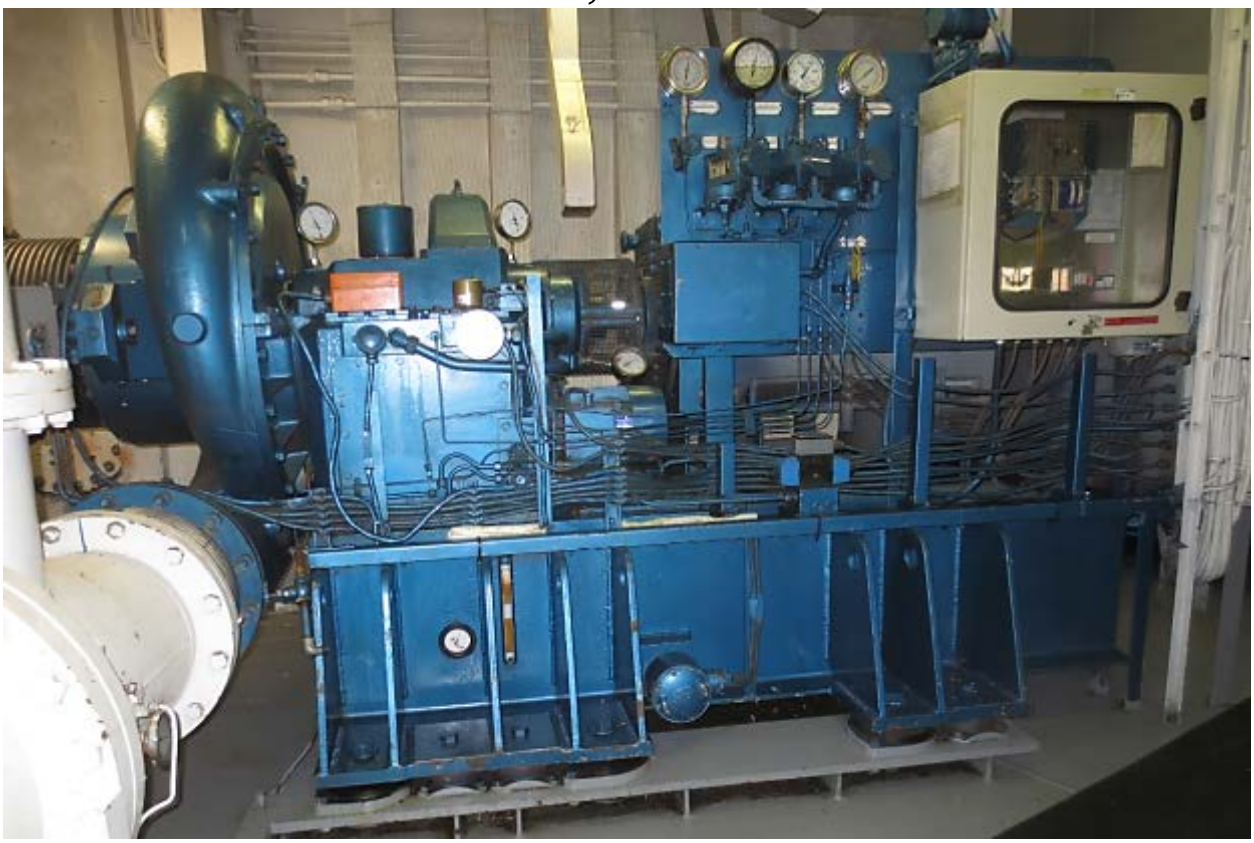
Statement of Requirements:
Supply of New Bubbler Compressors for the CCGS Henry Larsen
Jan 9, 2018



CANADIAN COAST GUARD
ATLANTIC REGION

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1 GENERAL

1.1 The Canadian Coast Guard vessel Henry Larsen is a 1200 class medium duty ice breaker displacing 6166 GRT. The vessel operates in the Gulf of St. Lawrence in the winter months and in Canada's high Arctic in the summer and fall. To assist in ice breaking the vessel utilizes an air bubbler system which blows low pressure air through nozzles in the hull, below the waterline, to help reduce ice friction or blow ice away from the hull. The bubbler system has multiple zones which are capable of being isolated and can also be used as a bow thruster for precise maneuvering.

1.2 The existing bubbler system is made up of two (2) separate units; one port and one starboard. Both units are comprised of; Compair Reavell Type 9006 CH Compressor, Rated Capacity 6.84 m3/sec, Press 1.61 Bar ABS , Blower Speed 11470 rpm coupled through a reduction gearbox to a 450kw , 4160vac , 60hz electric motor. Compressors are controlled locally in the bubbler compartment and remotely from the port and starboard bridge consoles.

1.3 The existing units are 30 years old, with reliability and supportability becoming an issue. The Coast Guard is seeking a suitable system that will be used to replace the existing bubbler compressor, starter and control panels in its entirety. Systems will be required to meet the minimum requirements listed, and will be evaluated accordingly.

1.4 The intent of this RFP is to supply new compressors, motors, 4160 starters and control panels and interconnecting controls. This will **NOT** include the existing bubbler valve control panel. The contractor will only replicate the existing interconnections between the compressor control panels and the valve control panel.

