

FORD MANUFACTURING STANDARD

**“CONTROL OF HEAT TREATING PROCESSES
AND AUXILIARY EQUIPMENT”**

W-HTX

FORD MANUFACTURING STANDARDS

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Page 1 of 46



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INDEX

Item No.	Subject	Page
1.	DESCRIPTION AND REQUIREMENTS	6
<i>1.1</i>	<i>Scope</i>	<i>6</i>
1.2	Specification of Requirements	7
1.3	Process Specification	7
1.4	Process and Quality Controls	8
1.5	Control Plan	8
1.6	Statistical Methods	8
1.7	Cleanliness of Parts Prior to Heat treat	8
2.	FURNACE PROCESSES	9
2.1	Process Monitoring	9
<i>2.1.1</i>	<i>Indicated Temperature</i>	<i>9</i>
2.1.2	Standardize Temperature Controller	10
2.1.3	Temperature Measurement Devices and Protection Tubes	10
<i>2.1.4</i>	<i>Monitor of the Furnace/Generator of Carbon Bearing Atmosphere</i>	<i>10-11</i>
<i>2.1.5</i>	<i>Atmosphere Flow Rate</i>	<i>12</i>
<i>2.1.6</i>	<i>Atmosphere Purging</i>	<i>12</i>
2.1.7	Monitor of an Ammonia Enriched Atmosphere	12
2.1.8	Monitor of the Salt Bath	12
2.2	Condition of Quench	13
2.2.1	Water-Soluble Polymer Quench	13
2.2.2	Water Quench	13
2.2.3	Soluble Oil	13
2.2.4	Oil	13
2.2.5	Salt Bath	13
2.2.6	Brine and Caustic	13
<i>2.2.7</i>	<i>High Pressure Gas Quench</i>	<i>13</i>
<i>2.3</i>	<i>Loading Rate and Cycle Time</i>	<i>14</i>
2.4	Material Control	14
2.5	Laboratory Controls	15
2.5.1	Concentration of Water-Soluble Polymer Quenchants	15
2.5.2	Cleanliness of Water Quench Systems	15
2.5.3	Soluble Oil Quenchants	15
2.5.4	Condition of Quench Oil	16
2.5.5	Salt Bath Analysis and Contaminants	16
2.5.6	Brine and Caustic Quench Solutions	16
2.6	In-Process Tests	16
<i>2.6.1</i>	<i>Microstructure</i>	<i>16</i>
<i>2.6.2</i>	<i>Hardness</i>	<i>17</i>
2.6.3	Case Depth	17

FORD MANUFACTURING STANDARDS

**W-HTX
MAY 2006**

**CONTROL OF HEAT TREATING PROCESSES
AND AUXILIARY EQUIPMENT**

**W-HTX
Page 2**

INDEX

Item No.	Subject	Page
3.	INDUCTION AND FLAME PROCESSES	18
3.1	Process Monitoring	18
3.1.1	Heating Parameters	18
<i>3.1.2</i>	<i>Atmosphere Flow Rate</i>	<i>18</i>
3.2	Condition of Quench	18
3.2.1	Water-Soluble Polymer Quench	18
3.2.2	Water Quench	18
3.2.3	Soluble Oil	19
3.2.4	Oil	19
3.3	Loading Rate and Cycle Parameters	19
3.4	Material Control	20
3.5	Laboratory Controls	20
3.5.1	Concentration of Water-Soluble Polymer Quenchants	20
3.5.2	Cleanliness of Water Quench Systems	21
3.5.3	Soluble Oil Quenchants	21
3.5.4	Condition of Quench Oil	21
3.6	In-Process Tests	21
<i>3.6.1</i>	<i>Microstructure</i>	<i>21</i>
<i>3.6.2</i>	<i>Hardness</i>	<i>22</i>
3.6.3	Case Depth	22
3.6.4	Induction/Flame Pattern	22

