described the history of thermometry and the development of the Gallium Cell and his other Sealed Fixed Points. Please ask for a free copy.

Following Henry's original work, recently Isotech have fully reconsidered his design for the Millennium. We have upgraded the purity of the Gallium, compared 10 and more recently 20 year old cells with a newly made cell, and intercompared cells with National Standards. The result of these investigations have left us satisfied that Henry's original design of cell needed no changes to meet the requirements of "optimal realisations" - the highest standard so far defined.

Henry's Melting Point Apparatus has been changed a little by fitting a timer to enable the Gallium Point to be automatically available every day of the year.

You will find this ITS-90 Fixed Point the very best that exists. *Some of its performance and other features are described overleaf.*

Our Gallium design is so good that if you prefer to put the Cell into a glass tube so that you can control the gas and its pressure, if you prefer a 2 week, or longer, plateau length, if you prefer liquid baths, if you want a housing for more than one Gallium Cell:

Isotech can supply the following accessories:

- Re-sealable Glass Holder
- 915 Bath for One Cell
- Gallium Maintenance Bath for up to Five Cells

TRANSPORTATION

Gallium Fixed Point Cells cannot legally be hand carried on aeroplanes. They must be packed in dry ice for air freight and shipped in accordance to IATA specifications.

The design of the Sostmann-Isotech Gallium Cell is ideally suited to this method of transportation and for 20 years over 600 of our Gallium Cells have been transported to all parts of the globe without damage.

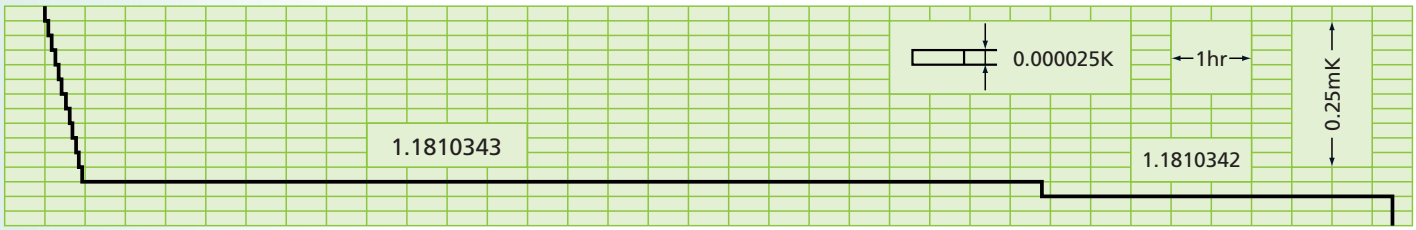
Features:

- 20 years of deliveries world-wide without a breakage
- 99.999,99% purity. for a slope-free plateau.
- A new Gallium plateau every day, all day, forever.
  Switch it on and forget it!
- Long term stability.
  After 10 years our Cell is still within 40µK of our newly made Reference Cell, audited to within 0.000030°C of our Nation's Standard Cell, and within 0.000,031°C of Italy's National Standard.
- Reproductibility day to day of ±0.000,025°C.
- Elapsed time indicator tells where you are on the plateau.
- 250mm immersion.
- No maintenance.
- No attention required.
- No liquids.
- UKAS certification available relating the Cell to ITS-90.

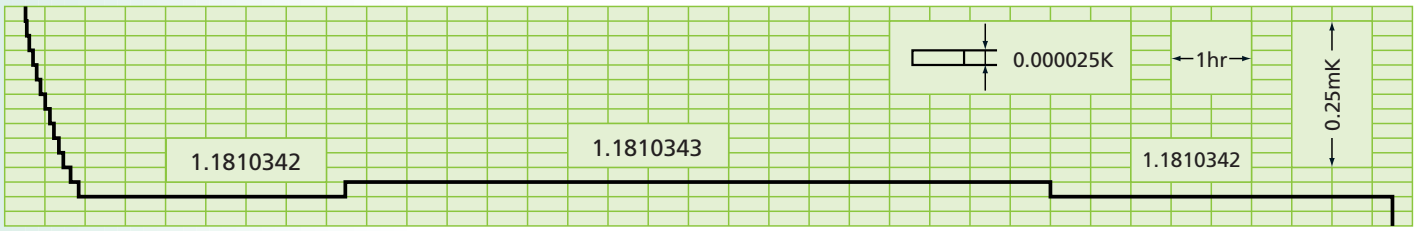
The Perfect Gallium Point

for the new Millennium

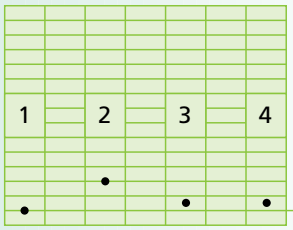
Melt 1 Day1



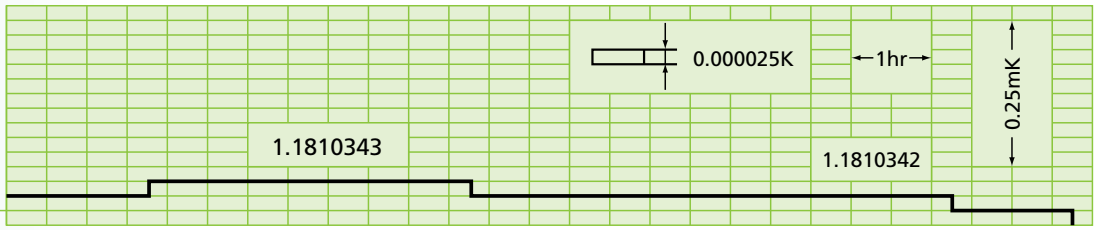
Melt 2 Day2



Shown on the same scale

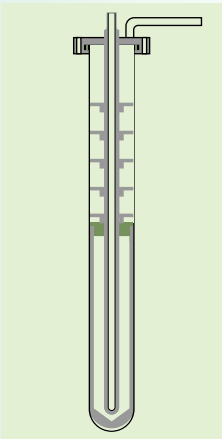


Melt 3 Day3



1 Value of 10 years old Cell
2 Value of N.P.L.'s Cell
3 Value of I.M.G.C.'s Cell
4 Value of Cell open for over 3 years

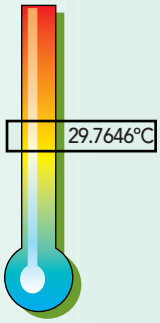
Re-sealable Glass Holder



Gallium Maintenance Bath
(For up to Five Cells)

915 Parallel Tube Liquid Bath
(For One Cell)

The Gallium Apparatus



Model 17402B Gallium Apparatus is not an adaptation from general purpose equipment, but is designed specifically to realize and maintain the Gallium Cell on the melt plateau, for calibration of thermometers on the International Temperature Scale of 1990.

The Cell will realize the melt plateau of gallium (29.7646°C). It is furnished with a certificate of verification or optionally full UKAS calibration can be provided at extra cost.

The apparatus will permit the gallium to melt coaxially over 12 to 16 hours. It is uniquely designed to also freeze the cell from the bottom up, which eliminates the danger of damage due to the expansion of gallium during freezing.

1. The Cell contains about 0.5 kg of electronic grade gallium, 99.999999% pure. The gallium is contained within a resilient inner housing, which safely allows its solidus expansion, surrounded by an aluminium sleeve for longitudinal uniformity of temperature.

2. Since the melting temperature of pure gallium is a recognized constant of nature (and a defining Fixed Point of ITS-90) recertification is normally never required.

3. Model 17401 Gallium Cell may be used, without the thermal environment provided by Model 17402B Gallium Apparatus, in a well controlled bath (see Databook 2). However, the advantages of automatic operation, convenience and cell protection, recommend the use of the Model 17402B environment in most cases.

4. No external connections other than power are required.

5. A completely automatic electronic control system provides a precise means for realization and maintenance of the plateau. The Apparatus can be turned on by a timer an hour before the laboratory day begins, the plateau utilized throughout the working day and the system recycled overnight. A thermal sink is provided which forces the gallium to refreeze upwards from the bottom (gallium expands when it freezes, requiring a specific freeze orientation to avoid rupturing the cell).

6. Confidence is a major requirement in a standard. The Isothermal Gallium Cell and Apparatus have a long (20 year) history and have been successfully used in most National and Primary Laboratories world-wide. This is one of the main reasons for choosing the Isothermal Cell and Apparatus.

7. The Cell and Apparatus are manufactured to the strict requirements of BS 5750 and ISO 9000. Each finished unit becomes part of the Isotech UKAS working Calibration Laboratory for two weeks or more, during which use the control circuits are set and checked for optimum performance. It is released only when Isotech is entirely satisfied with its performance.

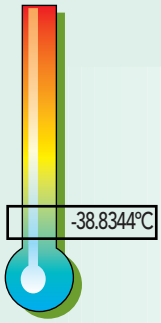
An International intercomparison between our open Gallium Cell and NISTs standard agreed within 10 micro Kelvins. Our uncertainty of Gallium Cell certificate is now the smallest outside the USA.

Model	ITL-M-17401 cell ITL-M-17402B cell apparatus
Temperature Range	29.7646°C
Accuracy	Refer to page 15
Ambient Limits	15°C to 28°C
Cycle Time	With cell at 20°C, time to plateau is 1 hour maximum. Recycling, including freezing the cell is typically 3 to 4 hours
Plateau Duration	Not less than 12 hours under specified ambient conditions; 16 hours typical
Power	75 Watts typical 100-130 or 208-240VAC* 50/60Hz * field Changeable
Dimensions	Height 429mm Width 259mm Depth 181mm
Weight	7kg

How to order
Model ITL-M-17402B
Gallium Apparatus (without cell)
Please specify voltage required.
Model ITL-M-17401
Gallium Cell

Mercury Triple

Point Apparatus



INTRODUCTION

At -38.8344°C the Mercury Triple Point is probably the third most important Fixed Point of ITS-90.

The embodiment of the Mercury Triple Point was originally developed in America with a very close cooperation between Henry Sostmann and Dr. Furukawa of N. B. S. (now NIST) over twenty years ago. The physical size, materials and metal purity are identical to this original design. The Mercury is distilled four times leaving impurities of 10 to 15 parts per billion. The cells made by Isotech still use the original design, purity and supplier of Mercury.

In International Intercomparisons the cells made by Isotech have always been within the National Laboratories uncertainty of calibration and with over 20 years of successful use throughout the world the cell embodies the finest traditions of production and use. Recently Dr. Furukawa opened some of his original cells which are over 20 years old, and the Mercury was still above 99.99995% pure. A reflection of the long term performance of the design.

In purchasing the Isotech Mercury Triple Point Cell you will join an elite group of satisfied users who have been using the cell for up to 20 years.

The Mercury Triple Point Cell is normally used on its Melt Curve, although it will also give very good results whilst it is freezing.

Henry Sostmann and his team designed a cryostat to Freeze and Melt the cell which is now described.

Mercury Apparatus

This apparatus is ideal and user friendly meeting all normal requirements. There is however a document describing "Optimal Realizations" and also occasions where very long plateaus are desired. For these special applications we have another piece of apparatus called the 915 'Neptune' Bath which will give week long plateaus. *The 915 is described fully in Databook 2.*

Model No	ITL-M-17724 Cell ITL-M-17725 Apparatus
Temperature Range	-36°C to -42°C
Accuracy	Refer to page 15
Ambient Limits	18°C to 28°C
Plateau Duration	8-12 hour Plateau
Power	750W typical. 208-240 VAC, 50/60Hz
Dimensions	Height 960mm Width 600mm Depth 560mm
Weight	96kg

How to order

ITL-M-17724 Cell

ITL-M-17725 Mercury Triple Point Apparatus

Iso-technical note

Accuracy

The accuracy of an ITS-90 Fixed Point can be defined in a number of ways. Its association to the ideal ITS-90 defined temperature can be calculated by knowing the impurities in the fixed point metal, and calculating the effect on the temperature by using Raoult's law.

Such a calculation would typically give an association of -0.02mK for a Mercury Cell of 7N purity (99.99999% pure).

It is more important to measure the performance of the Cell in its Apparatus. This is done by slowly melting and freezing the cell and measuring the slopes using thermometers and bridges. Rules exist that permit the association to the ITS-90 temperature to be calculated from the slopes.

The uncertainties of this measurement must include bridge, thermometer and apparatus. Inevitably the measurements increase the uncertainties.

Traceability

If a cell is to have legal status it must also be intercompared to other Primary Standards with International traceability.

This introduces additional uncertainties.

Uncertainties

A cell made with 7N pure metal may realize the ITS-90 temperature to within -0.02mK, but excepting the calculation, once thermometers and apparatus are brought into use to measure the melt and freeze characteristics of the cell, uncertainties are introduced much larger than the calculated association.

Uncertainties represent the ability to measure the Cell that has been produced.

Confidence

A strict procedure must be followed and repeated a number of times, the results are combined statistically to obtain mean values and standard deviations, uncertainties thus calculated are to a 63% confidence level (1 Sigma). It is normal to report results to a 95% confidence level by doubling the uncertainties (2 Sigma).

UKAS

Isotech, uniquely, can issue a UKAS certificate with each cell. Our UKAS procedures, traceability and surveillance are the strictest in the world.

Our uncertainties are very small. You will not find better accuracy and traceability than with a UKAS certified Isotech Fixed Point Cell, recognized world-wide as the best.

To learn more about accuracies, uncertainties and ITS-90 Fixed Points ask for Databook 5 or visit our web site at www.isotech.co.uk/primary

Quartz encased higher temperature fixed point cells

to the highest standards ever defined

Optimal Realizations

CCT/96-8 a document issued by the CCT in 1996 describes a set of constraints and procedures which would produce the most accurate realizations of the ITS-90 in the world. This was updated in 2000.

During two years when Isotech was upgrading its Primary Laboratory in preperation for a new accreditation from UKAS. We created a laboratory in which we realized the ITS-90 temperature scale in terms described in "Optimal Realizations".

So when the term optimal realization is used in this databook it is to be understood that the cell or apparatus conforms to the highest possible standards.

Those interested in optimally realizing ITS-90 should consult the document CCT/2000-13 and Isotech's Journal of Thermometry 10.1.

The Water Triple Point Cell and Apparatus, the Gallium Melt Point Cell and Apparatus and the Mercury Triple Point Cell already described meet the requirements of Optimal Realizations.

Above gallium, ITS-90 requires:-

Indium	156.5985°C	-0.5mK	typical 6N purity
Tin	231.9280°C	-0.3mK	typical 6N purity
Zinc	419.5270°C	-0.5mK	typical 6N purity
Aluminium	660.3230°C	-0.7mK	typical 6N purity
Silver	961.7800°C	-1.1mK	typical 6N purity

The document titled "Optimal Realizations" tells us that these Fixed Points must be contained in quartz in such a way that the internal pressure of argon can be measured and adjusted to I bar at the freeze point.