2 REFERENCES

2.1 References for existing equipment to be removed (2x)

a. Revelle Compressor 9006CH, serial number 9006CH101 and 9006CH102
   Capacity 6.84m3/s at 161 KPa absolute
b. Commander Electric Type 400HA-5R High Voltage contactor
c. Westinghouse compressor motor, Type HSB, 600HP, 1871RPM, 4160volts, 60Hz
d. Protech protection panel PK22
e. Ampower Canada Compressor control Panel

2.2 Drawings

Drawing Number	Description
13-0077-01	General Arrangement, Main Deck
22-0716-01	Air Bubbler system Diagram
RCS-0010-220	Bubbler blower & motor layout drawing
23-0716-02	Arrangement air bubbler (air inlet and outlet)
32-0800-02	Main Deck Plan Main Deck fwd
34-0821-01	Air Bubbler connection Diagram 1
34-0821-02	Air Bubbler connection Diagram 2
1110-16-0016-01	Seat for Unit 503 Zone 016 Air Bubbler Compressor Seat
1110-16-0016-03	Seats for Unit 505 Zone 016 Air Bubbler Machy. Compt. 821-01 Air Bubbler Starters
1110-16-0016-03	Seats for Unit 503 Zone 016 Air Bubbler Machy. Compt, Air Bubbler System Control Panel
E 39313 Shts 1 to 4	Compressor control panel
V15215-4-A2	W/H Control Mimic Assembly
V15337-6-A1	Bridge wing cntrl, bubble and bow thrust initiate
V15338-8-A1	Compressor Control and Valve Selection
V15340-6-A1	Valve Indication and Interlock
V15394-3-A0	Bubbler system control panel mimic
V15494-3-A2	Power supply main control relay panel
V15504-1-A2	General arrangement of system control panel
V153395-5-A1	Valve control and interlock
C7-194	IGV position vs air inlet temp
C7-195	Discharge pressure vs Air inlet temperature
TC7-196	Discharge pressure vs air flow at ambient temperature

3 SCOPE OF SUPPLY

3.1.1 The intent of this specification is to supply new compressors, motors, 4160 starters and control panels and interconnecting controls. This will NOT include the existing bubbler valve control panel. The contractor will only replicate the existing interconnections between the compressor control panels and the valve control panel.

3.1.2 The contractor must supply, test, and ensure satisfactory operation of two (2) electric motor driven, single-stage, integrally geared, single vane centrifugal compressor, local control panels, and compressor motor starters.

3.1.3 The anticipated install period will begin in April 2019 and all work will be completed in the 10 weeks during the scheduled refit period at the CCG base at 280 Southside Road, St. John's, Newfoundland.

3.1.4 All references to approval within this specification are defined as Class approval by one of the Recognized Organizations (RO) approved by Transport Canada within the Delegated Statutory Inspection Program (DSIP) and the Marine Machinery Regulations (CSA 2001).

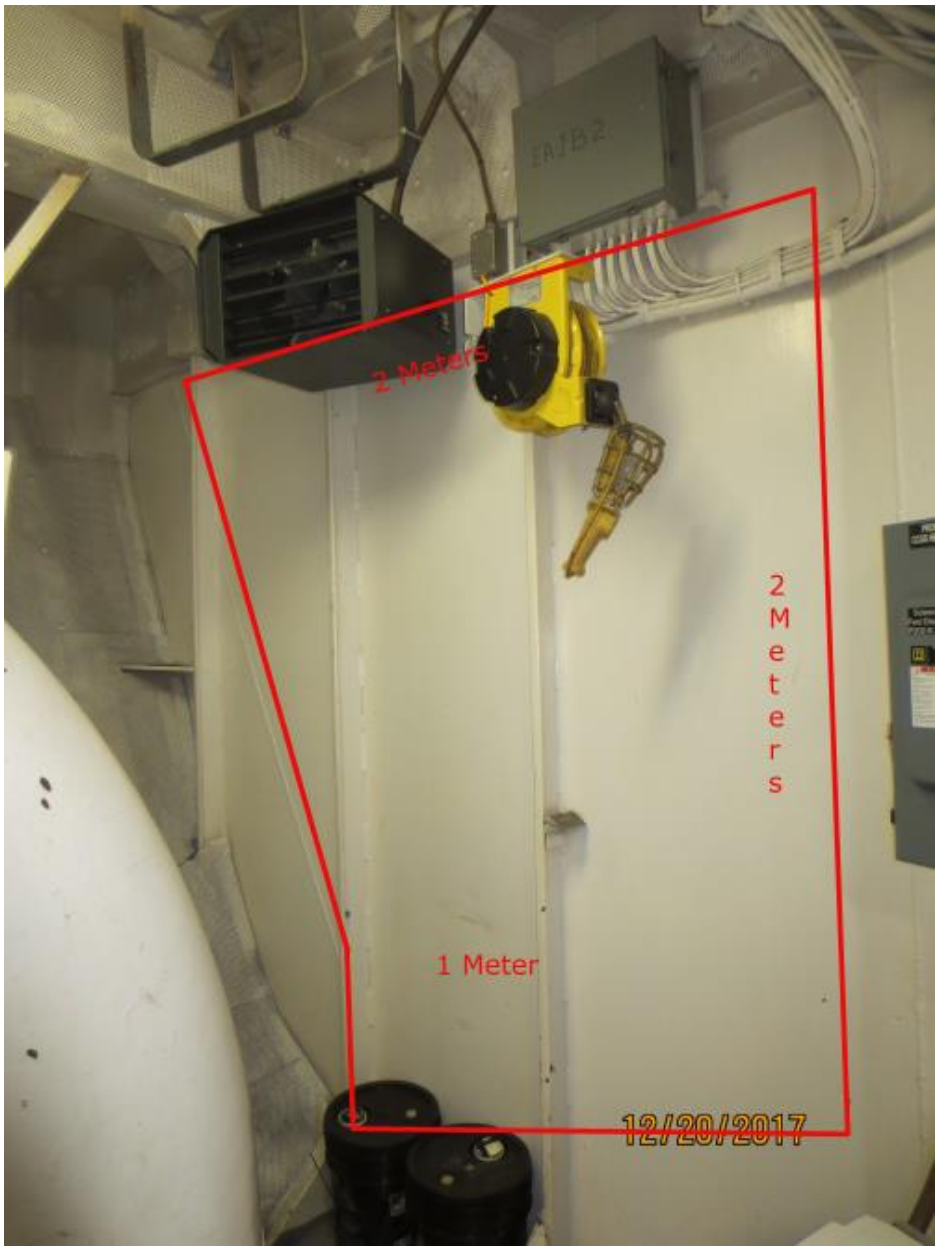
3.1.5 The existing compressor dimensions are included in the drawing package (RCS-0010-220 Bubbler blower & motor layout drawing). The contractor must supply full dimensional drawings showing that the new compressors and ancillary equipment will fit within the existing footprint.

