

Pyrometry - AMS2750E vs Nadcap

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ABSTRACT

AMS2750E and Nadcap requirements amount to 70% of all Nadcap Heat Treat Audit findings. This trend has been consistent for a decade now. This is attributable to a lack of comprehension of the spec, internal execution, and inadequate internal auditing systems at the supplier level as well as the prime level. Conrad Kacsik is committed to improving the comprehension of AMS2750E within the industry. We believe that this is the 1st step in creating a successful Pyrometry Compliance System for our customers.

INTRODUCTION

Pyrometry, as it relates to heat treat, Nadcap and AMS2750E does not embody the traditional definition of “Pyrometry”. Regardless, AMS2750E has been placed as the Aerospace Industry Standard to control thermocouples, furnace testing and related quality requirements. In this essay we will briefly explore the necessary steps to understand the requirements of AMS2750E and the separate requirements of Nadcap which are put forth in the Nadcap Pyrometry Guide.

PYROMETRY – HOW IMPORTANT?

I am a Metallurgical Engineer. I’ve worked about 50/50 R&D and production processing. This has provided me with, what I believe, is well-rounded experience in heat treat and related thermal processing. As a specific example, I have seen the effects that a non-thermally uniform furnace can have on the metallurgical results in a laboratory. During development of a diffusion braze process, I had 5 samples distributed throughout a vacuum furnace; one in the center and one in each corner. The sample in the back left corner had a dissimilar diffusion phase and, consequently, smaller solid solution loops in the braze joint. In the end, this makes for not only a less homogeneous microstructure between the hardware processed, but presents a much higher opportunity for re-melt in service. The furnace itself should have a $\pm 10^{\circ}\text{F}$ tolerance, although once tested, it was found to be $\pm 32^{\circ}\text{F}$ with the back left corner being -32°F from set-point.

Stating the importance of Pyrometry, negating Nadcap requirements and looking at this from a laboratory point of view, is not the hard part. If AMS2750E were employed strictly from a results-based laboratory perspective, the importance of Pyrometry is dependent on the sensitivity of the process itself. For example, a simple stress relieve of 4340 bar stock in an air furnace is not nearly as sensitive as, say, a braze cycle of small circular joints. From an engineering point of view, Pyrometry typically is not going to be the largest variable in most processes we work with. Braze joint size, filler material, temperature, time, ramp rates, and atmosphere are all typical examples of what engineers dwell on during development of a processes; not Pyrometry.

For those of us who have Nadcap requirements flowed down to us, it is important. It’s almost an entirely different aspect of Quality Engineering regarding any thermal process it applies to. In the end AMS2750E, when invoked by Nadcap flow down from customers, becomes top-priority for engineering and quality since it has been the largest source of Nadcap heat treat findings.

AMS2750E & THE PYROMETRY GUIDE

Taking on the task of writing a specification which should, in theory, encompass the variables of each furnace variety and the process being performed in the furnace would be a daunting task; this is the job of the AMEC committee which revises AMS2750. This task has been, in my opinion, handled well if we were to look at the inadequacies of revision D and (dare I say) revision C. Taken on its own with no comparison, AMS2750E still contains ambiguity and, sections that are poorly written. Let us not forget that Nadcap is part of PRI (Performance Review Institute) which is also affiliated with SAE/AMS; the authors/owners of AMS2750E. Due to the inadequacy of revision E, Nadcap felt the need to develop something called the Pyrometry Guide. This Pyrometry Guide attempts to fill in the (many) gaps within AMS2750E as interpreted by the Nadcap Heat Treat Task Group. If you’re not entirely familiar with the Pyrometry Guide, it can be downloaded for free on the eAudit.net website. Once you’ve obtained the guide, go to the FAQ section; this is where the interpretation begins and additional requirements are set forth.

The Nadcap Pyrometry Guide contains separate requirements from those of AMS2750E; this is an important fact and should be examined carefully as, during a Nadcap audit, the requirements from the Pyrometry Guide should be reflected in your process/procedure as they apply to your operation. If they are not, you will receive a Nadcap finding. In short, the Nadcap Pyrometry Guide should be treated as any other external specification within your document control system.

NEW TO NADCAP & AMS2750E

Throughout my consulting career, I have been approached by many companies who had attempted to get their initial Nadcap accreditation in heat treat, on their own. Typically, these companies have experienced less than satisfactory results. I've seen multiple reasons for this; from lack of knowledge regarding heat treat processing, incorrect interpretation of the checklists...to the most common reason...poor knowledge and execution of pyrometry requirements. Pyrometry requirements typically make up 70% of all Nadcap heat treat findings in a single year. If you're new to Nadcap, then you are most likely new to pyrometry, and I would recommend retaining the services of an experienced engineer who is familiar with pyrometry.

UNDERSTANDING AMS2750E

As with any specification, it must be read carefully. It would do no good to read the specification and attempt to implement it if you do not understand the material. Put another way, on a scale of 1-10, with 1 indicating zero knowledge of pyrometry, someone reading AMS2750E for the first time would need to be at least a 5 in order to properly comprehend and implement the AMS2750E Specification.

