Understanding AMS2750E

Intermediate Level (Heat Treatment)

Aerospace Heat Treat Standard

Introduction

The purpose of this guide is to provide an understanding of the AMS2750E standard* and is aimed at both suppliers and end users in the Heat Treatment Industry.

This guide is part of as a series of six separate publications which cover the following:

1. The Beginners Guide to Heat Treatment Control
2. Understanding CQI9 (intermediate)
3. **Understanding AMS2750E (intermediate)**
4. Practical PID for Heat Treaters (intermediate)
5. Advanced Control methods (expert)
6. Business Performance and algorithms (expert)

*this guide is not intended to replace the standard and concentrates on specific areas - for the full detail please view the original standard. In the AMS2750E guide; we have concentrated on typical TUS setups and do not cover property surveys

Guide Overview

These guides have been produced to help answer some of the common questions asked about Heat Treatment Control systems.

There are three levels:

Beginners - aimed at recent recruits or Engineers new to providing control systems into the Heat Treat Industry and who want to learn more about the role of control systems in the Heat Treatment process.

Intermediate – specific guides on industry standards for both suppliers and end users. These guides have been produced to explain the key points in the standard and provide an overview of how your instrument manufacturer can help you meet the requirements of the standard.

Expert – these guides are a deep dive into the detail of control and how modern instruments and associated algorithms can directly help Business Performance. These guides are for Engineers with prior knowledge of control systems.

Hyperlinks (links to websites) are included in the guides to provide quick access to more detailed information.

Contents

1. AMS2750E Overview

The key sections in the standard:

1. Temperature Sensors (Thermocouples)
2. Instrumentation (PID Controllers/Programmers)
3. Thermal Processing Equipment
4. System Accuracy Tests (SAT)
5. Temperature Uniformity Surveys (TUS)

The AMS2750 standard was created to provide a consistent specification for Temperature Control throughout the Aerospace supply chain. This standard forms a major part of the requirements of a NADCAP audit (National Aerospace and Defense Contractors Accreditation Program). The NADCAP audits are a 3rd Party audit conducted by the PRI – Performance Review Institute.

"Nadcap is an unprecedented cooperative industry effort to improve quality, while reducing costs, for quality assurance throughout the aerospace and defense industries."
http://www.pri-network.org/

The latest revision E was issued in July 2012.

Instrument Supplier

How can your Instrument Supplier assist with meeting the specification requirements?

1. Supply or assist selection of Calibrated Thermocouples
2. Provide Process Instruments (Controllers, Recorders ...) to meet the accuracy requirement of the standard.
3. Provide Field test (TUS/SAT) systems to meet the accuracy and reporting requirements of the standard.
4. Help with a Critical spares list and preventive maintenance for instruments.
5. Calibration of Instruments
6. Operator training on instrumentation
7. Provide input into Continuous Improvement (particularly for Control, Data management, TUS and SAT requirements)
8. Instruments to support Thermocouple, SAT and TUS management.
9. Provide Data Reports to enable analysis of Process information
10. Provide Full Data Management of Process Records

