HEAT TREATMENT RECOMMENDATION
Z-WEAR PM®
STANDARD VACUUM

GRADE
Z-Wear PM®

METHOD
Standard Vacuum (4 Bar Minimum Quench Recommended)

RACKING
Parts should be placed in basket with adequate spacing to allow even heating and good exposure to quench gas. Long thin parts should be held in vertical position to maintain flatness/straightness.

HEATING
Use of staged preheating recommended:
- Ramp furnace to 1250±50°F and equalize temperature.
- Use convective heating if possible
- Ramp furnace to 1550±50°F and equalize temperature.
- Ramp furnace to 1750±50°F and equalize temperature.
- Advance to high heat

HARDENING

<table>
<thead>
<tr>
<th>High heat set point</th>
<th>for toughness</th>
<th>for wear resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1900 °F</td>
<td>1950 °F</td>
</tr>
<tr>
<td>Acceptable batching range</td>
<td>± 15 °F</td>
<td>± 15 °F</td>
</tr>
<tr>
<td>Soaking time in min.</td>
<td>25 - 30 min.</td>
<td>20 - 25 min</td>
</tr>
</tbody>
</table>

QUENCHING
- Back fill to positive pressure (minimum 4-6 bar ideal), and fan quench.
- Cool at maximum possible rate until load temperature < 1300°F
- Continue cooling load to room temperature (<120°F)
- Parts should be tempered within 4 hours

TEMPERING
Select tempering temperature based on hardness specification:

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>After 1900 °F</th>
<th>After 1950 °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>950 °F</td>
<td>61-62</td>
<td>-</td>
</tr>
<tr>
<td>975 °F</td>
<td>60-62</td>
<td>63-65</td>
</tr>
<tr>
<td>990 °F</td>
<td>59-61</td>
<td>62-64</td>
</tr>
<tr>
<td>1000 °F</td>
<td>58-60</td>
<td>61-63</td>
</tr>
<tr>
<td>1010 °F</td>
<td>57-59</td>
<td>60-62</td>
</tr>
<tr>
<td>1020 °F</td>
<td>56-58</td>
<td>59-61</td>
</tr>
</tbody>
</table>

Optimum tempering range is 975 to 1000 °F

DOUBLE TEMPER MANDATORY, THIRD TEMPER RECOMMENDED

1st temper
Heat parts to selected temperature, equalize and soak 2 hours.
Cool parts completely to room temperature (<120°F)
Can use vacuum/inert gas or air (depending on finish); Use convective heating and fan cooling

2nd temper
Repeat first temper cycle

3rd temper/stress relieve
Heat parts to 925/950 °F, equalize and soak 1-2 hours.
Stress relieve can be performed in same manner after hard finishing and/or EDM operations (vacuum methods preferred on finished tools).
ANNEALING
Heat uniformly in a protective atmosphere (or vacuum) to 1600°F (870°C) and soak for 2 hours. Slow cool 30°F (15°C) per hour until 1000°F (540°C). Parts can then be cooled in air or furnace as desired. Hardness expected is BHN 225-248.

STRESS RELIEVING (SOFT)
Heat uniformly to 1100-1300°F (595-700°C), soak for 2 hours, and cool in air or furnace.

HARDENING
Vacuum, salt, or protective atmosphere methods are generally used. Care must be taken to prevent decarburization.

PREHEAT
Heat to 1500-1550°F (810-845°C) until temperature is equalized. Additional preheat steps including 1200-1250°F (620-650°C) and at 1700-1750°F (930-955°C) are suggested when using programmed control during vacuum processing.

AUSTENITIZING
Temperatures in the range of 1850°F (1010°C) to 2050°F (1120°C) are commonly used with the specific temperature and soak time determined by the hardness required. Higher hardening temperatures will provide maximum wear resistance and hardness while temperatures lower in the range will provide increased toughness. Refer to chart for further information.

QUENCHING
Methods include use of high pressure gas (minimum 4 bar preferred), salt bath, or oil. Quench rate from the hardening temperature range down to 1300°F (700°C) is critical to the development of optimum structure and properties. Part temperature can then be equalized at 1000-1100°F (540-595°C) after which cooling can continue to below 150°F (66°C) or “hand warm”. Step quenching in this manner will help to minimize distortion in larger section sizes.

TEMPERING
Tempering should be performed immediately after quenching. Temperatures in the range of 1000°F (540°C) to 1050°F (595°C) are generally used depending on the hardness required. Heat uniformly to the selected temperature and soak for 2 hours. Double tempering is absolutely necessary while triple tempering is recommended when hardening at 1950°F (1093°C) and over. Tempering temperatures of less than 1000°F (540°C) should not be used, and care must be taken to cool parts fully to room temperature between each temper.

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