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Appendixes



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Appendix 1:

Planning summary --

You selected the following QFD outputs for your project:

- (Better) statements of demanded quality, functions, and reliability
- Design opportunities and challenges (quality characteristics)
- Key design priorities related to customer demands
- Key substitute quality characteristics related to customer demands
- Value of new concepts relative to customer demands, functions and quality characteristics

The selection(s) above map(s) into the following QFD matrices:

VOCT *	Voice of the Customer Table
A1 *	Demanded Quality and Substitute Quality Characteristics
A2	Functions and Substitute Quality Characteristics
A3 *	Substitute Quality Characteristics Compared
E4 *	New Concept Selection Summary

An asterisk beside any chart name indicates that you directly selected its output. No asterisk beside a chart symbol indicates that it is required to provide an input to another chart.

Select DETAILS from the menu above for more information on these charts.

The following QFD charts offer an opportunity for concurrent QFD activity. This may reduce overall project cycle time. Each row introduces a combination with common inputs.

A2 A3

Select the 'Details' option in the menu above for information on each QFD chart above.

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Appendix 1: (Continue)

This is step 1 of 5

NOTE --

The output of this QFD matrix or form is an output you have chosen in the previous selection screen.

VOCT CHART - Voice Of The Customer Table --

The voice of the customer table is a form as its name implies. The VOCT allows you to collect customer verbatim inputs, organize them by the voice of the customer(s), and to restate them in usable form.

CONNECTIONS --

The output of the VOCT is often used in the following QFD matrices and forms for input of customer demanded quality, demographics, functions, and reliability:

A1

B1

D1

INPUTS --

Customer verbatim statements of requirements

Customer demographics from marketing (related to requirements)

Customer expectations of functions

Customer expectations of reliability

OUTPUTS --

(Better) Statements of customer demanded quality

(Better) Statements of customer demanded functions

(Better) Statements of customer demanded reliability

(Better) Statements of unacceptable failure modes

REFERENCES --

Cohen, Lou, "Quality Function Deployment: How to Make QFD Work for You," Reading, MA: Addison-Wesley, 1995.

Marsh, S., J.W. Moran, S. Nakui, and G. Hoffherr, "Facilitating and Training in Quality Function Deployment," GOAL/QPC, Methuen, MA, 1991.

Re Velle, Jack B., J. W. Moran, and C. A. Cox, "The Quality Function Deployment (QFD) Handbook," Wiley, New York, 1997.

Re Velle, Jack B., Normand L. Frigon, Sr., and Harry K. Jackson, Jr., "From Concept to Customer," Van Nostrand Reinhold, New York, 1995.

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Appendix 1: (Continue)

This is step 2 of 5

NOTE --

The output of this QFD matrix or form is an output you have chosen in the previous selection screen.

A-1 CHART - Demanded Quality and Substitute Quality Characteristics --

The A-1 chart is a key beginning matrix form in QFD. The chart begins with the inputs of customer demanded quality, functions, and reliability along with inputs of their weighting or priority. These customer demands may come directly from marketing or your customers. In either case you will often find that the Voice of the Customer Table is a useful form to organize customer inputs before applying to the A-1 chart.

The customer demands are placed on the vertical axis of the matrix. Your organization will identify through planning, brainstorming, etc., substitute quality characteristics and place these on the horizontal axis of the matrix. These substitute quality characteristics* are measurable design targets for the product or service. These form the initial organizational targets or plans.

This matrix form has the provision to show competitive benchmarking against customer demanded quality and technical benchmarking against substitute quality characteristics. These help the team analyze potential gaps between the new product or service and competitive offerings.

The substitute quality characteristics are correlated to the customer demands in the center of the matrix. Correlations are placed in the row-column intersections. Use traditional QFD symbology with weights of 9, 3, 1, and 0 respectively for high, medium, low, and no correlation. The team can multiply correlations by the respective customer weights and sum over the column. This will allow the substitute quality characteristics to be ranked by a weight linked to the voice of the customer..

*Substitute quality characteristics are re-stated quality measures. Often the customer statements of demanded quality cannot be used for design work. For example, a customer requirement for a car with 'high mileage' must be translated into specific miles-per-gallon targets. 'High mileage' is demanded quality. A target of 25 miles-per-gallon is a substitute quality characteristic.

