Regional Citizens' Advisory Council / *"Citizens promoting environmentally safe operation of the Alyeska terminal and associated tankers."*

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Prince William Sound Aquaculture Corporation

MEMORANDUM

DATE: February 10, 2017

SUBJECT: Prince William Sound Regional Citizens' Advisory Council Report: "A Review of the Proposed New Escort and Support Tugs for Tanker Operations in Prince William Sound"

FROM: Donna Schantz, Executive Director

By July 2018, Edison Chouest Offshore will replace Crowley Maritime as Alyeska Pipeline Service Company's marine services contractor. The services under this contract include providing escort tugs, general purpose tugs, oil recovery storage barges, and associated personnel, all of which are key oil spill prevention and response assets for the Valdez Marine Terminal and associated oil tankers operating in Prince William Sound. As part of this transition, Edison Chouest Offshore is building five escort tugs, four general purpose tugs, and two oil spill response barges. This report is a review of the new tug designs and specifications by Robert Allan Ltd., a naval architecture and marine engineering company, commissioned by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC or Council).

The Council is an independent non-profit corporation whose mission is to promote environmentally safe operation of the Valdez Marine Terminal and associated tankers. Our work is guided by the Oil Pollution Act of 1990, and our contract with Alyeska Pipeline Service Company (Alyeska). PWSRCAC's 18 member organizations are communities in the region affected by the 1989 Exxon Valdez oil spill, as well as commercial fishing, aquaculture, Native, recreation, tourism, and environmental groups.

The Council commissioned this report in an effort to verify that each vessel design is optimal for providing the highest level of oil spill prevention and response capability to protect Prince William Sound and the downstream communities. The drawings and other reference materials analyzed as part of this review were provided by Alyeska in early November through December 14, 2016. Additional information on the vessels may exist, but was not provided to the Council as part of this review. Because information provided to the Council may have been limited, issues identified in this review may have already been

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addressed. The Council welcomes additional information from Alyeska, and we may modify our concerns and recommendations as appropriate. While this report is complete, the review process for the vessels is ongoing.

Some key concerns noted in the report include:

- The bow height is low for operation in Gulf of Alaska conditions.
- Design of forecastle deck invites pooling of ice and water during heavy weather.
- The performance predictions for the large escort tugs are limited in scope and do not verify performance in the full range of operating conditions.
- The accuracy of the seakeeping predictions for the large escort tugs is uncertain.
- The indirect performance analyses were done only for calm conditions and for wind directly astern. Information provided does not identify performance in any cross-wind conditions.
- A large skeg, an extension of the vessels' keel, moves the lateral center of pressure towards the back.
- Mooring lines, tow lines, winches, and decks need to be free of ice and protected from freezing spray.

The Council acknowledges that the transition to Edison Chouest Offshore will bring many improvements to the oil spill prevention and response system for Prince William Sound. However, we have strived to provide our concerns and recommendations early in the construction process to allow the incorporation of additional design features or modifications.

It is a goal of the Council that information contained in this report be used to ensure the highest standards for oil spill prevention and response systems used to protect Prince William Sound and the people who live and work in the region. The Council believes that Alyeska's oil spill prevention and response system is one of the best in the world, and we will continue to work with industry and regulators in an effort to maintain these high environmental safeguards.

The Council appreciates the information provided thus far by Alyeska to facilitate this review, and we look forward to additional information, participation, and dialogue as the transition progresses.

ROBERT ALLAN LTD.
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A Review of the Proposed New Escort and Support Tugs for Tanker Operations in Prince William Sound

Prepared for:

Prince William Sound Regional Citizens' Advisory Council (PWSRCAC)
Anchorage, AK

Reference 216-036C
Revision 5
February 2, 2017

The opinions expressed in this PWSRCAC-commissioned report are not necessarily those of PWSRCAC.

Revision Control Sheet

Prepared by:	Robert G. Allan	**Date**	February 1, 2017	**Revision**	5
Checked by:	Mike Phillips	**Date**	February 1, 2017	**Revision**	5
Approved by:	R.G. Allan	**Date**	February 1, 2017	**Revision**	5

Engineer of Record: Robert G. Allan, P. Eng.

Rev.	Date	Description	By	Checked	Approved
1	December 12, 2016	Draft issued for Client review	RGA	RGA	RGA
2	January 10, 2017	Some additional comments, plus revised to reflect comments from reviewers	RGA	MP	RGA
3	January 11, 2017	Text alterations to reflect late addition of Alyeska memo 11/21/16 to reference material. No substantive change to conclusions	RGA	MP	RGA
4	January 18, 2017	Addition of discussion re dimensional discrepancies and impact on performance prediction. Some minor edits and reference corrections. Notes added re low specific BP of escort tug and impact	RGA	MP	RGA
5	February 1, 2017	Minor text edits per Owner feedback. Ref. 5 corrected for source. Disclaimer added per contract. Comments adjusted to reflect updated GA drawings received Feb.1, 2017	RGA	MP	RGA

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The opinions expressed in this PWSRCAC-commissioned report are not necessarily those of PWSRCAC.

Contents

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EXECUTIVE SUMMARY

This review has identified many aspects of both proposed tug designs that indicate:

a. A lack of thoroughness in proving suitability for purpose of the tugs, particularly in terms of overall performance and seakeeping, and
b. Failure to properly address the requirements for safe and sensible operation in the Alaskan climate.

The latter issues are perhaps not all critical to the vessel base mission but will certainly render the boats difficult to operate and to maintain well. Some issues are critical to the safe operation of the boats and must be clarified with some urgency. Many other issues are raised that are simply good design practise issues that could be revised at minimal cost to provide a safer and better operating environment for the crew, and result in less downtime and lower long term maintenance.

The most critical aspects of the design review are summarized below, categorized for each vessel type according to:

- Performance Predictions,
- General Design Configuration, and
- Suitability for Operation in Alaskan Environment

A. ESCORT TUGS

1. Performance Predictions

- Indicated specific Bollard Pull (BP) (tonnes/kW) is about 15% lower than what would be considered "normal" for a large Z-drive tug. Difference to be resolved. If result is actually higher than stated this could adversely affect stability analyses and winch design
- There was no evidence presented to indicate that this new hull form has been model tested to prove that all performance objectives will be met, or to verify fitness for purpose, as one would expect in a fleet investment of this magnitude.
- The existing performance predictions for the large escort tugs are very limited in scope and do not prove performance in the full range of operating conditions
- The seakeeping predictions are suspect in their accuracy
- The indirect performance analyses were done only for calm conditions and for wind directly astern. This does not identify what happens in any cross-wind condition. Discrepancies in vessel dimensions between referenced documents indicate that the indirect escort performance must be re-calculated for the latest vessel dimensions

2. General Design Configuration

- The forecastle deck area presents a significant "pool" to hold water when operating in heavy seas. This could result in serious seakeeping issues
- Given the high windage of this tug, and the presence of a very large skeg which will hinder lateral mobility/manoeuvrability, a bow thruster should be strongly considered for ship-handling operations at low speed
- Experienced tug Masters familiar with the SERVS tug operations advise that the fendering arrangement shown on the GA drawings will be insufficient for the PWS operations.
- No information has been provided with respect to the structural design of these tugs, and in particular with regard to the ice-strengthening of the hulls. Some ice-reinforcement is essential
- The bow height (to the knuckle at the bottom of fender) is extremely low for operation in the Gulf of Alaska: one should be very concerned about how this shape will perform in 4 to 6+ metre seas
- Refrigerators oriented transversely (doors opening athwartships) will spill their contents regularly; relocate
- The galley range/oven is oriented transversely (facing athwartships) and thus represents a hazard to galley crew. Suggest relocate to a transverse bulkhead as close to CL as possible.
- Consider providing lavatories close to bridge and to machinery control room
- Berths on the main deck level should be relocated to inboard bulkheads if possible and NOT be oriented transversely
- Consideration should be given to providing natural light to all crew cabins
- Consideration should be given to a crew lounge area separate from mess room
- Consideration should be given to fitting a crew exercise room

3. Suitability for Alaskan Environment

- In the absence of a Specification for this vessel it is unclear what measures have been taken in the design to cope with the heavy snow and sub-freezing temperatures prevalent in the operating area in winter. The following, in particular, are of serious concern:
    - measures to prevent ice/snow plugging the freeing ports in the fore deck well
    - measures for deck heating in all exposed working areas to prevent ice/snow accumulation.
    - methods/locations for protected/heated storing of mooring and other working lines
    - means of protecting winches from water ingress into shelters and from freezing spray
    - prevention of freezing in potable water and fresh water ballast tanks adjacent to the shell
    - protection from freezing in ALL piping systems and especially those exposed to weather such as drain lines
    - eliminate any topsides deck drains routed inside deckhouses
    - all window wipers must be equipped with heating elements and provision for adding anti-freeze to window-washing solution

- In many locations berths are placed adjacent to outboard bulkheads. This is poor design practise for cold climates, especially on a larger vessel such as this. Outboard locations are coldest, and have maximum motions leading to crew discomfort and fatigue

B. SUPPORT TUGS

1. Performance Predictions

- Very little information is provided about performance beyond the indicated BP of 65.8 tonnes from 4,480 kW. These figures indicate a very poor specific performance. Typically, that much power (6,005 BHP) should deliver closer to 75 tonnes BP. This discrepancy should be explained/resolved soonest.
- This performance should also be compared to that of the Crowley "Invader" class tugs to verify that equivalent BP performance is being offered.
- Provide evidence that the tug complies with USCG Towline Pull Stability criteria.
- Provide full details of Fs and Fb capability at 8 and 10 knots, within recognized escort stability criteria
- Demonstrate that the fixed pitch propellers will not stall the main engines in the full range of operating conditions
- The performance of this tug in all its intended roles should be clearly demonstrated by thorough analysis BEFORE the tugs are delivered

2. General Design Configuration

- The interior layout of the support tugs is inappropriate for the Alaskan environment and should be reviewed in detail. Specific issues are:
    - lack of a wet room or even wet gear lockers at the entry
    - the small tables in the mess will accommodate two people each at best, not the total of six persons indicated
    - bunks in the staterooms are located against the cold exterior bulkheads and some are oriented transversely; definitely not advisable, especially in a cold climate and where high seas are expected
- Provide details of the Fi-Fi system
- Review/approve details of the forward winch for indirect escort operations
- The arrangement of the stern tow-pin/roller system is vulnerable to contact damage when barge handling. Configuration should be reviewed and submitted for review/approval
- Ladder from fore deck to boat deck is too steep and potentially dangerous. Recommend that all ladders and gratings be GRP to minimize risks in snow/icy conditions
- Details of stern fendering and towing arrangement to be provided and reviewed/approved by Masters familiar with local towing operations and conditions
- Deck locker space is inadequate for mooring and towing gear, etc. in the cold climate

