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1 GENERAL REQUIREMENTS

1.1 PURPOSE

1.1.1 AWQ49658 is the standard procedure and specification that ensures the quality of all hot work tool materials and their heat treatment as required for GM tooling projects. This document is available for use by any GM allied organization. A copy will be made available by sending an email request to a GM employee involved in the relevant tooling project.

1.2 SCOPE

1.2.1 All hot work tool steel inserts, cores and core pins must be built to the standards of this specification; if not, they must be replaced by the Tool Source at their expense. All inserts or core pins that are not independently tested per this procedure must still meet the standards contained herein. The requirements of this specification supersede material and/or heat treat specifications given on individual insert drawings or CAD models.

1.3 RESPONSIBILITY

1.3.1 It is the responsibility of GM Commodities Management, Manufacturing Engineering, Laboratory, GM's Tooling Suppliers and Material & Heat Treat Sources to comply with or ensure compliance to this procedure. The Tool Supplier has primary responsibility to ensure compliance regardless of the buyer of material and heat treat. When the Tool Source is required to replace an insert (due to their failure to comply), it means that they will buy all material and heat treat per this specification and machine the insert to the specifications of their current contract. In other words, replacement will be at the expense of the Tool Source.

1.4 MATERIAL AND HEAT TREAT SOURCES

1.4.1 The current list of approved and provisionally approved material and heat treat sources will be made available by sending an email request to a GM employee involved in the relevant tooling project. The approved source list document is; AWQ49657 HPDC Die Insert Material and Heat Treating Source List.

1.5 APPROVED SOURCES

1.5.1 H-13 and all other hot work tool steels may only be supplied to GM or its Tool Sources by mills designated by the approved or provisional suppliers. Provisional and Approved material sources are designated by the mill that produces the material. In effect it is the mill that is approved as the supplier. It is not permissible for a Steel Supplier to buy steel from a mill not designated and sell it as their own. The Steel Supplier may not change mills without approval from General Motors. General Motors must certify any mills not presently designated before they can supply steel to GM.

1.5.2 Provisional and Approved heat treat sources are designated by the facility that contains the approved furnace. It is not permissible for the heat treater to heat treat at another facility that is not approved by General Motors.

1.5.3 An approved source cannot be self-certified. That is, all approved sources continue to be obligated to submit samples for each piece of purchased steel.
1.5.4 No material may be sold to GM or its Tool Sources that does not meet the requirements of this specification. If the material fails any of the Steel Mill Certification tests then it may not be shipped for use in GM tooling projects. Steel Mill Certification must demonstrate that all relevant values meet this specification especially with regard to Charpy Impact values.

1.6 PROVISIONAL SOURCES

1.6.1 A Provisional Source is not an approved source. A Provisional Source is one that has demonstrated the capability to meet all the requirements of this specification, but has not developed a long history of insert test results statistically confirming their capability.

1.6.2 The material or heat treat source shall be in close communication with GM throughout this process. GM reserves the right to review and witness all work in order to assure that this process is being conducted in the proper manner.

1.6.3 For a material source, a large population of various sized insert steels must be tested in an actual tool source production environment (tools built for GM) to confirm capability. The confirmation process and requirements are as follows:

1.6.4 The material source will obtain a serial number from GM and then send a piece of premium grade steel (steel size 400 mm X 400 mm X 400 mm approximate weight is 532 kg.) with a 13 mm sampling plane cut 98% through the sample to the approved testing lab for metallurgical tests. The sampling plane must be cut perpendicular to the grain direction of the steel. Grain direction and short transverse (thickness) direction shall be indicated on the steel block by way of etchings, hand ground arrows or engraving.

1.6.5 The approved testing lab will remove several samples and forward the test results to the potential material supplier and GM. The material source will pay for this testing.

1.6.6 The provisional testing period shall last a maximum of 30 months from the first production insert test submitted. The provisional source must meet all requirements of this specification.

1.6.7 During this period a minimum of 25 pieces shall be tested at the approved lab; 15 pieces must be at least 250 mm thick. GM has no obligation to create the opportunity to test these pieces within the prescribed period of time. The material source will have the chemistry of two randomly chosen pieces (different heats) verified by one of the approved independent labs at their own expense.

1.6.8 The first time acceptance rate must be 88% or better for the total population of inserts.

1.6.9 When a piece is rejected, a new block of steel must be substituted by the Supplier at his cost. This substitute piece must meet the requirements of the specification. If it fails, then the provisional testing period is at an end and the Supplier must start the whole process again.

1.6.10 If 30 months is not sufficient time to complete the confirmation process, the Supplier may elect to begin the process again subject to the approval of GM.

1.6.11 The Supplier’s mill will be inspected by GM at the end of the testing period if all the conditions are met. This inspection will primarily focus on QS-9000/ISO 9000 series audit items with particular emphasis placed on process control and quality systems. This is not a QS/ISO certification on the part of General Motors.

1.6.12 For a heat treat source, a large population of insert steels must be tested in an actual tool source production environment (tools built for GM) to confirm capability. The confirmation process and requirements are as follows (The heat treat source will do the following):

1.6.13 The heat treat source will buy a piece of premium grade hot work tool steel that meets this material specification. For example: steel size 400 mm X 400 mm X 400 mm
(approximate weight is 532 kg). Make sure the steel source cuts the 13 mm sampling plane 98% through. Obtain a serial number from GM.

1.6.14 Send the piece of steel to the approved testing lab for testing. They will remove several samples and forward the test results to the potential heat treat supplier and GM. All testing will be at the expense of the heat treat source.

1.6.15 Upon verification of material quality, the steel will be shipped to the heat treat source for heat treat. Surface thermocouple holes must be placed in the center of all six sides of the block. A core thermocouple hole must also be installed to the exact center of the block. The surface thermocouple hole may be offset 12 –13 MM from the core thermocouple hole. Data must be recorded from all seven thermocouples.

1.6.16 After heat treating the steel per this specification, send the entire block to the approved testing lab for analysis. Also send the furnace charts to the plant metallurgist at GM. The testing lab will remove several test pieces and forward the results to the potential heat treat supplier and GM. Both sides of the block in the short transverse plane may be sampled.

1.6.17 The metallurgist at the Die Caster will analyze and compare the results to the initial heat treat potential test and determine if the heat treat source is capable of meeting the GM specification.

1.6.18 Once the heat treater has demonstrated capability his name will be added to the current version of this specification as a source with provisional approval. The provisional testing period shall last a maximum of 40 months from the first production insert test submitted. The provisional source must meet all requirements of this specification. Full approval is only possible after heat treating 45 pieces (25 being at least 250 mm thick) of hot work tool steel for GM with an acceptance rate of 95% or more.

1.6.19 When a piece is rejected, it must be re-heat treated by the Supplier at his cost. This heat treat must then meet the requirements of the specification. If it fails, then the provisional testing period may be terminated by GM depending upon the circumstances and the Supplier must start the whole process again.

1.6.20 If 40 months is not sufficient time to complete the confirmation process, the Supplier may elect to begin the process again subject to the approval of GM.