It also specifies that Cells having 6N (99.9999%) purity will realize ITS-90 with typical depressions as tabled above. Further that the useable depth below the metal surface of the cell should be at least 20cm.

Having studied these and other requirements of the document, Isotech developed and can offer you fixed points conforming to the ideals of optimal realizations.

Furthermore recent research by members of the CIT has shown the desieability of impurity analysis to parts per billion rather that the parts per million traditionally supplied by the metal producer. Isotech can supply parts-per-billion analysis with our Optima realisations to special request.

Optimal Realizations are transportable and are assembled on site into one of two designs (see figures 1 and 2).

Additionally they can be supplied with UKAS certification for proven traceability.

A vacuum and pure gas supply is required to protect the Cells from contamination. Isotech can supply a complete system, please request details.

Fig 1

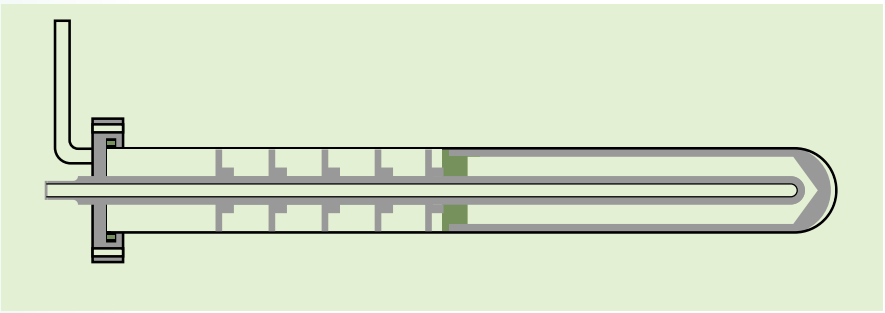
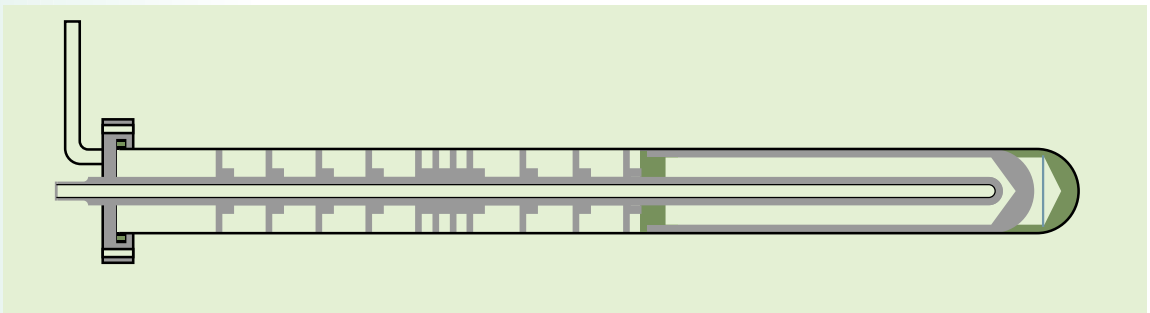
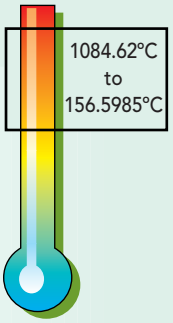


Fig 2



Sealed & Open
Fixed Point Cells



Sealed Cells

First developed during the 1970's by Henry Sostmann these cells meet all the requirements of science and industry for Fixed Point Realizations of ITS-90.

The cells now offered by Isotech are of the highest purity available and length conforms to the idealized requirements of optimal realizations except that we have sealed in 1 atmosphere of 6N pure argon at the freeze temperature for you. Sealed optimal realizations of ITS-90 are made from metal 6N purity and have a useable depth below the metal surface of 200mm. They come complete with Inconel basket, a carry case and the necessary heat shunts and reflectors to enable them to fit into our apparatus.

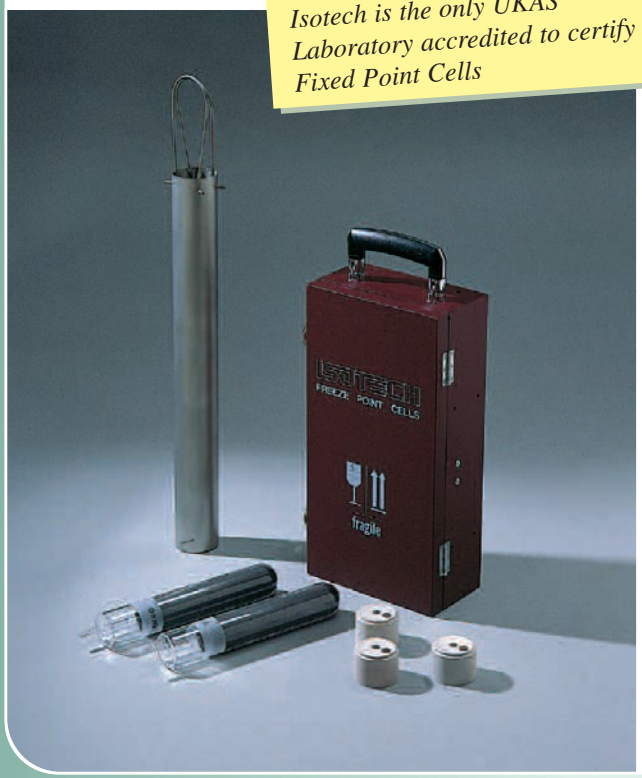
Sealed cells must be hand carried. UKAS certification is also available for sealed cells (see Databook 5).

Features of Isotech Optimal Realisations (sealed or open cells)

	Well depth below metal surface (mm)	Variation with Depth (mK/metre)	Pressure (mK/bar)
Mercury	200	7.1	5.4
TP. H_20	290	-0.73	-7.5
Ga	260	-1.2	-2.0
In	200	3.3	4.9
Sn	200	2.2	3.3
Zn	200	2.7	4.3
Al	200	1.6	7.0
Ag	200	5.4	6.0
Cu	200	2.6	3.3

Cells of International Acceptance
ITS-90 Fixed Points

Fact:
Isotech is the only UKAS Laboratory accredited to certify Fixed Point Cells



All Cells are intended for use in, and are dimensionally compatible, with the appropriate Isotech furnaces.

Diameter	typically 50mm
Length (sealed cell)	typically 275mm excluding sealing tip
Length (open cell) Indium, Tin, Lead, Zinc	520mm to underneath of flange
Antimony, Aluminium, Silver, Copper	610mm to underneath of flange
*Thermometer immersion	Below metal surface 200mm

*N.B. clients often confuse the immersion in the cell with the total immersion.

Weight	2.5kg or less, depending on metal

How to order

ITL-M-17668	Indium	156.5985°C
ITL-M-17669	Tin	231.928°C
ITL-M-17670	Lead (secondary)	327.462°C
ITL-M-17671	Zinc	419.527°C
ITL-M-18204	Antimony (secondary)	630.63°C
ITL-M-17672	Aluminium	660.323°C
ITL-M-17673	Silver	961.78°C
ITL-M-17674	Copper	1084.62°C

Quote model no and then add S for Sealed Cell or 0 for Open Cell.
Sealed Cells will be supplied if no additional instructions are given.
Other metals to special order.

Sealed & Open

Fixed Point Cells

Isotech Ultra Pure-Metal Freezing Point Cells are designed specifically to realize the liquid-solid equilibrium temperatures of certain high-purity metal elements, for calibration of thermometers at the ITS-90 Fixed Points.

Defining points of the ITS-90 include the freezing points of pure metals as shown in the table in the Specifications.

1. Cells are available as Sealed or Open Cells. All Cells contain the thermometric metals in graphite crucibles, surrounded by an envelope of pure fused quartz. Sealed Cells are completely enclosed in quartz and filled with an inert gas, which assumes a pressure of one standard atmosphere at the freeze point. Sealed Cells are consequently protected against contamination and the influence of ambient pressure. Open Cells include a gas port. A proper atmosphere must be supplied with suitable gas-handling and purification equipment. Unless circumstances are unusual, Isotech recommends Sealed Cells for all calibration laboratories.

2. All Cells are equipped with a re-entrant well for the insertion of a Standard Platinum Resistance Thermometer. The well's inside diameter is 8mm. The depth is sufficient to avoid stem losses in the thermometer being calibrated when used in conjunction with Isotech apparatus.

3. Sealed Cells are supplied with an Inconel Cell Holder, which is used to (a) contain the Cell (b) accommodate insulation above the Cell (c) allow lifting the Cell from the furnace (which must be done with tin, in realizing the equilibrium)

4. The mass of metal contained in the cell varies from 0.5kg (aluminium) to 1.5kg (silver). The volume of metal is the same in all cells.

5. Sealed Cells must be regarded as fragile and cannot endure the risks of commercial transportation. Isotech recommends that they be hand-carried from the factory. Pick-up in England will provide an opportunity for a visit to the Isotech Laboratory and some training in the use of Cells.

6. Open Cells may be shipped by common carrier, as a kit of components to be assembled by the user. Assembly instructions are provided.

7. Confidence is the main requirement from a Cell purchased commercially. Isothermal's cells have been in production for more than 20 years and are successfully in use in National and Primary Laboratories world-wide.

A Cell's performance is uniquely described only in conjunction with the apparatus used to create and maintain the freeze plateau. Isothermal's Cells and apparatus have been evaluated successfully by a number of National Laboratories.

All results have been within the National Laboratories uncertainty at the respective fixed points.

The long and successful history of our Cells and apparatus and the confidence this fact brings, is the main advantage in selecting Isothermal's product.

8. Isotech is uniquely UKAS accredited to verify the cells. A comprehensive Manual and Tutorial is also supplied.

During the 1970's Mr. Sostmann and a dedicated team of technologists developed a unique range of Fixed Point Cells that were sealed from atmospheric contamination. He undertook international inter-comparisons and his first results were published in 1972.

As part of the OIML committee Mr. Sostmann was instrumental in introducing these new designs and a new point Gallium onto the scale which was eventually to become ITS-90.

As part of the Yellow Springs company Mr. Sostmann's Cells, together with specially developed apparatus designed only to provide the best possible environment for the cells and thermometers that accompanied the Cells were distributed, tested and accepted world-wide and when in 1988 Yellow Springs decided to sell this division of the company to Isotech, Henry followed and became a consultant in the transfer of the methods of manufacture, ensuring that none of the science or skills were lost.

Following H. Sostmann's traditions, Isotech have continued to develop and improve the range by being able to issue an Internationally traceable UKAS certificate with each cell.

In 1994 Mr. Sostmann was presented with Americas highest metrology award for his outstanding contribution and devotion to temperature metrology.

When you purchase an Isotech Sealed Freeze Cell you are not just purchasing a kilo of metal inside a graphite crucible sealed within a quartz shell, you are getting the fruits of 20 to 30 years of experience and learning of not only how to make such an artifact without introducing contamination but an Internationally accepted embodiment of an ITS-90 fixed point, which has been fully evaluated in the premier UKAS laboratory.

As pedigree you can rest assured that over 600 other laboratories throughout the world are also relying on the same make of Sealed Fixed Point cell.

One disadvantage of any sealed item is that unless you can fit a pressure gauge to it, you do not know whether the seal is still good.

An innovation, suggested by Phil Metz is that we can now energise the gas inside the cell and check that there is no leak.

This development has removed the last concern about Isotech's Sealed Cells.

Free accessories:
Isotech Sealed Cells include an Inconel Cell Holder and carry case supplied free of charge, together with 2 or 3 ceramic 'bricks' and interleaving Platinum foil - recommended for the Aluminium and Silver point measurements

Traceability

"Traceability" is the ability to show an unbroken chain of relationships between a measurement and a calibration by an ultimate authority, usually one's own National Laboratory, or a recognized fundamental constant of nature. The Fixed Points of the ITS-90, which are realized by means of the equipment discussed in this section, are fundamental constants of nature and satisfy any requirement for traceability to accepted values of natural constants.

It is often convenient (and, where auditors are unfamiliar with the Scale, necessary) to establish, as well, traceability to calibration by a legal authority. Isotech is an accredited Laboratory of the British UKAS system, and can, uniquely, UKAS certify its Fixed Point Cells.

Through a system of international documents of metrological equivalence, Isotech's measurements and certificates are legally traceable to a number of other National Laboratories. A document entitled "The Recognition of Equivalence of the National Standards of the U.K. and the U.S.A. for the Measurement of Temperature" (copy on request) became effective on October 14, 1986, and establishes traceability from Isotech's UKAS certificates to NIST. In addition, NPL has negotiated agreements with National Calibration Services in a number of other countries, with the same end result of traceability. These countries, the National Organizations, and the effective year are shown in the table below.

Realization. traceability and mutual recognitions.

CCT/96-8 says:

Purpose of an International Temperature Scale.

The purpose of an International Temperature Scale is to specify Internationally agreed procedures and practical thermometers that enable laboratories to independently realize the scale and/or to independently determine highly reproducible values of temperature, closely approximating the thermodynamic temperature but more easily and accurately measured, such that the disagreement among measured temperature values obtained from independent realizations or determinations is small compared to the uncertainty of the thermodynamic values.

This is realization.

To work Nationally or Internationally the realization needs traceability, this is ideally achieved by accompanying the Cell with a UKAS certificate. The UKAS procedure follows the ideals laid out in CCT/96-8.

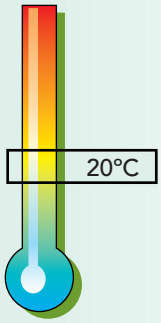
A series of International agreements means that a certificate issued in one country is, by mutual recognition accepted in another. A partial list is presented below.

Traceability of Measurements on a National and International Basis

COUNTRY	ACCREDITING BODY	DATE OF EQUIVALENCE AGREEMENT
Australia	NATA	1985
Germany	DKD	1981
France	BNM, RNE	1988
Hong Kong	HOKLAS	1989
Italy	SIT	1982
The Netherlands	NKO	1988
New Zealand	Telarc	1985
Sweden	SMO	1988
Switzerland	SCS	1989
United States	NIST	1986

UKAS calibration certificates issued by Isotech are legally traceable to National Standards in the Nations listed.

Standard Resistors



Eventually all resistance thermometry refers back to one or more fixed resistors. These are a key element in any laboratory which measures temperature. The resistors need to be very stable with time, temperature and transportation, and they need to have negligible inductance and capacitance.

They also need to have a long and successful history of use.

