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ABSTRACT

This unit of instruction is an introduction to comparison measurement, methods of amplification, types of instruments and scale selection, and care and calibration of these instruments. The booklet presents the goals, the specific block objectives, and a bibliography. The course outline is presented. Also listed are films which can be used and a quinmester posttest which can be administered. (EB)

SE

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

Course Outline
AVIATION QUALITY CONTROL - BASIC - 9225
(Dial Indicators and High Amplification Instruments)
Department 48 - Quin 9225.04

DADE COUNTY PUBLIC SCHOOLS
DIVISION OF INSTRUCTION • 1973

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

AVIATION QUALITY CONTROL - BASIC - 9225
(Dial Indicators and High Amplification Instruments)

Department 48 - Quin 9225.04

county office of

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Dade County Public Schools
Miami, Florida 33132

November, 1972

Published by the School Board of Dade County

Course Description

9225	48	9225.04	Dial Indicators and High Amplification Instruments
State Category Number	County Dept. Number	County Course Number	Course Title

An introduction to comparison measurement; methods of amplification; types of instruments and scale selection; care and calibration of these instruments.

Clock hours: 135

PREFACE

The following quinmester course outline will serve as a guide for the high school or adult trainee in the use and care of dial indicators and high amplification comparators used in precision measurement.

This outline consists of nine blocks of work or 135 hours of instruction which are subdivided into several units each. These blocks will involve the techniques of precision measurement with dial indicators and high amplification comparators in the laboratory and in the shop. Procedures of instrument calibration, care and maintenance will also be covered.

Adequate laboratory time and actual experience with serviceable parts will be provided to develop skills in the student.

The student is expected to be proficient in, not just familiar with the nature and application of these instruments and techniques.

Prerequisite for this course is Course No. 9225.03 entitled Using Gage Blocks as Measuring Standards.

Motion picture films and color slides will be used to bring into the classroom the application of these techniques.

Field trips to the industries where precision measurement is practiced will be provided.

Study periods, group discussions, and extensive use of the textbooks and training manuals will be used. These are listed along with references and periodicals in the Bibliography.

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

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with Suggested Hourly Breakdown

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BLOCK

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Methods of Amplification for Dial Indicators	1
Functional Features of the Dial Indicator	1
Metrological Features of the Dial Indicator	1

II. DIAL INDICATOR TYPES AND ACCESSORIES (10 hours)

Dial Indicator Movements	1
Types and Sizes of Dial Indicator Dials	1
Types and Shapes of Dial Indicator Contact Points	2
Dial Indicator Stands	2
Dial Indicator Accessories	2
Other Uses of Dial Indicators	2

III. TECHNIQUES OF MEASUREMENT WITH DIAL INDICATORS (15 hours)

Dial Indicator Measurement Setups	2
Percent of Error of Dial Indicators	2
The Ten to One Rule	3
Zero Setting of the Dial Indicator	3
Repeatability and Averaging of Final Readings	3

IV. PROPER CARE AND HANDLING OF DIAL INDICATORS (5 hours)

Calibration of Dial Indicators	3
Dial Indicator Maintenance	3

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V. MEASUREMENT BY COMPARISON WITH HIGH AMPLIFICATION INSTRUMENTS (15 hours)
How to Determine X Power or Amplification of Measuring Instruments 3
High Amplification Comparator Types . . . 3

VI. FUNCTIONAL FEATURES OF HIGH AMPLIFICATION COMPARATORS (5 hours)
Types of Gage Heads 4
Rigid Column 4
Heavy Base 4
Anvil or Reference Point 4
Range Adjustments 4
Comparator Amplifiers 4

VII. TECHNIQUES OF MEASUREMENT IN THE MICRO RANGES WITH HIGH AMPLIFICATION COMPARATORS (45 hours)
Selection of Contact Points 4
Scale Selection, the Ten to One Rule . . 4
Zero Setting the High Amplification Comparator 4
Repeatability of Readings and Averaging of Final Readings 4
Sources of High Amplification Comparator Errors 4