FORD MANUFACTURING STANDARDS

**W-HTX
MAY 2006**

**CONTROL OF HEAT TREATING PROCESSES
AND AUXILIARY EQUIPMENT**

**W-HTX
Page 3**

Item No.	Subject	Page
4.	FREQUENCIES FOR PROCESS MONITORS, LABORATORY CONTROLS AND IN-PROCESS TESTS FOR FURNACE PROCESSES	
	<i>Gas</i> Carburizing/Carbonitriding/Carbon Correction	23
	Process Monitor Test Frequencies	23
	Laboratory Control Test Frequencies	23
	<i>In-Process Test Frequencies</i>	<i>23</i>
	<i>Vacuum Carburizing/Carbonitriding – Gears and Shafts</i>	<i>24</i>
	<i>Process Monitor Test Frequencies</i>	<i>24</i>
	<i>Laboratory Control Test Frequencies</i>	<i>24</i>
	<i>In-Process Test Frequencies</i>	<i>24</i>
	Neutral Hardening-Atmosphere	25
	Process Monitor Test Frequencies	25
	Laboratory Control Test Frequencies	25
	In-Process Test Frequencies	25
	Tempering & Stress Relieving	26
	Process Monitor Test Frequencies	26
	Laboratory Control Test Frequencies	26
	<i>In-Process Test Frequencies</i>	<i>26</i>
	Nitriding/NitroCarburizing	27
	Process Monitor Test Frequencies	27
	Laboratory Control Test Frequencies	27
	<i>In-Process Test Frequencies</i>	<i>27</i>
	Annealing/Normalizing	28
	Process Monitor Test Frequencies	28
	Laboratory Control Test Frequencies	28
	<i>In-Process Test Frequencies</i>	<i>28</i>
	Aluminum Solution Heat treating/Age Hardening	29
	Process Monitor Test Frequencies	29
	Laboratory Control Test Frequencies	29
	In-Process Test Frequencies	29
	Brazing/Sintering	30
	Process Monitor Test Frequencies	30
	Laboratory Control Test Frequencies	30
	<i>In-Process Test Frequencies</i>	<i>30</i>
	Salt Bath Heat treating	31
	Process Monitor Test Frequencies	31
	Laboratory Control Test Frequencies	31
	<i>In-Process Test Frequencies</i>	<i>31</i>

FORD MANUFACTURING STANDARDS

W-HTX MAY 2006	CONTROL OF HEAT TREATING PROCESSES AND AUXILIARY EQUIPMENT	W-HTX Page 4
---------------------------	---	-------------------------

Item No.	Subject	Page
5.	FREQUENCIES FOR PROCESS MONITORS, LABORATORY CONTROLS, AND IN-PROCESS TESTS FOR INDUCTION AND FLAME PROCESSES	
	Induction Hardening/Flame Hardening/Annealing of Gears, Shafts and Crankshafts	32
	Process Monitor Test Frequencies	32
	Laboratory Control Test Frequencies	32
	<i>In-Process Test Frequencies</i>	<i>32</i>

FORD MANUFACTURING STANDARDS

**W-HTX
MAY 2006**

**CONTROL OF HEAT TREATING PROCESSES
AND AUXILIARY EQUIPMENT**

**W-HTX
Page 5**

Item No.	Subject	Page
6.	THERMOCOUPLE, TEMPERATURE INSTRUMENTATION, AND PROTECTION TUBE CHECKING AND REPLACEMENT PROCEDURE	
6.1	General	33
6.2	Scope	33
6.3	Equipment for Checking Service Thermocouples	33
6.3.1	Verification Instrument	33
6.3.2	Primary Standard Thermocouples	33
6.3.3	Test Thermocouples	33
6.3.3.1	Sources for Test Thermocouples	34
6.4	Rules of Procedure in Checking Service Thermocouples and Temperature Instrumentation	34
6.4.1	Independent portable verification	34
6.4.2	Placement of calibrated test thermocouple	34
6.4.3	Checking of Service Thermocouples	34
6.5	Allowable Temperature Deviation	34
6.6	Frequency of Checking and the Replacement of Thermocouple and Protection Tubes in Furnaces, Salt Baths and Related Equipment	34
6.6.1	Calibrate	34
6.6.2	General Rules/Notes	34
6.6.3	General Rules/Notes	35
6.7	Recording of Test Results and Replacement Dates	
6.7.1	Test Results	35
6.7.2	Replacement Dates	35