3.1.6 The compressors, instrumentation, controls and all other equipment shall be provided as shown on the contractor supplied drawings, and as specified herein for a complete compressor system. All equipment specified in this section shall be designed and furnished by the Contractor, who shall be responsible for the suitability and compatibility of all included equipment.

3.1.7 The replacement system must provide all original functionality, meet or exceed original performance criteria of the attached technical specification. The system must be compatible with the existing ship's machinery Alarm and Monitoring system and be connected to existing supply and discharge piping.

3.1.8 The new systems must be resiliently mounted and must utilize the existing zone valve control system.

3.1.9 The compressor assembly shall fit through a space of approximately1000 mm x 2000 mm. The below picture shows the proposed access route for the new equipment. If required for entry, contractor shall provide details on how to disassemble the compressor into appropriate sized components and reassembly once components are inside the compressor compartment.

3.1.10 

3.1.11 The electrical service, including cables shall match that of the existing compressors. The existing electrical service is comprised of a single 3 conductor 1/O marine braid cable entering the bottom of each starter cabinet (2x) which is then fed to the main switchboard in the main control room. The contractor is to provide details on the proposed motor starter to ensure it fits in the required space vacated by the original starter. The contractor must show details on the cable entry and connection points. The original motor starters are 1240mm High, 960mmWide and 1000mm deep.

3.1.12 The new compressors, starters and control systems must currently be in marine service and must have Original Equipment Manufacturer (OEM) representation in Canada. The manufacturer's appointed service organization must hold a stock of essential spares and be capable of providing qualified field service representatives (FSRs), thorough component documentation support, with the capability to provide technical support for standard

overhaul as well as repair. The service organization must be capable of delivering these services and parts to St. John's, NL, within 24 hours of notification by the CCG.

3.1.13 The Contractor must provide two (2) sets of training courses to be held onboard the vessel after commissioning of the compressor system. Each course must be for up to 12 students for 4 hours. These courses must be conducted by the Contractor's technical representative and must as a minimum provide:

a) Overview of compressor systems.

b) Overview of compressor functionality and capability.

c) Compressor start-up procedures and safe operation.

d) Routine maintenance.

e) Trouble shooting methods.

4 STANDARDS

4.1 The requirements of the following standards must be complied with in supplying the compressor and control systems. Current editions of documents at the time of solicitation are to be used.

a) Rules and Regulations for the Classification of Ships (Lloyds Register or equivalent)
b) Canada Shipping Act, 2001 (CSA 2001)
c) Marine Machinery Regulations
d) Transport Canada Publications
e) TP127 – Ships Electrical Standards
f) IEEE 45: Recommended Practice for Electrical Installation on Shipboard

5 WELDING

5.1 Not Applicable

6 TECHNICAL REQUIREMENTS

6.1 The compressors will be used for supplying a variable volume of air to designated portions of the ship's hull according to the operation required. All items specified in this section shall be supplied by the contractor to provide a properly functioning compressor system. All components shall be new and suitable for Marine Environments and per the general environmental conditions specified in section 6.4. It shall be understood that components specified establish minimum requirements only, and do not relieve the contractor of responsibility for providing a properly functioning system.

6.2 The compressors shall be electric motor-driven, centrifugal single-stage centrifugal, vertical split type complete with integral gearbox, self-contained lubricating oil supply, dedicated local control panels, and accessories as described herein.

6.3 DESIGN CONDITIONS

1. Rated Capacity: 6.84 m^3/s
2. Design inlet pressure at blower inlet (P0): 161kpa abs
3. Design minimum inlet temperature: -40°C
4. Compressor turndown, % of capacity: 100% to 45%
5. The maximum db of the compressors 100db

B. Compressors shall be capable of delivering a flow of at least 6.84 m^3/s at ambient conditions ranging from -40°C to 35°C

C. Compressors shall not surge or exceed the nameplate motor rating over the entire range of operation. Compressor shall not exceed 450kw of total power per unit

6.4 GENERAL ENVIRONMENTAL CONDITIONS

The equipment shall be designated for the following service conditions:

a) Air temperature range of - 40°C to 35°C and shall operate without deterioration in air temperature peaks up to 55°C.

b) Water temperature, minus -2°C to plus 30°C.

c) Inclination in all directions from the mounting position 22.5°, rolling 22.5°, 10 seconds full period; and linear vertical acceleration of ± 1.0g.

d) A permanent list of 15° port or starboard, not cumulative with the roll.

e) Pitch of vessel, +/-12°, cycle frequency 6 seconds.

f) A permanent trim of 5° above or below the horizontal, not cumulative with the pitch.

g) Under the following conditions of relative humidity: – 95% r. h. at temperatures up to 35°C; and – 70% r. h. at all other relevant temperatures.

h) Shock loading: 2.5 g horizontal, 1.5 g vertical.

i) Under the following vibration conditions: – 2.0 - 13.2 Hz, displacement amplitude ± 1.0 mm; – 13.2 - 80.0 Hz, acceleration amplitude ± 0.7 g, maximum acceleration .7 g natural frequencies at supports for equipment and parts of equipment shall not lie within the 0 - 80 Hz range, except that where they cannot be kept outside this range by constructional design methods, the vibration shall be damped so that undue amplification is avoided.

j) Any conditions not mentioned to follow most current version TP127E or IEEE45-2002.

k) Any power cables, protection devices; breakers/fuses, alarm & Monitoring cables and control cables shall be TCMS approved, marine rated cables, PVC jacketed bronze armored, suitable for intended use.