Wilkins and Swan at our National Physical Laboratory (N.P.L.) developed a resistor design flexible enough to allow windings with various resistance values to be made available and stable enough to be accepted world-wide as resistance standards. Particularly important is that the AC/DC characteristics are the same up to about 1000 Hz.

This design has been licensed to H. Tinsley & Co. who have been producing (and have made further improvements to) this product since 1970.

Isotech are pleased to be able to offer this design of resistor made for us by Tinsley with 1 of 2 calibration possibilities:

UKAS with an uncertainty of ±0.3ppm. Refer to Databook 5 for details.

NPL with an uncertainty of ±0.1 ppm (dependant on Ohmic value).

See page 41 for a suitable enclosure for your resistors.

TYPE S.R.A. Values	1, 10, 25 and 100 ohms
TYPE S.R.B. Values	1000, 10,000 ohms
Calibrated accuracy	0.3ppm (see UKAS schedule, Databook 5)
Accuracy of adjustment	±20ppm
Stability	2ppm/year (0.5ppm/year to special order)
Temperature coefficient of resistance	2ppm/°C 0.5ppm to special order
Recommended dissipation	10 milliwatts
Maximum dissipation	1 watt
Approximate load coefficient	6ppm/watt
A.C./D.C. transfer error at 1kHz	1ppm for values 10Ω, 25Ω, 100Ω, 1kΩ 5ppm for 1Ω and 10kΩ
Construction	
Element	Strain free, immersed in dry oil (No. 4 Kerosene)
Top panel	Bakelite with PTFE inserts and engraved lettering
Terminal - Current	0BA copper
Terminal - Potential	4BA copper
Earth	6BA brass
Dimensions	Container 114 x 76mm diameter Overall 140 x 83mm diameter
Weight	680 grammes

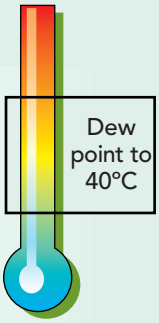
How to order

Standard Resistor S.R.

Please specify type, resistance value and calibration option

Standard Resistor

Maintenance Bath



As a result of many years development, Isothermal are now able to offer a temperature controlled Standard Resistor Maintenance Bath. Using Peltier heating/cooling modules, temperatures 20°C either side of ambient temperature may be set to a resolution 0.01°C.

Stability and temperature differences total less than ±0.015K when measured directly in the oil of the bath and ±0.003K when measured inside a Fixed Standard Resistor.

The bath will house several Resistors depending on their size and is ideal for measuring the temperature coefficients of Fixed Resistors, as well as maintaining them at a selected temperature.

The oil used in the bath is very special, it has to be very high resistance and very low viscosity. Wrong choice of oil will cause larger temperature gradients and may cause the motor to burn out.

Internal support assembly

Wide Temperature Range, ±0.005K stability and gradients ±0.01°C setting resolution, Sensitivity to ambient 4.8mK/K

Model No	455
Temperature Range	Dew point to 40°C
Accuracy	±0.005°C stability and gradients
Control	0.01°C Resolution
Power	15w typical, 100-130 or 208-240VAC*, 50/60Hz * field changeable
Dimensions	Height 910mm Width 635mm Depth 710mm
Weight	66kgs

Options

932-19-72	35 litres of special oil

How to order

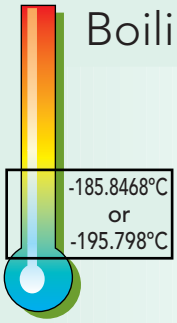
455 Standard Resistor Maintenance Bath

Please specify voltage required

Please specify number and type of Resistors

Nitrogen

Boiling Point Apparatus



The Isotech Nitrogen Boiling Point Apparatus is designed specifically to realize and maintain the liquid-vapour equilibrium (boiling point) of nitrogen or argon, for the calibration of thermometers on the International Temperature Scale of 1990.

The Boiling Point Apparatus is self-contained and refrigerated by liquid nitrogen or liquid argon, which must be supplied by the user. Either liquid is suitable for the purpose. Liquid nitrogen is generally less costly and more readily available than liquid argon. The Apparatus does not require electrical power for its operation.

The Boiling Point Apparatus will maintain the liquid-vapour equilibrium of nitrogen (-195.798°C) or of argon (-185.8468°C) indefinitely, provided boiled-off gas is replenished.

ITS-90 specifies the triple point of argon (-189.3442°C) as the low end of the long-stem Standard Platinum Resistance Thermometer range. As a practical matter, realization of this triple point is a costly (in equipment and time) and complicated process.

Most laboratories will choose to calibrate this end of the platinum range by comparison of the thermometer under test with a thermometer of known calibration. National Laboratories themselves will invariably calibrate thermometers submitted to them by comparison, realising the actual argon triple point only infrequently for calibration of their own reference thermometers. The National Physical Laboratory of England makes this statement:

"Most thermometers (submitted for calibration) will involve measurements (by) ... comparison with NPL standards in a bath of liquid nitrogen (about -196°C)"

N.B.:
The Nitrogen point apparatus may be adapted for use with liquid argon. Please contact the factory for details.

Model 18205 Comparator is designed for precisely such comparison calibration. It comprises a stainless steel dewar, an inner equalizing block having wells for 3 thermometers, top connections for filling and monitoring the level of liquid coolant, a pressure safety blow-off and a manifold which may be used to thermally tie the thermometers under test to the equalizing block with helium gas (optional).

Since the slopes (dR/dT) of Standard Platinum Resistance Thermometers are very similar at any temperature, calibration uncertainties not larger than 0.002K can be obtained at a small fraction of the cost of an absolute calibration.

Boiling point of Liquid Nitrogen, -195.798°C
High Accuracy ±0.002K, Handbook/Tutorial supplied
Self-contained, Bench mounted

Model No	ITL-M-18205
Temperature Range	-185°C or -196°C
Accuracy	±0.002°C
Uncertainties	The temperature distrbution across the copper block is less than 2mK. To this must be added the uncertainty issued with the calibration certificate from the National Laboratory. Extra uncertainties will also exist if dissimilar probes are compared.
Power	na
Dimensions	Below flange 430mm Diameter below flange 127mm Flange diameter 165mm
Weight	14kgs

How to order
ITL-M-18205 Nitrogen Boiling Point Apparatus

Carbon Dioxide Triple Point Cell

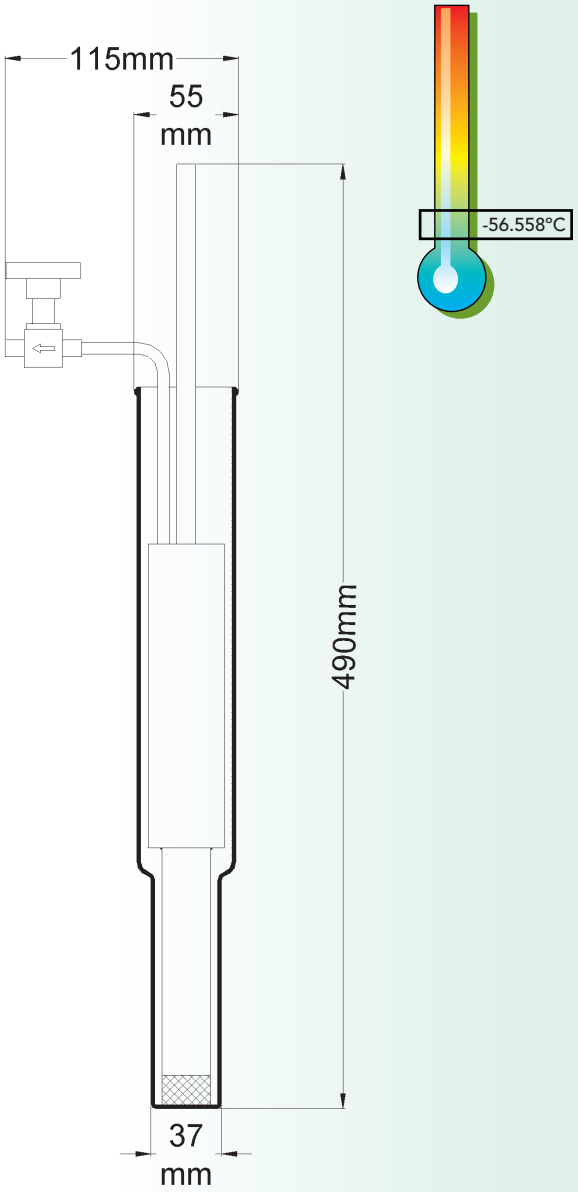
If you need to cover the Military ambient temperature range you need to measure from -55°C to +125°C.

The official ITS-90 fixed point closest to -55°C is the Mercury Triple Point at -38.8344°C, some 16°C above -55°C.

The Carbon Dioxide Triple Point at -56.558°C is much closer to -55°C, and below it.

Using 6N pure Carbon Dioxide uncertainties approaching ±0.1mK can be realised.

Isotech's Carbon Dioxide Triple Point Cell can be conditioned in the 814 Bench Mounted Circulating Liquid Bath used with a two stage chiller (refer to databook two) and can calibrate sensors up to 8mm in diameter.



Key Features

- ITS-90 Secondary Point
- Close to Military Ambient minimum temperature of -55°C
- Accurate to ±0.001°C
- Absolute Temperature Calibration
- Proven design

Model No.	Carbon Dioxide Triple Point Cell
Temperature Range	-56.558°C
Re-entrant Well	8mm diameter 440mm total depth 240mm immersion in cell
Suitable Apparatus	814 Bench Mounted Circulating Liquid Bath with 2 Stage Chiller (Refer to Pages 11 - 13, databook 2)
Dimensions	Height 490mm Diameter 55mm width (incl. valve) 115mm
Weight	1kg
How to Order	Carbon Dioxide Triple Point Cell

Furnaces

for the Primary Laboratory

Apparatus to melt and freeze the fixed points of ITS-90.

To get the best performance from the cells requires the best quality apparatus. We have, over the years, produced many models to satsify particular customer requirements, each has its own benefits and temperature range.

Considering first our very best apparatus, these are a range of 3 products we call dual furnaces. Based on a concept by Dr. Piero Marcarino of IMGC, Italy. The dual furnace is designed to have two independently controllable furnaces. One, a simple furnace to pre-warm and anneal the thermometers being calibrated. The second, a heat-pipe to perfectly melt and freeze the cell into which the thermometers will be immersed.

These are the apparatus in my own Primary Laboratory and once you use them nothing else will do, because they handle both the fixed point, and the thermometer's ideal thermal path.

For those laboratories who already have furnaces for pre-warming and annealing thermometers we offer a range of 3 heat-pipe furnaces. The dual furnaces and heat-pipe furnaces all meet the requirements of "Optimal Realizations".

A more economic solution to melting and freezing cells is by using three zones of heating. We offer two three zone furnaces. These will also meet the requirements of "Optimal Realizations".

Lastly, we have two single zone furnaces offering economic solutions to annealing and lower temperature fixed points, the following pages detail these options.

Other products, originally designed for comparison calibration can be adapted to freeze and melt fixed point cells, these are described fully in Databook 2.

Plateau lengths

CCT/96-8 says that a plateau length of 10 or more hours is suitable for optimal realizations.

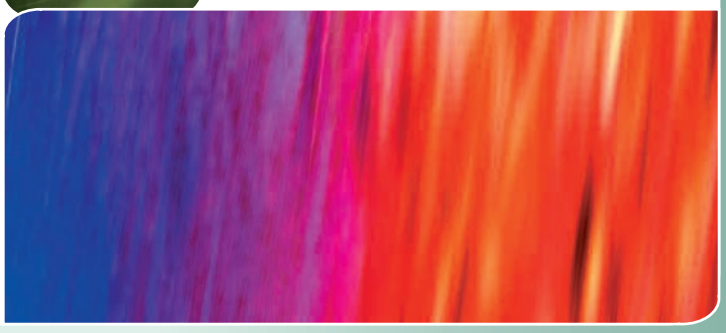
NIST in America like to work with long plateaus whereas according to our UKAS procedure we should calibrate an SPRT 2 or 3 times using a new plateau each time.

If our apparatus is good, which it is then the length of plateau is dictated mainly by how close the set point of the apparatus is to the fixed point we are realizing.

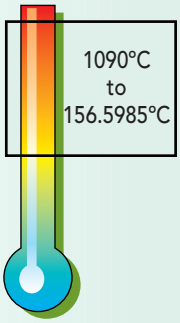
Plateau lengths at the silver point of over 70 hours (3 days) have been achieved using our furnaces. From a practical point we normally work with one working day long plateaus, remelting the cell overnight ready for a new freeze the next day.

Note:
For increased safety our High Temperature Furnaces operate from 110VAC.
To maintain low earth leakage currents, 230VAC and 110VAC - 110VAC Isolating Transformers are available

www.isotech.co.uk/primary



Dual Furnaces



Using standard platinum resistance thermometers presents many problems due to strain and contamination, which can too easily be introduced into the thermometer during thermal cycling.

Because such problems have been only partially understood, little published information or apparatus is available for the safe-handling of these sophisticated devices.

At Isotech, we feel that enough information exists for us to propose a new apparatus specifically designed, not only to create and maintain the Fixed Points of ITS-90, but also to pre- and post-condition the thermometers to be calibrated. Thus we have incorporated a second furnace which, because of its unique design, will safely (and without contamination) pre- and post-condition the thermometers.

To complete the apparatus, a further pre-warming tube (with a temperature approximately equal to that of the heat-pipe) made of a unique and gas-tight material, is provided, together with a storage rack for 4 thermometers.

Method of operation

The cell is melted in an essentially gradient-free heat-pipe. When melting is complete, the heat-pipe temperature is readjusted to be 0.5°C below the freeze temperature of the cell. A cold rod intrduced into the cell's re-entrant tube initiates the freeze, to give a plateau that will last for between 12 and 24 hours.

The thermometers are removed from their storage rack and placed in the pre-conditioning furnace. The furnace is slowly heated to the Cell temperature.

The thermometers are protected from contamination by a slow air flux around them.

One by one the thermometers are transferred into the cell for 20 to 30 minutes for calibration and thence back to the conditioning furnace.

When all the thermometers have been calibrated, the conditioning furnace is slowly cooled back to 400°C whence the thermometers can safely be removed into room temperature.

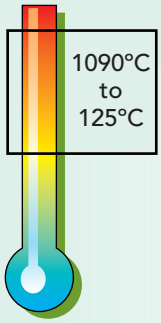
And our thanks to Dr P. Marcarino of IMGC Italy for his permission to develop the idea.