FORD MANUFACTURING STANDARDS

**W-HTX
MAY 2006**

**CONTROL OF HEAT TREATING PROCESSES
AND AUXILIARY EQUIPMENT**

**W-HTX
Page 6**

1. DESCRIPTION AND REQUIREMENTS:

- 1.1 SCOPE:** This Standard defines the requirements for the type and frequency of process monitors, laboratory controls, and in-process inspections and tests to be performed as part of the ongoing operation of production heat treating equipment and the maintenance of related records.

This Standard is applicable to the following Heat treat Processes:

- . Carburizing/Carbonitriding/Carbon Correction
- . *Vacuum Carburizing/Carbonitriding Gears and Shafts*
- . Neutral Hardening - Atmosphere
- . Tempering and Stress Relieving
- . Nitriding/NitroCarburizing
- . Annealing/Normalizing
- . Aluminum Solution Heat treating/Age Hardening
- . Brazing/Sintering
- . Salt Bath Heat treating
- . Induction Hardening, Flame Hardening, Tempering and Annealing of Gears, Shafts and Crankshafts

This Standard applies to all production and service parts.

For parts whose heat treat characteristics are not identified by any of the above criteria, the minimum requirements for a specific type and frequency of process monitor, laboratory control, or in-process inspection or test will be specified.

CAUTION: APPROPRIATE PRECAUTIONS MUST BE TAKEN RELATIVE TO HEALTH AND SAFETY AND ENVIRONMENTAL HAZARDS. FORD FACILITIES SHALL CONTACT THE APPROPRIATE FORD MOTOR COMPANY HEALTH AND SAFETY AND ENVIRONMENTAL ACTIVITIES FOR SPECIFIC INFORMATION REGARDING SUCH PRECAUTIONS.

These monitoring and control tests are required to keep heat treating processes and processing equipment under control to produce parts that will meet Product Engineering requirements and functional tests. Regularly scheduled maintenance as well as equipment operating responsibilities of the production operator are not included.

The emphasis on process control is to provide indications that the process is stable or is drifting out of control or actually is out of control before part quality is adversely affected. It is expected that such process monitoring will be of value in maintaining process stability and in bringing a process back into control.

The responsible outside supplier or Company plant or division shall consider requirements for each individual part and decide whether the minimum requirements of this general Standard is adequate or whether they should prepare a more specific or detailed local process control standard for the individual part.

Exceptions to this Standard and alternative plans for control of heat treating processes may be used provided they afford adequate protection of a process currently proven to be stable and capable, and have the concurrence of the affected Ford Supplier Technical Assistant (STA) and/or Quality Planning Team and are documented in a control plan.

Reduced sampling strategies for control of heat treating processes may be used provided they afford adequate protection of a process currently proven to be stable and capable, and have the concurrence of the affected Ford Supplier Technical Assistant (STA), Ford Heat Treat Assessor(s) and/or Quality Planning Team and are documented in a control plan.

The objective of this Standard is to define the requirements and to encourage Best Practices which will assure a quality part as well as promoting continuous improvement relative to quality and productivity.

The principal concerns which are addressed by this Standard include:

- . The heat treater must know the specification(s) to which the parts are to be heat treated.
- . The processes used to heat treat the parts must be clearly defined.
- . All parts must be heat treated to the defined process and specification.
- . Monitoring of the process through the use of an approved control plan must be such to assure that the process is in control and is being improved in order to minimize variability as well as minimize the risk of out of specification parts.
- . Incoming materials shall be specified and controlled in such a manner to assure a product which can be heat treated with minimum part variability.

1.2 SPECIFICATION OF REQUIREMENTS: The heat treater shall have an Engineering Drawing or a written specification listing the engineering requirements (e.g., incoming material, case depth, surface hardness, core hardness, etc.) of Ford parts processed.

