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ABSTRACT

The course provides students with advanced and exploratory experience in the area of plastic deformation of metals and in the changing of the physical characteristics of metals by the controlled application and timed removal of heat. Course content includes goals, specific objectives, safety in forge work, forging tools and equipment, industrial forging, and heat treating safety. Also studied are annealing, hardening tool steels, destructive materials testing, and nondestructive materials testing. Completion of two courses is required prior to entry into this course: "Foundations of Metal Technology" and "Hot Metals." A bibliography and posttest are appended. (NH)

ED 095459

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

Course Outline
TECHNICALLY ORIENTED INDUSTRIAL MATERIALS
AND PROCESSES 1 - 5898
(Forging, Heat Treating and Testing)
Department 48 - Quin 5898.05

DADE COUNTY PUBLIC SCHOOLS
DIVISION OF INSTRUCTION • 1974

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D A D E C O U N T Y P U B L I C S C H O O L S

1 4 5 0 N O R T H E A S T S E C O N D A V E N U E

M I A M I, F L O R I D A 33132

Course Outline

TECHNICALLY ORIENTED INDUSTRIAL MATERIALS AND PROCESSES 1 - 5898
(Forging, Heat Treating and Testing)

Department 48 - Quin 5898.05

county office of

VOCATIONAL AND ADULT EDUCATION

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Dr. E. L. Whigham, Superintendent of Schools
Dade County Public Schools
Miami, Florida 33132

August, 1973

Published by the School Board of Dade County

Course Description

5898	48	5898.05	Forging, Heat Treating and Testing
State Category Number	County Dept. Number	County Course Number	Course Title

This quinmester is designed to provide the student with advanced and exploratory experience into the area of Plastic Deformation of metals and into changing of the physical characteristics of metals by the controlled application and timed removal of heat. Included also are methods of testing these physical characteristics.

Indicators of Success: Prior to entry into this course, the vocational student will display mastery of the skills indicated in Foundations of Metal Technology, 5898.01 and in Hot metals 5898.02.

Clock Hours: 45

PREFACE

In this quin the student will experience several ways to heat metal, learn how to judge the proper temperatures and how to use some of the many ways to form metal into useful shapes through plastic deformation.

Prior to entry into this quin the student will have demonstrated interest in and mastery of the skills contained in Foundation of Metal Technology 5898.01 and Hot Metals 5898.02.

Of equal interest and importance will be the experiences of making controlled changes in the physical characteristics of metal through the application and timed removal of heat and the testing of the extent and success of these changes.

The classroom instruction includes lectures, demonstrations, group discussions, study periods, and use of various audio-visual aids.

The course of study is 45 hours in length. The outline consists of nine major blocks of instruction, which are subdivided into several units each.

This outline was developed through the cooperative efforts of the instructional and supervisory personnel, the Quinmester Advisory Committee, and the Vocational Curriculum Magerials Service, and has been approved by the Dade County Vocational Curriculum Committee.

TABLE OF CONTENTS
With Suggested Hourly Breakdown

GOALS

Forging, Heat Treating and Testing

The student will demonstrate:

1. Knowledge of safety instructions by grades of A or B in all related safety tests.

2. Ability and willingness to work safely by eliminating worker "caused" accidents.

3. Concern for safety of all laboratory personel by continued safe use of all shop procedures in the quin.

4. Knowledge of the impact and implications of the products of industrial forge, heat treatment and testing.

5. Knowledge of the occupational opportunities of this field of hot metal work.

6. Increased consumer knowledge pertaining to experiences gained within this body of metal work.

SPECIFIC BLOCK OBJECTIVES

The student will demonstrate:

BLOCK I - SAFETY IN FORGING WORK

1. Safe method of lighting the forge
2. Safe handling of all tools and equipment

BLOCK II - FORGING TOOLS AND EQUIPMENT

1. Knowledge and skill in proper use and care of, and profitable participation in the many facets of forge work.
2. Knowledge of the scope of possibilities in our culture for the use of forge tools.

BLOCK III - INDUSTRIAL FORGING

1. Knowledge of the industrial history, scope, and involvement of our culture of forging and forged products.
2. Knowledge of the different machines and methods used in industrial forging.

BLOCK IV - HEAT TREATING SAFETY

1. A respect for the fume hazards and the proper handling of them to prevent injury or sickness.
2. A respect for eye hazards and correct use of all eye protective procedures and devices.
3. A knowledge of safety procedures used to prevent accidents due to explosion, handling hot objects, and use of various heat sources.
4. Knowledge of the importance of prompt and thorough clean-up of the forging area.

