"Raw" Versus "Part" Heat Treatments - What Is The Difference?

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The fuzzy definitions of "raw material" and "parts" in specifications create variable and debatable heat treating quality standards.

Introduction

For years, military specification Mil-H-6875, often referred to as the bible of heat treating, never distinguished between "raw material" and "parts." Although "raw material" was viewed as steel that is processed in steel mills, forging, and casting shops and "parts" were the materials typically processed by heat treaters, this one spec encompassed the heat treatment of all steel without differentiation.

In 1998, when the Aerospace Metals Division (AMS) of Society of Automotive Engineers (SAE) agreed to take responsibility for many of these abandoned military specs, the majority were translated into AMS documents. Some were transcribed word for word with essentially no change except in formatting (e.g. Mil-F-7190 for forgings became AMS-F 7190). This was not the case for Mil-H-6875.

SAE revised the scope of paragraph 1.1 to note that Mil-H-6875 would now apply only to "raw materials" whereas "parts" would be processed in accordance to AMS 2759 E. This change spawned a great deal of controversy in the heat treating industry which continues to this day.

Definitions

Paragraph 6.11.1 of the new AMS-H-6875 B (formerly Mil-H-6875), defines "material" as all forms of steel products - more specifically mill products and parts. Paragraph 6.11.2 defines mill products as plates, sheets, strips, bars, rods, structural shapes, blooms, billets, slabs, and tube rounds. Forgings, castings, and extrusions which are not supplied in heat treated form are also considered as mill products. We are left to assume that all the above material is now to be referred to as "raw material."

Paragraph 6.11.3 defines a "part" as a rough-machined, finished-machined, or an individual piece. This piece must be made from a wrought or cast stock and heat treated by the user during the fabrication process for qualification of response to heat treatment or processed via another operation where achievement of final physical or mechanical properties is intended.

Finally, loophole Paragraph 6.11.4 states that it is ultimately the prerogative of each prime original equipment manufacturer (OEM) to designate whether they consider certain materials as either "parts" or "raw material."

Discussion

The differentiation between "Raw Material Heat Treatment" and "Part Heat Treatment" is not black and white. There are many gray areas that exist between the two

specifications. Nadcap (National Aerospace and Defense Contractors Accreditation Program), the independent auditor for the aerospace and defense industries, further defines “parts” as material that has a specific prime part number. In the absence of other specific direction, the material is considered a part if it is being supplied in either partial or full heat treatment to establish final properties.

Why then, is it imperative for the heat treater to determine whether the material that is being heat treated is a “part” or “raw material?”

1) Per AMS 2750 D (pyrometry specification), there are major differences in the testing frequencies for the System Accuracy Test (SAT) and the Temperature Uniformity Surveys (TUS) between the two specifications.
2) Test criteria (including hardness tensile, surface integrity, fracture toughness, chemical, bend testing, etc) are different between the two specifications.
3) Testing equipment calibration frequencies vary between the two specifications.

Problem

It is therefore incumbent upon the cognizant engineering organization, responsible for the design of the item being heat treated, to specify whether the material is raw material or a part. The term “cognizant engineering organization” is referred to in many different aerospace specifications. In a great majority of cases, by the time the material arrives at the down-stream processing (e.g. heat treating), it is out of the hands of a design engineer and into the hands of a purchasing agent. Many times the purchasing agent is not knowledgeable about form, fit and function of the material. This is where the all- important distinction becomes blurry.

Fig. 2. Test results for age hardening per AMS 2759 E

Heat	Rockwell (HRC31 minimum)	Tensile (140ksi minimum)	Charpy (27 Joules minimum)
1	32	151	43
2	33	152	16*
3	32	153	28
4	31	151	40
5	34	162	14*
6	33	160	55
7	33	162	12*
8	31	161	52

*Did not meet requirement

In addition to the nebulous classifications of the material in question, the way the two heat treating processors heat treat the metal is not equitable. Mills, forgers, casters, etc., heat treating per AMS-H-6875 B, are not held to the same standards as a heat treater that is Nadcap approved and therefore following the parameters of AMS 2759 E.

Furthermore, it is a known fact that there are both raw material suppliers and heat treaters alike who certify material IAW (In Accordance With) AMS 2759 E and are not Nadcap approved. The question that begs an answer is "why is this practice currently being allowed by many primes?" Many more questions arise regarding this issue.

Why do Nadcap approved heat treaters spend thousands of dollars everyday to maintain a comprehensive quality management system (calibration, internal audits, etc) not to mention the travel / auditing fees? Who is the international, unbiased, independent auditing service that is checking to see if the companies heat treating IAW AMS 2759 E, are following the parameters of the intended specification?

Finally, as metallurgists know very well, any and all previous heat treating processes that are performed upon a specific piece of metal are critical to the establishment of expected final properties. Therefore, all heat treaters are not immune to the possibility of questionable heat treating practices prior to their receipt of material.

Case History

To illustrate this point, barstock was received in the mill annealed condition per AMS-H-6875 B. These were 16 bars of 4" rounds x 12' random lengths made out of 17-4 PH (SA564-T630 Condition A bar) stainless steel with a total weight of 6,118 pounds. The load consisted of eight different heats of material from the mill. The customer purchase order required the heat treater to age harden their material to a H1100 Condition per AMS 2759 E.

Fig. 3. Test results for re-age of non-complying heats

Heat	Rockwell (HRC31 minimum)	Tensile (140ksi minimum)	Charpy (27 Joules minimum)
2	32	153	40
5	33	159	52
7	33	160	55

All bars were fully supported on a 24' long furnace bed. Round stainless steel dummy blocks of similar cross sections were used for internal thermocouple measurement at both ends of the bed. Other surface thermocouples wired in contact with bar surfaces were placed throughout the load.

A total of four (4) core and four (4) surface thermocouples monitored the temperature of the load throughout the cycle to assure that 1100°F ± 10°F soaking temperature was maintained.

Since the job was considered "parts" from the customer, the governing specification was AMS 2759 E. After age hardening per AMS 2759 E, it was required to not only perform a 100% hardness check but also to verify the tensile strength and charpy impact strength of each heat. The following results were achieved:

Noting that three of the eight heats failed the impact strength, it was suggested to the customer by the Nadcap approved heat treater to re-solution treat and re-age the non-complying heats. After re-solution annealing at 1900°F ± 25°F and cooled to below 90°F within 60 minutes prior to re-aging at 1100°F ± 10°F the following results were achieved.

Conclusions

If the material was properly mill annealed and cooled sufficiently, why then did the final "part" properties fail on three of eight heats? In addition, why upon resolution treating and duplicate aging of the three heats, did the material fully comply?

Ironically, these wrought bars were indentified to the heat treater as "parts" even though they did not follow the AMS-H-6875 B definition of "parts." They were not rough-machined nor were they assigned a part number by the prime. It is evident, with newer techniques to "hard" machine metal, that the raw material was going to be made into a part eventually after heat treatment.

Summary

There should be no difference between "raw material" and "part" specifications. There should be one unified heat treating specification for all steels, utilizing the best practices known in our industry. Likewise there should be one independent auditing firm, to eliminate the problematic "In Accordance With" heat treating dilemma. The prime contractors must therefore audit **all** sub tier suppliers to ensure that the proper documentation and information is flowing down the chain. Ultimately, the quality systems of our customers will dictate that the thermal processing from both the suppliers of their materials and their local heat treat shops be identical.