MV Grand Manan Adventure

Independent Review of the Reliability of the Main Propulsion Machinery

In consultation with: Max Harvey – Assistant Deputy Minister Marine Services – GNL
Stephen Mulrooney – Director of Fleet Renewal – GNL
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Introduction

At the request of the Department of Transportation & Infrastructure, Government of New Brunswick, the Marine Services Division of the Department of Transportation & Works, Government of Newfoundland & Labrador, performed an independent review of the design, build, operation, and reliability of the MV Grand Manan Adventure, specifically focusing on the failures that have plagued the main propulsion machinery onboard the vessel since it first entered service in July 2011. The mandate of the technical review is to specifically address the following questions:

1. Were the performance criteria laid out in the design & build contract appropriate for the type of vessel and service?

2. Did the propulsion machinery supplied by Eastern Shipbuilding Group Inc. meet the performance criteria found in the contract and were they consistent with industry standards at the time of the build?

3. Are the operating procedures of Coastal Transport Ltd. compatible with the design of the vessel and its machinery?

4. Are the operational, maintenance, and / or repair procedures of Coastal Transport Ltd. having an impact on the reliability of the vessel?

The MV Grand Manan Adventure is an 86 meter RO-RO type passenger ferry designed and built by Eastern Shipbuilding Group Inc. at their shipyard located in Panama City, Florida. The vessel’s design utilizes two EMD 710 series 12 cylinder 2-stroke medium speed marine diesel engines that produce a total of 6000bhp. The engines drive two Berg controllable pitch propellers guided by high lift rudders. Auxiliaries include three Caterpillar C-18 500KW diesel generator sets, two 600KW shaft generators, and two athwart ship tunnel bow thrusters.

Since entering service in 2011, both main engines have experienced multiple catastrophic failures that have taken the vessel out of service. The details of the failures are as follows:

Port Main Engine

- July 2013 – Main Engine turbocharger clutch failed during operation.
- June 2014 – Cast lubricating oil line in turbocharger failed during operation.
- August 2014 – Cylinder #6, cylinder liner failed during operation.
- March 2015 – Cylinder # 3, cylinder head failure during operation.
- April 2015 – Cylinder #4, exhaust valve failure during operation.
July 2015 – Cylinder #8, exhaust valve failure during operation.
August 2015 – Cast lubricating oil line in turbocharger failed during operation.

Starboard Main Engine

March 2014 – Cast lubricating oil line in turbocharger failed during operation.
April 2014 – Turbocharger gear train failure during operation.
June 2015 – Jacket water cooling pipe to cylinder #6 failed during operation.

This report shall discuss the relevant data contained in the various documents received from both the operator and the owner and conclude with recommendations, based on that data, in an attempt to improve the reliability of the main propulsion machinery. The relevant data was obtained from document review and interviews including, but not limited to:

- Engine room log book entries from July 2011 – August 2015.
- Detailed design documentation including the contract with the shipbuilder and the electrical load analysis.
- Detailed test and trial documentation including fuel and sea trial data.
- Various failure reports provided by the operator.
- OEM service reports.
- OEM service bulletins.
- Maintenance reports.
- Work order history.
- Data collected during onsite attendance.
- Statements from the operator including crew and shore personnel.
- Statements from the owner’s representatives including relevant consultants.
- Various email correspondence between the operator and OEM authorized representatives.

Methodology

The study began with a review of the design & build contract between the Department of Transportation & Infrastructure and Eastern Shipbuilding Group Inc. with specific attention paid to the decision making process surrounding the selection of the EMD 710 series marine diesel engines as the main propulsion machinery for the MV Grand Manan Adventure, and the engine’s suitability for this specific application. Following the review of the design criteria, research then focused on the reported failures affecting the main propulsion machinery.

As the MV Grand Manan Adventure appeared to have operated relatively problem and symptomatic free from its entry into service in July 2011 until the first recorded failure of a
turbocharger in July 2013, the initial approach was to review the relevant engine room log book data and service conditions prior to July 2013 and compare the findings with the engine room log book data, service conditions, and service reports just prior to and subsequent to the July 2013 failure in an attempt to identify any significant changes in operation or abnormalities that could point to the cause of the various failures.

To obtain an accurate history of the main engines and their operating condition, a review of the maintenance records and maintenance history was also performed to identify any irregularities or variances from the manufacturer’s recommendations that may have attributed to the various main engine failures.