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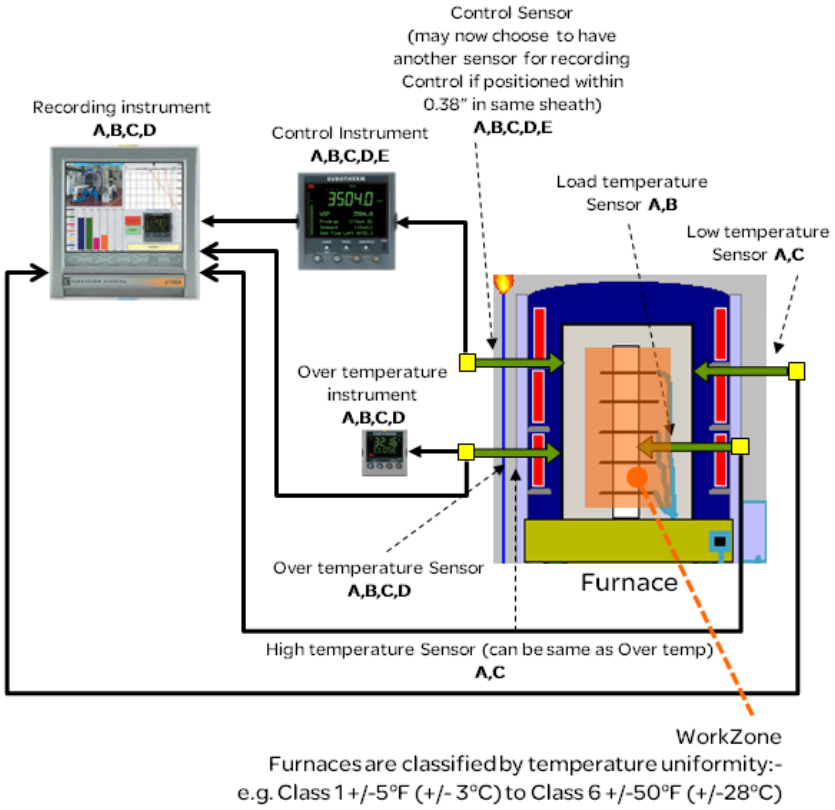
Instrument Type

2. Instrument Type

The following control system outlines the key thermocouples, recording systems and controllers used in meeting the different Instrument Types in the AMS2750E standard,



See the table below to compare Instrument Type with Thermocouples required per zone.

Instrument Type	Thermocouples Required per zone: Control	Record	Hot	Cold	Load	Overtemp
A	✓	✓	✓	✓	✓	✓
B	✓	✓			✓	✓
C	✓	✓	✓	✓		✓
D	✓	✓				✓
E	✓					

3

Thermocouple Types

3. Thermocouple Types

Thermocouples can be expendable (fabric or plastic covered wire) and non-expendable. A common non-expendable type is MIMS - mineral insulated in metal sheath.

Thermocouple types and accuracies are outlined on this page for non-expendable thermocouples.

General

Calibration intervals <250 °F (140 °C).

Roll calibration upto 5000ft (1525m) is allowed if the difference between the end samples is less than 2 °F (+/- 1.1°C) for SAT, TUS, Control, Monitor, Record, Load thermocouples.

Control, Record, Monitor

Max Error: Class 1 & 2 +/-2 °F (+/-1.1 °C) or +/-0.4% Base (E, J, K, N, T) or Noble (B, R, S)

Max Error: Class 3 to 6 +/-4 °F (+/-2.2 °C) or +/-0.75% Base or Noble

Calibration period: before first use

Load

Max Error: +/-4 °F (+/-2.2 °C) or +/- 0.75%

Recalibration period: 6 months B, R, S (Base metal not permitted).

Limit use by no./temp/days of use:

2300°F (1260°C) and above 1 use.

2200-2299°F (1205-1260°C) 3 months/10 uses.

1801-2199°F (980-1205°C) 3months/90 uses.

1200-1800°F (650-980°C) 3 months/180 uses.

Below 1200°F (650°C) 3 months or 270 uses

TUS

Max error: +/-4 °F (+/-2.2 °C) or +/-0.75%

Recalibration period: 6 months B, R, S.

3 months Base metal (J&N).

E&K only permitted below 500°F

SAT

Max Error: Base +/-2 °F (+/-1.1 °C) or +/-0.4%

Max Error: Noble +/-1.5 °F (+/-1.0 °C) or +/-0.25%

(+/-0.25% Type R, S, and +/-0.50% Type B)

Recalibration period: 6 months B, R, S.

