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SPECIFICATION
FOR HLCAC LIFT FAN

By:

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For:

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In Performance of:

P.O. # N61331-03-F-1609

Data Item A002

THIS SPECIFICATION HAS BEEN PREPARED BASED ON A CFD ANALYSIS AND THE RESULTING DESIGN ANALYSES CONDUCTED BY CDI MARINE SDD. IT MAY BE UPDATED AS A RESULT OF THE MODEL AND FULL-SCALE FAN TEST RESULTS.

FOREWORD

This document presents the final geometry, performance specification, and procurement specification requirements for the HLCAC Lift Fan. The specification follows the general format of U.S. Military Standard specifications as outlined in MIL-STD-490. CDI Marine Systems Development Division (CDIM-SDD) technical direction for this task was provided by Mr. Alan Becnel and Mr. John Purnell.

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1.0 SCOPE

1.1 Scope

This specification covers the physical and performance characteristics of the lift fans for the Heavy Lift LCAC (HLCAC) ACV. It includes the required aerodynamic performance and the physical requirements for the impeller, the inlet bellmouth and the volute (scroll). The shafts, bearings, bearing supports, volute casings, discharge duct and closures will be designed in accordance with the associated Interface Control Document.

1.2 Purpose

The purpose of this specification is to establish the requirements for the detailed mechanical design and fabrication of lift fans that will be used as technology demonstrators for the HLCAC ACV.

1.3 Classification

This material is unclassified.

1.4 Definitions

1.4.1 Lift-Fan Impeller

The lift-fan impeller is the moving part of the air-moving device whose purpose is to provide the cushion of air upon which the craft rides and to provide air for the bow thrusters.

1.4.2 Shipset

A shipset consists of four identical double-width, double-inlet (DWDI) lift-fan impellers.

1.4.3 Impeller

The impeller is the rotating element of the fan, not including the shaft upon which it is mounted.

1.4.4 Bearings

The bearings support the impeller shaft at each end (2 per fan). The bearings are not part of this specification.

1.4.5 Bearing Supports

The bearing supports are integrated with the fan volute casings and provide a place to mount each of the impeller shaft bearings (2 per fan). The bearing supports are not part of this specification.

1.4.6 Inlet Bellmouth

The inlet bellmouth provides an aerodynamically smooth duct connecting the outside of the fan casing to the eye of the impeller (2 per fan). The inlet bellmouths were designed by CDI Marine SDD to suit the impellers aerodynamically.

1.4.7 Volute (Scroll)

The volute collects and diffuses the air leaving the impeller and delivers it to the fan diffuser duct exits for lift and for bow thruster propulsion. The volute also supports the impeller bearings and their supports. The aerodynamic design of the volutes was designed by CDI Marine SDD and is shown in CDI Marine SDD Dwg. #755-01.

1.4.8 Volute Discharge Duct

The volute discharge ducts are integral parts of the volute that further diffuse the air leaving the volute proper and end at the fan discharge diffuser exit. These ducts were designed by CDI Marine SDD.

2.0 APPLICABLE DOCUMENTS

Documents are applicable to the extent they are referred to in sections 3.0, 4.0 and 5.0 of this specification. Unless stated otherwise, the current revision in effect on the date of issuance of this specification of the following documents will apply.

2.1 Government Documents

HLCAC Lift Fan Interface Control Document dated XX/XX/2003.

2.2 Other Documents

INS 0041 – Subcontractors requirements (NFT document).

ISO 1940/73/05/01 – Mechanical vibration. Balance quality requirements of rigid rotors.

A Handbook of Balancing, AiResearch Mfg. Co., 1960.

An Introduction to Fatigue in Metals and Composites, R.L. Carlson and G.A. Kardomateas, Chapman & Hall, 1996.

Drawings:

Dwg. #755-01 Lift Fan Impeller and Bellmouth
Dwg. #755-02 Lift Fan Volute

3.0 REQUIREMENTS

3.1 Critical Item Definition

The impeller is a fixed-geometry centrifugal rotor with two staggered rows of thirteen (13) backwardly-inclined airfoils, each mounted between a central backplate, and two conical end rings known as shrouds. Each backplate is, in turn, bolted to a central disc that is welded to the fan shaft. The fan shaft is coupled to the drive shaft via a coupling flange.

The function of the fan is to provide pressurized air to the air cushion of the HLCAC ACV and to the bow thrusters. The fan impeller structure shall be designed to sustain the loads and the environmental conditions encountered during operation on an Air Cushion Vehicle, otherwise known as a Hovercraft.

3.1.1 Special Requirements

The impeller shall be fabricated from lightweight, high-strength, corrosion-resistant materials to the greatest extent that is practicable. Any metallic parts shall be of corrosion-resistant material such as stainless steel or titanium. The shaft shall be made of 304 stainless steel for the shaft and center fitting while 15-5PH stainless steel shall be used for the end fitting.

3.1.1.1 Replaceable Impeller Blades

Each of the twenty-six (26) blades, thirteen (13) per side, in the impeller shall be removable and replaceable without the necessity of removing the fan from the craft or the impeller from the volute casing.

3.1.1.2 Access to the Impeller in the Craft

Access to each impeller for blade maintenance or replacement shall be provided via a removable access plate in the volute.

3.1.1.3 Use of Carbon-Fiber Reinforced Polymers (FRP/C)

The use of FRP with carbon fibers shall be considered for construction of the impeller blades, shrouds and backplates. Structural integrity of components using carbon fibers shall be demonstrated analytically and by physical test, with prudent safety margins for the loads imposed (see paragraph 3.2.1.7 Loads and 3.2.1.8 Strength).

3.1.1.4 Use of Closed-Cell Foam Fillers

If foam is used to fill the voids between FRP/C skins, it shall have physical properties allowing it to withstand the tensile and compressive loads inherent in the application due to the cyclical application of centrifugal, gyroscopic and all other acceleration-inertial or static loads the impeller will experience during its lifetime, as defined in 3.2.1.16.

3.1.1.5 Threaded Inserts for Blade Attachment (prohibited)

The means of attachment of the impeller blades to the backplate and to the shroud shall not be achieved by the use of threaded inserts in the foam or FRP material of the blades.

3.1.1.6 Use of Through-Bolts

The use of through-bolts to attach and restrain the impeller blades under centrifugal and other inertial loads is encouraged. Through-bolts may be non-metallic, non-metallic with metallic end-fittings, or metallic. All metallic material shall be of stainless steel or titanium grade 5.

3.1.1.7 Core Protection

Because blades must be replaceable, the foam core of blades (if used) shall be protected from damage when installing bolts with metal end-fittings. For this purpose, sleeves of high-strength polymer material shall be considered. Such sleeves may also help to spread the bolt lateral loads into the foam core.

3.1.1.8 Backplate Material Electrical Insulation

The backplate may be of FRP/C or of stainless steel or titanium grade 5. If metal is used, then bolts or end-fastenings shall be electrically insulated from the backplate.

3.1.1.9 Use of Compliant Materials

Compliant materials such as polyurethane in the form of gaskets between the blades and the backplate, and between the blades and the shrouds, shall be considered in order to reduce stress concentrations in the blade skin and foam when the blades are deformed under bending and torsional loads.

If used, such materials shall have a life expectancy under the specified environmental conditions of 5 years, as a minimum, without significant deterioration or failure that would be cause for replacement.

3.1.2 Interface Definition

3.1.2.1 Physical Interface

The impeller interfaces with the fan housing (with clearance) and with the drive shaft flange.

3.1.2.2 Functional Interface

The impeller is connected to the transmission system via an offset gearbox and flexible couplings which are supplied by the shipyard.

3.1.2.3 Electrical Interface

Not applicable unless special monitoring equipment is added, which must be compatible with existing craft systems.

3.1.2.4 Test Equipment Interface

The test equipment interface shall be the shaft flange bolt circles.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 Aerodynamic Design Point Performance Requirements

Each of the four double-discharge lift fans have been designed to produce static pressure of 7.9 kPa (165 psf) gauge at an air flow of 148.7 cms (66.1 cms for bow thruster, 82.6 cms for lift) at a design point fan speed of 1692 RPM and design point ambient conditions of standard atmospheric pressure (760 mmHg) and air temperature of 37.7^{o}C (100^{o}F). These nominal values are provided for information only.

3.2.1.2 Design Point Fan Slope

Each fan has been designed to have a negative fan slope of approximately –0.014 kPa/28.3 cms (–.3 psf/1000 cfs) at the design point pressure and flow.

3.2.1.4 Design Point Fan Shaft Power

The fan shaft power for each fan shall not exceed 1715 kW (2300 HP) at the design point conditions. Two fans per side will be installed on the HLCAC, and power to the forward fan will be via the aft fan shafting. The lift fan shaft shall be sized to allow for this additional power transmission requirement.

