Bosch-Norm

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Release of heat treatment processes

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Area of validity, binding force, freedom to disclose	
Valid for	Bosch Group
Binding for	No central agreement
Binding due to	No central agreement
Recommended for	Bosch Group
Disclosure	No restrictions

This Bosch-Norm is binding for suppliers if it is part of the order.

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In case of doubt, the original language edition of this Bosch-Norm applies.
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1 Scope

The technical area of validity of this Bosch-Norm covers all metallic, self-developed products and raw materials (EZRS), which pass through a heat treatment process (HT process) by the supplier or sub-supplier. This includes all HT processes, which influence the final Bosch-related material properties. The following special cases are included:

- Tempering of springs, which are exposed to high fatigue stress and the possible fracture of which would result in extensive damage
- Sinter hardening process (hardening by sintering heat) in which the component property is set by a rapid cooling
- Forming processes on components in which a controlled cooling process has a functional influence on the metallurgical microstructure (e.g. controlled cooling after the hot working)
- Setting of material properties on the bar steel (e.g. inductive prehardening of bars, annealing processes, tempering processes to avoid hydrogen embrittlement,...).

A case-to-case evaluation takes place for processes, which are required only for supplier-internal further processing steps and whose influence on the properties of the products to be delivered is negligible. The process of sintering (without sinter-hardening) is to be classified as HT process only in individual cases (e.g. special requirements in density, C-content, hardness). The case-to-case evaluation is carried out by the responsible Bosch-HT experts. A case-to-case evaluation by the responsible Bosch-HT expert is also carried out for HT processes on catalog parts and components of assemblies for which Bosch only specifies functional properties. Steel manufacturing processes, in which the final material microstructure is already created in the same process, are not considered part of the scope of this Bosch-Norm. Norm-components, which are functionally checked by the supplier in the framework of the manufacturing process (e.g. screws) are also not part of the scope.

For some individual Bosch divisions, a risk classification decides about the application of the methods described in this Bosch-Norm.

This Bosch-Norm contains:

- Specifications for the selection, classification and release of heat treatment suppliers
- Specification for the release of heat-treated parts
- Technical requirements for the heat treatment processes at heat treatment suppliers.

2 Release and rating of heat treatment companies

The first release and continuous rating of HT companies takes place in the framework of heat treatment audits (HT audits) and the evaluation of the HT process resulting therefrom. Framework conditions, content and scope of the HT-audits are described in chapter 3.3.2.

Deviating from this system, a quick and short-term downgrading of the HT supplier release status can take place based on production experiences and notes of the business divisions and Bosch-HT experts (irrespective of already evaluated processes).

3 Release of heat treatment processes

The release process of heat treatment processes is divided into the selection of the heat treatment company, the process development phase, the release phase as well as the validation of the series launch.

3.1 Selection of heat treatment companies

The supplier names possible HT suppliers in the procurement process of heat-treated parts. The Bosch-HT expert agrees based on the ratings of process available and/or suggests alternatives (see chapter 3.3.2). If the supplier suggests a HT company that is not listed at RB, then this company has to be audited and approved by Bosch-HT experts. The HT company and the processes available in the company have to be suitable for executing the component-specific HT process.

3.2 HT process development phase

During the HT process development phase, the HT process is designed in cooperation with the HT company and developed on a stable level. A Bosch-HT expert should be involved in the development phase in order to implement the process-specific Bosch requirements as well as the transfer of the Lessons-Learned experiences.

3.2.1 Specifications for HT processes

The component properties required for the component and the heat treatment processes and procedures required for the same are defined in drawings, heat treatment orders and test specifications.

The following documents are necessary for the description and quality assurance of heat-treated components and are included in the BOM:

- Parts drawing
- Material order specification
- Heat treatment order
- Test specification.

These are provided to the supplier by the Bosch Purchasing.
The respective production status of the components has to be specified in the respective document (e.g. measured on the finished part, measured on the component directly after the heat treatment) in order to test the requested specifications, which have to be generated by the heat treatment (HT).

3.2.2 Parts drawing

The drawing should include the set values for the physical component properties, incl. tolerances as well as describe the material condition. The specification of the measurement procedure is also necessary depending on the set value (e.g. surface hardness (OFH): (740 ± 50) HV10). The parts drawing can optionally contain the position of the measuring points (alternatively in the PV).

The HT process should be specified in accordance with the terminology of DIN EN ISO 4885:2018-07. Trade names should be avoided, if possible.

3.2.3 Material order specification

The material order specification defines the materials released for the component.

3.2.4 Heat treatment order

The description and definition of the sampled HT process takes place in a heat treatment order. In the heat treatment order, at least the processing condition and the structural condition before the HT, the batch composition, the process chain, the process parameters and media as well as the side effects on the surface layer and notes on the test processes should be recorded. The heat treatment order is finally created in the HT process development phase.

Note: For processes, which are based on Supplier-Know-How and for which there is no heat treatment order from RB, the corresponding supplier-internal heat treatment order ("Receipt“, Process specification, ...) is to be defined. This should be done through a cross-reference in the initial sample inspection report to a linked supplier-internal document.