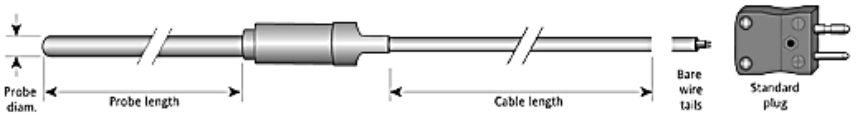
Recalibration period: Resident 3 months

Base metal - E, J, K, T only permitted below 500°F (260 °C)

Recalibration period: Non-Resident 3 months

Base metal – J,N

E,K only permitted below 500°F (260 °C)



See Aerodaq (thermocouple management)

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Instrument Calibration

4. Instrument Calibration

Calibration is performed to ensure the process instruments are providing a true reading (within limits) of the actual temperature being measured. A Field Test Instrument calibrated to a higher level of accuracy is used to inject signals into the Process Instrument to see if any deviation is observed. For Process Instruments this is usually performed at the minimum, midpoint and maximum temperature of the operating range.

Calibration Report detail required.

a. Instrument number or furnace number
b. Make and model of instrument calibrated
c. Standard used during calibration
d. Method of calibration (manufacturer's instructions, 3 point, single point)
e. Required accuracy
f. As found and as left data at each calibration point
g. Offset as found and as left (as required)
h. Sensitivity (pass/fail or sensitivity found in test)
i. Statement of acceptance or rejection
j. Any limitations or restrictions of the calibration shall be included
k. Date the calibration was performed
l. Due date of the next calibration
m. Technician who performed the calibration
n. Calibration company (if not performed in-house)
o. Signature of the calibration company (if not performed in-house)
p. Quality organization approval

Digital Instrument
(Control, Record, Monitor)
Calibration Accuracy
+/-2°F (+/-1.1°C) or 0.2%
Sensitivity 1°F or 1°C
Resolution 1°F or 1°C
Calibration points
3 points (min, max, midpoint)
of operating temperature

Field Test Instrument
Calibration Period 3 months
Accuracy +/-1°F (+/-0.6°C)
or +/-0.1%. Six point calibration

Temperature and Process Controllers
2-Loop Controllers (3500 series)
Process Recorder
Paperless chart (6000 series chart recorders)
Controller and Recorder Instrument
PID Controller / Recorder (nanodac)
Field Test Instrument / Survey Recorder
6100A TUS Portable Temperature Survey Recorder
Calibration Services
Eurotherm Calibration Services

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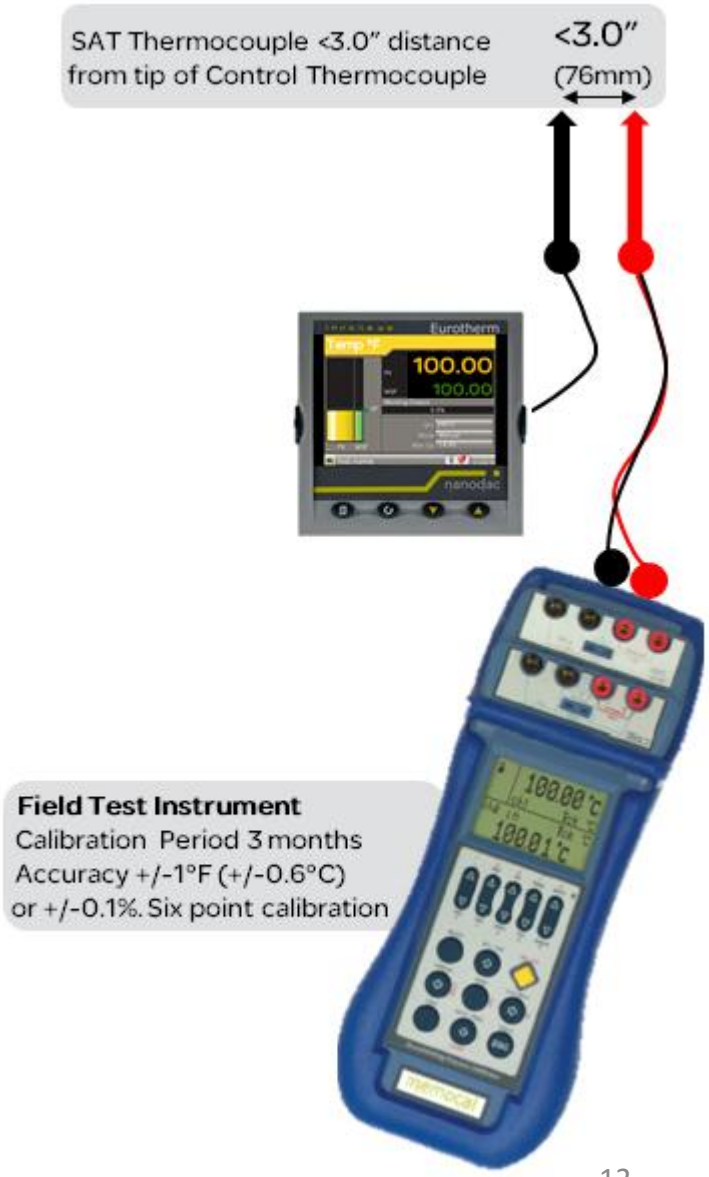
System Accuracy Test (SAT)