VIII. CARE AND HANDLING HIGH AMPLIFICATION COMPARATORS (5 hours)
Maintaining Proper Environment About Comparators 5
Rust Prevention of Bright Steel Parts of Comparators 5
Proper Lubrication Where Necessary of Comparator Parts 5
Avoiding Shock 5
Keeping Batteries Properly Charged . . . 5

IX. QUINMESTER POST TEST

APPENDIX: QUINMESTER POST TEST SAMPLE 8

GOALS

The aviation quality control student must be able to:

1. Develop skills in the use of dial indicators and high amplification comparators.

2. Develop the attitudes of patience and persistence to gain maximum accuracy.

3. Develop the habits of cleanliness of person and work area.

4. Be aware of the responsibility involved in his chosen work.

5. Maintain the standards required for the field.

6. Control quality of the finished product.

SPECIFIC BLOCK OBJECTIVES

BLOCK I - MEASUREMENT BY COMPARISON WITH DIAL INDICATORS

The student must be able to:

1. Describe how a dial indicator amplifies measurement.
2. List the functional features of a dial indicator.
3. List the metrological features of a dial indicator.

BLOCK II - DIAL INDICATOR TYPES AND ACCESSORIES

The student must be able to:

1. List and explain the use of at least four types of indicator dials.
2. List and explain the use of at least three types of indicator contact points.
3. Set up a dial indicator on a test stand using the right angle attachment.
4. Demonstrate the use of a dial bore gage by exploring the diameter of three cylinders.

BLOCK III - TECHNIQUES OF MEASUREMENT WITH DIAL INDICATORS

The student must be able to:

1. Demonstrate zero repeatability with a .1 mil dial indicator, on at least three parts.
2. Apply a known percentage of error to a dial indicator reading.
3. Measure a group of 10 parts to a tolerance of plus or minus point one mil using a dial indicator set-up.

BLOCK IV - PROPER CARE AND HANDLING OF DIAL INDICATORS

The student must be able to:

1. Calibrate three dial indicators of different discrimination.
2. Fill out properly an inspection report on the above calibration checks.
3. Determine the percent of error, if any, of the above indicators.

BLOCK V - MEASUREMENT BY COMPARISON WITH HIGH AMPLIFICATION INSTRUMENTS

The student must be able to:

1. Measure and compute the X power of a vernier scale.
2. Measure and compute the X power of a standard micrometer.
3. Measure and compute the X power of a .1 mil 3" dial indicator.
4. List and explain four methods of amplification used in high amplification comparators.

BLOCK VI - FUNCTIONAL FEATURES OF HIGH AMPLIFICATION COMPARATORS

The student must be able to:

1. Identify and explain the parts of an electronic high amplification comparator.
2. Identify and explain the parts of a reed and optical type high amplification comparator.

BLOCK VII - TECHNIQUES OF MEASUREMENT IN THE MICRO RANGES WITH HIGH AMPLIFICATION COMPARATORS

The student must be able to:

1. Set up a high amplification comparator and demonstrate his ability to repeat zero, on high amplification scale, at least five times in succession.
2. Set up a high amplification comparator and measure a precision part to within plus or minus 10 mike of the true size.
3. Run a calibration check on a high amplification comparator.

BLOCK VIII - CARE AND HANDLING HIGH AMPLIFICATION COMPARATORS

The student must be able to:

1. Demonstrate his ability to perform minor maintenance and service on a high amplification comparator.

BLOCK IX - QUINMESTER POST TEST

The student must be able to:

1. Satisfactorily complete the quinmester post test.

Course Outline

AVIATION QUALITY CONTROL - BASIC - 9225
(Dial Indicators and High Amplification Instruments)

Department 48 - Quin 9225.04

I. MEASUREMENT BY COMPARISON WITH DIAL INDICATORS

A. Methods of Amplification for Dial Indicators
1. Mechanical, the gear train
2. Length of the pointer
3. By lever action

B. Functional Features of the Dial Indicator
1. The contact point
2. The revolution counter
3. The rotating bezel
4. The dial
5. The spindle