3.2.5 Test specification

In the component-specific test specification, the operation sequences of the test laboratory are defined and the specifications are detailed. This includes:

- Measuring points for the layer, hardness and microstructural checks
- Procedure for the hardness test (number of indentations, evaluation,...)
- Procedure for preparing for metallography (cutting, etching,...)

- Description of the structural properties to be tested (needle length, needle width, carbide morphology, internal and external surface oxidation, unwanted phase components, compound layer,...)
- Structural comparative images (if required, reference to structure standard series)
- Type, scope and procedure of the retained austenite test.

Testing frequencies and sampling points for the test specimen are generally not part of the test specification (see chapter 3.4).

The test specification is finally created in the HT process development phase. A Good-Practice example for a test specification can be found in appendix B.

3.3 Release phase

The release phase can be divided into two subject areas: the sampling of the components and the evaluation of the process within the framework of a HT audit. The release of a HT process normally takes place in a component-specific and furnace-specific manner. Components, which are geometrically identical in material as well as process parameters, can be consolidated into part families.

3.3.1 Sampling

The sampling of a HT process for a component at HT suppliers is to be carried out in the following scenarios:

- New releases for components
- Release of additional facilities for HT
- Relocation or modification of already approved facilities (also affects peripheral facilities (e.g. process gas supply) as far as these have immediate effects on the process and could affect the process result
- Changes on the already released HT processes (time-temperature profile, gassing, batch size,...) deviating from the heat treatment order.

The sampling scope consists of the following validation aspects:

- extended specimen removal for sampling batch
- Temperature uniformity survey (TUS) with full batch.

Through the extended sampling removal and the TUS, the homogeneity of the HT results in the batch is checked, potential weak spots are identified and based on these, the scope of the series tests and positions is defined.

3.3.1.1 Extended test part removal for sampling batch

The proof of adherence to specifications as well as the homogeneity within a batch occurs through a targeted sampling at extreme places and/or places critical to the process.

For the sampling, a HT batch has to be heat-treated under series conditions. Here, the used process parameters as well as the batch structure have to correspond to the planned series. With this, the sample batch can consist of a full batch of series parts or alternative of series parts at the removal positions and ballast parts in the rest of the batch. The ballast parts have to be procured in such a way that the component geometry, mass and surface, as well as the chemical composition in case of thermochemical processes, are similar to the series part, so that the batch mass and component surface are comparable to the series batch. Here, it is to be noted that ballast parts that have been heat-treated multiple times can influence the furnace atmosphere.

The scope of the spot check (extended test part removal) complies with the batch geometry as well as the facilities used:

- In case of a rectangular batch geometry, the test parts removal takes place according to appendix C. The standard scope corresponds to Bk 15 (test part set with 15 parts). Reduced scopes are permissible only in consultation with a Bosch HT expert.
- In case of a cylindrical batch geometry, the test parts removal takes place according to appendix C. The standard scope corresponds to Br 12 (test part set with 12 parts). Deviating scopes are permissible only in consultation with a Bosch HT expert.

- In case of conveyor furnace processes, the test scope consists of the three initial parts, the three last parts as well as three parts, which were removed at half-time (test part set: 9 parts). As far as possible, the three parts for each sequence should be taken from three different band positions (left, center, right).
- In case of a single part HT (e.g. inductive hardening), the test scope consists of the three initial parts, the three last parts as well as two parts, which were deployed at half-time (test part set: 8 parts).

Further removal procedures and their descriptions are listed and described in appendix C.

If any facility-specific critical areas of the determined batch exist, deviating from sketch 1 and 2 and/or the recommended belt positions, which are known to the supplier, then these have to be considered accordingly.

Three test part sets each have to be removed from the sample batch (3 test parts each from every removal position). One test part set remains for testing in the HT company; from the remaining two test part sets, one test part set each goes to the direct supplier as well as to Bosch for an optional cross-examination. A reduction of the test scope is permissible only in consultation with a Bosch HT expert.

The test parts should be marked according to the furnace positions and/or removal time and the test results should be referenced to the same.

1. Testing by the HT company

A complete test part set is to be tested by the HT company according to the component specifications and test specifications. This includes, as far as specified:

- Hardness (surface hardness, core hardness, case hardness depth (CHD), hardness depth profile, ...)
- Microstructure:
  - Surface effects and close to the edge effects (carburization/decarburization, surface oxidation, ...)
  - Basic structure (needle length and width, phase fraction, retained austenite,...)
- Nitriding hardness depth (NHD)
- Coercive field strength
- Internal stress
- Chemical composition (e.g. carbon depth profile)
- Radiographic retained austenite examination.

The test scope in case of elaborate measurement procedures (e.g. radiographic retained austenite examination) has to be agreed upon individually with the Bosch HT experts.

The results should be prepared in tabular format and/or in an analyzable manner. The results are transmitted to Bosch via the direct supplier and assessed by a Bosch HT expert.

2. Testing by the direct supplier

The cross-examination of the test part set by the direct supplier is at their discretion.

3. Testing by Bosch

The necessity of a cross-examination at Bosch as well as their scope have to be agreed upon with the Bosch HT expert.