5. System Accuracy Test (SAT)

SAT is performed to assess the accuracy of the complete measurement system by using an independent device system (Field Test Instrument and Calibrated SAT Thermocouple). By placing a test thermocouple in close proximity to the zone thermocouple, the delta provides a good indication of the ongoing accuracy of the thermocouple and instrument setup.

System Accuracy Test Report Requirements

a. Identification of the sensor being tested
b. Identification of the test sensor
c. Identification of the test instrument
d. Date and time of day of the test
e. Set point of the furnace during test
f. Observed furnace instrument reading
g. Observed test instrument reading
h. Test sensor and test instrument correction factors
i. Corrected test instrument reading
j. Calculated system accuracy difference
k. Indication of test acceptance or failure
l. Identification of technician performing the test
m. SAT company (if not performed in-house)
n. Signature of the calibration (if not performed in-house)
o. Quality Organization approval



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Temperature Uniformity Survey (TUS)

6. Temperature Uniformity Survey

Temperature Uniformity Surveys are done to assess the temperature variation within the stated work zone. Typical configurations for thermocouple positions can be box type (see diagram) or cylindrical.

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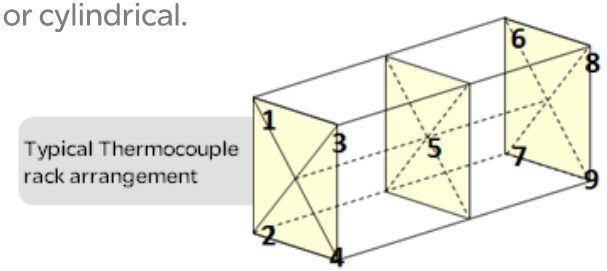
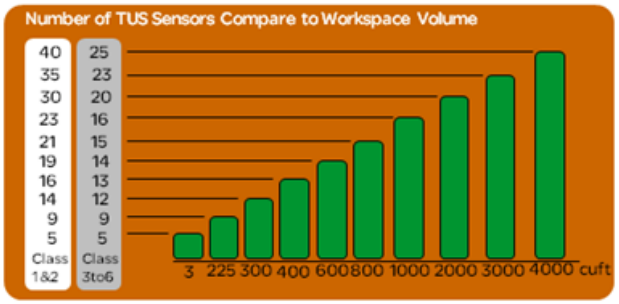
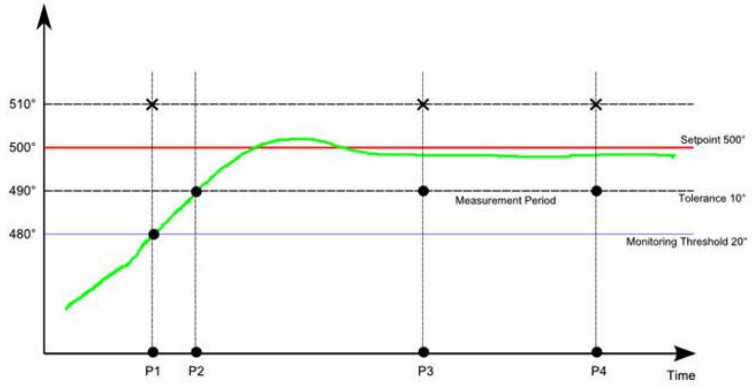


The number of thermocouples required depend on the Workspace Volume and Class of Furnace.