BLOCK V - ANNEALING

1. Knowledge of the reasons for annealing
2. Knowledge of the several methods of annealing.

BLOCK VI - HARDENING TOOL STEELS

1. Knowledge of the various types of quenches and quenching stages.
2. Skill in use of the color method of tempering a variety of tools
3. Knowledge and skill in hardening other steels.
4. Knowledge in uses of cold hardening
5. Skill in recognizing and solving the problems of correct heat treating

BLOCK VII - MATERIALS TESTING (DESTRUCTIVE)

1. Knowledge of surface hardness testing machines and testing procedures.
2. Proper use and care of the Universal Testing Machine to test at least tensile, compression and shear test on student made samples.

BLOCK VIII - NON-DESTRUCTIVE MATERIALS TESTING

1. Knowledge of its importance in our culture to the safe operation of our transportation system.
2. Knowledge of its importance to our industrial system.

BLOCK IX - QUINMESTER POST-TEST

1. Satisfactorily complete the quinmester post-test.

Course Outline

TECHNICALLY ORIENTED INDUSTRIAL MATERIALS AND PROCESSES 1 - 5898
(Forging, Heat Treating and Testing)

Department 48 - Quin 5898.05

I. SAFETY IN FORGE WORK

A. Lighting the Forge
1. Open door or shield
2. Close gas valve
3. Purge with air
4. Apply lighter
5. Open gas valve slightly
6. Adjust flame with air and gas

B. Handling Tools and Materials
1. Use hooks or hangers for all tools
2. Use tongs that fit work
3. Wear face shield or goggles
4. Wear leather apron and gloves
5. Be cautious of flying pieces of metal
6. Avoid hard hammer blows on anvil face
7. Label hot metal with chalk or soap stone
8. Hot cut on anvil chipping block only
9. Grip tong handles on end
10. Keep tong jaws parallel on work
11. Clean up promptly

II. FORGING TOOLS AND EQUIPMENT

A. Anvils
1. Body
2. Horn
3. Chipping block
4. Face
a. Round-edge
b. Pritchel hole
c. Hardy hole
5. Techniques
a. Drawing out
(1) Round to round
(2) Tapers
(3) Flats
(4) With flatters
(5) With fullers
b. Bending
(1) Over rounded edge
(2) In hardy hole
(3) Over horn
(4) Against chipping block

c. Upsetting
d. Forge welding
e. Hot cutting
f. Twisting
g. Punching
h. Measuring and marking
i. Scroll forming

B. Tongs
1. Types
a. Straight lip with round notch
b. Straight lip with vee notch
c. Gad
d. Curved lip with fluted jaw
e. Single pick-up
2. Techniques
a. Holding tong handles on end for good gripping
b. Keeping jaws parallel on stock

C. Hammers
1. Types
a. Cross peen
b. Ball peen
c. Straight peen
d. Sledge
e. Set
f. Flatter
2. Techniques

D. Other Handled Tools
1. Fullers
2. Chisels
a. Hot cut
b. Cold
3. Punches
a. Round
b. Square
4. Swages

E. Hardy's Tools (Bottom)
1. Swage
2. Hardy
a. Hot
b. Cold
3. Fuller

III. INDUSTRIAL FORGING
A. Hammer Types
1. Steam or compressed air
a. Single frame
(1) Self-contained (50 lbs. to 300 lbs.)
(2) Standard (250 lbs. to 6,000 lbs.)
b. Double frame (1,000 lbs. to 25,000 lbs.)

III. INDUSTRIAL FORGING (Contd.)

2. Drop hammers
   a. Steam (400 lbs. to 50,000 lbs.)
   b. Board drop
3. Pneumatic hammers

B. Plastic Deformation Industrial Processes
1. Hot
   a. Sheet reduction
   b. Die forging
   c. Extrusion
      (1) Direct
      (2) Indirect
   d. Shearing
   e. Stretch forming
   f. Aus forming
2. Cold
   a. Extrusion
   b. Sheet reduction
   c. Die forging
   d. Hydrostatic
   e. Impact extrusion
   f. Continuous roll forming
   g. Deep drawing
   h. Rubber pad forming
   i. Shear spinning
   j. Explosive forming
   k. Electromagnetic forming
   l. Electrohydraulic forming
   m. Press brake
   n. Shearing
   o. Punching
   p. H.E.R.F.
   q. Cold heading
   r. Intra forming
   s. Chipless machining