6.5 FACTORY TESTING

Each compressor shall be tested in accordance with manufactures published test procedures

a) The compressor net delivered flow rate and discharge pressure shall be measured, recorded, and guaranteed with no negative tolerance.

b) Velocity vibration versus frequency levels shall be recorded within 10-1,000 and 10-10,000 Hz frequency range for both the compressor and motor for both sets.

c) The compressor motors operating winding and bearing temperatures, and operating currents will be recorded from start-up to full load. Meggar readings of the motor windings will be provided as well.

d) Upon completion of assembly, each compressor, motor, and oil lubrication system shall be functionally tested with the local control panel (LCP). Operational test should be done connected to all skid mounted instruments, electric valve actuators and ancillary equipment. All start/stop sequences and all safety/alarm systems shall be tested, simulating start of the compressor drive motor.

e) The alignment of the motor and compressors will be recorded

6.6 BEARINGS

Bearings shall be fitted with RTD's for temperature monitoring. The RTD sensors shall be connected to each control panel and have the ability to view the temperature in real time.

6.7 Inlet Guide Vanes

a) The purpose of the inlet guide vane system shall be to facilitate turndown of each compressor from 100% to 50% of capacity, while maximizing efficiency over the entire turndown range.

b) An adjustable inlet guide vane assembly shall be provided to pre-rotate incoming air, thus, maximize efficiency. Inlet guide vanes shall be made in an aerodynamic, streamlined design in cross-section and located in a radial fashion around the annular inlet to minimize downstream wakes. The inlet vanes shall not be used for capacity control.

c) Inlet guide vane position shall be controlled from the LCP and will provide indication of the vane position on each panel.

d) The inlet guide vane assembly shall be mounted integrally with each compressor, multi-leaf and pivoted. All vanes shall be mounted in permanently lubricated sleeve bearings. Operating linkages for inlet guide vanes shall be housed within the compressor. Compressors with variable vane assemblies located external to the compressor housing, and/or have ball-in-socket linkages or other moving parts requiring periodic lubrication shall not be acceptable.

e) Each variable vane assembly shall include a compressor casing mounted electric actuator, limit switches, and open/closed indication on the LCP.

f) The position of the vanes, from fully open to fully closed, shall be transmitted to the LCP. Position of the vanes shall be indicated by an adjustable manual lever arm and calibrated dial on the compressor casing. The inlet guide vane position shall be indicated on the LCP

6.8 Oil Lubrication System

a) A complete lube oil system shall be provided with each compressor, installed integrally with the compressor base and arranged to permit ease of accessibility for operation, maintenance,

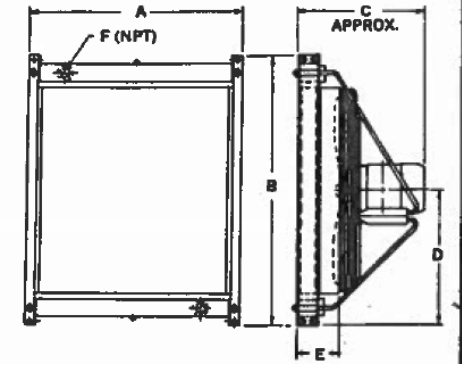
inspection, and cleaning. The system shall be factory assembled, consisting of main and auxiliary oil pumps, oil filter, oil cooler, pressure relief valve, and piping required for a complete system. All hose ends, tubing and fittings are to be stainless.

b) The electrical supply for heaters and pumps will be taken from the existing supply for the original compressors. (MCC #6 located in the Bubbler compartment, 575 volt, 3 phase 60Hz)

c) During equipment idle periods, while the vessel is operating without the bubbler system, the (i.e. the compressor is not in operation) electric oil pump shall operate to ensure the load bearing components are adequately lubricated to prevent wear from the vessel vibration and movement.

d) The oil filter shall be of the full flow, replaceable cartridge, duplex type with integral transfer valve, and capable of removing particles over ten (10) microns with a clean oil filter element pressure drop kept to a minimum. A visual gauge and electric switch connected to the LCP shall indicate when a filter is dirty and requires changing. Filters shall be designed such that changeover of the lube oil filters during operation is available.

e) Provide an air/oil cooler to maintain constant oil temperature and mount on each compressor skid. The cooler must be suitable for corrosive marine environment. The new oil coolers are intended to fit with-in the following dimensions. 800mm x 977mm x 478mm.