1.6.21 The heat treater’s facility will be inspected by GM at the end of the testing period if all the conditions are met. This inspection will primarily focus on QS-9000/ISO 9000 series audit items with particular emphasis placed on process control and quality systems. This is not a QS/ISO certification on the part of General Motors.

1.6.22 A Supplier becomes an Approved Source when it meets all the requirements of the provisional testing period and the GM on-site audit.

1.7 HEAT TREAT CONTRACTS

1.7.1 The end user (the die caster or casting organization using the tools in production) may elect to create contracts for the heat treat of the inserts. Otherwise, the Tool Source will create the heat treat contract with the Heat Treater. All invoices will be honored after the successful completion of the heat treat as determined by the lab test results, subject to applicable contract provisions.

1.8 INSERTS TO BE TESTED

1.8.1 All large die cavity inserts must be tested. All small inserts cut in multiples from a single piece of tool steel must have one coupon sent for material analysis to represent all the inserts from that piece. A coupon must be sent through heat treat and its’ analysis will represent the heat treat results for all the small inserts heat treated in that particular furnace lot. If necessary, a surrogate coupon (defined later) may be
used. This means that large inserts must have two coupons representing the material and heat treat respectively of each; whereas small insert coupons can represent more than one small insert, either material or heat treat. The end result must be that coupons will be submitted representing the material and heat treat of all inserts built by the Tool Source. The Tool Source must submit in advance a listing of all inserts that will be considered small inserts for the purpose of testing for approval by the GM Engineer.

1.8.2 If the Tool Source is unsure of the category of an insert (large vs. small), they must test per the requirements of a large insert, unless clarification is sought from the GM Engineer. The Engineer will then determine the category and the Tool Source will apply the proper test coupon representation.

1.8.3 Requests for minor exceptions to the testing program must be submitted in advance and in writing by the Tool Source to the GM Engineer. Generally they will not be granted and cannot be granted to rectify an error made by the Tool Source, Material Supplier or Heat Treater. The Tool Source is not relieved of the responsibility of building to the standards of this specification if test exceptions are granted. Therefore, the Tool Source will still be liable for replacing the insert at their expense if either the material or heat treat does not comply with this specification.

1.9 TESTING PROGRAM AND INVOICES

1.9.1 The Tool Source shall be required to maintain a testing program (per this specification) to verify and ensure compliance with the entire procedure and assure that only the highest quality premium grade hot work tool steel and heat treat is utilized. All tests will be performed by an outside, independent test lab (see listing in this specification). This lab will determine the suitability of the material and heat treat for each insert. The GM Metallurgist may, at his option, overrule the Laboratory's determination. The Tool Source will coordinate all the activities of the Material Suppliers and Heat Treaters in regard to the proper testing required in this specification. Heat Treat and Annealed test results (copies of lab reports) must be submitted with insert invoices and die build/rebuild invoices (where some or all of the inserts in the die are supplied by the die builder) to the GM Engineer. Invoices will not be paid without both test results. Altered test certificates will not be accepted. If altered, the test must be performed again to insure that the correct insert has been tested. All costs related to the removal of a test piece (late testing), testing and subsequent repair of the insert will be the responsibility of the Tool Source.

1.10 FAILURE TO PROPERLY TEST MATERIAL OR HEAT TREAT

1.10.1 If the Tool Source fails to test or fails to insure that the material test of the insert is properly performed, they will be required to replace the entire insert to include material, heat treat and labor unless subsequent heat treat test data indicates an acceptable insert. If the heat treat is acceptable then a penalty will apply ($400US or equivalent) to be deducted from the invoice for failure to test the insert material. The purpose of testing is to insure that proper die insert material is used in GM inserts. The testing also serves as a quality measurement and rating system of the Steel Suppliers. The Tool Source is the guarantor (though not necessarily the provider) of acceptable material. This provision does not change any previous Tool Source responsibilities.

1.10.2 If the Tool Source fails to test or fails to insure that the heat treat test of the insert is properly performed, they will be required to replace the entire insert to include material, heat treat and labor. The purpose of testing is to insure that properly heat treated inserts are installed in GM tooling. The Tool Source is the guarantor (though not necessarily the provider) of acceptable heat treat. This provision does not change
any previous Tool Source responsibilities. GM will have no obligation to test an insert once it has been received.

1.11 REJECTION OF MATERIAL

1.11.1 Rejection can occur at (but is not limited to) the following times:

1.11.1.1 At submission of certification (rejected by GM)
1.11.1.2 After test results from independent lab

1.11.2 The certification will be reviewed (optional) by GM and release/rejection will be forwarded immediately to the Tool Source. Work may not proceed on an insert until the independent lab test results are reviewed by the Tool Source. The test results constitute acceptance or rejection of the work piece. In the case of rejection, the Die Caster’s metallurgist must be notified immediately. The independent lab release can be rescinded by the Die Caster if, in its’ opinion, the test results are questionable.

1.11.3 In the case of rejected material, the Tool Source will work with the Supplier to furnish a replacement piece as quickly as possible. The Supplier will be responsible for all the related transportation, testing and machining costs.

1.12 REJECTION OF HEAT TREAT

1.12.1 Rejection can occur at (but is not limited to) the following times:

1.12.1.1 At submission of HT101 form by the Heat Treater
1.12.1.2 After test results from independent lab

1.12.2 The HT101 will be reviewed (optional) by GM and release/rejection will be forwarded immediately to the Tool Source.

1.12.3 Finish machining may not proceed on an insert until test results are reviewed by the Tool Source. The test results constitute acceptance or rejection of the heat treated work piece. In the case of rejection the Die Caster’s metallurgist must be notified immediately. The independent lab test results can be rescinded by the Die Caster if, in its opinion, the results are questionable.

1.12.4 In the case of rejected heat treat, the Heat Treater shall pay for a replacement piece, all machining to date, related transportation and additional testing. The Tool Source will work with the Heat Treater to assure that this occurs as quickly as possible. After discussion with the Die Caster and at their option; the insert may be re-heat treated. The tool is to be annealed before any second heat treat of the tool. A surrogate coupon with a Charpy Impact capability of over 13.5 Nm must be attached in the specified manner and then tested at the Heat Treater’s expense.

1.12.5 The cost of the replacement tooling including machining, material, heat treat, additional testing, transportation and other related costs will be paid by the Tool Source when a heat treat failure (generally quench cracking) is attributable to the Tool Source failing to collaborate or take adequate measures to prevent cracking as outlined in the heat treat section of this specification

1.13 TEMPERATURES

1.13.1 All temperatures specified are in degrees Celsius unless otherwise noted.
1.14 OTHER DOCUMENTS

1.14.1 There are several documents related to this specification. These documents supplement and provide information necessary to the proper implementation of this specification. They are issued and retained by GMPT and revised as needed. They are:

1.14.1.1 Material and Heat Treat Sources
1.14.1.2 Heat Treat Austenitizing Temperatures
1.14.1.3 Die Insert Hardness Table

2 PREMIUM GRADE HOT WORK TOOL STEEL

This part of the specification applies to the material to be used in making hot work tool steel inserts for Aluminum and Magnesium die casting die cavity steel. It is also useful in other applications where hot working conditions exist. This is the premium grade hot work tool steel material specification.