CONNECTIONS --

The output of the A-1 chart is often used in the following QFD matrices and forms:

- A-2
- A-3
- A-4
- B-1
- B-3
- B-4

Appendices 1: (Continue)

C-3
D-1
D-3
E-1
E-3

INPUTS --

Customer demands of quality
(the Voice of the Customer Table is a good source)
Customer expectations of functions
(the Voice of the Customer Table is a good source)
Customer expectations of reliability
(the Voice of the Customer Table is a good source)
Substitute quality characteristics
(from your organization)
Competitive benchmarks
(from your benchmarking efforts)
Technical benchmarks
(from your assessments of function performance)

OUTPUTS --

Key substitute quality characteristics related to customer demands
Key design priorities related to customer demands
Identification of customer reliability expectations

REFERENCES --

- Cohen, Lou, "Quality Function Deployment: How to Make QFD Work for You," Reading, MA: Addison-Wesley, 1995.
- Day, Ronald G. "Quality Function Deployment: Linking a Company with Its Customers." American Society for Quality Control. Milwaukee, WI. 1993.
- King, Bob, "Better Designs in Half the Time," GOAL/QPC, Methuen, MA, 1987.
- Marsh, S., J.W. Moran, S. Nakui, and G. Hoffherr, "Facilitating and Training in Quality Function Deployment," GOAL/QPC, Methuen, MA, 1991.
- Re Velle, Jack B., J. W. Moran, and C. A. Cox, "The Quality Function Deployment (QFD) Handbook," Wiley, New York, 1997.
- Re Velle, Jack B., Normand L. Frigon, Sr., and Harry K. Jackson, Jr., "From Concept to Customer," Van Nostrand Reinhold, New York, 1995.
- Terninko, John. "Step by Step: Customer Driven Product Design. Responsible Management." Nottingham, NH. 1995.

Appendix 1: (Continue)

This is step 3 of 5

NOTE --

The output of this QFD matrix or form is required as an input to another QFD matrix or form. This matrix or form is part of the path supporting your output choices.

A-2 CHART - Functions and Substitute Quality Characteristics --

The A-2 chart is used to identify the relationships between product or service functions and the substitute quality characteristics previously identified in the A-1 chart. This chart is used to identify functions with strong and weak (or no) linkages to key substitute quality characteristics. This is one of the many QFD charts that takes the form of a matrix.

In the original U.S. writing on this chart [King, 1987], functions were placed on the vertical axis and the substitute quality characteristics were placed on the horizontal axis. Further, there was no discussion regarding the use of the weightings developed for the substitute quality characteristics weights in the A-1 chart. Subsequent authors [Marsh, Moran, Nakui, and Hoffherr; 1991], suggested switching the orientation of the axes and using the substitute quality characteristic weightings. The product or service functions are developed by the team in the B-1 chart.

The recommended form of the chart is to place the functions on the horizontal axis and the substitute quality characteristics and their weights on the vertical axis. Correlations are placed in the row-column intersections. Use traditional QFD symbology with weights of 9, 3, 1, and 0 respectively for high, medium, low, and no correlation. If the substitute quality characteristic weights were taken from the A-1 chart, the team can multiply correlations by the respective substitute quality characteristic and sum over the column. This will allow the product or service functions to be ranked by a weight linked to the substitute quality characteristics and the voice of the customer.

When analyzing this chart, look for highly ranked functions. These are important for marketing and are key for design effort and control. Also, look for functions with low or no correlation to substitute quality characteristics. These represent either a case where adequate substitute quality characteristics were not identified or functions exist with no relation to customer needs. The latter are candidates for cost reductions.

CONNECTIONS --

The output of the A-2 chart is often used as inputs in the following Moran charts and forms:

- B-1
- C-2
- D-2
- E-2

Appendix 1: (Continue)

INPUTS --

(The following may be found in the completed A-1 chart)
 Key substitute quality characteristics related to customer demands
 Key design priorities related to customer demands
 Identification of customer reliability exceptions
 Identification of unacceptable failure modes
 Weights of the above elements
 Proposed functions for the new product or service
 (to be developed by the team)

OUTPUTS --

Key product or service functions
 Functions with little or no customer need

REFERENCES --

Cohen, Lou, "Quality Function Deployment: How to Make QFD Work for You," Reading, MA: Addison-Wesley, 1995.

