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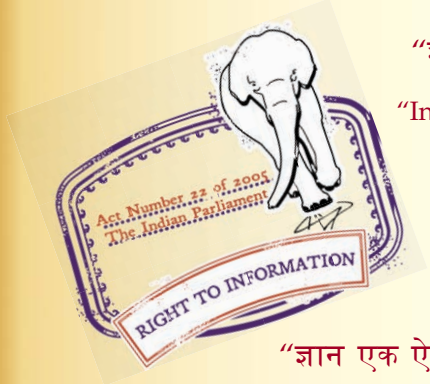
IS 14978 (2002): New Seven Tools for Quality Management
[MSD 3: Statistical Methods for Quality and Reliability]



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Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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भारतीय मानक

गुणता प्रबन्ध के लिए सात नए उपकरण

Indian Standard

NEW SEVEN TOOLS FOR QUALITY MANAGEMENT

ICS 03.120.30

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

April 2002

Price Group 7

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Statistical Methods for Quality and Reliability Sectional Committee had been approved by the Management and Systems Division Council.

In this era of globalization, the organizations are aiming for continuous quality improvement, for which they need tools and techniques. The basic seven tools, namely, Check-sheet, Histogram, Scatter diagram, Stratification, Pareto diagram, Cause-and-Effect diagram, and Control charts are useful for quality control. In addition the following new seven tools are also very useful for quality improvement:

a) Affinity Diagram,
b) Tree Diagram,
c) Arrow Diagram,
d) Process Decision Programme Chart,
e) Matrix Diagram,
f) Relations Diagram, and
g) Matrix Data Analysis.

These new tools are essentially systems and documentation methods, interrelated, used to achieve success in design by identifying customers needs and translating them to technical requirements in the intermediate steps in the finest detail as also for solving quality-related problems. Therefore, these tools are also used by the Quality Function Deployment (QFD) team in any organization to achieve better design in less time. Quality Function Deployment (QFD) refers to a system for designing a product or service by translating the customer's needs into appropriate technical requirements at each stage with the participation of members of all functions of the supplier organization.

It may be mentioned that these new seven tools are complimentary to old seven tools and therefore do not replace them.

The relationship among these new seven tools has been shown in **4**.

The Composition of the Committee responsible for the formulation of this standard is given in Annex A.

Indian Standard

NEW SEVEN TOOLS FOR QUALITY MANAGEMENT

1 SCOPE

This standard describes the following new seven tools for quality improvement:

a) Affinity Diagram,
b) Tree Diagram,
c) Arrow Diagram,
d) Process Decision Programme Chart,
e) Matrix Diagram,
f) Relations Diagram, and
g) Matrix Data Analysis.

The above tools have been illustrated with examples for better understanding.

2 REFERENCE

The following standard contains provision, which through reference in this text constitutes provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard given below:

IS No.	*Title*
12801 : 1989	Pareto diagram and cause and effect diagram

3 NEW SEVEN TOOLS

3.1 Affinity Diagram

3.1.1 *Application*

An affinity diagram is used to organize into groupings a large number of ideas, opinions or concerns about a particular topic.

3.1.2 *Description*

When a large number of ideas, opinions or other concerns about a particular topic are being collected, this tool organizes the information into groupings based on the natural relationships that exist among them. The process is designed to stimulate creativity and full participation. It works best in groups of limited size (a maximum of eight members is recommended) in which members are accustomed to working together. This tool is often used to organize ideas generated by brainstorming.

3.1.3 *Procedure*

a) State the topic to be studied in broad terms (details may prejudice the response).
b) Record as many individual ideas, opinions or concerns as possible on cards (one per card).
c) Mix the cards and spread them randomly on a large table.
d) Group related cards together as follows:
   — sort cards that seem to be related into groups, and
   — limit number of grouping to ten without forcing single cards into groups.
e) Locate or create a header card that captures the meaning of each group.
f) Place this header card on top.
g) Transfer the information from cards onto paper, organized by groupings.

3.1.4 *Examples*

3.1.4.1 Affinity diagram for 'Requirements for a Telephone Answering Machine' is shown in Fig. 1 and Table 1.

3.1.4.2 Affinity diagram for 'Developing Process for Continuous Improvement' is shown in Fig. 2.

3.2 Tree Diagram

3.2.1 *Application*

A tree diagram is used to show the interrelation between a topic and its component elements.

3.2.2 *Description*

A tree diagram systematically breaks down a topic into its component elements. Ideas generated by brainstorming and graphed or clustered with an affinity diagram can be converted into a tree diagram to show logical and sequential links. This tool can be used in planning and problem solving.

3.2.3 *Procedure*

a) State the topic to be studied clearly;
b) Define the major categories of the topic; (brainstorm or use the header cards from the affinity diagram);

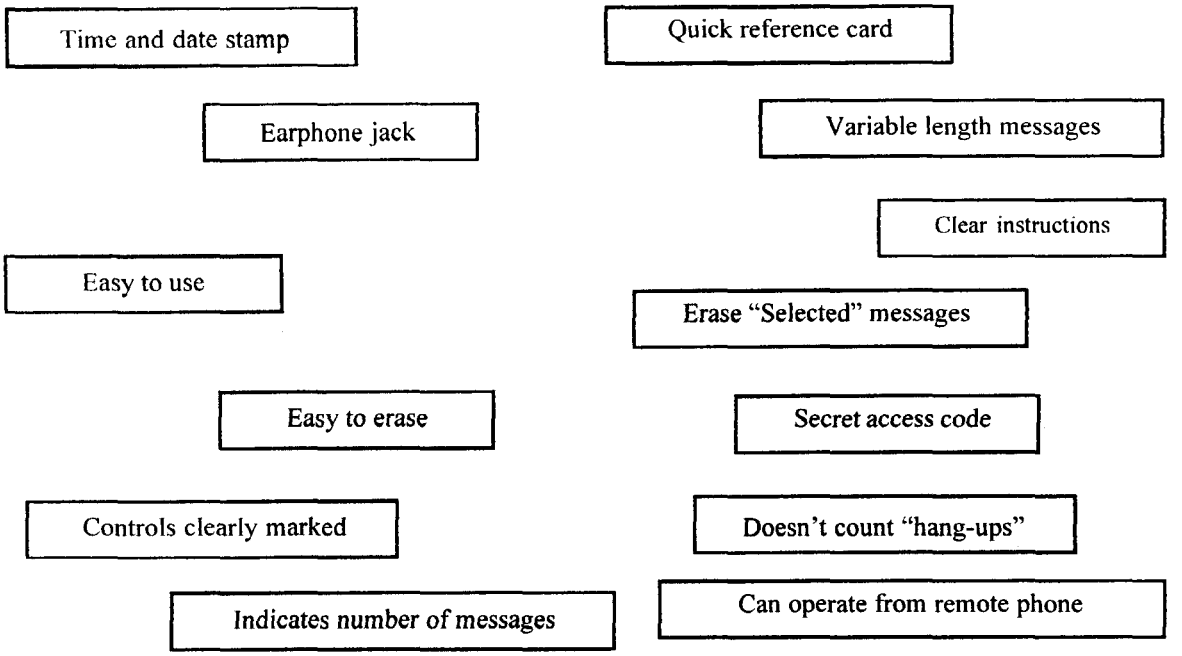


FIG. 1 RANDOM DISPLAY AS PER STEP (C) OF **3.1.3**

Table 1 Data Organized By Grouping As Per Step (e) of 3.1.3
(*Clause* 3.1.4.1)

Variable length messages Time and date stamp Doesn't count "hang-ups" Indicates number of messages	Incoming messages
Secret access code earphone jack	Privacy
Clear instructions Quick reference card	Instructions
Controls clearly marked Easy to use Can operate from remote phone	Controls
Easy to erase Erase "selected" messages	Erasing

c) Construct the diagram by placing the topic in a box on the left-hand side;

d) Branch the major categories laterally to the right;

e) For each major category, define the component elements and sub-elements, if any;

f) Laterally branch to the right the component elements and sub-elements for each major category; and

g) Review the diagram to ensure that there are no gaps in either sequence or logic.

