TROUBLESHOOTING OF MARINE STEAM TURBO ELECTRO GENERATORS USING ENGINE CONTROL ROOM SIMULATOR

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ABSTRACT

The aim of the present study is to examine the daily operation of steam - turbo engine driven electro generators used in maritime engineering for the auxiliary electrical power supply system of ship on real time operation and under malfunctions. On the ship, the preferred mode of operation is with shaft generator as base generator, the turbo generator as an auxiliary generator and with diesel generators in auto operation as stand by generators. Turbo generator modelled as high speed turbine with all vital subsystems such as rpm governor, lubrication oil and steam system with condenser. The research study attempts to make failure analysis and besides to provide solutions for real operating problems. The use of simulator under abnormal conditions helps the instructor and students to understand better the process while at the same time contributes significantly to the development of team spirit and enhances mutual respect and cooperation among to many job functions in the plant.

Key words: Engine Room Simulator, Turbo Generator, Malfunctions, Human factor

INTRODUCTION

The International Maritime Organization (S.T.C.W., 1995) has a key role to play in the successful implementation of new technology at sea. In line, with current policies on risk management and human factors, it will be advisable to research the full
long-term effects of the introduction of each new system on the whole working
environment, taking into account parameters such as the system design, mainte-
nance, reliability and training. Besides, on board technology must be friendly, must
leave humans in control and must not isolate the user from the outside environment.

One of the main purposes of computer simulation is to imitate the operations of
real life systems or processes. The advent of bridge and engine room simulators and
their use as modern research tools, now, allows us to test new technology before
implementing it on board. With the help of instructors (IMO Model Course 6.09,
2001; IMO Model Course 2.07, 2002), it is possible to simulate conditions five or
ten years ahead and measure the effectiveness of a fully implemented system, before
committing the industry to a particular path. This is particularly important when
training young people to meet future challenges. Training is costly and is made much
easier and cheaper if systems have common human–machine interfaces and besides
the main advantage of such simulations is that operational scenarios can be tested
and evaluated without the need or use of actual experimentation. Today many mar-
itime trainings centres apply engine room simulators in their didactic process.

Benefits of student by the incorporation of engine room simulator into a well
focused marine training course are the next: technical knowledge by associating with
his peers and absorbing the technical matter presented, the motivation of knowing
that students – colleagues are interested in the same subject matter, the personal satis-
faction of realizing that his knowledge are on par with those of others, personal
acquaintances with serious minded instructors, state of the art solutions to problems
where such solutions are not yet published and inspiration to enrol in and attend
special courses accumulating continuing education units. Human hazards become
less probable with adequate hands-on training, education, proper manning levels and
timely and appropriate change management.

Simulator exercises (Kluj, 1999; Gourgoulis et al., 2004; Gourgoulis et al., 2008)
could be used as far as practically reasonable to quantify work load, fatigue, stress lev-
els and available time for watch out, decision and planning under conditions of con-
tinuously troubleshooting. Also, it must be noted that STCW 95 Convention
(S.T.C.W., 1995) strongly recommends the application of engine room simulators in
the teaching process. The application of simulators in the professional training of
marine engineering is a mandatory requirement as determined by the standards of
training, certification and watch keeping, which is an international convention for
seafarers. The main objective of convention is to set a minimum level of specialized
knowledge and qualification between seafarers.

The careful use of steam turbo generator, the avoidance of water strike in combi-
nation with the periodical maintenance, using suitable checklists, can lead to
decreased consumption in cases that the demand of power are not extremely high.
For this purpose the influence of vital subsystems such as such as rpm governor,
throttle steam valve, lubrication oil and steam system with condenser on the normal
operation of steam turbo electro generators have been studied.

An attempt to examine the basic malfunctions of steam driven turbo electro generators and especially how they are could be avoided has been made. This paper discusses some of the faults of such systems and provides an insight into the various technical issues associated with the application and maintenance of electrical power systems for marine applications.

These experiments form part of a larger work (Gourgoulis et al., 2004; Gourgoulis et al., 2008) concerning the use of engine simulator that simulates a dynamic real time computerized slow speed main propulsion turbocharged diesel engine incorporating a waste heat steam boiler, a turbo generator and one shaft generator.

