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1. INTRODUCTION

“Necessity is the mother of all inventions”.

It was in 1902, when air conditioning was born as a solution to the problem of humidity at a printing press in Brooklyn. Air conditioning has come leaps and bounds from a mere de-humidifying system to providing living comfort in homes. Kool Air Air Conditioners are state-of-the art environment-friendly comfort systems. These revolutionary systems are enabled by extensive research and customer feedback. Our state-of-the art design promises comfort and ease of use with a 10ft wide remote control diameter. Advanced cut-in and cut-off and thermostat systems offer comfortable ambient temperatures across the year and through all seasons.

Next generation air filtration and purification technology used in our air conditioning systems guarantees clean and healthy air circulation ensuring your and your family's good health.

Breakthrough technology and innovation in compressor and pump systems enhance comfort and quality by providing and maintaining air at the precise temperature as input by the consumer.

Kool Air systems provide cost effective and energy-efficient comfort that reduces environmental impact to the lowest possible levels.

Kool Air Air Conditioners have the following key features:

1. Circulate Air at Optimum Temperatures.
 - The product promises circulation of air at the temperature set by the thermostat.
 - Remote controlled operation ensures setting the thermostat temperature from a maximum distance of 10ft.
 - High precision thermostat equipment offers precise temperature settings.
2. De-humidification of Air
 - Drain pan and drain line offer efficient drainage of the moisture collected over the evaporator coils.
 - Automated settings ensure automatic removal of condensate water.
3. Air Filtration And Purification
 - High quality air filters are used to ensure dust and particulate matter is filtered out before the cool air is expelled indoors.
 - Anti-bacterial mesh purifies the air and removes bacteria and other microorganisms.
4. Adequate Ventilation
 - This product an effective ventilated cooling option, which makes sure that contaminants from indoors are flushed outdoor based on a user-defined schedule, i.e. every 2 hours etc.

2. CUSTOMER SATISFACTION

2.1 STAKEHOLDERS ANALYSIS

Stakeholders are the people, government bodies, creditors; investors etc. who have interest in the company and they directly or indirectly support the company in its operations. The following are the key stakeholders for the air conditioner company *Kool Home*.

<i>S.No.</i>	<i>KEY STAKEHOLDERS</i>	<i>EXPECTATIONS</i>
1	Employees	<ul style="list-style-type: none"> Working environment should be safe and hazards free.
		<ul style="list-style-type: none"> Company should comply with the ISO AS/NZS 4801 : 2001, occupational health and safety management systems.
		<ul style="list-style-type: none"> Employees should be given training regularly and should be given equal chance for the growth.
2	Shareholders and investors	<ul style="list-style-type: none"> The ongoing business should give them profits.
		<ul style="list-style-type: none"> The position of business and sterilities used should be told to them in the management's quarterly reports.
3	Creditors & banks	<ul style="list-style-type: none"> They should be projected with the right situation of the ongoing business.
		<ul style="list-style-type: none"> The audit reports and income tax statements should be available when asked for.
		<ul style="list-style-type: none"> The principle amount borrowed and the interest should be timely paid.
4	Environment	<ul style="list-style-type: none"> The company's ongoing business should comply with all the legal environmental protection laws
		<ul style="list-style-type: none"> The company should follow system Environmental Management System (EMS) / ISO 14001:2004.
5	Government bodies	<ul style="list-style-type: none"> All the legislations laid down by the government should be strictly followed.
		<ul style="list-style-type: none"> Company is required to be transparent in its business

		activities and to the customers.
6	Customers	<ul style="list-style-type: none"> Company should carry out its business in ethical and honest way.
		<ul style="list-style-type: none"> Customers should be provided by the quality products at reasonable price and should be durable. <i>Value for money</i>
		<ul style="list-style-type: none"> Feedback about the service and customer satisfaction QUESTIONERS should be taken from the customers through phone, email, and feedback forms.
		<ul style="list-style-type: none"> After purchase service should be prompt and should meet customers service demands.
7	Suppliers	<ul style="list-style-type: none"> To make sure the ongoing business is in accordance with contractual agreements and conditions.
		<ul style="list-style-type: none"> The company should follow <i>Just in time</i> principle of lean manufacturing and Kanban cards.
		<ul style="list-style-type: none"> The company should not be involved in any kind of unfair means of business.
		<ul style="list-style-type: none"> Confidential information about the supplier should not be disclosed to third party.
8	Business partners	<ul style="list-style-type: none"> Should be apprised of the business activities and strategies on time.
		<ul style="list-style-type: none"> Company should hold regular meetings and discuss aspects pertaining to technological advancements, quality control methods, legal requirements etc
		<ul style="list-style-type: none"> Should strategize product delivery and marketing plan.
9	Communities	<ul style="list-style-type: none"> Apprise the communities about the emergencies the dangers involved in the production process and training should be imparted to them accordingly to counter these.
		<ul style="list-style-type: none"> Employment prospects.
		<ul style="list-style-type: none"> The factory waste should not affect the environment, rather it should be kept clean and green by

		implementation of legal laws concerning environmental protection strictly.
10.	Retail outlet/stores	<ul style="list-style-type: none"> The sales team should be given training on technological aspects for the various products.
		<ul style="list-style-type: none"> Information of the product should be correct and any new advancement should be updated to the stores.
		<ul style="list-style-type: none"> There should be incentives for more sales.
		<ul style="list-style-type: none"> The products should be supplied to the retail stores / outlets on time.

Table 1 - Stakeholders And Their Expectations.

2.2 CAPTURING CUSTOMER NEEDS

Customer needs is the basis of every invention and discovery. Every manufacturer should know what the customer exactly needs so that they get the right direction to work on. There are various ways to determine the needs of a customer; some of them are as follows:

- Customer Interviews
- Customer Survey QUESTIONERS
- Customer Visits
- Focus Groups
- Mystery Shoppers/Callers
- Market Trend Analysis
- Warranty Claims
- Customers Complaints
- Benchmarking

Customers Interview: The medium to do interview the customer to focus on his needs could be done personally or on telephone/mobiles, whichever might be the medium used there is a set format to interview the customer for the product and it gives instant results. The following should be considered in this method:

- Right time, right place and right context.
- Know whom are we interviewing.
- Right person conducting the interview.

