

# The Definitive Guide to CQI-9 Special Process: Heat Treat System Assessment (4th Edition)

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In the high-stakes world of automotive manufacturing, the integrity of structural components is non-negotiable. Among the various manufacturing stages, **heat treatment** stands out as a "Special Process." This designation implies that the results of the process cannot be fully verified by subsequent inspection and testing of the product alone; instead, the quality is built into the process itself. To standardize the control of these critical operations, the **Automotive Industry Action Group (AIAG)** developed the **CQI-9 Special Process: Heat Treat System Assessment (HTSA)**. Now in its 4th Edition, this standard has become the global benchmark for ensuring robust, repeatable, and high-quality heat treatment across the automotive supply chain.

## The Evolution and Purpose of CQI-9

The CQI-9 standard was born out of a need for a common approach to heat treat audits. Before its inception, various Original Equipment Manufacturers (OEMs) and Tier 1 suppliers used disparate auditing criteria, leading to confusion and redundancy in the supply chain. The primary goal of CQI-9 is the development of a heat treat management system that provides for **continual improvement**, emphasizing **defect prevention** and the reduction of variation and waste.

By adhering to CQI-9, organizations align themselves with the requirements of **IATF 16949**, specifically concerning supplemental requirements for special processes. The 4th Edition, released to address technological advancements and industry feedback, refines the assessment process to ensure that heat treaters are not just meeting minimum standards but are actively managing risks through technical excellence and management commitment.

## Core Components of the CQI-9 Assessment

The CQI-9 assessment is structured into four main sections, supplemented by various process tables. Understanding these sections is vital for any organization seeking certification or compliance.

### 1. Management Responsibility and Quality Planning

This section evaluates the organization's commitment to the heat treat process. It covers the necessity of having a **qualified heat treat auditor** on staff who possesses both technical knowledge of heat treatment and experience in quality auditing. Key requirements include:

- **Advanced Product Quality Planning (APQP)**: Integration of heat treat requirements into the product development lifecycle.
- **FMEA (Failure Mode and Effects Analysis)**: Organizations must utilize standards such as SAE J1739 or the AIAG & VDA FMEA Handbook to identify and mitigate risks.
- **Contingency Planning**: Ensuring production continuity in the event of equipment failure or utility interruptions.

### 2. Floor and Material Handling Responsibility

The physical handling of materials is as critical as the thermal cycle itself. This section focuses on **material identification**, **lot traceability**, and the prevention of **non-conforming material** from entering the supply chain. It

mandates strict controls on loading patterns, basket configurations, and the documentation of "as-quenched" hardness or other physical properties immediately following the process.

### 3. Equipment Requirements

CQI-9 requires rigorous maintenance and calibration schedules for all heat treat equipment. This includes the validation of temperature control systems, atmosphere controls (such as carbon potential or vacuum levels), and quenching systems. A significant focus is placed on **instrumentation**, ensuring that all sensors and controllers are calibrated to NIST-traceable standards.

### 4. Job Audit

The Job Audit is a unique feature of CQI-9 where the auditor selects a specific part and follows it through the entire process—from receiving to final shipping. This "walkthrough" verifies that the theoretical procedures documented in the first three sections are actually being followed on the shop floor.

## Technical Deep Dive: Pyrometry (SAT and TUS)

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Perhaps the most technically demanding aspect of CQI-9 involves **Pyrometry**. This refers to the measurement and control of high temperatures. To ensure accuracy, the standard mandates two primary tests: the **System Accuracy Test (SAT)** and the **Temperature Uniformity Survey (TUS)**.

### System Accuracy Test (SAT)

The SAT is designed to verify the accuracy of the entire measurement chain: the thermocouple, the lead wire, and the instrument. There are two types of SATs:

1. Probe Check SAT: Comparing a calibrated test thermocouple (placed near the resident thermocouple) with the furnace's control instrument.
2. Comparison SAT: Using a secondary instrument to verify the primary reading.

The mathematical requirement for a passing SAT is generally that the difference between the test system and the furnace system must be within  **$\pm 1.1^{\circ}\text{C}$  ( $2^{\circ}\text{F}$ )** or **0.7%** of the temperature, whichever is greater (though specific limits may vary by furnace class).