Upon completion of a review of the relevant operating data, site visits were conducted onboard the vessel, as well as visits to the offices of Coastal Transport Ltd., and the Department of Transportation & Infrastructure. The purpose of these site visits was to interview the stakeholders and view the operation of the affected machinery first hand in order to verify the data contained in the engine room log book. In addition, the operating practices and conditions of the vessel were observed in a relatively calm sea state.

Following the site visits, an in-depth review of all of the relevant data including log book entries, service reports, witness statements, OEM design data, and data collected from the onsite visits was completed.

**Findings**

A review of the design & build contract uncovered no notable issues in regards to the performance criteria or the main propulsion machinery requirements. While the contract could have been more detailed and prescriptive in requirements, it did represent a reasonable standard of performance given the nature of the service.

The EMD 710 series marine diesel engines appear to have adequately met the performance requirements of the contract. Interviews with key Department of Transportation & Infrastructure staff members indicate the engine selection process appeared to be based solely on a recommendation from the shipbuilder, Eastern Shipbuilding Group Inc., whose recommendation appeared to be influenced mainly on lead times associated with the delivery of new marine diesel engines at the time of the build in addition to a pre-established relationship between the shipbuilder and the engine manufacturer; which is not uncommon in the shipbuilding industry.

A look at the maintenance records, and maintenance history provided by both the operator and the owner, in comparison to the manufacturer’s recommendations, did not identify any
variances or irregularities. There was no evidence to support a finding that poor maintenance practices had contributed to the failures.

The maintenance records provided by the owner were in the form of an annual report received from the operator as per the existing agreement. The report simply indicates what major tasks were completed as well as containing a print out from the operator’s maintenance management program. Aside from this report there is little to no oversight from the owner when it comes to maintenance, vessel operation, or major repairs.

Upon review of the relevant data associated with the failures, beginning in July 2013, there appear to be several influencing factors that may have attributed to the various failures. The data, as well as statements from the operators, indicate that from the vessel’s entry into service in July 2011 up until the initial turbocharger failure in July 2013, the vessel had been operating in constant speed mode at 900 RPM not only while in transit but also while secured at the dock during loading and unloading operations. As a result there were several periods of approximately 30 minutes (the length of time between arrival and departure) throughout the day, in which the main engines were running at 900 RPM with little to no load on them.

The result of this “no-load operation” was that the turbocharger clutch assembly was likely engaged for extended periods of time reducing its life expectancy. EMD released a service advisory in October 2010 advising against this very practice. As a result of the failure, the operator changed the practice of remaining at 900 RPM while secured to the dock and began reducing the main engines to idle speed when not in transit. Since that change in procedure, there has been no other reported failure of this nature; this supports the recommendations and findings of the service bulletin issued by EMD in 2010.

The vessel underwent a scheduled refit during the autumn of 2013. At that time the operators elected to set up and employ a “combinator mode” on the vessel which would match propeller pitch settings with a predetermined engine speed to try and maintain a balanced load on the main machinery. Prior to this “combinator mode”, the vessel had only been set up to operate in “constant speed mode” which would maintain the engine speed at a constant 900 RPM no matter what the propeller pitch demand was; this mode is normally intended to utilize shaft generators in supplying electrical power to the vessel which require a constant RPM in order to provide reliable power.

Following the commencement of the “combinator mode”, various crew members, including one Master, indicated that there was a noticeable vibration present at main engine speeds below 900 RPM. The failures that occurred subsequent to the turbocharger clutch failure of July 2013 all appear to be that of a nature that suggests a possible vibration issue. During the site visit, it was observed that a slight vibration could be felt adjacent to the port main engine.
addition, when the vessel was put in “combinator mode”, a vibration was evident throughout the vessel.

Upon review of the engine room log book data, it is apparent that there is a difference in how the vessel is operated. Masters have discretion on the mode and had different mode preferences for operation. There appeared to be a pattern in which the vessel was operated for an extended period in “constant speed mode” and then changed to operate for an extended period in “combinator mode”. There was an extended period prior to each failure in which the vessel was operated in “combinator mode”.

Given the fact that the vessel operated for the first 2 years of its life in “constant speed mode” with no major reported issues, combined with the witness statements and observations made during the site visit, it is reasonable to suggest that the vibration caused while operating in “combinator mode” is a major contributing factor to the subsequent failures and is detrimental to the reliability of the main propulsion machinery.

During the site visit it was observed that there was a substantial imbalance between the port and starboard main engines. Review of the operating pressures and temperatures, as well as the fuel demand and consumption, indicated that the starboard engine appeared to be “carrying more load”, for the same amount of pitch on the propellers, than the port engine. This in itself may prove detrimental to the reliability of the vessel if allowed to exist for an extended period of operation.