3. Suitability for Operation in Alaskan Environment

- Provide details to demonstrate suitable drainage, ventilation and heating in ALL gear lockers to ensure lines are all readily usable in all weather conditions
- Accommodation arrangement must be addressed to deal with cold climate and keeping interior of the tug clean. Arrangement is completely inadequate as shown
- Define the measures taken to ensure safe operation in the Alaskan environment, and specifically:
    - hull strengthening measures for operation in ice
    - measures for deck heating in all exposed working areas to prevent ice/snow accumulation.
    - methods/locations for protected/heated storing of mooring and other working lines
    - means of protecting winches from water ingress into shelters and from freezing spray
    - prevention of freezing in potable water tanks adjacent to the shell
    - protection from freezing in ALL piping systems and especially those exposed to weather such as drain lines
    - revising any topsides deck drains routed inside deckhouses
    - ensure all wipers are equipped with heating elements and provision for adding anti-freeze to window-washing solution

In conclusion, neither design is sufficiently well-defined in terms of its expected performance to be declared unreservedly as "fit for purpose". Both designs suffer from design/layout issues which will render the tugs difficult and potentially unsafe to operate in Alaskan sea and weather conditions.

The issues of performance verification must be addressed quickly in order to prove that the entire operation will provide at least the same degree of safety as the existing operation long before the new tugs arrive on station.

The design issues must be addressed immediately before construction is so far advanced as to render changes impossible to accommodate without significant cost and delays.

The measurement of actual performance cannot be performed until the vessels are delivered, but more extensive analysis can and must be done to prove that the necessary performance can be achieved in all the boats before delivery.

It must be stated that waiting until completion of these vessels is much too late to identify any potential shortcomings in the designs. The deficiencies identified in this report should be resolved immediately in order that changes can be made during production design/construction at lower cost and time impact than if only considered on completion.

* * *

A Review of the Proposed New Escort and Support Tugs for Tanker Operations in Prince William Sound

For: Prince William Sound Regional Citizens' Advisory Council (PWSRCAC)
Anchorage, AK

1.0 BACKGROUND

Robert Allan Ltd. was retained by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) (the Client), "*To advise and provide input to PWSRCAC with regard to the design, testing and commissioning of the proposed new ECO (Edison Chouest Offshore) escort and support tugs for Prince William Sound.*"

This report comprises the findings as related to the pre-construction and required testing of the subject vessels. Further analysis will be required upon completion and trials of the vessels.

The opinions expressed in this PWSRCAC-commissioned report are not necessarily those of PWSRCAC.

2.0 REFERENCE MATERIAL

The following information was provided by the Client and was used as the basis of this evaluation:

a. Escort Tug Drawings:

- ***Damen 4517***
  - General Arrangement (in 10 constituent parts)
  - Specification Sheet
  - NAS Dwg. # 0315-331-002-00 "General Arrangement Design Plan" (received February 1, 2017)

b. Support Tug Drawings:

- ***Damen 3212***
  - General Arrangement (in 9 constituent parts)
  - Specification Sheet
  - NAS Dwg. # D2 "General Arrangement-Tethered Escort Tug" (received February 1, 2017)

c. Other Material/References:

- [1] Valdez Tug Escort Simulations-Rudder Failure Simulations (Glosten - July, 2016)
- [2] *TugSim* Calculation report – Damen Shipyards
- [3] ASD 4517 Seakeeping Analysis Rev.10
- "Tug Comparison Slide" - *Powerpoint* Slide
- D2_ Ross Utility AHTS for Alyeska Pipeline, Rev. P1
- Transition Plan
- Marine Contract Transition (pages 1 and 2)
- New Vessels Description (08/25/16) - *Powerpoint* Slides
- [4] New Vessels Description (09/12/16) - *Powerpoint* Slides
- Participant Team Meeting 08/18/16 - *Powerpoint* Slides
- [5] Alyeska Memorandum: 11/21/2016 from M. Day to P. La Pella re "Vessel Intended use"

Additional material was provided describing the planned oil recovery barges, but those vessels were not defined as part of the mandate for this work and have not been reviewed.

3.0 SCOPE OF WORK

The following is the mandate given to Robert Allan Ltd. with respect to this review:

a. To review the design drawings provided and comment on overall configuration of both the escort and support tugs as to suitability for purpose.
b. To provide a list of items/questions which PWSRCAC may raise with the Proponents/Service Providers to verify that the performance objectives for these tugs will in fact be met.
c. To provide a list of items which PWSRCAC should ask to be verified during the completion, testing and trials of the vessels before final acceptance.
d. To review and comment on final Tests and Trials data to identify any shortcomings.

This report obviously can cover only points (a.), (b.) and (c.) until such time as the vessels are built and tested.

4.0 DESIGN REVIEW – FINDINGS AND OBSERVATIONS

4.1 Escort Tugs – *Damen Model 4517*

4.1.1 Design

The profile and main deck plan views of the proposed vessel are illustrated in Figure 1 below:

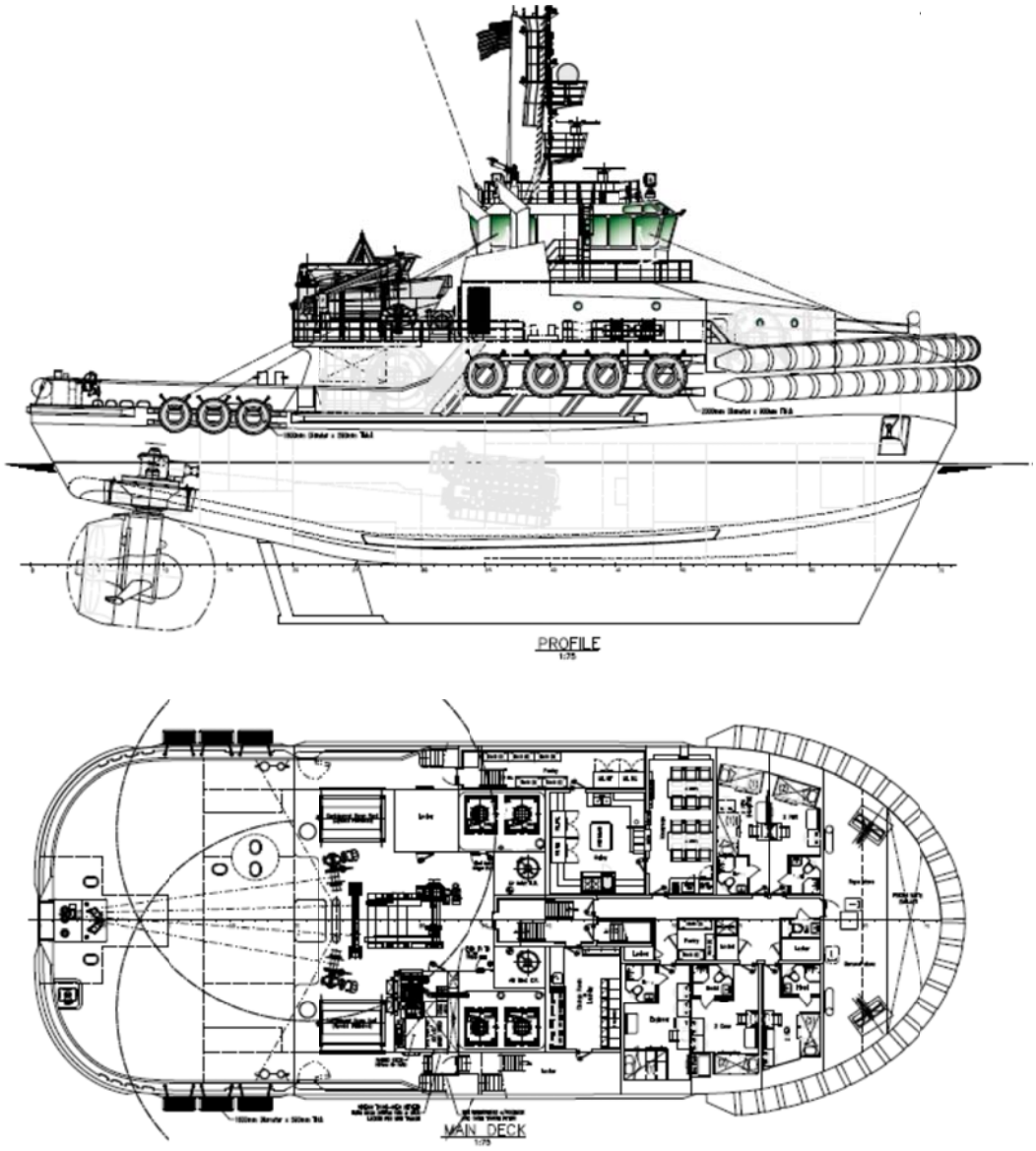

Figure 1 General Arrangement of Damen 4517 Tugboat

The following are the most critical observations concerning the overall design and general configuration of this tugboat in order to assess "fitness for purpose". There are numerous other minor design critiques which could have been included, but are not in this review as they are not related to primary escort or towing performance or basic safety, but relate more to crew comfort and general operational sensibilities based on experience, and thus may be construed as too "personal" a critique of the design. The following issues however are critical to the success of the tugs in the intended operation and must be addressed:

a. The 5.45 metre draft noted on the General Arrangement is presumably the moulded draft to the moulded keel line (USK) and NOT to the underside of the skeg. ECO to advise the total maximum navigational draft as this is the value most critical to the safe navigation of the tug. (Note: Based on other dimensions given, the max. draft is calculated as 8.15 metres (26.75 ft.))
b. The skeg is inordinately large for this type of tug, and accordingly moves the centre of lateral pressure further aft than desirable for efficient escort operations. ECO should be asked to present calculations defining why such a large skeg is necessary and how "fail-safe" operations are assured in the event of any tug propulsion or towline failure during indirect escort operations.
c. The forecastle deck area presents a significant "pool" to hold water during heavy seas, even with the freeing ports shown there. When this area fills with water the added trapped weight will severely impede the ability of the tug to rise back up in time to avoid the next large wave. ECO/Damen should define how long it will take to clear water from this space in a rough weather transit, and relate that to typical wave heights and wave periods in the area?
d. In the absence of a Specification for this vessel it is unclear what measures have been taken in the design to cope with the heavy snow and sub-freezing temperatures prevalent in the operating area. ECO must present detailed information with respect to the following measures, and revise the design accordingly to ensure safe operations in Alaska:

    1. Prevention of ice/snow plugging the freeing ports in the fore deck.
    2. Measures for deck heating in all exposed working areas to prevent ice/snow accumulation. Note: experience has shown that the ONLY really effective means to accomplish this is by use of a substantial steam generator and the fitting of heating lines in a composite compound poured on the decks, in combination with a hose/steam lance which can be used to clear any build-ups on deck quickly.
    3. Methods/locations for protected/heated storing of mooring and other working lines.
    4. Means of protecting winches from water ingress into shelters and from freezing spray.
    5. Prevention of freezing in potable water and fresh water ballast tanks adjacent to the shell.
    6. Protection from freezing in ALL piping systems and especially those exposed to weather such as drain lines.

