BAY DESIGN
& ENGINEERING

2900 Main Street Alameda CA 94501
Phn 510-337-9122 Fx 510-337-0154

August 12, 2008

Mr. Mike Peery
196 Seafarer Ct
Vallejo, Ca 94591

Subject: F/V Blizzard Propulsion System Design

Dear Mike;

We have completed our design of the propulsion system for the F/V Blizzard. Our objective was to raise the top speed of the vessel as much as possible. In conjunction with the modifications that you have begun (removing the steering gear and cutting down the existing skegs), we have designed a conventional propeller and rudder steering system that is optimized for free running performance.

The attached drawing (No 80451-01) shows the general arrangement of the new steering gear and calls out regular production components available from Buck Algonquin.

In general, the goal was to relocate the rudders further aft to enhance the vessels turning ability. The propellers were brought aft as well to maintain the slow speed maneuvering ability. The increased shaft length, coupled with a larger propeller and greater horsepower engines mandated an increase in shaft diameter. Even with the greater diameter, an additional bearing was required. As the original shafts were worn to the point of replacement, this modification was even more warranted.

The rudder was sized independently by both Buck Algonquin and this office. We both came to the same conclusions regarding the area and stock diameter. The steering components specified flowed from the specification of the rudder.

As the shaft line was increased, the hub of the propeller was lowered allowing for a larger diameter propeller to be installed. The larger propeller will allow for the application of more power without risk of cavitation, which is a concern considering its close proximity to the water line. A sizing analysis was performed to find the best pitch for the new propeller diameter. The predicted velocity of the vessel for the sizing analysis was 20 knots. The vessel should be capable of approaching this speed now due to the increased power, greater thrust available, and dramatic reduction in appendage drag. The clearance of the propeller to the tunnel is now 5% of the diameter, which is a minimum value. There will be attendant noise due to this minimal clearance. This was a sacrifice to achieve higher speed. If the noise is unacceptable, the propeller can be modified at a later date.

The gear ratio selected to match the QSB305 engines is 2.2:1. This puts the propeller selection in the heart of the curve and allows for flexibility in the future.

Additional considerations to achieve the maximum speed would be to use heat exchanged engines in place of the keel cooled engines. This would eliminate the existing coolers and a considerable source of drag.

I can provide Erik at our Richmond yard with construction details as part of the modifications in place of independently supplying the details.

If you have any questions regarding this report, please do not hesitate to contact us.

Kind Regards;

Brooks Dees
Design Engineer
Bay Design and Engineering

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80451 - F/V Blizzard Propulsion analysis
8/12/08
By: BD
Chk: jtw

Vessel Input Data

LWL	26 ft	Configuration	2 Screw
WL Beam	10 ft	Engine BHP	305 hp
Hull Draft Mean	1.5 ft	Engine RPM	2600 rpm
Displacement	7.5 LT	Gear Reduction	2.2 to 1
Vessel Design Speed	20.0 kts	Nozzels?	no
Vessel Towing Speed (DG)	5.5 kts		
Block Coefficient	0.673077		
Wake Factor from Cb	0.790769	Formula 6-4	

Free Running Values			
Bp = $shp^{.5}$ x N / $Va^{2.5}$	20.44		Formula 6-7
shp = BHP x .97	296	hp	
N = Eng rpm/gear Rat	1182	rpm	
Va = V x Wf	15.82	kts	
d(twin screw)=NxD/12/Va*.97	169.1295		Formula 6-8
Allowable Blade Loading			
BLa=1.9x$Va^{.5}$x$Ft^{.08}$	7.81	psi	
Ft	1.50	ft	WL to Prop CL
Actual Blade Loading			
BL=326xSHPxe/(VaxAd)	7.56	psi	
shp = BHP x .97	296	hp	Previous Calc
e (open water efficiency)	0.579685		Gerr Pg 80
Ad=DARxD^2/4xpi	468	in^2	

Towing Values			
Bp = $shp^{.5}$ x N / $Va^{2.5}$	515.61		Formula 6-7
shp = BHP x .97	296	hp	
N = Eng rpm/gear Rat	1182	rpm	
Va = V x Wf	4.35	kts	
d(twin screw)=NxD/12/Va*.97	615.1685		Formula 6-8
Allowable Blade Loading			
BLa=1.9x$Va^{.5}$x$Ft^{.08}$	4.09	psi	
Ft	1.50	ft	WL to Prop CL
Actual Blade Loading			
BL=326xSHPxe/(VaxAd)	15.07	psi	
shp = BHP x .97	296	hp	Previous Calc
e (open water efficiency)	0.318015		Gerr Pg 80
Ad=DARxD^2/4xpi	468	in^2	