3.2.4 *Example*

The Tree diagram for Telephone Answering Machine is shown in Fig. 3 and for Poor Attendance at Quality Circle Meeting in Fig. 4.

3.3 Arrow Diagram

3.3.1 *Application*

It uses a network representation to show the steps necessary to implement a plan. An arrow diagram establishes the most suitable daily plan for a project and monitors its progress efficiently. This tool is used to plan or schedule a task, or events, taking note of duration to complete each such sub-task. The tool is very useful in increasing the efficiency of jobs that are repetitive in nature. It is often used in PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method).

3.3.2 *Description*

The arrow diagram displays every job necessary for promoting a project and its subordinate relationships through the use of an arrow network.

The symbols for the following terms used in this diagram are given in Fig. 5:

— Event node, Job activity, Event number
— Preceding and succeeding jobs
— Parallel jobs
— Use of dummies
— Node number
— Job card

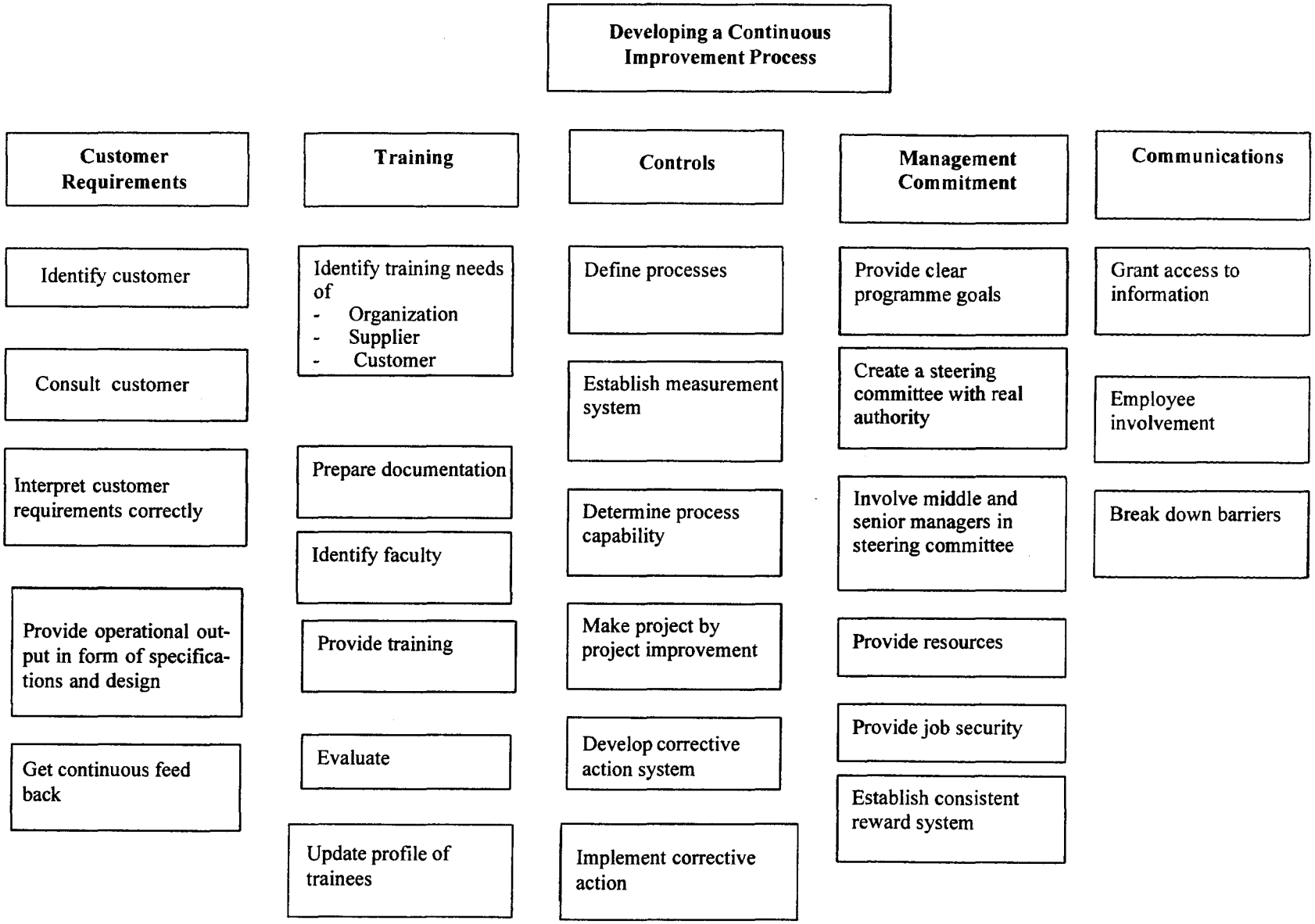


FIG. 2 AFFINITY DIAGRAM FOR DEVELOPING PROCESS OF CONTINUOUS IMPROVEMENTS

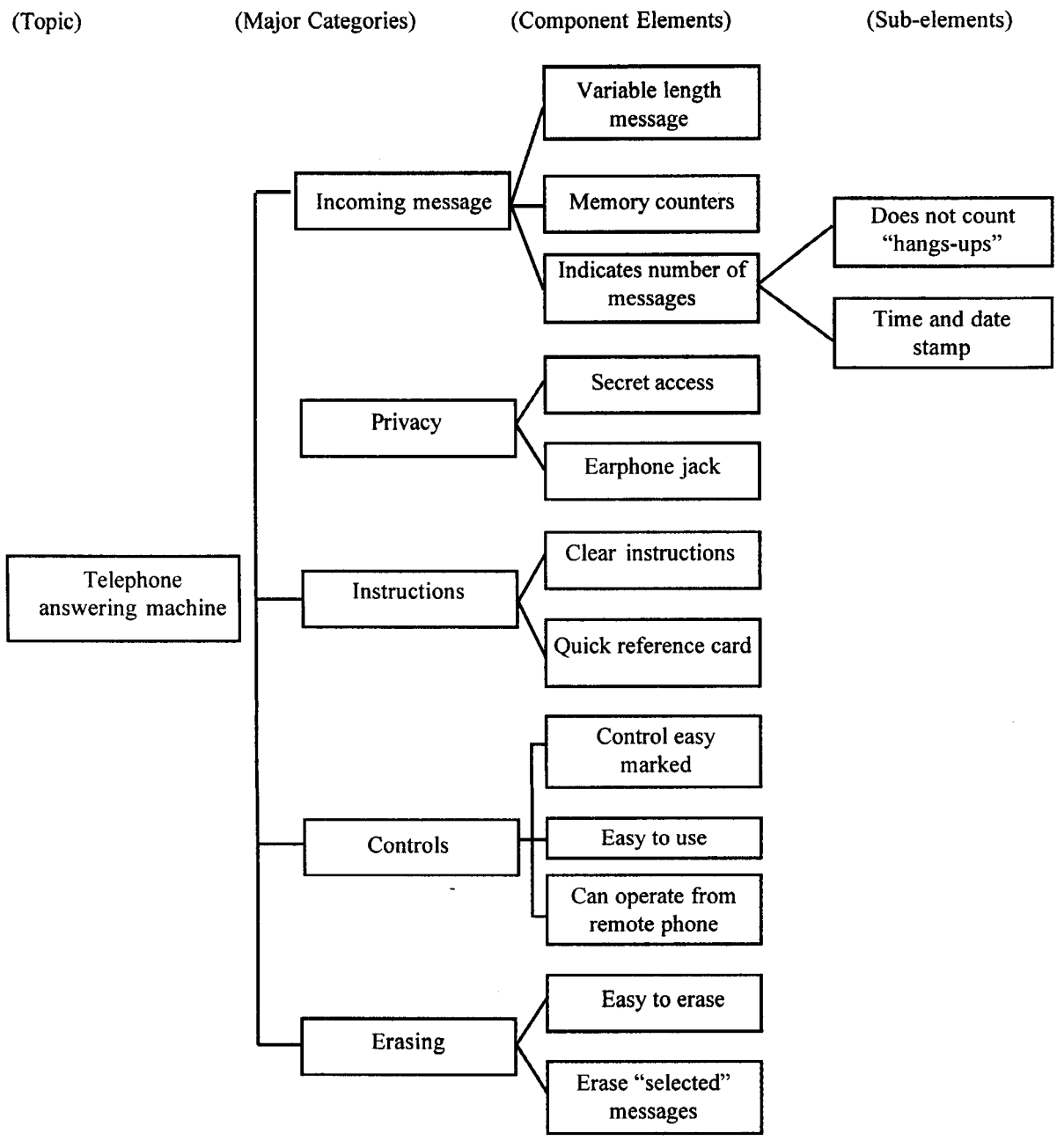


FIG. 3 TREE DIAGRAM FOR TELEPHONE ANSWERING MACHINE

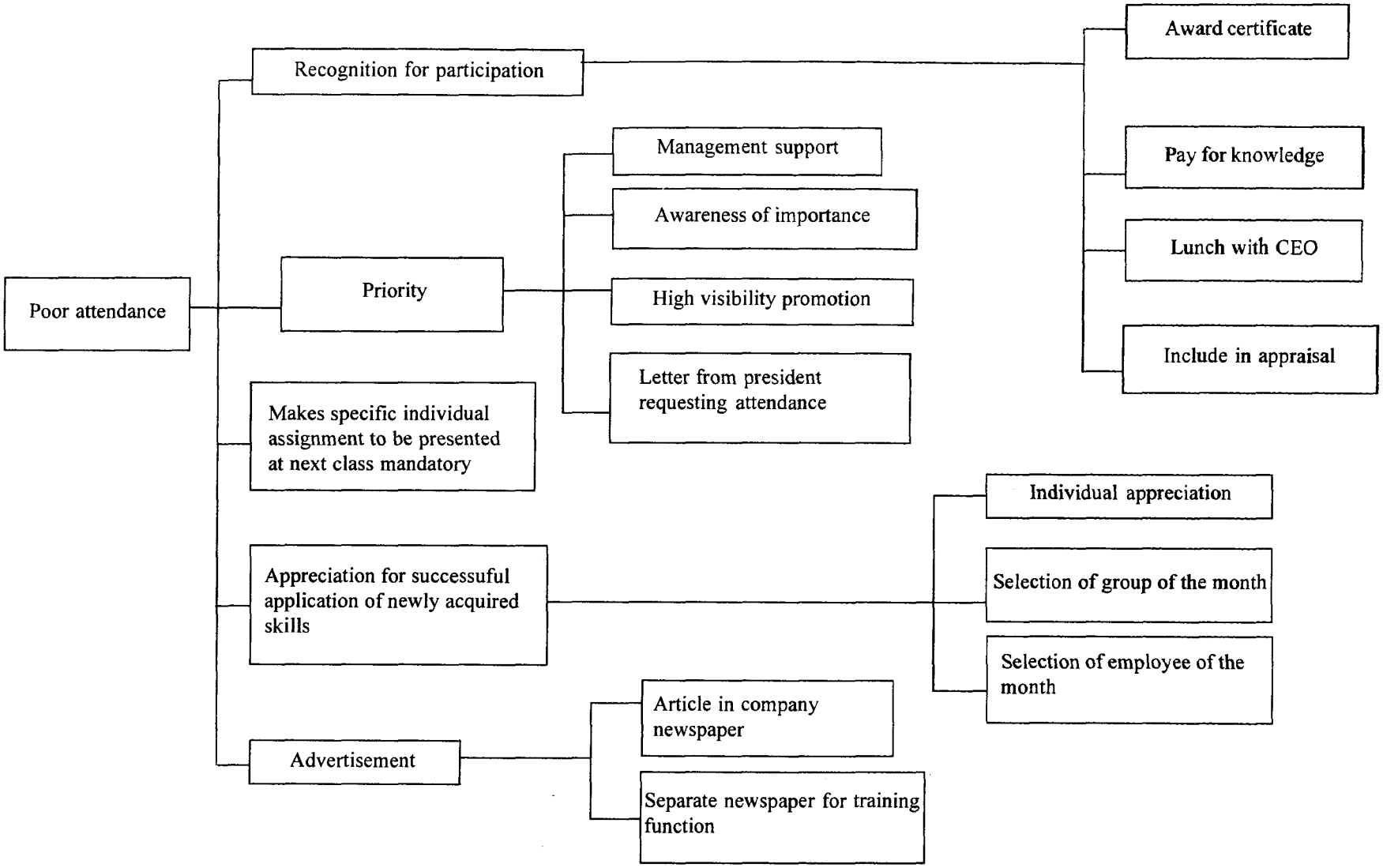


FIG. 4 TREE DIAGRAM FOR POOR ATTENDANCE AT QUALITY CIRCLE MEETING

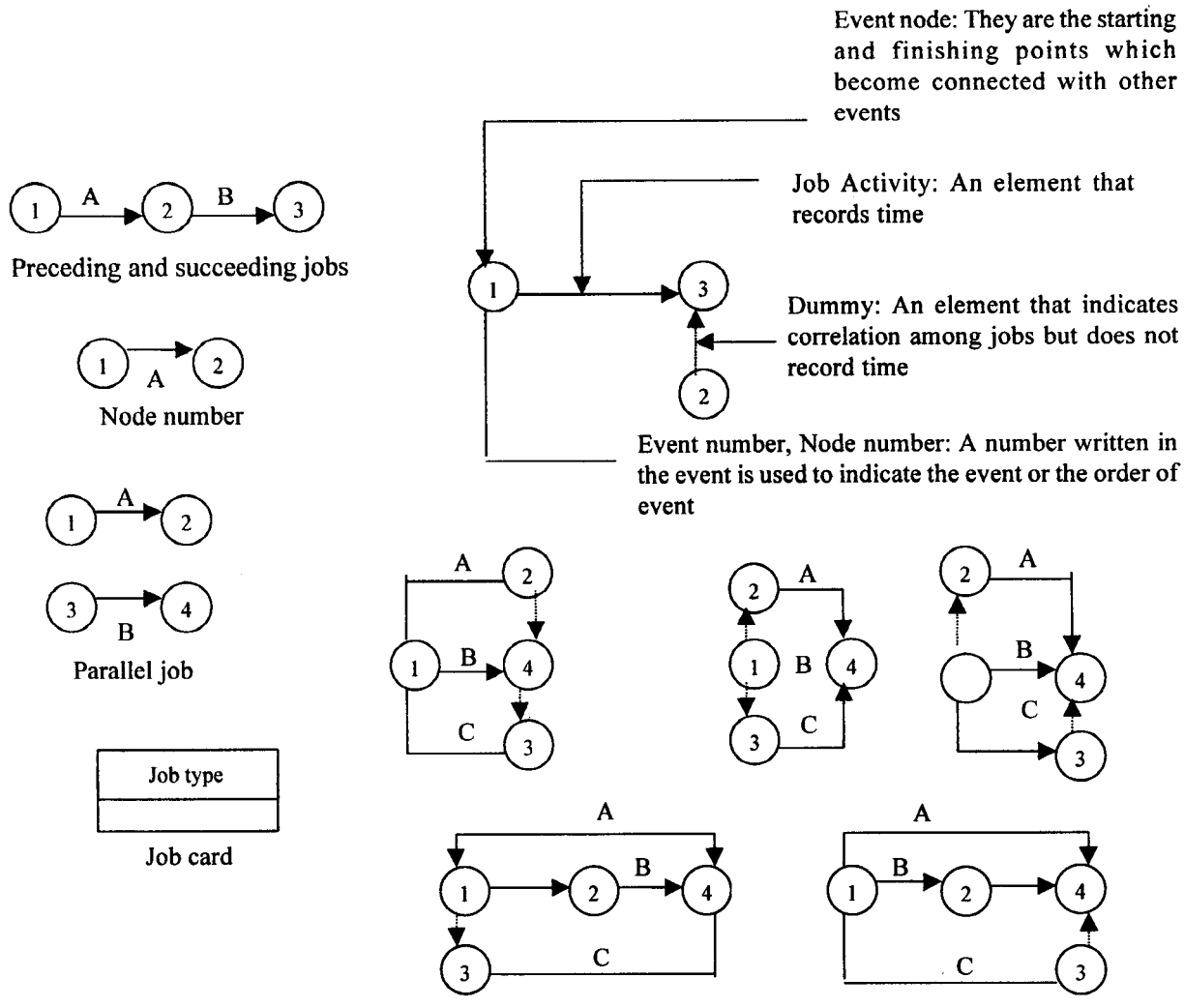


FIG. 5 SYMBOLS OF VARIOUS TERMS USED IN ARROW DIAGRAMS

3.3.3 *Procedure*

a) List the necessary jobs for project completion and then write them on the paper.

b) Prepare job card by writing the type of the work.

c) Arrange the job cards on a large piece of paper according to whether they are preceding, succeeding or parallel jobs.

d) Remove all job cards for unnecessary jobs and add the job cards of necessary jobs that have been omitted.

e) Determine the location of the cards as per following criteria:

— find the process where the maximum job cards can be placed in series. Position the job cards that have a preceding – succeeding relationship along this process with an interval enough for a node to be placed between them.

— job cards having parallel relationships must be positioned appropriately relative to the cards in above step. Decide on the final position for all cards and affix them to the paper.

— arrow diagram is finished by connecting the final arrangement of nodes and job cards with arrows. An arrow should not branch off or join with other arrows. Branching and joining shall be done only at nodes.

3.3.4 *Example*

Arrow diagram for 'Quality assurance during production preparation stage' is shown in Fig. 6.

3.4 Process, Decision Program Chart (PDPC)

3.4.1 *Application*

The process decision program chart (PDPC) method helps us select the best processes to obtain optimum

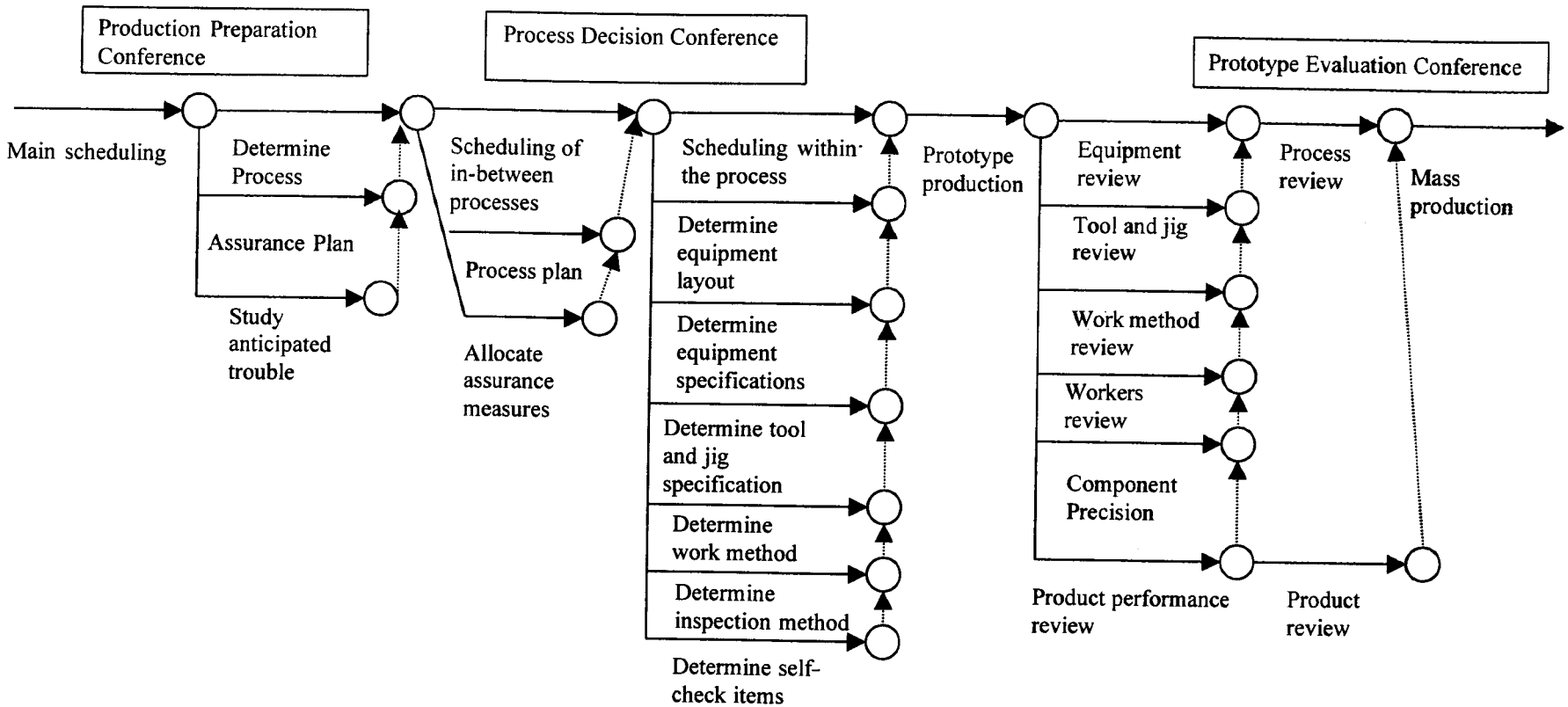


FIG. 6 ARROW DIAGRAM FOR QUALITY ASSURANCE DURING PRODUCTION PREPARATION STAGE

results by evaluating the progress of events and various conceivable outcomes.