In case of changes in the process of already approved HT processes, a cross-examination should always be carried out between the series process and the process to be released.

In case of a multistep HT process, an additional sampling as per the HT part steps is required, if need be.

It is to be noted that a statistically based process capability is not in line with industry standards and not feasible for heat treatment processes.

Subsequent to the sample batch, the definition of the series test plan takes place depending on the test results, in agreement between the Bosch HT expert, the direct supplier as well as the HT company.

It should be noted that the functional examination for limited components is not part of this Bosch-Norm and has to be considered within the framework of the general sampling scope (PPAP).

3.3.1.2 Temperature distribution measurement (TUS) with full batch

A temperature distribution measurement (TUS) has to be carried out under series loading conditions within the framework of the process release, in order to prove the adherence of the time and temperature specifications requested in the heat treatment order in the entire batch. If a TUS is not feasible technically, then the homogeneity has to be determined through an increased test effort (removal at critical positions).

As far as technically possible, the TUS can take place on the PPAP batch. Alternatively, the TUS has to take place on a separate batch with series loading (total mass and weight distribution). Series components should be used as measuring parts, the residual quantity can be filled with dummy parts.

For component families and similar geometries (size, weight), existing measurements can be drawn to the documentation multiple times, when the same HT programs and HT facilities are used. An assessment of the suitability is carried out by the Bosch HT Expert.

The application of the thermocouple should, as far as possible, take place on a position of the component, which is most critical for the functional relevance. The components applied with the thermocouples should be distributed as follows across the batch:

- in case of a rectangular batch geometry, according to appendix C, Bk 15
- in case of a cylindrical batch geometry, according to appendix C, Br 12
- in case of conveyor furnace processes, distributed across the furnace bandwidth (left, middle, right). In case of low fill depths (max. double layer) the measurement on one level (3 measuring points) is sufficient. Six measuring points have to be used in case of multilayer batch management, where 1 to 3 should be positioned in the lower layer and 4 to 6 in the upper layer.
- The repeatability of the temperature curve has to be proven from component to component in case of a single piece HT (e. g. inductive hardening).

Individual measuring points can be reduced, if necessary, after consulting with a Bosch-HT expert.

Calibrated sheath thermocouples (type K, N, S, class 1) and measuring instruments (preferably digital measurement technology) should be used as measuring aids. In the temperature profile, the HT process to be approved has to be represented according to the WBA, as far as technically feasible.

The documentation of the TUS has to be carried out according to the CQI9 specifications. The adherence of the following parameters should be evaluated with the help of the measured time-temperature profile:

- holding times on the component according to WBA
- permissible temperature tolerance according to WBA
- if required: heating and/or cooling gradients.

3.3.2 Bosch-HT audit

3.3.2.1 Execution

The HT audits will be carried out by the respective responsible purchase quality area and has to be carried out by a Bosch HT expert. As far as possible, the four-eye principle is recommended.

A Bosch-HT audit is carried out, e.g. for a component and HT process, which is to be approved or is already running. The questionnaires of the audit are created by the responsible purchase quality area. The questionnaires contain a level of expectation for the individual evaluation criteria, which is inspired by the requirements of the automotive area (VDA6.3, AIAG CQI9,...). The entire HT manufacturing chain, incl. test processes and logistics, are covered topically. The HT supplier audit additionally includes the assessment of the quality management system.

Bosch-HT audits are divided into two categories, which differ with regard to the scope and content, depending on the use case. Accordingly, there is a HT supplier audit and a HT process release audit.

3.3.2.2 HT-Supplier audit

A HT-Supplier audit has to be carried out, if:

- the HT-company has not been audited yet in the past (i.e. no Bosch components are released for heat treatment yet) or
- if the HT company was already audited, but the process for the component to be approved is not used yet for Bosch components.

Based on the "first audit", a new evaluation of the processes is carried out at regular intervals, within the framework of a re-audit, with the aim of ensuring the "state of the art technology". Furthermore, a HT-Supplier audit can be repeated based on production experiences and notes of the procuring divisions and Bosch HT experts.

Alternatively, a VDA6.3 audit with focus on heat treatment can be carried out by a general process auditor; however, the accompaniment of a Bosch HT expert is mandatory.

3.3.2.3 HT-Process release audit

If the concerned processes has already been approved within the framework of a HT Supplier audit, then the new release of components takes place within the framework of a HT process release audit (process approval). A HT process release audit also takes place mandatorily within the framework of the release of a new facility.

If a component of the same parts family is approved, then a single-case decision is taken by Bosch HT experts about the necessity of a HT process release audit.

In case of relocation or modification of the already approved facilities and/or changes in the already approved HT process, the necessity of a HT process release audit is taken by the Bosch-HT experts (single-case decision).

In case that the use of customer-specific questionnaires is demanded, these have to be completed additionally and do not replace the Bosch-HT audits. The execution is not part of this Bosch Norm and have to be decided separately in the business division.