3.2.1.5 Self Limiting Torque and Power

If the back pressure falls and approaches zero, the fan torque (and power) at constant speed shall reach a maximum before the flow exceeds 140% of the design point flow.

3.2.1.6 Peak Torque

The peak torque shall not exceed 115% of the design point torque.

3.2.1.7 Loads

Loads defined below are generally limit loads.

3.2.1.7.1 Inertial Loads

Inertia loads on impeller components due to impeller rotation and ship motion are very important.

Maximum rotational speed of the impeller (limit load) is 1692 RPM.

The case of $\pm$ 50% shaft torsional oscillation, acting simultaneously with a rotational speed of 1692 RPM, shall also be considered.

For shock loads and vibratory loading, see paragraph 3.2.10 Environmental Conditions. For acceleration (translational and rotational) of fan shaft supports from ship motion, see paragraphs 3.2.3 Accelerations, 3.2.4 Motions, and 3.2.10 Environmental Conditions.

Fatigue of all materials used shall be considered. Infinite fatigue life is a goal.

Moisture absorption effects for increased loading due to increased mass shall be considered.

3.2.1.7.2 Aerodynamic Loads

The aerodynamic load on the fan is small compared to the inertia load from fan rotation and shall be disregarded for design purposes. (The aerodynamic load acting subtracts a few percent from the inertia load on each fan blade).

3.2.1.7.3 Fan Axial Loads

Fan axial loads may arise from inertia loads acting on the fan.

Axial loads on the double-width, double-inlet (DWDI) impeller shall be disregarded for design purposes.

3.2.1.7.4 Fan Shaft Torsional Loads

The maximum torsional shaft moment must be calculated after the fan impeller is designed and confirmed as acceptable with the USN.

3.2.1.7.5 Gyroscopic Loads

Gyroscopic loads due to the combination of fan rotation and ship motion shall be taken into consideration. Maximum angular rates for fan shaft supports due to ship motion are (for fan shaft mounted horizontally in fore-aft direction):

Craft pitching:	0.5 radians/s
Craft yawing:	0.5 radians/s
Craft rolling:	Not applicable

See also paragraph 3.2.10 Environmental Conditions, Ship Motion.

3.2.1.7.6 Worst Case Load

The worst case load on the impeller is expected to be a combination of pitching and yawing acceleration and maximum rotational speed.

3.2.1.7.7 Thermal Loads

The thermal loads are given in paragraph 3.2.10 Environmental Conditions.

The possibility of internal heating of FRP materials due to sustained limit load conditions shall be considered.

3.2.1.8 Strength

The impeller shall have sufficient strength to support the loads (limit loads) specified in paragraph 3.2.1.7 Loads, also taking into consideration any degrading influence of environmental conditions as specified in paragraph 3.2.10, and the Foreign Object Damage (FOD) criteria specified in paragraph 3.2.1.11. Allowable stresses, per the safety factors below, shall not be exceeded for any operating condition.

Safety factors that apply are as follows:

Safety Factors (based on stresses for limit loads)

Yield safety factor (metals only):	3.0
Ultimate safety factor (all materials):	3.5, as a goal (for composites, 1st ply failure)

Note: For normal design point operation, these safety factors shall be no less than 4.0.

The design fatigue life of the structure must equal or exceed (unlimited) total craft life-cycle operating hours as defined in 3.2.1.16.

3.2.1.9 Stiffness

The critical rotational speed of the fan shall be above 2200 RPM.

The impeller shall not physically touch the volute housing or inlet bellmouth for worst case deflections.

Note: Strength of the impeller is far more important than stiffness. Some built-in compliance may reduce peak stresses in the FRP blade and shroud materials.

3.2.1.10 Creep

Creep effects for materials under load shall be taken into consideration.

3.2.1.11 Foreign Object Damage (FOD)

The fan shall be designed so that the required strength of the fan is obtained after the fan has been subjected to an impact/erosion damage of maximum non-detected (visual) magnitude that can be expected during assembly/installation/service. The magnitude of the impact, together with the level of visual inspection, shall be determined. Impact damage shall be reduced by the use of blade leading-edge protective film of polyurethane or equivalent material (paragraph 3.2.1.14).

It is expected that the design of the air inlet and application of grilles in the inlets will be used to minimize entry of foreign objects for the installed fan to, or below, the level in paragraph 3.2.10.

3.2.1.12 Icing

Ice accumulation on the fan itself is not expected under the assumption that proper deicing devices are situated ahead of the fan, hence no provision for deicing devices directly on the impeller is necessary.

For any ice particles breaking loose upstream of the fan, refer to paragraph 3.2.1.11.

3.2.1.13 Water Impact

Water impact on the fan (i.e., more than droplets) is not expected under the expectation that this is prevented by air inlet design.

3.2.1.14 Leading Edge Protection

The blade leading edges shall be protected from erosion and minor FOD by the use of replaceable polyurethane film or equivalent. The installed fan shall tolerate foreign objects to a limited extent, as specified in paragraph 3.2.10, without degradation in performance. Leading edge protective film shall be capable of operating for a minimum 150 hours with a goal of 300 continuous hours of fan operation prior to replacement.

3.2.1.15 Aerodynamic Surface Quality

Roughness/excrescencies shall be kept to a practical minimum to minimize drag and dirt accretion. The excrescencies include such things as surface waviness, rough surface finish, and projecting or countersunk fasteners. A surface waviness standard shall be submitted to the USN for approval.

The surfaces of the blades, inner shroud surfaces and backplates between the blades shall be glossy smooth. Other surfaces shall be smooth to the touch and joints shall be even. Surfaces shall have no visually detectable waviness.

There shall be no air gaps at foil ends. Any gaps shall be sealed, preferably by the use of compliant gaskets.

For dimensional tolerances of fan and foils, see CDIM-SDD Dwg. #755-01.

The foil manufacturing process planned during the design stage shall be able to produce foils of the proper shape repetitively so that blades are interchangeable with all other blades of the same hand, i.e., right-handed or left-handed.

3.2.1.16 Useful Life

The impeller life expectancy in years and operating hours shall be established, and recommendations for inspection intervals and major overhaul intervals and preventive maintenance shall be given.

The ultimate design goal will be 20 years life with 300 operating hours per year.

3.2.2 Physical Characteristics

3.2.2.1 Mass, Inertia and Balancing

The fan weight shall be kept to a minimum, consistent with aerodynamic and structural design requirements.

Moisture absorption effects on mass and balancing shall be considered.

The rotational inertia of the fan shall be minimized.

The rotating mass must be statically and dynamically balanced to ISO 1940/73/05/01 grade G3 for both planes (see paragraph 2.2, “A Handbook of Balancing”).

For a subsequent replacement of individual blades, repeated balancing of the complete mass will not generally be required provided blades are manufactured, weighed and marked per this specification.

3.2.2.2 Dimensional Envelope

The dimensions of the impeller and individual fan blades are given in CDIM-SDD Dwg. #755-01.

3.2.2.3 Impeller Geometry

The impeller geometry shall be in accordance with the drawings attached. The principal dimensions shall be as follows:

Blade trailing edge diameter	1600.2	mm	5.25	feet
Blade trailing edge width	325.3	mm	12.808	inches
Blade leading edge diameter	1068	mm	42.047	inches
Blade leading edge width	435.7	mm	17.152	inches
Blade chord	391.0	mm	15.394	inches
Blade maximum thickness	48.8	mm	1.923	inches
Blade angle (chord to tangent)	54.27	^{o}	54.27	^{o}
Impeller inlet diameter	1004.1	mm	39.528	inches
Backplate diameter	1616	mm	63.622	inches

3.2.2.4 Shelf Life Requirement

Shelf life for the fan and components shall be a minimum of 20 years when packaged in the original packing material and stored under proper conditions. Any special requirements necessary to meet this requirement must be identified by the manufacturer.

3.2.2.5 Surface Treatment

The surface treatment of the impeller and its components must be adequate to withstand corrosion and erosion from the environments specified in paragraph 3.2.10 and provide the surface quality specified in paragraph 3.2.1.15.

The impeller blades shall be further protected as specified in paragraph 3.2.1.8.

3.2.3 Accelerations

The fan, when operating at 1692 RPM, shall withstand, without failure or interruption of performance, the following accelerations:

4 g down
3 g up
0-6 g forward
0-3 g astern
0-3 g sideways

3.2.4 Motions

The fan shall be capable of continuous operation without failure of any kind, or interruption of operation, when subjected to the following sinusoidal (harmonic) continuous motions, separately or together, having dominant frequencies in the range 0-10 Hz.