Although fuel consumption was not part of the original scope of this review, it was presented as an issue on numerous occasions by the owner’s representatives. It goes without saying that running the engines and vessel at a slower speed will reduce the fuel consumption, however evidence has demonstrated that the reliability of this particular vessel is reduced as long as the main engines are run at speeds below 900 RPM with the current arrangement.

Conclusion

The EMD 710 marine diesel engines met the requirements of the design and build contract, therefore an argument to replace these engines is not supported.

Evidence indicates that there is no inherent problem with the existing main propulsion machinery, nor does there appear to be any link between the various failures and the maintenance practices of the operator. However it is apparent that there is a direct link between the failures and the manner in which the vessel is being operated. Vibration levels found during certain modes of operation appear to be substantial enough to cause recurring issues with the main engines.
Recommendations

Immediate

It is recommended that the vessel, given its current configuration, operate in “constant speed mode” as opposed to “combinator mode”. The main engines should be reduced to “idle speed” or shut down while in port. The evidence shows that vibrations occurring while in “combinator mode” have been harmful to the machinery, prolonged operation in this mode will likely cause further issues and reduced reliability. The “combinator mode” should not be used on this service in the current configuration.

It is recommended that the owners request the operators to employ a Vibration Analysis Technician to perform an in depth vibration analysis on the main propulsion machinery to identify and correct any vibration related issues.

Short Term (Within one year)

It is recommended that the owner requests the operator to task OEM service representatives for EMD and the Berg propeller systems to balance out the loading on the main engines and calibrate the load management system onboard. In order for this to be done properly, manufacturers’ representatives for both systems should be onsite at the same time. This should allow return to “combinator mode” operation which would reduce fuel consumption.

It is recommended that the owner request the operator to enroll in a routine vibration analysis program, once any existing vibration issues are corrected, to maintain the condition of the machinery plant. This will help improve the reliability of the vessel, and move towards a “preventative maintenance” routine as opposed to a “reactive maintenance” routine.

It is recommended that maintenance records should be forwarded to, and reviewed by, the owner no less than “quarterly” to ensure compliance with the OEM maintenance schedules.

It is recommended that the owner have a representative attend the vessel no less than “quarterly” to witness and review vessel operation. Had this been practiced prior to this report, the pattern that emerged in regard to the change in operating modes may had been discovered earlier, resulting in less “downtime”.

Medium Term (By end of scheduled refit)

It is recommended that the owner consider adding a technical and operational capability within its organization to oversee and monitor the contractor and the operation. This due diligence will promote greater, and earlier, operational and technical insight into the service. A more
informed and involved owner, when it comes to the operation, maintenance practices, and repair procedures onboard their vessel, will promote increased reliability and sustainability of the service.

It is recommended that the current switchboard configuration be modified to permit the shaft generators to provide electrical service for the entire vessel. The current electrical supply system consists of three diesel auxiliaries and two shaft driven generators. The shaft generators are currently only utilized for supplying power to the bow thrusters while maneuvering. The remainder of the vessel’s electricity is supplied by operating two of the diesel driven Caterpillar generators. If incorporated into the power management system, the shaft generators could provide the bulk of the electrical requirements with the diesel auxiliaries supplementing the power on an as needed basis. This would drastically reduce the fuel being consumed by the diesel auxiliaries as well as provide a load for the main engines while the vessel is secured to the dock. Any main engine not being utilized to provide power to the vessel should be reduced to idle, or ideally, shut down, between crossings.
Appendices
Appendix 1

Letter from Deputy Minister Sadie Perron (GNB) Convening the Technical Evaluation of the MV Grand Manan Adventure
Date:       June 26, 2015  
To/Dest.:   Stakeholders  
From/Exp.:  Sadie Perron, Deputy Minister  
Copies:     David Cogswell, Executive Director, Operations Division  
           Nancy Lynch, Director, Planning and Strategic Development  
Subject/objet:  TECVAL  

This memo is to advise and direct that a technical evaluation (TecVal) be conducted regarding the Grand Manan Adventure (GMA) engineering issues which have impacted service delivery. It follows from a number of discussions between the Government of New Brunswick/Department of Transportation and Infrastructure (GNB/DTI) and various stakeholders and the Government of Newfoundland and Labrador/Transportation and Works (GNL/TW) regarding support for an independent 3rd party look into the technical issues experienced by the GMA.