3.3.2.4 Assessment

The audits result in a classification of the audited HT process for the component, which is represented as follows with the help of stoplight colors:

Table 1 Identification in the audit report and process release status

Identification in the audit report	Process release status
green	HT process for the component approved without restrictions.
yellow	HT process for the component approved with restrictions. Shortcomings in the processes were determined, which can be, in principle, corrected "quickly" through suitable measures. The HT company has to define suitable measures for the determined deviations, which are evaluated by the Bosch HT experts and are finally checked through the transformation to efficacy. Release by the responsible purchase quality management (Bosch HT experts) and possible commissioning and/or process release follows only after the implementation of the measures.
red	Considerable shortcomings in the processes, which cannot be corrected through "quick" measures. No supplier release is granted. HT process is blocked for new commissionings; decisions on the existing orders (e.g. if an audit takes place within the framework of a new evaluation) are taken from case-to-case. A new evaluation has to be carried out after correcting the shortcomings.

If the heat-treated component is delivered to Bosch by a direct supplier, then an additional part flow audit is recommended at the direct supplier (tier 2). This is more important, if the direct supplier is integrated into the value stream before the heat treatment and if the processing preliminary stages can be mixed with heat-treated components.

3.4 Validation of series launch and series production

3.4.1 Validation of series launch

Subsequent to the process release, at least three subsequent batches (stabilization batches) have to be checked with an extended test part removal according to chapter 3.3.1.1. Deviations from the test scope are permissible only in agreement with the responsible Bosch-HT experts. Best practice is the official definition and tracking of this validation as part of an EPC (Early Production Containment) with the direct supplier.

Subsequent to the stabilization batches, warning limits should be determined. This should show a supplier-internal restriction of the tolerance width of the specification through early detection of process anomalies and should enable a timely reaction. The procedure for determining the warning limits is described in appendix D.

3.4.2 Validation of series production

In the series production with the selected random sampling, the heat treatment company has to ensure that the complete batch corresponds to the drawings and specifications. For this, a check according to the test specification (PV) should be carried out in the series production at, unless agreed otherwise, at least one component for each production lot and HT batch. The check has to take place on the critical positions of the batch identified within the framework of the sampling. Standing orders in line with industry standards should be considered while determining the test effort (e.g. AIAG CQI9).

Note: In HT processes with potentially critical microstructural effects, a microstructure test must be carried out on at least one component per HT batch.

The HT-company has to ensure the process stability after "Start of Production" (SOP) and to substantiate the same with suitable proof. The following proof is accepted:

- Process documentation of quality-relevant parameters
- technical function monitoring and documentation of the facilities and processes
- minutes of a representative temperature distribution measurement (repeated at least on an annual basis)
- targeted sampling for checking the homogeneity and tolerance adherence within the batch
- requalification of the series based on the scope of sampling (HT-based)
- 100 % test of all parts (e.g. with the help of the eddy current method).

4 Requirements for the heat treatment processes with HT-suppliers

There are certain requirements and boundary conditions for the HT processes of components in the external procurement for the automotive area in order to ensure component-, customer- and industry-sector-specific standards:

1. AIAG CQI9 and other OEM requirements to the HT

These define the requirements to the HT processes of components for the automotive area. These standards have to be adhered to by the HT suppliers in the concerned processes.

Purchasing demands, if necessary, that the direct supplier of a heat-treated component obtains a CQI9-System-Assessment (HTSA) as per AIAG in their respective HT suppliers. The supplier forwards the cover sheet to Bosch. The HT company has to define measures for the deviations from the requirements.

2. Traceability

It is necessary for the release of a HT process that parts with a clear batch identification are handed over to the subsequent process of the value chain in order to guarantee a demanded, batch-related traceability in the entire value stream. A mixing of HT batches should be avoided in the subsequent value chain. If there is a mixing of HT batches in the further production process, then these should be traceable and restricted.

3. Eddy current testing

If the direct supplier is integrated into the value stream before the HT, then the risk of mixing components of different processing stages increases. If a mixing cannot be ruled out, then a 100 % eddy current test enables the safeguarding of suppliers to Bosch against mixing (hard-soft). The testing should be safeguarded by the direct supplier. Bosch purchase decides about the necessity of an eddy current test under involvement of the product development.

4. Avoidance and/or restriction of residue from previous processes (e.g. phosphorus)

The HT company and the direct supplier have to define suitable methods and measures in order to ensure a possibly comprehensive freedom from residue of components before the heat treatment, since residue (e.g. phosphorus) represent a production risk in high-strength components for those components and/or for the products, into which the components are installed (e.g. through phosphorus embrittlement). An introduction of residue (e.g. through cleaning agents) or their carry-over (e.g. in cleaning machines) should be avoided. The necessity for surface cleanliness is to be assessed as component-specific and process-specific by the Bosch HT expert.

5. Reworking

Rework in the form of repeated HT is not permissible or requires a special release by Bosch. This is valid for every single process step. Unless otherwise specified in the WBA, multiple tempering is defined as rework. One exception represents multiple tempering during hardening and/or quenching and tempering, which is generally permissible.

6. Straightening

Straightening of the components is permissible only after previous involvement and release by a Bosch HT expert.