With harmonic angular accelerations corresponding to peak angular velocities of:

1) 0.5 radians/s pitch motion
2) 0.5 radians/s roll motion
3) 0.5 radians/s yaw motion

Note: The actual motions seen by the fan impeller will be more random in nature and may result in higher or lower time-averaged forces than those resulting from simple harmonic motions. The above peak velocities have been selected to provide some margin in calculation of the resulting loads and stresses.

3.2.5 Gyroscopic Torque (see paragraph 3.2.1.8.5 Gyroscopic Loads)

The fan impeller shall resist the gyroscopic torque resulting from the specified continuous motions without failure of any kind or interruption of operation. For the purpose of calculating gyroscopic torque, the fan shaft shall be considered to be parallel to the ship longitudinal centerline (i.e., running fore and aft).

3.2.6 Fatigue Life

The impeller shall be designed for infinite fatigue life, as a goal, based on the loads and stresses resulting from the method of operation, aerodynamic performance, motions, accelerations, or other effects specified herein. Justification shall be provided for less than infinite fatigue life.

3.2.7 Weight

The weight of the impeller shall be kept as low as is possible, consistent with aerodynamic and structural design requirements.

3.2.8 Reliability

The impeller unit Mean Time Between Failure (MTBF) shall be established in conjunction with the requirements in paragraph 3.2.1.16 Useful Life.

3.2.9 Maintainability

The intervals for, and scope of, periodic inspection, preventive maintenance and major overhauls shall be established.

Replaceable parts at the operator level shall be: impeller blades, impeller trailing edge wedges, blade bolts and fastenings, blade gaskets, and blade leading edge protective film.

3.2.10 Environmental Conditions (subject to revision)

The fan shall be designed to meet the environmental requirements as specified in Table 3-1.

Table 3-1

Environmental Conditions

ENVIRONM. CONDITIONS	SEVERITY		DURATION	TEST PROCEDURE	REMARKS
	Functioning during test	Functioning after test			
1) Temp high	+49° C	+71° C	16 h	MIL-STD-810D Method 501.2	
2) Temp low	-20° C	-30° C	16 h	MIL-STD-810D Method 502.2	
3) Humidity	31° C - 49° C 88%>RH>59%		240 h	MIL-STD-810D Method 507.2 Procedure 1	
4) Salt fog		+35° C 5% salt PH 6.5 to 7.2	30 days	MIL-STD-810D Method 509.2 Procedure 1	
5) Fluid contam	a) Hydr Oil MIL-H-5606 b) 60% Water-Glycol +65° C		48 h storage at +50° C or 6d storage at ambient temp after spraying	DEF STAN 07-55 Test: CA	May be applied on sample materials e.g. FRP/C
6) Mech shock				MIL-STD-810D Method 516.3	Impeller in container
6a) Transport shock		30+/-5g, 30 ms		Procedure II	
6b) 0.6m drop		0.6 meter	Drop on each corner, 6 drops	Procedure IV	Impeller in container
6c) Basic design test		15g/11 ms half sine	2 shocks in each direction, 3 princpl axes, total 12 shocks	Procedure I	
6d) Installed	10g/10ms half sine		Ditto	Procedure I	
7) Vibration					
7a) Reson search	N/A	5-500 Hz, 0.5g		MIL-STD-810D Method 514.3	
7b) Transport		Random	3 axes, 120 min each axis	Procedure I	Impeller in container
7c) Installed	Random		TBD	TBD	
8) Sand/dust/ salt crystals		+23° C to +63° C Dust 10+- 5g/m^3 Air velocity 1750 ft/min	28 h	MIL-STD-810D Method 510.2 Procedure I	
9) Ship motion		See paragraph 3.2.4		Motions	Motion of fan supports

3.2.11 Transportability

The fan transportation characteristics shall be compatible with transport by air, sea or land with packaging to give adequate protection from transportation environments.

3.3 <u>Design and Construction</u>

Design and construction of the impeller shall be executed in a manner commensurate with the impeller's intended use and with accepted aerospace industry practice. The design shall facilitate production, installation, and removal of parts requiring maintenance or replacement. Requirements for special tools shall be kept to a minimum.

3.3.1 Materials, Processes and Parts

3.3.1.1 General

Materials, processes and parts selected by the contractor shall be evaluated and/or tested to ensure that each possesses the capability of adequately supporting reliability, performance, maintainability and safety requirements to obtain the required service performance.

Standard materials, processes and parts shall be used to the extent possible to meet the requirements specified herein.

Adequate records shall be maintained to support the use of and to demonstrate that materials, processes and parts are entirely suitable for their intended use. These records shall include, as a minimum, specification or drawing of the item, test procedures, and test results.

3.3.1.2 Materials

Material properties considered in materials selection shall include, but not be limited to, fatigue considerations, susceptibility to corrosion damage, notch sensitivity, fracture toughness, biological degradation, water absorption, weathering and fabrication considerations, magnetic signature, and electrical conductivity.

Material stress values shall be based on appropriate available data or on test data derived from a number of test samples judged to be sufficient for the material in question and following engineering practice for the material in question. Statistical analysis of material data shall be applied when deemed necessary.

3.3.1.3 Processes

Processes used in the design and fabrication of the impeller shall be in accordance with aerospace contractor practices.

Non-destructive testing (NDT) of composite materials parts shall be used as applicable to verify processes and to verify integrity of manufactured parts, particularly to avoid or detect delaminations, especially in the blades.

3.3.1.4 Parts

Commercial off-the-shelf parts shall be used wherever they are suitable for the intended use and shall be identified on applicable drawings by their part number.

3.3.1.5 Protective Coating

The impeller unit shall be coated in accordance with requirements determined during the detailed design. (Color shall be determined by the procuring activity.) The use of a two-color system for monitoring of erosion shall be used if possible. Pigmentation of the laminate resin may be considered as an alternative to coating.

3.3.2 Electromagnetic Radiation

Not applicable.

3.3.3 Nameplates and Product Marking

Identification and marking applicable to the fan shall be specified using MIL-STD-130 and NS4005 for guidance. See also paragraph 5.3.

Product marking drawings shall be submitted to the USN for approval.

Handling precautions shall be marked on the fan unit at a clearly visible position.

3.3.4 Workmanship

Workmanship shall be of a quality to ensure compliance with the safety, proper operation, high reliability and useful life requirements specified herein, consistent with the best aerospace industry practice for rotating machinery such as aircraft propellers.

3.3.5 Interchangeability

Impellers shall be mutually interchangeable and replaceable in accordance with MIL-I-8500. Individual fan blades shall be replaceable. The maximum allowable weight deviation shall be 0.25%. See paragraph 3.2.2.1 for balancing requirements.

3.3.6 Safety

The impeller design shall provide for safe handling during service and assembly/disassembly.

3.3.7 Human Performance/Human Engineering

The access specified in paragraph 3.1.1.2 shall be sized to accommodate the 95th percentile person.

3.4 <u>Documentation</u>

Documentation for the fan shall be prepared in accordance with the following requirements.

3.4.1 Quality Assurance (Q/A) Reports

3.4.1.1 Dimensional Survey Reports

For the first article and subsequent impellers, a dimensional survey report, in metric units, shall be completed showing nominal (design drawing) dimensions and actual measured dimensions. Out-of-tolerance dimensions shall be highlighted. Out-of-tolerance items shall be resolved by means of correction or by waiver, depending on the sensitivity of the dimensions in question. Waivers will only be granted with the consent of the USN.

3.4.1.2 Material Reports

For each batch of material used, a report of the physical properties, in metric units, shall be submitted to the USN. Material documentation shall be traceable to point of manufacture. Where practicable, these properties should be confirmed by physical test of test specimens. Relevant dates shall be included.

3.4.1.3 Weight Reports

For each impeller, a metric weight report shall be prepared listing the weight of each component as follows:

1) Center disc with its own serial number.
2) Backplates with their own serial numbers.
3) Shrouds with their own serial numbers.
4) Left-hand blades with the serial number of each.
5) Right-hand blades with the serial number of each.

Note: This information is important as it enables selective replacement of damaged blades in situ without the need for re-balancing.

In addition, the collective weight of all other components, by category, shall be given.

After assembly, the completed impeller shall be weighed and its weight recorded:

1) Impeller assembly with its serial number and date of assembly.

3.4.1.4 Balancing Report

3.4.1.4.1 Blade Mass Properties

Each composite blade shall be balanced against a master balance blade. The blade shall balance horizontally and vertically at any two blade angles 90 degrees apart. The rotation of the blade caused by horizontal or vertical out-of-balance shall be stopped or reversed by an opposite moment of 0.36 Kgf-cm.

For the first article only, the weight and location of the center of gravity of each of the 26 blades shall be determined and recorded by serial number. Subsequently, three randomly selected blades for each impeller assembled shall be checked for center of gravity location.