1.3 PROCESS SPECIFICATION: The supplier shall establish a written process specification (complete with a control plan) for all processes used to heat treat parts supplied directly or indirectly to the Ford Motor Company. The specification shall completely describe the process and the pertinent variables and specify the principal operating parameters (e.g., temperature, cycle time, Carbon potential, etc.) and their acceptable ranges as part of the program to assure that the parts meet the requirements of the Engineering Drawing.

1.4 PROCESS AND QUALITY CONTROLS: Included in this Standard are the required checks, observations, and tests (including frequencies) to be performed to assure that the product is in conformance with the in-process and Engineering Drawing requirements.

- . Section 2 describes those requirements relative to Furnace Processes and Section 3 describes the same requirements for both Induction and Flame Processes.
- . Sections 2.1 and 3.1 include detailed descriptions of the process monitors which are normally done by production and/or maintenance personnel, usually requiring minimal testing apparatus, and often involving visual observations of monitoring equipment.
- . Sections 2.5 and 3.5 cover the laboratory controls which normally require skilled operators and involve checks and tests of a more exact nature than those controls which are considered to be process monitors.
- . Sections 2.6 and 3.6 cover the tests and inspections to be performed on heat treated parts or test samples.

An operations manual including emergency, start-up, shutdown, and general operating procedures should be readily available to the production supervisors and operators. It should also include process sheets, inspection sheets, control plan, trouble shooting guide, alerts, and other pertinent information needed by operating, inspection, and maintenance personnel. Rejects and scrap must be monitored as to cause and quantity to assist in prioritizing corrective action(s).

1.5 CONTROL PLAN: A written control plan as outlined in the current Ford Quality Standard is required for parts covered by this Standard.

1.6 STATISTICAL METHODS: The heat treater must demonstrate that the equipment used for the Heat treatment process is under control and demonstrates that the process produces parts which comply with the print specifications.

1.7 CLEANLINESS OF PARTS PRIOR TO HEAT TREAT: Parts must be clean, free of rust, burrs and chips, and free from detrimental amounts of drawing, forming and/or rust preventative oils and lubricants prior to heat treatment.

These oils and lubricants may adversely affect the carbon potential of the furnace atmosphere or may interfere with the carburizing or carbonitriding or quenching of the part. (Sulfur-containing oils and lubricants may have a detrimental effect on furnace and fixture life.)

2. FURNACE PROCESSES:

2.1 PROCESS MONITORING: As used in this Standard, process monitors are the observations, checks, and tests specified by Manufacturing Engineering, Plant Engineering, the Quality activity, and/or other designated activity, to be performed by inspectors, production operators, breakdown or light up personnel, electricians, and/or other skilled trades personnel, to assure heat treating conditions are within process specifications and that the heat treating equipment is operating properly.

The following are descriptions of the process monitors incorporated into this Standard. The process must be monitored and the data recorded. Process instructions, control plans, and/or process sheets must be located in the department and available to the responsible operators, maintenance specialists, and/or other designated individuals. Frequencies for performing certain of these Process Monitors are specified in Section 4 of this Standard.

2.1.1 INDICATED TEMPERATURE: All temperature controlling and indicating instruments on furnaces, generators, and quench systems shall be visually checked during the heat treat process for conformance to the set temperature of the process. On instruments with recording charts, the checker, at the time of the check, shall initial and date the face of the chart *or control document* to verify the check or shall log in the same fashion as done with non-recording instruments. On non-recording instruments, the set temperature, indicated temperature, time, date, and checkers initials shall be recorded in a log book, data logger or other record provided for that purpose.

. In certain types of equipment, such as continuous draw furnaces, a fixed thermocouple may be inadequate to detect changes in heating pattern within the furnace chamber. A traveling thermocouple can be used to supplement fixed thermocouples by providing a thermal profile.

. The use of non-contact infrared thermometry (in addition to the conventional thermocouple) is recommended to monitor the temperature of the high heat zones of continuous furnaces.

. Continuous strip charts and/or data loggers are required for recording of temperature data. Use of such charts permit review of the temperature history of a furnace/operation over a period of time (e.g., a shift) to determine if there is unexpected/unwanted drifting or peaks/drops in temperature.

