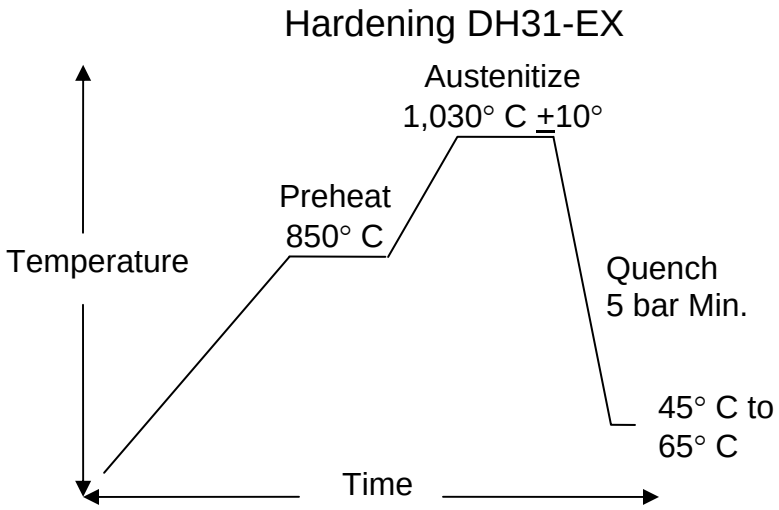
DH31-EX Heat Treat

DH31-EX Heat Treat – is a heat treatable air hardening premium hot work die steel with high toughness and heat check resistance. Its heat treat process is broken down into two segments, hardening & tempering. The hardening segment is best performed in a vacuum furnace with high pressure quench capabilities.



Vacuum Austenitize & Gas Quenching – DH31-EX should first be preheat at a rate of less than 220° C (400° F) per hour and held at 800° C (1,475° F) to 850° C (1,560° F) until the tools are uniformly heated from surface to core to within 60° C (100° F) and then increased to 1,030° C ±10° C (1,885° F±18° F) to austenitize otherwise known as soaking the tool.

When distortion in heating is concerned for large or complicated geometry parts, a double pre-heating is recommended: The first pre-heat is at 550° C (1,020° F) to 650° C (1,200° F) and the second at 800° C (1,470° F) to 850° C (1,560° F). The temperature should be allowed to equalize from the surface to the center of the part in each step before proceeding up to the austenitizing temperature.

Once the part reaches 1030° C (1,885° F) and is fully equalized in temperature, the holding time is 30 minutes. In cases where it is difficult to measure the temperature of the center of the part, the holding time from when the atmosphere reaches to 1030° C should be as shown in the Table considering the delay of the rise in the center temperature. As the time required for equalization of the temperature is ruled by furnace size, loading weight, heating method and so on, holding time is allowed to justify by the recommendation in the Table.

Maximum thickness Inch (mm)	Holding time (Min)
4” and under (100mm)	20 – 30 min/inch of thickness (longer than 1h)
Over 4” (100mm)	10 – 20 min/inch of thickness (longer than 2h)

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After austenitizing, the part will need to be quenched in inert high pressure gas (generally in nitrogen) to rapidly cool with at least 5 times atmosphere pressure (5 bar), however 10 bar pressure is recommended. The cooling rate at the center of the part should be at least 3° C (6° F) per minute in the temperature range of 500° C (930° F) to 200° C (390° F). Preferably the cooling rate should be higher than 5° C (9° F) per minute for obtaining better toughness.

An interrupted quench is preformed by temporarily halting the cooling process between 450° C and 400° C (840° F and 750° F) to allow the temperature throughout the part to equalize within 110° C (200° F) before continuing the rapid quench. This interrupted quench is recommended to reduce the distortion in quenching. The part should be immediately tempered once it has reached 65° C to (150° F) to 45° C (120° F).

Using Thermocouples - It is important that efforts be taken to measure temperatures at the center of the part throughout the heat treat process. Inserting a thermocouple in the center of the part insures that the entire part has reached the desired temperature before proceeding to the step in the heat treat process. The initial design should allow for the insertion of a thermocouple when possible. Water lines often make excellent locations for thermocouples. Be sure to pack thermocouple holes with a refractory fiber material to help prevent false readings. If the geometry of the part does not accommodate such a feature, it is recommended that a dummy part of similar shape and mass with a thermocouple mounted in the center be used as a temperature control.

There are two ways to use this control information. The first way is to run the part side by side with the dummy part using it to measure the temperature at the center of the part throughout the heat treat process. Realizing that this may not be practical when heat treating large parts, the second way is to cycle the dummy part through the heat treating process while documenting the times it takes for the tool to reach the desired temperatures and use that data to run the actual part. Thermocouples are useful in both the hardening and tempering processes.

Other Quenching Methods - As an alternative to vacuum furnace with gas quench, an atmosphere controlled furnace can be used for austenitizing. The holding time is recommended to be a little longer than that of a vacuum furnace. In this case salt bath or oil bath is used as quenching media to obtain quenching rate higher than 3° C per minute in the range of 500° (930° F) to 200° C (390° F).

