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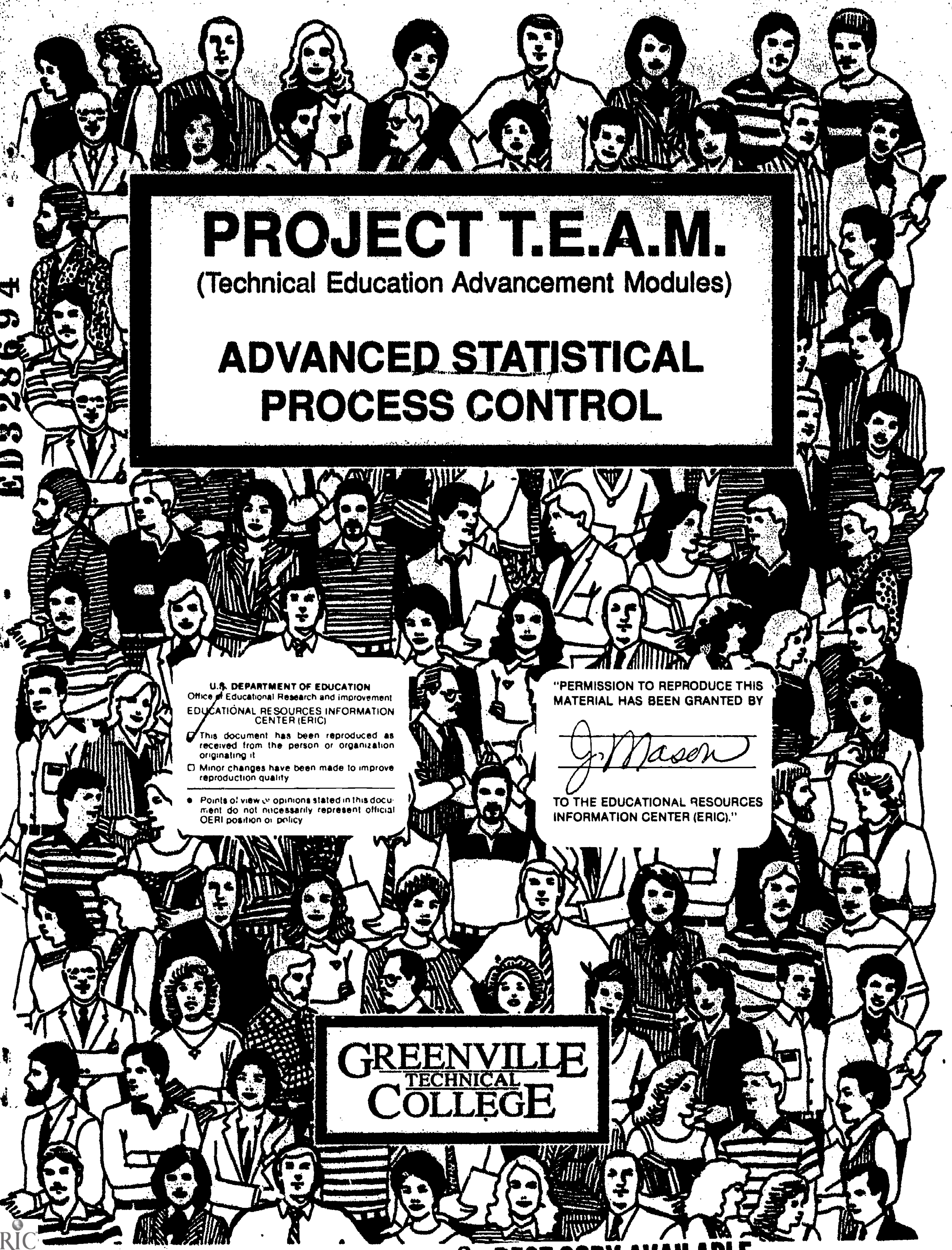
ABSTRACT

This instructional guide, one of a series developed by the Technical Education Advancement Modules (TEAM) project, is a 20-hour advanced statistical process control (SPC) and quality improvement course designed to develop the following competencies: (1) understanding quality systems; (2) knowing the process; (3) solving quality problems; and (4) working with SPC. Project TEAM is intended to upgrade basic technical competencies of unemployed, underemployed, and existing industrial employees. The materials in this module serve as a student outline and an instructor guide. The manual includes seven sections: (1) introduction to quality in the 1990s; (2) know your process--flow charting; (3) solving quality problems--problem-solving techniques and data collection; (4) data analysis techniques; (5) Statistical Process Control; (6) process capability studies; and (7) nontraditional SPC methods--control charts. Frameworks for various processes are included at the end of this manual. (NLA)



PROJECT T.E.A.M.
(Technical Education Advancement Modules)

ADVANCED STATISTICAL PROCESS CONTROL

GREENVILLE TECHNICAL COLLEGE

GREENVILLE TECHNICAL COLLEGE

PROJECT TEAM
TECHNICAL EDUCATION ADVANCEMENT MODULES

INSTRUCTIONAL MODULE:

ADVANCED STATISTICAL PROCESS CONTROL

Developed by:

Dale Dunlap

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Introduction:

The purpose of this manual is to serve as an instructional guide for the TEAM Grant module Advanced Statistical Process Control.

Advanced Statistical Process Control is a twenty hour overview course intended to develop competencies in the following skill areas:

Understanding Quality Systems
Knowing the Process
Solving Quality Problems
Working with SPC

Overview of Project TEAM:

Project TEAM (Technical Education Advancement Modules) is a program targeted toward the unemployed, underemployed, and existing industrial employees who are in need of upgrading basic technical competencies. The program seeks to give adequate preparatory educational opportunities in generic technical skill areas and to create a public awareness of the need for these basic skills. Curriculum content was determined by an assessment team of local industrial employers. Their evaluation resulted in the development of 15 instructional modules; some of which may be industry specific, but most of which are applicable in and necessary to a majority of industrial settings. The modules may be used collectively or as a separate curriculum for a specific course or courses. The material contained in each manual will serve as a student outline and as an instructor guide which may be used selectively or in its entirety.

ADVANCED STATISTICAL PROCESS CONTROL AND QUALITY IMPROVEMENT

1. INTRODUCTION

    A. QUALITY IN THE 90'S
    B. THE GURU'S: WHO'S RIGHT?

II. KNOW YOUR PROCESS

    A. FLOW CHARTING

III. SOLVING QUALITY PROBLEMS

    A. PROBLEM SOLVING TECHNIQUES

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        2. CAUSE AND EFFECT DIAGRAMS

    B. DATA COLLECTION

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        2. HISTOGRAMS
        3. PARETO DIAGRAMS
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    B. BENEFITS
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A. CONTROL CHARTS FOR INDIVIDUALS
B. MOVING AVERAGE/RANGE CONTROL CHARTS
C. CONTROL CHARTS FOR SHORT RUNS

I. INTRODUCTION

A. QUALITY IN THE 90'S

1. QUALITY CHALLENGE FACING INDUSTRY

-CUSTOMERS HAVE BEEN SHARPLY INCREASING THEIR QUALITY REQUIREMENTS
-AS A RESULT, CURRENT QUALITY PRACTICES AND TECHNIQUES ARE NOW, OR SOON WILL BE, OBSOLETE.

2. THE TOTAL QUALITY DEFINITION OF QUALITY

-THE TOTAL COMPOSITE PRODUCT CHARACTERISTICS OF MARKETING, ENGINEERING, MANUFACTURING, AND MAINTENANCE THROUGH WHICH THE PRODUCT IN USE WILL MEET THE EXPECTATIONS OF THE CUSTOMER.
-TRY SUBSTITUTING THE WORD "EXCEEDS" FOR THE WORD "MEETS"

3. THE TOTAL QUALITY SYSTEM

-OPERATING WORK STRUCTURE, DOCUMENTED IN TECHNICAL AND MANAGERIAL PROCEDURES, FOR GUIDING THE ACTIONS OF THE WORK FORCE, THE MACHINES, AND THE INFORMATION OF THE COMPANY IN THE BEST WAY TO ASSURE CUSTOMER QUALITY SATISFACTION.