7. Clarify whether any topsides deck drains are routed inside deckhouses. Note: although this is common practise in many shipyards it is an absolute "No-No" in the design of ships for arctic/subarctic conditions. Downpipes MUST be external to deckhouses in their entirety and should be designed to be easily removable/replaceable in the event of plugging/freezing.
8. All window wipers must be equipped with heating elements and with provision for adding anti-freeze to window washing solution?

e. There is no bow thruster on this tug. It is our experience that when a tug of this size is used for ship-handling, as these will be, Owners find that a bow thruster is highly desirable and even essential. Even though the Z-drives give significant control of heading, a bow thruster can provide a significant controlling influence over lateral movement at low speeds and reduce the amount of stern thrust needed to control the tug. Given the high windage of this tug, and the presence of a very large skeg, hindering lateral mobility, a bow thruster should be strongly considered.
f. There is only one primary means of access/egress each to the crew spaces on the main deck and on the fo'c'sle deck. On the fo'c'sle level this access is only on the port side. Has this arrangement been approved by Class for compliance with SOLAS? Do the Owners consider this configuration to be safe for the crew? Direct access/escape routes on both sides of the tug should be standard and safe practise on a tug of this size. (Noting that other routes DO exist in the design but involve rather convoluted egress through multiple doors and corridors)
g. Good design practise would place the refrigerators in the pantry on a transverse bulkhead (rather than on the longitudinal bulkhead as shown), as tugs pitch far less than they roll. With the refrigerators/freezers located as they are, their contents will be regularly found on the deck. Re-arrangement strongly advised.
h. The galley stove/range is also located on a longitudinal bulkhead which is potentially very dangerous for the galley crew during open water transits when the tug will be rolling. Strongly advise this be located on a transverse bulkhead and as close to CL as possible
i. This vessel will not satisfy current crew accommodation standards for a tug of this size in any country signatory to the Maritime Labour Convention (MLC) 2006. Although the USA is not a signatory to this ILO document, it is nevertheless a very useful reference to current modern and good practise in designing vessels for safe and comfortable crew operations. If the crew are uncomfortable or unable to get proper rest they will be fatigued and make poor judgments in critical situations. While some exemptions to the MLC requirements are permissible on vessels < 3,000 GT, such exemptions can only be granted by a "competent authority" which would presumably be the US Coast Guard (if applicable). The following aspects of the present arrangement are of particular concern, and should be addressed:

i.(1) Standard A3.1 – Accommodation and Recreational Facilities – Paragraph 11b calls for "*…sanitary facilities within easy access of the navigating bridge and the machinery space or near the engine room control centre.*" No such facilities are indicated on this large tug in either location. Given the critical nature of its role such an oversight could be considered as potentially dangerous or at the very least highly inconvenient if the officers in charge need to leave the bridge or control areas for any period of time.

i.(2) Crew Fitness Space: MLC Guideline B3.1.11 – Recreational Facilities, Mail and Ship Visit Arrangements – *Paragraph* 4d calls for "*sports equipment, including exercise equipment.…*". While this may not be mandatory, it has been standard practise to include this sort of facility on modern tug designs for the past 5 years at least, and especially so in a large vessel like this. This contributes to crew alertness and general well-being. Nothing is shown on the GA. An alternative (possibly preferable) would be to provide suitable facilities ashore which are readily accessible to the crew.

i.(3) Although not a strict requirement of MLC 2006, it is strongly advised to provide a crew lounge space, distinct and separate from the mess area. This is good design practise in any vessel of this size and provides crew the option of a quieter rest area than just the confined mess space.

j. Berth Arrangements: The arrangement of sleeping berths is not conducive to crew comfort or safety in the Alaskan environment. Numerous bunks are located outboard against the cold ship's side and where motions are at their maximum. This will lead to crew discomfort and fatigue especially on any Sentinel missions in the open gulf. Several other berths are oriented transversely which is potentially dangerous in a rolling ship. The crew rooms on the main deck are now shown (latest GA) without any source of natural light via portlights or similar. That may lead to crew complaints.

k. Fendering: Experienced Masters familiar with the PWS tug operations advise [Annexes A and B] that the fendering arrangement shown on the GA drawings will be insufficient for the PWS operations. Their recommendations include:

1. increase the fendering by adding 2,000 mm x 900 mm tires forward of frame 52 (on top of the cylindrical fenders), and
2. replace the 1,600 mm x 590 mm tires aft with 2,000 mm x 900 mm tires

l. Ice Strengthening: No information was provided with respect to the structural design of these tugs, and in particular with regard to the ice-strengthening of the hulls. Periodic ice impact damage is a fact of life with the present tugs in the area and measures must be taken to mitigate that risk. ECO must provide details of any ice-strengthening measures taken with regard to the hull, appendages (such as bilge keels) and the Z-drives and propellers.).

4.1.2 Performance Predictions

a. This vessel is quite different than any tug previously built by Damen and much larger than any of their standard tug designs. The hull shape also has considerable side flare, different to almost all other Damen tug designs which are wall-sided.

> There was no evidence presented to indicate that this new hull form has been model tested to prove that all performance objectives will be met or to verify fitness for purpose, as one would expect in a fleet investment of this magnitude.

Some calculations have been done to demonstrate the escort performance, [1], [2], and seakeeping performance [3] of the tug, but there are serious reservations concerning the completeness and adequacy of these evaluations.

Model tests or some equivalent analysis should be conducted to verify:

i. Free running speed at 50, 75, and 100% power in calm conditions.
ii. Free running speed in 1, 2, 4 and 6 metre seas to establish response speed and wetness.
iii. Self-propulsion tests to verify thrust deduction, manoeuvrability, and directional control.
iv. Seakeeping in head, stern and oblique seas at a range of speeds, with measurement of motions and accelerations at key control and working deck locations.
v. Steering and braking forces in calm conditions and in waves for a range of speeds.

b. It is noted that Reference [2] describes the desktop analysis (using "*TugSim*") of the tugs capabilities in calm water escort, but it is debatable whether such an analysis is viable for this design when all the hydrodynamic coefficients used are (presumably) based on much smaller vessels. At the very least a Class-approved CFD analysis should have been performed to predict the escort forces, but as noted above a comprehensive model test program really is required to demonstrate that all aspects of this design satisfy the mission demands.

c. Ref. [1] uses Glosten's "*ShipMan*" and "*TugMaster*" programs to identify the distances travelled by a disabled tanker under various emergency response scenarios. These all assume either calm conditions or winds only directly astern. Offset distances will be significantly different under any beam-on or oblique wind directions. The results given must therefore be considered inconclusive.

> Alyeska should require that the analysis include some cross-wind elements in order that the boundaries of safe operation can be properly defined for all operational areas. Assumptions of direct astern or zero wind are extremely limited in order to declare this tug as fully capable for the intended service.

In his review of Rev. 1 of this report, [*Annex A*], Capt. Leonard makes the point that during the development of the current PWS tug system the omission of sufficient testing and proof of performance at the initial stages ultimately resulted in extensive delays to the project, and he reinforces the need for further performance review in this case.

d. Ref. [3] reports on the predicted seakeeping performance of this tug. The analysis however is based upon the use of the software program *Shipmo* PC. That software was developed for the motions predictions of ships with relatively high length/beam ratios and of more normal hull form. It is our direct experience that this software can be extremely unreliable for predicting motions of vessels such as tugs with low length/beam ratios (< 3) , and especially so when the vessels have large appendages such as an escort skeg and Z-drives, and is even more unreliable in more extreme sea states. It is our opinion that the results presented are unreliable unless they could be correlated directly to some physical model testing.

> The roll and pitch amplitudes and accelerations at the control centres and on the working deck positions should be carefully analysed by a verifiable method (model testing or similar) in order to properly consider crew safety and fatigue issues for these critical missions, and to verify the design criteria for the critical winches.

Captain Leonard in his review [Annex A] makes the point that a CFD analysis could be considered to assess the performance of both vessels. This is partly true, but it is important to note that any such CFD analysis of indirect towing performance in particular can only be accurate if the analysis method has been validated against a sufficient number of full-scale and model-scale tests results. To our direct knowledge there are a very limited number of organizations worldwide which have this ability with methodologies approved by Class, of which Robert Allan Ltd was the first.

e. There are discrepancies concerning the vessel main particulars between the documents provided which could have an important bearing on the predicted performance results. The table below illustrates the differences encountered within various references. While some of these can be explained by different load conditions at which different analyses were performed, the critical difference is in the overall length. The length used in calculating the indirect steering forces is almost 2 metres longer than that shown in the other documents. This would have a significant difference in the calculation of indirect steering forces which are directly proportional to underwater lateral area. The discrepancies in overall draft are also concerning as this affects force predictions as well as being a potential major navigational limitation.