LIST OF SYMBOLS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>TG</td>
<td>Turbo Generator</td>
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<tr>
<td>ALxx</td>
<td>Alarm xx</td>
</tr>
<tr>
<td>Mxx</td>
<td>Malfunction xx</td>
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<tr>
<td>LO</td>
<td>Lubrication oil</td>
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</table>

DESCRIPTION OF SIMULATOR

The engine room simulator plant at Merchant Marine Academy of Makedonia was established in 2002 and was designed, implemented and integrated by Kongsberg Nor control Simulation (Kongsberg Nor control, PPT2000-MC90-III, 1999).

The simulator could be divided into two main parts: The simulated Engine Room and the Instructor system. The simulated engine room is arranged as subsystems identical to those found onboard a real Very Large Crude Oil Carrier Ship. The simulation models have been configured by Operator Training Industrial Simulation System software that it has been developed by Special Analysis and Simulation Technology Ltd, England.

Simulator training or research projects of Merchant Marine Academy of Makedonia are realized by the following phases: proposal phase, data collection and implementation, simulation and data recording, analysis and reporting. The instructor system of engine room simulator comprises the facilities and features needed for the instructor to prepare, control and evaluate the simulator training courses or research studies.

The simulated main engine is a B&W 5L90 MC, five cylinder in-line, low speed, two stroke engine with turbo-charging and scavenging air cooling. Turbo generator ‘TG’ is an auxiliary generator and with diesel generators in auto operation as stand by generators. TG is modelled as high speed turbine with all vital subsystems such as rpm governor, lubrication oil and steam system with condenser [Fig. 1, (Kongsberg Nor control, PPT2000-MC90-III, 1999)]. The turbine is modelled with torque dependent on steam flow, inlet steam pressure/temperature and con-
denser vacuum. TG is fed with superheated steam from the exhaust boiler. The exhaust fire boiler produces steam of approximately 290°C.

The electrical consumption is monitored and compared to the present possible power production. When deviation from present limits arises, the system will act in order to normalize the situation. The system also performs continuous controls of the frequency and load sharing. The preferred mode of operation is with Shaft generator as base generator, TG as an auxiliary generator and with two diesel generators in auto as stand by generators. Whenever, possible the TG should be prepared and connected and put to auto mode. In this case, the TG control must be changed from maximum load to frequency control mode. In auto mode it will be loaded according to available steam pressure. The recommended priority setting is priority 1 for the shaft generator, priority 2/3 for diesel generator 1 and 2. If only the shaft generator and turbo generator are connected there is no difference between operations in equal or optimal mode.

In any case, TG will take as much power as possible. The TG throttle valve is limited to a value sufficient for keeping it connected at minimum steam pressure and close to zero power. The steam pressure must be higher than 9 bar and the steam throttle valve more than 15% lower than limiting value. TG can never become slave generator. This is taken care of by the power chief. TG has its own logic which

Figure 1: Steam engine driven TG.
means the turbo generator does not take any notice of the different load limits in the different load sharing modes. This is because of the fact that the most economical way to run TG is running at full load all the time. Before start of turbo generator vacuum must be established and the condenser must be drained.

Table 1 displays the alarms of steam TG (Kongsberg Nor control, PPT2000-MC90-III, 1999). Alarms of TG are divided into two types: high and low level alarms. AL01 – AL07, rotor displacement (drain water strike or carry over water strike) and AL10 give a trip signal for the safety protection of turbo generator.

### Table 1: Alarms (high-low level) of TG.

<table>
<thead>
<tr>
<th>HIGH</th>
<th>LOW</th>
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<tbody>
<tr>
<td>AL01</td>
<td>Condenser hot well water level</td>
</tr>
<tr>
<td>AL02</td>
<td>Condenser pressure (low vacuum)</td>
</tr>
<tr>
<td>AL03</td>
<td>Steam generator water level</td>
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<tr>
<td>AL04</td>
<td>TG over speed</td>
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<tr>
<td>AL05</td>
<td>Stator temperature</td>
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<tr>
<td>AL06</td>
<td>Vibration (cold start)</td>
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<tr>
<td>AL07</td>
<td>Vibration (poor lubrication)</td>
</tr>
<tr>
<td>AL08</td>
<td>LO tank temperature</td>
</tr>
<tr>
<td>AL09</td>
<td>Lubrication oil tank level</td>
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<tr>
<td>AL10</td>
<td>LO pressure inlet bearings</td>
</tr>
<tr>
<td>AL11</td>
<td>Steam inlet temperature TG</td>
</tr>
<tr>
<td>AL12</td>
<td>Steam inlet pressure TG</td>
</tr>
<tr>
<td>AL13</td>
<td>Sealing steam pressure</td>
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</table>

**OBSERVATION PLAN**

In the examined scenario the ship was running in open sea following the mode ‘Full Ahead – Loaded’. The ambient sea water temperature was 15°C, the ambient air temperature was 20°C and the ambient air humidity was 50%. Sea water depth was 200 m, main engine fuel link position was 94.4% and the main engine speed command was 74 rpm. The pitch was fixed and for the electrical power supply shaft and TG were in operation.