4. FACTORS AFFECTING QUALITY

MARKETS
MONEY
MANAGEMENT
MEN
MOTIVATION
MATERIALS
MACHINES AND MECHANIZATION
MODERN INFORMATION METHODS
MOUNTING PRODUCT REQUIREMENTS

5. FOUR STEPS IN OVERALL CONTROL OF QUALITY

-SETTING STANDARDS
-APPRA ING CONFORMANCE
-TAKIN CORRECTIVE ACTION
-PLANNING FOR IMPROVEMENT

6. JOBS OF QUALITY CONTROL

INCOMING - MATERIAL CONTROL

- -ESTABLISHMENT OF VENDOR SURVEY, RESPONSIBILITY, AND SURVEILLANCE
- -CONTROL ON MATERIALS AND PARTS RECEIVED FROM OUTSIDE SOURCES
- -CONTROL ON MATERIALS OR PARTS PROCESSED BY OTHER PLANTS

NEW DESIGN CONTROL

- -ESTABLISHMENT AND SPECIFICATION OF THE NECESSARY COST, PERFORMANCE, SAFETY, AND RELIABILITY FOR THE PRODUCT REQUIRED FOR THE INTENDED CUSTOMER SATISFACTION.

PRODUCT CONTROL

- -CONTROL OF PROCESSING OF COMPONENTS
- -CONTROL OF PACKAGING
- -CONTROL OF CUSTOMER PRODUCT SERVICE

SPECIAL PROCESS STUDIES

- -INVESTIGATIONS AND TESTS TO LOCATE THE CAUSES OF NON CONFORMING PRODUCTS, TO DETERMINE THE POSSIBILITY OF IMPROVING QUALITY CHARACTERISTICS, AND TO INSURE THAT IMPROVEMENT AND CORRECTIVE ACTION ARE PERMANENT AND COMPLETE.

7. QUALITY MUST BE DESIGNED AND BUILT INTO A PRODUCT; IT CAN NOT BE EXHORTED OR INSPECTED INTO IT.

B. THE GURU'S

1. THE THREE
   - -JURAN
   - -DEMING
   - -CROSBY

2. HISTORY

   -JAPAN 40 YEARS, US 10 YEARS EXPERIENCE IN QUALITY IMPROVEMENT
   -QC, TQI, COQ, SPC HAVE BECOME FAMILIAR TERMS

3. DEMING

   -THE PIONEER, TOOK THE MESSAGE TO JAPAN IN 1950
   -INSTRUMENTAL IN TURNING JAPANESE INDUSTRY INTO AN ECONOMIC WORLD POWER
   -THE JAPANESE LISTENED - HEEDED ADVICE ON SPC AND 14 POINTS
   -DELIVERS HIS MESSAGE WITH VENOM

4. JURAN

   -ARRIVED IN JAPAN A FEW YEARS AFTER DEMING
   -DEFINED QUALITY AS FITNESS FOR USE
   -THE JURAN TRILOGY - QUALITY PLANNING, QUALITY CONTROL, QUALITY IMPROVEMENT
   -COSTS OF POOR QUALITY-MEASURES THE COSTS OF WASTE AND DEFECTIVE PRODUCTS

5. CROSBY

   -BEGAN CAREER AT ITT AS INSPECTOR, WORKING UP TO VP OF QUALITY
   -METHODS MARKED BY SLOGANS
   -ZERO DEFECTS, CONFORMANCE TO REQUIREMENTS, QUALITY IS FREE
   -HAS 14 POINT PROGRAM FOR QUALITY MANAGEMENT
   -FOUR ABSOLUTES - DEFINITION OF QUALITY, PREVENTION SYSTEM, PERFORMANCE STANDARD (ZERO DEFECTS), MEASUREMENT OF QUALITY

6. THE FUNDAMENTAL MESSAGE IS THE SAME

- -COMMIT TO QUALITY IMPROVEMENT THROUGHOUT THE ORGANIZATION
- -ATTACK THE SYSTEM RATHER THAN THE EMPLOYEE
- -STRIP DOWN THE WORK PROCESS TO FIND AND ELIMINATE PROBLEMS THAT PREVENT QUALITY
- -SATISFY THE CUSTOMER'S REQUIREMENTS
- -ELIMINATE WASTE
- -INSTILL PRIDE AND TEAMWORK

7. DIFFERENCES

- -CROSBY CALLS FOR ZERO DEFECTS, DEMING'S 10TH POINT SAYS TO ELIMINATE SLOGANS
- -DEMING'S 10TH POINT TELLS MANAGERS TO DRIVE OUT FEAR WHILE JURAN SAYS FEAR BRINGS OUT THE BEST IN PEOPLE
- -THE 2ND POINT OF JURAN'S TRILOGY CALLS FOR DISTINGUISHING THE VITAL FEW PROJECTS FROM THE TRIVIAL MANY WHILE CROSBY'S 11TH POINT ENCOURAGES EMPLOYEES TO INFORM MANAGEMENT OF ANY PROBLEM.
- -ALL 3 CALL FOR STATISTICAL TOOLS, BUT JURAN AND DEMING EMPHASIZE MORE
- -ALL STRESS COMMITMENT, BUT DEMING STARTS AT THE TOP, JURAN AT THE MIDDLE, CROSBY PUTS RESPONSIBILITY ON WORKERS

8. DEMING'S 14 POINTS

1. CREATE CONSTANCY OF PURPOSE TOWARD IMPROVEMENT OF PRODUCT AND SERVICE WITH A PLAN TO BECOME COMPETITIVE, STAY IN BUSINESS, AND PROVIDE JOBS.

2. ADOPT THE NEW PHILOSOPHY. WE ARE IN A NEW ECONOMIC AGE. WE CAN NO LONGER LIVE WITH COMMONLY ACCEPTED LEVELS OF DELAYS, MISTAKES, DEFECTIVE MATERIALS, AND DEFECTIVE WORKMANSHIP.

3. CEASE DEPENDENCE ON MASS INSPECTION. REQUIRE, INSTEAD, STATISTICAL EVIDENCE THAT QUALITY IS BUILT IN TO ELIMINATE THE NEED FOR INSPECTION ON A MASS BASIS.

4. END THE PRACTICE OF AWARDING BUSINESS ON THE BASIS OF PRICE TAG. INSTEAD, DEPEND ON MEANINGFUL MEASURES OF QUALITY, ALONG WITH PRICE. MOVE TOWARD A SINGLE SUPPLIER FOR ANY ONE ITEM, ON A LONG TERM RELATIONSHIP OF LOYALTY AND TRUST.

5. IMPROVE CONSTANTLY AND FOREVER THE SYSTEM OF PRODUCTION AND SERVICE, TO IMPROVE QUALITY AND

PRODUCTIVITY, AND THUS CONSTANTLY DECREASE PRICES.

6. INSTITUTE MODERN TRAINING METHODS.

7. SUPERVISE NEVER-ENDING IMPROVEMENT.

8. DRIVE OUT FEAR, SEE THAT EVERYONE MAY WORK EFFECTIVELY FOR THE COMPANY.

9. BREAK DOWN ORGANIZATIONAL BARRIERS-EVERYONE MUST WORK AS A TEAM TO FORESEE AND SOLVE PROBLEMS.

10. ELIMINATE ARBITRARY NUMERICAL GOALS, POSTERS, AND SLOGANS FOR THE WORKFORCE WHICH SEEK NEW LEVELS OF PRODUCTIVITY WITHOUT PROVIDING METHODS.