Day, Ronald G. "Quality Function Deployment: Linking a Company with Its Customers." American Society for Quality Control. Milwaukee, WI. 1993.

King, Bob, "Better Designs in Half the Time," GOAL/QPC, Methuen, MA, 1987.

Marsh, S., J.W. Moran, S. Nakui, and G. Hoffherr, "Facilitating and Training in Quality Function Deployment," GOAL/QPC, Methuen, MA, 1991.

Re Velle, Jack B., J. W. Moran, and C. A. Cox, "The Quality Function Deployment (QFD) Handbook," Wiley, New York, 1997.

Re Velle, Jack B., Normand L. Frigon, Sr., and Harry K. Jackson, Jr., "From Concept to Customer," Van Nostrand Reinhold, New York, 1995.

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Appendix 1: (Continue)

This is step 4 of 5

NOTE --

The output of this QFD matrix or form is an output you have chosen in the previous selection screen.

A-3 CHART - Substitute Quality Characteristics and Substitute Quality Characteristics --

The A-3 chart is used to identify the interrelationships between substitute quality characteristics. In the process of designing a product or service, changes may be required in the target values for substitute quality characteristics. Changing one substitute quality characteristic target may affect another, either positively or negatively. This chart identifies those relationships for opportunities and contingency planning. This is one of the QFD charts that uses a matrix format.

Substitute quality characteristics are taken from the A-1 chart and placed on both the horizontal and vertical axes. The diagonal cells of the resulting matrix may be blocked out as they are of no value. It is also only necessary to fill out the top or the bottom portion of the matrix as both contain the same relationships.

Interrelationships may be viewed as an assessment of linkage or positive-negative correlation between the substitute quality characteristics. If the target value for (a) is increased, will that tend to reduce (b), (c), ...? At the row-column intersection in the upper or lower part of the matrix, mark strong positive correlation with a double-plus (++), medium positive correlation with a single plus (+), medium negative correlation with a minus (-), and strong negative correlation with a double-minus (--). As with other matrix forms, leave the cell blank if there is no interrelationship.

Review the interrelationships in this matrix for opportunities to affect a key substitute quality characteristic through correlation with others. Consult this chart for contingency planning if substitute quality characteristics are changed for other reasons.

CONNECTIONS --

The output of this chart is not used directly in other QFD forms. It should be consulted if substitute quality characteristics are changed from work with the following forms and matrices:

- A-1
- A-2
- A-4
- B-3
- B-4

INPUTS --

Key substitute quality characteristics related to customer demands
(from the A-1 chart)

Appendix 1: (Continue)**OUTPUTS --**

Substitute quality characteristic interrelationships
Design opportunities and challenges

REFERENCES --

Cohen, Lou. "Quality Function Deployment: How to Make QFD Work for You." Addison-Wesley. Reading, MA. 1995

Day, Ronald G. "Quality Function Deployment: Linking a Company with Its Customers." American Society for Quality Control. Milwaukee, WI. 1993.

King, Bob, "Better Designs in Half the Time," GOAL/QPC, Methuen, MA, 1987.

Marsh, S., J. W. Moran, S. Nakui, and G. Hoffherr. "Facilitating and Training in Quality Function Deployment." GOAL/QPC. Methuen, MA. 1991.

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Appendix 1: (Continue)

This is step 5 of 5

NOTE --

The output of this QFD matrix or form is an output you have chosen in the previous selection screen.

E-4 CHART - New Concept Selection Summary

The E-4 chart is another QFD form that uses a matrix. The E-4 matrix is used to identify new concepts that will positively relate to all the criteria without causing unnecessary problems.

The left side of this L-shaped matrix lists customer demands, functions, and quality characteristics which can be extracted from the E-1, E-2, and E-3 matrices. The top side contains a variety of new concepts. Somewhere in the center of the matrix, a column is used to represent the standard or "best in class" for each customer demand.

Pluses (+s) and minuses (-s) are used to indicate whether the QFD team has judged a specific new concept as better or worse than the standard. The totals of the +s and -s at the bottom of the matrix are used to evaluate the relative strengths and weaknesses of each new concept.