The turbine (Kongsberg Nor control, PPT2000-MC90-III, 1999) is modelled realistically with torque dependent on steam flow, inlet steam pressure - temperature and condenser vacuum. The throttle valve is controlled by a speed governor. The speed can be remotely adjusted by lower / raise signals from the electric switchboard. Governor of TG was a proportional – intergraded (PI) controller with compressed lever (P) and compensating valve (I) to be adjusted to 14.0 (P) and 0.9 sec (I) respectively. The set point of speed was 6464 rpm and the speed drop of turbo generator
was 50%. Before start of TG vacuum has been established and the condenser has been drained using the vacuum pump and main condensate respectively [Fig. 2, (Kongsberg Nor control, PPT2000-MC90-III, 1999)]. The required lubrication and freshwater systems for the cooling of TG have been prepared [Fig. 1, (Kongsberg Nor control, PPT2000-MC90-III, 1999)].

Several faults have been introduced in order to demonstrate cascading of abnormal conditions that influence the operation of steam TG. From Table 2 it can be observed that M01-M08 malfunctions are related with the operation and subsystems of TG (Fig. 1) and the rest M10-M20 are related with the correct per formation of steam condenser (Fig. 2). Examining the possible malfunctions of TG and steam condenser it can be deduced that M08 (LO filter 2, Fig. 1) and M12-M13 (Auxiliary condensate pump, Fig. 2) were not possible to be activated due to the fact LO filter 1 and main condensate pump respectively were in operation. In addition, the next malfunctions (M07, M11, M13, M15 and M19) have not the possibility to be ramped and the starting malfunction point is 100%. The other malfunctions of Table 2 might be ramped from the initial set point 100% to the specified malfunction set point. Faults could be edited on line and for each inserted malfunction the observation time was specified to be 20 minutes in order to have a stable factor for evaluation. Each malfunction (Kongsberg Nor control, PPT2000-MC90-III, 1999) is activated (100%) immediately with the running of scenario.
Table 2: Malfunctions of TG – Steam Condenser.

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<tr>
<td><strong>TG</strong></td>
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</tr>
<tr>
<td>AL01</td>
<td>Condenser hot well water level</td>
</tr>
<tr>
<td>M01</td>
<td>TG speed controller gain high</td>
</tr>
<tr>
<td>M02</td>
<td>Turbine efficiency low</td>
</tr>
<tr>
<td>M03</td>
<td>TG mechanical LO pump wear</td>
</tr>
<tr>
<td>M04</td>
<td>TG LO cooler dirty</td>
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<tr>
<td>M05</td>
<td>TG LO filter 1 dirty</td>
</tr>
<tr>
<td>M06</td>
<td>TG LO system water inlet leakage</td>
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<tr>
<td>M07</td>
<td>TG gland steam controller fail</td>
</tr>
<tr>
<td>M08</td>
<td>TG LO filter 2 dirty</td>
</tr>
<tr>
<td><strong>LOWSTEAM CONDENSER</strong></td>
<td></td>
</tr>
<tr>
<td>M10</td>
<td>Main condensate pump wear</td>
</tr>
<tr>
<td>M11</td>
<td>Main condensate pump motor failure</td>
</tr>
<tr>
<td>M12</td>
<td>Auxiliary condensate pump wear</td>
</tr>
<tr>
<td>M13</td>
<td>Auxiliary condensate pump motor failure</td>
</tr>
<tr>
<td>M14</td>
<td>Vacuum pump 1 wear</td>
</tr>
<tr>
<td>M15</td>
<td>Vacuum pump 1 motor failure</td>
</tr>
<tr>
<td>M16</td>
<td>Vacuum pump 2 wear</td>
</tr>
<tr>
<td>M17</td>
<td>Vacuum pump 2 motor failure</td>
</tr>
<tr>
<td>M18</td>
<td>Vacuum condenser air leakage</td>
</tr>
<tr>
<td>M19</td>
<td>Vacuum condenser dirty</td>
</tr>
<tr>
<td>M20</td>
<td>Vacuum condenser sea water leakage</td>
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</table>