Most Quality Engineers are familiar with the term "Bubbling" as it relates to blue prints. Bubbling a print is a practice in which each requirement is assigned a sequential number. Once this is done on the print, it is then logged onto a form which contains the designated number, its associated requirements, the subsequent result and an accept/reject notice. Typically, this is done on machined parts that may have an intermediate process (such as heat treat) involved in their manufacture. When an intermediate process is performed, the specification is simply listed as the requirement and an accept designation is applied. The specification itself is not bubbled, but read by an engineer, and the applicable requirements flowed down.

My method is to bubble the specification itself. Take each requirement out of the specification and assign it a sequential number. Let's call them "Characteristic Requirements". Some paragraphs may have several requirements within a single paragraph; each would be separated and assigned its own sequential number. Let's look at an example of this:

AMS2750E PG 19, PARA 3.4.5.1:

"The displayed temperature indication and/or recording of the sensor being tested as used in production, with appropriate offsets or correction factors, at any operating temperature, shall be compared with the corrected temperature indication of the test sensor on a test instrument"

It may seem that a single requirement is being put forward; but there are actually 7 contained within this one paragraph.

1. The displayed temperature indication...
2. and/or recording of the sensor being tested...
3. as used in production...
4. with appropriate offsets or correction factors [*option for either*]
5. at any operating temperature...
6. shall be compared with the corrected temperature indication of the test sensor...
7. on a test instrument.

I have performed this task on both AMS2750D and AMS2750E. Revision E ended with 513 characteristic requirements, including tables and figures. Once bubbled, each requirement must be accounted for as they apply to your operations. For example, any requirement regarding a retort furnace would be designated "N/A" if your operation employed only vacuum furnaces. Of course, the continuing issue of comprehension arises at each step of this process. If you have a poor understanding of pyrometry it will be difficult to bubble AMS2750E, and nearly impossible to successfully complete the process of showing conformance. This brings us to the subject of training.

AMS2750E TRAINING

By training, I'm referring to comprehension of the specification itself. Instruction on how to properly calibrate an instrument, perform an SAT or wire up a rack to perform a TUS will be much easier once AMS2750E is understood.

Training programs on this subject are offered by multiple organizations. The most notable of these is the PRI sponsored eQualearn Introduction to Pyrometry training. PRI has engaged me as one of the several instructors who teach this course. It consists of 2 days spent providing a general overview of AMS2750E. Since the same course is taught by many different instructors, providing consulting or conveying a best practice for a specific question is not encouraged.

However, the training courses provided by other organizations do not have these restrictions. For example, I have designed my own 2 day course called "Principles of Pyrometry." In this course I not only go through AMS2750E, but the PRI Pyrometry Guide. The instruction is intended to be interactive and participant questions are often answered with specific recommendations or suggested best practices.

No matter which organization you choose for training, you and/or your team want to ensure that you would score at least a 5 on the AMS270E comprehension scale.

INTERNAL AUDITING

Internal auditing should be robust at a Nadcap approved heat treat supplier. A well designed internal auditing program will ensure that the proper checks & balances are in place within your organization. During consulting engagements, I see many version of this process. The best systems utilize only the specific Nadcap checklists within a supplier's scope. They also use the checklist itself and do not attempt to transfer the content of the applicable checklist into an internal company document (excel or word). Content can be lost or miss-typed during the transfer process. It is best to complete the Nadcap checklists provided by PRI which apply to your scope.

The technique used in completing the checklists is also a subject that warrants further discussion. Simply circling YES to the questions creates a false sense of complacency and reflects a lack of attention to detail. For example, AC7102 specifically requires that the procedure page and paragraph be present on the internal audit for each question, but I rarely see this requirement accomplished correctly. Being detailed on the internal audit form also conveys a sense of seriousness to the auditor. It shows that you not only understand AMS2750E, but take the internal audit process seriously, and know your own systems well.

When performing internal audits, be sure that you document the procedure, procedure revision, page and paragraph which applies to the question. Remember that some questions have more than one requirement within them, like the example given above. This may require that several procedures, revisions, pages and paragraphs be listed. It is common to see a supplier miss items within a question and receive a finding against it.

My recommendation is to create a robust internal audit system, as described above, and don't be afraid to give yourself findings. After all, this is a process designed to generate improvement within your organization. One challenge that suppliers often encounter has to do with the

results of their internal audits. For example, they perform an audit, and issue themselves 34 findings. Nadcap requires that those findings be issued internally within the corrective action system. A corrective action is required for each of the 34 findings. They cannot all be encompassed within one corrective action.

SUMMARY

The steps necessary to successfully implement AMS2750E and Nadcap requirements are few, though the task can take years to accomplish. In my experience, too many suppliers measure their success on the number of findings issued during their audits. This is especially true of "management," who are often unfamiliar with the process. The number of findings issued is not necessarily a true indicator of the quality of your heat treat, and is a poor unit of measure. It's a rare thing to receive zero findings during an audit and, in my opinion, should not happen. All organizations have areas which can be improved...no matter how good we may think we are. Aiming for zero findings is a great goal during internal audits, but not a goal that should have negative consequences when not attained. I feel that a supplier's Nadcap heat treat audit went well when the following criteria are met: a) there are no findings which require product impact investigation, and b) findings are comprised primarily of documentation issues.

In the end, ensure your comprehension of AMS2750E is in-line with Nadcap's expectations and that your internal auditing system is sound. This will expedite your success in implementing AMS2750E as it applies to Nadcap.

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