3.4.1.4.2 Blade Mass Properties After Water Soak

For the first article only, the mass properties, including moment of inertia about the impeller centerline, of three randomly selected blades shall be determined and recorded before and after soaking in seawater (or equivalent salt water) for 24 hours. Any change shall be brought to the USN's attention immediately so that corrective action can be taken, e.g., additional sealing.

3.4.1.4.3 Static Balance

During assembly, the manufacturer shall use reasonable diligence to ensure that each impeller is fairly well balanced statically by the use of selective blade assembly (by weight).

Static balance shall be determined and recorded prior to dynamic balancing.

3.4.1.4.4 Dynamic and Static Balance Report

Following completion of balancing in compliance with paragraph 3.2.2.1, a balancing report shall be submitted for each impeller. This report shall include the blade mass properties report of paragraphs 3.4.1.4.1 and 3.4.1.4.2 and the moment of inertia of the impeller assembly as it exists prior to delivery, expressed in kg m^2 about the axis of rotation.

3.4.2 Delivery Reports (see also paragraph 5.2)

When an impeller is ready for delivery, it shall be accompanied by a Delivery Report. This package shall contain copies of the dimensional survey report(s), balancing reports, and the weight report pertaining to the impeller identified by its assembly serial number and dates of manufacture of components and date of assembly.

3.4.3 Structural Report

3.4.3.1 Structural Analysis and Design Justification

A report shall be prepared and delivered prior to issuance of an order for the first article, setting forth the structural analysis of the proposed design in detail. Strength and stiffness and fatigue life shall be addressed.

Based on the structural analysis conducted and material properties, the justification for the design-for-manufacture shall be presented with the structural analysis report.

3.4.3.2 Supporting Data

Any available test data or other relevant information supporting the structural analysis and justification shall be reported in appendices to the structural analysis and design justification report.

3.4.3.3 Competitive Nature of the Structural Analysis and Justification

The quality and depth of the structural analysis and supporting data shall be one of the major factors in evaluating competitive bids for a manufacturing order for HLCAC ACV lift fans.

3.4.4 Drawings

Drawings shall be prepared and maintained in accordance with MIL-T-31000 standards for mechanical engineering or equivalent. For composite components, NFT document DRL 176 or similar shall apply.

3.4.5 Technical Manuals

Source information shall be prepared to enable the USN to prepare technical manuals covering technical description, handling, installation and maintenance.

3.4.6 Test Plans and Procedures

Test plans and procedures shall be prepared in contractor format for development tests and qualification tests. An Acceptance Test Procedure shall be prepared and submitted to the USN for approval.

3.4.7 Configuration Control Requirements

The contractor shall maintain a configuration control system in accordance with DOD-STD-480 and MIL-STD-483 or equivalent.

3.5 <u>Logistics</u>

3.5.1 Maintenance

The impeller shall be designed to be maintainable and provide for easy regular inspections, periodic replacement of erosion protection film, and replacement of damaged blades.

3.5.2 Supply

The contractor shall propose methods to ensure economic availability of support resources concurrent with delivery of the equipment for test and evaluation, if required, for operational use.

3.6 Precedence

3.6.1 Precedence of Requirements

In the event of conflict between specified requirements, the following design disciplines shall be given precedence in the order in which they are listed:

a) Performance
b) Safety
c) Reliability
d) Maintainability
e) Producibility
f) Interchangeability
g) Transportability

3.6.2 Precedence of Documents

The last approved version of the specification shall be used. Where conflicts arise, the following document priority shall apply:

a) The contract
b) This document
c) Referenced documents

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Manufacturing Tolerances

The performance of a centrifugal lift-fan is very sensitive to certain critical dimensions and angles. It is, therefore, most important that fabrication drawings call out suitable tolerances and that the manufactured article meets these tolerances. Otherwise, the design point performance may not be met, with undesirable consequences to the craft performance.

The manufacturing drawings shall reflect the following tolerances, expressed here as percentages of the nominal design dimension and in absolute degrees for angles.

4.1.1 Impeller Diameter

Impeller diameter shall be interpreted to mean the diameter of the circumscribing circle, which touches each blade trailing edge. The radius of a coaxial circle, whose center is coincident with the fan shaft longitudinal axis when measured to each blade trailing edge, shall not depart from one-half of the nominal impeller diameter by more than ± 0.25% at any point along the blade trailing edge.

Example: The nominal design impeller diameter as defined above is to be 1600.2 mm. The radius from the shaft axis to any point on the blade trailing edge shall not exceed 802.1 mm (+0.25% * diameter) nor be less than 798.1 mm (–0.25% * diameter).

4.1.2 Blade Width at the Trailing Edge

The blades shall be replaceable in situ, therefore strict tolerances apply.

Blade width shall be interpreted to mean the length of the blade trailing edge, which lies on the circumscribing cylinder, coaxial with the fan shaft axis, whose diameter is nominally equal to the impeller diameter.

The blade width measured at the blade trailing edge, as described above, shall not depart from the nominal design value by more than ± 1 mm (.0033 ft).

Example: The nominal design blade width of all blades, as defined above, is to be 325.4 mm (12.808 in). The measured width of any blade shall not exceed 326.4 mm nor be less than 324.4 mm.

4.1.3 Impeller Width at the Leading Edge

Similarly, the width of the blade at the leading edge is to be the length, which lies on a cylinder co-axial with the fan shaft axis, which touches the leading edge nose radius of each blade.

4.1.4 Blade Angle

The fan blade angle shall be defined on the impeller drawing by any of the standard methods, for example, as the angle between the blade section nose-tail line and a radial line through the fan axis on the blade trailing edge. In any case, no actual blade angle anywhere along the blade span shall depart from the nominal design blade angle by more than $\pm 0.5^{o}$. Also, the mean blade angle represented by the average of all blades, with three measurements per blade to be made at each end and at mid span, shall not depart from the nominal design blade angle by more than $\pm 0.25^{o}$ of arc. The blades are replaceable in situ, therefore, a positive indexing fit must be incorporated in the attachment design.

4.1.5 Other Dimensions

All tolerances for other dimensions shall be in accordance with good engineering practice for this type of rotating machinery. Final drawings showing all tolerances shall be subject to review by the USN or its designated agent prior to approval for manufacture.

4.1.6 Double-Width, Double-Inlet Fans (DWDI)

For the purpose of tolerances and measurements, the impeller of a DWDI fan shall be treated as two single-width, single-inlet impellers arranged back-to-back, with a common back disc which becomes the center disc.

4.2 <u>Non-Destructive Tests</u>

4.2.1 Balancing

Each impeller shall be balanced statically and dynamically after assembly. Balance shall be obtained by the addition of material to the impeller shroud near to the outer edge and between adjacent blades. Static balance shall be to 100 g*cm. For the dynamic balancing of the impeller assembly, two balancing correction planes shall be used. These planes shall be the planes which contain the outer edges of the two-impeller shrouds. The maximum unbalance in each correction plane shall be no greater than 50 g* cm.

4.2.2 Overspeed Impeller Test (First Article and Subsequent Impellers)

A completed and balanced impeller, which meets all the tolerances specified herein, shall be subjected to an overspeed test in an approved overspeed test facility such as the AMCA test facility.

The test shall be carried out in four stages for speeds of 100, 110, 120 and 125% of nominal design speed (2115 RPM). After each test speed, the impeller shall be examined for cracks and measured to determine if any permanent deformation (yield) has occurred. If any crack or measurable deformation has occurred, the test shall be suspended until remedial action has been taken and approved by the USN representative.

When the fan has operated at 2115 RPM for 30 minutes without cracking or permanent deformation, as revealed by subsequent examination, it shall be certified as having satisfied the overspeed test requirements of this specification.

Subsequent impellers which satisfy all the quality assurance criteria listed herein shall be subjected to overspeed of 2115 RPM for a period of 30 minutes, followed by examination and measurements exactly like those for the first article test.

4.2.3 Vibration (for information only)

After assembly of the fan, with the impeller mounted in its bearings attached to the volute and with the volute mounted in the ship structure or equivalent foundations, the vibration at the fan bearings shall not exceed a maximum velocity of 3 mm/s or a displacement of 0.04 mm when the fan is running at its design speed.

5.0 <u>PREPARATION FOR DELIVERY</u>

5.1 <u>Inspection</u>

5.1.1 Dimensional and Weight Check

Prior to assembly, all components shall be checked to ensure that they meet tolerances for material, finish and size as specified by the manufacturing drawings, individual part descriptions, and any other relevant documents. All principal parts shall be individually weighed, including all blades. Each blade, backplate, shroud, and center disc shall be marked with its serial number and weight.