Customer Survey QUESTIONERS: The main idea behind conducting customer survey QUESTIONERS is to know the customers views, what they think and feel about the product. The information gathered from this is a powerful tool to know what exactly is customer looking for and is the customer satisfied by the product. To carry out a effective Customer Survey QUESTIONERS following steps are followed:

- Goals and objectives should be defined for a survey.
- An ideal survey plan should be framed.
- The QUESTIONER should be tested before so that customers should not avoid it.
- Right medium for conducting the survey should be chosen. Example email, online chatting etc.
- Result scrutiny and analysis.

Customer Visits: In this kind of method customers visit the company and witness the manufacturing process, which gives them the clear picture about the company operations. This in turn benefits the company by making the customer aware of their products.

Example: Sharp electronics conduct factory sales in the sharp factory where they give 50% discounts, the motive behind this is customers visit the factory *marketing* & buy their products.

Focus Groups: The method to interview the customer remains same as stated above, the only difference is that here there are more number of customers who are interviewed as a group. This method gives following advantages:

- Building relations with customers.
- Customers come to know about the business.
- Suppliers come to know the needs of customers.

Mystery Shoppers: A person employed by watchdog organization works as incognito in order to assess the quality of the goods or services provided by the company and gives this feedback. This feedback in turn benefits company to improve its services or products according to the customer demands.

Market Trend Analysis: The analysis summarizes customer analysis, market demands, market performance, forecast of markets, market analysis by the sectors. This analysis is carried by professional market analyst and the results are published and distributed free of cost. This is done to project the clear picture of the business tends of various companies to the end users.

Warranty Claims: warranty is the assurance given to the customer that the product or service will last for certain number of life cycles. If it is returned within this period the it will give raise following questions:

- Why is the products disliked by the customer?
- What is performance of the product?

- What is the shortcoming in the products?

The customers give answer to these questions, which helps in the overall improvement of the product.

Customers Complaints: By the complaints of customer we can analyze and implement what does the customer *needs* and what *improvement* customer wants from the products. Nowadays for the complaints we have various means like call centers, direct complaints process.

Benchmarking: It is comparing the same product / service provided by various companies. It answers the company, why is my product good/bad compared to some other company's product. This method helps in finding the customer needs.

2.3 CUSTOMER NEEDS ANALYSIS

To determine the needs of the customer for *Kool Air* (air conditioner company) the *Customer Survey QUESTIONERS* method is selected to capture the customer needs. To determine this Kano model has been used according to this model there are three basic requirements of a customer:

1. **Must:** Without this *basic needs* customer will be extremely dissatisfied.
2. **Wants:** They are *performance needs*; here the customer satisfaction is directly proportional to the level of fulfillment (performance needs).
3. **Extras:** They are *excitement needs* makes the customer more satisfied, but without these customer will not be dissatisfied.

To perform customer needs analysis (*Kano analysis*) following steps were being followed:-

Step 1: Identification of product needs - "Walking in the customer's shoes" to find out what the customer requires and what are his needs, we gauge this with customer survey questioner.

Step 2: Preparation of the questioner - While designing the questions "voice of the customer" which is, what problem/requirement/needs does the customer thinks of should be considered and how much rating do they give. The customers living in various cities of Australia using the product were asked questions for *Kool Air* (air conditioning). In all total four cities were covered and twenty-five customers from each city who are using the product.

S.NO	CUSTOMER SURVEY QUESTIONER FOR KOOL AIR (AIR CONDITIONERS)	RATING (INSCALE OF 1-15)
1	Temperature control	
2	Keeps running continuously.	
3	Less noise	
4	7-8 speed fan control	
5	Detachable filter that can be cleaned by self	
6	3 speed fan control	
7	Manual control in electric panel	
8	Automatic condensate draining	
9	Compressor placed at different location	
10	Basic functions controlled by remote	
11	All the functions controlled by remote	
12	Temperature based automatic cut in / cut off	
13	Equated Monthly Installment (EMI) option for purchasing	
14	Optional warranty up to 5 years on additional payment	
15	Electrical safety feature	
16	Compliance with environmental regulations	
17	Color options	
18	Different cooling capacity options like 0.5,1,1.5 tones	
19	Online purchase option with home delivery	
20.	Display panel back light brightness adjustment feature.	
21	Inbuilt alarm clock	
22	Timer to run the air conditioner for desired time.	

23	All season air conditioning	
24	Longer wiring to connect to electrical source.	
25	In built voltage stabilizer	

PRODUCT RATING SCALE ACCORDING TO THE CUSTOMERS NEED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NOT IMPORTANT			SOMEWHAT IMPORTANT			IMPORTANT			VERY IMPORTANT			EXTREMELY IMPORTANT		

Table 2 - Customer Survey Questioner

Step 3: The data is collected from the customers by filling up this designed QUESTIONER.

Step 4: Evaluation and interpretation of the results.

S.NO	CUSTOMER SURVEY QUESTIONER FOR KOOL AIR (AIR CONDITIONERS)	Sydney	Melbourne	Perth	Brisbane	Absolute score	Average score
1	Temperature control	15	15	15	15	60	15
2	Keeps running continuously.	10	8	9	10	37	9.25
3	Less noise	15	13	15	15	58	14.5
4	7-8 speed fan control	5	4	3	2	14	3.5
5	Detachable filter that can be cleaned by self	10	9	10	8	37	9.25
6	3 speed fan control	14	15	15	14	58	14.5
7	Manual control in electric panel	15	15	14	15	59	14.75
8	Automatic condensate draining	9	10	8	8	35	8.75
9	Compressor placed at different location	5	4	4	3	16	4
10	Basic functions controlled by remote	15	15	15	15	60	15
11	All the functions controlled by remote	9	10	9	8	36	9
12	Temperature based automatic cut in / cut off	10	10	8	9	37	9.25
13	Equated Monthly Installment (EMI) option for purchasing	5	5	4	2	16	4
14	Optional warranty up to 5 years on additional payment	3	2	3	1	9	2.25
15	Electrical safety feature	15	15	15	13	58	14.5
16	Compliance with environmental regulations	15	14	14	14	57	14.25
17	Color options	8	8	7	6	29	7.25
18	Different cooling capacity options like 0.5,1,1.5 tones	12	14	13	15	54	13.5
19	Online purchase option with home delivery	8	7	8	10	33	8.25
20	Display panel back light brightness adjustment feature.	7	8	6	5	26	6.5
21	Inbuilt alarm clock	2	1	1	4	8	2
22	Timer to run the air conditioner for desired time.	10	9	9	8	36	9
23	All season air conditioning	15	12	11	11	49	12.25
24	Longer wiring to connect to electrical source.	15	11	10	12	48	12
25	In built voltage stabilizer	6	6	8	10	30	7.5
			MUST		WANT		EXTRA