Activating $M01$, $M02$, $M04$, $M06$, $M08$ the behaviour of systems was always the same in the observation period of 20 minutes. In 11:37 minutes from the activation of particular malfunctions one alarm was only presented (Fig. 3). As can be seen from figure 3 the caused alarm ‘High aft bilge well level > 0.5m’ is not vital for the correct operation of TG, there is plenty of time for the re-establishment of damage and for the above reasons malfunctions of Fig. 3 were not reprogrammed at lower percentage of damage.
For the demonstration of the TG driven alarm AL10 ‘LO pressure inlet bearings’, M03 ‘TG mechanical LO pump wear’ was activated after the running of scenario. The lowest limit of pressure for the correct lubrication of inlet bearings is 1,5 bar. Figure 4 shows the appearance time of alarm AL10 at the different stages of produced fault. From this figure it can be seen that the increase of damage over 80% does not give to personnel the adequate time for the quick re-establishment of damage. For the repair of damage [Fig. 1, (Kongsberg Nor control, PPT2000-MC90-III, 1999)] was activated the electrical LO pump and was deactivated the mechanical LO pump. Besides, AL10 can be presented by the activation of M05 ‘TG LO filter 1 dirty’. From figure 4 it can be seen that the increase of damage over 40% leads in the activation of AL10 in 12 sec for the avoidance of damage [Fig. 1, (Kongsberg Nor control, PPT2000-MC90-III, 1999)] the engineer who is doing watch keeping must inspect periodically the cleanness of TG LO filters. The cleanness of TG LO filters is not only vital for the operation of TG but for the total operation of ship. It was observed that for damages of M05 over 80% the shutdown of main engine was presented in 6 minutes after the running of scenario.

For the demonstration of the TG driven alarm AL01 ‘Condenser hot well water level’, M10 ‘Main condensate pump wear’ was activated after the running of scenario. The highest limit of condenser hot well water level is 650 mm. It can be observed that the decrease of damage under 80% does not display AL01. The careful maintenance of main or auxiliary condensate pump can lead in the avoidance of difficult situations. Besides, for the demonstration of the TG driven alarm AL13 ‘Sealing steam pressure’ [6], M07 ‘TG gland steam controller fail’ was activated after the running of scenario. M07 has not the possibility to be ramped and the percentage of damage is 100%. The lowest limit of sealing steam pressure is 0,1 bar. It was observed that AL13 was present in 6 sec after the running of scenario. For the avoidance of damage [Fig. 1, (Kongsberg Nor control, PPT2000-MC90-III, 1999)] the engineer who is doing watch keeping must inspect periodically the correct adjustment of TG gland steam controller.
For the demonstration of the TG driven alarm AL12 ‘Steam inlet pressure TG’ a different combination of malfunctions could be used. Six malfunctions (M03, M05, M07, M10 and M16) were able to cause AL12. In the same way, for the demonstration of the TG driven alarm AL02 ‘Condenser pressure (low vacuum)’ three malfunctions (M16 and M17) could be programmed. The lowest limit of steam inlet pressure to TG is 7,0 bar and the highest limit of condenser pressure is 0,2 bar. Figure 5 shows the average appearance time of alarm AL12 and AL02 at the different stages of produced faults. From this figure it can be seen that the increase of damage over 80% does not give to personnel the adequate time for the quick re-establishment of damage. Finally it can be observed that for damages of M16 over 60% the shutdown of main engine was presented in 4 minutes after the running of scenario.

CONCLUSIONS

Human factors are related to crew competence in terms of decision-making, communication, operating skills. Human error is an existence parameter that often proves almost impossible to remove from the maritime safety formula. Thus, the human failures can be avoided by different ways: firstly by improving the management and crew organisation; then by doing a careful selection of the crew and thirdly by increasing the training quality and quantity, both for ordinary and emergency situations. The use of marine simulators would improve both the training and the selection.

In open sea, TG is mainly an auxiliary generator and for the avoidance of malfunctions that influence the normal operation of TG during the drip, daily, officer in charge of an engineering watch keeping (IMO Model course 7.04, 1999; IMO Model course 7.02, 1999) must check the cleanliness of TG LO filters, the correct function of lubricant mechanical or electrical oil pump, the effective operation of auxiliary or main condensate pump, the correct adjustment of TG gland steam controller and the total function of steam condenser. Examining all produced faults it was deduced that the most dangerous faults were M05 ‘TG LO filter 1 dirty’ and
M16 ‘Vacuum pump 2 wear’. It was observed that for damages of M05 and M16 over 80% and 60% respectively the shutdown of main engine was presented in very short period after the running of scenario.

