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NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 1-69

Subj: Automated Main and Auxiliary Machinery

1. Purpose: This circular distributes a "Guide for the Automation of Main and Auxiliary Ship's Machinery" to all interested and affected members of the marine community. With the current trend to fewer engineering watchstanders, it is essential that all concerned be aware of the equipment and systems necessary to reduce the manning in machinery spaces without compromising the safety of life and property. This circular and the enclosed guide supersedes the information previously issued as NVIC 5-67.

2. Discussion: 46 U.S.C. 222 (R.S. 4463) specifies that no vessel subject to the inspection laws shall be navigated unless she shall have in her service and on board such complement of licensed officers and crew, as may in the judgement of the Coast Guard be necessary for her safe navigation. Thus the number of watchstanders required on any particular vessel is specified by the Officer in Charge, Marine Inspection of the appropriate marine inspection zone based upon his evaluation of the vessel, equipment, route, and service. With the rapid application of modern control technology to marine power systems, the Coast Guard has found it necessary to publish this circular for guidance and for uniformity in considering automation features to permit a reduction in the customary number of engineering watchstanders.

In recent years it has been customary to operate a steam propulsion plant with a three man watch. This consisted of a fireman/watertender supervising the boiler; an oiler or better acting as a data recorder, roving patrol and general assistant to; the licensed engineer, who supervised the watch, performed as throttleman, and conducted or supervised minor or routine maintenance. Additionally these three men by their sense of sight, sound, smell and engineering judgement or intuition, performed as trouble detection systems in the event of fire, flooding or machinery malfunction.

The evolution from manned to unmanned engineerooms as proposed by the industry is:

a. The elimination of the fireman/watertender by the installation of a fully automated boiler or by the installation of a self regulating boiler with certain re-allocations of responsibilities to the remaining watchstanders. Automatic boiler alarms and safety shut-down devices have been incorporated in both of these approaches.

b. The elimination of both the fireman/watertender and the oiler by the installation of a fully automated boiler, pilothouse throttle control, and a centralization of controls and instrumentation within the machinery space. The arrangement must permit the engineer to monitor and control the machinery from a single location.

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c. The elimination of all watchstanders by the installation, in addition to that of b above, of a sophisticated and extensive monitor and alarm system. The emphasis on machinery operation is from remote control to self regulation, i.e. fully automated. Alarm systems are required for fire and flooding detection. With this total substitution of machinery for human intelligence, the problems of reliability and maintenance must be considered and evaluated.

The final manning requirements established for any vessel will be based upon the results of: (1) a complete plan review of the equipment, and the monitoring safety and labor saving devices installed, (2) a period of proven operation and reliability following the initial testing and de-bugging, (3) a period of Coast Guard on-board observation, and (4) for unattended machinery operation, an acceptable plant maintenance program which insures the continued quality of the demonstrated plant reliability. Acceptance of an unattended engine room will not eliminate the requirement for engineering personnel to be on board. Sufficient qualified personnel will be required to: (1) Operate and monitor the plant in event of control failure, (2) make emergency repairs in event of machinery casualties, and (4) perform daily or periodic operations, inspections, and maintenance to insure the continued quality of plant performance.

The purpose of the enclosed guide then, is to provide an indication of the operational capabilities of the equipment and systems necessary to comply with the above concepts.

Design standards for shock, vibration, endurance, power supply fluctuation, and other environmental conditions have not been specified. These will be developed as experience is gained. Equipment which proves inadequate shall be replaced or the vessel manning shall be modified to compensate for the equipment failure.

The various sections of the guide should be applied as indicated above for the different manning levels. For diesel vessels the concepts of b and c above are applicable. Although the enclosure is a guide and therefore not mandatory by law, it does represent our experience and/or evaluation to date, and therefore in the context of 46 U.S.C. 222 represents the "judgement of the Coast Guard." Deviation from the enclosed guide must be well founded and acceptable to the cognizant Officer in Charge, Marine Inspection.

3. Action: Coast Guard marine inspection personnel, shipbuilders, ship designers and operators should consider the principles contained in enclosure (1) when considering automated machinery systems. Constructive comments and suggestions are invited.