Table 3 - Customer Survey QUESTIONER

To categorize must wants and extra the following scoring range has been used, also the color-coding is followed in the Table 3:

60-40	40-20	20-0
MUST	WANT	EXTRAS

Table 4 - Kano Categorization

Step 5: The *Voice Of Customer* gives both qualitative and quantitative information about the needs and requirements of the product and must wants and extras desired by the customer becomes the base on which we focus to establish competitive edge.

VOICE OF CUSTOMER		
MUST	1	Temperature control
	2	Less noise
	3	3 speed fan control
	4	Manual control in electric panel
	5	Basic functions controlled by remote
	6	Electrical safety feature
	7	Compliance with environmental regulations
	8	Different cooling capacity options like 0.5,1,1.5 tones
	9	All season air conditioning
	10	Longer wiring to connect to electrical source.
WANTS	1	Keeps running continuously.
	2	Detachable filter that can be cleaned by self
	3	Automatic condensate draining
	4	All the functions controlled by remote
	5	Temperature based automatic cut in / cut off
	6	Color options
	7	Online purchase option with home delivery
	8	Display panel back light brightness adjustment feature.
	9	Timer to run the air conditioner for desired time.
	10	In built voltage stabilizer
EXTRAS	1	7-8 speed fan control
	2	Compressor placed at different location
	3	Equated Monthly Installment (EMI) option for purchasing
	4	Optional warranty up to 5 years on additional payment
	5	Inbuilt alarm clock

Table 5 - Voice Of Customer

3. DESIGN REQUIREMENTS

3.1 TRANSLATING CUSTOMER NEEDS INTO DESIGN REQUIREMENTS (QFD)

Quality function deployment is a link, which combines voice of customer VOC with the design development and concurrent engineering technology. The QFD matrix analyses the systematic strategy for the product development and production plans.

IMPORTANCE RATING DESIGN REQUIREMENTS CUSTOMER REQUIREMENTS			COOLING AND HEATING	ELECTRICITY CONSUMPTION	NOISE LEVELS	AUTOMATIC TEMPERATURE CUT IN/CUT OFF	DESIGN OF A/C	RELATIVE HUMIDITY	REFRIGERANT	FAN SPEED	COST OF AIR CONDITIONER	SAFETY INTEGRITY LEVEL	
MUST	1	Temperature control	15	135	0	0	135	0	135	135	135	0	0
	2	Less noise	14.5	0	0	131	131	14.5	0	0	131	0	0
	3	3 speed fan control	14.5	131	131	131	43.5	0	43.5	131	131	0	0
	4	Manual control in electric panel	14.75	44.3	0	0	44.3	0	14.8	0	133	14.8	0
	5	Basic functions controlled by remote	15	135	15	0	45	0	15	0	45	15	0
	6	Electrical safety feature	14.5	0	0	0	0	0	0	0	14.5	0	131
	7	Compliance with environmental regulations	14.25	14.3	128	128	0	42.8	0	128	42.8	42.8	42.8
	8	Different cooling capacity options like 0.5,1,1.5 tones	13.5	0	122	40.5	40.5	122	40.5	122	40.5	40.5	122
	9	All season air conditioning	12.25	110	110	12.3	110	0	110	12.3	36.8	36.8	36.8
	10	Longer wiring to connect to electrical source.	12	0	0	0	0	0	0	0	0	0	36
			0	0	0	0	0	0	0	0	0	0	
WANTS	1	Keeps running continuously.	9.25	9.25	83.3	83.3	0	0	9.25	27.8	9.25	0	9.25
	2	Detachable filter that can be cleaned by self	9.25	0	0	0	0	27.8	27.8	0	0	0	0
	3	Automatic condensate draining	8.75	0	0	0	0	26.3	78.8	0	0	0	0
	4	All the functions controlled by remote	9	27	0	0	81	0	9	0	27	0	0
	5	Temperature based automatic cut in / cut off	9.25	9.25	83.3	27.8	83.3	0	83.3	9.25	83.3	0	9.25
	6	Color options	7.25	0	0	0	0	65.3	0	0	0	0	7.25
	7	Online purchase option with home delivery	8.25	0	0	0	0	0	0	0	0	74.3	0
	8	Display panel back light brightness adjustment feature.	6.5	0	0	0	0	0	0	0	0	0	6.5
	9	Timer to run the air conditioner for desired time.	9	81	81	27	81	0	27	9	0	0	27
	10	In built voltage stabilizer	7.5	7.5	22.5	0	0	0	0	0	22.5	22.5	67.5
			0	0	0	0	0	0	0	0	0	0	
EXTRAS	1	7-8 speed fan control	3.5	31.5	10.5	3.5	3.5	0	10.5	0	31.5	0	3.5
	2	Compressor placed at different location	4	0	12	0	0	36	12	36	0	0	12
	3	Equated Monthly Installment (EMI) option for purchasing	4	0	0	0	0	0	0	0	0	36	0
	4	Optional warranty up to 5 years on additional payment	2.25	0	0	0	0	0	0	0	0	20.3	0
	5	Inbuilt alarm clock	2	0	0	0	0	0	0	0	0	0	0
TARGET VALUE				2° C (MIN) TO 40° C (MAX)	FOR 1 TON A/C 1.2-15 kw/hr	3 DECIBELS db(A) MIN - 5 DECIBELS db(A)	WHEN SET TEMP. ACHIEVES	SPLIT / WINDOW / COLOR	40% - 60%	HFC, R-22, R-134a	3.5 SPEED	\$500 - \$700 PER TON	AS DEC) 61508
ABSOLUTE SCORE TOTAL				735	798	584	798	334	617	610	882	303	510
RELATIONSHIP : STRONG (9) MEDIUM (3) WEAK (1)													