IV. HEAT TREATING SAFETY

A. Fume Exhaust Systems
1. Furnaces
   a. Oil fired
   b. Gas fired
   c. Electric
2. Cyanide gas (industrial case hardening)

B. Eye Protection
1. From hot metal chips
2. From slag particles
3. From harmful rays
4. From extreme heat
5. From splashing quench liquid

C. Explosion Protection
    1. During quench
    2. From firing fuels
    3. From damp tools

D. Handling Hot Objects
    1. Metals
    2. Equipment
    3. Tools

E. Safety With Heat Source
    1. Forge
        a. Electric
        b. Oil
        c. Gas
        d. Coal
    2. Heat treat
        a. Electric
        b. Gas
        c. Oil
        d. Torches
            (1) Gas
            (2) Arc

F. Prompt Clean-Up
    1. Oil
    2. Water
    3. Chemical
    4. Scale and slug
    5. Tools

V. ANNEALING

A. Stress Relieving

B. Full Annealing

C. Process Annealing

D. Normalizing

E. Spheroidizing

VI. HARDENING TOOL STEELS

A. Quench Types
    1. Water
    2. Oil
    3. Brine
    4. Air
    5. Molten lead

B. Quenching Stages (liquid)
   1. Vapor film
   2. Vapor transport
   3. Liquid cooling

C. Tempering Tool Steels
   1. Color method
      a. Yellow
         (1) Center punches
         (2) Lathe centers
         (3) Scrapers (metal)
      b. Light yellow
         (1) Tool bits
         (2) Hammers
      c. Dark straw
         (1) Drills
         (2) Taps
         (3) Reamers
         (4) Dies
      d. Yellowish brown
         (1) Drill drifts
         (2) Wood chisels
      e. Purple
         (1) Cold chisels
         (2) Wood carving tools
      f. Pale blue
         (1) Screwdrivers
         (2) Springs
   2. Results of tempering
      a. Increased toughness
      b. Reduced brittleness
      c. Relieved internal stresses
      d. Stabilized structure
      e. Changed shape and volume
      f. Improved ductility
      g. More uniform grain size

D. Hardening Other Steels
   1. Low carbon
      a. Case hardening
      b. Pack carburizing
      c. Liquid salt (do not use cyanide)
      d. Gas nitriding
   2. High carbon and alloys
      a. Flame hardening
      b. Induction hardening
   3. Cold hardening
      a. Rolling
      b. Stretching
      c. Bending or flexing
      d. Spinning
      e. Hammering

E. Problems During Heat Treating
   1. Warping
   2. Dimensional changes
   3. Cracking
   4. Failure to harden sufficiently
   5. Soft spots
   6. Hard spots
   7. Excessive residual brittleness

F. Causes of Problems
   1. Faulty heating techniques
   2. Faulty quenching techniques
   3. Questionable steel quality and uniformity
   4. Residual internal stresses

VII. MATERIALS TESTING (DESTRUCTIVE)

A. Hardness and Strength
   1. Brinell
   2. Rockwell

B. Tensile

C. Compression

D. Shear

E. Torsion

F. Bend

G. Impact

H. Fatigue

I. Ductility

J. Harden Ability

K. Corrosiveness

L. Spark Test

M. File Test

VIII. NON-DESTRUCTIVE MATERIALS TESTING

A. Magnaflux

B. Eddy Current

C. Ultrasonic

VIII. NON-DESTRUCTIVE MATERIALS TESTING (Contd.)

D. Radiography

E. Penetrant Dyes

F. Fluorescent Dyes

G. Grain-Size Test

H. Rebound Elasticity (Shore Scleroscope)

IX. QUINMESTER POST-TEST

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(Forging, Heat Treating and Testing)

Basic References:

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2. Anderson, James and Tatro, Earl E. Shop Theory. 5th ed. New York: McGraw-Hill Book Co., 1968. Pp. 522.

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4. Feirer, John L. and Lindbeck, John R. Metalwork. 2nd ed. Peoria, Illinois: Charles A. Bennett Co., Inc., 1970. Pp. 248.

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7. Johnson, Harold V. Technical Metals. Peoria, Illinois: Charles A. Bennett Co., Inc., 1968. Pp. 462.

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Supplementary References:

See Quinmester Course Outline 5898.01 (Foundations of Metal Technology.)