C. Metrological Features of the Dial Indicator
1. Range, travel or displacement
2. Dial indicator discrimination
3. Line of measurement, Abbe's Law
4. Measured point
5. Dial indicator sensitivity
6. Dial indicator resolution

II. DIAL INDICATOR TYPES AND ACCESSORIES

A. Dial Indicator Movements
1. Left hand movement
2. Right hand movement

B. Types and Sizes of Dial Indicator Dials
1. Unilateral
2. Bilateral
3. American gage design standards
4. Continuous clockwise
5. Continuous counter clockwise
6. Balanced

II. DIAL INDICATOR TYPES AND ACCESSORIES (Contd.)

C. Types and Shapes of Dial Indicator Contact Points
   1. Standard point
   2. Flat point
   3. Button point
   4. Round point
   5. Tapered point

D. Dial Indicator Stands
   1. Comparator stands
   2. Test stands

E. Dial Indicator Accessories
   1. The hole attachment
   2. The right angle attachment
   3. Perpendicular indicators

F. Other Uses of Dial Indicators
   1. Indicating snap gages
   2. Dial micrometers
   3. Dial bore gages
   4. Dial calipers

III. TECHNIQUES OF MEASUREMENT WITH DIAL INDICATORS

A. Dial Indicator Measurement Setups
   1. Selecting the right indicator
      a. Type of dial
         (1) Balanced or continuous
         (2) Clockwise or counter clockwise
      b. Proper selection of contact point
      c. Indicator range
      d. Indicator discrimination
   2. Selecting the right dial indicator stand
      a. The precision required
      b. Rigidity required
      c. Convenience
      d. Availability

B. Percent of Error of Dial Indicator
   1. How to determine percent of error
   2. Applying percent of error for correction purposes

III. TECHNIQUES OF MEASUREMENT WITH DIAL INDICATORS (Contd.)

C. The 10 to 1 Rule
   1. Effects of the 10 to 1 rule on accuracy
   2. Applying the 10 to 1 rule

D. Zero Setting the Dial Indicator
   1. Area on dial for maximum accuracy
   2. Repeatability of zero setting

E. Repeatability and Averaging of Final Readings

IV. PROPER CARE AND HANDLING OF DIAL INDICATORS

A. Calibration of Dial Indicators
   1. Using gage blocks for calibration
   2. Making calibration charts

B. Dial Indicator Maintenance
   1. Proper lubrication
   2. Corrosion prevention

V. MEASUREMENT BY COMPARISON WITH HIGH AMPLIFICATION INSTRUMENTS

A. How to Determine X Power or Amplification of Measuring Instruments
   1. Vernier scale amplification
   2. Micrometer amplification
   3. Dial indicator amplification

B. High Amplification Comparator Types
   1. Mechanical reed type comparators
   2. Pneumatic type comparators
      a. Back pressure type
      b. Flow type
   3. Electronic type comparators
   4. Optical type comparators
      a. Shadowgraph type
      b. Light beam and target type
      c. Microscopes
   5. Combination type optical and mechanical

VI. FUNCTIONAL FEATURES OF HIGH AMPLIFICATION COMPARATORS

A. Types of Gage Heads
   1. Probe type
   2. Cylindrical type

B. Rigid Column

C. Heavy Base

D. Anvil or Reference Point

E. Range Adjustments

F. Comparator Amplifiers
   1. Scale selector
   2. Zero adjustment

VII. TECHNIQUES OF MEASUREMENT IN THE MICRO RANGES WITH HIGH AMPLIFICATION COMPARATORS

A. Selection of Contact Points
   1. Probe
   2. Cylindrical
   3. Flat

B. Scale Selection, the Ten to One Rule

C. Zero Setting the High Amplification Comparator
   1. Area on scale for maximum accuracy
   2. Repeatability of zero setting

D. Repeatability of Readings and Averaging of Final Readings

E. Sources of High Amplification Comparator Errors
   1. Effects of temperature
      a. Body temperature
      b. Sunlight and artificial light
      c. Airconditioning drafts
   2. Vibration
      a. From outside sources
      b. From handling stand