CONNECTIONS:

The output of the E-4 matrix is often used in the A-1 matrix for completely new products.

INPUTS:

Customer Demands of Quality

(the Voice of the Customer Table and the A-1 matrix are good sources)

Functions

(the A-2 matrix is a good source)

Quality Characteristics

(the A-3 matrix is a good source)

New Concepts

(the Research and Development Department, the Engineering Department, as well as the Material and Processes Department are good sources)

OUTPUT:

Value of new concepts relative to customer demands, functions and quality characteristics

REFERENCES:

Cohen, Lou. Quality Function Deployment: How to Make QFD Work for You. Addison-Wesley. Cohen, Lou. "Quality Function Deployment: How to Make QFD Work for You." Addison-Wesley. Reading, MA. 1995

Day, Ronald G. "Quality Function Deployment: Linking a Company with Its Customers." American Society for Quality Control. Milwaukee, WI. 1993.

Appendices 1: (Continue)

King, Bob. "Better Designs in Half the Time." GOAL/QPC, Matheun, MA. 1987.

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Appendix 2

VOCT

Voice of the Customer Table-1

Verbatim	Customer Demographics	Customer Expectation of Function	Customer Expectation of Reliability	Statement of Customer Demanded Quality	Statement of Customer Demanded Function	Statement of Customer Demanded Reliability	Statement of Unacceptable Failure Modes
<p>No Sweating and condensation at the external AHU surface when operation on the normal condition. The AHU should be able to use multi stages, variable position of equipment. The drain pan must be clean, easy flow. The vibration and noise should be low. The size of the AHU should be modular. Easy to access the major equipment for services, such as motor, fan, pulleys, baring, coil and filter. The Construction must be rugged and rigid. Able to install on floor or hanging platform. Good Price performance/ total investment trade off.</p>	<p>Senior Design Mechanical Engineer. Selecting and Recommend the AHU to customers.</p>	<ul style="list-style-type: none"> • Deliver Cooled/Heated Air. • Humidity Control • Dust Control • Duct Connected to monitoring and control equipment 	<ul style="list-style-type: none"> • No Condensation • Accurate Air Volume • Quality of Assembly • Air Tight Service Door • Baring Life • Low vibration during running 	<ul style="list-style-type: none"> • Air Humidity Control • Air Volume Control • No Thermal Bridge • Air Tight at the operating Pressure • Access to the internal components • On Floor Installation • On Hanging Plat Form Installation • Strong Construction • Modularity • Sizing • Low Vibration • Low Noise Generation • Dry Drain Pan • Good Value for Money • Multi- Stages, selectable modular component 	<ul style="list-style-type: none"> • Deliver Cooled Air • Deliver Hot Air • Air Cleanliness Control • Connected to Air Distribution Systems • Monitoring equipment installable • Controlling equipment installable 	<ul style="list-style-type: none"> • Workmanship • No Thermal Bridge • Long Baring Life • Air Tight Service Door • Low Vibration 	<ul style="list-style-type: none"> • Leakage Service Door • Thermal Bridge • Vibration during operation • Loud • Operating Noise • Leakage air from the unit

Appendix 2 (Continue)