Discrepancies re particulars - Damen 4617 Class tug						
	Source	*Data Sheet*	*Tug Sim Analysis (Ref.2)*	*Tanker Escort Simulations (Ref. 1)*		Seakeeping Analysis (Ref.3)
item	*Dimension*	*m.*	*m.*	*m.*	*ft*	m.
a	Loa	42.79	44.5	42.77	140.4	42.79
b	Lwl	40.99	n/a			41.25
c	Beam, moulded	16.50	16.42	16.48	54.1	16.50
d	Depth, moulded	7.00	7	7.01	23	7.00
e	Total Depth (incl. skeg)	9.70				9.70
f	draft, hull	5.45		4.75	15.6	5.00
g	draft overall	8.15	7.25			7.70
h	freeboard	1.55				2.00
i	Displacement (tonnes)	2158	1639	1885	1856	1993
				(Tonnes)	*(L.Tons)*	
	= calculated value from other particulars given					

At the very least the *TugSim* analysis should be re-done to reflect consistent dimensions with the other documents, and proof of performance be verified. Actual maximum operating draft must be clearly defined.

f. The bow height (to the knuckle at the bottom of fender) is extremely low for operation in the Gulf of Alaska; one should be very concerned about how this shape will perform in 4 to 6 metre seas. It is strongly recommended that at the very least the knuckle be raised as high as possible to just support the fenders. In addition, details of fender attachment and support should be provided to demonstrate that the significant vertical wave forces which will impinge on the fendering can be properly resisted.

g. The bow form is extremely bluff as illustrated in Figure 2 below showing a model of this boat:

Figure 2 Model of Damen 4517 Tug, Indicating Bluff Forward Shape and Low Effective Bow Height to Bottom of Fenders (see also O/B Profile Drawing)

The combination of the bluff shape and low knuckle height will result in high speed loss in waves and a generally wet boat. Model testing should be performed in order to define speed loss in waves, particularly for any Sentinel tug mission.

4.2 Support Tugs – *Damen Model 3212*

4.2.1 Design

The Damen 3212 is a standard harbour tug produced by that company. The General Arrangement for this design is indicated in Figure 3 below.

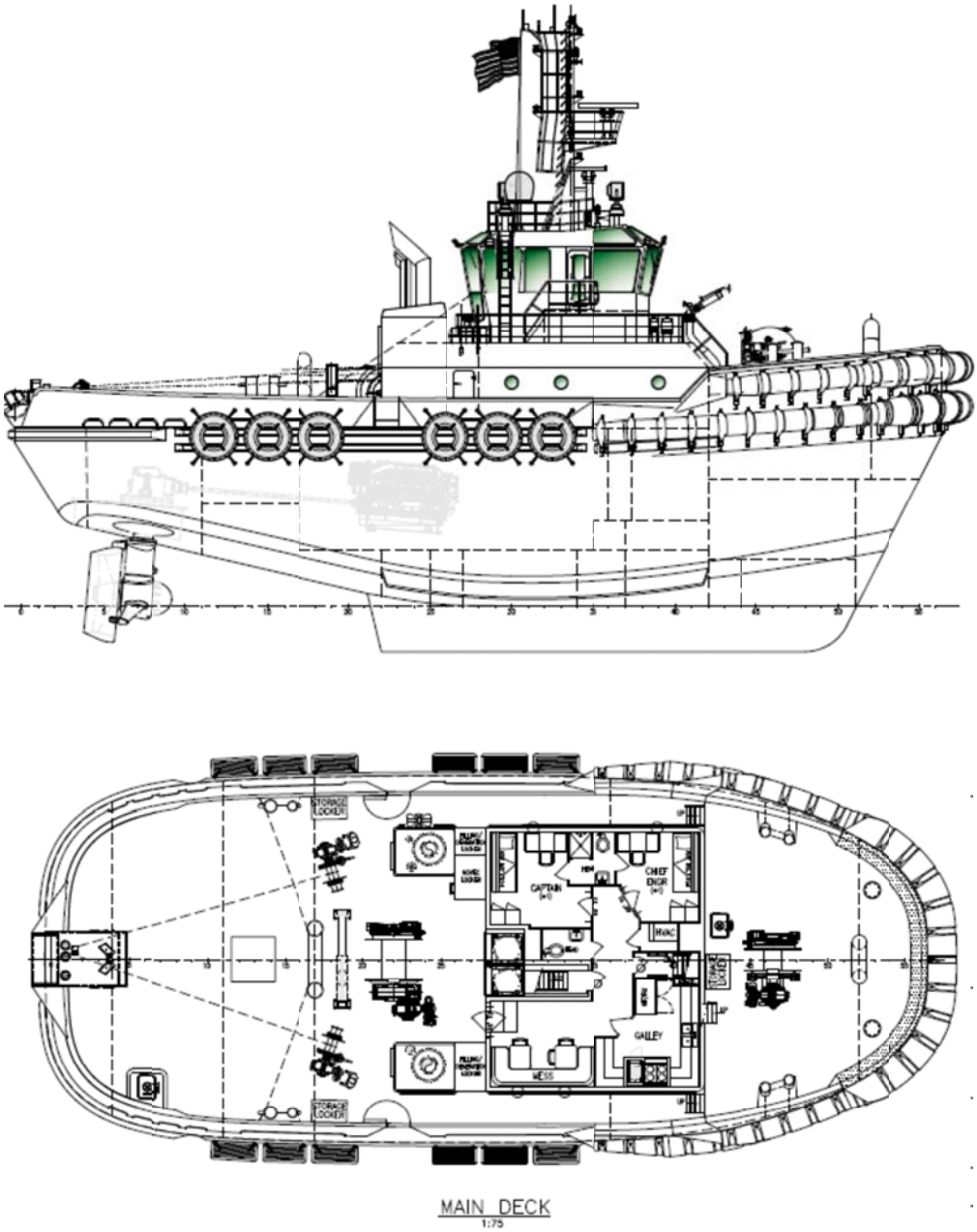

Figure 3 General Arrangement of *Damen 3212* Tugboat

The following are observations regarding this design for the intended application, which, according to Ref. [4], includes barge towing, fire-fighting (two tugs only), and oil "detection" (no mention of spill response or recovery capability). Reference 4 does not mention tanker escort operations at all, but Reference 5 describes a rather more extensive role for these smaller tugs which includes the following:

- Tethered escort of ships under ~ 90k DWT (Primary Escort)
- Untethered escort of ships (Secondary Escort)
- Ice Reporting Vessel
- Ice Scout Vessel
- Sentinel Escort
- Emergency Towing
- Off-vessel fire-fighting (two tugs only)
- Ship docking and undocking
- Recovery, storage, lightering, and nearshore barge towing, support, and operation

For purposes of this review it has been assumed that Ref. 5 is the operative document which defines the full mission of these tugs.

This assumption/conclusion however results in some serious issues with respect to the suitability of this 32 metre (105') tug design for all of these roles, and in particular in what weather conditions is it able to perform each of these roles safely. It is also alarming to read in Ref 5 that "*We do not intend to prove or test this [tethered escorting of < 90K dwt tankers] during contract transition. Our intention is to perform testing **following** a successful transition.*" (emphasis added). It is strongly recommended that this position be challenged.

It should be imperative that the performance of these tugs in all intended roles be clearly demonstrated by careful analysis and/or simulations at the earliest possible stage of this transition in order that there can be confidence in the end result. To wait until everything is in place and only then verify vessel performance invites significant technical risks to the project which could then result in delays.

The following are the more critical aspects of the 3212 design requiring review:

a. The tugs are fitted with fixed pitch (not controllable pitch) propellers. This will be problematic for indirect escort work, as the probability for stalling the engines is very high. An analysis of available engine torque vs propeller load should be presented to show that there is no risk of engine stall throughout the full operating range of rpm and azimuth angles
b. Details must be provided demonstrating the expected indirect and direct towing performance at 8 and 10 knots, in compliance with a recognized standard for escort towing stability

c. Details must be provided for the escort winch and all associated cordage; the winch must have a render-recover capability in keeping with the escort rating of the tug. The data sheet indicates a "dynamic line force" of only 15 tonnes for this winch which is seriously inadequate for escort work in Alaskan waters. It is strongly recommended that this winch be electric driven rather than hydraulic for the required performance, as well as being far superior in cold climate operations. It is further noted that this is a single drum winch only which provides no quick backup in case of a line break. That seems an inappropriate selection for such a critical mission. Winch specification must be reviewed/revised in the context of predicted indirect forces

d. The drawings provided do not indicate the Fi-Fi system described for two of the tugs. Details should be provided, including: one pump or two? driven from main engine PTO(s) or by independent engine? In addition, details of how the system can be thoroughly drained, flushed and purged to cope with the effects of (a) residual salt water, and (b) freezing conditions, must be provided

e. The arrangement of the stern tow-pin/roller system as shown is problematic: it will snag towing gear in the right angle space created between the pin "table" and the bulwarks. The top surface needs to extend diagonally outward to intercept the bulwarks at about a 45° angle and have no corners or overhangs to catch SWR sockets, shackles or similar towing fittings. Also, the position of the roller portion of these two-pin set is extremely vulnerable to contact damage when barge-handling. These rollers are normally set well forward of the contact area and are protected by fendering. Detailed drawings should be provided for approval

f. The main deck accommodation layout is inappropriate for the Alaskan climate:
    i. There is no wet room or even wet gear lockers at the entry. The main entry leads directly into the tiny mess area with no place to put wet boots, coats, etc. Maintaining this area in a semi-clean condition will be impossible. The mess space is tiny and abuts the main access corridor
    ii. The small tables in the mess will accommodate two people each for meals at best, not the total of six persons indicated. Although seats for six are indicated the table area will not be sufficient for all those people to eat comfortably
    iii. Bunks in the main deck staterooms are located against the cold exterior bulkheads and are oriented transversely which can be very dangerous for crews in heavy seas; alternate configurations should be evaluated

g. Ladder from fore deck to boat deck is very steep … potentially dangerous, especially in snow or icy conditions. It is also strongly advised that any exterior ladders and gratings be constructed of GRP to minimize potential for snow and ice accumulation. ECO to define what is presently specified for ladders and gratings and if necessary change for best crew safety

h. Fendering on the stern looks inadequate. Details of fendering and towing arrangement to be provided and reviewed/approved by Masters familiar with local towing operations and conditions

i. Configuration of quarter bitts aft: it is suggested that these bitts are too far aft and present a risk of the towline being snagged on the forward side. Bitts should be positioned closer to Frame 18, at least abeam of the spooling gear

j. Deck locker space is totally inadequate for towing gear etc. in the cold climate. Provide details to demonstrate suitable drainage, ventilation and heating in ALL gear lockers to ensure lines are all readily usable in all weather conditions

4.2.2 Performance Predictions

Very little information is provided beyond the indicated BP of 65.8 tonnes from 4,480 kW. However these figures seem to indicate a very poor specific performance. Typically, that much power (6,005 BHP) should deliver closer to 75 tonnes BP. **This discrepancy should be explained/resolved soonest as it indicates that excessive fuel will be used for the defined performance.** If the BP is under-predicted then the overall stability of the tug and the winch performance could be affected.

