

Annealing, Hardening, Tempering – Course: Working Techniques of Heat Treatment of Steel. Instruction Examples for Practical Vocational Training

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Annealing, Hardening, Tempering – Course: Working Techniques of Heat Treatment of Steel. Instruction Examples for Practical Vocational Training

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Introductory Remarks

The present material includes 6 instruction examples by means of which different common processes of heat treatment of unalloyed steels can be practised.

In this connection, the following processes are described in detail:

- soft annealing
- quenching
- interrupted hardening
- hot quenching
- casehardening
- tempering from inside
- tempering from outside

All the practising pieces can be produced in a locksmith's shop. The prefabricated practising pieces reach the required properties for use by means of the heat treatment process. In order to facilitate the preparation and execution of the works, the materials, tools and devices, as well as auxiliary accessories necessary for each of the instruction examples have been specified. Apart from the working diagrams attached, the sequences of operations have been described in short.

Hint on temperature data:

Temperature data specified in the sequences of operations and in the working diagrams are given in degrees centigrade.

The following conversion is valid when other units are used:

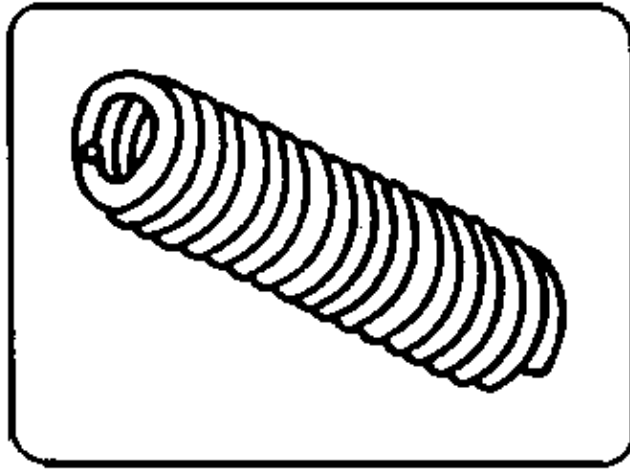
Centigrade	Kelvin	Fahrenheit
0°	273	32
100°	373	212

Instruction Example 16.1.: Spiral Spring

Practise the soft annealing of a spiral spring with subsequent hardening and tempering.

Material

Any hardened spiral spring of approx. 1.0 mm wire diameter



Tools and devices

Smith's hearth, quenching tank, round-nosed pliers

Auxiliary accessories

Blacksmith's tongs, coal shovel, swatter, furnace rake, quenching medium (water)

Previous required knowledge

Manual working of materials

Sequence of operations	Comments
1. Prepare workplace Make working material available	Check for completeness
2. Fire smith's hearth; wait until charcoal is glowing	Take care for fire protection!
3. Hold spiral spring by means of the blacksmith's tongs just over the fire	Phase 1 Annealing colour: dark-red 650°C to 750°C
4. After having reached annealing temperature, shortly move to and from over the charcoal fire	Increase and decrease distance to fire
5. Let spiral spring slowly cool down	Cool down in air!
6. Bend hooks on the ends by means of the round-nosed pliers	Phase 2 Check for flexibility
7. Heat spiral spring once again up to hardening temperature	Phase 3 Annealing colour: dark cherry red 750°C to 780°C
8. Keep shortly hardening temperature at reaching	Only few seconds
9. Dip spiral spring quickly into water and move it to and from	