11. REPLACE MANAGEMENT BY NUMBERS WITH NEVER-ENDING IMPROVEMENT.

12. REMOVE BARRIERS THAT ROB EMPLOYEES OF THEIR PRIDE OF WORKMANSHIP.

13. EDUCATE AND RETRAIN EVERYONE.

14. CREATE A STRUCTURE WHICH WILL PUSH THE PRIOR 13 POINTS EVERYDAY.

9. JURAN'S BREAKTHROUGH SEQUENCE

-PROOF OF THE NEED
-PROJECT IDENTIFICATION
-ORGANIZATION TO GUIDE EACH PROJECT
-ORGANIZATION FOR DIAGNOSIS
-REMEDIAL ACTION ON THE FINDINGS
-BREAKTHROUGH TO CULTURAL RESISTANCE TO CHANGE
CONTROL AT THE NEW LEVEL

10. JURAN'S PROJECT IDENTIFICATION

-PROJECT: PROBLEM CHOSEN FOR SOLUTION
-ALL BREAKTHROUGH IS ACHIEVED PROJECT BY PROJECT
-SYMPTOM: EVIDENCE THAT SOMETHING IS WRONG
-REMEDY: SOLUTION
-DIAGNOSTIC JOURNEY: SYMPTOM TO CAUSE
-REMEDIAL JOURNEY: CAUSE TO REMEDY

II. KNOW YOUR PROCESS

A. FLOW CHARTING

1. WHAT IS A PROCESS?

   INPUT > OUTPUT

2. OPERATION PROCESS CHART

   -A GRAPHICAL REPRESENTATION OF EVENTS OCCURING DURING A SERIES OF ACTIONS OR EVENTS

   -APPLICABLE TO ALL AREAS OF A COMPANY

   -PRESENTS A PICTURE OF A PROCESS SO CLEARLY THAT AN UNDERSTANDING OF ITS EVERY STEP IS GAINED BY ANYONE STUDYING THE CHART

   -EFFECTIVE IN ANALYSIS OF PROBLEMS

   -ENCOURAGES AN OVERALL, ANALYTICAL, VIEW OF THE PROCESS

   -DOESN'T PROVIDE ANSWERS

3. FLOW PROCESS CHARTS

   -SHOW ALL THE BASIC ACTIONS, INCLUDING TRANSPORTATION AND DELAYS

4. PRINCIPLES OF CHARTING

   1. DETERMINE THE PROCESS TO BE CHARTED
   2. DETERMINE THE STARTING AND ENDING POINTS
   3. RECORD THE SYMBOL AND A BRIEF DESCRIPTION OF EACH DETAIL
   4. NOTE DISTANCES OF MOVEMENT IF APPLICABLE
   5. RECORD QUANTITIES OF MATERIALS
   6. INDICATE TIME CONSUMED OR PRODUCTION RATES

5. WHAT TO LOOK FOR

REVIEW EACH OPERATION AND INSPECTION FOR

1. PURPOSE
2. DESIGN
3. TOLERENCES AND SPECIFICATIONS
4. MATERIALS
5. MANUFACTURING PROCESS
6. SETUP AND TOOLS
7. WORKING CONDITIONS

ALSO ASK

1. WHY IS THIS NECESSARY?
2. WHY IS IT DONE LIKE THIS?
3. WHY ARE THE TOLERANCES THIS CLOSE?
4. WHY IS THIS MATERIAL USED?

KEEP THIS IN MIND

1. CAN ANY OPERATIONS OR INSPECTIONS BE ELIMINATED?
2. CAN OPERATIONS BE COMBINED?
3. CAN A BETTER SEQUENCE BE FOLLOWED?
4. CAN OPERATIONS BE SIMPLIFIED?

III. SOLVING QUALITY PROBLEMS

A. PROBLEM SOLVING TECHNIQUES

1. BRAINSTORMING

GUIDELINES FOR BRAINSTORMING

1. GENERATE A LARGE NUMBER OF IDEAS
2. FREE-WHEELING IS ENCOURAGED
3. DON'T CRITICIZE
4. ENCOURGAE EVERYONE TO PARTICIPATE
5. RECORD ALL THE IDEAS
6. LET IDEAS INCUBATE
7. SELECT AN APPROPRIATE MEETING PLACE

2. CONSTRUCTING A CAUSE AND EFFECT DIAGRAM

1. NAME THE PROBLEM
2. DRAW A LONG PROCESS ARROW LEADING TO THE BOX
3. DECIDE WHAT THE MAJOR CATEGORIES OF CAUSES ARE. WE USUALLY START WITH THE 4 M'S; METHODS, MATERIALS, MACHINES, AND MANPOWER.
4. BRAINSTORM FOR CAUSES. ADD TO THE APPROPRIATE CATEGORY.
5. IF A CAUSE IS SUGGESTED THAT MODIFIES ONE OF THE EXISTING CAUSES, CONNECT IT TO THE MAJOR CAUSE BY AN ARROW.
6. ADD ANOTHER CATEGORY IF NECESSARY.
7. POST THE DIAGRAM.
8. ELIMINATE THE TRIVIAL AND FRIVOLOUS CAUSES.
9. DISCUSS THE CAUSES THAT REMAIN AND DECIDE WHICH ARE IMPORTANT. CIRCLE THEM.
10. INVESTIGATE THE CIRCLED CAUSES.

B. DATA COLLECTION

1. GRAPHS

WHAT ARE GRAPHS?

GRAPHS ARE VISUAL PRESENTATIONS OF DATA. DATA CAN BE UNDERSTOOD MORE EASILY WHEN PRESENTED IN A GRAPH.

WHAT ARE THE CHARACTERISTICS OF GRAPHS?

-SUMMARIZES DATA
-GUIDES PROBLEM SOLVING
-DEMONSTRATES A POINT
-DOES NOT MISLEAD
-IS VISUALLY INTERESTING

WHAT ARE THE TYPES OF GRAPHS?

-LINE GRAPHS
-COLUMN AND BAR GRAPHS
-AREA GRAPHS
-MILESTONE AND PLANNING GRAPHS
-PICTORIAL GRAPHS
-HISTOGRAMS
-PARETO DIAGRAMS

LINE GRAPHS
EASIEST TO CONSTRUCT. USED TO PRESENT CHANGE OVER TIME.

COLUMN AND BAR GRAPHS
USED TO COMPARE 2 OR MORE MEASUREMENTS. BASICALLY THE SAME, BUT BARS RUN HORIZONTALLY AND COLUMNS RUN VERTICALLY. THEY ARE RECORDS OF COLLECTED DATA AND ARE READ LIKE THERMOMETERS.

AREA GRAPHS
USED TO SHOW HOW BUDGETS OR OTHER TOTAL AMOUNTS ARE DIVIDED.

MILESTONE AND PICTORIAL GRAPHS
HELP ORGANIZE PROJECTS AND COORDINATE ACTIVITIES.

PICTORIAL GRAPHS
USE DRAWINGS TO REPRESENT DATA.

WHAT IS A LEGEND?
A LEGEND GOES ON ALL GRAPHS AND INDICATES THE SOURCE OF THE INFORMATION, WHERE AND WHEN IT WAS COLLECTED, WHO COLLECTED IT, WHO PREPARED THE GRAPH, AND OTHER INFORMATION.

HISTOGRAMS

WHAT ARE HISTOGRAMS?

A HISTOGRAM IS A SPECIAL TYPE OF COLUMN GRAPH. IT SHOWS HOW VARIABLE MEASUREMENTS OF A GIVEN OBJECT OR PROCESS ARE. THEY CAN HELP SHOW CHANGES IN A PROCESS BETTER THAN OTHER TECHNIQUES.

HOW DOES THE EXPRESSION "TWO PEAS IN A POD" APPLY?

PEAS IN A POD ARE QUITE SIMILAR, ESPECIALLY WHEN COMPARED TO APPLES. ARE THEY REALLY ALIKE THOUGH? IF YOU TAKE A CLOSE LOOK THERE ARE SMALL DIFFERENCES. IF YOU TOOK A RULER AND MEASURED THE DIAMETER OF THE PEAS, YOU WOULD FIND A SMALL DIFFERENCE. IF YOU PUT EACH PEA INTO A BIN BY SIZE RANGE, YOU WOULD FIND THAT THE MIDDLE BINS ARE THE FULLEST, AND THE SIDE ONES THE LEAST FULL. THE SHAPE OF THIS DISTRIBUTION IS A BELL SHAPED CURVE.