Diameter selection

Prop Dia	28
Prop Blades	4
Prop DAR	0.76
Pitch fr	25.2
Pitch tow	20.16

Free Running		
P/D	0.9	from chart
Thrust	3,535	lbs
Bp	20.44	
δ	169.1295	
eff chrt	0.607	from chart
eff fctr	0.955	table 6-3
eff	0.579685	
Allow Loading	7.81	
Actual Loading	7.56	**OK**

Towing		
P/D	0.72	from chart
Thrust	7,054	lbs
Bp	515.61	
δ	615.1685	
eff chrt	0.333	from chart
eff fctr	0.955	table 6-3
eff	0.318015	
Allow Loading	4.09	
Actual Loading	15.07	**Cavitation Danger!**

Option 1

	Option 1
Prop Dia	28
Prop Blades	4
Prop DAR	0.76
Pitch fr	25.2
Pitch tow	na
HP	305
RPM eng	2600
Ratio	2.2
FR Cav?	no
Tow Cav?	na

Calculations

Note: These calcs follow Gerr "Propeller Hand Book, Pages 66-82 and Harvald Pg 139-149

Check Propeller Shaft DIA

Selected Shaft Size **2.25 in**

Check 1

Dave Gerr, Prop Handbook Pg 89

Shafting Particulars

Item	Value	Units	Notes
Engine BHP	305	hp	QSB305
Engine RPM	2600	rpm	
Gear Box Ratio	2.2	to 1	
Shaft Mat Strength (St)	70000	psi	Torsional Yield
Safety Factor (SF)	3		(Heavy duty comercial craft)
Existing Shaft Dia	NA	in	

Calculated Results

Item	Value	Units	Notes
Shaft hp (SHP)	295.85	hp	BHP less 3% for gear losses
Shaft Rpm (RPM)	1181.81818	rpm	Engine rpm/gear ratio
Required Dia	**1.51**	in	D=(321,000 x SHP x SF / St / RPM) $^{1/3}$

The selected shaft size is larger than the calculated required diameter and therefore adequate.

Torsional yield strength for some commonly used materials

Aquamet 22	70000	psi
Aquamet 18	60000	psi
Aquamet 17	70000	psi
Monel 400	40000	psi
Monel K500	67000	psi
Tobin Bronze	20000	psi
304 Stainless Steel	20000	psi

Safety Factors

3 for yachts and light duty commercial craft
5 to 8 for heavy duty commercial craft

Check 2

ABS Shaft DIA (Pg 116 in under 90M steel vessels)