Applications

Choice of the optimum hot work tool steel alloy for a given tool application involves balancing the alloy’s resistance to heat check and its toughness properties.

Of all alloys tested to date, DIN 1.2367 offers the highest resistance to heat check. The current premium grades of this alloy offer excellent toughness as well, making it a preferred choice for most hot work applications. Unfortunately, availability remains an issue with this alloy.

DIN 1.2344 (H13) offers good heat check resistance and the newer premium grades offer more than adequate toughness for most applications. It is readily available from a supply perspective, providing another advantage.

Modified DIN 1.2344 alloys offer higher toughness levels as well as good heat check resistance.

Modified DIN 1.2343 alloy offers extremely high toughness levels. This alloy is an excellent choice for applications requiring high toughness such as block water jacket inserts. Applying a PVD coating with an ion nitride base significantly improves the performance of this alloy when used in small to medium size tooling. However, its heat check resistance is significantly lower than the alloys listed above, and should only be used where very high toughness properties are required. Improvements in the toughness levels of DIN 1.2344 and 1.2367 and their variants have made obsolete many of the historical advantages of this alloy.

DIN 1.2343 has high toughness but lacks in heat check and mechanical deformation resistance when compared to Din 1.2367, 1.2344, and similar alloys. DIN 1.2344 and 1.2367 material and heat treat improvements have reduced the need for this alloy due to similar toughness levels achieved by those alloys with superior heat check resistance.

2.1 SIZE, SHAPE AND TEST COUPONS

2.1.1 The size and shape of the tool block must be specified on the purchase order. The tool block should be cut from a parent block that allows for minimum parent block
thickness. In essence, the smallest of the three tool block dimensions will determine the parent block thickness. For example, a purchased tool block that is 350 X 500 X 550 mm will use a 350 mm (in the short, or thickness direction) parent block. The parent block must be less than 50 mm thicker than the tool block, unless the thickness of the parent block is 300 mm or less. The 50 mm thickness differential does not apply for parent blocks 300 mm or less. The width must be kept to the smallest possible dimension so that the forging and mill heat treatments produce the required properties.

2.1.2 The Tool Source will order or release the rough (tool) block for the insert to size. All directions refer to the parent block. The Steel Supplier will then be responsible for adding 16 mm in the longitudinal (grain) direction of the parent block to allow test coupons to be taken in the short-transverse plane. The Steel Supplier must cut this plane to insure the Tool Source correctly samples the block. The cut should not completely sever the coupon (testing) plane. A 97% cut-through is sufficient, such that the coupon plane is barely held to the insert block. The Tool Source will cut the remainder. The Steel Supplier must also engrave (stamp) the insert serial number assigned by GM on the block in an area not likely to be removed by machining operations.

2.1.3 The Tool Source must remove two test coupons from the center of the testing plane, 60 mm (parallel to the short/thickness direction) X 90 mm X 13 mm or (for round sections) 90 mm dia. X 13 mm long (+ 3 mm tolerance), from each block and engrave (in cursive with a high speed, small diameter bit, minimum 13 mm high) with the same serial number assigned to the block (insert) by GM. The 60 mm dimension will be in the same direction as the thickness of the parent block. The Steel supplier must stamp the insert block to correctly and clearly indicate this direction.

2.1.4 The first coupon will be sent immediately to the approved testing lab for analysis of the material. It is not permitted to accumulate material test coupons and suddenly send large groups to the testing lab. This causes delays. Send coupons as soon as they are removed from insert blocks. Batches greater than six will be cause for a delay in invoice payment to the Tool Source by GM. The second coupon will accompany the insert through heat treat and will be analyzed for heat treat quality.
2.2 **Material Chemistry, Properties & Requirements**

2.2.1 DIN 1.2344 (H-13) steel shall conform to the following chemical tolerances:

<table>
<thead>
<tr>
<th>Element</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.37-0.42</td>
</tr>
<tr>
<td>Mn</td>
<td>0.20-0.50</td>
</tr>
<tr>
<td>Si</td>
<td>0.80-1.20</td>
</tr>
<tr>
<td>S</td>
<td>Max. 0.003</td>
</tr>
<tr>
<td>Cr</td>
<td>5.00-5.50</td>
</tr>
<tr>
<td>V</td>
<td>0.80-1.20</td>
</tr>
<tr>
<td>Mo</td>
<td>1.20-1.75</td>
</tr>
<tr>
<td>P</td>
<td>Max. 0.015</td>
</tr>
</tbody>
</table>

2.2.1.1 All other hot work tool materials must conform to DIN or submitted factory specifications.

2.2.2 ESR / VAR

2.2.2.1 All DIN 1.2344 (H-13), DIN 1.2367, DIN 1.2343, and modified DIN 1.2344 alloy steel shall be produced using the electro-slag remelt (ESR) or vacuum arc remelt (VAR) process except small round stock when availability is non-existent. Under no circumstances may any piece above 75 mm in diameter be a non-ESR or VAR steel.

2.2.3 Forging

2.2.3.1 Forgings for dies must have a minimum upset forging ratio of 5 to 1, except where prohibited by block size; forging must be done in three directions. Forging ratios are determined linearly. Back forging is permitted but must not be used in calculating forging ratio.

2.2.4 Heat Treatment

2.2.4.1 Block after forging must have a maximum hardness of 235 HBW.

2.2.5 Inspection

2.2.5.1 Final annealed block is to be rough machined and ultrasonically tested by supplier. Block will be rechecked at GM’s option) ultrasonically after block is finished and ready for machining by the Tool Source. Block is to be free of stringers, pipes, oxides, and other defects deemed likely to cause failure. Block is to be rough machined to dimensions indicated on the purchase order.

2.2.6 Grain Size
2.2.6.1 Refer to paragraph "F" of NADCA 207-2003. Grain size shall be developed using the Direct Quench method per ASTM E-112 by austenitizing for 30 minutes at temperature determined by material and Table A at end of this specification. Rapidly quench and temper at 593 C minimum. Hardening should be in a protective media or by using an appropriately oversize sample in a non-protective media. Grain size to be measured by using the ASTM comparative method and shall be predominately ASTM no. 7 or finer.

2.2.6.2 An alternative method to rate the grain size may be used. The Shepherd Fracture Grain Size shall be predominately no. 7 or finer when made on a hardened (air cooled after heating for 30 minutes at 1030° C in a protective media or using an appropriately oversize sample in a non-protective media) and untempered specimen taken from a representative sample.

2.2.7 Annealed Microstructure

2.2.7.1 The annealed microstructure shall be free of significant banding or chemical segregation per the Banding Segregation Reference Chart NADCA 207-2003. Examine banding at 50X magnification. The annealed microstructure shall exhibit a uniform distribution of fine spheroidized carbide throughout a ferrite matrix at 500X after being polished and etched with 5% Nital. Photomicrographs of acceptable and non-acceptable limits will be determined by the Annealed Quality Microstructure Chart contained in NADCA 207-2003.