This performance should also be compared to that of the Crowley "Invader" class tugs to verify that equivalent BP performance is being offered.

Contrary to the statement in Ref. [5], the performance of this tug in all its intended roles should be clearly demonstrated by thorough analysis BEFORE the tugs are delivered, and ideally before they are even built.

5.0 QUESTIONS TO BE ANSWERED

Based on the previous observations, the following are the critical questions that need to be answered, ideally long before the vessels are delivered and better yet before construction advances any further.

5.1 Escort Tugs

a. Explain why this new unproven design (for multiple vessels) was not model tested to verify all aspects of performance for such a critical mission.
b. Advise the total navigational draft, not just the moulded hull draft.
c. Ask to have Damen/ECO resolve the discrepancies regarding the main dimensions of the escort tug and re-analyze escort forces to reflect true size
d. Advise why the specific BP performance (tonnes/kW power) for this tug is as low as it is.
e. How long will it take to clear water from the forecastle deck space in a rough weather transit, assuming a green water event? Relate this time to associated wave heights and wave periods in Gulf of Alaska storm conditions
f. Has the arrangement of accesses and escapes to the main deck accommodation been approved by Class and USCG for compliance with SOLAS? Do the Owners consider this configuration, with only one primary access on each deck level, to be safe for the crew?

g. Good design practise for modern tugs should demonstrate compliance with the requirements of the Maritime Labour Code-2006 (MLC-2006), even if in this instance the USA is not a signatory to that ILO standard. "*Although the Convention has not been ratified worldwide, it has widespread effect because vessels from non-signatory states that attempt to enter ports of signatory states may face arrest and penalties for non-compliance with the MLC.*" (Source –Wikipedia). In particular the designers should address the perceived shortcomings with MLC-2006 sections:
   - B3.1.5; Paragraph 7
   - A3.1; Paragraph 11b
   - B3.1.11; 4d

h. Expand the indirect towing/tanker save analysis to include some cross-wind elements in order that the boundaries of safe operation can be properly defined. Assumptions of direct astern or zero wind are extremely limited in order to declare this tug as fully capable. The analysis should reflect the full range of Met-Ocean conditions existent at the designated locations, not just two very limited conditions.

i. Provide evidence that the *Shipmo 3D* motion predictions for this vessel can be verified through correlation to full-scale or model-scale measurements. How have the effects of skegs, bilge keels, and thrusters been accounted for in the prediction? Ideally predict the motions based on a seakeeping model test rather than on this computer analysis.

j. Provide predictions of speed loss in waves (at least for H_s = 2, 4, and 6 metre) for this hull form to prove it can perform the Sentinel tug role adequately, particularly with regard to sustaining response speed in waves.

k. Define the method by which towline force information will be relayed to the tug Master during escort operations. Describe how the hawser winch complies with the Class requirements for rendering/recovery at defined stability limits for the tug.

l. Provide evidence that the tug can perform reasonable station-keeping or some side-stepping in the ship-assist mode without the aid of a lateral bow thruster

m. Describe all measures that have been taken to equip these vessels for year-round operation in the Alaskan climate; specifically address issues of deck heating, line storage and heating, prevention of shell tank contents and water line freezing throughout the ship

n. Describe what measures will be taken to protect hydraulic lines and control components to the winches in cold weather, and to ensure winch operation in such conditions.

o. Describe the full details of all towing lines, towing gear and hawsers to be fitted aboard the vessel. Provide SWL and breaking strengths for each component, and the criteria used to establish the relationships between components relative to winch brake capacities and line pulls.

p. Describe what ice-strengthening is incorporated into the hull.

5.2 Support Tugs

a. Advise why the predicted BP for this standard tug is only 65.8 tonnes with 4,480 kW of installed power.
b. Describe in detail the predicted F_s and F_b at both 8 and 10 knots?
c. Provide evidence that the tug complies with USCG Towline Pull Stability criteria and a recognized escort stability criteria.
d. .Define the arrangements for fire-fighting on two of these tugs.
e. Provide full details of the escort winches and the associated cordage. Prove the winch capabilities are commensurate with the intended escort missions in the full range of intended sea conditions.
f. Describe all measures that have been taken to equip these vessels for year-round operation in the Alaskan climate: specifically address issues of deck heating, line storage and heating, prevention of line freezing throughout the ship.
g. Describe what measures will be taken to protect hydraulic lines and control components to the winches in cold weather, and to ensure winch operation in such conditions.
h. Describe the full details of all towing lines, towing gear and hawsers to be fitted aboard the vessel. Provide SWL and breaking strengths for each component, and the criteria used to establish the relationships between components relative to winch holding and brake capacities and line pulls.
i. Describe what ice-strengthening is incorporated into the hull.

6.0 REQUIREMENTS FOR TESTING ON COMPLETION

It must be stated that waiting until completion of these vessels is much too late to identify any potential shortcomings in the designs. The deficiencies identified in this report should be resolved immediately in order that changes can be made during production design/construction at lower cost and time impact than if only considered on completion.

The following are critical performance parameters that should be established on final testing and trials of the tugs in order to establish the benchmark for all subsequent performance monitoring:

6.1 Escort Tugs

- Full range of stability conditions; intact, towing, escort operations
- Damaged stability analysis (is a one-compartment standard of subdivision achieved?)
- Bollard pull, ahead (over range of rpm): Provide Class certificate
- Bollard pull, astern (over range of rpm). Provide Class certificate
- Maximum Indirect Steering Forces at 8 and 10 knots, (within Class stability limits) and the tug position and attitude at which these forces are generated. Provide Class certification of maximum F_s
- Maximum Indirect Braking Forces at 8 and 10 knots, (within Class stability limits) and the tug position and attitude at which these forces are generated
- Maximum transverse arrest force at 6 and 8 knots
- Maximum direct astern braking force at 6 knots
- Fi-Fi system performance measurements proving compliance with Class Notation
- Free running speed in calm conditions at 50, 75, 90, and 100% rpm. Proof of directional stability/controllability during typical manoeuvres, running ahead and astern, and specifically while manoeuvring alongside the shoulder, quarter and approaching the bow/stern centreline of a tanker at 6, 8, and 10 knots while making way ahead and astern
- Crash stop manoeuvre (time and distance) at full speed ahead
- Time delay from full ahead command to commencement of astern movement
- Fuel consumption measurements at bollard condition and free running at 8, 10, 12 knots and at max. free running speed

6.2 Support Tugs

- Full range of stability conditions; intact, towing, escort operations
- Damaged stability analysis (is a one-compartment standard of subdivision achieved?)
- Bollard pull, ahead (over range of rpm). Provide Class certificate
- Bollard pull, astern (over range of rpm). Provide Class certificate
- Maximum transverse arrest force at 6 and 8 knots
- Maximum direct astern braking force at 6 knots

- Provide details of:
  - maximum Indirect Steering Forces at 8 and 10 knots, (within Class stability limits) and the tug position and attitude at which these forces are generated. Provide Class certification of maximum F_s. Provide Class certification of maximum F_s
  - maximum Indirect Braking Forces at 8 and 10 knots, (within Class stability limits) and the tug position and attitude at which these forces are generated
- Fi-Fi system performance measurements proving compliance with Class Notation
- Free running speed in calm conditions at 50, 75, 90, and 100% rpm
- Proof of directional stability/controllability during typical manoeuvres, running ahead and astern, and specifically while manoeuvring alongside the shoulder, quarter and approaching the bow/stern centreline of a tanker at 6, 8 and 10 knots while making way ahead and astern
- Crash stop manoeuvre (time and distance) at full speed ahead
- Time delay from full ahead command to commencement of astern movement
- Fuel consumption measurements at bollard condition and at 8, 10, 12 knots and at max. free running speed

7.0 SUMMARY

This review identifies many aspects of both proposed tug designs that indicate (a) a lack of thoroughness in proving suitability for purpose of the tugs, and (b) unfamiliarity with the requirements for safe and sensible operation in the Alaskan climate. The latter issues are perhaps not all critical to the vessel base mission but will certainly render the boats difficult to operate and to maintain well. Many other issues are raised that are simply good design practise issues that could be revised at minimal cost to provide a safer and better operating environment for the crew, and result in less downtime and long term maintenance.

The most critical aspects of the design review are summarized below, categorized for each vessel type according to:

- Performance Predictions
- General Design Configuration, and
- Suitability for Operation in Alaskan Environment

7.1 Escort Tugs

7.1.1 Performance Predictions

- Indicated specific BP is about 15% lower than what would be considered "normal" for a large Z-Drive tug. Difference to be resolved. If result is actually higher than stated this could adversely affect the current stability analyses
- There is no evidence presented to indicate that this new hull form has been model tested to prove that all performance objectives will be met or to verify fitness for purpose, as one would expect in a fleet investment of this magnitude.
- The existing performance predictions for the large escort tugs are very limited in scope and do not prove performance in the full range of operating conditions
- The seakeeping predictions are suspect in their accuracy
- The indirect performance analyses were done only for calm conditions and for wind directly astern. This does not identify what happens in any cross-wind condition, a serious omission considering the full extent of the escort route.
- Discrepancies in vessel dimensions between referenced documents indicate that the indirect escort performance must be re-calculated for the latest vessel dimensions

7.1.2 General Design Configuration

- The forecastle deck area presents a significant "pool" to hold water during heavy seas
- Given the high windage of this tug, and the presence of a very large skeg which will hinder lateral mobility/manoeuvrability, a bow thruster should be strongly considered for ship-handling operations at low speed
- Experienced Masters familiar with the tug operations advise [Annexes A and B] that the fendering arrangement shown on the GA drawings will be insufficient for the PWS operations.
- No information was provided with respect to the structural design of these tugs, and in particular with regard to the ice-strengthening of the hulls. Some ice-reinforcement must be required
- The bow height (to the knuckle at the bottom of fender) is extremely low for operation in the Gulf of Alaska: one should be very concerned about how this shape will perform in 4 to 6 metre seas.
- Galley range facing athwartships will be a safety hazard in rough seas
- Refrigerators oriented longitudinally will spill their contents regularly.
- Should consider providing lavatories close to bridge and to machinery control room
- Bunks should be arranged, wherever possible, away from exterior bulkheads and not oriented transversely
- Consideration should be given to a lounge area separate from mess room
- Consideration should be given to fitting a crew exercise room