Phase 4
Until complete cooling

10. Control hardness by means of tensile and pressure test

If the spiral spring is too hard, subsequently temper

11. Heat spiral spring once again

Phase 5
Temper colour: dark-blue
290°C

12. After having reached tempering temperature, quickly cool down

Phase 6

13. Control useful hardness by means of tensile or pressure test

①

② 650°C - 750°C

③ 750°C - 780°C

④ 10°C - 15°C

⑤ 290°C

⑥ 10°C - 15°C

				16.1.
IBE	Spiral Springs			3116

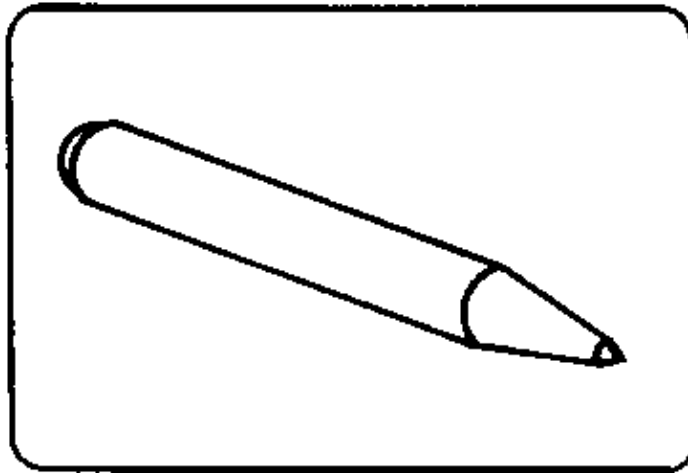
Spiral Springs

Instruction Example 16.2.: Marking and Riveting Tools

Practise the quenching with subsequent tempering from outside.

Material

Prefabricated scribe, sentrepunch, rivet header, rivet drawer made of tool steel with a carbon content between 1.1 and 1.25%



Tools and devices

Muffle furnace, quenching tank, abrasive cloth, file

Auxiliary accessories

Quenching medium (water), scouring cloth (fat-free)

Previous knowledge required

Manual working of materials

Sequence of operations

Comments

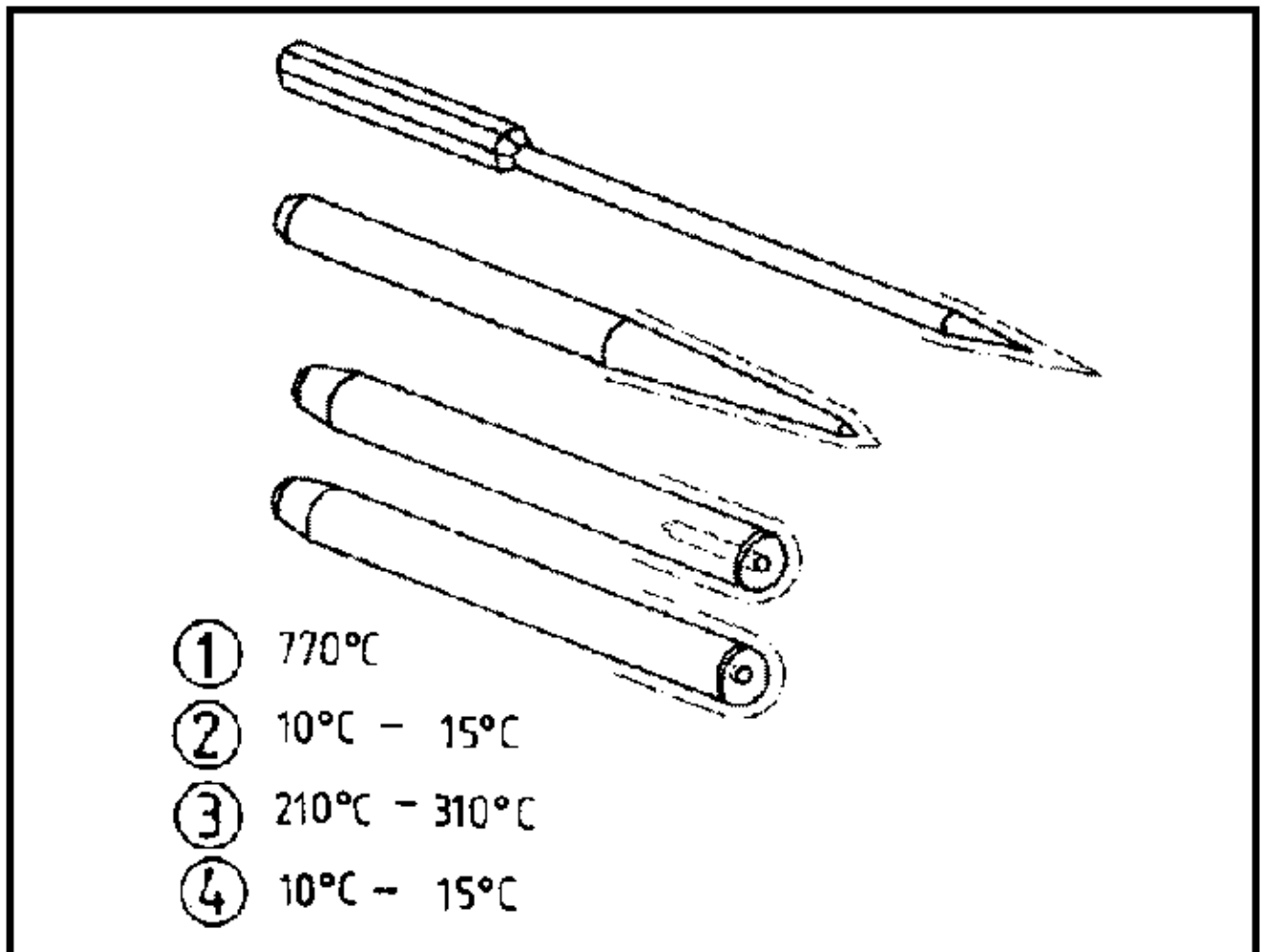
- | | |
|---|---|
| 1. Prepare workplace Make working material available | Check for completeness |
| 2. Fire muffle furnace, wait until nominal temperature is reached | In case of an existing temperature controller, adjust hardening temperature |
| 3. Place tools with the side to be hardened into the furnace and heat up to hardening temperature | Phase 1
Annealing colour: dark cherry red
770°C |
| 4. Keep scribe at temperature for approx. half a minute; keep centrepunch and riveting tools for approx. 1 minute | |
| 5. Quickly cool down tools, move them to and fro in the quenching tank | Phase 2
Until complete cooling |
| 6. Carry out file test; if hardness is not enough, harden again | Hardness is enough when the file slips! |
| 7. Wipe the tools dry, grind surfaces or points blank | Use abrasive cloth |
| 8. Heat tools up to tempering temperature once again in the muffle furnace: | Phase 3
Observe tempering colours |
| scribe: white-yellow – 210°C | |
| centre-punch: violet – 280°C | |
| riveting tool: light-blue – 310°C | |