Generally, the quench rate should be as rapid as possible to obtain optimum balance of strength and toughness. Quenching too fast, however, may cause distortion and cracking. In controlling the cooling rate by vacuum furnace quenching, it must be considered not only gas pressure, but also gas flow, its rate, heat exchanger efficiency, gas running path and so on.

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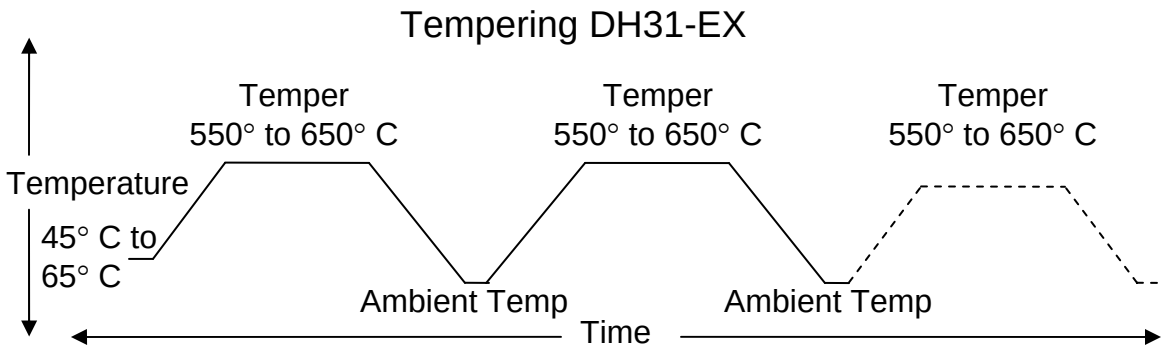
Tempering – Preferably, tempering is performed in air convection or atmosphere type furnace however can also be vacuum tempered when aided by the use of thermocouples and special care is taken to monitor temperatures. Triple tempering is recommended for die-casting molds and minimum twice for forging and extrusion tools.

The first tempering temperature is 550° C (1,022° F) to 650° C (1,200° F). 580° C (1,075° F) to 600° C (1,110° F) is generally applied for die casting molds. Second tempering is carried out at 550° C (1,022° F) to 650° C (1,200° F) depending on the required hardness. If the resulting hardness is higher than specified, hardness, it can be decreased by a third tempering. When the hardness meets the specification by second tempering, the third tempering is done at 30° C (54° F) to 50° C (90° F) lower than that of the second.



Tempering temperature for each aimed hardness is shown in the table hereunder.

Celsius	Fahrenheit	HRC
600° C	1,110° F	HRC 46-50
615° C	1,140° F	HRC 42-46
630° C	1,165° F	HRC 38-42

Holding time after atmosphere temperature reaches aimed temperature is 60 minute per 25mm (1 inch) in thickness in cross section with a minimum tempering time of 2 hours.

Note: As with any tool steel, actual heat treat results may vary depending on the circumstances of each application. Therefore the information pertaining to this document is given as a starting point and may require modification based on the size of a given load, fixturing, and equipment capabilities therefore some adjustments in the process may need to be developed and fine tuned base on you combination of circumstances to achieve optimum. Empirical data from heat treating other hot work grades of similar size in specific equipment can be helpful in developing optimum heat treat process for DH31-EX.

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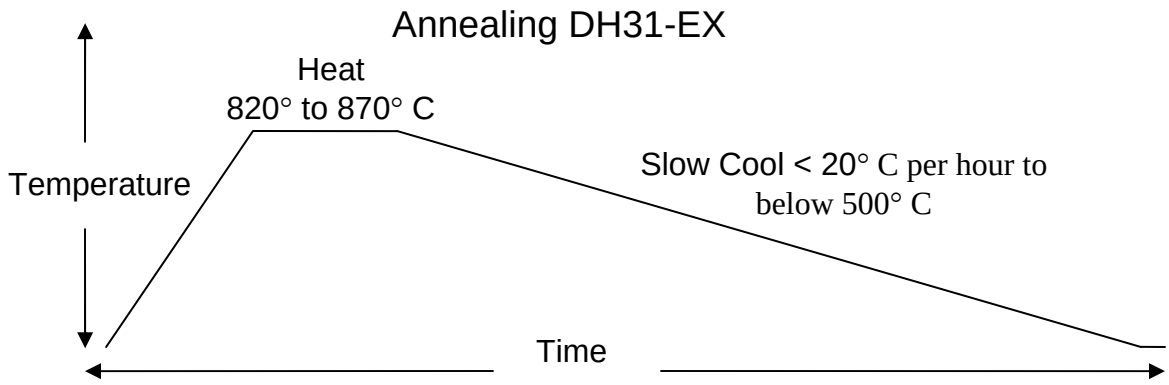
Annealing and re-hardening – If re-hardening is needed, it is necessary to first re-anneal the part.



Annealing – DH31-EX can be annealed by uniformly heating the part to between 820° C (1,508° F) and 870° C (1,598° F), and hold for 2 hours followed by a slow cooling at no more than 20° C (36° F) degrees per hour to until the temperature of the part has dropped below 595° C (1,100° F). The part can then be furnace cooled or left in still air to room temperature to complete the annealing process. The part is now ready to be re-hardened.