D= 100xK^3x((H/R)x((c1/(U+c2)))^.33333 **2.13** in

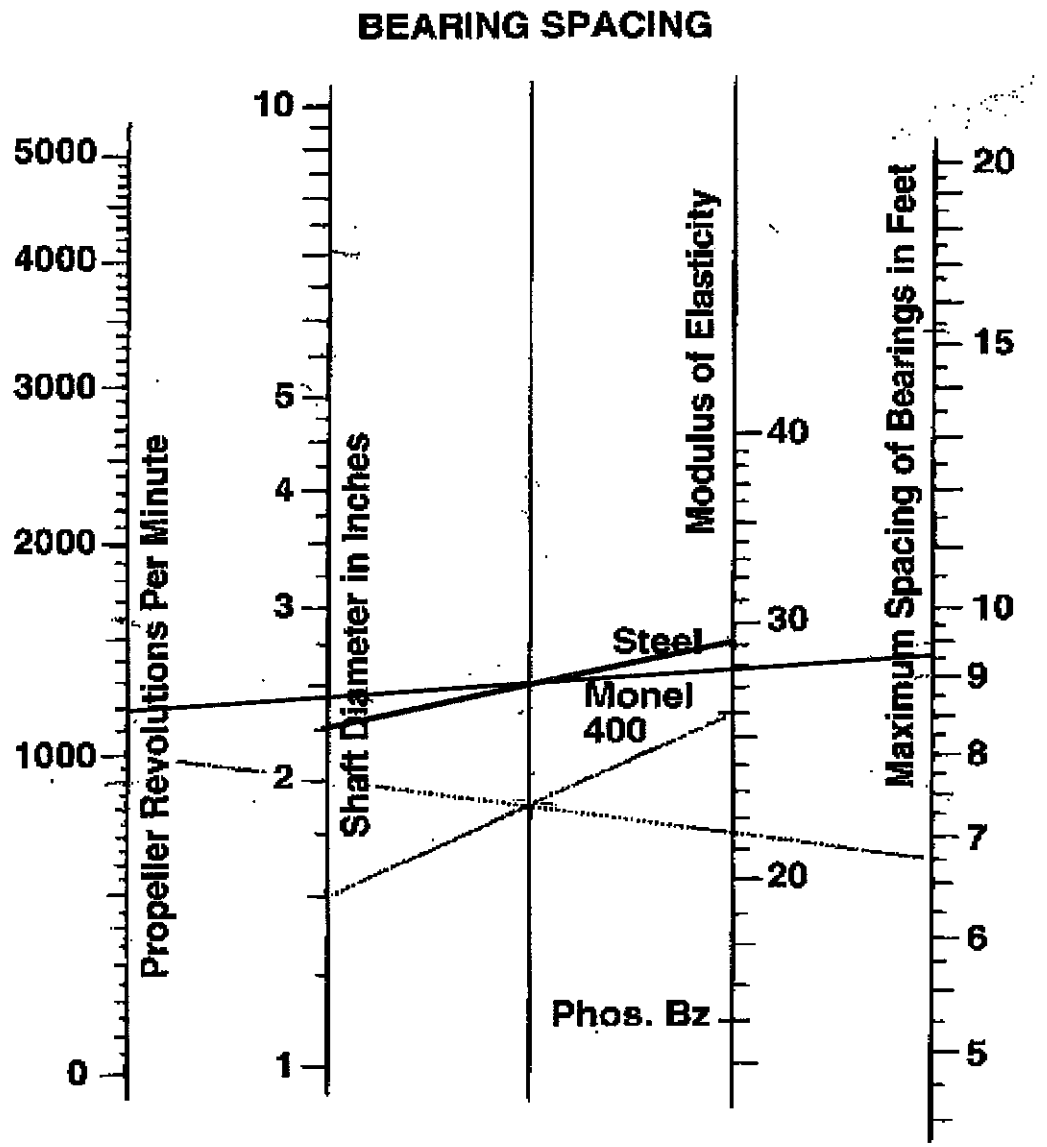
K	1.29	Tail Shaft, water lubricated
H	305	HP
R	1181.81818	Rpm
c1	2.75	
c2	23180	
U	135000	psi

The selected shaft size is larger than the calculated required diameter and therefore adequate.

Check Longest Bearing Spacing

Longest Required Span	**9 ft**
Shaft RPM	1181.81818 RPM
Modulus of Elasticity	29 Mpsi
Max allowable Spacing	**9.25 ft**

The required bearing spacing is less han the calculated maximum allowable bearing spacing and therefore OK



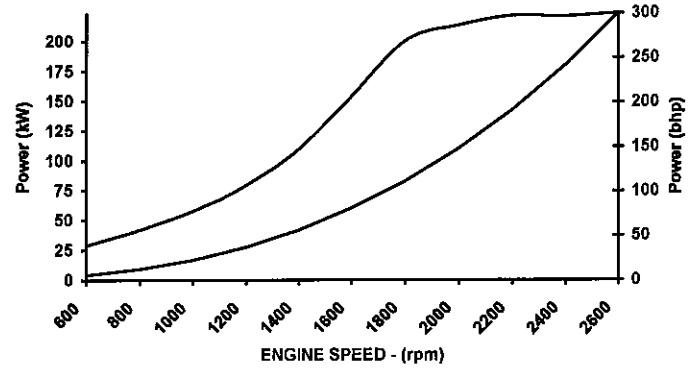
CUMMINS MERCRUISER DIESEL Charleston, SC 29405 Marine Performance Curves	Basic Engine Model: QSB5.9-305 HO	Curve Number: M-91369	
	Engine Configuration: D403075MX03	CPL Code 8464	Date: 31-Jan-06