Table 6 - Quality Function Deployment

3.2 DESIGN RISK ANALYSIS (FMEA)

I haven't failed; I have found ten thousand ways that don't work - Thomas Edison

Similar to what Thomas Edison said failure Modes and Effects Analysis (FMEA) finds ways the product can fail and corrective actions we can take to prevent that occurrence of failure. FMEA is a tool, which has potential to anticipate and prevent problems, reduce the cost, shorten production times and achieve highly safe and reliable products. For companies cost of product and manufacturing failure are very high and lots of money and time is spent in fixing the problems during the warranty period of the product.

FAILURE MODE EFFECTS ANALYSIS (FMEA)										
Part name or function	Potential Failure	Effect on system	Root cause	Risk before action taken			Action to reduce risk	Risk after action taken		
				P	S	R		P	S	R
COOLING AND HEATING	Compressor failure	Air conditioner stops working	Motor failure	4	5	20	Improved motor quality	2	2	4
ELECTRICITY CONSUMPTION	High electricity consumption	Increased energy consumption	Compressor/fan motor impeller bearing failure	3	3	9	High amperage warning	2	2	4
AUTOMATIC TEMPERATURE CUT IN/CUT OFF	Thermostat failure	Air conditioner keeps working continuously	Improper installation	3	2	6	Proper thermostat installation	2	1	2
RELATIVE HUMIDITY	Condensate drainage failure	Increased humidity levels of output air	Clogged condensate drain	3	4	12	Condensate drain blockage indicator and air filter change indicator	1	2	2
FAN SPEED	Fan motor fails	System stops cooling	Failure from wear and tear	4	4	16	Safety device to protect the fan from failure	2	3	6
		1	2	3	4	5				
P	PROBABILITY (CHANCE) OF OCCURRENCE	LOW	LOW TO MODERATE	MODERATE	MODERATE TO HIGH	HIGH				
S	SERIOUSNESS OF (EFFECT) FAILURE	MINOR	MINOR TO SERIOUS	SERIOUS	SERIOUS TO CRITICAL	CRITICAL				

Table 7 - Failure Modes And Effects Analysis

4. SUPPLIER SELECTIONS AND EVALUATION

4.1 IDENTIFYING COMPONENTS

The major components of an air conditioner are as follows:

- COMPRESSOR
- CONDENSER
- EXPANSION VALVE
- EVAPORATOR
- REFRIGERANT (134 a)
- REFRIGERANT OIL
- HOSE ASSEMBLY
- CONTROL PANEL
- DRIER
- CHARGE PORT / SCHRADER VALVE
- COMPRESSOR CLUTCH
- CYCLING SWITCH

4.2 DEVELOPING SUPPLIER SELECTION CRITERIA

Following criteria is used for selection of supplier of Refrigerant (134 a):

1. Provide these gases in small and big sized cylinder.
2. Complaint with environmental regulations.
3. Should have ISO certification.
4. Economical.
5. Easy to use.
6. Quality control methods and practices implemented.
7. Non-hazardous and safe to use.
8. Effective.
9. Accurate composition.
10. The product should be packaged and delivered in a good condition.
11. Location of supplier from the factory.

12. Product delivery time.

13. The suppliers should maintain confidentiality while rendering services.

4.3 SUPPLIER SELECTION SYSTEM

Refrigerant to air conditioner is similar to blood to human, the reputation of the Kool Air (air conditioner) depends upon the refrigerant supplied. The supplier should provide quality product at competitive price, which should be safe and convenient to transport, and the product is technologically advanced. *Kool Air* has selected thirteen criteria for selection the supplier for refrigerant and rate them in scale of 1 to 10.

SUPPLIER SELECTION AND EVALUATION SYSTEM				
S.No.	SELECTION AND EVALUATION CRITERIA	SUPPLIER NAME		
		SUPPLIER A	SUPPLIER B	SUPPLIER C
1	Provide these gases in small and big sized cylinder.	9	10	6
2	Complaint with environmental regulations.	5	8	4
3	Should have ISO certification.	4	7	7
4	Economical.	6	8	10
5	Easy to use.	5	6	6
6	Quality control methods and practices implemented.	8	8	6
7	Non-hazardous and safe to use.	7	7	7
8	Effective.	6	8	4
9	Accurate composition.	7	8	8
10	The product should be packaged and delivered in a good condition.	8	9	8
11	Location of supplier from the factory.	5	7	9
12	Product delivery time.	7	8	8
13	The suppliers should maintain confidentiality while rendering services.	7	7	8
	TOTAL SCORE OUT OF 130	84	101	91
	SCORING SCHEME: 1: LOWEST SCORE 10 : HIGHEST SCORE			

Table 8 - Supplier Selection And Evaluation System

4.4 REPORT ON SUPPLIER SELECTION

Relations with the suppliers are important as they come in category of stakeholder. For a company's reputation supplier play a major role.

Supplier B is selected for supplying refrigerant to Kool Air as from table 8 it has the highest score of 101 out of 130. The supplier selection was based on four fundamental supplier selections. The four fundamentals are as follows:

1. Procurement
2. Quality
3. Logistics
4. Technology

Procurement: Supplier B will supply the refrigerant as required. They have strong provision to supply in various quantities and continuers of different sizes as compared to others. Though their prices are more than supplier c, but their payment options are flexible.

Quality: Supplier B is ISO certified company and all the operations of the company are in accordance with environmental regulations. Their internal and external audit reports show no non-conformity since last 4 years.

Logistics: the Supplier B is located far as compared to supplier c ,but they have their own trucks to deliver the product where as other suppliers hires third party to deliver the products. The safety measures taken by the Supplier B during to transportation is found to be high.

Technology: Supplier B has a well-designed random sampling method, which increases the quality control on the product. All the codes for the control of refrigerant during manufacturing is well documented and followed.