Specific Field Test instruments are used to record the TUS sensors (not the Process Recorder).

The survey requires a minimum of 30 minutes of good data (recorded at 2 minutes intervals or less).



Key Points during the survey (shown on the graph above).

P1 – Start of monitoring. When first thermocouple crosses the Monitoring Threshold line. This point is a beginning of the trend and a first marker on the graph. Data is captured from this point.

P2 – When Last Thermocouple crosses the tolerance of Setpoint.

P3 – Start of Stability Period. All thermocouples within tolerance and not trending away from the Setpoint.

P4 – End of stability Period. It's defined as P3 + Measurement Period. This point is the end of trend and the third marker on the graph. This is also end of data tables. A minimum of 30 minutes of data needs to be captured during the stability period.

The furnace is allowed time to settle into the stable/measurement period but this time to stabilize must not be in excess of any other customer/internal specifications.

Survey Recorder
6100A TUS Portable Temperature Survey Recorder

6. Temperature Uniformity Survey

Temperature Uniformity Report Requirements

a. Furnace identification name or number
b. Survey Temperatures
c. TUS sensor and location identification including a detailed diagram, description or photograph(s) of any load or rack used
d. Time and temperature data from all recorded sensors required for furnace instrumentation type for all zones tested
e. Correction factors to TUS sensors at each survey temperature
f. As found and as left TU S offsets (if used in production)
g. Corrected or uncorrected readings of all TUS sensors at each survey temperature. Readings shall be identified as corrected or uncorrected
h. Testing company identification (if not performed in-house)
i. Signature for the testing company (if not performed in-house)
j. Identification of technician performing survey
k. Survey start date and time
l. Survey end date and time
m. Survey test instrument identification number
n. Indication of test pass or test fail
o. When required, documentation of furnace survey sensor failures
p. Summary of corrected plus and minus TUS readings at each test temperature after stabilization
q. Quality organization approval

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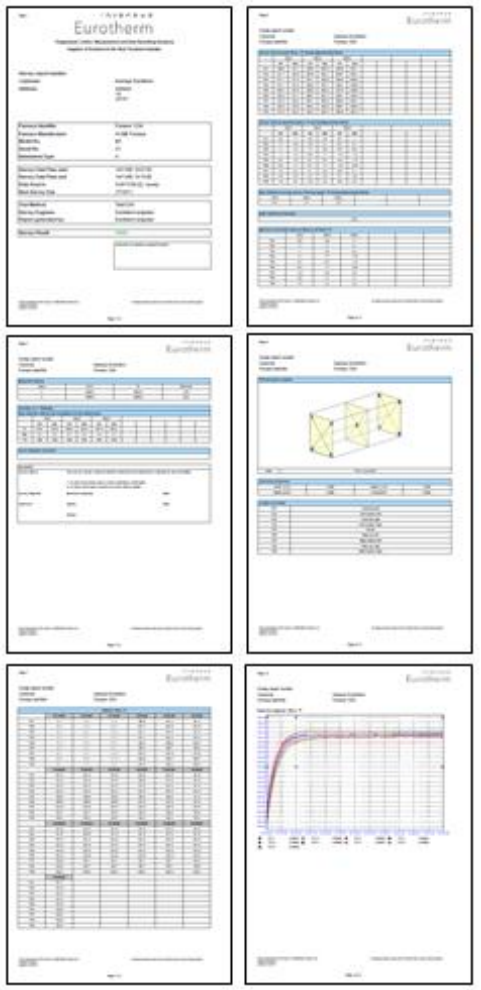

TUS Auto Report Generator
AMS2750E TUS report software

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Equipment Class (1-6)

7. Equipment Class Overview

Equipment Class Summary Sheets

The following six pages illustrate a snapshot of the key parameters for each Equipment class. The idea is to serve as a quick guide to assess the resource requirements for each class and instrument type.