Model	Dimensions, Inches (mm)							Motor*		Fluid Cap. Gal. (l)	Shpg. Wt. lb. (kg)
	A	B	C	D	E	F (npt)	Fan Dia.	HP (kW)	RPM		
SB-1	12.5 (317.5)	17.5 (444.5)	18.5 (469.9)	8.8 (223.5)	5.4 (137.2)	0.75 (91.1)	9.0 (228.6)	0.5 (0.4)	3450	0.42 (1.6)	90 (40.8)
SB-2	17.0 (431.8)	23.5 (596.9)	17.0 (431.8)	11.8 (299.7)	5.8 (147.3)	1.0 (25.4)	14.0 (355.6)	0.75 (0.6)	3450	0.83 (31.4)	150 (68.0)
SB-4	26 (660.4)	33.3 (844.6)	18.8 (477.5)	16.6 (421.6)	6.3 (160.0)	1.25 (31.8)	22.0 (558.8)	1.5 (1.1)	1725	1.73 (6.6)	275 (124.7)
SB-6	31.5 (800.1)	38.5 (977.9)	18.8 (477.5)	19.3 (490.2)	6.2 (157.5)	1.5 (38.1)	27.0 (685.8)	2.0 (1.5)	1725	2.47 (9.36)	370 (167.8)

f) Provisions for an oil heater to heat the oil if the ambient temperature around the compressor falls below 10° C (50°F). The oil heater shall be designed to heat lightweight oil as required by OEM instructions. The heater operation shall be controlled by the LCP based on the oil reservoir temperature transmitter reading. The compressor shall not start unless the oil is above a minimum permissive limit. Low oil temperature warning indication shall be provided on each LCP.

6.9 EQUIPMENT BASE AND MOUNTINGS

a) A base sized to support the compressor, gearbox, motor, lubricating system, and accessories shall be supplied.

b) The base shall be fully self-supporting and mounted on Contractor supplied vibration isolators suitable to absorb the weight and vibration of the compressor assembly without undue stress or distortion.

c) The base and compressor assembly must be designed to withstand the forces exerted by the ship movements as specified in section 6.4.

d) The units shall be factory precision aligned on the base prior to shipment. After installation of all equipment the complete unit will be verified to be still with-in alignment specifications prior to shipment.

6.10 ELECTRIC MOTORS

a) The compressor motor horsepower shall be equal to, or in excess of, the maximum load that will be imposed at any point in the operating range of the design conditions specified. Each motor shall have a 1.15 service factor with Class "B" temperature rise at rated load and Class "F" insulation. Motors shall be supplied with lifting lugs. The motor at no point will exceed the 450KW rating for each system in normal operation.

b) Each Motor must have a stand still heater. The heater shall be wired to and controlled by the motor starter or compressor control panel.

c) All motors shall be suitable for operation on 4160volts/60 Hertz/3 phase power for ambient air temperature up to 40°C. Motors shall be suitable for reduced voltage start. The motor shall be designed to start on 90% of rated voltage.

d) Motors shall have factory installed fail-safe winding protection in each phase consisting of two embedded 3-wire, RTD temperature sensors per phase (one operational, one spare). Winding temperature RTD's shall connect to the LCP for monitoring and alarm. The temperature of each RTD will be able to be monitored at the local control panel.

6.11 AIR INLET, OUTLET AND BLOWOFF SILENCER

a) The new compressors must incorporate a custom bellows and adaptor piping of a minimum schedule 80 pipe to connect to the existing inlet, outlet and blow off piping. This will include a stainless steel bellows from the corresponding inlet/outlet/blowoff.

b) The current inlet bellows is Vokes Type EA10, size: 450mm N/BNP6 BS.4504

c) The current discharge bellows is Vokes EA08, size: 350mm NB/NP6 BS4504

d) The current blow off is 12" gooseneck leading ending on the foc'cle deck. The contractor will include dimensions and arrangement drawings for a silencer including minimum distance from compressor outlet. The contractor will supply pricing for an optional silencer to be included in the evaluated total.

6.12 INSTRUMENTATION

a) Instrumentation components shall be provided and mounted on the compressor skid, except as noted, with all electrical connections external to the skid, wired to the LCP by the Contractor. The following design parameters apply:

1. Butt type connectors for any connections shall not be used, only terminal strips are

acceptable. All wires shall be marked at both ends.

2. The LCP must be designed to withstand heavy vibration for icebreaking conditions and provided with compression style spring loaded terminal block isolators. Screw type isolators shall not be used.

3. Instrumentation must be designed for marine environments and shall be highly resistant to vibration.

b) Instrumentation and warning/status/alarm functions for each compressor must include, as a minimum, the following items. Digital and analog signals shall be indicated on the Operator Interface. Operator interface shall include the ability to change set points for testing and confirming functionality and accuracy.

1. Inlet air temperature gauge

2. Inlet air temperature sensor/transmitter, Inlet high temperature and recirculation surge indicator

3. Surge switch

4. Discharge air pressure gauge

5. Differential pressure (inlet/discharge) transmitter

6. Oil temperature sensor/transmitter, installed in the oil reservoir

7. Oil temperature gauge

8. Oil low pressure switch

9. Oil low-low pressure switch

10. Oil pressure gauge

11. Oil filter differential pressure indicator/switch – filter change warning

12. Low oil level switch

13. Inlet guide vane position transmitter and open/closed limit switches

14. Blow-off valve limit switches, integral with blow-off valve and capable of being wired to the LCP

c). The temperature monitoring system shall include 3-wire, RTD temperature sensors embedded in the motor windings (two per phase; one active, one spare) and one each per bearing of both the motor and compressor/gearbox. The system shall monitor and display actual winding and bearing temperature at the LCP. The LCP Operator Interface shall display an alarm when rising temperature levels reach the alarm set point, and then follow

with a compressor shutdown when temperature levels continue rising to the trip set point. The trip shall be displayed until the condition is corrected and the trip is acknowledged at the Operator Interface.

d) Pressure transmitters shall be 4-20 mA. Gauge pressure transmitters shall be supplied with a 316 stainless steel block and bleed valve for process isolation and calibration.

e) Process temperature sensors (inlet/discharge air, lube oil) shall be RTD, 3- or 4-wire, assembled to a termination head that houses the temperature transmitter. Temperature sensors installed into the compressed air stream or lube oil system shall include a 316 stainless steel thermo well.

f) A shaft vibration monitoring system must be furnished for each compressor and motor. The system must include:

1. A vibration transmitter must be installed on the compressor gearbox casing to alarm and shutdown on excessive vibration.