3.4.2 *Description*

3.4.2.1 The process decision program chart (PDPC) method is used to define the solution process when dealing with problems that have more than one possible outcome. It anticipates the unexpected outcomes at each stage and plans for it.

3.4.2.2 PDPC has two following patterns:

Pattern I – In this pattern process starts with initial condition 'A' and proceeds to the desired final condition 'Z' in an organized manner (*see* Fig. 7).

Pattern II - In this pattern, first the final condition 'Z' is set. Then the process from 'Z' to the initial point 'A' is developed with the inclusion of various alternatives from many points of view (*see* Fig. 7).

3.4.3 *Procedure*

a) Discuss the issues related to the project among a cross-functional team.

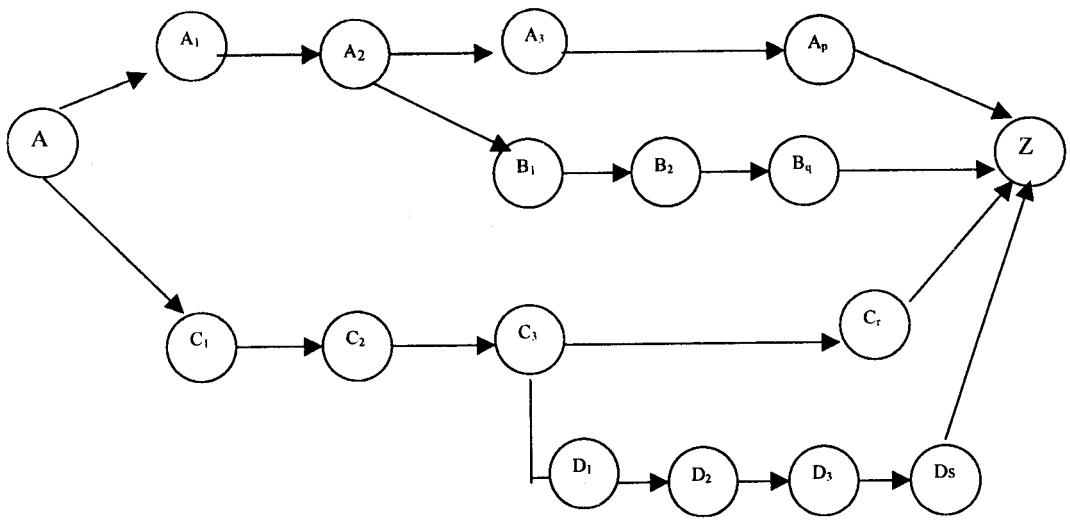
b) Discuss which issues must be examined and identify those issues.

c) Consider and note down all the anticipated results for the identified issues.

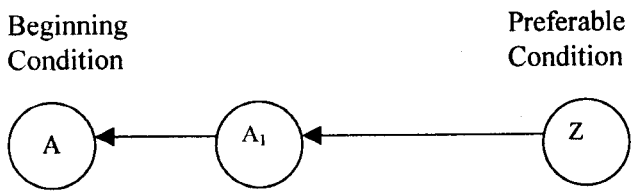
d) Weigh the feasibility of each solution proposed and investigate alternate solutions.

e) Classify each issue according to its urgency, number of operations required, likelihood of occurrence and difficulty.

f) Consider the anticipated results and alternative solutions related to issues that must be addressed immediately and link the items with arrows to the desired goal.



Pattern - I



From desired condition Z, consider how to link Z to A through Intermediate event A_1 A_2.

Pattern - II

When Z is an undesired condition, we must find a solution that cuts the chain $Z \rightarrow A_1 \rightarrow A$

FIG. 7 PATTERN I AND II OF PDPC

g) Prioritize the different issues and consider them all together. Information related to one set of possibilities could influence another set. Related items shall be linked with a broken line.

h) If the department that will handle a process involving several lines is determined, circle the process and write the name of the department within.

j) Set a target date for completion.

k) Have regular meetings to check progress in terms of the original PDPC.

3.4.4 *Examples*

3.4.4.1 Process decision program chart for decrease main drive kW variability by Pattern I is shown in Fig. 8.

3.4.4.2 Process decision program chart for technique review by Pattern II is shown in Fig. 9.

3.5 Matrix Diagram

3.5.1 *Application*

Matrix diagram is used to systematically identify, analyze and rate the presence and strength of relationships between two or more sets of information/ factors. It is often used in deploying quality requirements into counterpart (engineering) characteristics and then into production requirements.

3.5.2 *Description*

3.5.2.1 The matrix diagram method is designed to seek out principal factors from a plethora of phenomena concerning a subject under study. It clarifies problematic spots through multidimensional thinking. Matrix diagram method is also the best method of organizing data in order to apply multivariate analysis.

3.5.2.2 Most commonly used matrix diagrams are L-type matrix and T-type matrix. Examples of these types of matrix diagrams are shown in Fig. 10.

3.5.3 *Procedure*

a) Select the key factors affecting successful implementation. Begin with the right issues and best format will define itself.

b) Assemble the proper team members who can realistically assess the chosen factors.

c) On the basis of number of sets of items and types of comparison needs to be made, select an appropriate matrix format.

d) Choose and define relationship symbols. Most commonly used symbols are as given below:

— Strong Relationship = ◎

— Relationship = o

— Likely Relationship = Δ

e) Complete the matrix

3.5.4 *Example*

L-type matrix diagram for 'quality functions and responsibilities' is shown in Table 2.