Phase 4

9. Quickly cool down the tools as soon as reaching the tempering temperature

10. Carry out hardness test

File test with a dry workpiece



① 770°C
 ② 10°C – 15°C
 ③ 210°C – 310°C
 ④ 10°C – 15°C

				16.2.
IBE	Marking and Riveting Tools			3116

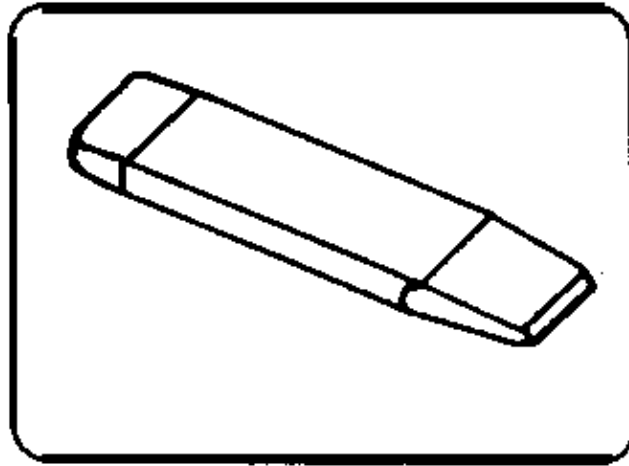
Marking and Riveting Tools

Instruction Example 16.3.: Flat Chisel and Cape Chisel

Practise the quenching with subsequent tempering from inside

Material

Prefabricated flat chisel and cape chisel made of tool steel with a carbon content of 0.9%



Tools and devices

Muffle furnace, quenching tank, abrasive cloth, file

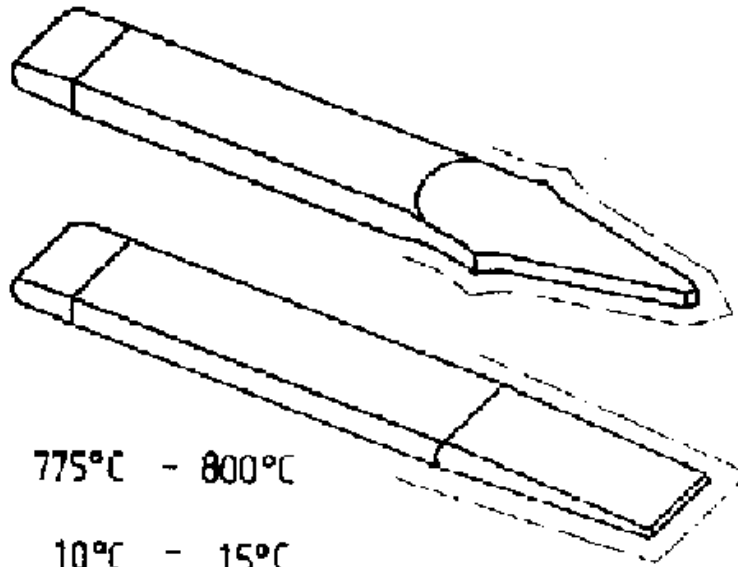
Auxiliary accessories

Quenching medium (flame-resistant, heatproof lubricating oil) or water, scouring cloth (fat-free)