2.2.8 Primary Carbides

2.2.8.1 The presence of large primary carbides will be cause for rejection. Heat treated microstructure should reflect the fine spheroidized carbide structure specified in the annealed steel.

2.2.9 Microcleanliness

2.2.9.1 The permissible limits of microcleanliness (severity levels of non-metallic inclusion content) shall be determined by ASTM E-45, Method A (latest revision). Plate I-r should be used to obtain rating increments of 0.5. The maximum allowable limits are:

<table>
<thead>
<tr>
<th>Inclusions Type</th>
<th>Thin</th>
<th>Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (sulfide)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>B (aluminide)</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>C (silicate)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>D (globular oxides)</td>
<td>1.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

2.2.10 Impact Capability

2.2.10.1 Specimens shall be tested per NADCA #207-2003 I.E. page 4 items 1 – 7 with the exception that the austenitizing of the Charpy sticks will be at a temperature determined by the material and the Austenitizing Table.
which is a separate document issued by General Motors. The test specimens will be hardened to the same hardness as the destination insert by the testing lab. The five specimens shall be tested at room temperature on machines that meet the requirements of ASTM E23. The values of the highest and lowest specimens shall be discarded and the average of the remaining three results shall be computed.

2.2.10.2 The impact capability of die steel must average no less than 13.5 Nm with any single value to be no less than 10.8 Nm (Charpy V-Notch).

2.3  

**Certification of Conformance**

2.3.1 Certification of Conformance (by the Steel Supplier) for premium grade hot work tool steel supplied in accordance with this document shall include the following information:

- 2.3.1.1 Supplier Heat Designation
- 2.3.1.2 Annealed Brinell Hardness
- 2.3.1.3 Chemical Analysis
- 2.3.1.4 Microcleanliness Levels
- 2.3.1.5 Confirmation that Ultrasonic Testing has been performed
- 2.3.1.6 Grain Size number
- 2.3.1.7 Microbanding Designation Level (Pass / Fail)
- 2.3.1.8 Annealed Microstructure Rating Number
- 2.3.1.9 Response to Heat Treatment
- 2.3.1.10 Impact Capability Test results (should include all results plus average, heat treatment and final hardness of specimens). Average of three values shall be no less than 13.5 Nm with any single value to be no less than 10.8 Nm.

2.3.2 The Tool Source must clearly indicate to the Steel supplier (a P.O. number is not sufficient) that the die steel is destined for use at GM so that he will properly prepare the certification for transmittal. The above certification shall be sent immediately by the Steel Supplier (at the time of shipment) to the Tool Source and to the GM die caster’s plant metallurgist. The original certification shall be sent to the Tool Source.

2.3.3 The purchaser (or GM) reserves the right to monitor the control processes of the supplier to determine compliance with this specification.

2.3.4 In addition, the serial number engraved on each block by the Steel Supplier shall be provided in the purchase order or release by the Tool Source.

2.4  

**TESTING REQUIREMENTS (MATERIAL)**

2.4.1 Test items shall be those listed in the Certification of Conformance.

2.4.2 Frequency of testing - 100%. All inserts will be tested without exception.

2.4.3 Testing to be performed by the approved testing lab. The test results are to be forwarded to the Tool Source, Steel Supplier and appropriate GM Metallurgical Laboratory.
3HEAT TREAT OF PREMIUM GRADE HOT WORK TOOL STEELS

3.1 EQUIPMENT AND CALIBRATION

3.1.1 This part of the procedure applies to PREMIUM GRADE DIN 1.2344 (H-13) die steel and other die steels heat treated at approved, off-site Heat Treat Sources. To meet the requirements of this specification, the following equipment is required:

3.1.1.1 Vacuum furnace with a capability of at least ten bar nitrogen pressure backfill. The capacity of the furnace must be sufficient to achieve a minimum quench rate of 40°C per minute (based on the surface thermocouple placed in the center of the back of the die, 16 mm deep) under load. This will require a furnace of sufficient size to accept large blocks while maintaining adequate circulation to minimize distortion of the block. Exception: Tools less than 90 Kg in weight may be heat treated in a 5 bar minimum vacuum furnace provided the tool is quenched at a minimum rate of 39.0°C (70.0°F) per minute. Both rates are calculated based on the temperature drop from the austenitizing temperature to 537.7°C.

3.1.1.2 Programmable furnace controller capable of monitoring at least six thermocouples simultaneously and capable of programming specified quench rates with an isothermal hold and a high differential between thermocouples. The thermocouple size must be 3 mm diameter to match the size of the dedicated thermocouple holes. Inconel sheathed, Type K 3 mm thermocouples are required.

3.1.1.3 Digital data recorder capable of capturing an entire heat treating cycle including heat-up, austenitizing, and quench to below 150°C. Numerical data acquisition is required in order to completely record and define the heat treat process; the numerical data must be imported to an Excel spreadsheet and be made available to the Die Caster’s metallurgist and Tool Source. A color coded chart can be a supplement to the digital data but not a substitute for it.

3.1.1.4 Furnace must be certified and maintained in accordance with MIL-H-6875. Thermocouples and furnace controller must be calibrated to an NBS (NIST) traceable standard within 90 days prior to use on GM materials.

3.2 Steel Purchase

3.2.1 Purchase steel per this specification. See the Premium Grade H-13 Material portion of this specification. Use GM approved or provisional suppliers only.

3.3 Tool Source / Heat Treater Consultation

3.3.1 The Tool Source must consult with the Heat Treater in either the design phase or steel purchase phase of the tool project (whichever is sooner) to avoid potential cracking problems during heat treat. The Heat Treater is expected to quench die inserts at a very high rate. It is the responsibility of the Tool Source to rough machine the tool in such a manner that minimizes the danger of quench cracking. Adjacent thick and thin sections (widely varying cross sections) should generally be avoided in the die design and build
especially for large inserts. Sharp edges or corners are not allowed during rough machining. Generous radii, bridges between thick and thin areas and elimination of sharp edges all minimize the risk of quench cracks. Some portions of the insert will distort more than others. Sufficient machine stock must be included to accommodate for the expected distortion due to high quench rates. It is required the heat treat supplier position the tool in the furnace so that it is evenly cooled, and not focus the quench towards the coupon area. This causes undue stress to the tooling, and has resulted in quench cracks.

3.3.2 Tooling rough machined geometry and surface condition requirements:

3.3.2.1 The tooling supplier must ensure the rough machined tool surface is free from surface tearing and sharp steps between cuts. These issues greatly increase the risk of cracking during heat treat.

3.3.2.2 The heat treater is obligated to refuse to heat treat a tool that is not machined in such a manner that does not permit the heat treater to properly quench the tool.

3.3.2.3 GMPT Engineering is required to include a check-off in the SOR for new tooling programs requiring rough machined geometry preapproval by the intended heat treat source.