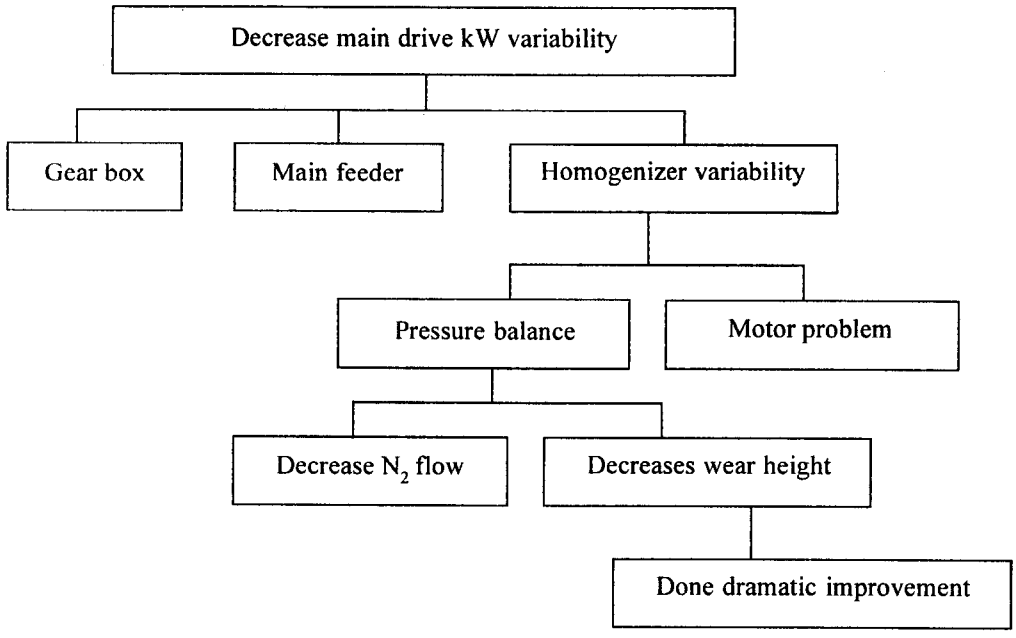


FIG. 8 PROCESS DECISION PROGRAMME CHART

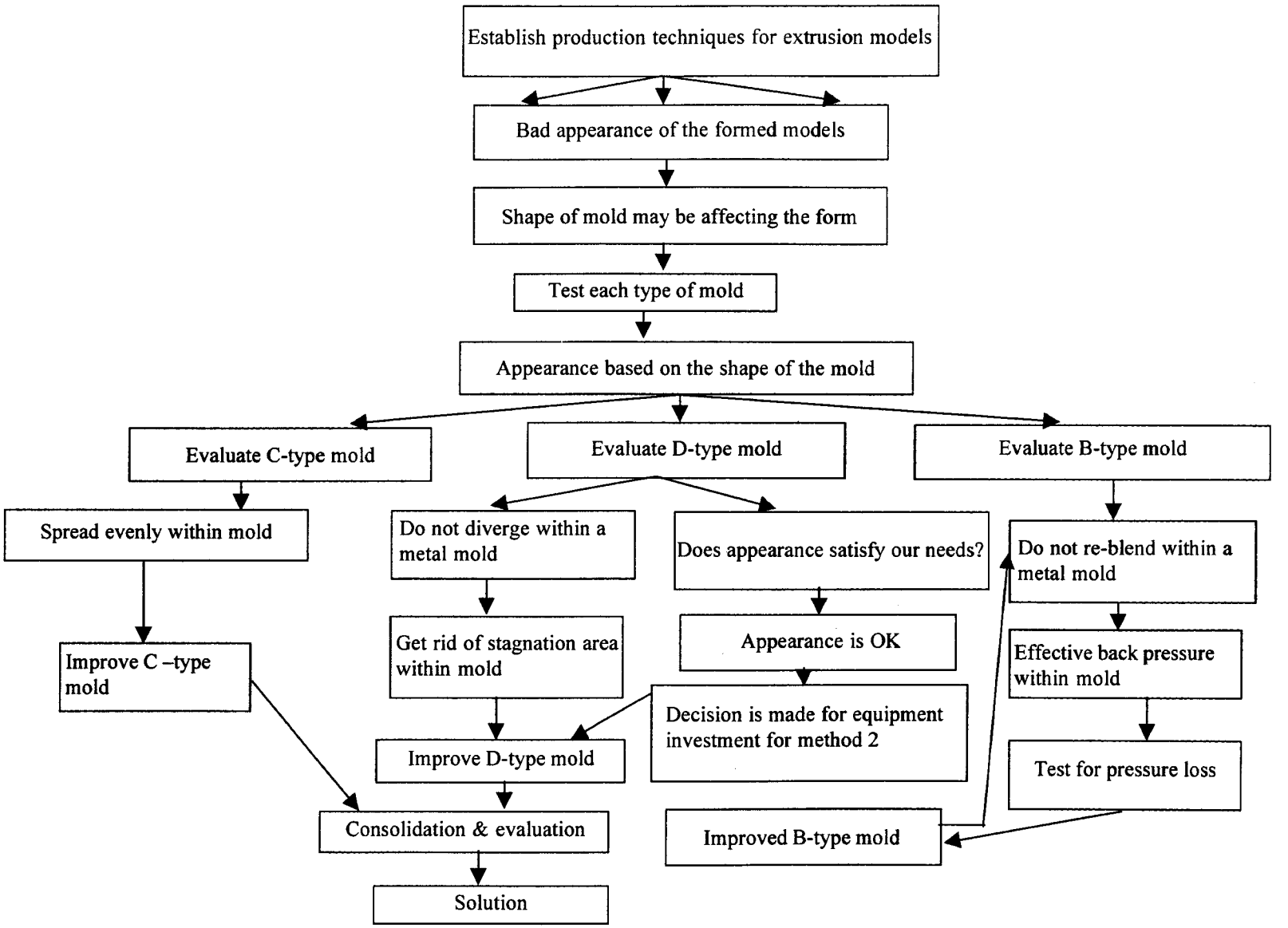


FIG. 9 PDPC FOR 'TECHNIQUE REVIEW'

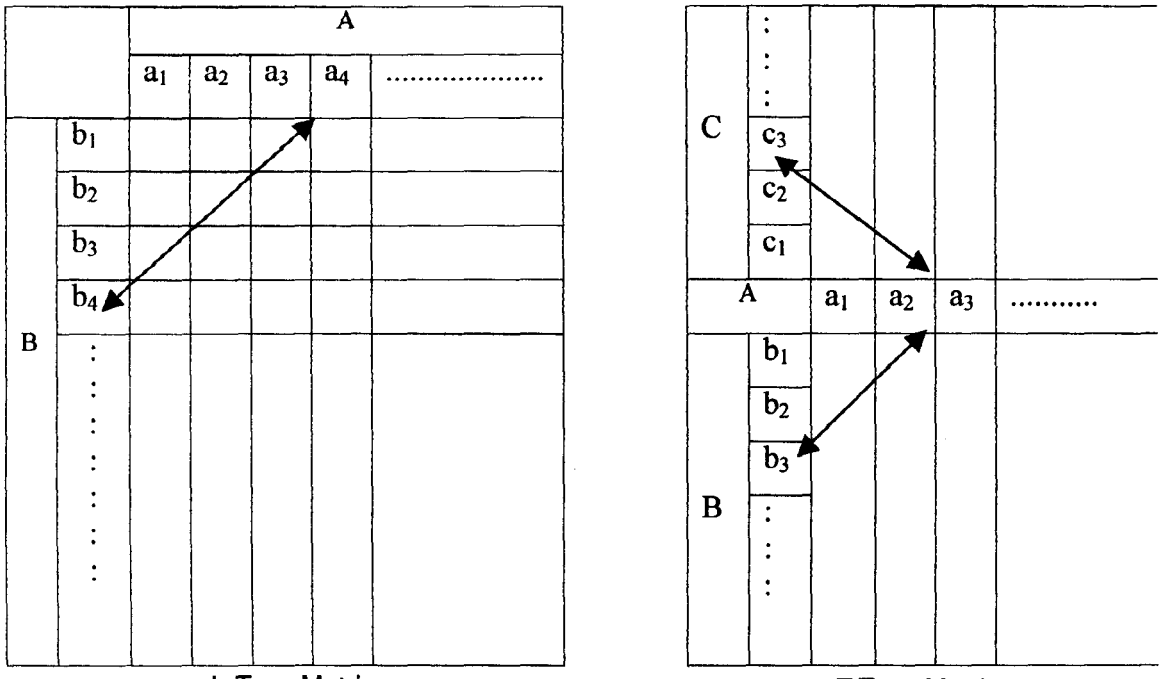


FIG. 10 L-TYPE AND T-TYPE MATRIX

3.6 Relations Diagram

3.6.1 *Application*

This diagram clarifies the interrelations in a complex situation involving many interrelated factors and serves to clarify the cause and effect relationships among factors.