Voice of the Customer Table-2							
Verbatim	Customer Demographics	Customer Expectation of Function	Customer Expectation of Reliability	Statement of Customer Demanded Quality	Statement of Customer Demanded Function	Statement of Customer Demanded Reliability	Statement of Unacceptable Failure Modes
<p>AHU must be flexible and modular in both section and equipment. The installation of AHU should be easy and fool proof. The knock down feature is the competitive edge for the retrofit project. The insulation must be perfect providing no condensation on the severe operation condition. The vibration produce and the noise level should be at the acceptable level. The product must have clean and simple look and strong enough for talk on. The connection of pipe work, ductwork and the electrical wiring should provided for convenience of the installation. Exterior finished should have color coated galvanized steel, interior finished can varied from simple galvanized sheet to the stainless steel. The coil and drain pan must of have the water carry over. The motor, fan and drive should have the physical protection. The access door should be airtight and can be open from inside for emergency case, lighting should provided for internal work, cleaning and inspection.</p>	<p>Turnkey contractor of the international company.</p>	<ul style="list-style-type: none"> • Deliver Conditioned Air • Strong Construction • Modular Section Size & Component Safety • protection for moving part • Knock-Down • No water carry over from drain pan and coil • Can work on the medium pressure and high pressure systems • Lighting • Prepared Connection 	<ul style="list-style-type: none"> • Good Insulation • Low Vibration and noises • Non-corrosive construction • Constant flow of the air 	<ul style="list-style-type: none"> • Flexible Configuration • Modular in size • Modular in equipment • Knock down • Clean internal construction • Pipe Connection • Wiring Terminal • Duct Connection • Color Finished • Exterior • Multi Material • Interior • Sufficient Insulation • Easy to remove & install wall panel 	<ul style="list-style-type: none"> • Deliver Constant Air • Conditioned the Air • Modular Section Size • Modular Equipment Section • Safety Protection for moving and dangerous part • Knock Down • Protection of Water Carry Over from Coil • Dry Drain Pan • Lighting Equipment 	<ul style="list-style-type: none"> • Thermal Insulation • Thermal Bridge • Low Vibration • Low Noise • Non-Corrosive • Good Fan Performance 	<ul style="list-style-type: none"> • Air Leakage of the Unit and Access Door • Condensation at Exterior • Loud Noise • High Vibration