GNL/TW has offered a team of three senior Marine personnel to conduct the TecVal. There have been some preliminary discussions as well as a round table meeting on Fri Jun 19, 2015 in St. George with major stakeholders - Minister Melanson and Minister Doucet, senior DTI leadership, senior Coastal Transport (CT) leadership including the senior Captain of GMA, and senior Village of Grand Manan (VGM) leadership.

During this discussion, two principal objectives were outlined - improved communication channels and a long term solution to the GMA engineering issues. This meeting, in setting the way ahead for the TecVal, was very positive and there was consensus on the approach methodology to be taken. It was highlighted by the Ministers and stakeholders alike, that for success in finding solutions, frank and full exchanges were needed. The introduction of outreach and improved communication channels is in progress with more to follow as a separate initiative.

To ensure the TecVal activities and expectations are aligned for all stakeholders, some direction and guidance to the GNL team and stakeholders are detailed below:

ISSUE

Loss of confidence in the GMA engine reliability to maintain schedule due to repeated breakdowns and out of service periods on an essential and busy marine link for Grand Manan Island.
BACKGROUND

GMA was delivered as new build vessel designed to serve the Village of Grand Manan Island in 2011. It was to bring long term capacity and reliability to a key provincial ferry route. Since that time, there has been a number of unexpected breakdowns and repeat failures of machinery. This has resulted in out of service periods, lost trips and delayed service as well as passenger and traffic disruption to residents, tourists, and commercial users who depend on the reliability of the service. As well, it has introduced considerable additional and unforecast costs to operate the service.

There are a range of stakeholder insights and perspectives on the causes of the breakdowns and potential solutions. An independent 3rd party review is considered the best option to consolidate the views of stakeholders and to conduct their own inquiry into the technical issues in exploring the cause and potential solutions.

GNL TECVAL TEAM

GNL has access to additional technical expertise support from it shore staff and fleet personnel. The GNL TecVal team will consist of:

- GNB Lead: Max Harvey – Assistant Deputy Minister, Marine Services
- Principal Contact: Shawn Marshall - Director of Operations
- Stephen Mulrooney - Director of Fleet Renewal

TECVAL MANDATE

The New Brunswick Department of Transportation & Infrastructure (NBTDI) is requesting an independent 3rd party review of the GMA’s performance criteria and operation procedures to determine what options are available to reduce the down time and number of missed trips for this ferry service. Following are the main areas to be reviewed:

- Review of the performance criteria established by the Province for the GMA vessel design and engine requirements to determine if they were appropriate for the type of vessel required;
- Review of the engines supplied by Eastern Shipbuilding to see if they meet the standards for industry and the performance criteria specified in the Agreement;
- Review of the operational requirements in the Operations Agreement with CT to determine if they are compatible with the engines supplied and vessel design;
- Review of the operation, maintenance and repair procedures of CT to determine if they may be impacting the performance of the vessel.

KEY STAKEHOLDER GROUPS/CONTACTS

Noted below are the primary stakeholder groups and contact information. They are the primary contacts for the TecVal teams and direct liaison is authorized. It is recognized that stakeholders will have a number of secondary stakeholders - internal team, shipbuilders and equipment providers, designers, suppliers, consultants and other personnel - who will have information, insights, and documentation which will be helpful to the TecVal team. The TecVal team will follow up with primary stakeholders to request that these personnel be identified, contact information provided, and the type of information and connection to the TecVal themes of inquiry. Prior to contacting these individuals, the TecVal team will request that the primary stakeholder contact the individual and assist in arranging an interview or visit as appropriate.
Stakeholders
Page 3 of / sur 3
June 26, 2015 / Le 26 juin 2015

- GNB Convening Authority: Sadie Perron, Deputy Minister, Transportation and Infrastructure, is the authority for the mandate. She will liaise with GNL as required.
- GNB Lead: Sadie Perron, Deputy Minister and David Cogswell, Executive Director. Operations Division - Principal Contact: Nancy Lynch nancy.lynch@gnb.ca Phone: 2(1)
- GNB/Design Consultants: E.Y.E Marine Consultants
- CT: Gregg Ryder – Service policies, vessel operations, schedule, records
- VGM: Mayor2(1) (residents and ferry users)
- VGM: Harbour Authority (wharf operations)
- VGM: Fishing Leadership (wharf users)

PROCESS GUIDANCE

- Reporting: GNL will make their report to GNB via the DM DTI. GNB is responsible for all communications regarding this mandate.
- Documentation: All documentation to be submitted to Nancy Lynch for submission to GNL TecVal Team
- Access: GNL has direct liaison authority with stakeholders noted above and those identified by the stakeholders in the course of the TecVal
- GNL Approach: Impartial, honest and frank discussions – common cause to resolve issues. Stakeholders as separate groups
- GNL Stakeholder Visits: GNL team will make arrangements with stakeholders to conduct discussions via phone, email, and on site visits.
- GNL TecVal: Areas of Inquiry – Cause, Fix, Fix Validation, Service Strategy

TIMELINES

Noted below are draft timelines for the GMA TecVal. They will be updated as required.