WHAT IS A NORMAL CURVE?

THIS IS THE COMMON NAME FOR THE BELL SHAPED CURVE.

WHAT IF THE CURVE IS NOT BELL SHAPED?

YOU SHOULD BE SUSPICIOUS IF YOUR DATA IS NOT BELL SHAPED, THIS MAY INDICATE SOMETHING IS WRONG.

STEPS IN CONSTRUCTING A HISTOGRAM.

1. IDENTIFY AND DEFINE YOUR PROBLEM. WHAT ARE YOU MEASURING?
2. COLLECT DATA. TAKE AS MANY MEASUREMENTS AS YOU CAN. TRY 50 OR MORE.
3. CONSTRUCT A CHECKSHEET TO COLLECT THE DATA.
4. COLLECT DATA.
5. FIND THE LARGEST MEASUREMENT ON YOUR CHECKSHEET.
6. FIND THE SMALLEST MEASUREMENT.
7. FIND THE RANGE.
8. DIVIDE THE NUMBER IN STEP 7 BY THE VALUE FROM THE FOLLOWING GUIDE.

50-100 MEASUREMENTS	DIVIDE BY 6-10
100-250	7-12
OVER 250	10-20

9. COUNT THE TOTAL NUMBER OF MEASUREMENTS AND DIVIDE BY 3 (ARBITRARY, BASED ON PROBABILITY).

10. DRAW THE VERTICAL AND HORIZONTAL AXES OF A GRAPH.

11. PUT THE NUMBER FROM 5 ON THE RIGHT OF THE HORIZONTAL AXIS, THE NUMBER FROM STEP 6 ON THE LEFT.

12. PUT THE NUMBER IN STEP 9 ON THE TOP OF THE VERTICAL AXIS, AND A ZERO AT THE BOTTOM.

13. DIVIDE THE AXIS INTO EQUAL SPACES (NUMBER FROM STEP 8).

14. ADD THE NUMBER FROM STEP 8 TO THE LEFT NUMBER ON THE HORIZONTAL AXIS, AND PUT THE SUM BELOW THE NEXT MARK.

15. ADD THE SAME NUMBER TO THE ONE YOU JUST PLACED ON THE GRAPH, AND WRITE THE SUM ON THE NEXT MARK.

16. REPEAT STEP 15 UNTIL THE HORIZONTAL AXIS IS COMPLETE.

17. CONSTRUCT THE VERTICAL AXIS. DETERMINE A SCALE THAT WILL WORK WITH THE DATA YOU HAVE.

18. COUNT THE NUMBER OF MEASUREMENTS THAT FALL BETWEEN THE FIRST TWO NUMBERS. MAKE A MARK AT THE CORRECT HEIGHT.

19. IF A MEASURE FALLS ON THE LINE, INCLUDE IT WITH THE GROUP THAT BEGINS WITH THAT NUMBER.

20. DO THE SAME FOR THE REMAINING INTERVALS. FILL IN THE COLUMNS.

21. ADD A LEGEND.

22. OBSERVE THE SHAPE OF THE HISTOGRAM.

STEPS IN CONSTRUCTING A PARETO DIAGRAM

1. .COLLECT AND RECORD DATA
   .CALCULATE THE PERCENTAGES FOR THE CATEGORIES
   .CALCULATE THE CUMULATIVE PERCENTAGES

2. .SCALE THE CATEGORIES ON THE HORIZONTAL LINE
   .SCALE THE FREQUENCIES ON THE LEFT HAND VERTICAL LINE
   .SCALE THE PERCENTAGES ON THE RIGHT HAND VERTICAL LINE

3. .PLOT AND DRAW THE COLUMNS ON THE GRAPH
   .INCLUDE THE "OTHER" COLUMN WHENEVER FEASIBLE

4. .PLOT THE CUMULATIVE ("CUM") POINTS
   .DRAW THE "CUM" LINE

5. .LABEL EACH AXIS
   .ADD THE LEGEND

4. CHECKSHEETS

WHAT ARE CHECKSHEETS?

CHECK SHEETS ARE TOOLS FOR ORGANIZING AND COLLECTING FACTS AND DATA. THEY ALLOW QUALITY CIRCLES TO MAKE BETTER DECISIONS AND SOLVE PROBLEMS FASTER.

WHAT IS DATA?

DATA IS OBJECTIVE INFORMATION, INFORMATION THAT EVERYONE AGREES ON. AN OBJECTIVE MEASUREMENT OF A PIECE OF STRING WOULD BE USING A RULER TO MEASURE IT'S LENGTH. IF EVERYONE'S RULERS ARE ALIKE, ALL MEASUREMENTS SHOULD BE SIMILAR.

TYPES OF DATA

COUNTED DATA ARE RECORDED AS PRESENT OR ABSENT. COUNTED DATA IS GENERALLY THE ANSWER TO "HOW MANY" OR "HOW OFTEN". EXAMPLES ARE:

- -HOW MANY OF THE FINAL PRODUCTS ARE DEFECTIVE?
- -HOW OFTEN ARE THE MACHINES REPAIRED?
- -HOW MANY DAYS DID IT RAIN LAST MONTH?

MEASURED DATA GIVES MORE INFORMATION THAN COUNTED DATA. FOR EXAMPLE, YOU WOULD KNOW MORE ABOUT THE WEATHER IN AN AREA IF YOU KNEW HOW MUCH IT RAINED RATHER THAN JUST HOW MANY DAYS IT RAINED.

LOCATION DATA

A THIRD TYPE OF DATA OFTEN USED BY QUALITY CIRCLES IS LOCATION DATA; THIS TYPE OF DATA ANSWERS THE QUESTION, "WHERE?"

CONSTRUCTING CHECKSHEETS

THERE ARE THREE TYPES OF CHECKSHEETS USED TO RECORD COUNTED, MEASURED AND LOCATION DATA. A RECORDING CHECKSHEET IS USED TO COLLECT MEASURED OR COUNTED DATA. YOU BEGIN BY DESCRIBING THE TYPE OF DATA YOU WANT TO COLLECT. IS IT COUNTED, MEASURED, LOCATION, OR SOME OTHER TYPE? HOW MUCH DATA DO YOU NEED TO COLLECT? IMAGINE WHAT YOU WANT YOUR CHECKSHEET TO LOOK LIKE. DECIDE WHAT YOU NEED TO KNOW ABOUT EACH MEASUREMENT. DO YOU NEED TO KNOW WHO COLLECTED IT? WHERE IT CAME FROM? WHEN IT WAS COLLECTED? WHAT ABOUT SIZE, COLOR, OR WEIGHT?

THE SIMPLEST CHECKSHEETS ARE FOR COUNTED DATA. IN THIS KIND, DATA IS COLLECTED BY MAKING TICK MARKS.

A SECOND TYPE OF CHECKSHEET IS THE CHECKLIST CHECKSHEET. WHEN WE HAVE SEVERAL THINGS TO DO, WE SOMETIMES MAKE A LIST. AS WE FINISH EACH THING, WE CHECK IT OFF. AT HOME GROCERY LISTS ARE GOOD EXAMPLES. ON THE JOB, CHECKLISTS MAY BE USEFUL FOR INSPECTING EQUIPMENT. CHECKLISTS ARE HELPFUL WHEN YOU ARE LEARNING TO OPERATE COMPLEX EQUIPMENT. SUPERVISORS HAVE CHECKLISTS SOMETIMES SO THEY CAN REMEMBER TO CHECK THE WHOLE AREA.

THE THIRD TYPE OF CHECKLIST IS THE PROBLEM LOCATION OR DEFECT LOCATION CHECKLIST. THESE CHECKLISTS ARE PICTURES, ILLUSTRATIONS, OR MAPS ON WHICH DATA ARE COLLECTED.