Appendix 3:**Customer Demand Weight Calculation**

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Quality/Function/Reliability	Weight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50			
Access to the internal components	8	8	7	5	6	7	9	8	7	8	6	7	8	6	9	6	5	8	8	6	9	8	6	7	8	8	8	9	8	8	9	9	8	8	6	8	8	8	8	8	9	9	8	8	8	7	8	8	6	7				
Accurate Air Volume	8	8	9	8	8	9	9	8	8	8	7	9	8	8	8	9	9	8	7	8	9	8	7	8	8	8	9	8	7	9	9	9	9	8	9	7	9	8	8	9	7	8	9	9	8	7	9	8	7					
Air Cleanliness Control	6	6	7	6	6	5	5	5	6	5	5	6	6	5	5	6	5	6	6	6	7	6	6	7	6	6	7	6	5	7	8	7	6	5	7	8	8	6	5	7	6	7	6	5	5	6	5	6						
Air Humidity Control	9	8	9	8	9	9	8	8	9	9	9	8	9	9	8	8	8	9	9	8	8	8	8	8	8	8	9	9	9	9	9	9	9	8	9	8	8	8	9	8	9	9	9	8	9	9	9	9	8					
Air Tight at the operating Pressure	9	8	8	8	9	9	9	8	9	9	9	8	8	8	8	9	9	9	8	9	9	9	8	9	9	9	9	8	9	9	9	9	8	9	8	8	8	9	8	9	8	9	8	9	9	8	9	9	9					
Air Tight Service Door	8	7	8	7	8	8	7	7	8	8	8	7	8	8	8	8	7	8	8	8	9	7	9	9	9	9	7	9	9	7	9	8	8	7	9	7	9	7	9	8	9	8	9	8	9	7	9	7	8					
Air Volume Control	7	6	7	8	7	7	7	8	8	8	8	8	8	7	8	8	7	7	8	8	7	7	6	7	7	8	8	7	6	7	6	8	8	8	7	6	9	9	8	8	9	9	8	9	8	9	8	9	8	7	8			
Clean internal construction	8	8	9	7	8	9	8	7	8	9	9	9	8	7	8	8	9	8	7	8	8	8	8	8	8	8	8	9	9	9	8	8	8	8	8	8	9	9	8	8	7	7	8	9	8	7	8	9	9	8				
Color Finished Exterior	8	7	6	8	7	8	8	7	8	9	9	8	7	7	7	6	7	7	7	7	8	8	8	8	8	8	8	9	9	9	8	8	8	8	8	9	9	9	8	8	7	7	8	9	8	7	8	9	9	8				
Color Finished Interior	5	5	5	4	5	6	4	5	6	6	5	4	4	5	6	5	4	4	5	6	6	6	7	5	5	6	6	6	7	5	5	6	5	6	5	6	7	7	6	5	5	6	8	6	5	6	8	6	5					
Connected to Air Distribution Systems	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9					
Controlling equipment installable	7	8	7	8	8	7	8	7	8	7	8	7	8	7	7	8	7	7	8	7	7	6	8	7	6	6	7	8	7	8	6	7	8	7	6	7	8	7	6	7	8	7	6	7	8	7	6	7	8	7	6	7		
Deliver Constant Air	8	8	7	9	9	8	7	8	9	9	9	9	9	8	8	8	8	8	8	8	8	9	9	9	7	8	8	9	9	9	8	7	7	8	8	8	8	9	9	9	9	9	9	9	8	8	9	8	8	9				
Deliver Cooled Air	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9			
Deliver Hot Air	7	6	7	6	7	8	7	9	6	6	7	6	7	7	6	7	7	6	7	6	6	7	6	5	5	6	6	5	6	7	8	9	8	8	7	6	7	8	8	7	6	5	7	8	6	5	6	7	8					
Dry Drain Pan	7	7	6	6	6	7	7	6	7	7	7	7	6	6	7	7	6	6	7	7	6	6	5	6	6	5	6	7	8	9	7	6	5	6	6	7	8	7	6	5	6	7	8	7	6	5	6	7	8	7				
Duct Connection	8	8	8	9	9	9	9	8	8	8	7	8	7	8	9	9	8	8	8	8	8	9	8	8	9	8	8	9	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	8	8	8	9	9	8	8	8			
Easy to remove & install wall panel	8	7	8	6	7	8	9	9	7	8	6	8	6	7	7	7	8	7	8	7	8	9	8	7	7	8	7	8	9	8	7	7	7	8	7	8	9	9	8	7	7	8	7	7	8	7	7	9	7	8	6			
Flexible Configuration	7	6	7	8	8	7	7	7	7	8	8	7	7	6	7	7	7	7	8	8	9	9	9	8	8	7	8	7	8	7	8	9	8	7	6	7	8	9	7	7	8	7	6	7	8	7	6	7	8	7	6	8		
Good Fan Performance	8	8	7	7	9	9	9	8	9	9	9	8	8	9	8	8	9	8	7	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Good Value for Money	8	8	7	9	8	7	7	7	8	9	9	7	8	7	8	9	8	7	8	8	9	7	7	7	8	8	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Knock down	6	6	7	6	5	6	7	8	7	6	5	6	7	6	5	6	7	6	5	6	7	6	5	5	6	4	5	6	5	7	7	8	8	8	6	6	7	6	5	8	6	5	8	6	5	7	7	8	8	7				
Lighting Equipment	8	6	7	7	9	9	9	8	8	7	6	6	7	7	8	7	7	8	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Long Maintenance Life	8	8	9	7	8	8	9	8	8	7	8	9	8	7	8	9	8	7	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	
Low Noise Generation	8	7	8	9	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8	9	8	7	8		
Low Vibration	8	9	7	7	8	8	9	7	7	7	8	8	9	7	8	9	7	8	9	7	8	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8		
Modularity Sizing	8	6	7	8	9	7	6	7	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		
Monitoring equipment installable	8	7	8	7	7	8	8	8	8	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	
Multi Material Insulation	7	9	7	8	7	8	6	7	8	8	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	
Multi Material Interior	7	8	7	6	7	8	7	6	7	8	7	6	7	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7		
Multi-Stages, selectable modular component	9	8	9	9	9	9	8	9	9	9	9	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	
No Thermal Bridge	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	
Non-Corrosive	7	8	7	8	7	6	8	9	8	7	8	9	8	7	7	6	7	6	7	6	7	6	9	6	9	6	8	6	7	6	9	7	8	6	9	6	6	7	6	8	6	9	7	6	8	6	9	6	7	6	7	6		
On Floor Installation	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	
On Hanging Plat Form Installation	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	
Easy to maintenance	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Protection of Water Carry Over from Coil	7	7	8	6	8	7	9	6	7	9	9	7	8	6	9	7	8	6	9	7	8	6	9	7	8	6	9	7	8	6	9	7	8	6	8	7	9	8	7	6	8	6	7	8	6	7	8	6	7	8	7			
Safety Protection for moving and dangerous parts	7	5	7	8	6	9	5	8	6	7	5	9	6	8	7	5</																																						

Appendix 5:

The Quality Function Deployment (QFD) Matrix A2

QFD METRIX A2: Customer Demand Function and the Substitute Characteristic from A1		Function																						
Substitute Quality Characteristic	Weight	Thermal insulation	Build Static Pressure	Clean Air	Clean Internal Structure	Controlling equipment installable	Cooling	Deliver Constant Air	Delivery Air to Distribution System	Demounting	Dry Drain Pan	Heating	High Static Operation	Humidifying	Knock-Down system	Lighting Equipment	Maintainability, Service ability and Installation	Minimum Vibration	Modular Equipment Section	Modular Cross Section Size	Monitoring equipment installable	No Thermal bridge and internal-external condensation	Quiet operation	Safe
Double Skin Construction 2", Thermal transmission insulation 1-1.4 W/m2/K	885	9	9	3	9	9	9	0	3	1	0	1	3	1	0	0	0	0	0	0	0	0	0	0
Door and Service Panel Removal in 1 min	858	3	0	0	9	3	0	0	0	0	3	0	1	0	9	0	0	0	0	0	0	0	0	0
Rigid-Tough Construction	843	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centrifugal Fan Installation	784	0	9	0	0	0	0	9	9	0	0	0	9	0	3	0	0	0	0	0	0	0	0	0
Insulated Drained Floor(With Expanded metal cat walk, on large unit)	705	0	0	3	9	0	9	0	0	3	9	0	0	0	9	0	0	0	0	0	0	0	0	0
Knock Down Structure	690	1	9	0	0	0	0	0	0	0	0	0	9	0	9	0	0	0	0	0	0	0	0	0
High Performance Fan & Drive	685	0	9	0	0	0	0	9	9	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0
Stackable Unit 2 level	684	3	3	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4, 6, 8, 10, 12 roll Cooling Coil with various fin type	680	0	0	3	0	0	9	0	9	3	0	0	9	3	0	0	0	0	0	0	0	0	0	0
Internal Inlet Damper @ Mixing Box	613	9	3	0	0	3	9	9	3	0	0	9	0	0	3	0	3	0	3	0	3	0	3	0
Height Variable Base Structure 10cm-20cm	612	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V Grooved Elevated Drain Pan	597	0	0	1	9	0	1	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fan Set Vibration Isolator	537	0	1	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	1	1	0	0	0	0
Service Door Air Tight 100%	532	9	9	3	3	0	1	1	0	3	0	1	9	9	9	9	9	1	3	3	0	3	1	0
Service Panel-Air Tight 100%	532	9	9	3	3	0	1	1	0	3	0	0	9	9	9	9	9	1	3	3	0	3	1	0
Heating Element	510	0	0	1	0	3	0	0	0	9	0	9	0	3	0	0	0	0	0	0	0	0	0	0
Multi-Choice Internal Skin	473	3	1	1	9	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	9	3	0
Fool Proof Fan Connection	438	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perfect Sealed Gasket	412	9	1	3	3	0	3	0	3	1	0	0	0	0	9	0	0	0	0	0	0	0	0	0
180 Removable Pin Hinge for Access Door	396	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0
Modular Filter Section 305x305	393	0	0	9	3	3	0	0	9	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Section Labeling Indicator	389	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	9	9	0	0	0	0
305mm Base Dimension Modular (Internal)	385	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colour Coated Interior	378	0	0	3	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Out Let Flange	373	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walkable Unit Top 400 kg	365	0	0	0	0	0	0	0	0	0	0	0	3	0	9	0	0	0	0	0	0	0	0	0
Insulated Sight Glass	357	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Pipe Header	354	0	0	0	0	9	0	0	1	0	1	0	0	3	0	9	0	0	0	0	0	0	0	0
Guide Hole-Guide Pin for Installation	351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Washer Section	346	0	0	9	0	9	0	0	1	3	3	9	9	9	9	9	9	9	9	9	9	9	9	9
Forklift Access From Side	346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lift Hook	338	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coil velocity up to 700 fpm	332	0	3	0	0	0	9	0	0	9	0	0	0	0	9	0	0	0	0	0	0	0	0	0
Wiring Terminal for Power Connector	332	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Multi-Choice Insulation (PU, PS, Rockwool, Fiberglass)	329	0	0	3	0	0	9	0	0	0	0	0	0	0	3	0	0	0	1	1	0	9	0	0
Powder Coated Exterior	312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inlet Flange, Duct Bolt Connect	308	0	0	0	0	9	0	3	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Side Access Pre Filter & Medium Filter Housing	306	0	0	3	0	0	0	0	0	0	0	0	3	0	3	0	9	0	3	0	0	0	0	0
Multi-Type Fan Configuration	292	0	3	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wire Guide Wire Way	257	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Assembly Foul Proof	255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Droplet Eliminator after coil	246	0	0	3	0	9	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Coil Sliding	217	0	0	0	0	9	0	0	0	0	0	0	0	0	9	0	3	0	0	0	0	0	0	0
Control Connector Terminal	210	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Air Mixer	207	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixing Box	143	0	0	0	0	0	3	3	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0
Internal Lighting Switch	123	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
0, 90, 180, 270° L-R degree blow outlet	114	0	3	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Fan Inlet Guard	108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lighting IP55	108	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
Shaft Guard	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belt Guard	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trap In alarm	93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Score		1000	885	858	843	800	784	705	690	685	684	680	613	612	597	537	532	532	510	473	438	412	396	393
Rank		14	8	10	10	19	7	16	13	17	10	22	4	20	1	23	2	11	6	6	21	12	9	3