Previous knowledge required

Machining of material

Sequence of operations	Comments
1. Prepare workplace Make working material available	Check for completeness
2. Fire muffle furnace and bring to nominal temperature	In case of an existing temperature controller, adjust hardening temperature
3. Place chisel with face edge into the furnace and heat up to hardening temperature	Phase 1 Annealing colour: cherry red 775°C to 800°C
4. After having reached hardening temperature, keep for approx. 1 minute	
5. Shortly cool down the chisel with the top in the quenching tank	Phase 2 Until hissing fades away!
6. Quickly clean face edge of chisel and grind one point blank	Use abrasive cloth
7. Observe the residual heat running in the direction of the face edge – temper colour becomes visible	Phase 3 Temper colour: yellow 230°C to purple 270°C
8. Quickly cool down chisel when reaching the tempering temperature	Phase 4
9. Clean chisel and carry out hardness test	File test, impact test



- ① 775°C - 800°C
- ② 10°C - 15°C
- ③ 230°C - 270°C
- ④ 10°C - 15°C

				16.3.
IBE	Flat Chisel and Cape Chisel			3116

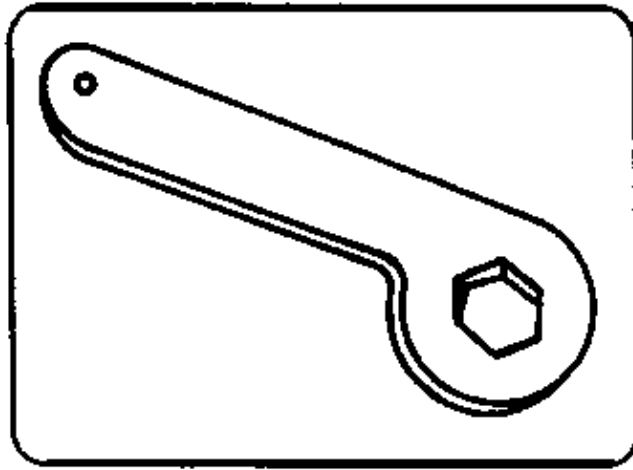
Flat Chisel and Cape Chisel

Instruction example 16.4.: Assembly Tools

Practise the interrupted hardening with subsequent tempering from outside.

Material

Prefabricated hexagon socket wrench, box wrench, screw driver made of tool steel with a carbon content between 1 and 1.1%



Tools and Devices

Furnace, quenching tank (two pieces), abrasive cloth, file

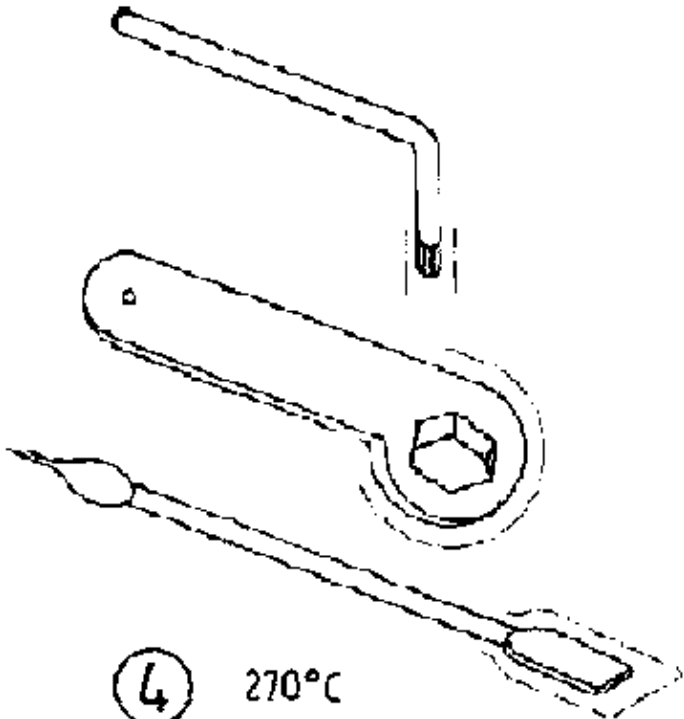
Auxiliary accessories

Powerful quenching medium (water), mild quenching medium (lubricating oil heated to 150°C), scouring cloth (fat-free)