5 Normative references

The following documents are necessary for using this Bosch-Norm. With dated references, solely the edition referred to applies. Intentionally cited historical documents are additionally identified as "H" in the column "Type".

No.	Document number (edition date)	Title	Type
1	DIN EN ISO 4885:2018-07	Ferrous materials - Heat treatments - Vocabulary (ISO 4885:2018); German version EN ISO 4885:2018	Z

Type: M = Document to be supplied; Z = Cited document; H = Historical document

6 Literature

No.	ISBN-Number (edition date)	Title
1	ISBN 9781605344492 (2020-06) respectively actual follow-up-versions	CQI-9 Special Process: Heat Treat System Assessment 4th edition

A Appendix Good-Practice example for test specification

BOSCH Prüfvorschrift Test specification	Common Rail Injektor CRI/CRIN Härte- und Gefügeprüfung nach Wärmebehandlung / hardness- and microstructure check after heat treatment of Bauteil / Produkt	Blatt / page 1 von / of 5

1. Grundsätzlich muss jede WBH-Charge nach folgender Prüfvorschrift (PV) geprüft werden.	**1. In principle every HT-batch has to be checked according to the following test specification**
1.1 Prüfteilentnahme WBH Betrieb Prüfteil-Entnahmepositionen und Prüfhäufigkeiten werden nach Absprache mit RB in einem Prüfteil-Entnahmeplan festgelegt. Alle Prüfteile müssen eindeutig beim Dechargieren gekennzeichnet, getrennt und als Rückstellmuster archiviert werden. Dauer nach Absprache mit RB.	1.1 Sampling at HT facility Test specimen position and test intervals have to be laid down in an inspection plan as per details agreed upon with RB. All test specimens have to be clearly marked, separated and archived as “retained samples” during the sampling operation. The archiving duration is subject to agreement with RB.
1.2 Verwerfen von Prüfteilen Alle Prüfteile der Härteprüfung sind als Ausschuss zu entsorgen bzw. als Rückstellmuster aufzubewahren.	1.2 Discarding of test specimens All test specimens used for hardness check have to be disposed as scrap or stored as samples to be retained.
2. Überprüfung von Härteprüfgeräten Die Härteprüfung ist nach DIN EN ISO 6507 durchzuführen. Das Prüfgerät ist täglich bei Gebrauch mittels zertifizierter Prüfplatte zu überprüfen. Die Überprüfung muss mit dem gleichen Verfahren und entsprechender Prüflast durchgeführt werden. Die Messwerte sind zu dokumentieren.	**2. Inspection of hardness testing devices** The hardness check has to be carried out according to DIN EN ISO 6507. Each day the testing equipment is used it has to be checked using a certified master specimen. The hardness check has to be performed using the same procedure and test load each time. All measured values have to be documented.
3. Oberflächenhärte Sollwertangabe siehe Zeichnung. Die Härtevorgaben gelten für das gesamte Bauteil.	**3. Surface hardness** Required values see drawing. The hardness requirements are valid for the complete part.
3.1 Die Prüfung der Oberflächenhärte erfolgt nach der WBH an der Messstelle (siehe Bild 2) (Die Prüfung erfolgt mittels dreier Einzelmessungen auf der Planseite injektorseitig, Werte siehe Zeichnung).	3.1 The surface hardness has to be checked after the heat treatment at the hardness testing position (see pict. 2). (The hardness test is carried out with three separate impacts at the plane surface injector side, values see drawing).

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BOSCH Prüfvorschrift Test specification	Common Rail Injektor CRI/CRIN Härte- und Gefügeprüfung nach Wärmebehandlung / hardness- and microstructure check after heat treatment of Bauteil / Produkt	Blatt / page 2 von / of 5

3.2 Das Ergebnis für die Oberflächenhärte ist der rechnerische Mittelwert der drei einzelnen Messwerte. Alle drei Einzelwerte müssen innerhalb der Toleranz liegen.

4. Lichtmikroskopische Untersuchung des Gefüges

4.1 Die Prüfung der Mikrostruktur erfolgt für jede WBH-Charge. Zu diesem Zweck, werden die Prüfteile längs getrennt und eingebettet, geschliffen, poliert und angeätzt.

4.2 Vergütungsgefüge (Bild 3); Nadellänge max. 25µm (vereinzelt bis 50µm zulässig). lamellarer Perlit und freier Ferrit nicht zulässig; Korngrenzenferrit im Bereich bis 20µm zulässig.

4.3 Metallographisch sichtbarer Restaustenit ist nicht zulässig.

4.4 Randoxidation: max. 10µm
An nach der WBH bearbeiteten Flächen ist eine Randoxidation nicht zulässig.

4.5 Aufkohlung bis 200µm zulässig, lichtmikroskopisch sichtbare Karbide sind nicht zulässig.

3.2 The result of the surface hardness measurement is the arithmetic mean of the three separate values. All three single values must be within the tolerance.

4. Light microscope check of the microstructure

4.1 The check of the microstructure has to be executed for each HT batch. For this check, the specimens will be longitudinal cut and embedded, polished and etched.