Specific requirements for Resident Thermocouples for SATs (thermocouples installed in the furnace at all times) is not covered in this section.

For example:

- The main differentiator between the classes is the temperature uniformity of the work-zone, starting at +/-5°F (+/-3°C) for Class 1 Furnaces.
- Each Class has frequency inspections – SAT and TUS – the frequency depends on both the Furnace Class and Instrument Type selection.
- For TUS; if you have successive numbers of good TUS results, you can reduce the frequency of the TUS – example Class 1, Instrument B Furnace can reduce from 1 month Surveys to a survey every 3 months if 4 consecutive good surveys have been produced. Please note a major rebuild on the furnace will require going back to the initial survey frequency.
- Equipment Class 1&2 have a higher number of thermocouples required to cover the work-zone in a TUS (this is true for work-zone sizes greater than 300cuft or 8.5m^3).
- Calibration Intervals change with Equipment Class.
- SAT accuracy changes with Class Type and SAT intervals change with both Class and Instrument Type.

7. Equipment Class 1

Digital Instrument (Control, Record, Monitor)

Calibration Accuracy	+/-2 °F (+/-1.1 °C) or 0.2%
Sensitivity	1 °F or 1 °C
Resolution Required	1 °F or 1 °C

TUS Accuracy	+/-5°F (+/-3 °C)
Number TUS sensors (workspace volume)	3cuft 0.085m³ (5T/C's)
	225cuft 6.4m³ (9T/C's)
	300cuft 8.5m³ (14T/C's)
	4000cuft 113m³ (40T/C's)
Calibration interval	monthly
SAT Accuracy	Difference +/-2°F (+/-1.1°C) or 0.2%
	Max offset +/-2.5°F (+/-1.5°C)

Paper charts

Resolution Required	Paper Charts max 50 °F/inch, 2 °F/line (11 °C/cm, 1 °C/line)
Strip Paper Charts	Cycle <1hr soak, 2 inches/hr (50mm/hr) min. Cycle >1hr soak 1 inch/hr (25mm/hr) min.

Instrument Type	Thermocouples Required per zone: Control	Record	Hot	Cold	Load	Overtemp
A	✓	✓	✓	✓	✓	✓
SAT frequency	2wk					
TUS frequency	1 month					
Qty (red. freq.)	2 (6 months)					
B	✓	✓			✓	✓
SAT frequency	1wk					
TUS frequency	1 month					
Qty (red. freq.)	4 (3 months)					
C	✓	✓	✓	✓		✓
SAT frequency	1wk					
TUS frequency	1 month					
Qty (red. freq.)	4 (3 months)					
D	✓	✓				✓
SAT frequency	1wk					
TUS frequency	1 month					
Qty (red. freq.)	8 (2 months)					

7. Equipment Class 2

Digital Instrument (Control, Record, Monitor)

Calibration Accuracy	+/-2 °F (+/-1.1 °C) or 0.2%
Sensitivity	1 °F or 1 °C
Resolution Required	1 °F or 1 °C

TUS Accuracy	+/-10°F (+/-6 °C)
Number TUS sensors (workspace volume)	3cuft 0.085m³ (5T/C's)
	225cuft 6.4m³ (9T/C's)
	300cuft 8.5m³ (14T/C's)
	4000cuft 113m³ (40T/C's)
Calibration interval	3 months
SAT Accuracy	Difference +/-3°F (+/-1.7°C) or 0.3%
	Max offset +/-5°F (+/-3°C)

Paper charts

Resolution Required	Paper Charts max 150 °F/inch, 5 °F/line (33 °C/cm, 3°C/line)
Strip Paper Charts	Cycle <1hr soak, 2 inches/hr (50mm/hr) min. Cycle >1hr soak 1 inch/hr (25mm/hr) min.