Previous knowledge required

Manual working of materials

Sequence of operations	Comments
1. Prepare workplace Make working material available	Check for completeness
2. Fire the furnace and bring to nominal temperature	In case of an existing temperature controller, adjust hardening temperature
3. Heat quenching tank with lubricating oil up to approx. 150°C	
4. Place tools with the side to be hardened into the furnace and heat up to hardening temperature	Phase 1 Annealing colour: dark cherry-red 770°C
5. After having reached the hardening temperature, keep for approx. 1 minute	
6. Dip tools into the quenching tank filled with water, for a short time	Until hissing fades away!
7. Dip tools into the quenching tank with heated oil	Phase 2 Until temperature balance
8. Let tools cool down in air	Phase 3
9. Clean tools, carry out hardness test	File test
10. Grind tools at hardened side blank	Abrasive cloth
11. Heat tools in the furnace once again	Phase 4 Temper colour; purple 270°C
12. After having reached the tempering temperature, cool down tools	Phase 5

			
①	770°C		
②	150°C	④	
③	20°C	⑤	
		10°C - 15°C	
		16.4.	
IBF	Assembly Tools		3116

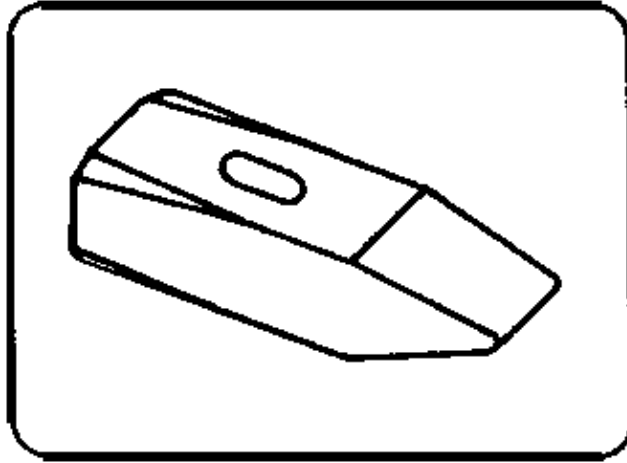
Assembly Tools

Instruction Example 16.5.: Locksmith's Hammer

Practise the hot-quenching with subsequent tempering from outside.

Material

Prefabricated locksmith's hammer made of tool steel with a carbon content between 1 and 1.1%



Tools and devices

Furnace, salt melting bath, quenching tank, abrasive cloth, file

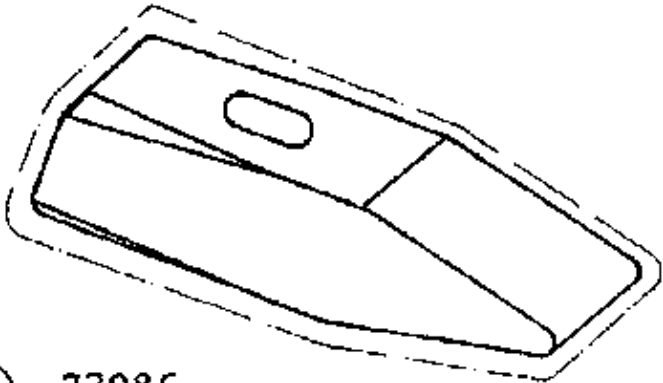
Auxiliary accessories

Quenching medium (lubricating oil) scouring cloth (fat-free)