In order to avoid trip signal of TG breaker due to water strike, rotor displacement and vibration is recommended TG to start without the presence of water in the line of steam, the increase of speed of TG to become very slow, the emergency stop valve to open very late keeping the speed of TG at low limits in case of cold TG. The TG is protected by a separate safety system and trip signal is given on the following conditions: low LO pressure (by the activation of M05) high back pressure (by the activation of M14, M16 and M17).

ACKNOWLEDGMENTS
Author would like to thank the Department of Marine Engineering of Merchant Marine Academy of Makedonia, Greece for the use of Engine room simulator.
REFERENCES

Conference Papers


Journal articles

Manuals

Standards
STCW (1995): International Convention on Standards of Training, Certification and Watch keeping for Seafarers, (IMO Sales No. 938), and 1997 Amendments to STCW 95 (IMO Sales No. 945).


IMO (1999): International Maritime Organization, Model course 7.04, Officer in charge of an engineering watch.

IMO (1999): International Maritime Organization, Model course 7.02, Chief engineer officer and second engineer officer.
LOCALIZACIÓN DE AVERÍAS EN LOS ELECTRO TURBO DE VAPOR DE LOS GENERADORES MARINOS USANDO EL SIMULADOR DE LA SALA DE MÁQUINAS

Resumen

La puntería del actual estudio es examinar la operación diaria del vapor – generadores accionados por el motor de turbo electro usados en la ingeniería marítima para el sistema de fuente auxiliar de la corriente eléctrica de nave en la operación en tiempo real y bajo malfuncionamientos. En la nave, el modo de operación preferido está con el generador de eje como generador bajo, el generador de turbo como generador auxiliar y con los generadores diesel en la operación auto como hace una pausa los generadores. Generador de Turbo modelado como turbina de alta velocidad con todos los subsistemas vitales tales como gobernador de la rpm, aceite de lubricación y sistema del vapor con el condensador. El estudio de la investigación intenta hacer análisis de la falta y además de para proporcionar las soluciones para los problemas verdaderos del funcionamiento. El uso del simulador bajo condiciones anormales ayuda al instructor y a los estudiantes a entender mejor el proceso mientras que al mismo tiempo contribuye perceptiblemente al desarrollo del alcohol de equipo y refuerza respecto y la cooperación mutuos entre a muchas funciones de trabajo en la planta.

INTRODUCCIÓN

La organización marítima internacional (S.T.C.W., 1995) tiene un papel dominante a jugar en la puesta en práctica acertada de la nueva tecnología en el mar. En línea, con políticas actuales en la gestión de riesgos y factores humanos, será recomendable investigar los efectos de largo plazo completos de la introducción de cada nuevo ambiente de trabajo del sistema en general, considerando parámetros tales como el diseño de sistema, mantenimiento, confiabilidad y el entrenamiento. Además, a bordo tecnología debe ser amistoso, debe dejar a seres humanos en control y no debe aislarse al usuario del ambiente exterior.

Uno de los propósitos principales de la simulación de computadora es imitar las operaciones de los sistemas o de los procesos de la vida real. El advenimiento de los simuladores del sitio del puente y de motor y de su uso como herramientas modernas de la investigación, ahora, permite que probemos nueva tecnología antes de ejecutar de ella a bordo. Con la ayuda de los instructores (IMO Model Course 6.09, 2001; IMO Model Course 2.07, 2002), es posible simular condiciones cinco o diez años a continuación y medir la eficacia de un sistema completamente ejecutado, antes de confiar la industria a una trayectoria particular. Esto es particularmente importante
al entrenar a gente joven hacer frente a desafíos del futuro. El entrenamiento es costoso y se hace mucho más fácil y más barato si los sistemas tienen interfaces persona-máquina comunes y además de la ventaja principal de tales simulaciones es que los panoramas operacionales se pueden probar y evaluar sin la necesidad o el uso de la experimentación real. Muchos centros de entrenamientos marítimos aplican hoy los simuladores del sitio de motor en su proceso didáctico.