- Prior to Jun 19 - Pre Meeting consultations
- May/Jun – GNL review and discussions
- Fri Jun 19 – Stakeholders Meeting – St. George
- By Fri Jul 3 – Documentation collection completed
- Jul-Aug – Stakeholder consultations
- Mon Aug 24 – Consultations completed
- By end of September – Final report to GNB

This TecVal is an important activity in determining the technical way ahead for the GMA and the ongoing service for Grand Manan Island. The support and partnership of all is much appreciated.

Sincerely,

Sadie Perron
Deputy Minister
Appendix 2

Sample Engine Room Log Book Entries Including “Constant Speed Mode” Operation & “Combinator Mode” Operation
### #1 Ship's Service Generator

<table>
<thead>
<tr>
<th>RPM</th>
<th>Oil (kPa)</th>
<th>Jacket Temp.</th>
<th>Boost (kPa)</th>
<th>Max/Min Temp.</th>
<th>FO (kPa)</th>
<th>FO Cons. (L/Hr)</th>
<th>Batt. Volts</th>
<th>Volts</th>
<th>Amps</th>
<th>Kilowatts</th>
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<td>666</td>
<td>85</td>
<td>28</td>
<td>14/18</td>
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<td>19</td>
<td>25.7</td>
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<tr>
<td>1/300</td>
<td>1100</td>
<td>85</td>
<td>34</td>
<td>17/18</td>
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<td>60</td>
<td>25.7</td>
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### #2 Ship's Service Generator

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<th>Jacket Temp.</th>
<th>Boost (kPa)</th>
<th>Max/Min Temp.</th>
<th>FO (kPa)</th>
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### #3 Ship's Service Generator

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<th>Boost (kPa)</th>
<th>Max/Min Temp.</th>
<th>FO (kPa)</th>
<th>FO Cons. (L/Hr)</th>
<th>Batt. Volts</th>
<th>Volts</th>
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<td>170</td>
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### Fuel Bunkering

- **Bunkers + Day Tanks:**
  - **At 07:00 Hours:** 150 m³

- **Tank Name:**
  - **Inside:**
    - **Previous Total Fuel:** 180 m³
    - **Today's Fuel Consumption:** 13 m³
  - **Outside:**
    - **Previous Total Fuel:** 180 m³
    - **Today's Fuel Consumption:** 13 m³

- **Fuel Monitor at Finished with Engines:** N/A

### Potable Water

- **07:00 Hours:**
  - 39.1 m³
- **Finished with Engines:**
  - 16.5 m³

### Remarks

- **GEN #1 and #3 Online @ 08:50
  - ME Top Deck Inspection Carried Out - All OK - 21(1)

- **OIL WAT: STAT#1 1740少 18.95
  - OIL WAT: STAT#2 18.70 (EE 6.8)

- **Gen 24: 2249 Shore Power 2241 Gen #3: 5.2 20.9**

**Chief Engineer:**

21(1)
### Coastal Transport Limited

#### Main Engines

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<tr>
<th>PME Time</th>
<th>RPM</th>
<th>Lube Oil In</th>
<th>Air Compressor</th>
<th>Fuel Oil</th>
<th>Bar</th>
<th>Jacket Water</th>
<th>M.R. High Temp</th>
<th>M.R. Low Temp</th>
<th>Soak Back Bar</th>
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<td>5</td>
<td>95 96</td>
<td></td>
<td>7</td>
<td>8</td>
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#### Machinery Oil Make Up

- Main Engines
- Gear Boxes
- Ship's Service Geens.
- Emergency Generator
- Steering Gear
- MacGregor Hydraulics

#### Machinery Hours

- Port Main Engine Hours: 1930
- Stbd Main Engine Hours: 1914
- #1 Generator Hours: 1983
- #2 Generator Hours: 1420
- #3 Generator Hours: 1753
- Emergency Generator Hours: 365
- #1 MacGregor Pump Hours: 2589
- #2 MacGregor Pump Hours: 3365