Model	17707 for Indium and Tin Fixed Point Cells 17706 for Zinc, Aluminium and Silver Fixed Point Cells 17705 for Aluminium, Silver and Copper Fixed Point Cells
Dimensions	Height 960mm (excluding holding rack) Width 600mm Depth 560mm
Control	The heat-pipe and the thermometer conditioning furnaces are controlled independently to a resolution of 0.1°C
Communications	Included as standard, see page 42 for details
Over-temperature Protection	Provided on each furnace with independent sensor
Supply	110VAC, 3kw, 50/60Hz CTE (230VAC and 110VAC to 110VAC Isolating Transformers are available) (Model 17707 available 108 - 115 or 208 - 240 VAC)
Performance	Essentially gradient-free heat-pipes provide the ideal apparatus for fixed point calibration and give the perfect profile within the fixed point cell. The addition of the second furnace with its air-flow enables thermometers to be easily and safely calibrated. A comprehensive handbook accompanies each delivery.
Comparison calibration	A temperature-equalising block is available for comparison calibration purpose.

Options
420-02-15 Inconel Equalizing block (17705 + 17706)
425-02-07 Aluminium Equalizing block (17707)
824-01-00 Fan Assembly (to cool the thermometer handle)
425-06-01 Gantry (holder for thermometer)
935-19-43 230v/110v Transformer
935-19-48 110v/110v Transformer
How to order
ITL-M-17707 Low Temperature Dual Furnace
ITL-M-17706 High Temperature Dual Furnace
ITL-M-17705 Very High Temperature Dual Furnace

Heat Pipe

Furnaces



Heatpipes provide the ideal conditions for the creation and maintenance of freeze points from ITS-90.

1. The furnace core is an especially-designed stress-free isothermal heat pipe, which provides a very low thermal gradient along the core working length. The furnace heater is of the parallel-tube design used at NIST.

2. The heat pipe is designed so that the inner wall is not subject to thermal expansion stresses from the outer wall before the heat pipe reaches conduction temperature. The working fluid is permanently and safely sealed within the plasma-arc-welded enclosure.

3. Three temperature ranges are available

Low Temperature	125°C to 250°C	17702W	Water
High Temperature	400°C to 1000°C	17702P	Potassium
Very High Temperature	500°C to 1090°C	17702S	Sodium

Connections are provided for a water supply of 0.5 to 1 litre per minute to cool the top of the apparatus (not on 17702W). Water supply and waste connections may be ordinary garden hose. Use without cooling is not recommended above 700°C.

4. An advanced proportional electronic control system controls the furnace temperature. The control may be self-calibrated using Freeze Point Cells as references. Two entirely independent over-temperature safety circuits are provided. The active safety is a second (off-on) control circuit driven by a second thermocouple. The passive safety is a fusible link in the main power supply.

Model	ITL-M-17702W (Water) Low Temperature Heat Pipe Furnace ITL-M-17702P (Potassium) High Temperature Heat Pipe Furnace ITL-M-17702S (Sodium) Very High Temperature Heat Pipe Furnace
Temperature Range	Low Temperature 125°C to 250°C High Temperature 400°C to 1000°C Very High Temperature 500°C to 1090°C
Accuracy	see page15 for details
Control	±0.1°C Resolution
Communications	Included as standard, see page 42 for details
Supply	110VAC, 3kw, 50/60Hz CTE (230VAC and 110VAC to 110VAC Isolating Transformers are available)
Dimensions	Height 960mm Width 600mm Depth 560mm
Weight	115kg

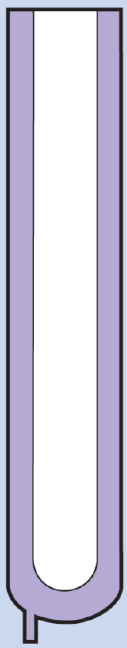
Options

411-01-11B Annealing Adaptor
410-02-18 Aluminium Equalizing Block (17702W)
420-02-15 Inconel Equalizing Block (17702P + 177025)
422-00-00 Special Blackbody Source with Gimbles
824-01-00 Fan Assembly (to cool the thermometer handle)
935-19-43 230/110v Transformer
935-19-48 110v/110v Transformer

How to order

ITL-M-17702W (Water)	Low Temperature Heat Pipe Furnace
ITL-M-17702P (Potassium)	High Temperature Heat Pipe Furnace
ITL-M-17702S (Sodium)	Very High Temperature Heat Pipe Furnace

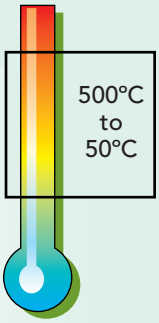
Gradient free freezing and melting of In, Sn, Zn, Al, Ag, Cu



HEAT PIPE
Isothermal cavity
17.000" (431.8mm) deep
2.060" (52.3mm) diameter

Low Temperature

Furnace 17701



The Isotech Low Temperature Fixed Point Furnace is designed specifically to realize and maintain the freeze plateaux of Isotech Indium, Tin and Zinc Fixed Point Cells, for calibration of thermometers on the International Temperature Scale of 1990.

The Low Temperature Furnace is a single-zone furnace.

The recommended procedure for establishing a freeze plateau requires operator attention until the plateau is realized. Following that, the Model 17701 Furnace will maintain the indium or the tin plateau, essentially automatically, for a period of 10 to 12 hours and the zinc plateau for 6 to 8 hours.

1. The furnace core, into which the freeze-point cell is inserted, is of aluminium alloy, which provides a very low thermal gradient along the core length. The main furnace heater is of the parallel-tube design as used at NIST. A pre-warming tube is provided.

2. An advanced proportioning electronic control system regulates furnace temperature, using a platinum resistance thermometer as sensing element. The control may be calibrated in-situ using Freeze Point Cells as references.

Two entirely independent over-temperature safety devices are included. A dedicated (on-off) over-temperature control circuit provides active safety. A fusible link in the main power circuit provides passive safety.

3. The Low Temperature Furnace is completely self-contained, castor mounted and requires no external supplies (except power).

Fixed Points of: Indium 156.5985°C, Tin 231.928°C, and Zinc 419.527°C, 6 to 12 Hours Plateau
Annealing Adaptor, Active and Passive Safety Circuits


photgraph of annealing adaptor

Model	ITL-M-17701
Temperature Range	50°C to 500°C
Accuracy	see page 15 for details
Control	0.1°C Resolution
Communications	Included as standard, see page 42 for details
Power	1.5kW, 108-130 or 208-240VAC, 50/60Hz
Dimensions	Height 960mm Width 600mm Depth 560mm
Weight	115kg

Options

411-01-11	Annealing Adaptor
824-01-00	Fan Assembly

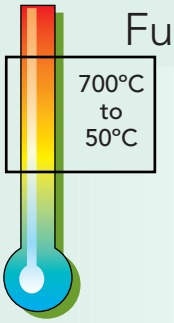
How to order

ITL-M-17701

Please specify voltage required

Medium Temperature

Furnace 17703



The Isotech Medium Temperature Furnace is designed specifically to realize and maintain the freeze plateaux of Isotech Indium, Tin, Zinc and Aluminium Cells, for the calibration of thermometers on ITS-90. It can also be used with an insert, as an annealing facility of the highest order for SPRT's or as a comparison calibration facility.

a. The Medium Temperature Furnace will operate between 50°C and 700°C.

b. The Medium Temperature Furnace is operated by 3 controllers in a master/slaves configuration which enables small temperature differences to be achieved along the Furnace. This is important when freezing cells, since the assumption made is that Cells freeze in concentric shells. This is true only if there is a small temperature gradient along the furnace. The controller resolution is 0.1°C.

c. The recommended procedure for establishing a freeze plateau requires operator attention until the plateau is realized. Following that, the Furnace will maintain the plateau essentially automatically for a period of 10 to 20 hours, (longer if the heat flux from the Cell minimised).

Fixed Points of: Indium 156.5985°C, Tin 231.928°C, Zinc 419.527°C, and Aluminium 660.323°C 10 to 20 Hour Plateau, Annealing Adaptor, Active and Passive Safety Circuits, Equalizing Block for Comparison Calibration

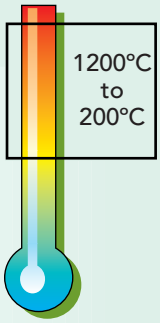
Model	ITL-M-17703
Temperature Range	50°C to 700°C
Accuracy	see page 15 for details
Control	0.1°C Resolution
Furnace	Depth 431mm Diameter 54mm
Communications	Included as standard, see page 42 for details
Power	3kW, 108-130 or 208-240 VAC, 50/60Hz
Dimensions	Height 960mm Width 600mm Depth 560mm
Weight	115g

Options	
410-02-14	Aluminium Bronze Equalizing Block
824-01-00	Fan Assembly (to cool the thermometer handle)
411-01-01B	Annealing Adaptor

How to order
ITL-M-17703
Medium Temperature Furnace
Please specify voltage required

3 Zone High Temperature Furnace

Model 465



Introduction

The recent addition to our long-established range of metrology furnaces offers an alternative for those who prefer 3 Zone furnaces to Heat-Pipe technology.

The 3 Zones create a control volume of constant temperature within the furnace in which High Temperature Fixed Points such as Aluminium, Silver and Copper can be frozen and melted.

Because High Temperature thermometers can be easily contaminated by metallic vapours, great care has been taken to eliminate the use of metals throughout the calibration volume.

The cell holder is made of Alumina.

For Comparison Calibration

A ceramic equalizing block is available comprising a closed ended tube, Alumina tubes to house the sensors being compared and Alumina powder to act as an equalizing media.

Operation

The sensor for the main controller is a mineral insulated type N thermocouple which has been found to be more stable than the type R thermocouple (see Ancsin Metrologia).

In addition two slave controllers compensate for any temperature gradient along the furnace by eliminating any temperature difference that they sense.

Connections are provided for a water supply of 0.5 to 1 litre per minute to cool the top of the apparatus. Water supply and waste connections may be ordinary garden hose. Use without cooling is not recommended above 700°C.

This 3 Zone Furnace can be used for the realizations of the Tin, Zinc, Aluminium, Silver, Gold and Copper points, or with an optional equalizing block used for annealing or comparison calibration.

Long plateaus from Fixed Point Cells
Self-Tuning controller optimizes each Fixed Points performace
3 zones controlled to compensate for end loss to give a perfect profile

Model No	465
Temperature Range	200°C to 1200°C
Accuracy	see page 15 for details
Control	0.1°C Resolution
Furnace	Depth 500mm Diameter 100mm
Communications	Included as standard, see page 42 for details
Supply	110VAC, 3kw, 50/60Hz CTE (230VAC and 110VAC to 110VAC Isolating Transformers are available)
Dimensions	Height 960mm Width 600mm Depth 560mm
Weight	115kg

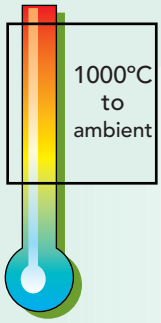
Options	
465-04-00	Cell holder assembly
465-02-06	Ceramic Equalizing Block
935-19-43	230/110v Transformer
935-19-48	110v/110v Transformer

How to order

465 3 Zone Metrological Furnace

Annealing Furnace

Model 414



The Annealing Furnace, model 414, is designed to heat, anneal and cool SPRT's (Standard Platinum Resistance Thermometers) prior to calibration. The temperature range of the Furnace - from ambient to 1000°C enables all types of SPRT's to be annealed.

One of the duties of a calibration laboratory manager is to ensure that the SPRT's used in the Laboratory are fully annealed and still within specification.

Just using the thermometers within the laboratory will cause work-hardening to take place within the platinum coil of the SPRT.

Therefore regular annealing is required to ensure the SPRT's are in an ideal condition.

In 1990 the new temperature scale ITS-90 specified the use of SPRT's up to the Silver point (961.78°C). At these temperatures quartz is very porous and in reducing atmospheres the SPRT's can quickly become contaminated.

The Isotech Annealing Furnace offers a safe solution for those who wish to anneal SPRT's up to 1000°C.

To prevent contamination at high temperatures a constant flux of pre-heated air passes the SPRT's being annealed.

A comprehensive handbook accompanies the Furnace.

This Furnace is installed simply and requires no maintenance.

Maintenance Free Use. Available with programmable controller with communications
Designed to pre-warm and anneal Standard Platinum Resistance Thermometers

Model No	414
Temperature Range	Ambient to 1000°C
Control	0.1°C Resolution
Furnace	Depth 450mm Diameter 50mm
Communications	Included as standard, see page 42 for details
Supply	110VAC, 3kw, 50/60Hz CTE (230VAC and 110VAC to 110VAC Isolating Transformers are available)
Dimensions	Height 800mm Width 400mm Depth 620mm
Weight	40kg

Options

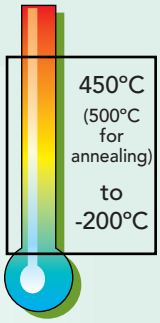
935-19-43	230/110v Transformer
935-19-48	110v/110v Transformer

How to order

414 Annealing Furnace

Meyers

Thermometer



In Isotech's "Realizing ITS-90" collection of products we have tried to build respectfully on those foundations that were already in place - more specifically those products of Henry Sostmann and Jim Cross.

There is another product that we strongly believe deserves inclusion in our collection, the Standard Platinum Resistance Thermometer of C. H. Meyers. This product is currently in production at YSI Inc.in Ohio and we have arranged with them that their SPRT be included in Databook 1.

This thermometer is the direct descendent of those developed by C. H. Meyers at the NBS in the early 1930's. Meyers' paper, Coiled Filament Platinum Resistance Thermometers, is reprinted in the Isotech Journal of Thermometry along with an informative introduction by Henry Sostmann.

Meyers produced some number of these as a home business and then it was transferred to Leeds and Northrup. L&N produced them for many years. In early 1981, the product was acquired by YSI and transferred by Henry Sostmann. In this transfer every effort was made to preserve its history and excellent performance. The goal was to change nothing. Nearly 20 years later, it indeed appears that this was successful.

This thermometer was the ideal interpolation device for the IPTS-68, however the ITS-90 offers temperature ranges where the mica construction of these thermometers is not suitable. It can give excellent performance over the range Argon through Zinc.

There are two forms of the YSI SPRT. In one, the 8163, the sensor element consists of a bifilar coiled coil of platinum. The 8167 consists of a simple bifilar solenoid type coil of platinum. In this design the platinum wire is all very close to the inside surface of the quartz tube giving a shorter time constant. In actual use, there is virtually no difference in performance, the choice is only one of personal preference.