Las ventajas del estudiante por la incorporación del simulador del sitio de motor en un curso de aprendizaje marina enfocado pozo son las siguientes: el conocimiento técnico asociándose a sus pares y absorbiendo la materia técnica presentó, la motivación de saber que los estudiantes - los colegas están interesados en el mismo tema, la satisfacción personal de realizar que su conocimiento está junto con los de otros, conocidos personales con los instructores importados serios, soluciones avanzadas a los problemas donde tales soluciones todavía no se publican e inspiración para auster adentro y para atender a los cursos especiales que acumulan unidades de la formación permanente. Los peligros humanos llegan a ser menos probables con el entrenamiento con manos adecuado, la educación, los personal apropiados y la gerencia oportuna y apropiada del cambio.

Los ejercicios del simulador (Kluj, 1999; Gourgoulis et al., 2004; Gourgoulis et al., 2008) se podrían utilizar hasta prácticamente razonable para cuantificar la cantidad de trabajo, la fatiga, niveles de tensión y la hora disponible para tienen cuidado, decisión y planeamiento bajo condiciones continuamente de la localización de averías. También, debe ser observado que la convención de la STCW 95 (S.T.C.W., 1995) recomienda fuertemente el uso de los simuladores del sitio de motor en el proceso de enseñanza. El uso de simuladores en el entrenamiento profesional de la arquitectura naval es un requisito obligatorio según lo determinado por los estándares del entrenamiento, de la certificación y del reloj guardando, que es una convención internacional para los navegantes. El objetivo principal de la convención es fijar un nivel mínimo de conocimiento y de calificación especializados entre los navegantes.

El uso cuidadoso del generador de turbo del vapor, la evitación de la huelga del agua conjuntamente con el mantenimiento periódico, usando listas de comprobación convenientes, puede llevar a la consumición disminuida en casos que la demanda de la energía no es extremadamente alta. Con este fin la influencia de subsistemas vitales tales como por ejemplo el gobernador de la rpm, la válvula de vapor de la válvula reguladora, el aceite de lubricación y el sistema del vapor con el condensador en la operación normal generadores de turbo del vapor de los electro se ha estudiado.

Se ha hecho una tentativa de examinar los malfuncionamientos básicos de los electro generadores conducidos vapor de turbo y especialmente cómo son se podría evitar. Este papel discute algunas de las averías de tales sistemas y proporciona una penetración en las varias ediciones técnicas asociadas al uso y al mantenimiento de los sistemas eléctricos eléctricos para los usos marinas.
Estos experimentos forman la parte de un trabajo más grande (Gourgoulis et al., 2004; Gourgoulis et al., 2008) referente al uso del simulador del motor que simula un motor diesel turbocharged automatizado tiempo real dinámico de la propulsión principal despacio que incorpora una caldera de vapor del calor residual, un generador de turbo y un generador de eje.

CONCLUSIONES

Los factores humanos se relacionan con la capacidad del equipo en términos de toma de decisión, comunicación, funcionando habilidades. El error humano es un parámetro de la existencia que prueba a menudo casi imposible quitar de la fórmula de la seguridad marítima. Así, las faltas humanas se pueden evitar por las maneras diferentes: en primer lugar mejorando la organización de la gerencia y del equipo; entonces haciendo una selección cuidadosa del equipo y en tercer lugar aumentando la calidad y la cantidad del entrenamiento, para el ordinario y las situaciones de emergencia. El uso de simuladores marinas mejoraría el entrenamiento y la selección.

En el mar abierto, el TG es principalmente un generador auxiliar y para la evitación de los malfuncionamientos que influencian la operación normal de TG durante el goteo, diario, oficial a cargo de un reloj de ingeniería que guarda (IMO Model course 7.04, 1999; IMO Model course 7.02, 1999) deben comprobar la limpieza de los filtros del TG LO, la función correcta de la bomba mecánica o eléctrica del lubricante de aceite, la operación eficaz de la bomba condensada auxiliar o principal, el ajuste correcto del regulador del vapor de la glándula del TG y la función total del condensador del vapor.

Para evitar la señal del viaje del triturador del TG debida regar huelga, la dislocalización del rotor y la vibración es TG recomendado a comenzar sin la presencia de agua en la línea de vapor, el aumento de la velocidad del TG a llegar a ser muy lento, la válvula de parada de emergencia para abrir muy tarde la custodia de la velocidad del TG en los límites bajos en caso del TG frío. El TG es protegido por un sistema de seguridad separado y la señal del viaje se da en las condiciones siguientes: presión trasera baja de la presión de LO (por la activación de M05) alta (por la activación de M14, de M16 y de M17).