. Overtemperature and undertemperature (where applicable) controls can serve to alert the operator to gross process variations, can protect furnaces from damage and can prevent parts from being overheated. To be most effective, the overtemperature limit should not be set more than approximately 25°C (50°F) over the process set temperature.

2.1.2 STANDARDISED TEMPERATURE CONTROLLER: All instruments without built-in automatic self-compensation or constant voltage supply units must be manually checked and balanced daily against a standard. This manual standardization shall be recorded in a log book, data logger or other record provided for that purpose.

2.1.3 TEMPERATURE MEASUREMENT DEVICES AND PROTECTION TUBES: There shall be a scheduled checking of temperature measurement devices and protection tubes on all heat treating furnaces, molten salt baths and auxiliary equipment (generators, etc.). For detailed procedures, see Section 6.0.

2.1.4 MONITOR OF THE FURNACE/GENERATOR OF CARBON BEARING ATMOSPHERE: All carbon-bearing atmospheres for use in carburizing, *nitrocarburizing*, carbonitriding, carbon correction, or neutral hardening furnaces must be controlled and monitored on a regular basis to assure conformance with the specified carbon potential. This shall be accomplished by one or more of the following methods:

- . CO₂ Content *
- . Oxygen Partial Pressure *
- . Complete Gas Analysis *
- . Carbon Potential
- . Dew Point (Not acceptable for parts designated as Control Items (∇) *)

at the frequency specified in Section 4 of this Standard.

The accuracy of instruments must be verified at a frequency sufficient to demonstrate control. The date and time of the verification shall be logged in an appropriate record.

**This requirement does NOT apply to vacuum carburizing. However, for parts designated control items (∇), the following checks should also be made if vacuum carburizing is used.*

FORD MANUFACTURING STANDARDS

**W-HTX
MAY 2006**

**CONTROL OF HEAT TREATING PROCESSES
AND AUXILIARY EQUIPMENT**

**W-HTX
Page 11**

For the processing of parts designated as Control Items (▽) using reactive carbon-bearing atmospheres, correlation must be determined and demonstrated between the control variable and the actual carbon potential of the furnace atmosphere.

For the processing of parts not designated as Control Items (▽), a periodic check should be used to verify that the routine monitor is providing accurate results.

Such correlation shall be initially determined and periodically verified by measurement of carbon potential using shim stock, carbon gradient bars, or other standard techniques, as identified in the control plan. The date and time of the verification shall be logged in an appropriate record. Correlation checks include the following:

- Carbon Gradient Check: The carbon gradient of the heat treating atmosphere and process shall be checked by the method described in Ford Laboratory Method AA 101-4 or equivalent. The test bars shall be processed concurrent with production parts to determine the carbon gradient. Normally this check is used with processes developing total case depths in excess of 0.4mm (0.015in).
- Carbon Shim Stock: The carbon potential of the heat treating atmosphere can be checked by the method described in Ford Laboratory Test Method AA 101-3 or equivalent. Test pieces shall be located in the furnace zone to be checked while production parts are being processed. If there is no diffusion cycle utilizing a different carbon potential, the test pieces may be processed with parts through the entire furnace cycle.

On atmosphere generators utilizing a refrigerator, the refrigerator temperature must be monitored.

A program of routine furnace/generator burnouts must be employed, especially when a unit is used for carburizing or carbonitriding.

NOTE: In some instances, the specified control system may not be applicable to a particular furnace or gas generator. It is the heat treater's responsibility to verify that the specified control will be effective with the unit in question. When equipment design prevents the monitoring of important properties (such as atmosphere quality) as specified, an alternative method may be used provided it affords equal protection and is included in the control plan which has been reviewed by the responsible Ford Supplier Technical Assistance (STA) Office and/or Quality Planning Team.

Furnace conditions must be checked to assure positive internal furnace pressure, to determine presence of air and gas leaks and to verify the condition of radiant tubes relative to burn through and cracks. (The internal furnace pressure can be verified by manometer or by visual confirmation in the instance of open retort or rotary retort furnaces.)