3.3.3 Radius Requirements: Inside radii smaller than 5.0 mm must be avoided in large tooling to reduce the risk of quench cracking. Although 3.0 mm radii will work in some applications, it still carries some risk of cracking when the geometry of the tool is complex. Larger steps and complex geometry will require larger radii, typically ranging in size from 5.0 mm to 10.0 mm. Steps larger than 150.0 mm may require a radius of 13.0 mm or greater. Also, all holes should have a minimum 3.0 mm chamfer at the surface.

3.3.4 Hole spacing: Holes drilled prior to heat treat should retain at least 6.0mm wall thickness between them. 10.0mm minimum wall thickness is optimal.

3.3.5 This guide line does not relieve the tool maker of their responsibility to communicate with the heat treater regarding rough machining issues.

3.3.6 At the request of the GM Tool Engineer, Tool vendors must provide documentation that shows communication and agreement with Heat Treat Sources regarding acceptance of roughing criteria (Example: Pictures, PPT’s, PDF’s, Video’s, Cad Models, etc.).

3.4 Hole work, Coupons & Test Criteria

3.4.1 The Tool Source will add the hole work for the surface thermocouple after consulting with the Heat Treater and will surface grind the coupon face that will make contact with the insert.

3.4.2 The Tool Source shall attach the coupon (tack welded) to the insert detail at the center of the largest surface on the same plane as the cavity face whenever non-cavity face room allows (firmly in contact, no gaps) and be subjected to the same heat treat as the insert. The heat treater is not allowed to move the coupon without the die casters permission. Moving the coupon without the die casters permission is grounds for loss of source approval. No tack welds will be allowed in the area of the Charpy notches. Consult testing lab. See the diagram below. If the coupon is missing from the insert then the Heat Treater must notify the Tool Source and the Caster. No insert may be heat treated without the attached
coupon. Forward the insert detail, Form #HT101 (see Exhibit A), and the attached coupon (per this specification) to the heat treat source. This coupon will be removed by the heat treater after heat treat then forwarded to the testing lab along with a completed HT101 form. The coupon must be hardened to Rc44 – 46 in order to insure a valid comparison to the material Charpy impacts. The Heat Treater will hold the insert until approval is obtained from the approved testing lab. The Tool Source may at their own risk continue the machining of the insert pending test results.

3.4.3 As an alternate the Tool Source may have a supply of coupons prepared in advance to be used as heat treat coupons. These coupons must also be surface ground to assure proper contact with the tool surface. The coupons must be produced from a small, high quality heat of steel that is homogeneous and removed from a block no larger than 150 mm thick. The length (grain direction) may not exceed 600 mm. The width may not exceed 350 mm. The 60 mm dimension of each coupon will be parallel to the thickness (short transverse direction). The Charpy impact capability of the heat of steel must be checked by the approved lab to provide the capability of the small block (and particular heat) that serves as the source for all the coupons. When the coupon is marked for identification, the serial number shall have a suffix attached with the letter “S” and a number identifying the coupon batch. (Such as serial # 10899-S1) The Die Caster’s metallurgical lab must be provided with a list of coupon batch capability values from any Tool Source using these surrogate coupons. When the heat treat is tested using these coupons the Charpy impact average of three (after high and low are discarded) must exceed 80% of the capability of the coupon less ½ the difference of the high and low values or 10.8 Nm whichever is greater. Individual values below 8.1 Nm will be cause for rejection.

3.4.4 If an insert fails commercial heat treat then the die caster must be notified by the tool source. The insert may be heat treated again after annealing. A surrogate coupon shall be attached meeting the requirements of the previous paragraph or the coupon may be derived from left over stock in the original sampling plane of the insert.

3.5 Heat Treatment Details

3.5.1 All heat treatment processes are to comply with the following requirements. Deviations must be requested by the heat treater in writing and approved by GM. Rarely, will deviations be permitted. Attach two thermocouples to the piece to measure surface Ts and core Tc temperatures. (The Ts thermocouple hole is located and machined (by the Tool Source) on the center of the back of the insert 3 mm dia. x 16 mm deep. This location is mandatory unless conditions are such that a proper heat treat will not occur unless the insert is placed on its back. Then the heat treater is responsible for proper placement of the hole.) Use of this dedicated thermocouple hole is mandatory. If the heat treater receives a tool that does not have this hole properly drilled in it; the heat treater shall either return the tool to the machine shop or drill the hole themselves. It is the responsibility of the heat treater and the tool builder to determine proper hole placement. Heat treatment without this dedicated thermocouple hole may be cause for rejection.

3.5.2 The Tc thermocouple is located in the central interior portion of the insert (a water fountain is a good place). If multiple pieces (must be similarly sized) are to be heat treated together, place the thermocouples in the largest piece.
3.5.3 Stress temper prior to hardening will be at the option of the heat treat source. Some complex pieces may need stress relief. Stress relieve to remove cold work effects due to rough machining. Heat to 593 - 621 °C and hold Tc at 593-621 °C for 60 minutes. Heat at a rate not exceeding 220 °C per hour. Cool to 427 °C at a rate not exceeding 110 °C per hour and then air cool to below 65 °C. Time, temperature and rates are based upon the core thermocouple, Tc.

3.5.4 Austenitize – See Table A below for approved Austenitizing temperatures. Attach surface (Ts) and core (Tc) thermocouples to the piece as indicated above. Ts must be inserted in the dedicated thermocouple hole as described above. If multiple pieces are to be hardened together, place the thermocouples in the largest piece. On multiple piece loads insert sizes should be similar. Do not mix large and small inserts. If in doubt consult the GM Metallurgist. Load into cold furnace Heat to 593-649 °C at a rate not exceeding 220 °C per hour based upon Tc and hold until Ts – Tc is less than 110 °C. Continue heating to 857 ± 14 °C at a rate not exceeding 165 °C per hour based upon Tc and hold until Ts – Tc is less than 55 °C. Rapidly raise furnace gas temperature 5 °C above the Austenitizing temperature (e.g. 1038 °C + 5 °C = 1043 °C). When Ta – Ts <= 3 °C then hold for 30 minutes; at the end of the hold quench as rapidly as possible.
Austenitizing Temperatures

Table A

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Temperature (°C) ± (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-13 Superior (NADCA Grade B)</td>
<td>1038 ± 6</td>
</tr>
<tr>
<td>KDA1, DAC55, Tuf-Die</td>
<td>1038 ± 6</td>
</tr>
<tr>
<td>1.2367 (NADCA Grade C, Hot-Die, W403, S+B 2367)</td>
<td>1038 ± 6</td>
</tr>
<tr>
<td>ADC3</td>
<td>1010 ± 6</td>
</tr>
<tr>
<td>Dievar</td>
<td>1010 ± 6</td>
</tr>
</tbody>
</table>

Note: Austenitizing soak times must be carefully controlled per section 3.5.4

3.5.5 Quenching - Inserts must be quenched at 0.9 megapascal or higher based on methods listed below. Quench pressure should be as high as possible without risk to the tool to improve the metallurgical properties. Therefore, if quench pressures higher than the 0.9 megapascal minimum can be used, they should be.