After selective assembly of the impeller to minimize out-of-balance prior to balancing, a comprehensive inspection shall be carried out to measure and record all dimensions shown on the impeller drawing, including each blade trailing edge width (span), each blade angle, and each blade trailing edge radius, i.e., distance from the shaft centerline at each end and mid span of each blade, including the fan inlet diameter for each shroud. These key dimensions and other dimensions shall be entered on a chart for each impeller.

All out-of-tolerance dimensions and angles shall be so indicated on the chart. The chart shall be submitted to the USN representative with the other fan documentation prior to acceptance and delivery. The USN shall have the right to refuse to accept the impeller if any of the key dimensions are out-of-tolerance and corrective action acceptable to the USN cannot be made. The dimensional inspection of the impeller shall include checks for concentricity and perpendicularity between the shaft axis and the impeller discs and flange attachments, etc. All run-out and wobble shall be recorded on the fan inspection report, including both shrouds, the shroud inlet rings where they interface with the bellmouth lips, the centerplate at the outer diameter, and any other location where run-out or wobble is detected.

All dimensions are to be in metric units.

5.1.2 Material Inspection

All materials used in construction shall be verified with the fan manufacturing drawings and shall be listed on the fan inspection report. Any material distortion of the fan blades, shrouds and centerplates shall be recorded. Such distortion may affect the performance or structural integrity of the fan and may be cause for rejection.

Hardness checks shall be performed on the metallic components of the impeller, including bolts, to ensure that the material has been properly heat-treated and/or is in its appropriate work-hardened or annealed condition. All components supplied by subcontractor (e.g., titanium bolts) shall be accompanied with material certification documentation.

All FRP materials shall be constantly monitored during fabrication for conformance to material specifications.

5.1.3 Finish

The impeller and fan shall be inspected to ensure that the proper finishes and corrosion protection processes, if any, have been applied.

5.1.4 Blade Leading Edge Erosion Protection Inspection

The blade leading edge protection material shall be inspected for complete adhesion and freedom from bubbles and defects such as cracks, pits or non-uniformity.

5.2 Deliverable Documents

5.2.1 Drawings

For the first article and each subsequent fan delivered, two sets of as-built fan manufacturing drawings shall be supplied. The drawings shall specify the serial numbers of the fans to which they apply.

5.2.2 Fan Inspection Reports

For each impeller delivered, a completed inspection report shall be supplied clearly and boldly marked with the impeller serial number. It shall contain details of each of the 26 blades, including serial number, weight and measured dimensions, plus comments; likewise for each shroud, backplate, and the center disc.

The fan inspection report shall include, but not be limited to, the results of the dimensional check, the material inspection, the overspeed test report, and the table of key dimensions, together with any other relevant information.

5.3 Markings

Each impeller shall bear a non-metallic nameplate recording the manufacturer’s name, fan serial number, and date of manufacture.

The direction of rotation shall be clearly indicated by an arrow stamped on both sides of the impeller, clearly visible through the fan inlet bellmouths.

5.4 Packing

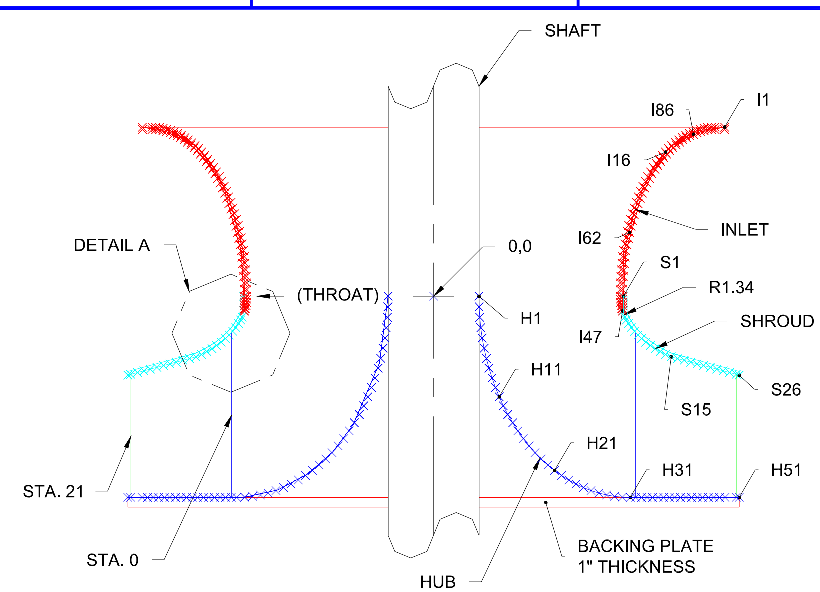
Each impeller shall be delivered mounted on a timber skid or frame, in a strong container, with adequate shock protection to prevent damage if the fan is jarred during transit. The packing shall be such that the impeller is undamaged if the container is dropped 0.6 m in any attitude.

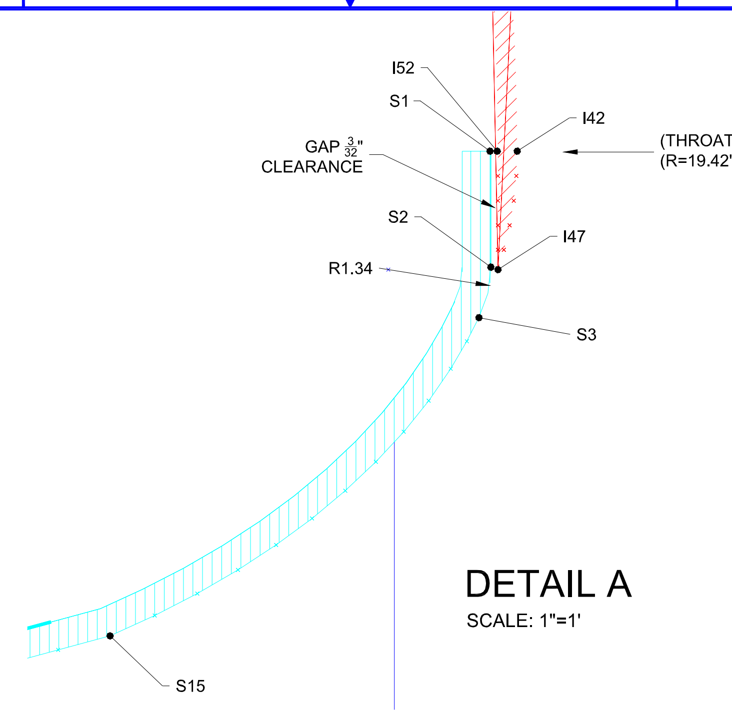
5.5 Warranty

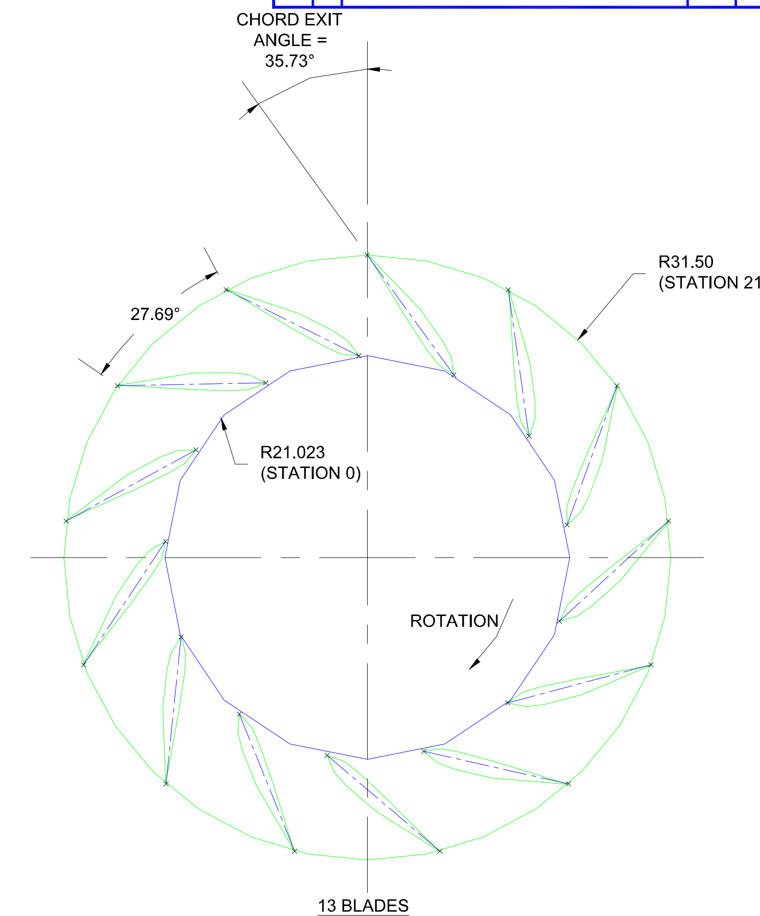
Each fan shall be guaranteed for one year against defects of material and workmanship. However, defects of design discovered subsequently in later impellers requiring re-work or replacement of entire impellers shall invoke similar corrective action on all previously delivered impellers.