### Temperature Uniformity Survey (TUS)

While an SAT checks a single point, a TUS checks the entire **work zone** of the furnace. It involves placing multiple thermocouples throughout the furnace to ensure that every part, regardless of its location in the load, experiences the same thermal profile. The 4th Edition provides clear guidelines on the number of thermocouples required based on the volume of the furnace.

| Survey Parameter                    | Requirement / Detail                                  | Standard Frequency                              |
|-------------------------------------|-------------------------------------------------------|-------------------------------------------------|
| SAT (System Accuracy Test)          | Comparison of test sensor vs. control sensor.         | Quarterly (or as determined by equipment class) |
| TUS (Temperature Uniformity Survey) | Mapping of temperature variance within the work zone. | Annually (or semi-annually for strict classes)  |
| Instrument Calibration              | Calibration of control and recording instruments.     | Quarterly                                       |

## The Eight Process Tables of CQI-9

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CQI-9 utilizes specific Process Tables to define requirements for different types of heat treatment. An organization must apply the tables relevant to their specific operations.

| Table Number       | Process Category                             | Examples of Processes Covered                    |
|--------------------|----------------------------------------------|--------------------------------------------------|
| Process Table I    | Ferrous - Carburizing / Carbonitriding       | Gas Carburizing, Neutral Hardening, Austempering |
| Process Table II   | Ferrous - Nitriding / Nitrocarburizing       | Gas Nitriding, Ferritic Nitrocarburizing (FNC)   |
| Process Table III  | Aluminum Heat Treating                       | Solutionizing, Aging, Annealing                  |
| Process Table IV   | Induction Heat Treating                      | Case Hardening, Tempering (using induction)      |
| Process Table V    | Annealing, Normalizing, and Stress Relieving | Spheroidizing, Sub-critical Annealing            |
| Process Table VI   | Vacuum Heat Treating                         | Vacuum Hardening, Vacuum Annealing               |
| Process Table VII  | Brazing                                      | Furnace Brazing, Vacuum Brazing                  |
| Process Table VIII | Sintering                                    | Powder Metallurgy Sintering                      |

## Key Changes in the 4th Edition

The transition from the 3rd to the 4th Edition brought several significant changes aimed at modernization and clarity. One of the most critical updates is the requirement for **digital data recording**. The industry is moving away from paper charts (analog recorders) toward digital systems that offer better resolution, data integrity, and easier auditing.

Another major change involves the **Auditor Qualification** criteria. The 4th Edition places a heavier emphasis on the auditor's metallurgical background. An auditor is now expected to understand the "why" behind the processes—for example, understanding how carbon potential affects the microstructure of steel, rather than just checking if a box is ticked.

## Practical Implementation: A Step-by-Step Guide

Implementing a CQI-9 compliant system is a multi-month project that requires cross-functional collaboration. Below is a procedural framework for successful adoption:

### Step 1: Gap Analysis

Obtain the current copy of the **AIAG CQI-9 Guideline**. Conduct an internal audit against all 4 sections and relevant Process Tables. Identify where the current system fails to meet the stringent pyrometry or management requirements.

### Step 2: Equipment Assessment and Calibration

Ensure all thermocouples (Control, Safety, and Recording) are of the correct **Type** (e.g., Type K, Type N, or Type S). Perform a fresh TUS and SAT to establish a baseline. If the furnace fails to meet uniformity standards, thermal insulation or burner/heating element adjustment may be required.

### Step 3: Documentation and Training

Update **Standard Operating Procedures (SOPs)** to reflect CQI-9 requirements. This includes establishing clear "Pass/Fail" criteria for all tests. Train shop-floor operators on the importance of load patterns and the documentation of quench delays (the time taken to move a part from the furnace to the quench tank).

### Step 4: The Internal Self-Assessment

Execute the formal self-assessment. Use the **Job Audit** to find hidden non-conformities. It is highly recommended to involve an external consultant or a certified lead auditor for the first formal assessment to ensure objectivity.

## Common Failure Modes and Troubleshooting

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During a CQI-9 audit, several common issues often result in non-conformities. Understanding these can help organizations prepare more effectively.