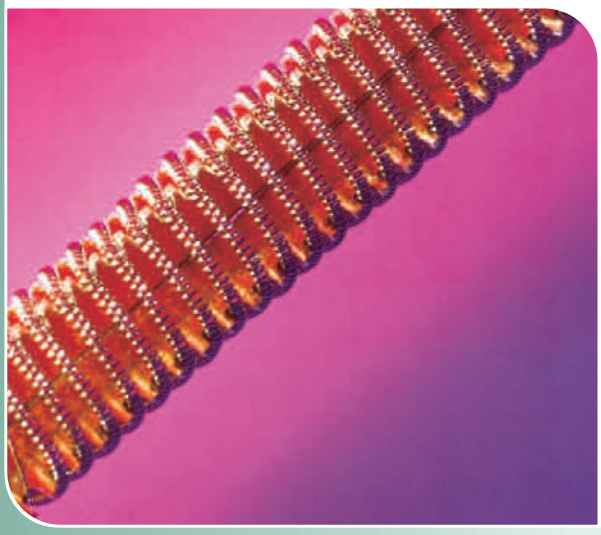
As a result of the evolution of calibration requirements, due in part to ITS-90, YSI introduced another model of each type with a sheath length of 560mm in addition to those with the traditional 470mm length. These longer types with the model number suffixed L, are otherwise identical.

Two Types of Thermometers

ITL 8163 and 8167 SPRTs are designed for measurements from -200 to +500°C. Both have protection tubes of fused quartz. The only difference between them is the time constant: 6 seconds for the ITL 8163, 3.5 seconds for the 8167. Your preference is the only basis for the choice.
We supply each thermometer with a protective case for storage and shipping. RTPW and WGA are also included.

Calibration Reports

With each SPRT, you may order a UKAS calibration report, relating temperature to resistance. Standard calibration ranges are listed in Databook 5.



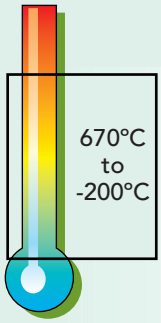
	8163	8163L	8167	8167L
Useable range	-200°C to +500°C			
Calibration range	-196°C to +420°C			
Ro	25.5Ω			
Sheath material	Quartz			
Filled with	dry air			
Time constant*	6 secs		3.5 secs	
Length under handle	470mm	560mm	470mm	560mm
Immersion	7" min to 14" max			
Sensing length	33mm			
Lead wires	4 lead flexible copper cable 2.4m long with gold plated connector lugs			

* to 63% of final value in water moving at 1fps

How to order
ITL-M-8163
ITL-M-8163L
ITL-M-8167
ITL-M-1867L
With or without UKAS Calibration
State range - see Databook 5

Standard Thermometer

Model 670s



This is our latest thermometer, to be specifically designed to give optimum performance up to the aluminium point. Its construction permits the four internal platinum lead wires to expand and contract in the same manner as those of silver-point thermometers. The all-quartz construction of the support-members gives the most stable performance with minimal drift, and a unique platinum radiation shield prevents heat radiating up the inside of the sheath. The temperature range and design of this new unit means that we can now offer 25.5Ω (Ro) and 100Ω Ro. The construction, including the coiled sensing element, heat-shunt baffles and light scattering barriers, creates a thermometer of unsurpassed stability. Because the 670s goes beyond the temperature range of oxide growth to the level at which the oxide dissociates, the 670s is filled with a unique argon/oxygen mixture.

A 2-metre length of low thermal emf, high temperature, screened cable is connected in the handle, via a strain-relieving transition, to the all pure-platinum construction of the thermometer. Gold-plated U-shaped terminals complete the cable construction, and the 670s is delivered in an elegant soft lined carry-case of our own design.

A 670s is supplied only after a stabilising process which is complete when the reproducibility of R_{TPW} is within 0.0005°C after excursions to the extremes of its temperature range. Values of R_{TPW} and W_{GA} are routinely provided with the 670s.

The 670s can be supplied with R_{TPW} and W_{GA} only or with full UKAS calibration. "With calibration" means that you will get an Internationally accepted Fixed Point calibration.

For best accuracy, recommended maximum measuring currents for the 670s are1ma for the 25.5Ω (Ro) and 0.5ma for the 100Ω Ro.

A comprehensive handbook and tutorial will help you get the very best performance and stability from your 670s.

The thermometer has a standard length of 650mm.

Model No	670s/25.5 or 670s/100
Temperature Range	-200°C to 670°C
Resistance Value (°C)	25.5Ω Ro or 100Ω Ro
Resistance Ratio	W_{GA}>1.11807 as required by ITS-90
Sensitivity	0.1Ω/°C (25.5Ω) 0.4Ω/°C (100Ω)
Long term drift	from 0.001°C/year. depending on use
Calibration (UKAS)	Water T.P., Tin F.P., Zinc F.P., Aluminium F.P. with print-out of temperature at W-intervals of 0.01. Please see Databook 5

See microK and T.T.I. 3 for suitable readout instrument.

How to order

Model 670s/25.5 or 670s/100

State "with UKAS Calibration" or "without UKAS Calibration".

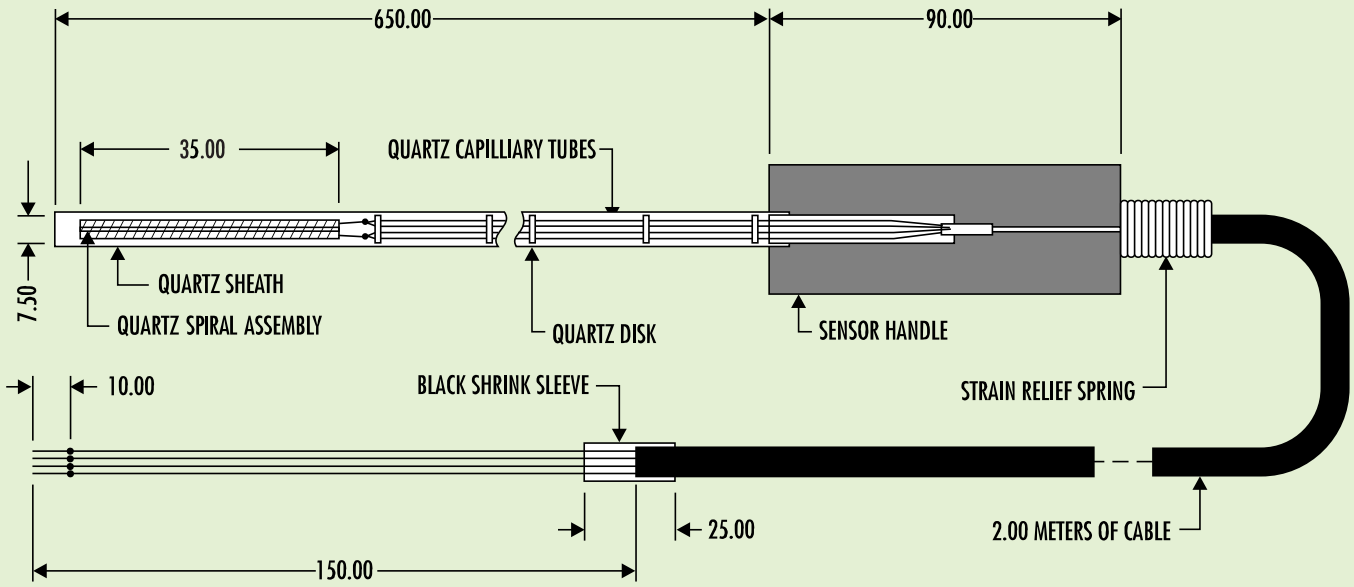
Refer to Databook 5 for temperature ranges.

In default of information you will be supplied with a 670s/25.5 without calibration

Super Stable Standard Platinum Resistance Thermometer

Super-Stable Standard Thermometer

Model 670s



N.B. Please note that if the sheath becomes broken it is not possible to re-seal it; however, if it is possible to remove the broken fragments, another sheath can be supplied to fit over the internal parts, provided that these have not been damaged or contaminated. Use should then be restricted to 0ºC and above

SPRT's

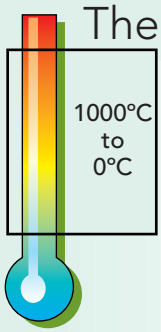
Having selected the finest cells and apparatus these must be matched by the finest SPRT's. With nearly thirty years experience of manufacturing platinum resistance thermometers for science and industry it is not surprising that we have developed the finest standard thermometers.

Two models offer outstanding performance and are the preferred standards at Isotech's Primary Laboratory. These are the 670s/25.5 and the 96178/0.25 thermometers. Extensive evaluations have been written about the thermometers which are available free of charge.

The benefits to your laboratory are increased stability, longer life with better performance and less contamination.

A New Silver Point

Thermometer 96178



Isotech has produced over 200 high temperature thermometers which have been sold world-wide for use up to the silver point. As a consequence of our pre-delivery testing alone we have probably made more silver point calibrations than anyone else in the world.

No one fully appreciates all the mechanisms at work when a coil of pure platinum wire inside a quartz envelope is taken to 1000°C and back. However, endless hours of study at National and International level, plus our own significant work at Isotech, have enabled us to design, build and test a superior Silver-Point Thermometer. This, we feel, is a significant contribution to better high temperature calibration.

First, the 96178 can breathe, a valve in the handle can be opened to allow oxygen depleted or moist air to escape from inside the sheath and replacement by fresh air containing 20% oxygen. The valve is normally opened at elevated temperatures and closed to prevent moisture ingress before water triple point measurements are performed.

Second, the 96178 is the only thermometer ever designed with platinum heat radiation shields built into the sheath, to prevent heat radiating up inside the sheath.

Third, a new ultra pure quartz, developed for the semiconductor industry at a cost of between 20 and 30 million pounds, has been adopted for use in the construction of the 96178. This new thermometer exemplifies our commitment to achieve the highest possible quality and minimum of contamination.

How the thermometer is handled is most important for its stability and a purchaser will receive a comprehensive manual and tutorial with each 96178.

To exploit fully the accuracy of the 96178, a user will need a furnace for warming and annealing the thermometer as well as one to house the silver-point/aluminum-point cells.

A Dual Calibration Furnace from Isotech combines these two features together with all the special accessories and handling know-how we have discovered. See page 23

Model No	96178
Temperature Range	0°C to 1000°C
Resistance Value (°C)	0.25Ω (others to special request)
Resistance Ratio	W_{GA}>1.11807
Length	650mm
Diameter	7.5mm

Drift during use

a. Smallest	When taken to 970°C slowly over 1 to 2 hours and cooled slowly again (overnight) to 450°C, the triple point of water resistance will repeat to better than a temperature equivalent of 0.0005°C.
b. Largest	When thermally shocked from 970°C to 20°C the triple point of water resistance will increase by a temperature-equivalent of up to 35mK; this is mostly recoverable upon annealing at 650°C for a few hours and then cooling slowly (overnight) to 450°C.
Long term drift	Most changes occur during heating and cooling. If this process is done carefully, long term stabilities of a few mK per year can be expected, with reproducibility at the silver point of 3 to 5 mK.

How to order

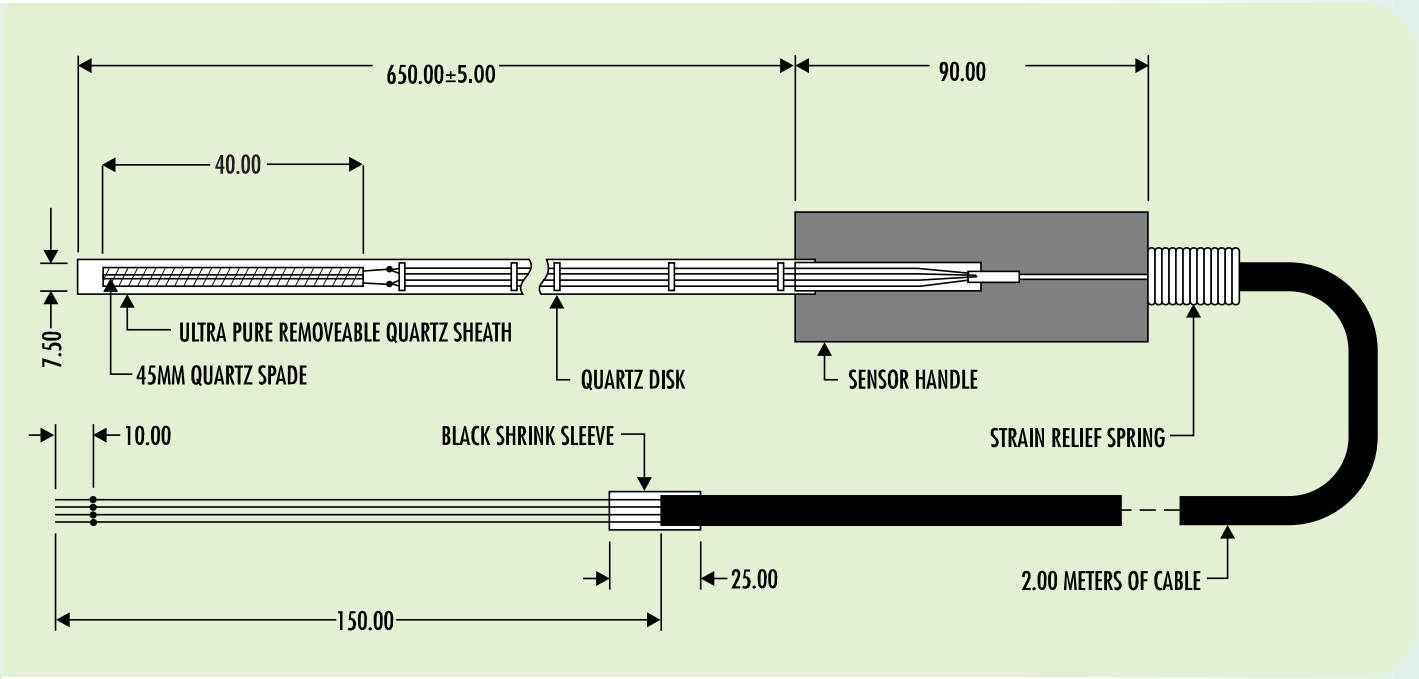
Model 96178/0.25

Then state “with UKAS calibration” or “without UKAS calibration”.

Refer to Databook 5 for temperature ranges

A New Silver Point

Thermometer 96178



Isotech Note
Why choose 0.25Ω for HTSPRT's?

Note1: It is necessary to make the former on which the platinum is wound of high-purity quartz. Even quartz does not provide absolute isolation at the high temperature end of the range. The former, or mandrel, is thus a shunt resistance across the platinum winding, and because of the uncertainty of the contacts between platinum and quartz, it is uncertain and unstable in magnitude. The practicable solution is to reduce the element resistance so that the shunt resistance produces a smaller network effect. For example, for a 25.5Ω thermometer, suppose that the shunt resistance were 20 MΩ. Then the network resistance is 25.499967Ω. But we require measurement assurance of better than 1 part per million, so this won't do, even if the shunt were a constant (calibratable) value, which it is not. For a 0.25Ω thermometer, a 20 MΩ shunt gives a network resistance of 0.24999997Ω, which is tolerable. The cost, and there is a cost, is increased difficulty on the electrical measurement side, particularly in the face of noise, which is present at high temperatures.