3.5.6 Exception: Tools less than 90 Kg in weight may be heat treated in a 5 bar minimum vacuum furnace provided the tool is quenched at a minimum rate of 39.0°C (70.0°F) per minute. Both rates are calculated based on the temperature drop from the austenitizing temperature to 537.7°C.

3.5.7 Interrupt - Method 1

3.5.7.1 Gas quench at 0.9 megapascal minimum to 427°C plus or minus 8°C based upon surface thermocouple Ts, then interrupt the quench if needed to reduce the temperature differential between the surface and the core. If the interrupt differential (Ts - Tc) is less than 110°C when Ts first reaches 427°C then the interrupt is not required, and quench must not be interrupted. Hold interrupt until either (1.) temperature differential between Ts and Tc is less than 110°C, or (2.) Ts reaches 399°C or (3.) 5 minutes has lapsed, whichever occurs first. Additional heat energy shall not be added with heating elements during the interrupt. If the surface temperature increases to 440°C during interrupt additional cooling should be used to keep Ts between 413°C and 440°C during the interrupt. Quench rate shall be a minimum of 39.0°C (70.0°F) per minute down to 538°C, that is, it will take less than 13 minutes to quench down to 538°C from the Austenitizing temperature (Ta).

3.5.7.2 Resume quench to 65°C (Tc, plus or minus 5°C) when the above conditions are satisfied. The 0.8 megapascal minimum quench pressure must be maintained until the quench cycle is complete. Quenching must remain as rapid as possible; if tool geometry allows quench pressure greater than 0.8 megapascal, the higher pressure should be used to maximize heat treat quality. Interrupt times should be kept to a minimum and avoided when not necessary. Remove the tool from the furnace and continue cooling in still air if needed until Ts is below 50°C. Do not allow the tool surface temperature to fall below 45°C. Temper immediately.

3.5.7.3 Quench gas pressure after interrupt shall be the same as before interrupt, or a minimum of 0.8 megapascal. Resume quench to 65°C (Tc, plus or minus 5°C) when the above conditions are satisfied. Interrupt times should be kept to a minimum, and avoided when not necessary. Remove from the furnace and continue cooling in still air until Ts is below 50°C if needed.
Do not allow surface temperature to fall below 45°C. The use of floor fans or open doorways is absolutely forbidden.

3.5.8 No Interrupt - Method 2

3.5.8.1 The heat treater using his own discretion based on good technical data may delete the 427°C hold from the quenching process and simply quench down to 149°C (based on Tc) at 0.8 megapascal bar minimum and at a rate exceeding 39.0°C (70.0°F) per minute (based on Ts down to 538°C). **Deleted reduction in quench pressure wording!!**

3.5.8.2 Engine Block Water Jacket Inserts Quench with 1.0 megapascal pressure with no interrupt. Position jackets so the quench gas flows directly through the cylinder bore holes in the insert cavity to achieve maximum quench rate. This would mean the 127 x 432 mm plane will be parallel to the ground in most cases. Rc 42-44 required.

3.5.8.3 Upon cooling to 65°C (Tc, plus or minus 5°C), remove the tool from the furnace and continue cooling in still air if needed until Ts is below 50°C. Do not allow surface temperature to fall below 45°C. Immediately temper at 538-565°C for one hour per 25 mm of thickness, two hours minimum. Cool to 32°C in still air and measure hardness. Again, no floor fans or open doorways allowed.

3.5.8.4 Re-temper at 552-649°C to obtain the specified hardness of Rc 44-46 except for engine block water jackets, which must be hardened to Rc 42-44. Contact steel supplier if any question concerning tempering temperatures exists. Hold at temperature one hour minimum per 25 mm of thickness, two hours minimum total. Cool in still air to room temperature and measure hardness. If desired hardness is attained, re-temper at 538-565°C for one hour per 25 mm of thickness, one hour minimum. If desired hardness is not attained, re-temper to appropriate temperature, hold one hour per 25 mm of thickness, two hours minimum total. Measure and record final hardness. Minimum of three total draws (tempers) required.

3.5.9 Stepped Quench Pressure with No Interrupt - Method 3

3.5.9.1 Quench from the austenitizing temperature down to 315-350°C Tc at a minimum of 1.1 megapascal.

3.5.9.2 At 315-350°C (Tc,) reduce quench pressure to .8 -.9 megapascal minimum depending on complexity of tooling geometry. Continue quenching to 204-232°C (Tc).

3.5.9.3 At 204-232°C (Tc) reduce quench pressure to .4 -.6 megapascal depending on complexity of tooling and rough machined geometry.

3.5.9.4 Continue quenching down to 65°C (Tc, plus or minus 5°C). Remove from furnace and Do not allow surface temperature to fall below 45°C. Refer to sections 3.5.8.3 and 3.5.8.4 above for temper requirements. **Throughout the steps, maintain quench pressures and quench rates as high as possible and always above the minimum required to optimize the physical properties of the tooling.**
3.6 Requirements for EDM Processed Inserts

3.6.1 Leave enough stock from rough EDM to eliminate arc puddles during finish EDM. Adjust EDM process (current, frequency, etc.) to achieve the proper balance between rough and finish operations.
3.6.2 Before stress relieving, stone or sand blast insert to remove the white layer.
3.6.3 Stress relieve after finish machining - Heat the insert to 552°C or 27°C below the highest tempering temperature if known. Hold it for one hour per 25 mm of section thickness or for two hours minimum.
3.6.4 Cool in still air to room temperature.

3.7 Stress Relief Temper (General)

3.7.1 Stress temper all inserts when all machining operations are complete and the insert is in a ready to ship condition. This is a requirement regardless of EDM status. Stress relieve per this specification. Only approved or provisional suppliers of heat treat may provide stress relieving service.
3.7.2 Both the heat treat supplier and the tool supplier must recheck hardness of the tool after final stress relief. Both parties must check a minimum of 3 areas on the tool and record the average. Any average hardness checks that fall out of the specified hardness range given above must be reported both verbally and in writing to the GM Metallurgist within 24 hours of the test. The heat treat supplier shall record the post stress relief hardness for all inserts in an Excel spreadsheet that can be made available to GMPT Engineering on request. The tooling supplier must record the final hardness after stress relief on the HT-101 form.

3.8 Welding

3.8.1 Inserts that have weld in the cavity area before heat treat must be annealed by the heat treater before commencing heat treat. The Tool Source must notify the heat treater of existing welds.
3.8.2 Inserts welded in the cavity area after heat treat must be sent to the heat treat source to be stress relieved. Stress relieve the insert at a temperature 27°C below the highest tempering temperature using thermocouple placement as defined above. Hold at this temperature for 60 minutes. Heat at a rate not exceeding 220°C per hour. Cool to 427°C at a rate not exceeding 110°C per hour and then air cool to below 65°C. Time, temperature and rates are based upon the core thermocouple, Tc. The tooling supplier must check the hardness of the tool after this stress relief per the requirements of this specification.