3.6.2 *Description*

Relations diagram is defined as a technique used to solve problems that have complex cause and effect relationships among a number of problems and factors that influence them.

NOTE — Cause-and-effect diagram (details given in IS 12801) shows the various causes for an effect. But relations diagram is an effective tool for reaching the root cause of the problem.

3.6.3 *Format*

A special feature of relation diagram is its unrestricted format. However general formats are as given below.

3.6.3.1 *Centrally converging relations diagram*

The major item or problem to be solved is located in the center, and the related factors are arranged around the item or problem in such a way as to indicate close relationships.

3.6.3.2 *Directionally intensive relations diagram*

The major item or problem to be solved is located on one side of the diagram, and the various factors arranged in accordance with the flow of their major cause-and-effect relationships on the other side.

3.6.3.3 *Relationship indication relations diagram*

There are no restrictions on this format because the main point is to arrange the cause-and-effect relationships of the application items or factors so that they are expressed in a straightforward manner in a diagram.

3.6.4 *Procedure*

a) Define the issue/problem in such a way that it is clearly understood and agreed on by team members.
b) Assemble the cross-functional team.
c) Layout all the ideas/issue cards that have been brought from other tools.
d) Look for cause/influence relationships between all ideas and draw relationship arrows:
   — choose any of the ideas as a starting point and work through them in sequence;
   — an outgoing arrow from an idea indicates that it is the stronger cause or influence;
   — draw only one way relationship arrows in the direction of the stronger cause or influence. Make a decision on the stronger direction. Do not draw two headed arrows.
e) Review and revise the relations' diagram.
f) Tally the number of outgoing and incoming arrows and select key items for further planning:
   — record and clearly mark next to each issue

Table 2 Matrix Diagram for Quality Functions and Responsibilities

(*Clause* 3.5.4)

Sl No.	Quality Function	Disciplines Involved												
		Management	Marketing - Sales	Finance	Standards	Design	Planning	Purchase	Production	Quality Control	Calibration Lab	Maintenance	Personnel	Suppliers
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1.	Policy on quality	◎	o	Δ	o	o	o	o	o	o	o	o	o	
2.	Customer's requirement	o	◎		Δ	o		o	Δ	Δ	Δ		Δ	Δ
3.	Specifications and standards		Δ		◎			Δ	Δ	o	o	o	Δ	Δ
4.	Preparation of inspection plan								o	◎				Δ
5.	Selection of instruments													
6.	Quality survey of suppliers	o		o		o		◎		o				o
7.	Receive inspection					Δ	Δ	◎	Δ	o				
8.	Vendor evaluation and rating			o			Δ	◎		o				o
9.	Handling, storage, issue		o				◎		o					
10.	Process capability studies		Δ		o	o			o	◎				Δ
11.	First piece inspection					o			o	◎				
12.	In-process control					Δ			◎	o		o	Δ	
13.	Final product testing		Δ						o	◎				
14.	Packing, delivery, shipping		◎	o										
15.	After sales service		◎							o				
16.	Calibration of measuring and testing equipment	o				Δ		o	o	o	◎		Δ	
17.	Maintenance								o	o		◎		
18.	Customer's feed back and analysis	o	◎	Δ		Δ	Δ	o	o	o	Δ	Δ	Δ	
19.	Quality costs	o		◎						Δ				
20.	Quality audit	o	o	Δ	o	o	o	o	o	◎	o	o	o	o
21.	Training		o	o	o	o	o	o	o	o	o	o	◎	o

the number of arrows going in and out of it;

— find the items with the highest number of outgoing arrows and the items with the highest number of incoming arrows;

— a high number of outgoing arrows indicate that the item is a root cause and should be tackle first;

— a high number of incoming arrows indicate that the item is a key outcome and may become a focus for planning either as a meaningful measure of overall success or as a redefinition of the original issue under discussion.