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Encl: (1) Guide for Automated Machinery

Dist. (SDL No. 88)

- A: None
 - B: n(45); c(10); q(6); eg(3); bdp(1)
 - C: m(4); o(2)
 - D: i(2); k(1)
 - E: o(2)
 - F: None
- List 112-155

Enclosure (1) to Navigation and Vessel Inspection Circular No. 1-69

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Guide for the Automation of Main
And Auxiliary Ship's Machinery

A. INTRODUCTION

1. This guide defines the areas of interest to the Coast Guard and specifies the systems or safety devices presently deemed necessary for the various degrees of main propulsion and ship's service machinery automation. The degree of automation is predicated upon the proposed number of engineering watchstanders. In summary the requirements for the three degrees of automation for a steam turbine propelled vessel are:

a. A licensed engineer and a QMED per watch. The installation of a fully automated boiler or the installation of a self monitored and self regulating boiler with other labor saving devices permitting the re-allocation of certain of the fireman/watertenders duties to the remaining watch.

b. A licensed engineer per watch. The installation of a fully automated boiler, pilothouse control of the propulsion machinery speed and direction, and the centralization of the instrumentation and controls to a single operating station.

c. Unattended machinery operation. In addition to the requirements of a one man watch there must be an extensive monitoring, control and alarm system. Vital auxiliaries must be in duplicate with automatic transfer capability. The emphasis is from remote control to self regulation. Machinery space fire and bilge flooding detection systems are required.

2. For diesel vessels there are only two degrees of automation equivalent to paragraphs (b) and (c) above. In regard to small diesel vessels such as tugs, harbor tankers, crew boats, etc, it is not the intent of this guide to require changes from designs which have been accepted and proven successful by experience.

B. PLAN APPROVAL

1. General. Plans should be submitted for approval prior to the assembly or manufacture of the equipment. The plans submitted should include:

- (a) Specifications or a description of the equipment and the control systems, including the proposed manning and operation of the ship's engineering department.
- (b) General arrangement of the equipment in the machinery spaces and control areas.
- (c) Schematic or logic diagrams of the control systems with a written description or a line sequence diagram giving the sequence of events.
- (d) Wiring diagrams with bills of material.
- (e) Control instrument, and alarm panel layouts.
- (f) Enclosure drawings of consoles, cabinets, and panels.
- (g) Instruction books including maintenance and test procedures.

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C. GENERAL

1. Applicable Regulations. The requirements of CG-115, Marine Engineering Regulations and Material Specifications, CG-259, Electrical Engineering Regulations, and other Coast Guard regulations applicable to the particular vessel shall be met.

2. Alternate Control

- (a) Provisions should be made to permit an alternate means of control in the event of failure of any automatic or remote control component, system, or power supply. The alternate means of control shall be independent of the primary system, but may, with specific approval, actuate a common device. Manual operation is an acceptable alternate means of control.
- (b) The equipment in the machinery spaces should be suitably arranged for the primary and alternate means of control.
- (c) Transfer of the control from the primary to the alternate means should be easily accomplished in a reasonable amount of time. Special tools or equipment necessary to accomplish this transfer shall be permanently located in a convenient location.

3. Alarm and Call Systems.

- (a) All ships with automated machinery plants shall, in addition to the general alarm required by 46 CFR 113-25, be provided with an engineers' assistance-needed alarm, an engineering trouble alarm, and an engineers' call system.
- (b) The assistance-needed alarm shall be operated by contact makers located at the engine-room control station and if separate from the control station, in the engine room and the boiler room. The alarm sound producing devices should produce a sound distinct from the general alarm and should be located in the passage ways and lounge areas of the licensed engineer's quarters and should be capable of being heard in the rooms with the doors closed. Power should be taken from the general alarm power supply.
- (c) On ships with unattended machinery spaces the assistance alarm shall automatically be sounded:
 - (i) On power failure of the engineering trouble alarm system.
 - (ii) When the engineering trouble alarm is not acknowledged from the engine room control station within a reasonable period of time.
- (d) The engineering trouble alarm or "alarm", as used herein, is the system or systems which respond as the alarms specified within this guide other than the general alarm or the engineers' assistance-needed alarm. This system shall provide a visual and audible response at the engine room control station and/or other specified locations. Details of these alarms are contained in subparagraph E. 7 and in those subparagraphs of this guide applicable to the specific system.

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- (e) For vessels with unattended machinery, the engineering trouble alarm system shall be extended to the engineer's quarters and lounge areas or the bridge as necessitated by the particular system, machinery, and manning level.
 - (f) A call system should be provided at the engineroom control station to selectively call any licensed engineer's or unlicensed watchstander's quarters.
 - (g) For vessels with a single engineering watchstander, a dead man type alarm shall be provided. This alarm shall sound on the bridge unless it is routinely acknowledged in the machinery space or machinery control space.
4. Component Design. Components used in the assembly and manufacture of the equipment covered by this guide should be selected for reliability, maintainability and adequate capacity or size.
- (a) Components should be suitable for the expected temperature, ship motions, vibrations, power supply, and environment. Specific design standards for these conditions shall be developed as experience is gained.
 - (b) Operating components should be suitable for the expected loading, stress, and fatigue for the number of operating cycles expected over the vessel or component life.
5. Instruction Books. Technical manuals should be provided for the control systems and the monitoring and alarm systems. These manuals should include:
- (1) Operating instructions.
 - (2) Test procedures to evaluate the operation and safety features of the complete system.
 - (3) Maintenance and special repair procedures.