IV. DATA ANALYSIS

-DESCRIPTIVE STATISTICS - GATHERING AND SUMMARIZING DATA SO THAT IT IS UNDERSTANDABLE
-STATISTICAL INFERENCE - USING DATA TO ARRIVE AT A CONCLUSION

A. SAMPLING

-POPULATION - SET OF DATA WHICH CONSISTS OF ALL POSSIBLE OR HYPOTHETICALLY POSSIBLE VALUES PERTAINING TO A CERTAIN SET
-SAMPLE - A FRACTION OF THE POPULATION
-SAMPLE SIZE

B. MEAN, MEDIAN, MODE

MODE - MEASUREMENT THAT OCCURS MOST FREQUENTLY. NOT MEANINGFUL UNLESS DATA SET IS LARGE

MEAN - EQUAL TO THE SUM OF THE MEASUREMENTS DIVIDED BY THE NUMBER OF MEASUREMENTS CONTAINED IN THE DATA SET

X = SAMPLE MEAN U = POPULATION MEAN

ACCURACY OF THE MEAN

-LARGER THE SAMPLE, MORE ACCURATE THE ESTIMATE WILL TEND TO BE
-THE MORE VARIABLE THE DATA, THE LESS ACCURATE THE DATA

MEDIAN - NUMBER SUCH THAT HALF OF THE MEASUREMENTS ARE ABOVE AND THE OTHER HALF BELOW.
1. RANK THE MEASUREMENTS
2. IF N IS ODD, USE THE MIDDLE MEASUREMENT 3. IF N IS EVEN USE THE MEAN OF THE OF THE MIDDLE TWO.

C. VARIANCE, STANDARD DEVIATION

RANGE-A MEASURE OF VARIABILITY EQUAL TO LARGEST MINUS SMALLEST

REPRESENT MEAN AS X. WHAT IS X - X? DEVIATION FROM X. IF LARGE, THE DATA ARE SPREAD OUT AND HIGHLY VARIABLE. IF SMALL, DATA ARE CLUSTERED ABOUT THE MEAN.

WE WOULD LIKE TO GET A SINGLE VALUE. IF SUM TO AVERAGE, WILL ALWAYS BE 0. TWO WAYS TO DEAL WITH THIS (1) CONSIDER THE VALUES POSITIVE OR (2) SQUARE.

SAMPLE VARIANCE - SUM OF THE SQUARED DISTANCES FROM THE MEAN DIVIDED BY (N-1)

SAMPLE STANDARD DEVIATION - POSITIVE SQUARE ROOT OF THE SAMPLE VARIANCE

S = SAMPLE VARIANCE
r = POPULATION VARIANCE
s = SAMPLE STANDARD DEVIATION
r = POPULATION STANDARD DEVIATION

V. STATISTICAL PROCESS CONTROL

SPC - CONTROL OF THE PROCESS
SQC - CONTROL OF THE PROCUCT

A. WHY?

INVALID REASONS

- -THE JAPANESE ARE DOING IT
- -THE BOSS WANTS IT

REALISTIC REASONS

- -REDUCE QUALITY COSTS
- -REDUCE VARIABILITY
- -REDUCE DEFECTS

REQUIREMENTS

- -MANAGEMENT COMMITMENT
- -SOME STATISTICAL KNOWLEDGE

USES

- -FINAL PRODUCT CHARACTERISTICS
- -IN-PROCESS CHARACTERISTICS
- -RAW MATERIALS
- -MEASUREMENT CONTROL

B. BENEFITS OF SPC

- -STATISTICAL CONTROL - PROCESS THAT OPERATES CONSISTENTLY OVER TIME
- -PROCESS CAPABILITY - MEETS CUSTOMER REQUIREMENTS AND PRODUCT SPECIFICATIONS

QUALITY AND YIELDS ARE PREDICTABLE
THE EFFECT OF PROCESS CHANGES CAN BE MEASURED
ARGUMENTS CAN BE MADE FOR ALTERING SPECIFICATIONS
PERFORMANCE CAPABILITY OF THE PROCESS CAN BE MEASURED, COMMUNICATED, AND UNDERSTOOD

C. TYPES OF VARIATION

NORMAL

COMMON CAUSES

- -INFLUENCE ALL OBSERVATIONS
- -OBSOLETE EQUIPMENT, POOR LAB PROCEDURES ARE EXAMPLES

CHANCE CAUSES

- -CAUSE VARIATION EVEN IF CONDITIONS ARE HELD CONSTANT
- -TEMPERATURE VARIATIONS RAW MATERIAL VARIATIONS ARE EXAMPLES

UNUSUAL

RESULT FROM SPECIFIC CAUSES

- -NOT COMMON TO ALL PROCESS VARIATIONS
- -CAUSE SIGNIFICANT VARIATION IN PROCESS OBSERVATIONS
- -USE OF INCORRECT RAW MATERIAL, USING WRONG PROCEDURE ARE EXAMPLES

D. RATIONAL SUBGROUPS

- -MAXIMUM CHANCE FOR SAMPLES IN SUBGROUP TO BE ALIKE
- -MAXIMUM CHANCE FOR SUBGROUPS TO BE DIFFERENT
- -SCHEME 1: SUBGROUPS CONTAIN SAMPLES PRODUCED AT ONE TIME
- -SCHEME 2: SUBGROUPS CONTAIN SAMPLES REPRESENTATIVE OF PRODUCTION OVER TIME
- -SHEWHART SUGGESTED 4
- -MOST INDUSTRIES USE 5
- -CAN USE 10-20
- -SOMETIMES DETERMINED BY ECONOMICS
- -LARGER SUBGROUPS MORE SENSITIVE TO SHIFTS IN THE PROCESS AVERAGE

E. X AND R CHARTS

PROCESS FOR IMPLEMENTING

PREPARATION

- SET OBJECTIVES
- CHOOSE THE VARIABLE
- DETERMINE THE METHOD OF MEASUREMENT

START THE CONTROL CHARTS

- MAKE THE MEASUREMENTS
- RECORD THE MEASUREMENTS (25 NEEDED FOR VALID CONTROL LIMITS)
- CALCULATE THE X OR THE MEAN
  X IS THE AVERAGE OF THE SAMPLE MEASUREMENTS
- CALCULATE X: THE GRAND AVERAGE, THE AVERAGE OF ALL THE SUBGROUP AVERAGES
- CALCULATE THE SUBGROUP RANGES
- CALCULATE R, THE AVERAGE OF ALL THE SUBGROUP RANGES
- PLOT THE POINTS ON THE CHART

PLOT THE CONTROL LIMITS

- FOR THE X CHART
  UCL = X + A R
  LCL = X - A R
- FOR THE R CHART
  UCL = D R
  LCL = D R

DRAW CONCLUSIONS

OUT OF CONTROL?