2. Motor velocity type vibration transmitters (2 each): The instrument shall be a combination vibration sensor/transmitter and be mounted over the bearing on each end of the motor.

g) The LCP shall receive, and the Operator Interface must numerically display, the vibration signals. The Operator Interface shall include an adjustable alarm feature on the rising vibration levels that first alarms and is followed by unit shutdown. The alarm/shutdown shall be displayed until reset. Provide necessary hardware for direct communication between vibration probes, PLC, and Operator Interface. All components shall be designed to be highly resistant to vibration.

h) Two modes of operation shall be selectable, ice breaking mode and thruster mode. For ice breaking mode, contractor shall coordinate with CCG on agreeable alarm and trip vibration set points to avoid nuisance alarms, while still protecting the machine.

i) The LCP will have the ability to trend and record all parameters in this section to an external memory card. Fully licensed software to view the recorded parameters will be provided.

6.13 LOCAL CONTROL PANEL (LCP)

a) Each compressor must be furnished with a skid-mounted sequencing panel. The control panel shall be mounted on anti-vibration mounts for withstanding in both the vertical and horizontal planes. All instruments and controls on the skid shall be factory wired to the skid-mounted LCP. All controls and instruments shall fail into a safe condition. The controls shall be designed such that the compressor cannot operate unless the controls are energized, nor can they operate with any defective controls. Vibration mounts shall be designed to withstand the vibration and forces specified in section 6.4 of this Specification.

b) The control panel must have a minimum IP55 rated enclosure fitted with a hinged door for front access.

c) Each compressor LCP must contain controls for compressor motor starting, surge and overload detection, shutdown control and sequencing, alarm and emergency shutdown systems, inlet guide vanes, blow-off valve, and the oil lubrication system operation. The Compressor LCP must be capable of seamless interface with the existing Bubbler Master Control Panel & Bridge System.

d) Each LCP must contain a main power disconnect, which will be fed from the existing power feed P101-12-2(120Vac) for port and P101-12-3(120VAC) for stbd. Starters for variable vane operators, air/oil cooler, and oil pump shall be mounted inside the panel. Provide for power distribution to feed motorized valve motor controllers located at the valves. Note: This is for the original control voltage only. The contractor may utilize 575volt, 3 phase, 60Hz supply if required in the same space. Currently, lube oil heaters, pumps and ancillary equipment is fed from 575volt supply with separate 120volt control. The contractor must provide details of voltage required for the intended control panel.

e) Surge suppressors must be provided for "noise" protection and to remove transient peaks across all inductive loads. No MOV's will be allowed for surge suppression.

f) Isolation amplifiers, R/I transmitters, RTD/vibration transmitters, and other controls must be supplied, as required, for complete system control.

g) The contractor must identify each end of each wire by a unique wire number printed on a heat shrunk sleeve marker.

h) The LCP must be provided with indicating lights, selector switches and pushbuttons to allow for operation and monitoring. Full monitoring and operation of the compressor should be available through the use of the selector switches, indicating lights and push buttons

i) The LCP will contain a display screen, the Operator Interface shall provide easy access to all functions that operating personnel will need for operation and maintenance of the compressor. The controls/displays shall generally be functionally grouped as operations, service, alarms/trips or configuration. Access to these separate control functions shall always be displayed in the form of a touch-sensitive screen point selection button/tab on each operator interface screen and be accessible by one-touch selection. The following general design protocol shall be followed:

    1. A main operations page shall be provided that consolidates the basic control functions on one screen, including: start and stop control, local and remote operating mode selection, important operating status message display, capacity increase and decrease control, capacity indication in % and motor amperage indication. All operating parameters and transmitter values shall be accessible from the main operations page. If multiple pages are required to display operating data, navigation between pages shall be simple and obvious to the operator, in the form of one-touch selection buttons or tabs. Operating data shall be organized and clearly identified to facilitate fast and easy viewing by the operator.
    2. A service page shall be provided to allow maintenance and troubleshooting of the compressor controls and ancillary devices. From the service page, one-touch selection buttons shall be provided to select the normal mode of operation or the service mode of operation.

3. In the event that an alarm or trip is detected, there shall be a message displayed and/or a visual indication of the presence of an alarm on the main operations page. An alarm/trip status page shall be accessible from any other page or mode of operation with a one-touch push button selection. The Alarm/Trip status page shall give a listing of all active alarms or trips with a detailed description of each and the time of occurrence. All alarms, once corrected, may automatically be cleared without acknowledgement. However, any trip condition shall require an operator to acknowledge the trip condition after it has been corrected by a one-touch selection button on the alarm/trip page. Compressor start shall be inhibited if there are any active alarms. The control system shall also prevent a re-start of the compressor until all trips are corrected and acknowledged. A horn shall sound (and a beacon shall illuminate) when any alarm or trip condition occurs to alert plant operating personnel. A one-touch selection button on the alarm/trip page shall be provided to silence the alarm horn.
4. A configuration page shall be provided which includes power-up default settings. The power-up default settings will determine the control mode the compressor will be in upon power up of the LCP. The configuration page shall also include a Test Mode that diverts main motor starter start signal to test logic that simulates motor start to facilitate testing of the control system without starting the drive motor.