After evaluating the suppliers on these four fundamentals supplier B is chosen as supplier for refrigerant for Kool Air.

5. STATISTICAL PROCESS CONTROL

5.1 IDENTIFYING PROCESSES

*“A process is a set of activities that transform inputs into outputs with the aim of adding value”-
Dr. Hasan Akpolat*

1. Designing Process: The design engineers make the draft for the air conditioners. The exact quantity and the components required in production process is calculated. This design is then approved and various teams start their appropriate work accordingly.
2. Supplier Selection: The supplier is selected by using Supplier Assessment criteria used by Procurement team by advertising various needs in form of tenders. The best-suited suppliers are then selected for the company's ongoing business.
3. Raw Materials procurement: For the production of air conditioners various types of raw materials like aluminum or copper tubes, plastic and metal frames, electrical circuits are bought from selected suppliers. The manufacturing team calculates the exact demand and supply of these materials.
 - The manufacturing process:
 - Different Sub Departments in the *Kool air* are as follows:
 - Creating encasement parts from sheet metal.
 - Bending the tubes for the condenser and evaporator & joining then with plates
 - Electrical circuit boards for the controls
 - Painting department
 - Plastic molding

The sub parts of the air conditioner are produced in various departments. In the *Kool Air* lean manufacturing method is implemented which focuses on reduction of wastage and increasing productivity.

4. Sub Parts testing process: The function of individual parts is then tested by the testing team at every step according to the checklist provided by company. If any fault is found at this stage the process is rectified or modified.
5. Quality Control: Quality of the individual parts is always checked at various stages of the manufacturing process. Each Sub Departments have their own quality assurance trained staff. The final product is finally checked for quality control before handing it over to the end user.

6. Assembly: all the individual parts are then assembled.
7. Finish Product Testing process: Finally placing it in the chamber for which it is designed tests air conditioner and then its cooling or heating function is tested by the thermometer. Also its performance is calibrated for other functions.
8. Product shipped to retailer / end user: the logistics department then dispatches the order to the retailer / end user by convenient mode land, air or sea.
9. Updating inventory: the consumption of spares and finished products are updated in the inventory software. Accordingly new purchase orders are made just to have minimum stock in the stores.
10. Gathering customer feedback: customer feedback is the important feature for the company. Based on this our future designs and modifications are made. The customer's input is taken by various means and then customer needs are analysed and implemented.

5.2 MONITORING PROCESSES USING SPC CHARTS

Statistical process control is a method used when large number of similar items is produced. Every item will have some variation from each other. From Statistical process control we want to know if process stable or capable of meeting customer specifications. The control charts are combination of run charts and histograms.

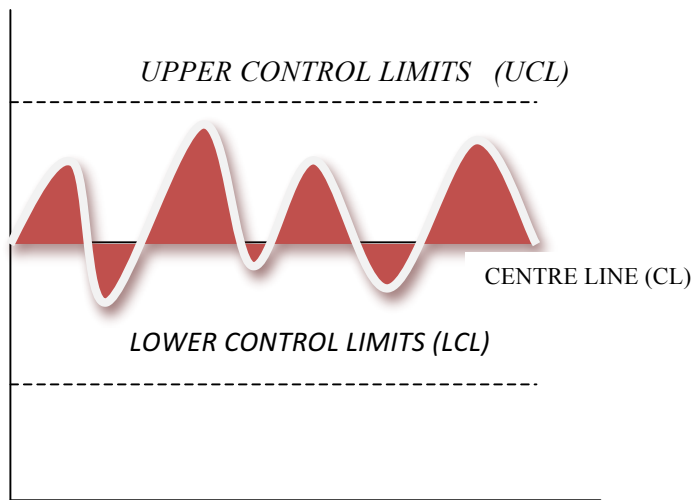


FIGURE 1 - RUN CHART

Run chart tells about the consistency in the process.

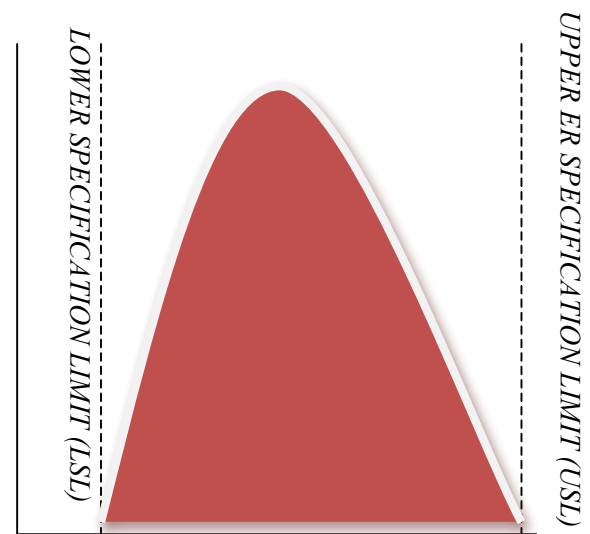


FIGURE - 2 HISTOGRAMS

Histogram tells deviation from customer desired specification.

The control charts are selected according to quality characteristic they are supposed to follow, they classification is as follows:

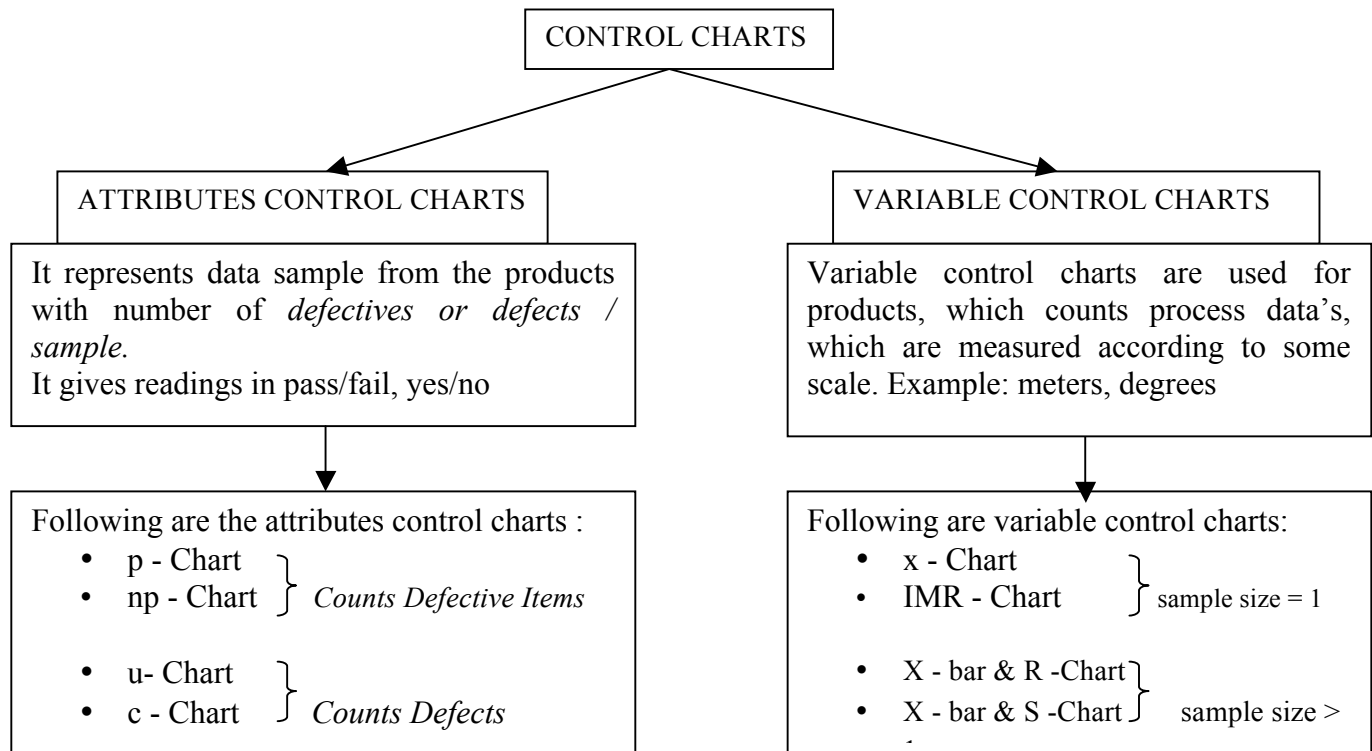


Figure 3 - Control Charts Tree

ATTRIBUTES CONTROL CHARTS

- **np - Chart** : The np Chart is used to yield **number of defectives**, this method is used for constant sub group sample size.

Following steps are followed to plot **number of defectives**:

- Calculate average number of defective items. With this we plot *centre line (CL)*.
- After this we draw upper control limit (UCL) & lower control limits (LCL).

- **p - Chart** : The p Chart is used to yield **proportion or percentage of defectives**, this method is used for variable sub group sample size.

Following steps are followed to plot **proportion or percentage of defectives**:

- Calculate average proportion of defective items. With this we plot *centre line (CL)*.
- After this we draw upper control limit (UCL) & lower control limits (LCL).

- **c - Chart** : The c Chart is used to yield **number of defects**, this method is used for constant sub group sample size.

Following steps are followed to plot **number of defects**:

- Calculate average number of defects. With this we plot *centre line (CL)*.

- After this we draw upper control limit (UCL) & lower control limits (LCL).
- ***u - Chart*** : The u Chart is used to yield ***proportion of defects***, this method is used for variable sub group sample size.

Following steps are followed to plot ***proportion of defects***:

- Calculate average proportion of defects. With this we plot *centre line (CL)*.
- After this we draw upper control limit (UCL) & lower control limits (LCL).

VARIABLE CONTROL CHARTS

- ***I - MR - Chart***: The I-MR Chart contains two different charts, I - Chart and MR - Chart. It is used when subgroup size equal to 1.

I chart (individual chart) displays the individual process value.

MR chart (moving range) displays the variation in the process.

I - MR - Chart is used to interpret:

- The process is in control or is it out of control.
 - Comparison of the processes.
- ***X (bar) and R Chart***: X-bar and R (range) it is used for variable data with sample size between 2 - 9. The two charts are used to determine the following :
X - Bar: How average changes over time.
R - Chart: How range of sub groups changes over time.
- ***X (bar) and S Chart***: X- bar and S chart it is used for variable data with sample size greater than 10. The two charts are used to determine the following:
X - Bar: How average changes over time.
S - Chart: How process standard deviation changes over time.

5.3 CONSTRUCTING AND USING A SPC CHART

- In statistical quality control, p - Chart is used to monitor the proportion of defective compressors in a sample of compressors taken each date by the compressor-testing operator. p - Chart is used because the samples of compressor are variable.

DATE	NUMBER OF COMPRESSOR INSPECTED	NUMBER OF DEFECTIVE COMPRESSORS	PROPORTION OF DEFECTIVES	AVERAGE PROPORTION OF DEFECTIVE ITEMS	UPPER CONTROL LIMIT	LOWER CONTROL LIMIT
K	n	X	p	CL	UCL	LCL
1-May-14	30	13	0.4333	0.2451	0.4807	0.0095
2-May-14	31	8	0.2581	0.2451	0.4768	0.0133
3-May-14	34	14	0.4118	0.2451	0.4664	0.0238
4-May-14	34	7	0.2059	0.2451	0.4664	0.0238
5-May-14	35	4	0.1143	0.2451	0.4632	0.0270
6-May-14	30	5	0.1667	0.2451	0.4807	0.0095
7-May-14	29	7	0.2414	0.2451	0.4847	0.0054
8-May-14	33	2	0.0606	0.2451	0.4697	0.0204
9-May-14	28	5	0.1786	0.2451	0.4889	0.0012
10-May-14	32	6	0.1875	0.2451	0.4732	0.0170
11-May-14	31	7	0.2258	0.2451	0.4768	0.0133
12-May-14	32	12	0.3750	0.2451	0.4732	0.0170
13-May-14	31	4	0.1290	0.2451	0.4768	0.0133
14-May-14	28	9	0.3214	0.2451	0.4889	0.0012
15-May-14	30	11	0.3667	0.2451	0.4807	0.0095
Σ	468		3.675988			