- OUT OF THE CONTROL LIMITS
- 2 OUT OF 3 POINTS ABOVE 2 SIGMA
- 4 OUT OF 5 POINTS ABOVE 1 SIGMA
- 8 CONSECUTIVE POINTS ABOVE OR BELOW THE CENTER LINE

GET THE PROCESS INTO CONTROL

- CAREFUL DOCUMENTATION OF THE PROCESS
- USING APPROPRIATE CONTROL CHARTS
- SEEK OUT ASSIGNABLE CAUSES AS INDICATED BY CONTROL CHARTS
- TAKE ACTION TO ELIMINATE THE ASSIGNABLE CAUSES

AFTER THE PROCESS IS IN CONTROL YOU CAN DETERMINE WHETHER THE PROCESS IS CAPABLE OF MEETING THE SPECIFICATIONS

GENERAL RULES

- -NEVER PLACE SPECIFICATIONS ON A CONTROL CHART
- -DON'T CONFUSE SPECIFICATIONS AND CONTROL LIMITS
- -AVERAGES ARE USED BECAUSE THEY ARE MORE SENSITIVE TO CHANGE

VI. PROCESS CAPABILITY

-A TECHNIQUE FOR ANALYZING THE VARIABILITY IN A PROCESS
-EXPRESSED AS THE PROPORTION OF PROCESS OUTPUT THAT REMAINS IN SPECIFICATION

A. DOING A PROCESS CAPABILITY STUDY

1. SELECT THE VARIABLE TO BE MEASURED
2. COLLECT THE DATA
3. DRAW A HISTOGRAM
4. DETERMINE THE PROCESS CAPABILITY

   CP = TOLERANCE

   CPk = MIN USL-MEAN, MEAN-LSL

5. COMPARE

   >1.33 CAPABLE
   1.0 TO 1.33 MARGINALLY CAPABLE
   <1.0 NOT CAPABLE

B. USES

1. EVALUATING NEW EQUIPMENT
2. PREDICTING WHETHER SPECIFICATIONS CAN BE MET
3. MAKING ADJUSTMENTS DURING MANUFACTURE
4. SETTING SPECIFICATIONS

VII. STATISTICAL PROCESS CONTROL WHEN THE TRADITIONAL TECHNIQUES DON'T WORK

A. CONTROL CHARTS FOR INDIVIDUALS

1. USES INDIVIDUAL MEASUREMENTS
2. CALCULATE THE AVERAGE
3. CALCULATE THE STANDARD DEVIATION (   )
4. CONTROL LIMITS FOR X CHART
   UCL = X + 3
   LCL = X - 3

B. MOVING AVERAGE/RANGE CONTROL CHARTS

1. AVERAGE POINT 1 AND POINT 2, POINT 2 AND POINT 3, ETC. (MOVING AVERAGE OF 2)
2. CALCULATE X
3. CALCULATE THE RANGE OF POINT 1 AND 2, POINT 2 AND 3, ETC
4. CALCULATE R
5. CONTROL LIMITS X
   UCL = X + E R
   LCC = X - E R
6. CONTROL LIMITS R
   UCL = DyR
   LCC = D R
7. RUN TESTS NOT APPLICABLE

C. CONTROL CHARTS FOR SHORT RUNS

1. REASONS FOR DIFFICULTIES
   -NUMBER OF SUBGROUPS FOR CONTROL LIMIT CALCULATIONS
   -FORMATION OF RATIONAL SUBGROUPS
   -NUMBER OF SAMPLES IN SUBGROUPS
   -PRODUCTION RUN FINISHED BEFORE ENOUGH SAMPLES CAN BE TAKEN

2. INDUSTRIES WITH DIFFICULTIES
   -BATCH OPERATIONS
   CHEMICAL INDUSTRY
   -MAKE A SINGLE LARGE PART
   DEFENSE INDUSTRY
   COMPUTER INDUSTRY
   -MAKE A FEW SIMILAR PARTS
   INJECTION MOLDING
   MACHINED PARTS
   -USE JUST-IN-TIME
   ANY INDUSTRY

3. PROCESS IS COMPOSED OF 5 THINGS
   -OPERATOR
   -MACHINE
   -MATERIAL
   -METHOD
   -TOOLING

4. PROCESS IS INDEPENDENT OF SIZE OF THE PARTS, PURPOSE, SHAPE

5. GROUP THE PARTS
   -MATERIAL
   -MACHINE
   -METHOD

6. SHORT R RUN X AND R CHARTS
   -ALLOWS RESULTS FROM DIFFERENT PARTS TO BE PLOTTED ON THE SAME CHART
   -DOES NOT REQUIRE SIMILAR STANDARD DEVIATIONS