Instrument Type	Thermocouples Required per zone: Control	Record	Hot	Cold	Load	Overtemp
A	✓	✓	✓	✓	✓	✓
SAT frequency	1 month					
TUS frequency	1 month					
Qty (red. freq.)	2 (6 months)					
B	✓	✓			✓	✓
SAT frequency	2wk					
TUS frequency	1 month					
Qty (red. freq.)	4 (3 months)					
C	✓	✓	✓	✓		✓
SAT frequency	2wk					
TUS frequency	1 month					
Qty (red. freq.)	4 (3 months)					
D	✓	✓				✓
SAT frequency	1wk					
TUS frequency	1 month					
Qty (red. freq.)	8 (2 months)					

7. Equipment Class 3

Digital Instrument (Control, Record, Monitor)

Calibration Accuracy	+/-2 °F (+/-1.1 °C) or 0.2%
Sensitivity	3 °F or 2°C
Resolution Required	1 °F or 1 °C

TUS Accuracy	+/-15°F (+/-8 °C)
Number TUS sensors (workspace volume)	3cuft 0.085m³ (5T/C's)
	225cuft 6.4m³ (9T/C's)
	300cuft 8.5m³ (12T/C's)
	4000cuft 113m³ (25T/C's)
Calibration interval	3 months
SAT Accuracy	Difference +/-4°F (+/-2.2°C) or 0.4%
	Max offset +/-8°F (+/-5°C) or 0.38%

Paper charts

Resolution Required	Paper Charts max 150 °F/inch, 5 °F/line (33 °C/cm, 3 °C/line)
Strip Paper Charts	Cycle <1hr soak, 2 inches/hr (50mm/hr) min. Cycle >1hr soak 1 inch/hr (25mm/hr) min.

Instrument Type	Thermocouples Required per zone: Control	Record	Hot	Cold	Load	Overtemp
A	✓	✓	✓	✓	✓	✓
SAT frequency	3 months					
TUS frequency	3 months					
Qty (red. freq.)	2 (1 year)					
B	✓	✓			✓	✓
SAT frequency	1 month					
TUS frequency	3 months					
Qty (red. freq.)	3 (6 months)					
C	✓	✓	✓	✓		✓
SAT frequency	1 month					
TUS frequency	3 months					
Qty (red. freq.)	3 (6 months)					
D	✓	✓				✓
SAT frequency	2 wk					
TUS frequency	3 month					
Qty (red. freq.)	4 (6 months)					

7. Equipment Class 4

Digital Instrument (Control, Record, Monitor)

Calibration Accuracy	+/-2 °F (+/-1.1 °C) or 0.2%
Sensitivity	3°F or 2°C
Resolution Required	1 °F or 1 °C

TUS Accuracy	+/-20°F (+/-10 °C)
Number TUS sensors (workspace volume)	3cuft 0.085m³ (5T/C's)
	225cuft 6.4m³ (9T/C's)
	300cuft 8.5m³ (12T/C's)
	4000cuft 113m³ (25T/C's)
Calibration interval	3 months
SAT Accuracy	Difference +/-4°F (+/-2.2°C) or 0.4%
	Max offset +/-10°F (+/-6°C) or 0.38%

Paper charts

Resolution Required	Paper Charts max 250 °F/inch, 10 °F/line (55 °C/cm, 5 °C/line)
Strip Paper Charts	Cycle <1hr soak, 2 inches/hr (50mm/hr) min. Cycle >1hr soak 1 inch/hr (25mm/hr) min.

Instrument Type	*Thermocouples Required per zone* Control	Record	Hot	Cold	Load	Overtemp
A	✓	✓	✓	✓	✓	✓
SAT frequency	3 months					
TUS frequency	3 months					
Qty (red. freq.)	2 (1 year)					
B	✓	✓			✓	✓
SAT frequency	1 month					
TUS frequency	3 months					
Qty (red. freq.)	3 (6 months)					
C	✓	✓	✓	✓		✓
SAT frequency	1 month					
TUS frequency	3 months					
Qty (red. freq.)	3 (6 months)					
D	✓	✓				✓
SAT frequency	2 wk					
TUS frequency	3 month					
Qty (red. freq.)	4 (6 months)					

7. Equipment Class 5

Digital Instrument (Control, Record, Monitor)