Displacement: **5.9 liter** **[359 in^3]**
Bore: **102 mm** **[4.02 in]**
Stroke: **120 mm** **[4.72 in]**
Fuel System: **HPCR**
Cylinders: **6**

kW [bhp, mhp] @ rpm
Advertised Power: **224 [300, 305] @ 2600**

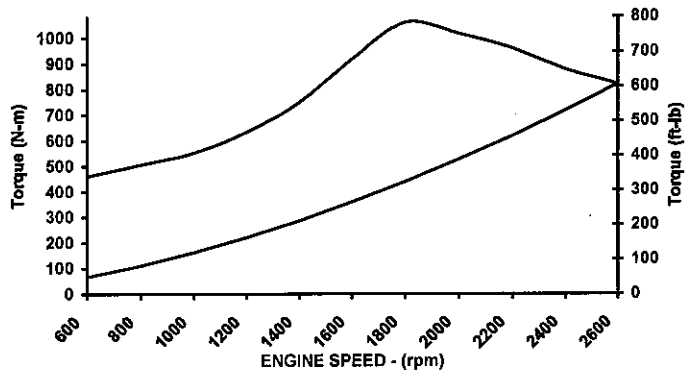
Aspiration: **Turbocharged / Sea Water Aftercooled**
Rating Type: **High Output**

CERTIFIED: This marine diesel engine is certified to the model year requirements of EPA Marine Tier 2 per 40 CFR 94 and conforms with the NOx requirements of the International Maritime Organization (IMO), MARPOL 73/78 Annex VI, Regulation 13 as applicable.



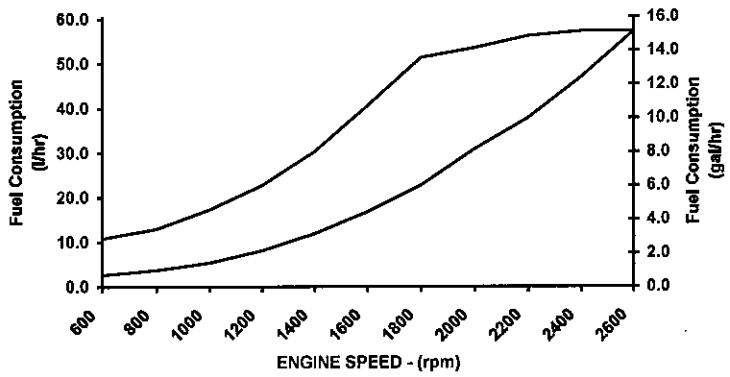
RATED POWER OUTPUT CURVE

rpm	kW	bhp
2600	224	300
2400	221	296
2200	222	297
2000	213	286
1800	200	268
1600	154	206
1400	110	147
1200	80	107
1000	58	77
800	42	57
600	29	39



FULL LOAD TORQUE CURVE

rpm	N-m	ft-lb
2600	822	606
2400	879	648
2200	961	709
2000	1018	751
1800	1062	783
1600	918	677
1400	750	553
1200	633	467
1000	552	407
800	506	373
600	461	340



FUEL CONSUMPTION - PROP CURVE

rpm	l/hr	gal/hr
2600	57.3	15.1
2400	47.0	12.4
2200	37.9	10.0
2000	30.8	8.1
1800	22.7	6.0
1600	16.8	4.4
1400	11.9	3.1
1200	8.1	2.1
1000	5.4	1.4
800	3.8	1.0
600	2.7	0.7

Rated Conditions: Ratings are based upon ISO 8665 and SAE J1228 reference conditions; air pressure of 100 kPa [29.612 in Hg], air temperature 25 deg. C [77 deg. F] and 30% relative humidity. Power is in accordance with IMCI procedure. Member NMMA.

Rated Curves (upper) represents rated power at the crankshaft for mature gross engine performance capabilities obtained and corrected in accordance with ISO 3046. Propeller Curve (lower) is based on a typical fixed propeller demand curve using a 2.7 exponent. Propeller Shaft Power is approximately 3% less than rated crankshaft power after typical reverse/reduction gear losses and may vary depending on the type of gear or propulsion system used.

Fuel Consumption is based on fuel of 35 deg. API gravity at 16 deg. C (60 deg. F) having LHV of 42,780 kj/kg [18390 Btu/lb] and weighing 836.9 g/liter [7.001 lb/U.S. gal].

High Output Rating: This Rating is for use in variable load applications where full power is limited to one (1) hour out of every eight (8) hours of operation. Also, reduced power operations must be at or below 200 RPM of the maximum rated RPM. This rating is for pleasure/non-revenue generating applications that operate 500 hours per year.