7.1.3 Suitability for Alaskan Environment

- In the absence of a Specification for this vessel it is unclear what measures have been taken in the design to cope with the heavy snow and sub-freezing temperatures prevalent in the operating area. The following in particular are of serious concern:
  - prevention of ice/snow plugging the freeing ports in the fore deck
  - measures for deck heating in all exposed working areas to prevent ice/snow accumulation.
  - methods/locations for protected/heated storing of mooring and other working lines
  - means of protecting winches from water ingress into shelters and from freezing spray
  - prevention of freezing in potable water and fresh water ballast tanks adjacent to the shell
  - protection from freezing in ALL piping systems and especially those exposed to weather such as drain lines
  - avoid any topsides deck drains routed inside deckhouses
  - all wheelhouse windows should be heated type
  - all wipers should be equipped with heating elements and provision for adding anti-freeze to window-washing solution?
  - hull strengthening must be provided to cope with ice conditions
  - Crew berths should, wherever possible, be located away from exterior bulkheads and definitely not be oriented transversely in order to maximize crew comfort and safety and to minimum fatigue

7.2 Support Tugs

7.2.1 Performance Predictions

- Very little information about performance is provided beyond the indicated BP of 65.8 tonnes from 4,480 kW. These figures indicate a very poor specific performance. Typically, that much power (6,005 BHP) should deliver closer to 75 tonnes BP. This discrepancy should be explained/resolved soonest
- This performance should also be compared to that of the Crowley "Invader" class tugs to verify that equivalent BP performance is being offered
- Provide evidence that the tug complies with USCG Towline Pull Stability criteria
- Provide evidence that the tug complies with a recognized escort stability criteria
- Provide full details of F_s and F_b capability at 8 and 10 knots, within recognized escort stability criteria
- Demonstrate that the fixed pitch propellers will not cause the engine to stall in the full range of operating conditions during indirect escort operations

In conclusion, neither design is sufficiently well defined in terms of its expected performance to be unreservedly declared fit for purpose at this time. Both designs as reviewed suffer from design/layout issues which will render the tugs difficult and potentially unsafe to operate in Alaskan sea and weather conditions.

The issues of performance verification must be addressed quickly in order to prove that the entire operation will provide at least the same degree of safety as the existing operation long before the new tugs arrive on station.

The design issues should be addressed immediately, and before construction is so far advanced as to render changes impossible to accommodate without significant cost and delays.

The measurement of actual performance cannot be assessed until the vessels are delivered, but more extensive analysis can and must be done to prove that the necessary performance can be achieved in all the boats before delivery.

for **ROBERT ALLAN LTD.**

Robert G. Allan, P. Eng.
Executive Chairman

RGA:da

Attachments:

- Annex A – RCAC's comments on Robert Allan Ltd.'s Review of Tugs
- Annex B – Robert Archibald's comments on Robert Allan Ltd.'s Review of Tugs

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Annex A

PWSRCAC's comments on Robert Allan Ltd.'s Review of Tugs

Comments on Robert Allan Ltd.'s A Review of the Proposed New Escort and Support Tugs for Tanker Operations in Prince William Sound

Prepared for:
Prince William Sound Regional Citizens' Advisory Council
Valdez, Alaska

Prepared by:
Little River Marine Consultants
P.O. Box 504
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Date: December 22, 2016

Project No: 8020-16-01
Revision: **1.2**

The opinions expressed in this PWSRCAC-commissioned report are not necessarily those of PWSRCAC

Contents

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Comments on Robert Allan Ltd.'s A Review of the Proposed New Escort and Support Tugs for Tanker Operations in Prince William Sound

1.0 BACKGROUND

Little River Marine Consultants was retained by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) to review and provide input of "A Review of the Proposed New Escort and Support Tugs for Tanker Operations in Prince William Sound" by Robert Allan Ltd.

2.0 REFERENCE MATERIAL

The following information was provided by the Client and was used as the basis of this review:

a. Escort Tug Drawings:

- ***Damen 4517*** - General Arrangement (10 pages)

b. Support Tug Drawings:

- ***Damen 3212*** - General Arrangement (9 pages)

c. Other References not provided by the Client

- ***International Labour Conference - Maritime Labour Convention, 2006***

3.0 SCOPE OF WORK

The following is the instruction given to Little River Marine Consultants with respect to this review and comment:

a. To review the report from Robert Allan Ltd. and provide comment for additional insight, input and observations.

b. Review vessel drawings and simulations as to performance and suitability.

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4.0 DESIGN REVIEW – FINDINGS

4.1 Escort Tugs - *Damen Model 4517*

4.1.1 Design

a. The Escort Tug dimensions list the draft at estimated 98 percent consumables as 5.45 meters. It could be inferred to mean from the underside of the skeg or keel or navigational draft, but the numbers do not correspond to that premise. Clarification from ECO.

b. Agreed, the size and position of the skeg will impact the tugs maneuverability when coming alongside a tanker at speeds in excess of 5 kts due the pressure wave caused by the tankers hull through the water. Additionally, this type of skeg may interfere with course stability when the tug approaches the stern of the tanker to pass the working line to the ship at higher speeds due to the skegs interaction with the propeller wash from the tanker.

c. The pooling effect mentioned in Robert Allan's report is a valid concern which will be further complicated in winter icing conditions when spray freezes on the bulwarks, fittings, winches, and deck. The unknown effects of the "pooling" on the rise of the tugs could cause delays in the timing to provide the intended service to the tanker, and could add potential safety issues when approaching the disabled vessel.

   In addition to being a crew safety hazard and possible water egress into the tug interior spaces, the breaking or "sluffing" of ice onto the inside of the bulwarks could congest the freeing ports and allow additional water to accumulate in the foredeck area, thus further impeding the ability of the vessel to rise back out of the seaway. This is particularly applicable in the Hinchinbrook Entrance where the waves are more confused and stack up in comparison to the more open Gulf of Alaska.

   Vessels returning from escort (or other duties) are subject to pitching while transiting the Valdez Arm in the winter, which produces heavy icing on the forward area of the vessel. A very important system that appears to be overlooked is a means of heating the weather decks to minimize snow and ice accumulations, which can cause a considerable crew safety hazard as well as a crew effectiveness issue when trying to handle lines.

   Another concern with the accumulation of water on the forward deck is that the escort winch is partially open to head seas during escort operations and lite boat transits. This will require that some protection should be installed above and below the plane of the working line, or a winch cover installed to keep the winch brake and drum free from freezing in the open or closed position thus preventing the working line from retrieving or paying out properly, in addition to freezing in place on the winch.

   The potable water tanks between Frames 59-64 adjacent the hull will be subject to freezing

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during the winter period without consideration of heating elements. The same concern holds true for the freshwater ballast tank forward of Frame 64. Additionally, heated decks and line lockers will be an absolute must during the coldest periods of the winter.

d. Agreed, clearing of both the forward and after decks of ice and snow are crucial to the safety of the crew and vessel. Low voltage deck heating is generally ineffective during the coldest periods of the Valdez winter. Lack of sufficient heat to completely melt the ice and snow build up on deck causes a dangerously slippery deck as the slush accumulation is not melted.

e. Agreed, a bow thruster is always a helpful tool to have, especially when holding the tug in position during wind events from either the east or west in the Port of Valdez, enhancing oil spill recovery operations to keep equipment on station during deployment and recovery or making tow to a disabled tanker.

General consensus from the tug industry is that bow thrusters become ineffective at speeds above 5-7 kts. With that being said, the current Prevention and Response Tugs of similar size, but 2,000 hp less, were able to handle the maneuvering demands required of them with minimum impact. The deep skeg forward on the 4517 is additional evidence for rigorous tank testing of the vessel design.

f. There is some question as to what Robert Allan is implying in this paragraph. As it appears he is pointing out that each stateroom has only one access, if so, this may be a difference in construction regulations between countries. Most tugs in our experience been aboard generally have one access in each stateroom unless there is a common head between the two.
    i. The drawings indicate there are three hatches to the weather deck from the main deck: One just forward of the winch, one on the port side of the galley, and one on the forward house bulkhead on the port side of the centerline.
    ii. On the boat deck, plans indicate there is one access on the port side aft of the Masters room, and one forward between the two mate's rooms of the forward house bulkhead.
    iii. It will ultimately be up to ABS to assess access/egress during examination of the plans for Class.

g. Agreed, the same goes for the galley range and stove.

h. Agreed.

i. Although Robert Allan's comments are helpful and good practice, the United States is not a signatory to the Maritime Labor Convention (MLC 2006) and therefore would not be a concern of the USCG or ABS.

    i. Berths on an outboard bulkhead in the winter are intolerable and cold. In addition, the heads located on the forward bulkhead of the house, aft of the store rooms, will also be

cold and plumbing subject to freezing. Suggest the store areas be heated, first to keep the line and general stores from freezing, second to keep the plumbing from freezing and fracturing. The same holds true for the locker adjacent to the changing room on the starboard side.

ii. [RAL topic: sanitary facilities within easy access of the nav. Bridge & machinery space] Sanitary facilities in the machinery space and navigation bridge are valuable in allowing the navigational watch or engineer to remain close by the area of responsibility. The importance of this concept on tugs built in the U.S. is not generally recognized. In addition, the manner in which the vessel watches are arranged also can assist in filling the vacancy of someone using the sanitary facilities. In the engineering department, there are sufficient alarm systems to notify both the navigation bridge and engineer's stateroom that an issue needs attendance.

In the Prince William Sound service, it is expected that there will be two mates and a non-watch standing Captain. This is done to allow strict adherence to the 12-hour rule due to additional ancillary duties for the vessels designed in the system. This allows the watch stander to call an off-watch officer to cover while the facilities are used. It is worthwhile to mention that the United States is not signatory to the Maritime Labor Convention (MLC 2006) and therefore would not be a concern of the USCG or ABS.

iii. Crew fitness space: When recreational facilities have not been included in a vessel design utilizing equipment suitable for a dynamic environment, the crew will typically cobble one together of their own. This, in our experience, poses a significant safety risk because machines are not secured properly to the bulkhead and deck, improper athletic material is used, or machines are not suited for the dynamic environment.