Table 9 - p - Chart Calculations

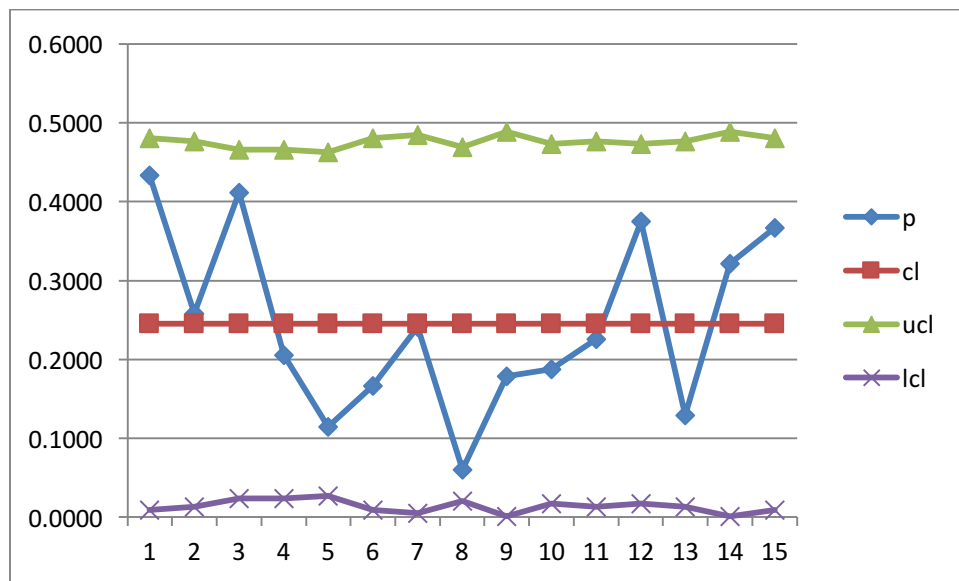


Figure 4 - p - Chart

6. PROBLEM SOLVING

6.1 IDENTIFYING PROBLEMS AND PROBLEM SOLVING TOOLS

Problems that could occur during the use of air conditioners is as follows:

- Refrigerant Leak
- Thermostat Malfunction
- Electric Circuit Failure
- Condensate Drainage Failure
- Frozen Evaporator Coils
- Capacitor Burnout.

Tools that can be used for problem solving are as follows:

- Problem Solving Form
- Process Flow Chart
- Check Sheet
- Pareto Diagram
- Brainstorming
- Cause-and -Effect Diagram
- Gantt Chart

6.2 CONSTRUCTING AND USING PROBLEM SOLVING TOOLS

Refrigerant leak is a problem, which occurs very often in air conditioners. Various methods used for solving the refrigerant leak problem are as follows:

BRAINSTORMING

The best way to have a good idea is to have many ideas - Alex F Osborne

This technique is used to support creative problem solving in a group of individuals. The first principle of brainstorming is the theory of associations. It is based on the fact that word associations

expressed by one person can instigate thought in other people of the group. This leads to a cumulative problem solving approach.

The second principle of brainstorming is to create a calm and relaxed atmosphere to hold the session. This allows open and un-influenced thinking and discussion.

A typical brainstorming session is composed of three phases:

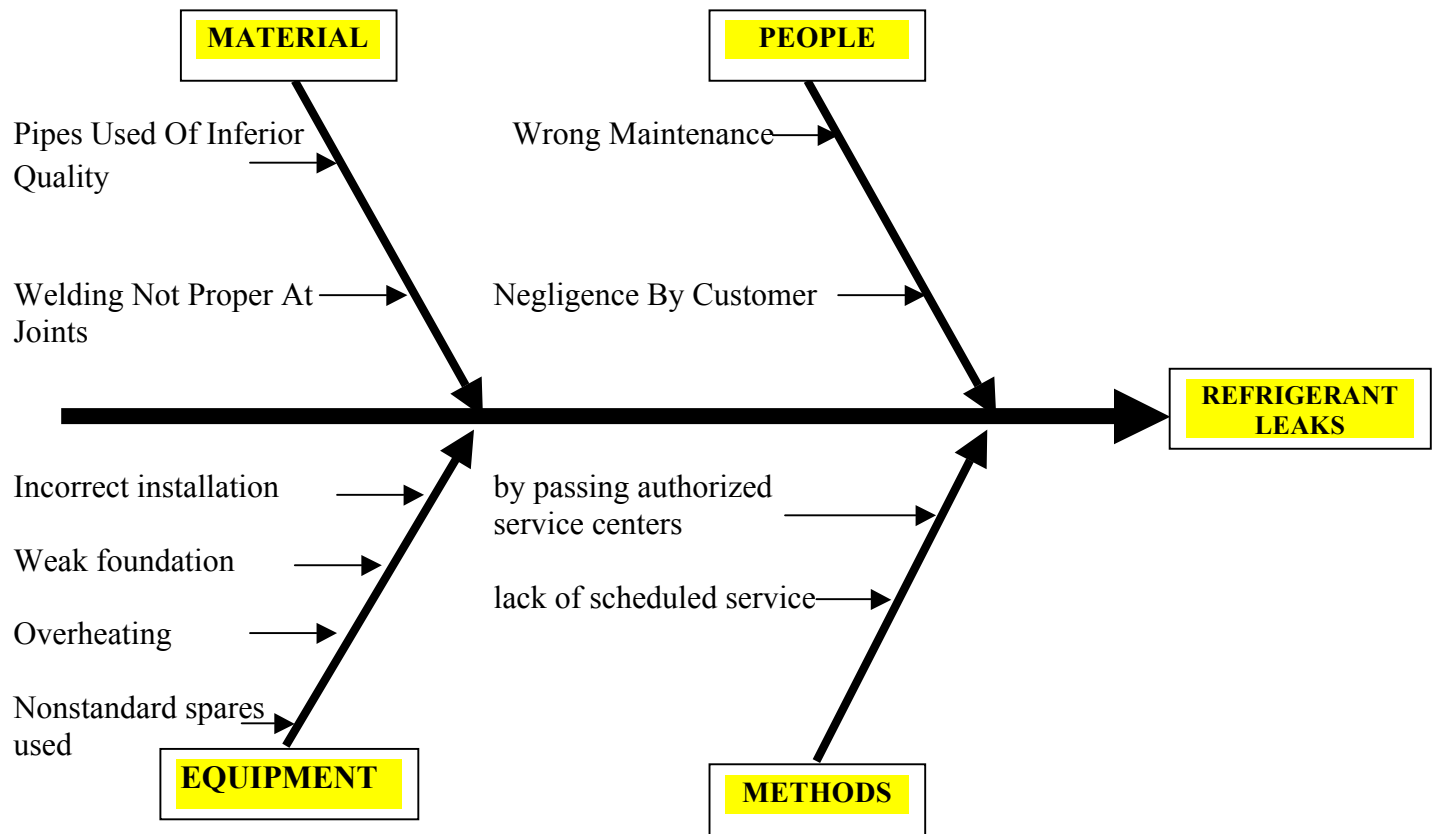
- Preparation phase,
- Brainstorming session, and
- Evaluation and implementation on results.