j) Additional selector switches, pushbuttons, and indicators shall include:

1. Emergency stop mushroom button on panel door
2. Separate, non-resettable hour meter on panel door
3. In addition to the OIT indicating lights, pushbuttons shall be provided to allow for operation and monitoring of the compressor in the event that the OIT is inoperable or Operator prefers not using the OIT.

k) The Operator Interface shall display and monitor all analog signals, including, but not limited to:
1. Motor amps
2. Inlet guide vane position
3. Temperature signals
4. Pressure signals
5. Vibration signals

l) The compressors shall start under an automatic sequence initiated by the local start signal or the remote start signal (i.e. bridge or Bubbler Master Panel) when in remote/auto control. Upon signal to start, the LCP shall confirm the inlet guide vanes are at minimum, the blow-off (bypass) valve is open, and the discharge valve (if used) is properly positioned, and bubbler vent doors are opened. All vanes and valves are equipped with limit switches on both the open and closed position to indicate position. Bubbler vent doors are provided with proximity switches to indicate open or close position of doors. If components are not properly positioned, they shall be moved to their respective start positions automatically by the control panel with the exception of bubbler vent doors. These must be manually opened by ships staff. The LCP will indicate the status of all permissive's in real time so that remedial action can be taken if a permissive is not met.

m) The oil pre-lubrication system shall energize and run for the minimum time as required by the compressor manufacturer. Once all pre-start permissives are confirmed, the compressor motor shall be started. A feedback signal from the main motor starter shall confirm the main drive motor starter has been energized. When the compressor reaches operating speed, as determined by the motor start sequence, the controls shall open the inlet guide vanes and electrically actuated discharge valve (if used), close the blow-off (bypass) valve, stop the electric oil pump, and release control of the inlet guide vanes to local/remote control. If the components are not correctly positioned, interlocks shall prevent compressor operation after a pre-set delay time. Provide sequence fail alarm and trip if any portions of the start, run, or stop sequence are not properly executed. The Operator Interface shall annunciate the function that caused the trip.

n) The surge detection system shall sense unbalanced/surge conditions by use of pressure sensing devices. Detection of surge conditions shall trip the compressor off-line.

o) Motor overload protection must be provided to control the maximum vane setting on the compressor, so that motor current does not exceed a pre-set level.

p) The output of the compressor shall be graphically and numerically displayed on the operator interface as a percentage of maximum capacity from 0 to 100%.

q) There shall be three means of shutting down the compressor:

1. Normal Stop – Initiated by pushing the stop button on the Operator Interface or remote stop. The unit normally stops such that no surging occurs.

2. Soft Stop – Initiated by:
   i. High oil temperature
   ii. High inlet air temperature (recirculation/surge)
   iii. High motor winding temperature
   iv. High bearing temperature (compressor or motor)
   v. Discharge valve has not fully opened within two (2) minutes after feedback signal from main motor starter
   vi. Blow-off valve has not closed within five (5) minutes after feedback signal from main motor starter
   vii. High discharge temperature or pressure
   viii. High motor amps
   ix. Surge

   Soft stop shall de-energize the main drive motor eight (8) seconds after alarm initiation to allow the blow-off valve to partially open. Normal post-lube and other normal stop functions follow.

3. Emergency Stop – Initiated by:
   i. Pushing emergency stop button
   ii. Low-low oil pressure

iii. High vibration
iv. No feedback signal from main motor starter during Start Sequence
v. Loss of feedback signal from main motor starter during Normal Operation
vi. Sequence failure during start-up
vii. Stop sequence failure during shutdown (vanes not at minimum, discharge valve not closed, blow-off valve not open within 120 seconds of issuing a stop command).

Emergency stop shall de-energize the main drive motor immediately. Normal post-lube and other normal stop functions follow.

r) The high inlet air temperature (recirculation) alarm and the zero speed switch shall be active when there is no main motor feedback present at the LCP from the main motor starter. The purpose of these sensors is to detect reverse air flow through the compressor and reverse rotation of the impeller.

6.14 BUBBLER MASTER CONTROL PANEL (MCP)

The following connections will have to be provided from the compressor control panel to the existing MCP. List is for one compressor only, a duplicate set of contacts will be needed for the opposite compressor.

a) Remote start signal consisting of a Normally open/Normally closed (NO/NC) set of contacts.
b) NO/NC for compressor running
c) NO/NC contact for stopping of compressor
d) NO/NC contact for low oil pressure ok
e) NO/NC contact for compressor failure
f) BOV open indicating lamp in panel
g) BOV Closed indication in panel

6.15 Cables to be removed

a) Not applicable

6.16 Cables to be renewed

a) Not Applicable

7 QUALITY ASSURANCE

7.1 START-UP

A. The Contractor shall provide a fully trained technician with a minimum of 5 years' experience to inspect the final installation and supervise the field start-up tests of the equipment. The services shall be provided for a minimum of four (4), eight-hour (8-hr.) days for each unit.

B. Compressors and controls – Initial Start-Up

1. Provide, as a minimum, the following field commissioning:
   a) Visually inspect for proper connection of piping and installation of accessories
   b) Run motor uncoupled to verify motor rotation and operation.
   c) Field precision align drive motor to the compressor.
   d) Check leveling of compressor base
   e) Confirm proper local control panel (LCP), master control panel (MCP), Bridge Control Panel terminations for all field installed instruments and devices.