Note2: Gases, like Iron, Chromium, Nickel under reducing conditions, can penetrate the quartz sheath and poison the platinum.
It is necessary to purchase not only the 96178, but items such as the Dual Furnace to ensure that your high temperature thermometer does not become contaminated.
Only Isotech offers a comprehensive solution to the measurement and use High Temperature Thermometry.

Note3: Our know-how and expertise in the field of High Temperature thermometry has been written down and is available in the Isotech Journal of Thermometry. See Databook 5.

Bridges and resistors

for the Primary Laboratory

With cells, apparatus and thermometers of the highest quality. A Primary Laboratory only requires the finest bridges and resistors.

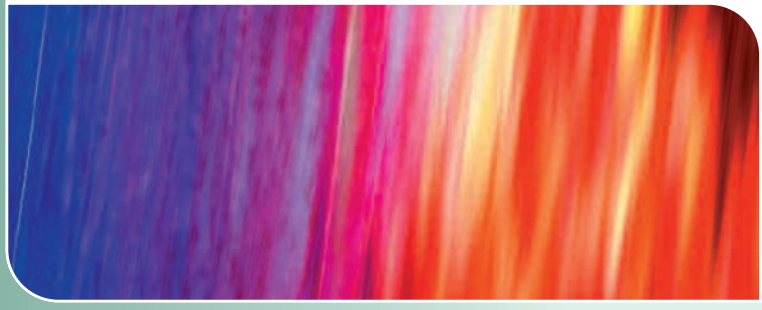
In Isotech's Primary Laboratory we are fortunate enough to have two of the finest bridges available. The Measurements International 6010 and the A.S.L. F900. Each has its own merits. However, for our most accurate intercomparisons, where differences of temperature of I or 2 microdegrees can be measured. We find the software/hardware combination of the Measurements International Bridge our preferred choice:

A limited edition has been made especially for us and our customers, called the T.T.I.3 (True Temperature Indicator 3). It conveniently has its connections on the front panel.

With the T.T.I.3 and its automatic software program we can measure temperature differences of 1 or 2μK. Ask for our free technical document describing our special measuring technique, surpassing even UKAS requirements.

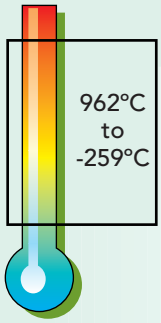
To enable such small measurements, very accurate resistors are required and they need to be maintained at a very stable temperature. This section of the databook describes the main features of bridge resistors and maintenance bath.

www.isotech.co.uk/primary



True Temperature

Indicator 3 (T.T.I. 3)



This is our most sophisticated instrument.

This automated bridge is made for us by Measurements International of Canada. Isotech call it the T.T.I. 3. It is the solution to sub-millikelvin measurement problems. In co-operation with the National Research Council in Ottawa, this design has been tested and approved to the highest standards. Used in conjunction with two or more of our standard PRT's this bridge is capable of the most demanding measurements.

Thermometers are described on pages 29 to 33.

A 20-way Matrix Scanner and full software control is available with this indicator.

The only changes made for us by this supplier is the repositioning of the terminals to the front panel for ease of use.

Stand alone operation or IEEE-488 bus controllable

Auto balancing measurements to nine significant digits

Microprocessor controlled self calibration

Accuracy	<0.05 PPM
Linearity	<0.01 PPM
Resolution	0.001 PPM of Full Scale
Stability	<0.02 PPM/Year
Measurement Range	1.5 to 1 Ratio
Lead Connections	True Four Terminal
Measurement Time	<20 Seconds to Full Balance
Filter Selection	0.5s, 1.0s, 3s, None
Thermometers	0.25, 2.5, 25.5, 100 Ohms
Standard Resistor Range	0.1 to 1000 Ohms
Sensor Current	Reversed DC (Frequency: 2 to 1000 seconds), Resolution 16 bits, Ranges 2µA, 20µA, 200µA, 2mA, 20mA, 200mA FS √2 & 1/√2 of any value, Accuracy 100 PPM, Temperature Coefficient 5 PPM/°C, Output Impedance: Infinite
Noise	<2nV
Insulation resistance	$>10^{11}$ (typically 10^{12})
Temperature Coefficient	0
IEEE488 Interface	Yes
General	
Thermometer Connections:	Four Terminal Front or Rear Panel Connections for external standard resistor and sensor connections.
Balancing Modes:	Automatic via Front Panel Push Buttons & IEEE488
Power	110/120/220/240 Vac 50/60 Hz 40 VA
Warm-up-time	No Warm Up
Ambient Temperature	10°C to 35°C
Size	266mm x 451mm x 306mm
Weight	22.7 Kg

An Enhanced accuracy TT13H.A. is available with accuracy <0.02ppm. Please contact Isotech for details

Stand alone operation or IEEE-488 bus controllable
Auto balancing measurements to nine significant digits
Linearity of 0.02ppm or better
Measurement range from 0.001 ohms to 10 kilohms

True Temperature

Indicator 3 (T.T.I. 3)

AUTOMATED RESISTANCE THERMOMETER BRIDGE SYSTEM:

APPLICATIONS

Calibration of resistance standards

Calibration of resistance boxes

Calibration of platinum resistance thermometers (PRTs)

THE T.T.I 3 RESISTANCE BRIDGE

Improvements on the basic principle of the Direct Current Comparator are the basis for Measurements International's Model T.T.I.3 self-balancing resistance/thermometer bridge. Used as a stand alone bridge for ratio measurements or controlled over the IEEE-488 interface bus for measuring resistance and temperature, the Model T.T.I 3 was designed to decrease the workload of calibration personnel while increasing throughput with better uncertainties.

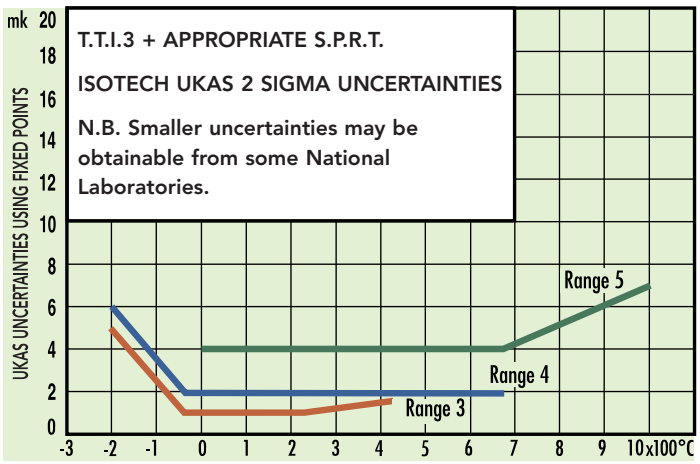
The Model T.T.I 3 meets the laboratory requirements of scaling between the certified 1 ohm standard resistor and 10 kilohm standard resistors. With a measurement range of 0.001 ohm to 10 kilohms and a resolution of ±0.01 ppm of full scale, it covers the entire range of Platinum Resistance Thermometers (PRT). Temperature measurements are further enhanced by the √2 and 1/√2 times the test currents. Test currents are selectable from 0.1mA to 100 mA in 0.001mA steps. Through automatic self-calibration, ratios to nine significant digits with linearity deviations of less than 0.01ppm can be achieved.

ELIMINATES THERMOCOUPLE EFFECTS

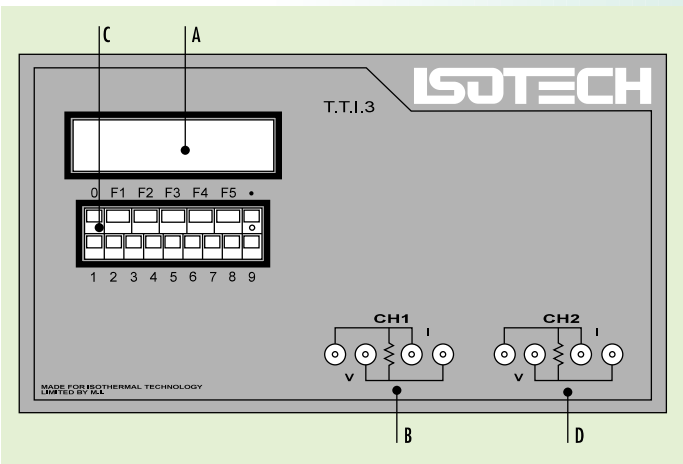
Model T.T.I 3 eliminates thermocouple effects sometimes generated during DC measurements. A generator reversal technique is used to effectively cancel out any errors created by thermal voltages that may appear during measurements. Generator reversal rates from 4 to 1000 seconds can be selected in 1 second intervals. The DC generator reversal rate also eliminates the quadrature component normally associated with AC resistance bridges.

OPERATION

Menu driven firmware for the T.T.I 3 bridge is displayed on the front panel LCD display. Menus control all of the measurement parameters using the function and numerical buttons located directly below the display. Setup parameters include selecting: generator current (Ix) through the PRT or standard resistor, generator reversal rate (settling time). A measurement sequence is then initiated by selecting the measurement function, either continuous or a set number of measurements. There are no other adjustments required. The Model T.T.I 3 will measure the ratio of two resistors, or with the addition of a Model 4220A Matrix Scanner up to 20 resistors can be measured in a single run.



Microprocessor controlled self calibration
Measurement uncertainty <0.2ppm of full scale
<0.05mK for a 25.5ohm thermometer



A. L.C.D. display
B. Channel 1
C. Keypad for local operation
D. Channel 2

Laboratory

Matrix Scanner

LOW THERMAL DESIGN

Measurements International's Model 4220A utilises ultra-sensitive high efficiency polarized relay technology to deliver an automated low thermal matrix scanner. The relays used are 2 coil latching type, requiring only a short millisecond pulse to activate to eliminate self heating in the relay. The relay boards are thermally isolated to maintain thermal equilibrium in the switching area.

The Model 4220A has a total of 80 inputs and 8 outputs. For resistor applications it will handle up to 20 four terminal resistors and 40 two terminal connections for voltage applications. Connections to the resistors and measuring apparatus are made at the back of the scanner. Provisions have also been made for connecting the shields of the resistors.

True four terminal Matrix Scanner

20-four terminal inputs

40-two terminal inputs

Front panel or bus operation

Thermals in the nanovolt region

Number of inputs	
Model No 4220A	2-terminal = 40 channels 4-terminal = 20 channels
Model No 4210A	2-terminal = 20 channels 4-terminal = 10 channels
Thermoelectric Potentials	<100 nanovolts maximum typically 50-70 nanovolts
Error Contribution	<20 nanovolts
Bus Input	24 pin IEEE-488 connector
Relay Contact Rating	
Max switching power	60W, 125 VA
Max switching Voltage	220V DC, 250 V AC
Max switching current	2A AC, DC
Max carrying current	2A AC, DC
Contact Resistance	<0.02 ohms
Expected Life	Mechanical 5 x 10^7 Electrical at 1A 30V DC 5 x 10^5
Power	120/240V, 50/60Hz, 40VA
Rear Panel Connections	Low thermal tellurium copper MIL binding posts
Switch Outputs	Low thermal tellurium copper MIL binding posts
Display	Two LED displays indicating open circuit (flashing) and input select (solid) on both A and B inputs
Control	Front panel local control IEEE-488 remote control
Dimensions	Height 266mm Width 451mm Depth 306mm

How to order

Model 4220A or 4210A Matrix Scanner

Please specify voltage required

OPERATION

The Model 4220A provides an easy means for intercomparing resistors, standard cells or 10 volt references. The relays selecting the rear panel input terminals are activated by front panel push-buttons or by commands sent over the IEEE-488 interface bus. The rear panel inputs are selected by pressing the channel desired and then the A or B button. The corresponding LED will be illuminated.

Several protection circuits are built into the 4220A. The corresponding LED is driven directly from a separate contact on the relay. Only one set of relays can be activated at any one time. It is necessary to open the closed set before another can be activated on the same side.

APPLICATIONS

Resistance calibrations

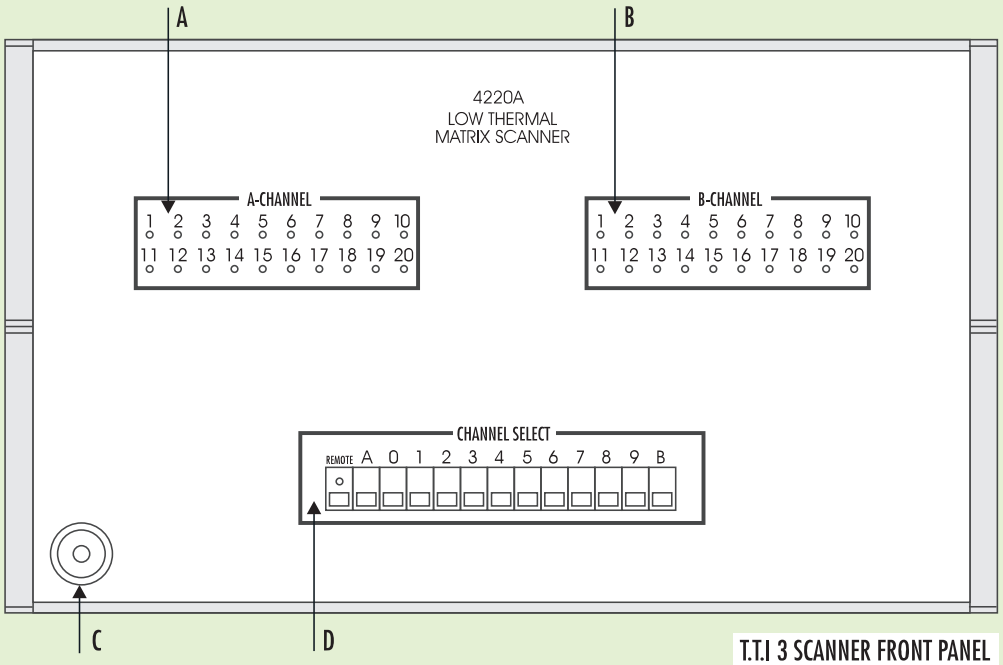
Thermometry scanner

Low thermal voltage measurement

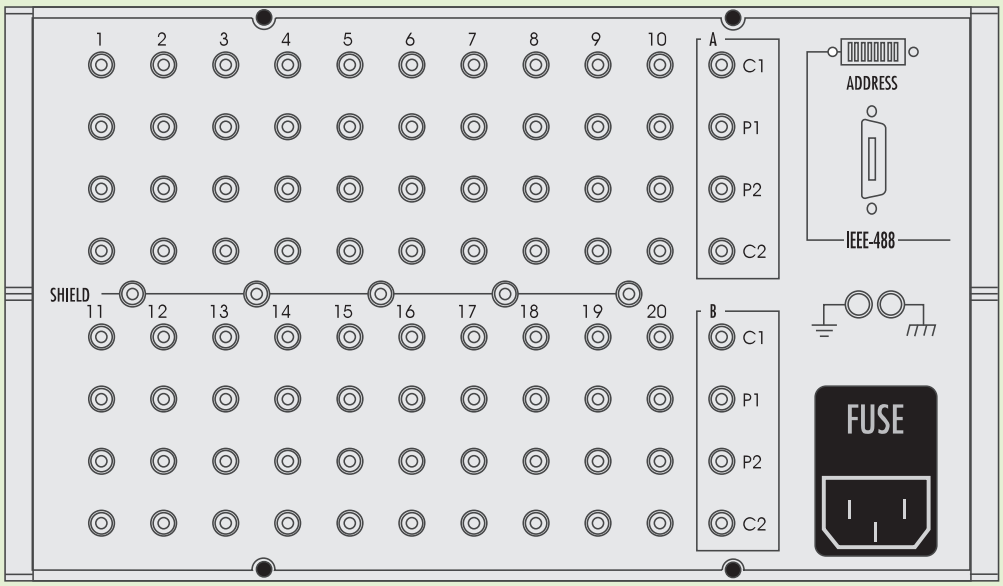
True four terminal Matrix Scanner
20 x four terminal inputs
40 x two terminal inputs
Front panel or bus operation
Thermals in the nanovolt region

