

Guide for Heat Treatment Conformity Inspection

Rev A

Project number		MIDO tracking Number	
----------------	--	----------------------	--

This guide has been developed for conformity inspections of heat treatment processes and parts. These questions/statements are memory joggers that can impact the heat treatment process. **Should the answer be negative it may be necessary to note that on the conformity inspection record 8100-1, if that subject is applicable to the part in question. FAA engineering or authorized DER listed on the 8120-10 should also be notified.**

Heat treat processes are complex, varying with chemical composition of material and the desired characteristics for parts. These characteristics include strength, hardness, and ductility, all of which contribute to the machinability of the material. Heat treat involves heating and cooling material to give it certain physical characteristics. Some procedures are applied to the stock prior to machining while others are applied to the parts, after machining. All of these processes are controlled by the chemical composition of the material, temperature, and the rate of heating and cooling.

Heating: Prior to heat treating, steel is considered soft. Heat is applied at such high temperatures that the atomic structure of the material is altered. The maximum temperature and the cooling method alter the material to a more desired state. The temperature at which steel properties change depends on the specific chemical content. The critical point is the temperature above which the material will harden when quickly cooled. For most steel, the critical point is between 1200 F and 1800 F.

Fast cooling: When steel is heated to such high temperatures, it must be cooled so the steel is left with the desired physical properties. Quick cooling, or *quenching*, is done in a number of environments, including air, water, oil, sand, and chemical baths. Rapid cooling locks in the chemical changes created at the high temperatures, resulting in harder steels. Water is a quick and inexpensive medium for quenching. With low carbon steels, water quickly cools the material, increasing its hardness and strength. Quenching with oil and air results in slower cooling, which means less strength and hardness. The trade off? Quicker cooling leads to stronger, harder materials, but it also means more distortion and cracking of the material.

Slow cooling: Slower cooling results in softer, more ductile steels with less strength and hardness--but with less cracking and distortion. One type of slow cooling is *normalizing*, which cools material at room temperature. Normalizing is a much slower process than quenching and results in steel that is easier to machine. *Annealing* is even slower than normalizing. The heated material is placed in a temperature-controlled oven and cooled very slowly. The hardest material is achieved by quenching in water. This process also results in a brittle material with high internal stress. Annealing provides the most ductile material with the least amount of internal stress, but this is also a softer, weaker substance.

Carburizing: Carburizing adds carbon and/or nitrogen to the outer skin of machined parts by forcing machined parts into direct contact with a solid, liquid, or gas, containing large amounts of carbon or nitrogen. Because of the direct contact, the chemical is transferred to the outside of the parts. Once the carbon transfer is complete, the chemical change must be locked in. The parts are heated and quenched to achieve a hardened state. This process gives the parts a hard outer surface, while keeping the softer, more ductile inner material. This is an ideal solution for parts that need a tough, outer film, and a flexible core.

Guide for Heat Treatment Conformity Inspection

Rev A

Distortion: All heat treat methods have one major drawback: distortion. Heating and cooling of stock and parts alters the chemical composition as well as the physical dimensions of the material. Distortion is both growth and shrinkage of parts. The trick is to know which will occur. Physical alteration depends on many factors. The science of metallurgy is devoted to the study of these properties and the interaction between them; any metallurgy textbook will review this topic in great detail.

Stock allowances: Manufacturing plans often include rough machining, heat treatment and then finish machining, generally a grinding process. It is vitally important to employ the proper stock allowances in rough machining. Too much stock results in excessive grinding and parts with small stock allowances will not clean up. A good rule of thumb allows 0.007'' per surface.

HEAT TREAT

1. 1. What types of heat treatment is being performed at the facility Homogenize Stress Relief Normalize Heat Soak Anneal Tempering/Quenching Age Hardening Other:
2. Is heat treating specification DER or FAA approved?
3. Is the heat treating specification listed on the part drawing?
4. Are the heat treatment operations performed by a continuous process or individual furnace loads?
5. If a continuous process is used, is the following information documented completely?
 - a. Specific equipment identified (e.g. model numbers):
 - a. Heat source type identified:
 - b. Location:
 - c. Controls:
 - d. Placement of temperature monitoring equipment (i.e. thermocouples):
6. If individual furnace loads are heat treated, is the following information documented completely?
 - a. Furnace type (e.g. car bottom, front load or side load). Including make or model number if possible:
 - b. Burner controls, including method of on/off switching:
 - c. Placement of temperature sensors (thermocouples) - In the oven or on the Product:

Guide for Heat Treatment Conformity Inspection

Rev A

- d. Method of loading furnace(s):
- e. Method of unloading furnace(s):
- f. Method of cooling, including transport to cooling location:
 - g. Does the furnace have sufficient temperature sensing devices to insure uniform furnace temperature?
7. Does supplier's procedures address fuel source's requirements?
8. Do supplier's equipment contain mercury?
 - a. Is it identified?
 - b. Are necessary controls in place to prevent contamination of the part?
9. Do the procedures contain parameters which meet applicable specifications (e.g. MIL-H-6875, MIL-STD-1684) for time and temperature?
10. Is a traveler or equivalent work process control document utilized?
11. Does the work process control document contain requirements for time, temperature, cooling methods and documentation requirements?
12. Are time and temperature charts produced? If not, what alternative controls are used:
 - a. Are the at-temperature charts traceable to the material?
13. What is the method utilized to confirm successful heat treat to specific required mechanical properties? (hardness, tensile testing, etc.).
 - a. Does this method meet the specified requirement?
 - b. Does the procedure ensure test coupons are heat treated together with the material?
14. Is there an approved procedure for resolving nonconformances on heat treated material?
15. Does the company have a system for calibration of the temperature control equipment? (e.g. controller, thermocouple, lead wire):
16. Are heat treating and test equipment (including hardness testing) identified in a manner to reflect (ISO 4.11.1)
 - a. Are personnel responsible for performing calibration inspection identified?

Guide for Heat Treatment Conformity Inspection

Rev A

- b. Is equipment number or serial number identified?
- c. Is calibration current?
- d. If calibration is subcontracted, are sufficient subcontractor controls in place?

HEAT TREAT OVEN SURVEYS (e.g. MIL-STD-1684)

- 17. Does the supplier have a system for documenting the heat treat oven/furnace survey?
- 18. Has the survey been performed at the correct time interval?
- 19. Has it been done at the correct temperature?

HEAT TREAT WORK IN PROCESS

- 20. Is heat treating being performed to approved specifications?
- 21. Is/Are the furnaces and controllers calibrated?
- 22. Is the temperature correct?
- 23. Is the correct cooling method/medium being utilized?
- 24. Are personnel cognizant of parameters (time, temperature cooling method) required by procedure/s and work instructions?
- 25. Are results being properly documented (furnace charts)?
- 26. Are approved heat treat specifications readily available to operators?
- 27. Are heat treat procedures and control documents readily available to operators?
- 28. Is traceability being maintained and is the material being heat treated identified by heat number, batch number, serial number or equivalent to assure material control and prevent material mix up?
- 29. Are test coupons being heat treated together with the material?