Step 1: Identification of various reasons that could develop the refrigerant leaks

- Crack developed in the pipes carrying refrigerant.
- Pitting corrosion in the pipes due to formic acid.
- Debris getting in the system clogged air filters.
- If foundation is not firm it causes vibration and leads to cracks in joining connection.
- Overheating of system.

CAUSE AND EFFECT DIAGRAM this is also known as fish bone diagram. it is used when to identify root cause of any problem and to find out relationship between the causes of problem. It displays generic categories such as:

- People
- Methods
- Materials
- Equipment

*Figure 5 - Cause And Effect Diagram*

PROBLEM SOLVING FORM

- **Problem Description**

1. The air conditioner stops working due to refrigerant leaking from the system.

- **Problem Analysis**

1. Crack developed in the pipes carrying refrigerant.
2. Pitting corrosion in the pipes due to formic acid.
3. Debris getting in the system clogged air filters.
4. If foundation is not firm it causes vibration and leads to cracks in joining connection.
5. Overheating of system.
6. Wrong Maintenance
7. Welding Not Proper At Joint
8. Lack of scheduled service.

- **Corrective Action**

1. Quality control of material procured from the supplier.
2. Production process to be modified.
3. After sales maintenance schedule to be more streamlined.
4. Installation of the air-conditioned to be done by professionals.

- **Follow-Up**

1. The customer feedback should be taken for further requirements and needs.
2. Customer complaints should be attended and followed immediately.

PARETO ANALYSIS

It is a technique which suggests that 80 percent of the trouble comes from 20 percent of the problems identifies the problems by prioritizing its potential causes.

PARETO ANALYSIS				
S.No.	REFRIGERANT LEAK REASONS	FREQUENCY	CUMULATIVE FREQUENCY	PERCENTAGE
1	Crack developed in the pipes carrying refrigerant.	60	60	20.00
2	Pitting corrosion in the pipes due to formic acid.	46	106	35.33
3	Debris getting in the system clogged air filters.	41	147	49.00
4	If foundation is not firm it causes vibration and leads to cracks in joining connection.	35	182	60.67
5	Overheating of system.	32	214	71.33
6	Wrong Maintenance	30	244	81.33
7	Welding Not Proper At Joints	29	273	91.00
8	Lack of scheduled service	27	300	100.00
TOTAL		300		

Table 10 - Pareto Analysis

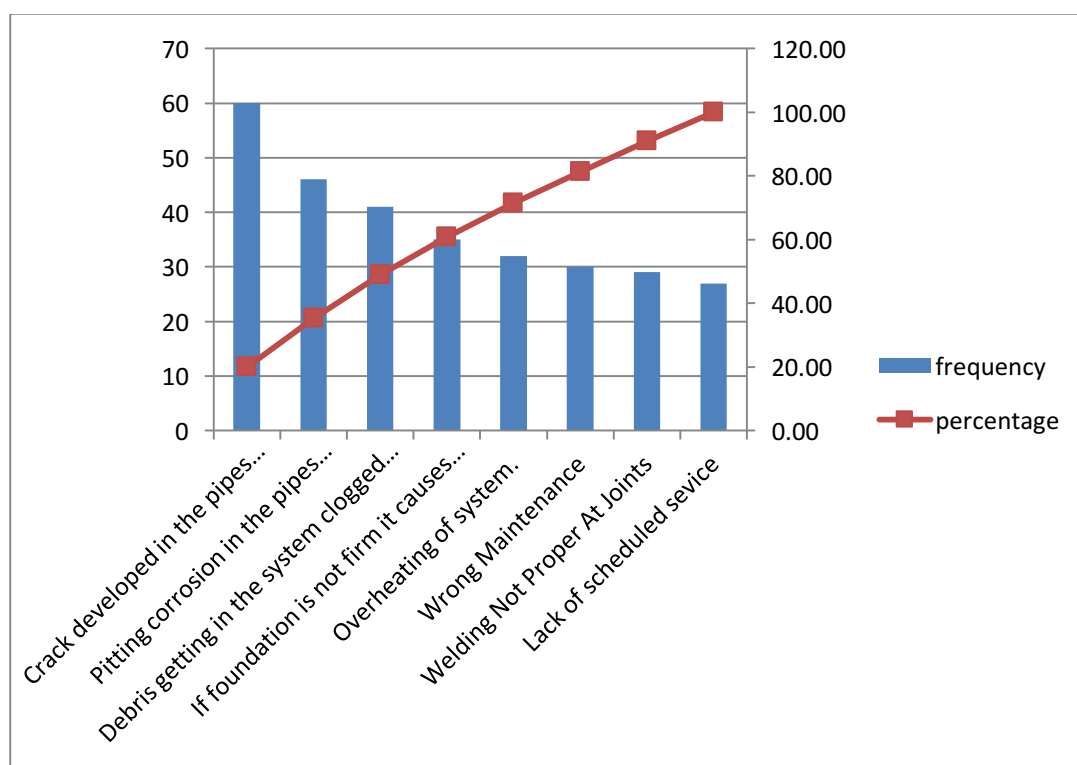


Figure 6 - Pareto Analysis

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