4.2 Quenched and tempered microstructure (Pict. 3); martensite needle length max. 25µm (isolated needles up to 50µm acceptable). Lamellar Perlite and free Ferrite is not acceptable. Grain boundary Ferrite is acceptable up to 20µm from surface.

4.3 Metallographical visible retained austenite is not permissible.

4.4 Internal Oxidation: max. 10µm
At after HT machined surfaces no internal oxidation allowed.

4.5 Carburization allowed up to 200µm, lightmicroscopical visible solid carbides are not allowed.

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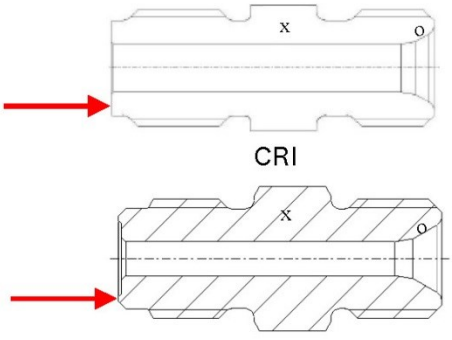
5. Prüftstellen / Schnittlinien
Check points / cutting lines

Schnittlinie
cutting line

Bild 1 / Pict. 1



x: Prüfpunkt Kernhärte und Kerngefüge
check point core microstructure
Kernhärte mit HV1 / core hardness in HV1

o: Prüfpunkt oberflächennahes Gefüge
checkpoint microstructure nearby surface

➔: Prüfpunkt Oberflächenhärte
check point surface hardness

Bild 2 / Pict. 2

6. Gefügebilder / Microstructure pictures

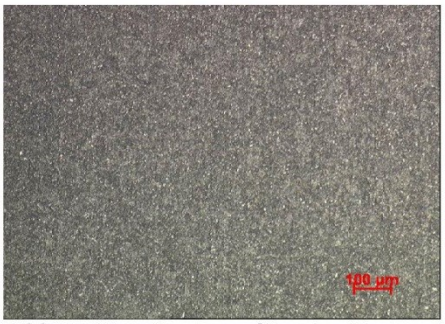


Bild 3: Vergütungsgefüge im Kern
Pict. 3: QT microstructure in the core

Gefüge i.O.
Homogenes Vergütungsgefüge
Angeätzt mit alkoholischer Salpetersäure (Nital).
Microstructure ok
Homogenous quenched and tempered microstructure.
Etched with alcoholic nitric acid (Nital).

	Datum	Name			
gez.					
gepr.					
ges.					
Original:		Entw.:	Änderungs-Nr.	Datum	Abt./Name

BOSCH Prüfvorschrift Test specification	Common Rail Injektor CRI/CRIN Härte- und Gefügeprüfung nach Wärmebehandlung / hardness- and microstructure check after heat treatment of Bauteil / Produkt	Blatt / page 4 von / of 5

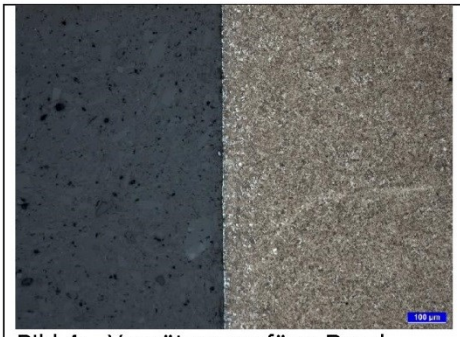


Bild 4: Vergütungsgefüge Rand
Pict. 4: QT microstructure surface

Gefüge i.O.
Abkohlung / Weichhaut im Bereich < 20µm.
Angeätzt mit alkoholischer Salpetersäure (Nital).
Microstructure ok.
Decarburization / soft skin at area < 20µm from surface.
Etched by alcoholic nitric acid (Nital).

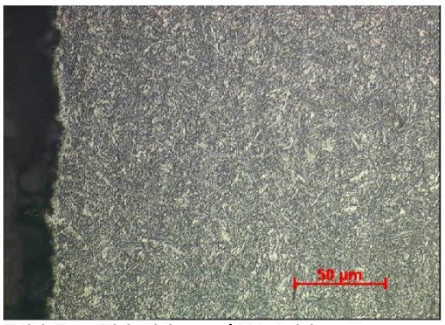


Bild 5: Abkohlung / Weichhaut
Pict. 5: Decarburization / soft skin

Gefüge i.O.
Abkohlung / Weichhaut im Bereich < 20µm.
Angeätzt mit alkoholischer Salpetersäure (Nital).
Microstructure ok.
Decarburization / soft skin at area < 20µm from surface.
Etched by alcoholic nitric acid (Nital).

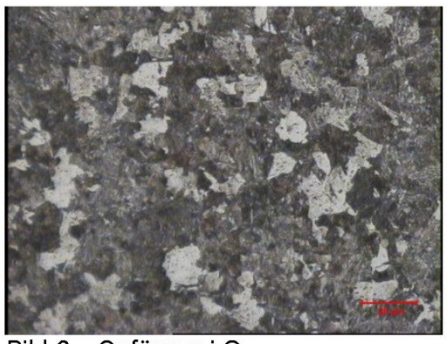


Bild 6: Gefüge n.i.O.
Pict. 6: microstructure not ok

Mikrostruktur im Bereich Kern n.i.O.
Mischgefüge aus Ferrit, Perlit und Zwischenstufe.
Angeätzt mit alkoholischer Salpetersäure (Nital).