A P P E N D I X

Quinmester Post-Test Sample

Quinmester Post-Test

Name _____ Date _____ Score ____

True-False Test Items

Each of the following statements is either true or false. If the statement is true, draw a circle around the letter T following it; if the statement is false draw a circle around the F. If a statement is false in part, it is entirely false.

1. Hand forging is one small part of the industry of forging. T F
2. Forge temperatures are just above melting temperatures. T F
3. Small diameter rods are bent only by use of the pritchel hole. T F
4. Forging is plastic deformation of either hot or cold metal to change its shape. T F
5. Mild steel is forged only at bright red heat. T F
6. Tool steel is forged at the same temperature as mild steel. T F
7. The anvil horn is used to bend the larger bends in scroll work. T F
8. An untempered, hardened tool could be brittle. T F
9. Tools usually warp somewhat during the hardening process. T F
10. Only ferrous metals can be heat treated. T F
11. Only ferrous metals can be forged. T F
12. Most forging in industry is done by specialists. T F
13. Forging a piece of metal to greater length and less thickness is called upsetting. T F
14. Forging improves grain structure and strength of tools such as crescent wrenches. T F
15. Gravity is the force applied to a board drop hammer. T F
16. Press forging is done by squeezing action. T F
17. Melting, forging and heat treating temperatures are measured by use of a pyrometer. T F
18. Quenching may be done in water, oil or air. T F

19. Low carbon steel is easier to temper than high carbon steel. T F

20. Heating to red hot and cooling slowly is called annealing. T F

21. Tempering removes some of the brittleness and makes tools tougher. T F

22. Case hardening is the best way to make low carbon steel tougher. T F

23. The simplest test for surface hardness is by trying to file it with an old file. T F

24. The Rockwell Hardness Test is a resistance to surface penetration test. T F

25. The Shore Scleroscope Test tests for elastic rebound quality of metal surfaces. T F

Multiple Choice Test Items

Each statement needs a word, figure or phrase to make it correct. Only one of the choices listed is correct. Place the letter of the choice you make in the space provided at the left.

___ 1. The anvil face is made of:

a. Mild steel
b. Tempered tool steel
c. Annealed tool steel
d. Non-ferrous metals
e. None of these

___ 2. Which hammers are used to hand forge:

a. Ball peen
b. Cross peen
c. Set hammer
d. Sledge
e. All of these

___ 3. The proper tong to use in forging a bolt is the:

a. Curved, fluted lip
b. Gad
c. Pick-up
d. Straight lip
e. None of these

___ 4. In cold forging the metal temperature is:

a. $1000^{o}F$
b. $800^{o}F$
c. $1545^{o}F$
d. $575^{o}F$
e. None of these

___ 5. Upsetting means:

a. Drawing out
b. The opposite of drawing out
c. Stretched out
d. Forged to ring shape
e. All of these

___ 6. Drawing out a piece of metal means:

a. Shortening it
b. Bulging or enlarging
c. Making a plan of it
d. Stretching or lengthening it
e. None of these

___ 7. The heating fuel for forging could be:

a. Oil
b. Coal
c. Gas
d. Electricity
e. Any of these

___ 8. The heating fuel for heat treating could be:

a. Gas
b. Oil
c. Electricity
d. Acetylene
e. Any of these

Spelling Test Items

Check the spelling of these words. If correct place a "C" in the blank, if incorrect, write in the correctly spelled word.

1. anvel _____
2. fuller _____
3. Swage _____
4. Ferous _____
5. prichel _____
6. hardy _____
7. hamers _____
8. chisel _____
9. tongue _____
10. upsetting _____
11. bord drop _____
12. dye forging _____
13. nuematic _____
14. tempering _____
15. anneling _____
16. carburizing _____

17. pyrometer _____

18. quinching _____

19. brittle _____

20. marten sight _____

ANSWER KEY TO QUINMESTER POST-TEST

True-False Test Items

1. T	10. F	19. F
2. F	11. F	20. T
3. F	12. T	21. T
4. T	13. F	22. T
5. T	14. R	23. T
6. F	15. T	24. T
7. T	16. T	25. T
8. T	17. T	
9. T	18. T	

Multiple Choice Test Items

1. b	5. b
2. e	6. d
3. a	7. e
4. e	8. e

Spelling Test Items

1. anvil	11. board drop
2. "C"	12. die forging
3. "C"	13. pneumatic
4. ferrous	14. "C"
5. pritchel	15. annealing
6. "C"	16. "C"
7. hammer	17. "C"
8. "C"	18. quenching
9. tong	19. "C"
10. "C"	20. martensite