Appendices 6**The Quality Function Deployment (QFD) Matrix A3**

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

Appendices 7**Filter Conversion Table**

สถาบันวิทยบริการ
จุฬาลงกรณ์มหาวิทยาลัย

International Filter Classifications

Group	EN 779 prEN 1822 (Draft)	Arrestance Efficiency Penetration	EUROVENT 4/5, 4/4	SWKI 84 DIN 24183 (Draft)	DI N 241 85	Luwa Quality Filter	Luwa Filter Type
Average Weight Arrestance A [%]							
G (Coarse Dust Filters)	G 1	60	EU 1	EU 1	EU 1		Filter pads
	G 2	70	EU 2	EU 2	EU 2		
	G 3	80	EU 3	EU 3	EU 3	G3	GS - G3 / Filter pads
	G 4	90	EU 4	EU 4	EU 4	G 4	GS - G4 / Filter pads
Average Atmospheric Dust Spot Efficiency E [%]							
F (Fine Dust Filters)	F 5	40					
		50	EU 5	EU 5	EU 5	55	FS - 55
		60					
	F 6	70	EU 6	EU 6	EU 6	65 75	FP - 65 / FS - 65 FP - 75
	F 7	80	EU 7	EU 7	EU 7	85	N - 85 / FP - 85 / FS - 85
	F 8 F 9	90	EU 8 EU 9	EU 8 EU 9	EU 8 EU 9	95 98	N - 95 / FP - 95 / FS - 95 FP - 98 / JP - blue
						blue	PB - / V - / P - blue
Initial Penetration P_A [%]							
H (HEPA Filters)	MPPS	15	NaCL	MPPS	Paraffin		
	H 10	10	(EU 9)	EU 10		98 red	PB - red / V - red PB - red / P - blue
		5.0			Q		
	H 11	3.0		EU 11		yellow R	P - yellow PB - yellow / V - yellow FP - R / PL - R
		1.0	EU 10			H 11	CR - ... H 11 / N - R
		0.5					
	H 12	0.3		EU 12	R	S H 12	CR - ... H 12 FP - S
		0.10					
	H 13	0.03	EU 12	(EU 13)		glass S H 13	JK - S / JG - S / PB - glass V - glass / P - glass / PL - S CR - ... H 13 / N - S - 29 / N - S - 40 N - S - 34 / N - S - 35
		0.01					
	0.005	EU 13		S			
H 14	0.003		(EU 14)		H 14	CR - ... H 14 CRM - ... H 14	
	0.001						
U (ULPA Filters)		0.0005			(T)		
	U 15	0.0003	EU 14	(U 15)		T U 15	N-T / CR - ... U 15 N-T / CRM - ... U 15
		0.0001					
	5E-05			(U)			
U 16	3E-05		(U 16)		U 16	JM CR - ... U 16 / CRM - ... U 16	

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Biography

Peerasut Thirakomen was born on July 17th, 1975 in Bangkok, Thailand. He graduates from Assumption University, School of Engineering in 1996 with a Bachelor degree in Electronics Engineering. He has been working with an air filter and clean room equipment supplier in Thailand as the General Manager since 1998.



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