Microstructure at core area not ok.
Inhomogeneous microstructure with Ferrite, Perlite and Bainite.
Etched with alcoholic nictric acid (Nital).

	Datum	Name			
gez.					
gepr.					
ges.					
Original:		Entw.:	Änderungs-Nr.	Datum	Abt./Name

BOSCH Prüfvorschrift Test specification	Common Rail Injektor CRI/CRIN Härte- und Gefügeprüfung nach Wärmebehandlung / hardness- and microstructure check after heat treatment of Bauteil / Produkt	Blatt / page 5 von / of 5

7. Dokumentation

Alle Messwerte sind zu dokumentieren und müssen zusammen mit den Chargen-dokumenten aufbewahrt werden. Die Schliffe der Prüfteile müssen ebenfalls auf die WBH-Chargen bezogen gekenn-zeichnet und aufbewahrt werden.

7. Documentation

All measured values have to be documented and archived along with the HT-batch documents. The microsections of the test specimens have to be labeled and archived related to the HT-batch reference.

	Datum	Name			
gez.					
gepr.					
ges.					
Original:		Entw.:	Änderungs-Nr.	Datum	Abt./Name

B Appendix Batch positions

There are different approaches and necessities for the removal of samples. The following table explains the different removal procedures, their abbreviation and, if required, the corresponding figures.

Table 2 Explanation of the removal procedure, their abbreviation and figure

Abbreviation [a)]	Explanation	Figure
Bk 9 (P1, P2, ... Pn) -X	Batch treatment in case of a cubic form of treatment chamber with 9 sampling points; optional specification of positions in brackets if the test should take place only at these positions; arrow indicates the removal direction.	Figure Bk9
Bk 11 (P1, P2, ... Pn) -X	Batch treatment in case of a cubic form of treatment chamber with 11 sampling points; optional specification of positions in brackets if the test should take place only at these positions; arrow indicates the removal direction.	Figure Bk11
Bk 15 (P1, P2, ... Pn) -X	Batch treatment in case of a cubic form of treatment chamber with 15 sampling points; optional specification of positions in brackets if the test should take place only at these positions; arrow indicates the removal direction.	Figure Bk15
Br 12 (P1, P2, ... Pn) -X	Batch treatment in case of a cylindrical form of treatment chamber with 12 sampling points; optional specification of positions in brackets if the test should take place only at these positions.	Figure Br12 (Pos. 1-12)
Br 20 (P1, P2, ... Pn) -X	Batch treatment in case of a cylindrical form of treatment chamber with 20 sampling points; optional specification of positions in brackets if the test should take place only at these positions.	Figure Br20 (Pos. 1-12 and Pos. A-H)
Cb-X, Cm-X, Ce-X, CtY-X	Continuous treatment "C", e.g. continuous furnace "b" = Begin, "m" = Middle, "e" = End of the process "t" = Removal according to a certain process time "Y"	
Eb-X, Em-X, Ee-X, EnY-X	Individual treatment "E", e.g. inductive hardening "b" = Begin, "m" = Middle, "e" = End of the process "n" = Removal according to a certain number "Y"	
100 %	The test is to be carried out on each part.	
Min(Z), Max(Z)	The test is to be carried out at the limits of the test results of a previous test "Z".	
RefP	The test is to be carried out on a reference sample. Type, material, heat treatment condition, geometry and position of the reference sample have to be defined in the PV.	