2.1.5 ATMOSPHERE FLOW RATE: All flowmeters shall be monitored for proper flow (as per the process specification) and the readings recorded *or PLC monitored. In the case of vacuum furnace, this would be either propane or acetylene flow rate.*

2.1.6 ATMOSPHERE PURGING: When the process for which a furnace is being used is to be changed (for example: carburizing to neutral hardening) the correct furnace atmosphere required for the new process must be fully developed within the furnace and confirmed by O₂ analyzer, gas analysis, CO₂, or resistance wire before production to the new process can be started.

To assure the atmosphere is free from ammonia, there *shall be a three hour minimum* purge period after using an ammonia atmosphere before a Ford order not specifying ammonia enrichment of the atmosphere may be processed.

When changing over a furnace from one utilizing ammonia to one in which no ammonia is to be used, the ammonia supply line must be completely disconnected from the furnace and the open ends capped, to avoid any possibility of shut-off valve leakage. An alternative method utilizing a valve arrangement which will vent any ammonia from a leaking valve to the air rather than to the furnace may be employed. Record action in a log book, data logger or other record. Where applicable, quick disconnect couplings designed for use with ammonia may be utilized.

2.1.7 MONITOR OF AN AMMONIA ENRICHED ATMOSPHERE: All ammonia enriched atmosphere furnaces must be controlled and monitored on a regular basis to assure conformance with the specific dissociation rates through an analysis of percent dissociation. The date and time of the verification shall be logged in an appropriate record, along with any necessary corrective actions.

2.1.8 MONITOR OF THE SALT BATH: All salt bath equipment must be controlled and monitored on a regular basis including the temperature-control system, exhaust smoke from the combustion chamber of fuel-fired furnaces, and bath activity through a rapid performance test. The date and time of the verifications shall be logged in an appropriate record, along with any additions of fresh salt, water, and graphite cover material.

FORD MANUFACTURING STANDARDS

**W-HTX
MAY 2006**

**CONTROL OF HEAT TREATING PROCESSES
AND AUXILIARY EQUIPMENT**

**W-HTX
Page 13**

2.2 CONDITION OF QUENCH:

2.2.1 WATER-SOLUBLE POLYMER QUENCHANT: The quench system shall be checked to assure that quench temperature, concentration, suspended solids, pressure, and agitation adhere to the process specification and the checks recorded.

2.2.2 WATER QUENCHANT: The quench system shall be checked to assure that quench temperature, suspended solids, pressure, and agitation adhere to the process specification and the checks recorded.

2.2.3 SOLUBLE OIL: The quench system shall be checked to assure that quench temperature, concentration, suspended solids, pressure, and agitation adhere to the process specification and the checks recorded.

2.2.4 OIL: The quench system shall be checked to assure that quench temperature, agitation, and visual condition of the oil adheres to the process specification and the checks recorded.

Flash and fire point checks of the quench oil are recommended to safeguard against possible contamination or dilution which could create a fire hazard.

2.2.5 SALT BATH: Molten salt systems shall be checked to assure that agitation (if specified), time parts are in the salt (in the instance of martemper and austemper operations), and salt temperature adhere to the process specification and the checks recorded.

2.2.6 BRINE AND CAUSTIC: Brine and caustic quench systems shall be checked to assure that agitation, quench temperature, and specific gravity adhere to the process specification and the checks recorded.

2.2.7 High Pressure Gas Quench: Gas quench systems water flow, water temperature, quench pressure and fan speed shall be checked to insure adherence to the process specifications and the checks recorded.

The time and temperature that parts are to remain in the quench media must be specified, monitored and logged. *For vacuum carburizing, transfer time to quench must also be monitored.*

CAUTION: Special attention must be given to assure that the quench is used within the appropriate temperature and concentration ranges that are compatible with the part/material being heat treated. Quenching characteristics of some quenchants can change significantly with relatively minor changes in temperature or concentration.

NOTE: Records of quench condition shall be recorded in a log book, data logger *or PLC*, or other record provided for that purpose.