James D Kuhlman

CHIEF ENGINEER

Marine Engine Performance Data

Curve No.: M-91369
DS-3075
DATE: 31Jan06

General Engine Data			
Engine Model			QSB5.9-305 HO
Rating Type			High Output
Rated Engine Power		kW [bhp]	224 [300]
Rated Engine Speed		rpm	2600
Rated HP Production Tolerance		±%	5
Rated Engine Torque		N•m [ft•lb]	822 [606]
Peak Engine Torque @ 1800 rpm		N•m [ft•lb]	1062 [783]
Brake Mean Effective Pressure		kPa [psi]	1755 [255]
Indicated Mean Effective Pressure		kPa [psi]	N/A
Minimum Idle Speed Setting		rpm	600
Normal Idle Speed Variation		±rpm	10
High Idle Speed Range	Minimum	rpm	2665
	Maximum	rpm	2685
Maximum Allowable Engine Speed		rpm	2685
Maximum Torque Capacity from Front of Crank[2]		N•m [ft•lb]	468 [345]
Compression Ratio			17.2:1
Piston Speed		m/sec [ft/min]	10.4 [2045]
Firing Order			1-5-3-6-2-4
Weight (Dry) Engine only - Average		kg [lb]	N.A.
Weight (Dry) Engine With Heat Exchanger System - Average		kg [lb]	612 [1350]
Weight Tolerance (Dry) Engine only - Average		kg [lb]	N.A.
Noise and Vibration			
Average Noise Level – Top	(Idle)	dBA @ 1m	76
	(Rated)	dBA @ 1m	97
Average Noise Level – Right Side	(Idle)	dBA @ 1m	76
	(Rated)	dBA @ 1m	98
Average Noise Level – Left Side	(Idle)	dBA @ 1m	77
	(Rated)	dBA @ 1m	107
Average Noise Level – Front	(Idle)	dBA @ 1m	76
	(Rated)	dBA @ 1m	98
Fuel System[1]			
Average Fuel Consumption – ISO 8178 E3Standard Test Cycle		l/hr [gal/hr]	38.7[10.2]
Fuel Consumption @ Rated Speed		l/hr [gal/hr]	57 [15]
Approximate Fuel Flow to Pump		l/hr [gal/hr]	189 [50]
Maximum Allowable Fuel Supply to Pump Temperature		°C [°F]	60 [140]
Approximate Fuel Flow Return to Tank		l/hr [gal/hr]	132 [35]
Approximate Fuel Return to Tank Temperature		°C [°F]	66 [150]
Maximum Heat Rejection to Drain Fuel[5]		kW [Btu/min]	2 [99]
Fuel Transfer Pump Pressure Range		kPa [psi]	76 [11]
Fuel Rail Pressure	Gauge	kPa [psi]	N.A.
	INSITE	kPa [psi]	135,999 [19,725]
Air System[1]			
Intake Manifold Pressure		kPa [in Hg]	172 [51]
Intake Air Flow		l/sec [cfm]	278 [589]
Heat Rejection to Ambient		kW [Btu/min]	32 [1810]
Exhaust System[1]			
Exhaust Gas Flow		l/sec [cfm]	600 [1272]
Exhaust Gas Temperature	Turbine Out	°C [°F]	421 [789]
	Manifold	°C [°F]	559 [1038]

TBD = To Be Decided **N/A = Not Applicable** **N.A. = Not Available**

[1]All Data at Rated Conditions
[2]Consult Installation Direction Booklet for Limitations
[3]Heat rejection values are based on 50% water/ 50% ethylene glycol mix and do NOT include fouling factors. If sourcing your own cooler, a service fouling factor should be applied according to the cooler manufacturer's recommendation.
[4]Consult option notes for flow specifications of optional Cummins seawater pumps, if applicable.
[5]May not be at rated load and speed. Maximum heat rejection may occur at other than rated conditions.