3.9 Documentation Requirements by Supplier

3.9.1 Die Shop Responsibility

3.9.1.1 Issue a Heat Treatment Purchase Order or Release to the selected heat treatment source containing the following information:

3.9.1.1 Quantity of each detail to be heat treated
3.9.1.2 Detail name
3.9.1.3 Detail number
3.9.1.1.4 GM drawing number or CAD model name  
3.9.1.1.5 GM part number  
3.9.1.1.6 GM serial number  
3.9.1.1.7 Latest released copy of the AWQ49658 HPDC Die Insert Material and Heat Treating Standard Criteria.  
3.9.1.1.8 Documentation showing collaborative agreement and acceptance that the heat treater agrees to the rough machined steel to be heat treated.  
3.9.1.1.9 Documentation showing collaborative agreement to follow the AWQ49658 HPDC Die Insert Material and Heat Treating Standard Criteria (Latest Revision).  

3.9.1.2 Furnish the Heat Treat Source the following information on a shipping document accompanying each insert shipment per attached form # HT101:  

3.9.1.2.1 Builder's name (Die shop name).  
3.9.1.2.2 Shipment date.  
3.9.1.2.3 GM Part Number.  
3.9.1.2.4 GM Detail Number.  
3.9.1.2.5 GM Drawing Number or CAD model name.  
3.9.1.2.6 GM detail name.  
3.9.1.2.7 Quantity of each detail being shipped.  
3.9.1.2.8 Brand name of steel.  
3.9.1.2.9 Shipping weight of each detail.  
3.9.1.2.10 GM serial number.  
3.9.1.2.11 Die Number (if known)  
3.9.1.2.12 Caster's Heat Treat Source P.O. number  
3.9.1.2.13 Required final hardness (Rc).  
3.9.1.2.14 Die steel's heat number  

3.9.1.3 All heat treat coupons returned to the Tool Source must be stored for three years.  
3.9.1.4 Maintain shipment/receipt records of each shipment of steel shipped for heat treatment for five years.  

3.9.2 Heat Treat Source Responsibility  

3.9.2.1 Submit each invoice to the proper party for payment of heat treatment of steel received from GM Tool Sources with the following information:  

3.9.2.1.1 Quantity of each detail heat treated and serial numbers.  
3.9.2.1.2 GM detail number.  
3.9.2.1.3 Weight of each detail heat treated.  
3.9.2.1.4 Type of heat treatment furnished.  
3.9.2.1.5 Heat Treat Purchase Order number.
3.9.2.1.6  GM Purchase Order item number (for insert build).
3.9.2.1.7  Testing Lab report - acceptable heat treat.

3.9.2.2  Complete GM form #HT101 and return it and the insert to the die builder after approval by the testing lab. Conformance to this specification must be certified to General Motors via GM form #HT101 with the following information:

3.9.2.2.1  Equalization temperatures and times at temperature.
3.9.2.2.2  Furnace temperature at start of first temper.
3.9.2.2.3  Temperature, time at temperature, and hardness for all tempers and final stress relieve temperature.
3.9.2.2.4  As-quenched hardness no longer required.
3.9.2.2.5  Quench interrupt temperature and quench rate.
3.9.2.2.6  Acceptance of rough machined geometry and surface condition of tool

3.9.2.3  The Tool Source will forward a copy of the HT101 form to the GM Metallurgical Lab.
3.9.2.4  Maintain sufficient records of each Heat Treat Purchase Order to comply with this procedure (i.e. furnace charts, process sheets, etc.) for a minimum of five years.

3.10  Testing Requirements (Heat Treat)

3.10.1  Charpy Impact, microstructure (to include carbide precipitation, bainite/pearlite and hardened structure, use NADCA 207-2003 “HS” Heat Treated Microstructure Reference Chart with the following exception, HS8 & HS9 are now included in the unacceptable category), surface condition (decarburization, carburization, nitride effects) and hardness tests will be performed on the test coupon removed from the insert. Five Charpy impacts will be broken. The high and the low values will not be used in computing the average, the remaining three values will be used to compute an average which must be the greater of 10.8 Nm or 80% of the annealed Charpy average (ideal lab heat treat at material test) minus one half the difference between the high and low values of the five heat treat Charpy impacts. Any single value of the three shall be no less than 8.1 Nm. The hardness shall be the same as the insert.

3.10.2  Example: HT Charpy values - 19, 19, 21.7, 17.6, 20.3

\[ \text{Nm Material Charpy} = 21.7 \]

3.10.3  \[ \text{Average} = \frac{(19+19+20.3)}{3} = 19.4; \text{ half difference} = (21.7 - 17.6)*0.5 = 2.0 \]

3.10.4  \[ \text{Pass / Fail criteria} = 0.8*21.7 - 2.0 = 15.3 \ldots 19.4 > 15.3 \text{ thus heat treat has acceptable Charpy impact value.} \]

3.10.5  The microstructure specimen will be etched with a 5% Nital solution and be prepared per ASTM E3. The microstructure shall consist primarily of tempered martensite and some bainite. There will be no evidence of pearlite, retained austenite, decarburization, carburization or excessive intergranular precipitation.

3.10.6  Frequency of testing - 100% . Every insert must be tested.
3.10.7  Testing to be performed at an outside independent lab. See the listing at the end of the specification. The test results are to be forwarded to the Tool Source and Heat Treater. The results and the completed HT101 form must be sent to the GM Metallurgical Laboratory.
3.10.8  The heat treater will make at least 5 hardness checks (four corners and a central region) on the insert per ASTM E10, E18, A956, E384.
4 Miscellaneous

4.1 Liability Statement

4.1.1 The GM metallurgical lab will inspect & store HT 101 forms and independent lab reports as part of its records. Any heat treat that deviates from this procedure must be reported to the GMPT Engineer responsible for the project.

4.2 Patent Liability

4.2.1 By accepting this specification, the supplier agrees to defend, protect, and save harmless the buyer, its successors, assignees, customers and users of its products against all suits at law or in equity, and from all damages, claims and demands for actual or alleged infringement of any United States or foreign patent or copyright by reason of the use of sale of the material ordered.

4.3 Test Coupon Details
4.4 Material and Heat Treat Flow Chart

Material and Heat Treat Flow Diagram

- Buy steel from approved or provisional supplier
- Send certification to tool source and die caster
  - Steel source makes 97% cut for sampling plane
  - Tool source removes two coupons from insert block sampling plane
  - Pass
  - Notify tool source and die caster
    - Steel source supplies a new piece of steel
    - Tool source and die caster review
  - Fail
  - Send test coupon to approved testing lab
    - Fail
    - Notify tool source and die caster
    - Steel source supplies a new piece of steel
  - Pass
    - Rough machine insert
    - Heat treat insert and coupon
      - Send heat treat coupon and HT101 form to approved testing lab
        - Fail
        - Notify tool source and die caster
        - Re-heat treat? Die caster and tool source decide
          - Yes
          - Find a surrogate coupon and weld to insert for re-heat treat
          - No
        - Pass
          - Finish machine the insert at tool source
4.5 General Motors-HEAT TREAT DOCUMENTATION FORM HT101

<table>
<thead>
<tr>
<th>Operation</th>
<th>Temp</th>
<th>Time</th>
<th>Furn</th>
<th>Hardness</th>
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<tbody>
<tr>
<td>Anneal</td>
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<td>Normalize</td>
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<td>Quench Rate</td>
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<tr>
<td>Post Stress Rel</td>
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</table>

We certify that the above statements are true and correct and that all temperatures were obtained with standard and approved equipment.