7. CONTROL LIMITS

   BASED ON SUBGROUP SIZE

   R CHART

   UCL Dy

   LCL D

   PLOT POINT

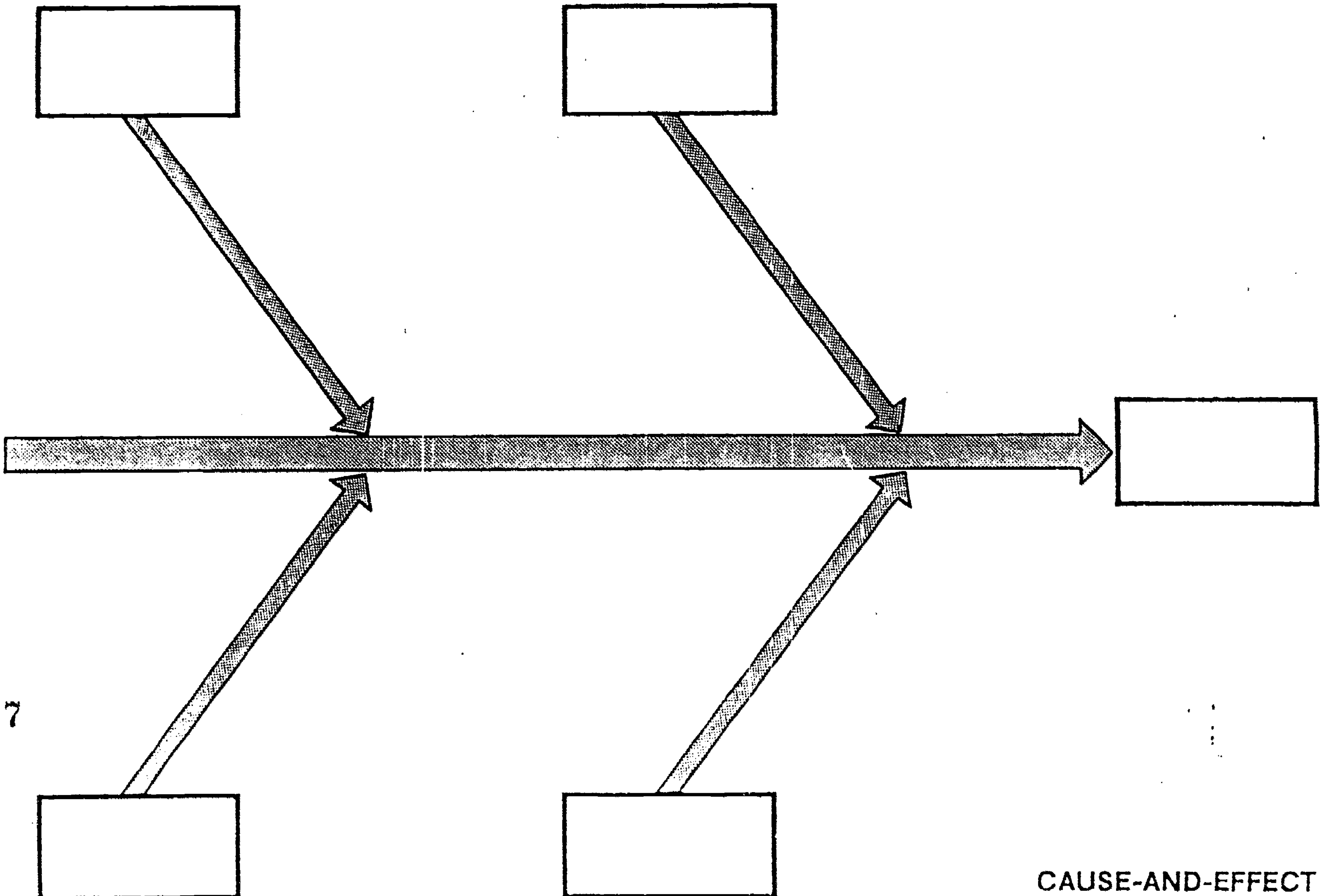
   X CHART

   UCC + A

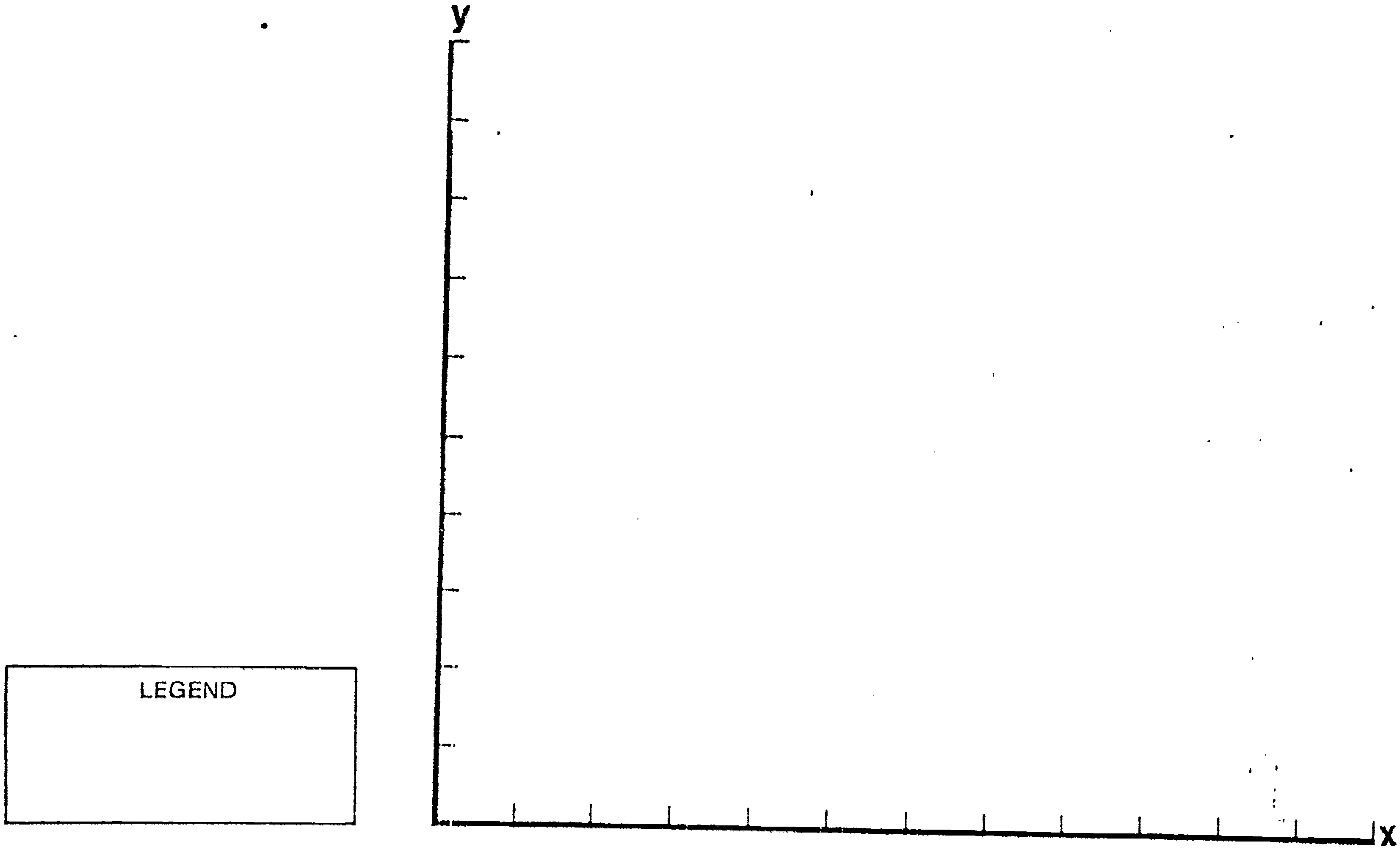
   LCL - A

   PLOT POINT

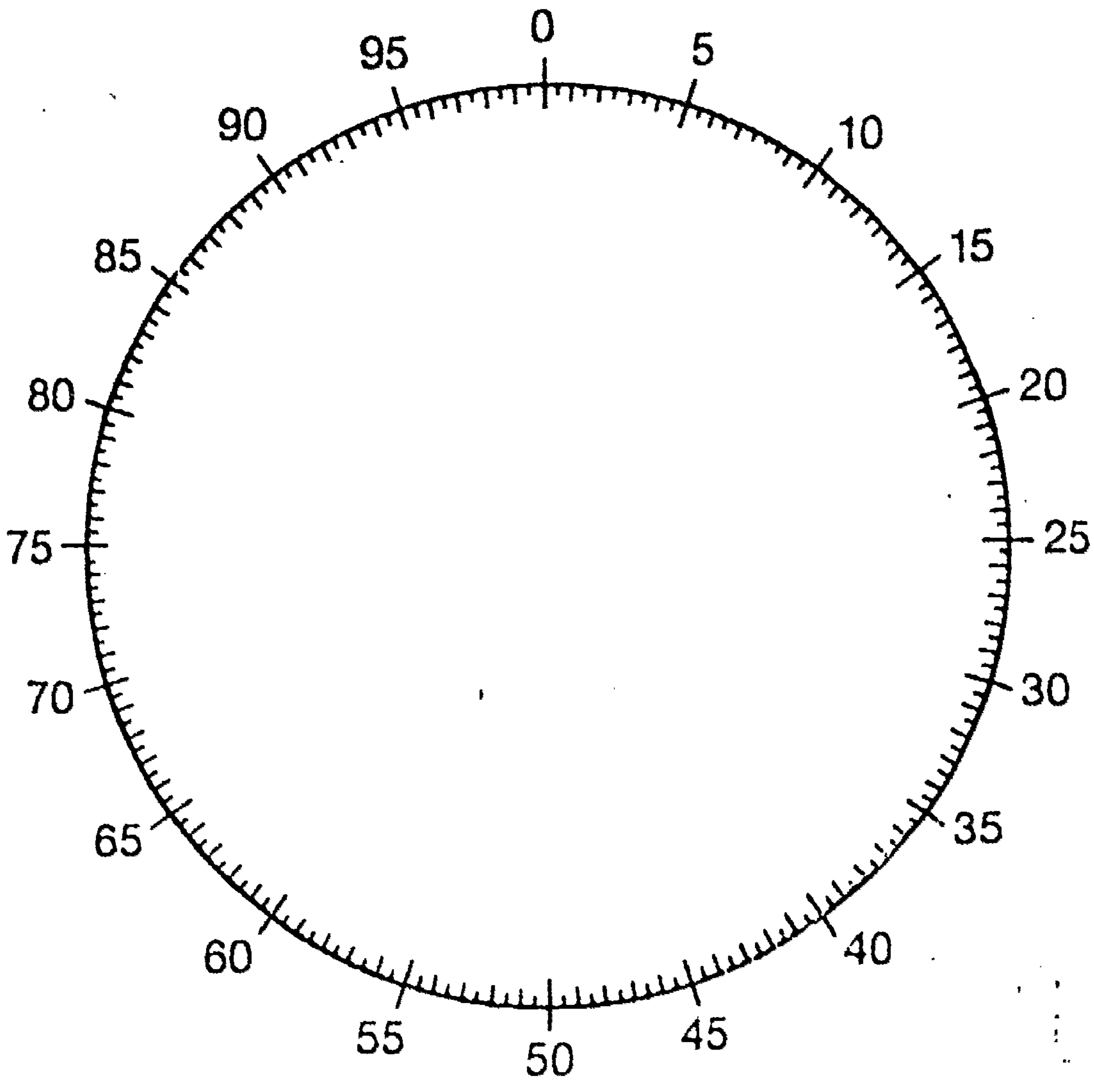
8. ADVANTAGES
   -CONTROL LIMITS ARE INDEPENDENT OF X AND R
   -CAN PLOT MULTIPLE PARTS ON ONE CHART
   -CAN CHART BEGINNING WITH THE FIRST SUBGROUP
   -CAN PLOT MULTIPLE QUALITY CHARACTERISTICS
   -NO NEED TO RECALCULATE CONTROL LIMITS