CUMMINS ENGINE COMPANY, INC.
COLUMBUS, INDIANA

All Data is Subject to Change Without Notice - Consult the following Cummins intranet site for most recent data: http://www.cummins.com

Marine Engine Performance Data

Curve No.: M-91369
DS-3075
DATE: 31Jan06

Emissions (In accordance with ISO 8178 Cycle E3)		
NOx (Oxides of Nitrogen)	g/kw·hr [g/hp·hr]	6.227 [4.644]
HC (Hydrocarbons)	g/kw·hr [g/hp·hr]	0.104 [0.078]
CO (Carbon Monoxide)	g/kw·hr [g/hp·hr]	0.208 [0.155]
PM (Particulate Matter)	g/kw·hr [g/hp·hr]	0.103 [0.077]
Cooling System[1]		
Sea Water Pump Specifications	MAB 0.08.17-07/16/2001	
Pressure Cap Rating (With Heat Exchanger Option)	kPa [psi]	103 [15]
Engines without Low Temperature Aftercooling (LTA)		
Sea Water Aftercooled Engine (SWAC)		
Coolant Flow to Engine Heat Exchanger	l/min [gal/min]	238 [63]
Standard Thermostat Operating Range Start to Open	°C [°F]	74 [165]
Full Open	°C [°F]	85 [185]
Heat Rejection to Engine Coolant[3]	kW [Btu/min]	166 [9470]
Engines with Low Temperature Aftercooling (LTA)		
Single Loop LTA		
Coolant Flow to Cooler (with blocked open thermostat)	l/min [gal/min]	238 [63]
LTA Thermostat Operating Range Start to Open	°C [°F]	66 [150]
Full Open	°C [°F]	80 [175]
Heat Rejection to LTA Coolant[3]	kW [Btu/min]	183 [10420]
Maximum LTA Coolant Return Temperature	°C [°F]	54 [130]

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1All Data at Rated Conditions
2Consult Installation Direction Booklet for Limitations
3Heat rejection values are based on 50% water/ 50% ethylene glycol mix and do NOT include fouling factors. If sourcing your own cooler, a service fouling factor should be applied according to the cooler manufacturer's recommendation.
4Consult option notes for flow specifications of optional Cummins seawater pumps, if applicable.
5May not be at rated load and speed. Maximum heat rejection may occur at other than rated conditions.

CUMMINS ENGINE COMPANY, INC.
COLUMBUS, INDIANA

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	X			

RUDDER
10R40SS1.5

UPPER BRNG FLG
00RBF150
SEE NOTE 1

COLLAR
00RC150

TILLER FOR
Ø 1-1/2" SHAFT

4"

BACKING PLATE
00RPBP12CC

RUDDER PORT
10RP150ACC

PL 1"

NOTES:
1. STRUCTURE TO SUPPORT UPPER BEARING FLANGE TBD
2. MODIFY STEERING RAM AND JOCKY BARS AS REQ'D
3. TILLER CAN BE MOUNTED ABOVE OR BELOW FLG BEARING PENDING APPROVAL FROM BUCK ALGONQUIN
4. STRUT DETAILS TBD

CUT BACK STRUT
JUST ENOUGH TO FIT
STERN BEARING HSNG

12'-7 1/2" VERIFY

4'-4 7/16"

NEW Ø 2-1/4" AQUAMET 17 SHAFT

4-1/2" OD x 3-1/2" ID CS TUBE
W/ DURAMAX "CARE" BRNG

NEW BRONZE STERN BEARING HSNG
BUCK ALGONQUIN #00STBR250
W/ DURAMAX "CART" BRNG

NEW 28x25 "DURA-QUAD" PROP
FROM MICHIGAN WHEEL

4"

1'-2"

2'-5 7/16"

7'-6 3/4"

BAY DESIGN 2900 Main Street Alameda CA 94501
Phn 510-337-9122 Fx 510-337-0154

UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES	DRAWN	BD	08/12/08
TOLERANCES:	CHECKED	JW	08/12/08
FRACTIONAL ±	ENG APPR.		
ANGULAR: MACH ± BEND ±	OWNER APPR.		
TWO PLACE DECIMAL ±			
THREE PLACE DECIMAL ±			

INTERPRET GEOMETRIC TOLERANCING PER:

JOB # 80451

ITEM # 80.01

TITLE:
F/V BLIZZARD
STEERING GEAR
ARRANGMENT AND DETAILS

SIZE D | DWG. NO. 80451-01 | REV 0

SCALE: 3" : 1" | SHEET: 1 of 1

REV 0 | D 80451-01

file: G:\bay\fish boats\Blizzard\ Blizzard Inboard Profile - 2.dwg date: Aug 12, 2008 09:24 user: brooksd