#### Run Times

<table>
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<tr>
<th>M/E Start</th>
<th>Clutch In</th>
<th>Constant Speed</th>
<th>Shaft Generator</th>
<th>Stand By</th>
<th>Finished With Engines</th>
<th>Shutdown Complete</th>
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<tbody>
<tr>
<td>0714</td>
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<td>0725</td>
<td>0728</td>
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#### Precurrence and Arrival Times

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<tr>
<th>Depart</th>
<th>Arrive</th>
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- 2
#1 Ship's Service Generator

<table>
<thead>
<tr>
<th>RPM</th>
<th>Oil (kPa)</th>
<th>Jacket Temp.</th>
<th>Boost (kPa)</th>
<th>Manifold Temp.</th>
<th>FO (kPa)</th>
<th>FO Cons. (Lit)</th>
<th>Batt. Volts</th>
<th>Volts</th>
<th>Amps</th>
<th>Kilowatts</th>
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<tbody>
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<td>150</td>
<td>644</td>
<td>83</td>
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<td>2000</td>
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#2 Ship's Service Generator

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<th>Jacket Temp.</th>
<th>Boost (kPa)</th>
<th>Manifold Temp.</th>
<th>FO (kPa)</th>
<th>FO Cons. (Lit)</th>
<th>Batt. Volts</th>
<th>Volts</th>
<th>Amps</th>
<th>Kilowatts</th>
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<tbody>
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#3 Ship's Service Generator

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<th>Boost (kPa)</th>
<th>Manifold Temp.</th>
<th>FO (kPa)</th>
<th>FO Cons. (Lit)</th>
<th>Batt. Volts</th>
<th>Volts</th>
<th>Amps</th>
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<td>552</td>
<td>83</td>
<td>7</td>
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<td>70</td>
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<td>426</td>
<td>358</td>
<td>240</td>
<td>170</td>
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</table>

Fuel Bunkering

- Amount at Start: 93 m³
- Previous Total Fuel: 137 m³
- Fuel Monitor at Finished with Engines: N/A

Fuel Ticket #25.087

<table>
<thead>
<tr>
<th>Potable Water</th>
<th>Berg System</th>
<th>Tank</th>
<th>Dip</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>Dirty Oil</td>
<td>54/11</td>
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<tr>
<td></td>
<td>B</td>
<td>Dirty Bilge</td>
<td>893</td>
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<td></td>
<td></td>
<td>hydraulic</td>
<td>111</td>
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<td></td>
<td></td>
<td>Lube Oil #1</td>
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<td>Lube Oil #2</td>
<td>726</td>
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<tr>
<td></td>
<td></td>
<td>Gear Oil</td>
<td>1280</td>
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07:00 Hours

07:00 Hours: 34 m³
Finished with Engines: 31.5 m³

Water Tight Doors Tested:
Start Up Procedures Completed: OK

Remarks:

- Gen #1 and 3 online at 05:00 due to scheduled power outage on May 3rd.
- Max engine deck inspection carried out at 11:00 AM.

Chief Engineer: 21(1)
Coastal Transport Limited

Main Engines

<table>
<thead>
<tr>
<th>RPM</th>
<th>Lube Oil</th>
<th>Start Air</th>
<th>Fuel Oil</th>
<th>Bar</th>
<th>Jacket Water</th>
<th>A/C</th>
<th>Air Box</th>
<th>M.B.</th>
<th>High</th>
<th>M.B.</th>
<th>Low</th>
<th>Soak Back</th>
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<tbody>
<tr>
<td>In</td>
<td>Diff</td>
<td>TC</td>
<td>Temp</td>
<td>Bar</td>
<td>In</td>
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<td></td>
<td></td>
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Port Shaft Gen Temp.        | Port Shaft & CPP Temp. | Thrust | Journal |
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Port Main Engine Exhaust</td>
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<tr>
<td>Cyl # High Cyl # Low</td>
<td>High Cyl # Low</td>
<td></td>
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</tr>
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<tr>
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</thead>
<tbody>
<tr>
<td>Stbd Main Engine Exhaust</td>
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<tr>
<td>Water Temperature Press</td>
<td>Oil Temp</td>
<td></td>
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</table>

Run Times

<table>
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<tr>
<th>M/F Start</th>
<th>Clutch In</th>
<th>Constant Speed</th>
<th>Shaft Generator</th>
<th>Stand By</th>
<th>Finished With Engines</th>
<th>Shutdown Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>0720</td>
<td>0720</td>
<td>0720</td>
<td>0720</td>
<td>0729</td>
<td>0729</td>
<td>2256</td>
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</table>