Laboratory

Matrix Scanner



T.T.I 3 SCANNER FRONT PANEL



T.T.I 3 SCANNER REAR PANEL

A: Indicators for selected 'A' channel
B: Indicators for selected 'B' channel
C: Power on/off switch
D: Local (manual) channel select

microK

Precision Thermometer

We are proud to introduce a new type of precision thermometer, which sets new world standards for accuracy and stability. Designed for a wide range of highly accurate industrial and scientific calibration applications, the instrument uses a completely new measurement technique to achieve accuracies better than 0.4 parts per million (ppm) - equivalent to 0.0004°C - when used with a standard platinum resistance thermometer (SPRT).

The microK is intended for low uncertainty precision thermocouple measurements and should be used with an external 0°C reference unit such as the Isotech TRU Model 938. Internal cold junction referencing is not provided but the microK can be used to measure an external junction with a resistance thermometer on a different input channel.

The microK range consists of two instruments, offering a choice of measurement accuracy: The **microK 400** is accurate to 0.4 ppm and the **microK 800** is accurate to 0.8 ppm. For SPRT's with Ro $\geq$ 2.5Ω this is equivalent to 0.4mK (0.0004°C) and 0.8mK (0.0008°C) over the whole temperature range. With thermocouple sensors the voltage uncertainty is 0.25µV, equivalent to 0.01°C for Gold / Platinum thermocouples.

The two instruments in the microK range offer performance characteristics and features which are simply not available elsewhere. Comparable instruments available internationally do not achieve the same accuracy or stability (zero drift characteristics with SPRT measurements are not obtainable in any other instrument), do not support the same variety of sensors, and offer considerably less operational features. As a result, the 'Cost of Ownership', a key feature of growing international importance, has been considerably reduced.

Stable: The inherently stable 'substitution technique' used in the microK means that it achieves zero drift for resistance measurements and only 3ppm/year for voltage measurements so you can be confident in your measurements between calibrations.

Versatile: This is the only instrument of its type that works with PRTs, thermocouples and thermistors, so you only need to purchase one product for your thermometry application rather than two or more instruments.

Easy to Use: The microK includes a comprehensive range of features, including direct reading in temperature for all sensor types, data logging, easy export of data to Excel™ and graphing facilities. Despite its sophistication the microK is very easy to use. The built in 6.4" full VGA colour touch screen, powered by the Window CE operating system provides a familiar and powerful operator interface so you can get on with making measurements rather than learning how to control the instrument.

Best Practice Ready: Best practice guidelines recommend the use of two reference thermometers for calibrations. That is why we have included three channels in the microK, enabling you achieve best practice without having to buy additional and costly multiplexers.

Cable Pod™ Connector System: The connectors accept 4mm plugs, spades or bare wires. The 3/4" separation is compatible with standard 4mm to BNC adaptors, so you can use thermometers with any normal termination type. The Cable Pod connector system uses gold- plated, tellurium-copper to give the lowest possible thermal EMF and the best measurement uncertainty. The connectors have a clamping arrangement that does not rotate as the terminal is screwed down, thereby protecting the wire from mechanical damage.

Low Noise: The new ADC, together with the low noise pre-amplifiers used in the microK, means you achieve a lower measurement uncertainty in a shorter time.

Keep-Warm Current: The microK includes keep-warm current sources to maintain the power in a PRT when it is not being measured, eliminating uncertainty resulting from power coefficients.

Unequalled combination of accuracy, stability and versatility.

Key Features...

- Accuracy ±0.4ppm
- Zero drift for PRTs
- PRT, thermocouple and thermistor sensing
- <2 second measurement time
- Keep-warm currents
- 0-10mA sensor current
- Touch screen

microK

Precision Thermometer

Specifications

Ranges	Resistance Thermometers 0Ω to 500kΩ Thermocouples ±125mV
Accuracy - PRTs	µk400: 0.4ppm maximum over whole range for SPRT with R0 ≥ 2.5Ω (equivalent to 0.1mK at 0°C, or 0.4mK over full range) 1ppm maximum over whole range for SPRT with R0=0.25Ω mk800: 0.8ppm maximum over whole range for SPRT with R0 ≥ 2.5Ω (equivalent to 0.2mK at 0°C, or 0.8mK over full range) 2ppm maximum over whole range for SPRT with R0=0.25Ω
Accuracy - Thermocouples	Voltage uncertainty: 250nV at 20mV (equivalent to 0.01°C for Gold-Platinum thermocouples at 1000°C)
Resolution	Resistance: 0.01ppm of range Stability: 10nV (125mV range)
Stability	Resistance (excluding resistance standard): 0[1] Voltage: 3ppm / year
Measurement Time	< 2 seconds
Temperature Conversions	PRTs: ITS-90, Callendar-van Dusen Thermocouples: IEC584-1 1995 (B, E, J, N, R, S, T), L and gold-platinum Thermistors: Steinhart-Hart
Sensor Current	0-10mA in 3 ranges: 0.1mA ±0.4% of value, ±70nA, resolution 28nA 1mA ±0.4% of value, 0.7µA, resolution 280nA 10mA ±0.4% of value, ±7µA, resolution 2.8µA
Keep Warm Current	0-10mA ±0.4% of value, ±7µA, resolution 2.8µA

Cable Length	Limited to 10Ω per core or 10nF shunt capacitance (equivalent to 100m of RG58 coaxial cable)
Internal Standard Resistors	1Ω ±0.1% TCR = ±10ppm/° typical, stability = ±25ppm / year 10Ω ±0.1% TCR = ±0.6ppm/° typical, stability = ±5ppm / year 25, 100, 400Ω ±0.1% TCR = ±0.3ppm/° typical, stability = ±5ppm / year
Input Connectors	"Cable Pod" connector accepting: 4mm plugs, spades or bare wires Contact material: gold plated tellurium copper
Interfaces	RS232 (9600 baud) USB (1.1) - host
Display	163mm / 6.4" VGA (640 x 480) Colour TFT LCD
Operating Conditions	15-30°C / 50-85°F, 10-90% RH (for full specification) 0-50°C / 32-120°F, 0-99% RH (operational)
Power	88-264V (RMS), 47-63Hz (Universal) 20W maximum, 1.5A (RMS) maximum
Size	520mm x 166mm x 300mm 20.5" x 6.6" x 11.9" (W x D x H)
Weight	12.4kg / 27lb

Specifications are subject to change without prior notice.

Notes:

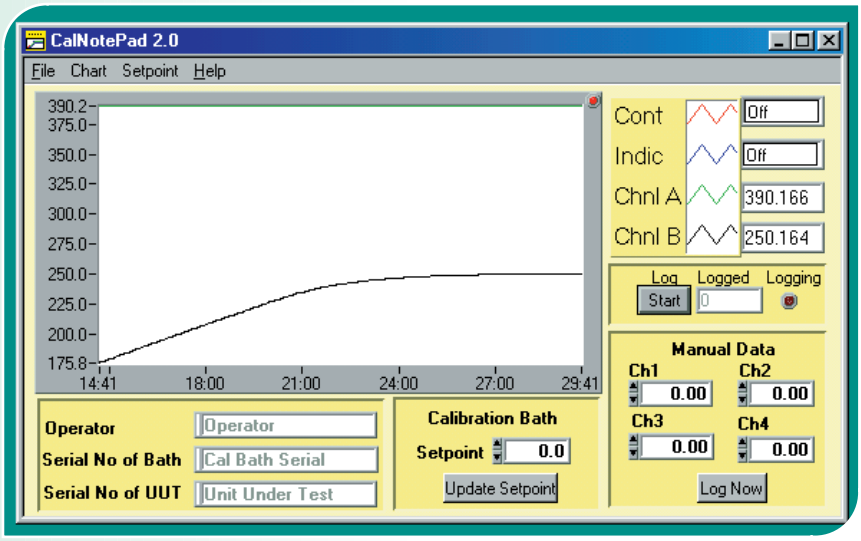
1. The microK uses a "substitution technique" in which the Device-Under-Test and the Reference are successively switched into the same position in the measuring circuit. This means that the stability of resistance ratio measurements is immeasurably small.

Parameter	microK 400	microK 800	Units
Accuracy (25Ω SPRT)	0.4	0.8	ppm
Accuracy (0.25Ω SPRT)	1	2	ppm
Probes Supported	PRT'S, Thermistors & Thermocouples	PRT'S, Thermistors & Thermocouples	
Channels	3	3	
Resolution	0.01	0.01	mK
Stability	0[1]	0[1]	ppm/yr
TC (resistance ratio)[2]	0[1]	0[1]	ppm/°C
Resistance Range	0 - 500	0 - 500	kΩ
Cold Junction Mode	External and Remote	External and Remote	%
Keep-Warm Current	Yes	Yes	
Internal Resistance Standards	1, 10, 25, 100, 400	1, 10, 25, 100, 400	Ω
Measurement Time	< 2	< 2	s
Units	Ratio, V, Ω, °C, °F, K	Ratio, V, Ω, °C, °F, K	
Switching Technology	Solid-state	Solid-state	

Notes:

1. The microK uses a "substitution technique" in which the Device-Under-Test and the Reference are successively switched into the same position in the measuring circuit. This means that the stability of resistance ratio measurements is immeasurably small.
2. Using external reference resistors.

PC Communications



Furnace Support Software

The furnaces include a communication port and a PC Connectivity Package, which includes the cal NotePad software and an interface lead that is connected to PC's RS232 port. The software for Windows 95/98 allows the furnace temperature to be monitored and changed from the PC, the furnace can be set to ramp between two temperatures or temperatures can be programmed to change with time. A re-scaleable chart recorder display shows the furnace controller temperature and optionally an external indicator, including the True Temperature Indicator 2 (TTI 2), can be connected to allow the cell temperature to be monitored. (see Databook 2 for details)

IEEE-488

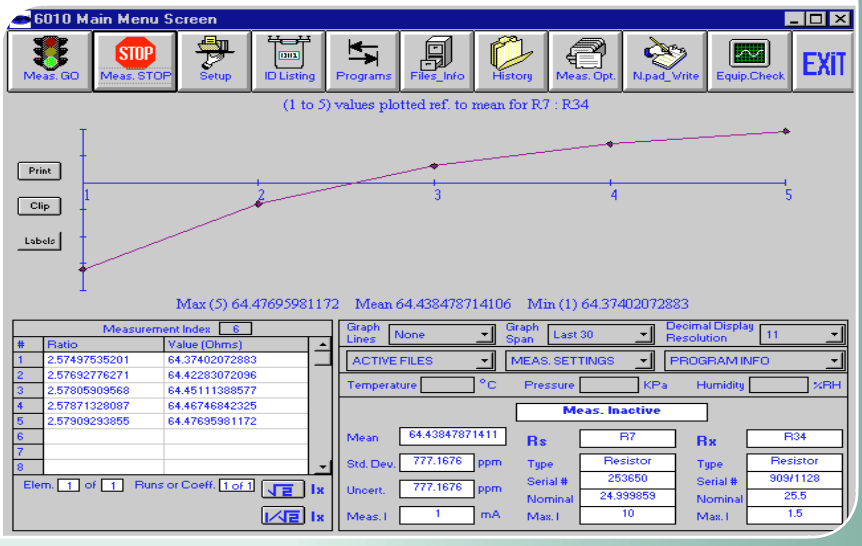
Isotech recommends a serial interface for use with the calibration baths as this is the most cost-effective route and is supported by Isotech software. Where furnaces *have* to be controlled by IEEE-488 it is possible to use an external intelligent interface that converts the RS232 to the IEEE bus. Using this route the user will need to write their own software to communicate with the furnace. A suitable converter can be provided pre-tested and with the necessary connecting leads. An application note is available on request.

T.T.I.3 Software

The TTI3 software is a Windows based facility which provides a dynamic screen output in the form of a continuously updated graph as measurements proceed. The Typical Graphical User Interface allows measurements to be performed easily.

Data for up to 40 standard resistors or SPRT's can be stored allowing output to be presented in either ohms or degrees C, F or K, with a resolution of up to 11 decimal places.

A typical measurement run eliminates the first few measurements, where self heating can occur, then the mean of those left, along with the standard deviation at 95% confidence are calculated. The data gathered can then be either output to printer or saved to disc for import to other packages like Excel for further processing.



ITS-90 Software

The purpose of a Primary Laboratory is to calibrate Standard Platinum Resistance Thermometers (SPRT's). The thermometers are placed into each fixed point in turn and the resistances are recorded.

These resistances need to be substituted into a set of polynominals specified in ITS-90 which eventually prints out a resistance/temperature table enabling the sprt to be specified at any temperature within the range of intent.

Developed for our own use and now available commercially, the Daedalus program is described below.

ICARUS

Software for the Primary Laboratory.

Icarus is designed to calculate and display the relationship between resistance and temperature for Standard Platinum Resistance Thermometers between the triple point of Hydrogen and the freezing point of Silver. All calculations are performed using the equations and values defined in the International Scale of 1990 (ITS-90).