6.0 NOTES

1) It is the responsibility of the shipbuilder to ensure that this specification is in compliance with such additional requirements, restrictions and regulations as may be applicable for military or naval use in the United States.







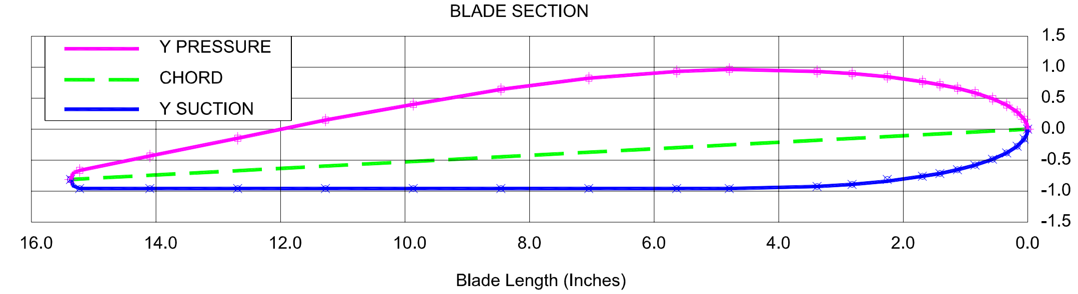
INLET POINTS						
Dim in Inches						
Point #	Outside Radius	Length		Point #	Inside Radius	Length
I1	30.300	17.598		I93	30.300	17.348
I2	29.300	17.598		I92	29.300	17.348
I3	28.912	17.585		I91	28.922	17.335
I4	28.525	17.544		I90	28.544	17.295
I5	28.138	17.476		I89	28.168	17.228
I6	27.754	17.382		I88	27.793	17.135
I7	27.372	17.260		I87	27.421	17.015
I8	26.993	17.112		I86	27.052	16.869
I9	26.618	16.938		I85	26.686	16.697
I10	26.247	16.737		I84	26.324	16.499
I11	25.880	16.511		I83	25.967	16.276
I12	25.519	16.259		I82	25.615	16.028
I13	25.163	15.982		I81	25.268	15.755
I14	24.814	15.680		I80	24.928	15.457
I15	24.472	15.355		I79	24.594	15.136
I16	24.137	15.005		I78	24.268	14.792
I17	23.811	14.633		I77	23.950	14.425
I18	23.492	14.237		I76	23.639	14.035
19	23.183	13.820		I75	23.338	13.624
I20	22.883	13.382		I74	23.046	13.192
I21	22.593	12.923		I73	22.763	12.739
I22	22.314	12.444		I72	22.490	12.267
I23	22.045	11.946		I71	22.228	11.776
I24	21.787	11.429		I70	21.977	11.267
I25	21.541	10.895		I69	21.737	10.740
I26	21.307	10.344		I68	21.509	10.197
I27	21.085	9.777		I67	21.293	9.638
I28	20.876	9.195		I66	21.089	9.064
I29	20.679	8.599		I65	20.898	8.477
I30	20.497	7.990		I64	20.719	7.876
I31	20.327	7.368		I63	20.554	7.263
I32	20.172	6.735		I62	20.403	6.639
I33	20.030	6.091		I61	20.265	6.005
I34	19.903	5.438		I60	20.141	5.361
I35	19.791	4.777		I59	20.031	4.709
I36	19.693	4.108		I58	19.936	4.050
I37	19.610	3.433		I57	19.855	3.384
I38	19.541	2.753		I56	19.788	2.714
I39	19.488	2.068		I55	19.737	2.039
I40	19.450	1.381		I54	19.700	1.361
I41	19.427	0.691		I53	19.677	0.681
I42	19.420	0.000		I52	19.670	0.000
I43	19.431	-0.323		I51	19.670	-0.323
I44	19.463	-0.645		I50	19.670	-0.645
I45	19.517	-0.966		I49	19.670	-0.966
I46	19.593	-1.285		I48	19.670	-1.285
I47	19.670	-1.543		I47	19.670	-1.543

HUB POINTS		
Dim in Inches		
Point #	Radius	Length
H1	4.725	0.000
H2	4.747	-1.096
H3	4.811	-2.190
H4	4.919	-3.277
H5	5.069	-4.355
H6	5.262	-5.422
H7	5.496	-6.473
H8	5.771	-7.507
H9	6.087	-8.520
H10	6.442	-9.510
H11	6.835	-10.474
H12	7.266	-11.409
H13	7.733	-12.313
H14	8.235	-13.183
H15	8.770	-14.017
H16	9.338	-14.812
H17	9.936	-15.567
H18	10.563	-16.279
H19	11.217	-16.947
H20	11.897	-17.568
H21	12.600	-18.141
H22	13.325	-18.664
H23	14.069	-19.136
H24	14.831	-19.556
H25	15.608	-19.922
H26	16.399	-20.234
H27	17.200	-20.490
H28	18.011	-20.690
H29	18.829	-20.833
H30	19.651	-20.919
H31	20.475	-20.948
H32	21.055	-20.948
H33	21.636	-20.948
H34	22.216	-20.948
H35	22.796	-20.948
H36	23.376	-20.948
H37	23.957	-20.948
H38	24.537	-20.948
H39	25.117	-20.948
H40	25.697	-20.948
H41	26.278	-20.948
H42	26.858	-20.948
H43	27.438	-20.948
H44	28.018	-20.948
H45	28.599	-20.948
H46	29.179	-20.948
H47	29.759	-20.948
H48	30.339	-20.948
H49	30.920	-20.948
H50	31.500	-20.948
H51	31.811	-20.948

SHROUD POINTS		
Dim in Inches		
Point #	Radius	Length
S1	19.764	0.000
S2	19.764	-1.511
S3	19.919	-2.169
S4	20.075	-2.476
S5	20.286	-2.835
S6	20.573	-3.251
S7	20.899	-3.655
S8	21.262	-4.046
S9	21.661	-4.423
S10	22.095	-4.784
S11	22.563	-5.129
S12	23.062	-5.455
S13	23.591	-5.762
S14	24.147	-6.048
S15	24.730	-6.314
S16	25.407	-6.496
S17	26.084	-6.679
S18	26.761	-6.861
S19	27.438	-7.044
S20	28.115	-7.227
S21	28.792	-7.409
S22	29.469	-7.592
S23	30.146	-7.774
S24	30.823	-7.957
S25	31.500	-8.140
S26	31.811	-8.223

BLADE POINTS				
Dim in Inches				
Station	X	Y suction	Y pressure	Radius
0	0.000	0.000	0.000	0.248
1	0.056	-0.158	0.158	
2	0.169	-0.276	0.276	
3	0.338	-0.383	0.389	
4	0.564	-0.485	0.491	
5	0.846	-0.581	0.586	
6	1.128	-0.654	0.660	
7	1.410	-0.716	0.716	
8	1.692	-0.761	0.767	
9	2.256	-0.840	0.846	
10	2.820	-0.891	0.897	
11	3.383	-0.925	0.930	
12	4.793	-0.959	0.964	
13	5.639	-0.959	0.930	
14	7.049	-0.959	0.823	
15	8.459	-0.959	0.643	
16	9.868	-0.959	0.400	
17	11.278	-0.959	0.147	
18	12.688	-0.959	-0.147	
19	14.098	-0.959	-0.434	
20	15.226	-0.959	-0.665	
21	15.372	-0.812	-0.812	0.147

BLADE SECTION



NOTES:

1) INLET SHAPE IS ELLIPTICAL AND IS BASED ON 1/4" INLET WALL THICKNESS WITH A 1/4" ALLOWANCE FOR VOLUTE WALL THICKNESS.
2) SHROUD THICKNESS IS TBD. DRAWING USES 3/8"
3) BLADE LEADING EDGE AND TRAILING EDGE RADIAL LOCATIONS ARE BASED ON STATION "0" AND STATION "21" RESPECTIVELY.

-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	FIND NO	NOMENCLATURE OR DESCRIPTION	CAGE CODE	PART OR IDENTIFYING NO	MATERIAL/SPECIFICATION	ZONE
QUANTITY																

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
DRILLED HOLES SEE AND-10387
.X=±.050 FRACTIONS ±
.XX=±.015 ANGULAR ±
.XXX=±.005 THREADS CLASS 2
BREAK SHARP EDGES
SURFACE ROUGHNESS
SHEARED, DRILLED, SAW CUT, ROUGH MACHINE OR STOCK FINISH ACCEPTABLE
WHERE GOVT. SPEC. INDICATED, EQUIV. NATIONALLY RECOGNIZED NON-GOVT. SPECS. ACCEPTABLE, EXCEPT FOR MIL-STD-242 ITEMS.
MFG. TYPE AND NUMBER STATED FOR REF. ONLY; COMPONENTS AND/OR MATL. OF EQUAL SPECS., ACCEPTABLE.