3.6.5 *Example*

3.6.5.1 Relation diagram for issues involved in repeat service calls is shown in Fig. 11.

3.6.5.2 Relation diagram for resource priorities is shown in Fig. 12.

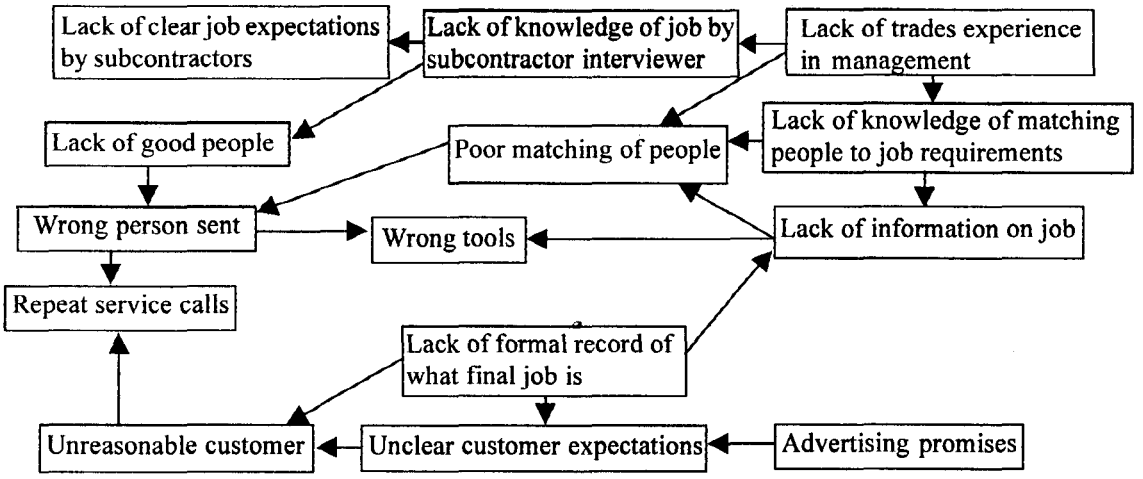


FIG. 11 RELATIONS DIAGRAM FOR ISSUES INVOLVED IN REPEAT SERVICE CALLS

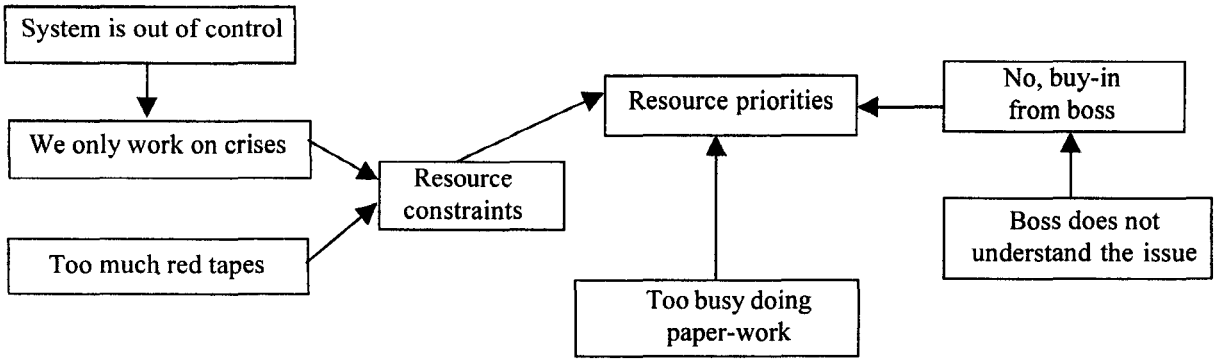


FIG. 12 RELATIONS DIAGRAM FOR RESOURCE PRIORITIES

3.7 Matrix Data Analysis

3.7.1 *Application*

This technique is used when the matrix diagram does not provide sufficiently detailed information. This is the only method within the new seven tools that is based on data analysis and gives numerical results.

3.7.2 *Description*

This technique uses the data presented in matrix diagram so that large array of numbers can be visualized and comprehended easily. The relationships between the elements shown in a matrix diagram are quantified by obtaining numerical data for intersection cells.

3.7.3 *Procedure*

a) Assemble the cross functional team.

b) Identify corresponding elements involved in a problem situation/event.

c) Arrange elements in rows and columns on a chart that shows the presence or absence of relationship among collected pairs of elements.

d) Select an appropriate matrix format.

e) Quantify the relationship between elements by obtaining numerical data for intersection cells.

f) Analyze the data to provide answers for the problems.

3.7.4 *Example*

Matrix data analysis for product uses and their desired qualities is shown in Table 3.

4 INTER-RELATIONSHIP AMONG NEW SEVEN TOOLS

The inter-relationship among seven new tools described in **3.1** to **3.7** is shown in Fig. 13.

Table 3 Matrix Data Analysis

(*Clause* 3.7.4)

Product uses and Desired Qualities

Sl No.	Qualities → / Products ↓	Resists Fading 1	Washable 2	Resists Perspiration 3	--	Flame Retardant 23	Chemical Resistant 24	Non-irritating to Skin 25
1.	Men's summer suits	$X_{1.1}$	$X_{1.2}$	$X_{1.3}$	--	$X_{1.23}$	$X_{1.24}$	$X_{1.25}$
2.	Men's all-season suits	$X_{2.1}$	$X_{2.2}$	$X_{2.3}$	--	$X_{2.23}$	$X_{2.24}$	$X_{2.25}$
3.	Ladies summer dresses	$X_{3.1}$	$X_{3.2}$	$X_{3.3}$	--	$X_{3.23}$	$X_{3.24}$	$X_{3.25}$
4.	Ladies all-season dresses	$X_{4.1}$	$X_{4.2}$	$X_{4.3}$	--	$X_{4.23}$	$X_{4.24}$	$X_{4.25}$
5.	Skirts	$X_{5.1}$	$X_{5.2}$	$X_{5.3}$	--	$X_{5.23}$	$X_{5.24}$	$X_{5.25}$
6.	Trousers	$X_{6.1}$	$X_{6.2}$	$X_{6.3}$	--	$X_{6.23}$	$X_{6.24}$	$X_{6.25}$
7.	Overcoats	$X_{7.1}$	$X_{7.2}$	$X_{7.3}$	--	$X_{7.23}$	$X_{7.24}$	$X_{7.25}$
8.	Raincoats	$X_{8.1}$	$X_{8.2}$	$X_{8.3}$	--	$X_{8.23}$	$X_{8.24}$	$X_{8.25}$
9.	Office wear	$X_{9.1}$	$X_{9.2}$	$X_{9.3}$	--	$X_{9.23}$	$X_{9.24}$	$X_{9.25}$
10.	Work clothes	$X_{10.1}$	$X_{10.2}$	$X_{10.3}$	--	$X_{10.23}$	$X_{10.24}$	$X_{10.25}$
11.	Sports wear	$X_{11.1}$	$X_{11.2}$	$X_{11.3}$	--	$X_{11.23}$	$X_{11.24}$	$X_{11.25}$
12.	Student wear	$X_{12.1}$	$X_{12.2}$	$X_{12.3}$	--	$X_{12.23}$	$X_{12.24}$	$X_{12.25}$
13.	Home wear	$X_{13.1}$	$X_{13.2}$	$X_{13.3}$	--	$X_{13.23}$	$X_{13.24}$	$X_{13.25}$
14.	Baby wear	$X_{14.1}$	$X_{14.2}$	$X_{14.3}$	--	$X_{14.23}$	$X_{14.24}$	$X_{14.25}$
15.	Dress shirts	$X_{15.1}$	$X_{15.2}$	$X_{15.3}$	--	$X_{15.23}$	$X_{15.24}$	$X_{15.25}$
:	:	--	--	--	--	--	--	--
:	:	--	--	--	--	--	--	--
:	:	--	--	--	--	--	--	--
40	Foot warmer blankets	$X_{40.1}$	$X_{40.2}$	$X_{40.3}$	--	$X_{40.23}$	$X_{40.24}$	$X_{40.25}$
Material A		X_1	X_2	X_3	--	X_{23}	X_{24}	X_{25}

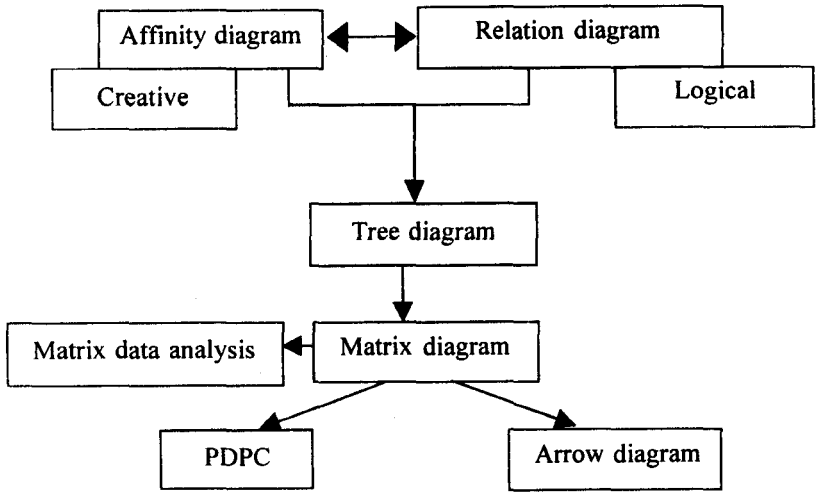


FIG. 13 INTER-RELATIONSHIP AMONG NEW SEVEN TOOLS

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Statistical Methods for Quality and Reliability Sectional Committee, MSD 3

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(*Continued on page* 16)

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