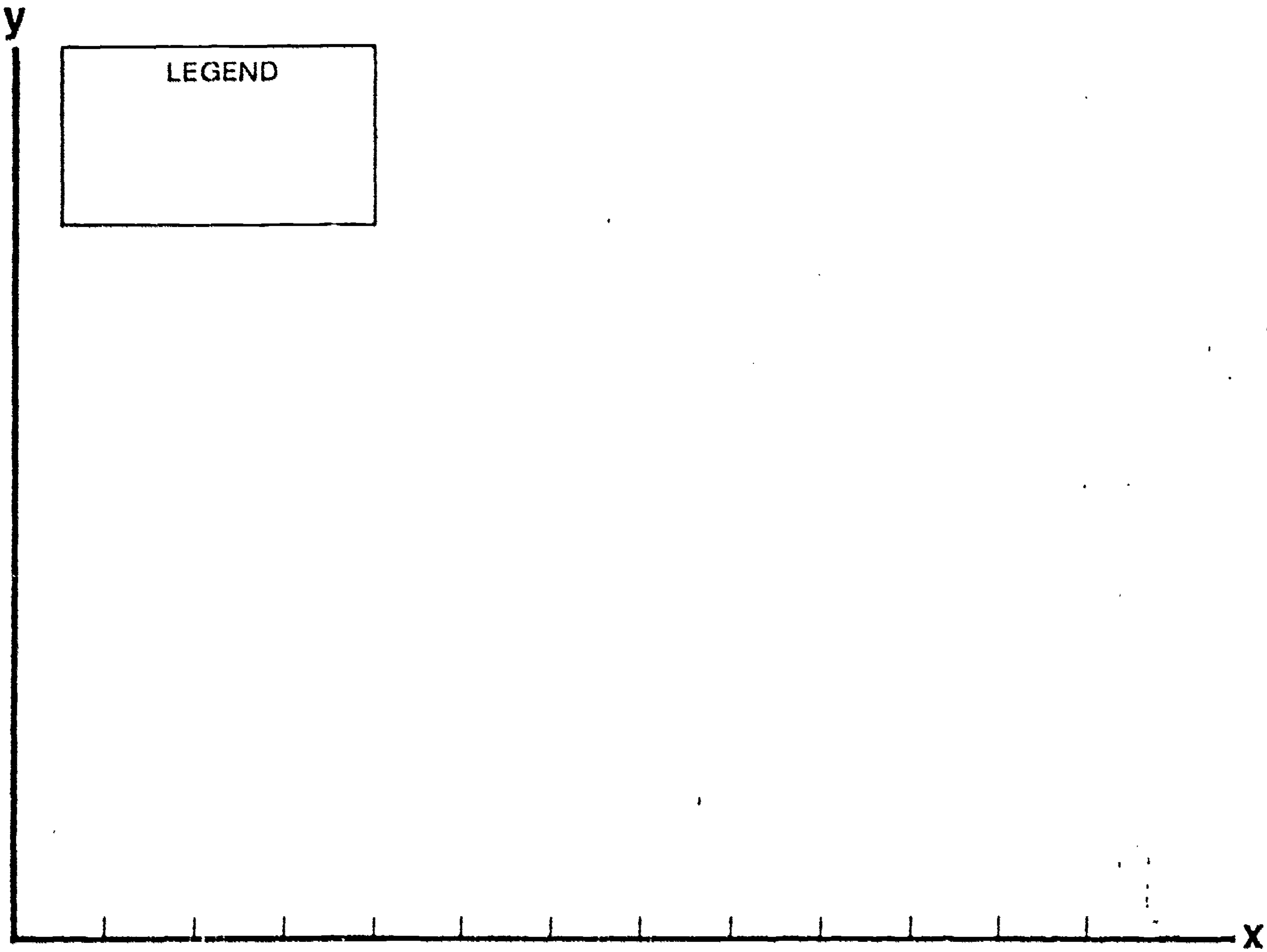
CAUSE-AND-EFFECT
DIAGRAM



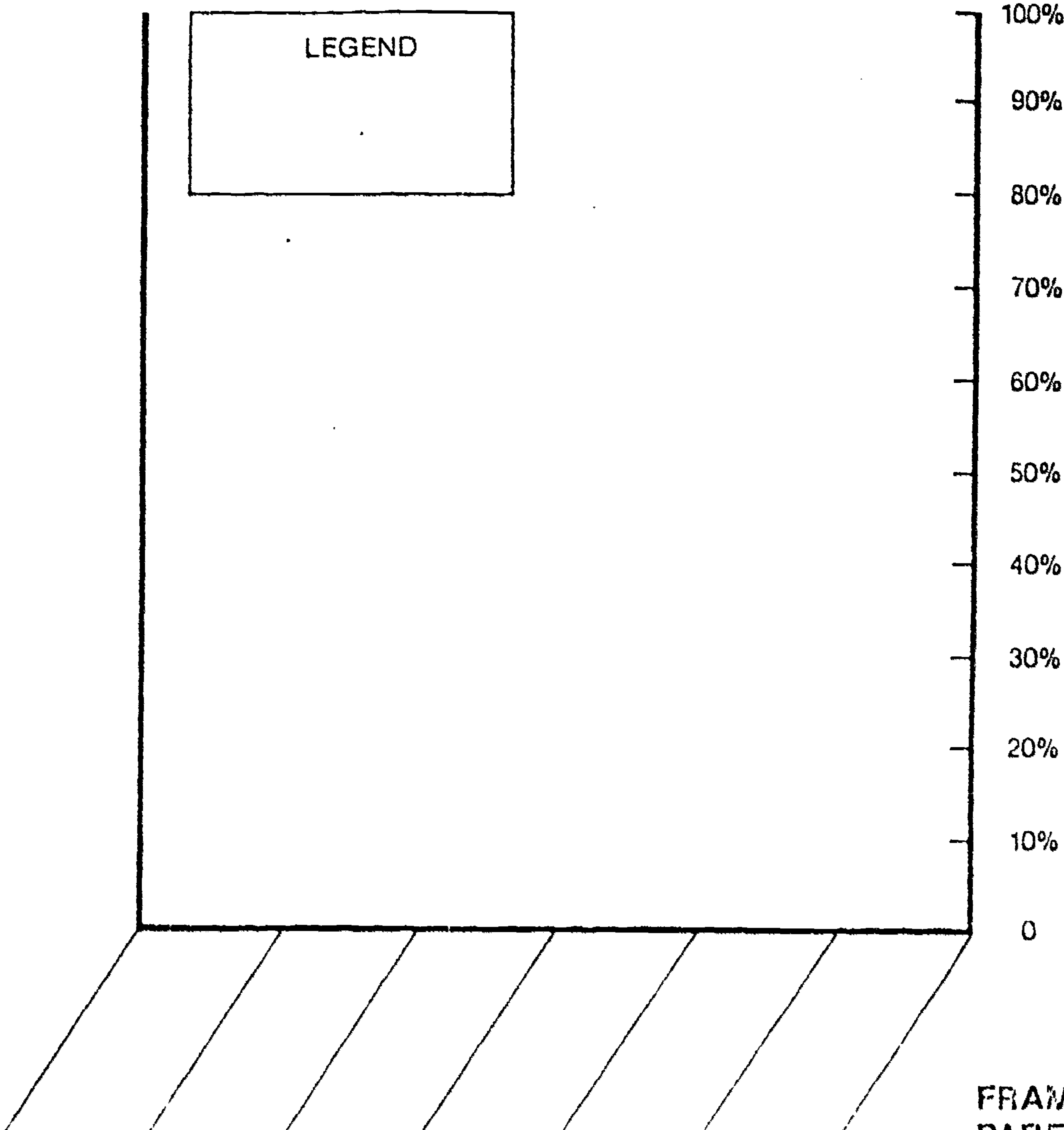
FRAMEWORK FOR
COLUMN GRAPH,
BAR CHART,
LINE GRAPH



FRAMEWORK FOR
AREA GRAPH
(percentages identified)



FRAMEWORK FOR
HISTOGRAM



FRAMEWORK FOR PARETO DIAGRAM