THIRD ANGLE PROJECTION

CAD — THIS DRAWING HAS BEEN COMPUTER GENERATED USING AUTOCAD. DO NOT MAKE MANUAL CHANGES.

DO NOT SCALE DRAWING

INTERPRET DRAWING IN ACCORDANCE WITH ASME Y14.100M

NEXT ASSY | USED ON
APPLICATION

CONTRACT NO. GS23.45.0126

APPROVALS	DATE
DRAWN WMB	7-1-03
CHECKED J.P.	7-1-03
ENGR J.P.	7-1-03
DESIGN ACTIVITY J.P.	7-1-03

CDI — BAND, LAVIS & ASSOCIATES
A division of CDI Government Services
900 RITCHIE HIGHWAY, SEVERNA PARK, MD 21146
TELEPHONE: (410)544-2800

TITLE: HLCAC LIFT-FAN IMPELLER AND BELLMOUTH

SIZE: D | CAGE CODE: 9N195 | DWG NO. 755-01 | REV. -
SCALE: 1 1/2" = 1' | CALC.WT | ACT.WT | SHEET 1

REVISIONS: REV | ZONE | LTR | DESCRIPTION | DATE | APPROVED

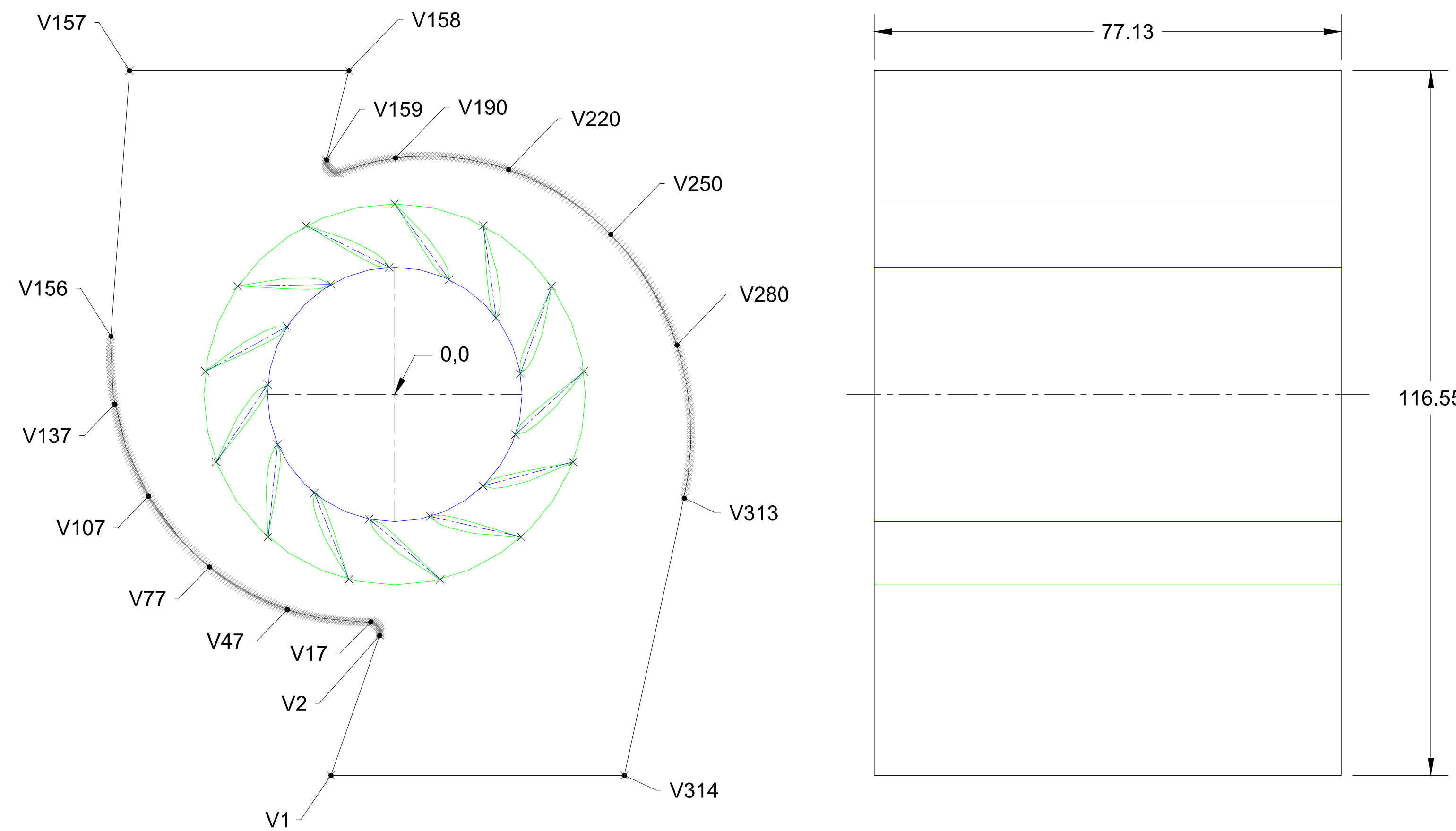
CDIM-SDD DWG. #755-01 Lift Fan Impeller and Bellmouth

										SHT
-	-	-	-	-	-	-	-	-	1	SHT
-	-	-	-	-	-	-	-	-	-	REV

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

NOTE:

1. TONGUE RADIUS OF 1.7325" WAS USED.



VOLUTE

Point #	X	Y
V1	-10.523	-63.000
V2	-2.496	-39.884
V3	-2.439	-39.684
V4	-2.407	-39.479
V5	-2.400	-39.271
V6	-2.418	-39.064
V7	-2.461	-38.861
V8	-2.527	-38.664
V9	-2.617	-38.476
V10	-2.728	-38.301
V11	-2.860	-38.140
V12	-3.010	-37.996
V13	-3.176	-37.871
V14	-3.356	-37.767
V15	-3.547	-37.685
V16	-3.746	-37.627
V17	-3.951	-37.593
V18	-4.407	-37.606
V19	-4.863	-37.615
V20	-5.320	-37.617
V21	-5.778	-37.615
V22	-6.237	-37.606
V23	-6.696	-37.593
V24	-7.156	-37.573
V25	-7.617	-37.549
V26	-8.077	-37.518
V27	-8.539	-37.482
V28	-9.000	-37.441
V29	-9.462	-37.394
V30	-9.924	-37.341
V31	-10.386	-37.283
V32	-10.848	-37.219
V33	-11.311	-37.150
V34	-11.773	-37.075
V35	-12.235	-36.994
V36	-12.696	-36.908
V37	-13.158	-36.816
V38	-13.619	-36.718
V39	-14.079	-36.615
V40	-14.540	-36.506
V41	-14.999	-36.391
V42	-15.458	-36.271
V43	-15.916	-36.144
V44	-16.374	-36.013
V45	-16.831	-35.875
V46	-17.286	-35.732
V47	-17.741	-35.583
V48	-18.195	-35.429
V49	-18.648	-35.269
V50	-19.099	-35.103
V51	-19.549	-34.932
V52	-19.998	-34.755
V53	-20.446	-34.572
V54	-20.892	-34.384
V55	-21.336	-34.189
V56	-21.779	-33.990
V57	-22.220	-33.785
V58	-22.660	-33.574
V59	-23.098	-33.357
V60	-23.534	-33.135
V61	-23.967	-32.908
V62	-24.399	-32.675
V63	-24.829	-32.436
V64	-25.257	-32.192
V65	-25.682	-31.942
V66	-26.105	-31.687
V67	-26.526	-31.426
V68	-26.944	-31.160
V69	-27.360	-30.889
V70	-27.773	-30.612
V71	-28.184	-30.329
V72	-28.592	-30.042
V73	-28.997	-29.749
V74	-29.399	-29.450
V75	-29.798	-29.147
V76	-30.195	-28.838
V77	-30.588	-28.524
V78	-30.978	-28.204
V79	-31.365	-27.880
V80	-31.749	-27.550
V81	-32.129	-27.215
V82	-32.506	-26.876
V83	-32.880	-26.531
V84	-33.250	-26.181
V85	-33.616	-25.826
V86	-33.979	-25.466
V87	-34.338	-25.101
V88	-34.694	-24.732
V89	-35.045	-24.357
V90	-35.393	-23.978