Calculate ITS-90 Coefficients

Generate coefficients from data or data from coefficients

Design and Print Certificates

Use built in layouts including R vs T, T vs R, W vs T etc
Design your own certificates using HTML
Use powerful keywords and additional statements

Check the calibration quality

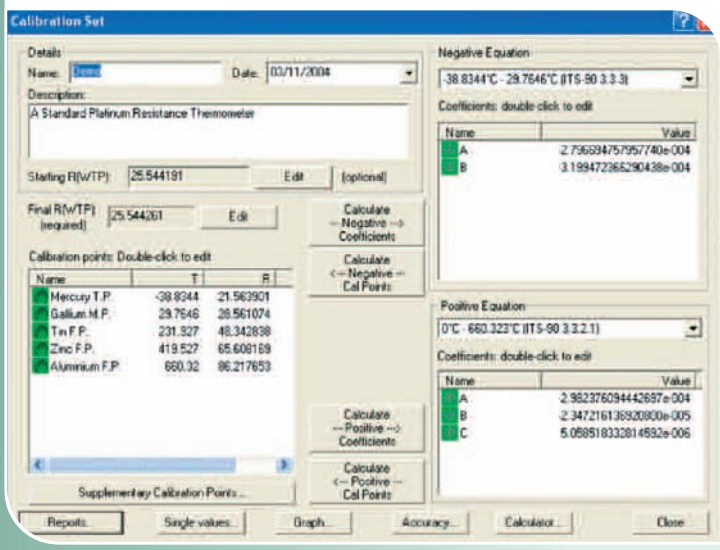
Fit extra calibration points to the curve

Create a distributable "Calculator" for any individual SPRT

Accuracy Estimator

See Graphical Representation of data

Icarus is used at NTPL, if you have a recent certificate from Isotech for an SPRT it will have been created with Icarus. After test and verification for more than 12 months Icarus is now available to save you lab time and increase confidence. The features of Icarus are as a result of requests made from Isotech Calibration Engineers. Quite simply if you calibrate SPRTs you need Icarus !

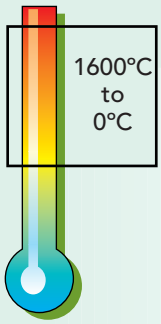


Thermocouples in the Primary Laboratory

Thermocouples are no longer a part of the ITS-90 scale. However they are so important to industry that every Primary Laboratory should consider having a thermocouple calibration system.
Isotech offers a selection of fine thermocouples designed specifically for the Primary Laboratory.

Standard Thermocouple

Model 1600



The Isothermal range of Thermocouple Standards are the result of 5 years development. The type R and S standards will cover the range from 0°C to 1600°C.

The thermocouples are complete as follows:

The measuring assembly comprises a 7mm x 300mm or 600mm gas tight 99.7% recrystallized alumina sheath inside which is a 2.5mm diameter twin bore tube holding the thermocouple.

The inner 2.5mm assembly is removable since some calibration laboratories will only accept fine bore tubed thermocouples and some applications require fine bore tubing.

1.7 metres of covered noble metal thermocouple wire connect the measuring sheath to the reference sheath which is a 4.5mm x 250mm stainless steel sheath suitable for referencing in a Zeref 0°C reference system (see data book 4 page 14). Two thermo electrically free multistrand copper wires (teflon coated) connect the thermocouple to the voltage measuring device.

The thermocouple material is continuous from the hot or measuring junction to the cold, or referencing junction. The thermocouple is complete with an attractive carrying case.

CALIBRATION

The 1600 is supplied with a certificate giving the error between the ideal value and the actual emf of the thermocouple at the gold point. For types R and S thermocouples, manufacturing tolerances are small and, therefore, the use of a standard reference table is particularly apt. A few calibration points, only, are required to determine the (small) differences between the characteristics of an individual thermocouple and the standard reference table. As an example of consistency, 48 thermocouples calibrated at NPL, had a standard deviation of the differences from the reference table value at the gold point (11, 364µV) of only 7µV, equivalent to about 0.5°C.

Thermocouple characteristics are sufficiently smooth to allow interpolation of deviations from the reference table to be carried out over fairly wide temperature spans without introducing unacceptable errors. Isotech can offer a 4-point UKAS calibration for temperatures up to 1100°C (supplied as standard), a 6 point UKAS calibration up to 1300°C with the option of a table of millivolts to degrees Celsius in 10°C steps or, alternatively, arrange for an NPL calibration for temperatures up to 1600°C.

Please contact Isotech to obtain current prices for calibration.

Model No	1600
Hot Sheath Temperature Range	0°C to 1600°C (R or S)
Emf Vs Temperature	According to relevant document
Response Time	5 mintues
Hot Junction Dimensions	see diagram
Connecting Cable	see diagram
Cold Junction	250mm long x 4.5 diameter
Copper Extension Wires	2000mm
Immersion	100mm min.
Case Dimensions	Height 65mm Width 710mm Depth 165mm
Gross Weight	900g
Feature	Removeable inner assembly

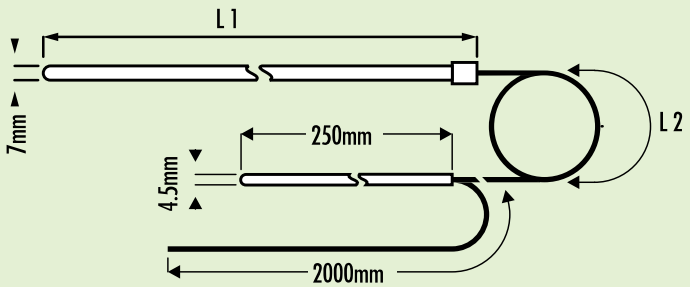
The standard thermocouple described can be supplied in the following noble metal combinations

TYPE R:	Platinum vs Platinum 13% Rhodium
TYPE S:	Platinum vs Platinum 10% Rhodium

How to order

Model 1600 R/300
Model 1600 R/600
Model 1600 S/300
Model 1600 R/600
Specify either Type R or S.
UKAS calibration is included - see Databook 5

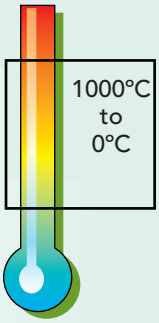
Type R & S Standard Thermocouple, Model 1600,
Premium grade wire, gas tight assembly,
No intermediate junctions, Reference junctions fit into Zeref



TYPE R & S STANDARD THERMOCOUPLE	CODE	L 1	L 2
	/600	600	1150mm
	/300	300	1450mm

Platinum/Gold

Thermocouple



Since 1995 Isotech have been producing various designs of special Pt/Au, Pt/Pd, Pd/Au thermocouples for researchers. From our experience we can now offer the most popular of these, the Pt/Au thermocouple in a standard form.

All wires are 99.999+% pure and are fully annealed according to the recommendations of McLaren Assembly also follows his prescriptions which have never been bettered.

After final assembly and annealing the Pt/Au thermocouples will conform to the reference function derived by Burns within ±0.05°C.

For smaller uncertainties we calibrate the thermocouple at the Tin, Zinc, Aluminium and Silver Fixed Points. The associated uncertainties being Zinc±2.5mK, Aluminium±4mK and Silver ±6mK (1 sigma). The reproducibility of the thermocouples is less than ±0.05°C.

We achieve these results because:

1. All materials are selected for their purity and high quality.

2. All parts are pre-aged and annealed prior to construction.

3. The construction allows for differential expansion of the Gold and the Platinum by having a coil of platinum bridge the two thermo elements at their measuring junction.

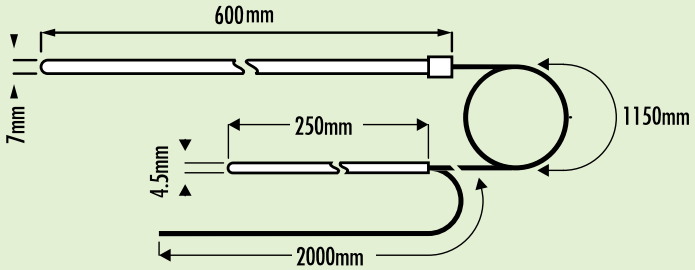
4. There are no joins between the measuring and reference junctions.

5. The reference junction is also researched and we use thermally pure copper wire of selected diameter which has been pre-annealed in inert gas to maintain the accuracy of the measuring junction.

6. The reference junction needs to be placed in an accurate reference system such as a Water Triple Point Cell or an Isotech Zeref.

7. An article describing in detail the construction, handling and operation of the thermocouple is provided free with each unit.

Economic alternative to HTSPRT's
Construction allows for differential expansion
Accuracy of ±0.05°C over the whole temperature range



Temperature Range	0°C to 1000°C
Sheath materials	
Measuring Junction	Quartz
Reference Junction	Stainless Steel
Thermo-element Purities	
Platinum	99.999% Pure
Gold	99.999% Pure
Calibration Uncertainties	less than 0.015°C with fixed points (refer to text)
Stability	±0.05°C
Dimensions	Refer to drawing
Carrying Case	Included as standard

How to order

Model type Pt/Au Thermocouple

Including emf vs. temperature traceable calibration certificate and carrying case

ISOTECH'S Au/Pt thermocouple conforms to the reference function and uncertainties listed below
For more information see "Gold Versus Platinum Thermocouples: performance data and an ITS-90 based reference function". G.W. Burns et al. American Institute of Physics.

The new reference function for Au/Pt thermocouples is of the form:

$$E=p(t_{90}) = \sum_{i=1}^{9} a_i (t_{90})^i$$

Equation ②

where t_{90} is in degrees Celsius and E is the *emf* in microvolts. The coefficients of Eq. (2) for the range 0°C to 1000°C are given in Table II. The random component of uncertainty for $p(t_{90})$, where $p(t_{90})$ is data from two typical thermocouples fitted with a 9th degree polynominal by the method of least squares, is calculated using Working-Hotelling confidence bands. The upper and lower 95% confidence bands at temperature t_h are $p(t_h) \pm v(t_h)$, where

$$V(t_h) = \sqrt{9F_{0.95}(9,995)s_h}$$

Equation ①

the critical value $F_{0.95}(9,995) = 1.89$ is the upper 95 percent point of the F distribution with 9 and 995 degrees of freedom, and s_h is the standard deviation of $p(t_h)$ at temperature t_h. The Working-Hotelling bands are appropriate for unlimited use of the reference function. Representative values are shown in table 1. Values of E and the first and second derivatives of E with respect to t_{90} computed from Eq. (2) at selected values of t_{90} are given in Table III.

Table I

Random uncertainties (μV) for $p(t_{90})$ from 95% Working - Hotelling Confidence bands.

t_{90} / °C	$P(t_{90})$	$V(t_{90})$
0	0.00	0.00
100	777.90	0.02
200	1845.08	0.02
300	3141.77	0.02
400	4633.43	0.02
500	6300.95	0.02
600	8135.10	0.01
700	10132.25	0.02
800	12290.89	0.02
900	14609.31	0.02
1000	17085.31	0.04

Table II

Coefficients for Au/Pt thermocouple reference function for the range 0°C to 1000°C

a_1	6.03619861	a_5	$-4.24206193 \times 10^{-11}$
a_2	$1.93672974 \times 10^{-2}$	a_6	$4.56927038 \times 10^{-14}$
a_3	$-2.22998614 \times 10^{-5}$	a_7	$-3.39430259 \times 10^{-17}$
a_4	$3.28711859 \times 10^{-8}$	a_8	$1.42981590 \times 10^{-20}$
		a_9	$-2.51672787 \times 10^{-24}$

Table III

Values of *E* and the first and second derivatives of *E* with respect to t_{90} computed from equation (2) at selected values of t_{90}

t_{90} / °C	*E*μV	dE/dt_{90} μV/°C	d^2E/dt^2_{90}, nV/°C^2
0.00	0.00	6.036	38.73
0.01	0.06	6.037	38.73
29.7646	196.26	7.133	35.08
156.5985	1350.94	10.861	24.90
231.928	2236.18	12.599	21.46
419.527	4945.63	16.157	17.27
630.615	8729.30	19.658	16.24
660.323	9320.44	20.139	16.20
961.78	16120.49	24.945	15.65
1000.00	17085.31	25.543	15.64

Since the reference given by Eq. (2) is not well suited for calculating values of temperature from values of *emf*, two inverse functions are included here for that purpose. These inverse functions give values of temperature that agree with values obtained from the reference function to at least ±5m°C, where the *emf* (*E*) is given in microvolts. Equation (3) gives the form of an inverse function for the Au/Pt thermocouple for the temperature and *emf* ranges, 0°C to 209°C and 0μV to 1953μV. The coefficients for Eq. (3) are given in Table IV.

$$t_{90} = \sum_{i=1}^{8} b_i (E)^i$$

Equation ③

Table IV

Table IV. Coefficients of the inverse function, Eq. (3), for the Au/Pt thermocouple for the range 0°C to 209°C.

b_1	1.6543903×10^{-1}	b_5	$4.8495536 \times 10^{-14}$
b_2	$-8.4098835 \times 10^{-5}$	b_6	$-2.0138760 \times 10^{-17}$
b_3	8.4166132×10^{-8}	b_7	$4.7475626 \times 10^{-21}$
b_4	$-7.5174691 \times 10^{-11}$	b_8	$-4.7973082 \times 10^{-25}$

Equation (4) gives the form of an inverse function for the Au/Pt thermocouple for the temperature and *emf* ranges, 209°C to 1000°C and 1953μV to 17085μV. The coefficients for Eq. (4) are given in Table V.

$$t_{90} = \sum_{i=0}^{11} b_i ((E - 9645)/7620)^i$$

Equation ④

Table V

Table V. Coefficients of the inverse function, Eq. (4), for the Au/Pt thermocouple for the range 209°C to 1000°C.

b_0	6.763360×10^{2}	b_6	-3.385575
b_1	3.735504×10^{2}	b_7	3.853735
b_2	-5.537363×10^{1}	b_8	1.178891
b_3	1.701900×10^{1}	b_9	-2.702558
b_4	-6.098761	b_{10}	-1.686158
b_5	2.457162	b_{11}	1.876968

To get the most accurate results from thermocouples a 0°C reference and a very high quality digital voltmeter are required.

For the very smallest uncertainties from our Platinum/Gold thermocouple we recommend that the cold junction be a Water Triple Point Cell. See page 5.

Alternatively the Automatic Zeref apparatus is nearly as good (see Databook 4).

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Isothermal Technology Limited, Pine Grove, Southport, Merseyside, PR9 9AG, England
Telephone: +44 (0) 1704 543830 Fax: +44 (0) 1704 544799 E-mail: info@isotech.co.uk Web-site: www.isotech.co.uk