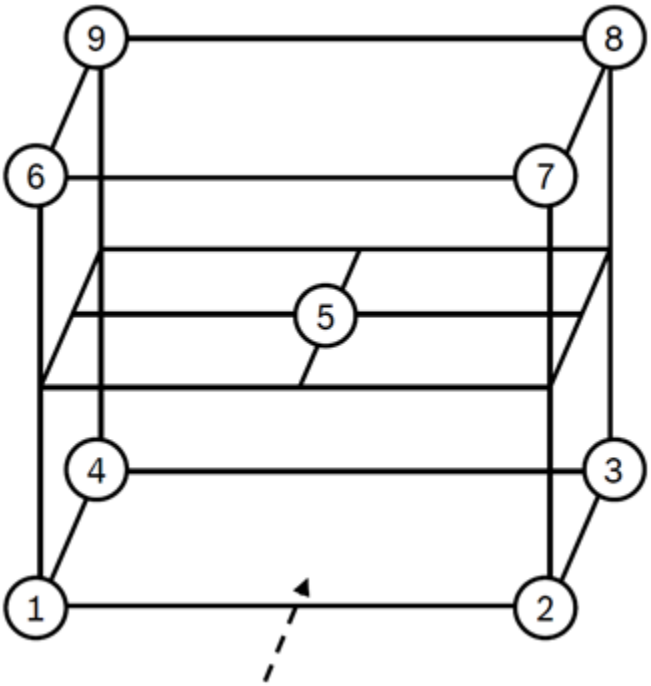


Figure Bk9

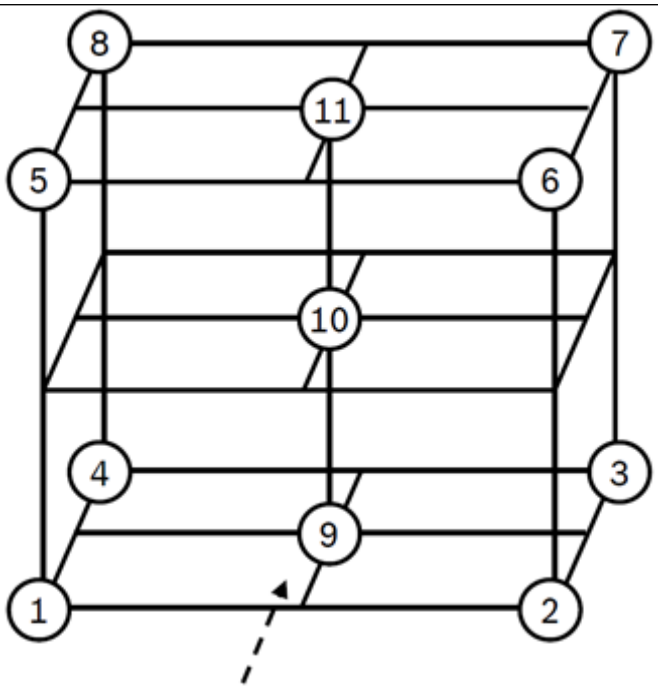


Figure Bk11

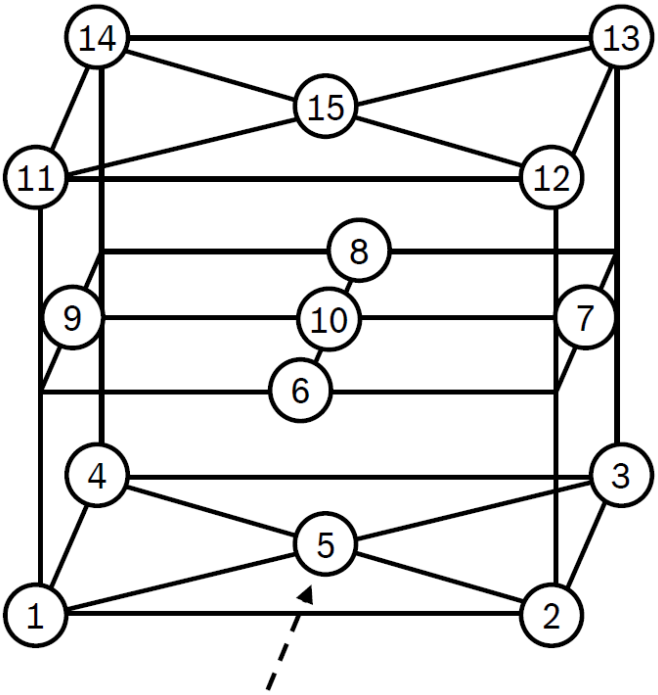


Figure Bk15

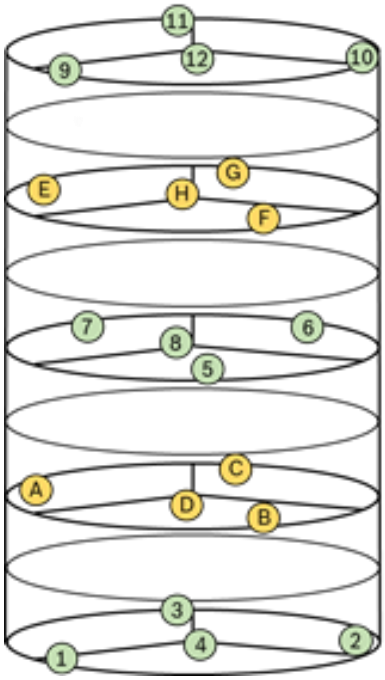


Figure Br12 and Br20

C Appendix Determination of warning limits

Subsequent to the stabilization batches, warning limits should be determined.

The definition of values of the warning limits takes place empirically based on the series experience, by expanding the range of the measuring values, available after the first 5 batches, by 10 % and by defining the limits resulting therefrom as warning limits.

If the warning limits defined according to this method lie outside the tolerance of the specification, then the introduction of warning limits is not possible.

The following is an example for the determination of warning limits.

Example

The following diagram shows the measuring values of the surface hardness for a hardened and tempered component made of 100Cr6 after the first 5 stabilization batches. The tolerance lies between 670 HV10 and 770 HV10. The upper limit value of the measuring values lies at 740 HV10, the lower limit value of the measuring values lies at 700 HV10. The range thereby amounts to 40 HV10.

The upper action limit (OEG) and the lower action limit (UEG) are calculated as follows:

OEG = OGW + (0,1 x SB) = 740 HV10 + (0,1 x 40 HV10) = 744 HV10

UEG = UGW - (0,1 x SB) = 700 HV10 - (0,1 x 40 HV10) = 696 HV10

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