2. A minimum four (4) hour field run test(to start after all temperatures have stabilized at their maximum levels) shall demonstrate that, under all conditions of operation, each unit:
   a) Has not been damaged by transportation or installation
   b) Has been properly installed
   c) Has no mechanical defects
   d) Has fully functional controls and instrumentation
   e) Will start, run, and stop in the prescribed manner
   f) Will run through the entire range of specified pressure and flow
   g) Has the proper shutdown sequence of standard stop, soft stop, and emergency stop
   h) Is free of overheating of any parts
   i) Is free of objectionable vibration and unusual noise
   j) Is free of overloading of any parts
   k) Inlet guide vanes are automatically positioned by the control system according to the efficiency optimization algorithm.

C. Contractor must provide a qualified Certified Field Service Representative (FSR), to be present during two (2) five (5) day sea trials. FSR must be available to make compressor adjustments and training as required during the sea trial. There will be training for both shifts. At least one Sea Trial shall be arranged to occur during ice conditions with FSR. During this Sea Trial, vibration system shall demonstrate that unnecessary vibration trips (nuisance alarms) are not present during ice breaking mode.

8 DELIVERABLES

8.1 Documentation

NOTE: All documentation shall be provided in electronic PDF format, bookmarked and searchable.

8.1.1 The Contractor must supply Canadian Coast Guard Technical authority with (3) hardcopies and (1) electronic copy of all the following to the TA

a) All readings, videos (electronic only), photos, tests, defects.

b) All hardware manuals from as-fitted equipment in English and an electronic copy of French to be provided if available from manufacturer.

c) All engineered drawings in Cad and pdf format.

d) Electrical drawings will show as a minimum
- Interconnects to all shipped loose equipment
- Full wiring diagram showing all connections (ladder diagram)
- Door layout
- Interior layout

e) All modified drawings from original in Cad and pdf format

f) Complete listing of service FSR's and location for installed equipment.

g) Hard copies of all software (including PLC programs) on OEM supplied discs with installation procedures for all PLC's and equipment specific software.

h) All calibration and service procedures required for replacement of any components of new system

i) A full priced listing with part numbers of all parts used with contact info for ordering.

j) OEM specification sheets of all components with the exact revision and part number identified.

k) Procedures for functional testing of the entire package, including oil lube system, instrumentation, ancillary components and control panels

l) Instrument alarm and trip set points

8.1.2 **Final Detailed Design Submittal –** a final revised and detailed version on the initial design proposal indicating any changes or modifications made**.**

8.1.3 **Removal and Install Scope of Work.** – shall include final engineering drawings and technical specifications for the installation on new bubbler units, and control systems.

8.1.4 **Torsional Critical Speed Analysis Report** - conducted to ensure the compressor, motor, and coupling are properly installed. All torsional critical speeds shall be outside of the compressor operating shaft speeds by +10/-15%.

8.1.5 **Final Detailed Design Submittal** – a final revised and detailed version on the initial design proposal indicating any changes or modifications made.

8.1.6 **Factory Test Reports** – Compressor, main drive motor, and control panel test reports shall be submitted and approved prior to shipment of the equipment to the jobsite.

8.1.7 **Installation, Operating and Maintenance (IOM) Manual** - The final IOM Manual manual shall be complete with final test reports and as-built drawings. The IOM Manual must include the following specific information:

1. Receiving and handling information, with a diagram of the recommended lifting method.
2. Storage requirements when not in service for extended periods
3. Mechanical installation instructions for shipped loose components:
   a) Compressor skid
   b) Compressor inlet components and instrumentation
   c) Compressor discharge components and instrumentation
4. Electrical installation instructions
5. Lube oil filling instructions
6. Operating and maintenance instructions
   a) Compressor troubleshooting guide
   b) Recommended spare parts
   c) Suggested preventative maintenance schedule
   d) Operating manuals for all major components of the compressor and control system
7. Complete spare part drawings and listings for
   a) Compressor units and gearboxes including pumps, sensors, couplings, and associated instrumentation
   b) Electric propulsion (main compressor) motors
   c) All auxiliary components (pump sets, motors, filter sets, cooler units)
   d) All electrical control equipment in LCP and interface panels

8.2 Tools and spare parts

A. The contractor shall furnish all special tools and appliances necessary to disassemble, service, repair, and adjust the equipment and appurtenances.

B. The following spare parts shall be furnished:

1. Two sets of oil filter elements for each unit
2. One set of compressor seals and bearings for each unit
3. One set of gearbox bearings and seals
4. One set of motor bearings for each unit
5. One inlet guide vanes actuator
6. One mechanical oil pump
7. One complete auxiliary oil pump assembly
8. One spare PLC (will include 2 of every type of board) This includes but is not limited to:
    a) Power supplies
    b) CPU
    c) Memory module
    d) Digital and Analog Input/Output
    e) Communication
9. One (1) laptop loaded with PLC program and software licenses
10. One of every type of electrical component not mentioned previously:
    a) Relays
    b) Contactors
    c) Power supplies
    d) Switches
    e) Contact blocks
    f) Indicating lights
    g) Breakers
11. Two spare operator interfaces
12. 10 of every type and denomination of fuse size used in the new panels and motor starters
13. One motor/compressor coupling
14. One fan motor for the oil cooler if used
15. Two spare pressure transmitters for each pressure range.
16. Two spare process temperature RTD's for each temperature range.

C. All spare parts shall be suitably packaged for marine environments and long term storage. Packing shall be clearly identified with indelible marking on the containers. Tools and spare parts (except for the air and oil filters) shall be supplied in a wooden tool chest for long-term storage and marked with Equipment name, along with a description of contents and any applicable part or identifying number. Individual boxes will include a packing list in each box detailing the part number, description and qty. A master list of all parts will also be included with all spare parts provided.