Final Inspection _________________ Rc          Test Blocks Attached: Yes [ ] No [ ]

Work Order No. _________________

Authorized Signature ____________________________________________
### 5 Release and Revisions

<table>
<thead>
<tr>
<th>Rev</th>
<th>Approval Date</th>
<th>Description (Organization)</th>
<th>Name</th>
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<tbody>
<tr>
<td>11</td>
<td>10-10-95</td>
<td>Updated to current practice</td>
<td>E. Flynn</td>
</tr>
<tr>
<td>12</td>
<td>8-1-96</td>
<td>Re-organized text &amp; upgraded processes and definitions</td>
<td>E. Flynn</td>
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<tr>
<td>13</td>
<td>1-13-97</td>
<td>Hardness revised; note added to supersede insert drawing specifications</td>
<td>E. Flynn</td>
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<tr>
<td>14</td>
<td>4-9-98</td>
<td>Add provisional material sources and alter the heat treat quench method</td>
<td>E. Flynn</td>
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<tr>
<td>15</td>
<td>11-25-98</td>
<td>Quench pressure minimum of 9 bars to reflect current practice. FWD side and bottom cores hardness raised to Rc 44-46. Steel Mill Certs must meet requirements of this spec. Austenitizing temperatures have been changed (raised).</td>
<td>E. Flynn</td>
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<tr>
<td>16</td>
<td>7-28-99</td>
<td>Added mandatory dedicated surface thermocouple hole.</td>
<td>J. Finn</td>
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<tr>
<td>17</td>
<td>6-25-01</td>
<td>Deleted shot sleeves from the spec. Added internet web addresses for this spec. Made additions to list of Provisional Material Sources. Made additions to list of Provisional Heat Treat Sources. Collaboration between Tool Source and Heat Treater is required before rough machining of inserts. Anneal tool before a second heat treat. Developed two quenching protocols – methods 1 &amp; 2. Reduced time at austenitizing temperature and time at Isothermal hold (if used). Added new version of flow chart. Inconel Type K thermocouples required, no longer optional. Surface grinding of heat treat test coupon is now required. Surrogate coupons for primary heat treat are allowable.</td>
<td>J. Finn</td>
</tr>
<tr>
<td>18</td>
<td>3-01-05</td>
<td>Require digital time &amp; temperature data from heat treat furnace. Minimum quench rate now 70° F. Commercial heat treat Charps now at least 80% of Annealed Charps minus ½ difference of the high and low values (5 samples). All Charps at Rc44 –46. Temper trigger changed to Ts &lt; 120° F. Added detail regarding grain size. Added new NADCA 207 – 2003 material and heat treat photomicrograph charts and banding chart. No tack welds on coupon near potential Charpy notches. Test coupons stacked rather than side by side. Check post stress temper hardness. Stress relieving must be performed by Approved or Provisional Heat Treat Sources only. More detail added. New website locations; minor changes to provisional sourcing procedures. Added Provisional and Approved sources. Heat treat contracts with caster only. 5 Impact samples, throw out the high and the low. Additional detail to heat treat process (temperature ramp and quenching).</td>
<td>J. Finn</td>
</tr>
<tr>
<td>19</td>
<td>9-1-09</td>
<td>Rough machined radius recommendations, Austenitizing times and temps added to table A, stress temper temp, welding requirements removed, small tools</td>
<td>J. Finn</td>
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<td>20</td>
<td>07-14-11</td>
<td><strong>Added 1.4 - MATERIAL AND HEAT TREAT SOURCES</strong></td>
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<td>21</td>
<td>07-30-12</td>
<td><strong>New 1.4 - Updated Material &amp; Heat Treat Sources document inserted</strong></td>
<td>B. Appold</td>
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<tr>
<td>22</td>
<td>08-13-12</td>
<td><strong>Modified 1.2 – Changed link to GM Sharepoint site</strong></td>
<td>B. Appold</td>
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<tr>
<td>Date</td>
<td>Notes</td>
<td>Author</td>
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<tr>
<td>03-25-13</td>
<td>New 1.4 - Updated Material &amp; Heat Treat Sources document</td>
<td>B. Appold</td>
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<td>06-17-13</td>
<td>New 1.4 - Updated Material &amp; Heat Treat Sources document</td>
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<td>06-27-13</td>
<td>New 1.4 - Updated Material &amp; Heat Treat Sources document</td>
<td>B. Appold</td>
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<td>10-04-13</td>
<td>New 1.4 - Updated Material &amp; Heat Treat Sources document</td>
<td>B. Appold</td>
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<td>9-01-15</td>
<td>Updated format to latest standard. Renamed document, was: Global_Die_Insert_Material_and_Heat_Treating_Standard_08-06-2014_(HPDC-G-1)” Modified 1.4.1 to add the document name for the material and heat treating source list (AWQ49657 HPDC Die Insert Material and Heat Treating Source List)</td>
<td>J.Goller</td>
<td></td>
</tr>
<tr>
<td>1-26-17</td>
<td>Updated 3.5.4 Austenitizing Temperatures Table A on page 17.</td>
<td>J.Goller</td>
<td></td>
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<tr>
<td>2-7-18</td>
<td>Added heat treater rough machined geometry sign-off (3.3.2) on new tooling, including change to HT101 form, fixed minor conversion errors on pages 17 and 18, clarified wording in quench section to ensure proper quench. All Changes are Highlighted in Yellow and found on pages 13, 14, 17, 18, 19, and 26.</td>
<td>Finn</td>
<td></td>
</tr>
<tr>
<td>4/26/18</td>
<td>- Removed requirements for “Rough Machining 3D Model”. - Added requirements for Tool Vendor and Heat Treaters to collaboratively agree to the AWQ49658 standard and agree to the rough machine steel. - Added requirements for Tool Vendor to supply documentation upon GM request that all agreements to the AWQ49658 standard and the rough machined model has been met. - Added Step quench process. - Increased temperature minimum coming out of the austenitizing furnace to protect tool from cracking. - Removed item from HT101 document stating the rough machine 3D model. - All Changes are Highlighted in BLUE. Sections include: 1.1.1, 3.3, 3.5.5, 3.5.7, 3.5.8, 3.5.9, 3.9.1, &amp; 4.5.</td>
<td>J.Finn/ J.Goller</td>
<td></td>
</tr>
<tr>
<td>11/28/18</td>
<td>Added Dievar (1010°C +/-6°C) to the Austenitizing Temperatures Table A. Page 17 (per recommendation by John Finn and Patricia Miller)</td>
<td>J.Goller</td>
<td></td>
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