This generally leads to injury, or worse, to crewmembers using the equipment. Based on our experience, it is best to have an "off ship" exercise area. In that way costs of providing such equipment are minimized, there is reduced risk of crew injury, and it is accessible to all vessel personnel. One last note on exercise, if an injury does take place, there is a fair chance it might be deemed an OSHA recordable or Lost Time Injury resulting in an elevated OSHA recordable rate.

Crew lounge spaces are helpful on larger vessels. On board a tug with current crew levels, generally the on-watch is working and off-watch are resting or are generally considerate of the crew that are resting. The one concern on the Model 4517 is the fact that one berth on the opposite (forward) side of the mess area bulkhead (Fr 53) is not only transverse, making sleeping uncomfortable in a heavy sea, but is directly against the mess area bulkhead making it very noisy to rest during meal times.

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4.1.2 Performance Predictions

a) Tank modeling of this design is critical to assure the stakeholders the Escort and General Purpose tugs will perform as required at different power settings and sea conditions. Deck wetness calculations are critical in order to establish stability in icing conditions and the ability of the crew to work on deck in the event of a tanker causality in heavy weather. Calculations done on the escort performance are based on best case vessel attack angles, and vary significantly from operator to operator based on their ability to understand and apply the proper vectors to develop optimal vessel performance. Therefore, real time exercises must be executed in various weather conditions to prove the actual "live" performance of the vessels.

b) Agreed.

c) Ref. [1] Modeling scenarios, the premise used when David Gray designed the "Shipman" program was that the two areas with minimum room for tanker track transfers are the Valdez Narrows and Valdez Arm. When weather events occur in those areas, the wind will generally blow through the passes from a NW direction, thus putting the wind directly on the stern of the tanker. Since the only maneuver available in Valdez Narrows is a retarding (braking) maneuver, consideration of anything but winds from astern might confuse the findings.

   Once the tether is released at buoy #9, the traffic scheme widens into Prince William Sound allowing additional room for maneuvering. Winds from other directions other than the Northwest, which would considerably affect the results of the simulation, must be considered. This plays a significant role when "sea room" is reduced in the sound or in the vicinity of Cape Hinchinbrook due to a tug's difficulty attaching a line to a ship.

   During the design of the current tug system in PWS, this became an issue. Both winds and currents became topics for additional testing during the design of the previous system. Several months of delays were experienced while additional tests were designed and agreed upon by all parties before Glosten could run the additional model tests. As the different wind and current conditions were modeled, the results led to the need for additional testing, which led to more delays. It is suggested that sufficient emphasis be placed on this shortcoming to ensure that potential changes to the tugs could be made, if necessary, prior to final construction.

d) In this section, Robert Allan's group discussed the uncertainty of predicting seakeeping performance using Shipmo PC mentioning the motions of a vessel with a large skeg. One factor that has not been examined by simulation, that will be an important factor in the manner that the tugs handle, is the ability of the tug to safety cross the pressure wave alongside the tanker as she makes way.

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It might be worthwhile for the PWSRCAC to undertake an independent review of modeling both vessels using Computational Fluid Dynamics. This type of modeling would provide a verification of assumptions made in the vessel design. This service is relatively inexpensive and can be researched at http://cfdanalysis.com/about-us/.

The current ETT's have a small skeg forward in the direction of tethered movement and the ability to simultaneously and instantly control both longitudinal and transverse thrust angles, allowing the vessel to "push through" the pressure wave, and once inside, remove the transverse thrust needed to overcome the opposite force of the hull pressure of the tanker. Since the PRT's have no skeg forward, this force does not significantly affect the maneuvering of the vessel.

In the case of the Model 4517 escort tug, there is a significant skeg that extends aft from Frame 60 to Frame 17. As ASD propulsion has a notable lag time to azimuth direction, this may cause the tug to come alongside the tanker with considerable force risking inset to the tanker hull plating or cracked welds.

It will be absolutely necessary to increase the fendering by adding 2000 mm x 900 mm tires forward of frame 52 and replace the 1600 mm x 590 mm tires aft with 2000 mm x 900 mm tires to absorb the weight of the tug.

e) Agreed.

f) The bow shape and low height are concerns for both a reduction in high running speeds and making a "wet" boat and harder for the crew to perform tasks on the foredeck. In addition, there is no apparent indication that the Shibata fendering has any saddle foundation to support it. This will be necessary to stabilize the fender in head seas and when pushing on a tanker in swell conditions.

There are many concerns that would be potentially eliminated (bow wetness, performance, seakeeping, etc.) by model testing of this vessel. It is strongly recommended that model testing be conducted at the soonest opportunity to identify any potential issues that could be rectified at this early stage. At a bare minimum, a class-approved CFD analysis should be conducted.

Additional details on the winch, how the towline forces are relayed to the master, and how the winch complies with the class requirements for render/recovery need to be provided.

4.2 Support Tugs - *Damen Model 3212*

These tugs are proposed to be used as primary escort tugs for tankers under 90,000 DWT. In order for them to be effective as such, these tugs must be outfitted with a skeg. At this point there are no plans to conduct any type of modeling. If in fact they are included in the C-Plan as a primary escort, it is

absolutely necessary to have modeling scenarios run to verify the suitability of the tugs to perform safely.

a) Fixed pitch propellers are less than suitable for any type of indirect maneuvers at or above 8 knots. The slow rotation of the ASD units and inability of the units to reverse the thrust delays the time for the master to react in the event the tug reaches a critical stability condition due to deck edge immersion by applying corrective forces to right the vessel quickly and overcome the lift created by the attack angle of the skeg through the water flow. Under the assumption that the 3212 will be used as a primary escort, torque versus propeller load analysis should be conducted on the fixed pitch propellers to determine if there is the potential for engine stalling with the intended use.

   It appears that these tugs may be called on to perform tethered escorts, and as such, additional analysis is needed to establish predicted performance, suitability, and conformity. To say that this will be done at a later date may be extremely limiting (if there is greater potential for engine stalling) for the escort system where maximum flexibility should be maintained.

b) As ABS, DNV, Lloyds and BV all recommend full scale testing at 6, 8, and 10 knots, it would be advisable to adopt the standards of the classification societies for consistency. Although 6 knots is the lower threshold for an effective indirect maneuver it is important to test the tugs performance as the results may be used in designing emergency maneuver protocols.

c) Agreed, ABS has requirements for the minimum breaking strength of deck fittings and towline. Without listing the details of the winch and line it is impossible to determine conformity to the ABS requirements.

d) Without the controllable pitch control of the ASD units, the fire pump will have to be a separate power system. If the intention is to use a main engine, the engine used to power the pump would have to be declutched from the ASD unit and run at a specific RPM specified by the pump manufacturer.

   A note on FiFi system piping: Proper post use draining is critical in both mild steel and stainless steel systems. Salt water accumulated in low sections of the piping causes corrosion in mild steel and worm holes in stainless. The fire monitor system must have proper drains and a means to blow out remaining water to prevent this condition, or be constructed of bronze or suitable material.

e) A more detailed drawing of the tow pin and roller is needed to visualize any operational challenges.

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f) The main deck living area for the Captain and Engineer have several areas for concern.

   i. Agree with Robert Allan's review regarding gear lockers. This also presents a safety concern as not having a gear room brings water into the house from crew entry, and makes the decks very slippery leading to slips and falls of the crew.
   ii. Without seeing the exact measurements of the mess table, it would be hard to determine if it would accommodate more than two people. However, the seating arrangements indicate that seven people could be seated between the two tables.
   iii. The common head and shower are on an outboard bulkhead; this could potentially result in the waterlines freezing and bursting in cold temperatures. Other than the freezing of pipes, repairs to the system would take the vessel out of service until complete. Additionally, the bunks in both staterooms are on the same outboard bulkhead. This placement will expose the occupants to the cold radiating from the thin insulation between the interior and exterior of the house.

g) There is no indication as to the material used in constructing the ladders exposed to weather. It is beneficial to use non-skid fiberglass grating to prevent icing and snow accumulation on all exterior ladder treads. Since the vessel executes contact with the tanker on the bow, the stern is mainly used for towing operations due to the travel across the transom during towing operations Fendering across the transom is problematic, especially when towing out of the tow pins. The wire must have unrestricted travel across the transom when connected and getting underway with a tow. During this period the tug must have the ability to adjust its heading in order to prevent getting in irons and controlling the tanker. (Refer to the reports from in Sound towing drills with the PRT class tugs.)

h) The main deck quarter bitt arrangement seems to be not represented in the drawing properly for each side of the vessel. The Robert Allan review has a point in that the bitts could be moved forward to Frame 17. Additionally, a bulwark chock on the Frame 7 line would be helpful when making up to response barges, docks, and alongside other tugs.

i) Heated line lockers for deck lines on this vessel will be an absolute necessity in the winter. Any line left on deck will be frozen and covered with snow. It will also be necessary to fabricate heavy Arctic grade covers for both the tow and bow winches. If covers are not fitted, the winch brakes, gear,s and line will freeze during the cold season and become unusable for ship or barge work.

4.2.2 Performance Predictions

With the expectation of these tugs serving as Primary Escort Tugs for tankers less than 90,000 DWT, hydrodynamic simulations are required at a minimum, with tank testing being optimal. There must be some evidence that Model 3212 is capable of meeting the demands of that mission.

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There should also be confirmation of the bollard pull for the 3212 as the tugs are rated as 65.8 tons with 6008 hp at 1800 rpm as the Crowley Invader class has a bollard pull of 75 tons with 7200 hp at 900 rpm. Equally as important is the fact that the fire pumps, if run from a PTO off the main engines, will reduce the bollard pull of the 3212 significantly depending on the maximum RPM the pump is rated for. The Crowley docking tugs equipped as fire boats all have a separate engine to power the fire pump.

5.0 QUESTIONS TO BE ANSWERED

- Since the model 3212 is an "off the shelf" model, Damen must have performance calculations and validation, in addition to hydrodynamic testing. The PWSRCAC should request this information be obtained by SERVS from ECO or Damen at the earliest opportunity.

- Obtain more detailed drawings of the stern tow pin area so a proper evaluation of tow wire travel may be assessed.

- Obtain a revised drawing of the main deck showing proper bitt configurations and locations.