Previous knowledge required

Manual working of materials

Sequence of operations	Comments
1. Prepare workplace Make working material available	Check for completeness
2. Fire the furnace and bring to nominal temperature	In case of an existing temperature controller, adjust hardening temperature
3. Heat salt melting bath to approx. 200°C	
4. Heat the hammer up to hardening temperature in the furnace	Phase 1 Annealing colour: dark cherry red 770°C
5. After having reached the hardening temperature, keep for approx. half a minute	
6. Cool down the hammer in the melting bath at approx. 220°C until temperature balance	Phase 2 Holding time: max. 2 1/2 minutes
7. Cool down the hammer to lukewarm in the quenching tank	Phase 3
8. Clean the hammer, carry out the hardness test	File test
9. Grind one point of the hammer blank	Abrasive cloth
10. Heat the hammer up to tempering temperature in the furnace	Phase 4 Temper colour: violet 280°C
11. After having reached the tempering temperature, cool down the hammer	Phase 5
12. Clean the hammer and again carry out the hardness	File test Impact test

		
①	770°C	
②	220°C	
③	20°C - 35°C	
④	280°C	
⑤	10°C - 15°C	
		16.5.
IBE	Locksmith's Hammer	3116

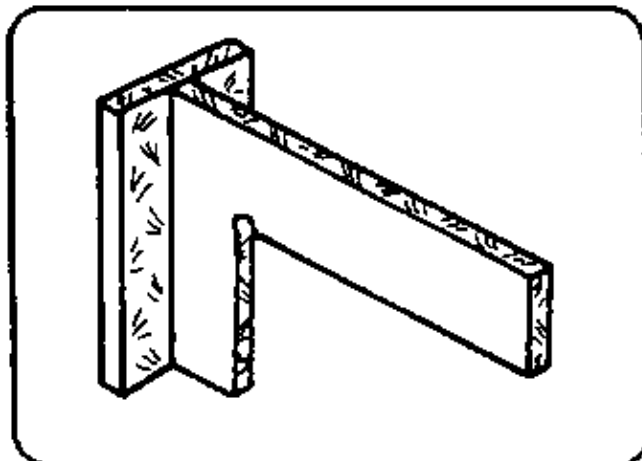
Locksmith's Hammer

Instruction Example 16.6.: Testing Means

Practise the casehardening and tempering of testing means.

Material

Prefabricated steel straightedges, back squares and centre squares made of unalloyed steel with a carbon content between about 0.1 and 0.15 %



Tools and devices

Controllable furnace with temperature gauge, quenching tank, fireproof inserts for sand charcoal filling, emery cloth

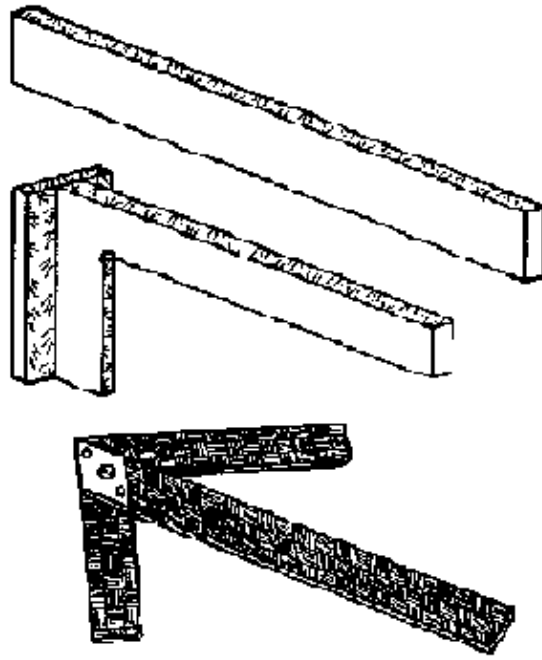
Auxiliary accessories

Charcoal (evenly cut into small pieces), clay, paper, quenching medium (heavily inflammable, heatproof lubricating oil), scouring cloth

Previous knowledge required

Manual working of materials

Sequence of operations	Comments
1. Prepare workplace Make working material available	Check for completeness
2. Wrap testing means into paper, lay into the insert with charcoal, cover the insert and lute by means of clay	
3. Place insert into the furnace and heat; keep for about 5 hours	Phase 1 Starting temperature: 880°C to 920°C; Penetration depth of carbon: approx. 0.5 mm
4. Take the insert out of the furnace, unpack testing devices and let cool down in air	Phase 2
5. Harden the testing means at about 770°C	Phases 3 and 4
6. Temper the testing means at about 220°C	Phases 5 and 6
7. Clean the surfaces of the testing means	



① 880°C - 920°C

② 20°C

③ 770°C

④ 10°C - 15°C

⑤ 220°C

⑥ 10°C - 15°C

				16.6.
IBE	Testing Means			3116

Testing Means