VII. TECHNIQUES OF MEASUREMENT IN THE MICRO RANGES WITH HIGH AMPLIFICATION COMPARATORS (Contd.)

3. Direct drafts
4. Material difference between standard and part
5. Surface finish differences
6. Improper handling of standards, gage blocks and parts

VIII. CARE AND HANDLING HIGH AMPLIFICATION COMPARATORS

A. Maintaining Proper Environment About Comparators
   1. Stable temperature
   2. Dry atmosphere
   3. Filtered air

B. Rust Prevention of Bright Steel Parts of Comparators

C. Proper Lubrication Where Necessary of Comparator Parts

D. Avoiding Shock

E. Keeping Batteries Properly Charged

IX. QUINMESTER POST TEST

BIBLIOGRAPHY
(Dial Indicators and High Amplification Instruments)

Basic References:

1. Busch, Ted. Fundamentals of Dimensional Metrology, Wilkie Brothers Foundation. Albany, New York: Delmar Publishers, Inc., 1966. The above consists of a text of 428 pages and a lab workbook of 226 pages.

Supplementary References:

2. Juran, J.M. Quality Control Handbook. 2nd edition. New York: McGraw Hill Book Co., Inc., 1951. Pp. 800.

3. Kennedy, Clifford W., and Andrews, Donald E. Inspecting and Gaging. New York: Industrial Press, Inc., 1967. Pp. 590.

Films:

1. Black Granite Gages. 16mm. 19 min. Color. Sound. 1969.

2. How to Calibrate Gage Blocks. 16mm. Color. Sound. 1969.

3. Profile in Precision. 16mm. 20 min. Color. Sound. 1969. Brown and Sharpe Manufacturing Company.

4. Tools and Rules for Precision Measuring. 16mm. 38 min. B&W. 1969. L.S. Starrett Co.

5. Wright Builds for Air Supremacy. 16mm. B&W. Sound. 20 min. G.T. Baker Aviation School. Index #4-14.

6. Inspecting and Reconditioning Piston Assembly. 16mm. B&W. Sound. 20 min. G.T. Baker Aviation School. Index #3-29.

A P P E N D I X

Quinmester Post Test Sample

QUINMESTER POST TEST
(Dial Indicators and High Amplification Instruments)

Name_____ Date_____ Score_____

1. Dial indicators are used for comparison measurement, this is known as the _____ method of measurement.

2. Amplification of a measuring instrument or a comparator is expressed as the _____ of the instrument and is the ratio of the _____ to the _____.

3. Explain the term TOLERANCE.

4. Explain the term ALLOWANCE.

5. Amplification in a dial indicator is provided by the _____, _____ and the _____.

6. Amplification in a micrometer is provided by the _____.

7. What is the "TELLTALE" of a dial indicator?

8. Discrimination of dial indicators range from _____ mil to _____ mil.

9. Dial indicators have their greatest accuracy
(Circle the correct answer)
    1. At the beginning of a spindle movement. (zero)
    2. At maximum spindle movement. (near full scale)
    3. At 25% spindle movement
    4. At 50% spindle movement

10. Dial indicators dials are of two general types, _____ and _____.

11. Explain and give an example of UNILATERAL TOLERANCE.

12. Explain and give an example of BILATERAL TOLERANCE.

13. Does the use of the dial indicator conform to Abbe's Law?

14. In a dial indicator setup what is the reference point?

15. What is the BEZEL of a dial indicator?

16. Gage block standard being used on a dial indicator setup is .050", dial indicator reads .048', what is percentage of error? (Circle the correct answer)
    1. 2%
    2. 3%
    3. 4%
    4. 5%

17. In above problem unknown part is being measured with dial indicator, indicator reads .035", with percentage of error known actual size of part could be somewhere between the following figures. (Circle the correct answer)
    1. .0345" to .0355"
    2. .0340" to .0360"
    3. .0346" to .0364"
    4. .0336" to .0364"

18. Exploring the condition of a cylinder with a dial bore gage we can determine at least four things about the cylinder. What are they?