Depart: 0720; Arrive: 0729

To: Blacks Harbour, NB
Appendix 3

EMD Service Advisory – Light Load Conditions
SERVICE ADVISORY - 710 Light Load Operation and Inspection
Form CEF-001 Rev B. 7/1/2006
Page 1
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Components Affected:
12, 16, and 20 cylinder Model 710 Turbocharged Engines in Generator Service or Synchronous Operation

Purpose:
To reiterate the consequences of light load operation and provide an inspection guideline for turbocharger gear trains that have been subjected to excessive high driving torque

Background:
EMD engines, like other internal combustion engines, operate most efficiently when producing the power for which they were designed. Under normal operating conditions load can vary based on environmental conditions and equipment demands. Power Plant Load Management systems can and should be designed to minimize the number of engines on line at any time in order to maximize load, optimize fuel economy, and minimize any issues related to light load. The rapid response of the EMD two-cycle engine allows for fewer engines to be on line at any time to meet transient power requirements*. Under typical drilling operations EMD engines provide durable and reliable performance for operators. Recent failures of EMD turbochargers with relatively low operating hours have identified a potential problem which we believe to be attributed to extremely light load operation during the construction and testing phases of equipment. The practice of using main engines for hotel power during construction in the shipyards has been identified as a leading contributor to early wear of drive gears and turbocharger failures. Shipyard practices of running engines for hotel power during construction of the vessel/drilling unit should be avoided.

As a general rule load management systems for Model 710 turbocharged engines running at 750 or 900 RPM should not be less than 30% of the full load rating for optimum life. There is no minimum load restriction for operation at lower engine speeds.
* EMD is available to assist in optimizing power plant load management systems with our two cycle engines.

Under typical operating conditions it is normal for high driving torque to be transmitted through the turbo gear train for a short time. As the engine load is applied, the power needed to mechanically drive the turbo is proportionally decreased on the gear train by the turbine. The turbine uses exhaust gas energy to decrease the gear train load. At approximately 70% of full rated load, the exhaust energy is sufficient to drive the turbocharger rotating assembly without any gear train assist. At this operating condition, the overrunning clutch allows the turbo to speed up and run independent of the gear train: the gears continue to turn at their corresponding speed ratio to engine RPM without transmitting torque.

If engines are operated for extended periods at full speed with light loads, turbo gear train wear is accelerated. At loads of 30% and above there is no significant wear on the drive gears and EMD expects full turbocharger life. At loads below 30% wear rates gradually increase, however operating the engines during construction where loads could easily be below 10% load for sustained periods of time the wear rates could reduce the life of the drive gears to 3000 hours of operation.

EMD engines operated at full speed and less than 20% load can experience oil accumulation in the exhaust system. Engines equipped with Low Lube Oil power assemblies or engines that carry a US EPA Tier 2 certification will experience less accumulation. The exhaust system can be cleaned out by operating the engines at 70% load or more for at least 30 minutes. This should be performed after 8 hours of idling or 100 hours of continuous operation at synchronous speed with less than 20% load.

**Recommended Action:**
1. Change any operational activities that allow engines to operate at light loads for extended periods of time such as construction.
2. If it is suspected that engines have already been operated under very lightly loaded conditions, it is
recommended that an inspection of the gears be made to insure the gears have not worn to a point where a failure would ensue. The following can be indicators of early stage turbocharger gear train failure due to light engine loading:

- Noise generated from worn involute turbo spur gears will be louder than a turbo with unworn gears
- Visual wear on Turbo Spur Gears

Figure 1-Turbocharger Gear Train
Inspect these 3 gears

Figure 2
3. Use the exposed opening as an access point for viewing the gears as shown in figure 3 below.

Figure 3
The following can be indicators of early stage turbocharger gear train failure due to light engine loading:

- Visual wear on Turbo Spur Gears (Turbo Drive Gear, Turbo Idler Gear, Carrier Drive Gears) See Figures 6 & 7 on page 6
- Loose, broken, or missing Oil Lube Jumper Bolts

Remove Aux Gen Cover Plate Aux Gen
Due to space limitation, you may only be able to view of the turbo drive gear, idler gear, and the jumper bolts (Reference Figures 4 & 5 below).