Point #	X	Y
V91	-35.737	-23.594
V92	-36.076	-23.205
V93	-36.412	-22.812
V94	-36.743	-22.413
V95	-37.070	-22.011
V96	-37.393	-21.603
V97	-37.712	-21.192
V98	-38.026	-20.775
V99	-38.335	-20.355
V100	-38.640	-19.930
V101	-38.941	-19.500
V102	-39.237	-19.067
V103	-39.528	-18.629
V104	-39.814	-18.186
V105	-40.096	-17.740
V106	-40.373	-17.290
V107	-40.645	-16.836
V108	-40.911	-16.377
V109	-41.173	-15.915
V110	-41.430	-15.449
V111	-41.681	-14.979
V112	-41.928	-14.505
V113	-42.169	-14.028
V114	-42.404	-13.547
V115	-42.635	-13.062
V116	-42.860	-12.574
V117	-43.079	-12.082
V118	-43.293	-11.587
V119	-43.502	-11.088
V120	-43.704	-10.587
V121	-43.901	-10.082
V122	-44.093	-9.573
V123	-44.278	-9.062
V124	-44.458	-8.548
V125	-44.632	-8.031
V126	-44.800	-7.510
V127	-44.962	-6.987
V128	-45.119	-6.461
V129	-45.269	-5.933
V130	-45.413	-5.402
V131	-45.551	-4.868
V132	-45.682	-4.332
V133	-45.808	-3.793
V134	-45.927	-3.252
V135	-46.040	-2.708
V136	-46.147	-2.163
V137	-46.247	-1.615
V138	-46.342	-1.065
V139	-46.429	-0.513
V140	-46.510	0.041
V141	-46.585	0.596
V142	-46.653	1.154
V143	-46.715	1.713
V144	-46.770	2.274
V145	-46.818	2.836
V146	-46.860	3.400
V147	-46.895	3.965
V148	-46.924	4.532
V149	-46.945	5.100
V150	-46.960	5.669
V151	-46.968	6.239
V152	-46.970	6.810
V153	-46.964	7.382
V154	-46.952	7.955
V155	-46.933	8.529
V156	-46.858	9.601
V157	-43.785	53.550
V158	-7.562	53.550
V159	-11.245	38.777
V160	-11.266	38.543
V161	-11.295	38.306
V162	-11.272	38.069
V163	-11.216	37.838
V164	-11.130	37.617
V165	-11.013	37.410
V166	-10.870	37.220
V167	-10.702	37.052
V168	-10.512	36.909
V169	-10.305	36.792
V170	-10.084	36.706
V171	-9.853	36.650
V172	-9.616	36.627
V173	-9.379	36.636
V174	-9.145	36.677
V175	-8.594	36.893
V176	-8.038	37.100
V177	-7.479	37.299
V178	-6.915	37.490
V179	-6.347	37.672
V180	-5.775	37.846

Point #	X	Y
V181	-5.199	38.012
V182	-4.620	38.168
V183	-4.037	38.317
V184	-3.450	38.456
V185	-2.860	38.587
V186	-2.267	38.708
V187	-1.671	38.821
V188	-1.072	38.925
V189	-0.470	39.019
V190	0.135	39.105
V191	0.742	39.181
V192	1.351	39.248
V193	1.963	39.306
V194	2.577	39.354
V195	3.193	39.393
V196	3.811	39.422
V197	4.430	39.442
V198	5.051	39.452
V199	5.673	39.453
V200	6.297	39.444
V201	6.922	39.425
V202	7.547	39.397
V203	8.174	39.359
V204	8.801	39.311
V205	9.429	39.253
V206	10.057	39.185
V207	10.685	39.108
V208	11.313	39.020
V209	11.942	38.923
V210	12.570	38.816
V211	13.197	38.698
V212	13.824	38.571
V213	14.450	38.434
V214	15.076	38.287
V215	15.700	38.129
V216	16.323	37.962
V217	16.945	37.785
V218	17.566	37.598
V219	18.184	37.400
V220	18.801	37.193
V221	19.416	36.976
V222	20.029	36.749
V223	20.639	36.511
V224	21.247	36.264
V225	21.852	36.007
V226	22.455	35.740
V227	23.055	35.463
V228	23.651	35.177
V229	24.245	34.880
V230	24.834	34.574
V231	25.421	34.257
V232	26.003	33.932
V233	26.582	33.596
V234	27.157	33.251
V235	27.727	32.896
V236	28.293	32.532
V237	28.855	32.158
V238	29.411	31.774
V239	29.964	31.382
V240	30.511	30.980
V241	31.052	30.568
V242	31.589	30.147
V243	32.120	29.718
V244	32.646	29.279
V245	33.166	28.831
V246	33.679	28.374
V247	34.187	27.908
V248	34.689	27.433
V249	35.184	26.950
V250	35.673	26.458
V251	36.155	25.957
V252	36.630	25.448
V253	37.098	24.931
V254	37.560	24.405
V255	38.014	23.871
V256	38.460	23.329
V257	38.899	22.779
V258	39.331	22.221
V259	39.754	21.655
V260	40.170	21.081
V261	40.578	20.500
V262	40.977	19.912
V263	41.368	19.316
V264	41.751	18.712
V265	42.125	18.102
V266	42.490	17.484
V267	42.847	16.860
V268	43.194	16.229
V269	43.533	15.591
V270	43.862	14.947

POINTS #	X	Y
V271	44.182	14.296
V272	44.492	13.639
V273	44.793	12.976
V274	45.084	12.307
V275	45.365	11.632
V276	45.637	10.951
V277	45.898	10.265
V278	46.149	9.573
V279	46.391	8.876
V280	46.621	8.174
V281	46.841	7.467
V282	47.051	6.755
V283	47.250	6.038
V284	47.439	5.317
V285	47.616	4.591
V286	47.783	3.862
V287	47.939	3.128
V288	48.083	2.390
V289	48.217	1.649
V290	48.339	0.904
V291	48.450	0.155
V292	48.549	-0.596
V293	48.637	-1.351
V294	48.714	-2.108
V295	48.779	-2.869
V296	48.832	-3.631
V297	48.873	-4.396
V298	48.903	-5.164
V299	48.921	-5.933
V300	48.927	-6.704
V301	48.921	-7.477
V302	48.903	-8.251
V303	48.873	-9.026
V304	48.830	-9.803
V305	48.776	-10.580
V307	48.710	-11.358
V307	48.631	-12.137
V308	48.540	-12.916
V309	48.437	-13.695
V310	48.321	-14.474
V311	48.194	-15.253
V312	48.053	-16.032
V313	47.813	-17.150
V314	37.941	-63.000

-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	FIND NO	NOMENCLATURE OR DESCRIPTION	CAGE CODE	PART OR IDENTIFYING NO	MATERIAL/SPECIFICATION	ZONE
QUANTITY																

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
DRILLED HOLES SEE AND-10387
.X=±.050 FRACTIONS ±
.XX=±.015 ANGULAR ±
.XXX=±.005 THREADS CLASS 2
BREAK SHARP EDGES
SURFACE ROUGHNESS
SHEARED, DRILLED, SAW CUT, ROUGH MACHINE OR STOCK FINISH ACCEPTABLE
WHERE GOVT. SPEC. INDICATED, EQUIV. NATIONALLY RECOGNIZED NON-GOVT. SPECS. ACCEPTABLE, EXCEPT FOR MIL-STD-242 ITEMS.
MFG. TYPE AND NUMBER STATED FOR REF. ONLY; COMPONENTS AND/OR MATL. OF EQUAL SPECS., ACCEPTABLE.

THIRD ANGLE PROJECTION

CAD

THIS DRAWING HAS BEEN COMPUTER GENERATED USING AUTOCAD.
DO NOT MAKE MANUAL CHANGES.

DO NOT SCALE DRAWING

INTERPRET DRAWING IN ACCORDANCE WITH ASME Y14.100M

NEXT ASSY	USED ON
APPLICATION	

CONTRACT NO.
GS23.45.0126

APPROVALS	DATE
DRAWN WMB	7-1-03
CHECKED J.P.	7-1-03
ENGR J.P.	7-1-03
DESIGN ACTIVITY J.P.	7-1-03

CDI
BAND, LAVIS & ASSOCIATES
A division of CDI Government Services
900 RITCHIE HIGHWAY, SEVERNA PARK, MD 21146
TELEPHONE: (410)544-2800

TITLE
HLCAC
ACV LIFT-FAN
VOLUTE

SIZE	CAGE CODE	DWG NO.	REV.
D	9N195	755-02	-

SCALE: 1"=1' CALC.WT ACT.WT SHEET 1

CDIM-SDD DWG. #755-02 Lift Fan Volute