19. What is the best procedure to follow when overhauling a dial indicator?

20. Most dial indicator movements turn CLOCKWISE, COUNTER CLOCKWISE. (Underline the correct answer)

21. Name FOUR methods that have been devised for high amplification comparison measurement.

22. Define the following terms:

    ANALOG _____

    DIGITAL _____

23. Which of the following statements best explains the principle of the SHEFFIELD Model 510-E comparator? (Circle the correct answer)

1. Reed type
2. Combination mechanical and optical
3. Mechanical
4. Combination reed and electronic

24. In your own words explain the TEN TO ONE RULE.

25. We have a part to be measured that has a tolerance of minus 0.001", plus 0.002". Using the TEN TO ONE RULE which of the following comparator scales would you select? (Circle the correct answer)
    1. Minus 0.015", plus 0.015" scale
    2. Minus 0.003", plus 0.003" scale
    3. Minus 0.0015", plus 0.0015" scale
    4. Minus 0.0003", plus 0.0003" scale

26. Name two types of electronic height gage heads.

27. In relation to the electronic height gage head, contact arm, and work piece, explain COSINE ERROR. Tell when the error exists and what increases the error.

28. In high amplification instruments explain what the difference is between the comparator and the height gage. Which is considered the most reliable?

29. Repeat error or dispersion of repeated readings is known as the _____ of the instrument.

30. What are the four axioms (generally accepted principles or things) that affect reliable measurement at high amplification?

31. Heat is transmitted by three methods, explain or describe these: CONVECTION, RADIATION, CONDUCTION.

32. The "NORMALIZING PLATE" utilizes which of the above methods to equalize temperature between gage block and work piece?

33. Does the "PROBE HEAD" of an electronic high amplification height gage obey ABBE'S LAW?

34. A comparator has its greatest accuracy. (Circle the correct answer)
    1. When on its greatest discrimination
    2. At or near zero
    3. When reading full scale
    4. When readings are on a minus side

35. Does the range of a comparator increase as the discrimination is increased?

36. One important basic feature of pneumatic gaging is that it eliminates _____ to _____ contact.

37. Name two types of pneumatic air gages.

38. What kind of master or standard is used for the measurement of holes?

ANSWER KEY TO QUINMESTER POST TEST
(Dial Indicators and High Amplification Instruments)

1. Interchange.
2. Power; imput; output
3. Permissible variation in part size.
4. Space between mating parts.
5. Gear train; hand or pointer.
6. Screw thread.
7. Revolution counter.
8. 1 mil to .1 mil
9. No. 1, at the beginning of spindle movement.
10. Continuous; balanced.
11. Tolerance entirely on one side of basic dimension
12. Tolerance partly on both sides of basic dimension.
13. Yes.
14. Surface plate or a standard.
15. Knurled edge that rotates dial face.
16. No. 3, 3%.
17. No. 4, .0336" to .0364".
18. Taper, out of round, barrel shape, hourglass shape, bell mouth, size.
19. Send it back to the manufacturer.
20. Clockwise.

21. Mechanical, optical, pneumatic, electronic.

22. Analog: Uses a physical quantity to correspond to numbers (measures).
Digital: Deals with numbers directly (counts).

23. No. 2, Combination mechanical and optical.

24. Total tolerance should cover about 10 divisions on scale.

25. No. 2, Minus 0.003", Plus 0.003".

26. Probe; cylindrical.

27. Spindle, or moving part of head should be as near perpendicular to surface of piece being measured as possible. As angle increases error increases.

28. Height gage uses surface plate as reference point. Comparator contains both measured and reference point.

29. Uncertainty.

30. Cleanliness; positional relationships; 10 to 1 rule; temperature.

31. Convection: Transfer of heat by air currents
Radiation: Transfer of heat by rays of light
Conduction: Transfer of heat by direct contact

32. Conduction.

33. No.

34. No. 2, At or near zero.

35. No.

36. Metal; metal.

37. Back pressure; flow rate or balanced.

38. Ring gages.