**Figure 4**

**Figure 5**

Turbo Drive Gear
Turbo Idler Gear
Oil Lube Jumper Bolts

4. Inspect at the surface of the gear flanks (called involute). On the involute check for signs of pitting/scoring/scuffing. (Reference Figure 6 & 7 below)

**Figure 6**

**Figure 7**

5. Replace the aux gen cover plate on the RB side of the turbocharger.

6. If light loading damage is confirmed as outlined in this document it is recommended that the engines not be operated to avoid more serious failures that can damage the entire gear train. Contact your licensed EMD distributor for resolution.

Pitting above the pitch line area accompanied by scuffing near the tip
Pitting on the pitch line on one side of the gear face farther away from the impeller
Pitting above the pitch line area accompanied by scuffing near the root
Scuffing near the
root (dedendum)
Scuffing at the tip
SA#: 10-026
REVISION: Original
REVISION DATE: 6/25/10
ISSUE DATE: 6/25/10
AUTHOR: 21(1)

Customer Engineering • Electro-Motive Diesel, Inc. • 9301 W. 55th Street • LaGrange, IL 60525

SERVICE ADVISORY - 710 Light Load Operation and Inspection
Form CEF-001 Rev B. 7/1/2006
Page 7

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(For EMD Office Use Only)

Approvals (Required):

Approval
Needed
Y N

Approver
Approved
Y N

Approved By
Date
CES/CEM 21(1) 6/25/10

Warranty
Marketing

Service Advisory – General Classification (Select All that Apply):

GENERAL INFORMATION: This document is being issued to provide general information to the Customer Care Field Organization.

REQUEST FOR FIELD SUPPORT: This document is being issued to request Customer Care Field resources for the purpose of information/data collection in support of a current field issue investigation.

PRELIMINARY: This document is being issued to provide notable preliminary findings with regard to a current field issue. It will be followed by the issuance of an appropriate revision, or revisions, as the investigation progresses through closure, or more information becomes available.

FINAL: This document is being issued to provide final findings and recommendations on the proper handling of a current field issue. This document is intended to provide official closure of the subject field issue.
Appendix 4

Main Engine Failure History Report as Supplied by the Operator
### MV Grand Manan Adventure - Main Engine Failures

<table>
<thead>
<tr>
<th>Engine</th>
<th>Date of Failure</th>
<th>Total Engine Hours</th>
<th>Remarks</th>
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<tr>
<td>Port</td>
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<td>10.122</td>
<td>Turbogenerator Overrunning Clutch failed due to Light Load Operation.</td>
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<tr>
<td>Stbd</td>
<td>03/Mar/2014</td>
<td>13.931</td>
<td>Cracked Cast Lube Oil Line to Turbo Planetary Gear - Turbocharger Failed.</td>
</tr>
<tr>
<td>Port</td>
<td>21/Jun/2014</td>
<td>14.504</td>
<td>Cracked Cast Lube Oil Line to Turbo Planetary Gear - Turbocharger Failed + Gear Train destroyed.</td>
</tr>
<tr>
<td>Port</td>
<td>09/Aug/2014</td>
<td>15.156</td>
<td>Cracked Liner - #6 Cylinder, Inboard Bank, Replaced #6 Power Pack.</td>
</tr>
<tr>
<td>Port</td>
<td>25/Mar/2015</td>
<td>18.441</td>
<td>Cracked Head #3 Cylinder, Inboard Bank, Replaced 3 &amp; 9 Power Packs (Blade &amp; Fork), New Style Turbo Clutch fitted &amp; Turbocharger replaced on Warranty due to pieces missing from Diffuser.</td>
</tr>
<tr>
<td>Stbd</td>
<td>02/Jul/2015</td>
<td>19.400</td>
<td>Water leaking into #6 Cylinder, Power Pack replaced. Source of leak confirmed to be crack in way of water jumper.</td>
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<tr>
<td>Port</td>
<td>05/Jul/2015</td>
<td>19.999</td>
<td>Failed exhaust valve - #6 Cylinder, Outboard Bank, Replaced Cylinder Head.</td>
</tr>
<tr>
<td>Port</td>
<td>08/Aug/2015</td>
<td>20.419</td>
<td>Turbogenerator Cast Lube Oil Line to Planetary Gear came adrift - Turbocharger Failed. UTEX Turbocharger installed.</td>
</tr>
</tbody>
</table>

**Notes:**

1. Due to exhaust valve failures on the Port Main Engine (manifested by apparent cracked liners), Cylinder Heads No. 1, 2, 5, 7, 10, 11 & 12 replaced with new Heads on August 10, 2015 at 20,419 Hours. Heads on No. 3, 4, 6, 8 & 9 Cylinders not replaced due to Power Packs on Cylinders being recently replaced.