- **Quench Delay Exceedance:** For aluminum alloys, the time between the furnace door opening and full immersion in the quench tank is critical. If the SOP says 15 seconds and the operator takes 20, the parts may be scrap. Solution: Automate the quench transfer mechanism or implement digital timers.
- **Incorrect Thermocouple Placement:** During a TUS, placing sensors too close to heating elements or air intakes will provide false readings. Solution: Use standardized TUS frames that lock sensor positions according to the defined work zone.
- **Lack of Management Review:** Often, technical teams handle the audit, but the results are never reviewed by upper management. Solution: Schedule quarterly CQI-9 status meetings that include the plant manager and quality director.

## Case Study: Improving Yield through Pyrometric Discipline

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A Tier 2 automotive supplier of transmission gears was experiencing a 4% scrap rate due to inconsistent hardness profiles. Upon implementing the **CQI-9 4th Edition** protocols, they discovered that their **SAT (System Accuracy Test)** was being performed at a different temperature than their primary production temperature. This meant the instruments were inaccurate in the range where the actual heat treating occurred.

By synchronizing their SAT temperatures with their production setpoints and upgrading to **Type N thermocouples** (which are more stable at high temperatures than Type K), the supplier reduced their hardness variation. Within six months, the scrap rate dropped to 0.5%, and the organization passed their OEM audit with zero major non-conformities. This demonstrates that CQI-9 is not just a compliance burden, but a powerful tool for **Operational Excellence**.

## Integration with Digital Transformation (Industry 4.0)

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The 4th Edition of CQI-9 encourages the use of advanced technology. **Predictive maintenance** and **Real-time thermal monitoring** are becoming integral to compliance. Modern furnaces are now equipped with **PLC (Programmable Logic Controllers)** that log data every second, creating a "Digital Twin" of the heat treat cycle. This data-rich environment allows for automated generation of TUS reports and instant notification if an SAT fails, preventing the processing of large batches of non-conforming material.

The CQI-9 Heat Treat System Assessment is more than a checklist; it is a comprehensive philosophy of thermal processing. By integrating management responsibility, rigorous equipment maintenance, and precise pyrometry, manufacturers can ensure that every gear, bolt, or structural component they produce meets the highest standards of safety and performance. As the automotive industry shifts toward electric vehicles (EVs), the requirements for

lightweight aluminum and high-strength steel components will only become more stringent. In this evolving landscape, CQI-9 remains the indispensable roadmap for quality assurance in heat treatment. Organizations that embrace these standards will not only remain compliant but will also gain a competitive edge through improved efficiency, reduced waste, and superior product reliability.

## Baca Juga (Artikel Terkait)

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- [Mastering ISO 9001:2015 Gap Analysis: The Definitive Technical Guide for QMS Compliance](http://123caramba.com/iso-9001-gap-analysis-comprehensive-guide.pdf)

URL: <http://123caramba.com/iso-9001-gap-analysis-comprehensive-guide.pdf>

- [Mastering ISO 9001:2015 Risk-Based Thinking: A Comprehensive Technical Guide for Quality Leaders](http://123caramba.com/iso-9001-2015-risk-based-thinking-guide.pdf)

URL: <http://123caramba.com/iso-9001-2015-risk-based-thinking-guide.pdf>

- [Comprehensive Guide to Aerospace Quality Management Systems: Navigating AS9100, AS9103, and AS9131 Standards](http://123caramba.com/comprehensive-guide-aerospace-quality-management-systems-as9100-as9103-as9131.pdf)

URL: <http://123caramba.com/comprehensive-guide-aerospace-quality-management-systems-as9100-as9103-as9131.pdf>

- [Comprehensive Guide to Advanced Product Quality Planning \(APQP\): 2024 AIAG 3rd Edition Updates and Technical Implementation](http://123caramba.com/comprehensive-guide-to-advanced-product-quality-planning-apqp-2024.pdf)

URL: <http://123caramba.com/comprehensive-guide-to-advanced-product-quality-planning-apqp-2024.pdf>

Tags: #CQI 9 #Heat Treatment #AIAG #IATF 16949 #Automotive Quality #Pyrometry