5.1 Escort Tugs

a) Included in Robert Allan's questions, additional questions as follows:
   i. Are heated decks (fore & aft) planned, and if so, what is the method of heating?
   ii. What additional lines do the 4517 carry (e.g., 12" dia. Nylon/AmSteel emergency tow hawser) to connect into the ship's Prince William Sound Package?
   iii. Is there an easily deck-accessible, protected storage for this line?
   iv. Specify type and construction of escort line and any sacrificial pennant connected to the escort line.
   v. Will the tug carry any surge chain of proper size and length?
   vi. What are the ABS certified Safe Working loads and Breaking Strengths of all tow connecting gear?
   vii. In what manner will the termination connections for the tow wire be attached?
   viii. Has the hull been strengthened in way of the waterline to prevent ice damage or breaching of the hull? (The Nanuq and O/S Ohio suffered impact and damage from contact with a bergy bit.)

5.2 Support Tugs

a) Included in Robert Allan's questions, additional questions as follows:
   i. Will the difference in bollard pull between the 3212 and the Invader be a reduction in the system?

ii. Are heated decks (fore & aft) planned, and if so, what is the method of heating?
iii. What additional lines does the 3212 carry, (e.g., 10" dia. Nylon/AmSteel emergency tow hawser) to connect into the ship's Prince William Sound Package?
iv. Is there an easily accessible, protected storage for this line?
v. Specify type and construction of working/escort line and any sacrificial pennant connected to the working/escort line.
vi. What are the ABS certified Safe Working loads and Breaking Strengths of all tow connecting gear?
vii. Will the tug carry any surge chain of proper size and length?
viii. In what manner will the termination connections for the tow wire be attached?
ix. Has the hull been strengthened in way of the waterline to prevent ice damage or breaching of the hull? (The Alert suffered impact and damage from contact with a bergy bit.)

6.0 REQUIREMENTS FOR TESTING ON COMPLETION

Agree with Robert Allan's review.

6.1 Escort Tugs

In addition to Robert Allan's suggestions, additional items are identified below:

- ABS Certificate of Bollard Pull Test (ahead).
- ABS Certificate of Bollard Pull Test (astern).
- Proof of directional stability/controllability maneuvering alongside the shoulder, quarter, and approaching the bow/stern centerline of a tanker at 6, 8, and 10 knots while making way ahead and astern.
- Maximum transverse arrest force at 6 and 8 kts.
- Maximum braking force at 6 kts.

6.2 Support Tugs

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- Maximum braking force at 6 kts.

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7.0 Summary

In addition to Robert Allan's suggestions, additional items are identified below:
A major concern that comes forth from this report is the ability of the tugs to use their design capabilities and for the crews to be able to carry out their responsibilities and do so safely. In order to avoid the modeling problems that came up during the first escort (ETT/PRT) tug design, it is suggested that this report more clearly emphasize modeling and potential design changes for operation in the Prince William Sound tanker operational conditions up to closure

As Robert Allan's review stated, it appears both the 4517 and 3212 vessels are inadequately outfitted for the rigors of the Alaska winter environment. Transiting Prince William Sound or standing by/escorting a tanker during a Cape Hinchinbrook closure will cause the vessel to develop heavy icing conditions on both the deck equipment and working lines. Loitering in Port Valdez will generate deep snow accumulations on the deck of the tug. The ability to clear the decks of snow, ice, and water is of paramount importance for the safety of the vessel, crew, and mission of the tug.

Access to pliable deck lines when making up to a response barge and docking is imperative as frozen lines will not hold on cleats bitts and bollards. Heated store rooms or deck boxes will be the single manner to provide line in an acceptable condition.

Adequate fendering in the form of large earth mover tires on the shoulder and large aircraft tires in line with the ASD units on both class of tugs, will lessen the chance of heavy impact to tankers and response barges.

If PWSRCAC believes these areas are addressed insufficiently for this stage of the project, they may wish to emphasize these concerns in more detail during their interactions with industry.

It will be very important to have the PWSRCAC represented by a Subject Matter Expert (SME) at initial tank testing, all sea trials, full scale trials and bollard pull testing. Furthermore, it is absolutely necessary to conduct intensive tether and towing exercises at all speed ranges, weather conditions, and failure recognition times to validate the performance of these vessels.

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Annex B

Robert Archibald's comments on Robert Allan Ltd.'s Review of Tugs

Comments on Robert Allan Ltd. Review and Little River Marine Consultants Comments on ECO New Escort and Support Tugs

By
Robert Archibald

The following are comments that I have on the above reports. In general, I agree with all comments provided and add the following observations.

Escort Tugs – Damen Model 4517

4.0 Design

4.1.1

a. Agree with Robert Allan Ltd., (RA) and Little River Marine Consultants (Little River).

b. Looking at the design of the foredeck area, there is no doubt that drainage could be a problem. The provided drawing shows four freeing ports on each side of the foredeck. The Shibata Fendering System may hamper the free water flow out of these ports. During freezing weather operations, ice build up will further reduce water-shedding ability.

The tether line opening through the winch room forward bulkhead will allow water ingress during rough weather escorts. The deck drain scuppers inside the winch room will have to be designed to allow adequate service to prevent flooding during freezing conditions.

Not mentioned is weather deck heating to help shed ice and snow. This is a major operational and safety concern for personnel working out on deck during winter months.

The tether line will pass through the forward staple and in cases where this line angles down from the bow of the escort tug to a barge or dock it will ride on the Shibata Fender. There is no Panama Chock to run tether line through to provide a clear lead as is on a PRT.

Design consideration must be given to sub-zero temperatures and freezing seawater. This includes all piping and fresh water tanks that will be exposed to freezing temperatures. The potable water tanks appear to have side shell for a boundary. Tank heat will be needed to keep these tanks from freezing.

c. Agree with Little River comments.

A bow thruster is open to conjecture. As RA points out with wind area and large keel forward, it would be desirable for close maneuvering.
The PRTs do not have a bow thruster and operated with success, however they do not have the hull configuration of the ECO escort tugs. This new tug design with its large bow skeg, rigorous tank testing should be required to demonstrate the performance of this vessel.

d. I agree with Little River.

e. I agree with RA & Little River.

f. I agree with RA. Galley seems excessively large fore and aft.

g. I agree with Little River.

h. i. I agree with Little River.
ii. & iii Non-issue as crew will work this out with Edison Chouest (ECO).
iv. I agree with RA. This tug has a small mess area and no crew lounge. It is considered good practice to have a lounge TV area.

i. Ice strengthened hull or water line ice belt is not mentioned. The tug design should incorporate society design to permit contact with expected ice conditions in Port Valdez and brash from Columbia Glacier. Damage has occurred to a tanker and a tug as a result of collision with glacier ice.

j. These vessels are noted as Fire Fighting Vessels, FIFI 2. Requirements for this notation include an onboard SCBA Compressor.
I see no mention for off vessel firewater conections. Current vessels have 8 ea. 2 ½ inch fire hose connections, supplied from the fire monitor pumps. There are four connections on each side of current escort vessel fleet.

k. Have bilge keels been designed so they will not make contact with tanker side shell if tug maneuvers alongside in rough weather or has to make a radical maneuver while alongside?

4.1.2 Performance Predictions

a. Agree with RA & Little River.
This is a new, powerful vessel that will have operational limitations. The technology is available to test this design and PWSRCAC should pursue agency & Alyeska requirements for testing this new hull design.

b. Agree with RA.
Simulations for hull performance should represent actual conditions for entire escort at just under closure conditions.

c. Agree with Little River.

d. Agree with RA and Little River.

The conversation on the tanker generated pressure wave is of vital importance as the performance of this new tug coming alongside a tanker doing 8 to 10 knots will be influenced by its large skeg. This is where crew simulator training will be imperative.

I would say that maneuvering alongside underway ships with a tug is a major cause of significant damage to ship's side shells.

e. I agree with RA and Little River and am at a loss as to why tank testing has not been carried out on this new hull design.

Hull repairs underway at regular yard period to replace set-in plating from contact with glacier ice, which made initial contact near waterline and rolled down to strike vessel again below the water line. After close inspection of vessel in the water it was determined there was no breach of hull plating but very close.

Vessel icing does happen in Valdez
Tugs at SERVS Dock

Tug *Protector* de-icing at SERVS Dock.

Tug *Nanuq* christening at SERVS Dock. Crew used ball bats to uncover name.

Mid-Sound ice from Columbia Glacier

Near closure weather at Hinchinbrook
ERV Gulf Service

4.2 Support Tug – Damen Model 3212

a. Agree with RA & Little River, Additionally if these tugs are to be used primarily for docking tankers, the forward skeg design may hinder the vessel coming alongside an underway tanker.

If these vessels are to be used for primary escorts on small tankers and expected to perform indirect maneuvers, all scenarios need to be modeled for safe operation.

b. Agree strongly with RA & Little River.

c. Agree with RA & Little River.

d. Agree with RA & Little River.

e. Agree with RA & Little River on all subjects. These look to be very uncomfortable vessels.

f. Agree with RA & Little River.

g. Agree with Little River. All docking and tether jobs will be over the bow. Fendering around stern may interfere with tow wire.

h. Agree with RA & Little River.

i. Agree with RA and Little River. The bow on these vessels will be very wet resulting in cold weather icing. To keep bow winch functional a good cover will be needed to protect it from icing up.

4.2.2 Performance Predictions

Agree with points made by RA & Little River.

5.0 Questions to be answered

I agree with all questions RA and Little River have presented.

The lack of proper tank testing of the escort tugs is problematic. When these tugs arrive in Valdez they must be made to demonstrate contracted requirements, as past vessels have had to demonstrate. PWSRCAC should request these demonstrations before the Crowley vessels depart.

As pointed out by Little River, it will be imperative that PWSRCAC has oversight at all performance tests to ensure all equipment is operated to normal operating specifications.

This is pointed out in their following statement, which I strongly support:

> It will be very important to have the PWSRCAC represented by a Subject Matter Expert (SME) at initial testing, all sea trials and bollard pull testing. Furthermore, it is absolutely necessary to conduct intensive tether and towing exercises at all speed ranges, weather conditions and failure recognition times to validate the performance of these vessels.

Thank you for the chance to comment on these two reports.

Robert E. Archibald

Robert E. Archibald

Chief Engineer of Motor Vessels, Unlimited (Retired)

PWSRCAC Board Member from

The City of Homer, Alaska