Calibration Accuracy	+/-2 °F (+/-1.1 °C) or 0.2%
Sensitivity	3 °F or 2°C
Resolution Required	1 °F or 1 °C

TUS Accuracy	+/-25°F (+/-14 °C)
Number TUS sensors (workspace volume)	3cuft 0.085m³ (5T/C's)
	225cuft 6.4m³ (9T/C's)
	300cuft 8.5m³ (12T/C's)
	4000cuft 113m³ (25T/C's)
Calibration interval	6 months
SAT Accuracy	Difference +/-5°F (+/-2.8°C) or 0.5%
	Max offset +/-13°F (+/-7°C) or 0.38%

Paper charts

Resolution Required	Paper Charts max 250 °F/inch, 10 °F/line (55 °C/cm, 5 °C/line)
Strip Paper Charts	Cycle <1hr soak, 2 inches/hr (50mm/hr) min. Cycle >1hr soak 1 inch/hr (25mm/hr) min.

Instrument Type	Thermocouples Required per zone: Control	Record	Hot	Cold	Load	Overtemp
A	✓	✓	✓	✓	✓	✓
SAT frequency	3 months					
TUS frequency	3 months					
Qty (red. freq.)	2 (1 year)					
B	✓	✓			✓	✓
SAT frequency	1 month					
TUS frequency	3 months					
Qty (red. freq.)	3 (6 months)					
C	✓	✓	✓	✓		✓
SAT frequency	1 month					
TUS frequency	3 months					
Qty (red. freq.)	3 (6 months)					
D	✓	✓				✓
SAT frequency	2 wk					
TUS frequency	3 month					
Qty (red. freq.)	4 (6 months)					

7. Equipment Class 6

Digital Instrument (Control, Record, Monitor)

Calibration Accuracy	+/-2 °F (+/-1.1 °C) or 0.2%
Sensitivity	3 °F or 2°C
Resolution Required	1 °F or 1 °C

TUS Accuracy	+/-50°F (+/-28 °C)
Number TUS sensors (workspace volume)	3cuft 0.085m³ (5T/C's)
	225cuft 6.4m³ (9T/C's)
	300cuft 8.5m³ (12T/C's)
	4000cuft 113m³ (25T/C's)
Calibration interval	6 months
SAT Accuracy	Difference +/-10°F (+/-5.6°C) or 1.0%
	Max offset +/-0.75%

Instrument Type	Thermocouples Required per zone: Control	Record	Hot	Cold	Load	Overtemp
E	✓					
SAT frequency	3 months					
TUS frequency	1 year					
Qty (red. freq.)	No reduction					

Paper charts

Resolution Required	Paper Charts max 350 °F/inch, 25 °F/line (77 °C/cm, 15 °C/line)
Strip Paper Charts	Cycle <1hr soak, 2 inches/hr (50mm/hr) min. Cycle >1hr soak 1 inch/hr (25mm/hr) min.

Useful Links

Sensors

Carbon (Oxygen Probes)
Carbon Probe Sensors

Instruments

Simple Electronic Timers
Electronic Timer
Cycle (Setpoint) Programmers
Programmer (3504 Programmer)
Temperature and Process Controllers
2-Loop Controllers (3500 series)
Process Recorder
Paperless chart (6000 series chart recorders)
Controller and Recorder Instrument
PID Controller / Recorder (nanodac)
Thermocouples, SAT and TUS Management
Aerodaq (thermocouple management)
Data Management
eos (data storage solutions)
Field Test Instrument / Survey Recorder
6100A TUS Portable Temperature Survey Recorder
TUS Auto Report Generator
AMS2750E TUS report software

Services

AMS2750E Information
Regulatory Compliance (AMS2750E)
Calibration Services
Eurotherm Calibration Services

Regulatory Standards and Professional Organizations

SAE AMS2750E Standard
standards.sae.org/ams2750e
NADCAP Audits
www.pri-network.org
AIAG CQI9 Standard
www.aiag.org

Eurotherm
by Schneider Electric