D. PILOTHOUSE CONTROL

1. General. The pilothouse control system should be designed for safe and effective control of the ship's propulsion speed and direction. Subsystems should be designed to insure satisfactory performance of the total system. The propulsion system should not be jeopardized by the rate at which the controller is operated.

2. Control Stations

- (a) Means for controlling the direction and speed of the propulsion machinery should be provided in the pilothouse and in the engineroom. Additional remote propulsion control stations may be included.
- (b) The engineroom station should at all times be able to override any remote station. Such action should be alarmed at the remote station affected.

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- (c) Transfer of control from one station to another, except for the engineroom override, should be possible only after acknowledgement by the receiving station. An indicator should be provided at the pilothouse and engineroom stations showing which station is in control. Alternative arrangements of control and/or control transfer will be considered for stations under the supervision of a single person, i.e., pilothouse to bridgewing.
- (d) Failure of the propulsion control system including the power supply (electric, hydraulic, and pneumatic) should be alarmed in the pilothouse and on the engineering trouble alarm system.
- (e) If the control system automatically shuts down the propulsion machinery for any reason (such as a safety shut-down), this should be alarmed on the engineering trouble alarm system and at the pilothouse control station and at each remote propulsion control station when it is in control. The controlling station should not regain control without some form of reset such as bringing the controller to the stop position.
- (f) Pilothouse and other remote control station controllers should be levers of substantial size and should move in the fore-and-aft-direction with a detent at the stop position.
- (g) Shaft RPM and direction of rotation indicators should be provided at each station.

3. Emergency Trip. Means for emergency shut-down of the propulsion machinery should be provided at the engineroom control station, at the machinery location, and, for unattended machinery spaces, in the pilothouse. This emergency trip should be independent of the bridge to engineroom propulsion control system.

4. Throttle limits. The remote throttle control system for steam propulsion plants shall automatically close the throttle valve on high and low boiler water levels, and on low steam pressure. Throttle control from the engineroom console need not be subject to these limits.

5. Engine Order Telegraph. An engine order telegraph should be provided in accordance with 46 CFR 113.35, except that it may be a flush mounted knob control type.

E. Machinery Control

1. General

- (a) A centralized engineroom control station should provide the controls and instrumentation necessary for the operation of the propulsion and auxiliary systems. Auxiliary systems which are essentially independent and self controlled, i.e., evaporators, refrigeration systems, need not be controlled from the central station. Consoles or control systems shall be provided with two sources of power, one of which shall be from the emergency switchboard.

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- (b) The engineroom control station should have direct access to the main machinery space.
 - (c) If enclosed, the engineroom control station should comply with the following:
 - (1) There should be at least two means of escape, at least one of which is independent of the machinery space.
 - (2) The material used in the construction of the control station enclosure should be incombustible.
 - (3) Windows in the control station enclosure should be of the shatter-resistant type.
 - (4) When a ventilation duct serving the control station penetrates the machinery space boundaries, an automatic fire damper should be fitted so as to insure the integrity of the machinery space boundaries.
 - (5) If a fixed carbon dioxide extinguishing system is installed for protection of the machinery space, the predischage warning alarm should be capable of being heard inside of the control station as well as in the machinery space.
 - (6) The remote operating controls located at the engineroom exit for the fixed extinguishing system should be duplicated within the control station enclosure.
2. Propulsion Lube Oil Service Pumps
- (a) Two lube oil service pumps should be provided.
 - (b) Controls for the lube oil service pumps should be provided at the engineroom control station.
 - (c) Automatic transfer upon loss of lube oil pressure should be provided.
 - (d) For vessels with unattended machinery, provision shall be made for an adequate temporary lube oil supply, such as large gravity tanks or battery powered pumps, in event of ship's service power failure.
3. Fire Pumps
- (a) Controls for fire pumps located within the engineroom should be included at the engineroom control station. Sufficient controls should be provided to enable the watch to charge the fire main from the engineroom control station.
 - (b) Controls for fire pumps located outside the engineroom may be included at the engineroom control station. Damage to these controls should not prevent operation of the pumps from the pump location.

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- (c) On ships with unattended machinery spaces at least one of the fire pumps shall be controlled from the bridge as well as one controlled from the engineering console. This control shall include control of the associated pump suction and discharge valves. Instrumentation shall be provided at or adjacent to the fire pump controls to indicate that adequate fire main pressure is available. Inadequate firemain pressure shall be alarmed.

4. Bilge Pumps

- (a) Automatically controlled bilge pumps should be provided for the engine room and shaft alley bilges. The bilge pumps required by part 56 of subchapter F, Marine Engineering, may be used if automatically controlled. As an alternative in manned spaces, bilge pump controls at the engine room control station along with a bilge water level indicator or high bilge water alarm may be substituted.
- (b) In unattended machinery spaces the automatic bilge pumps shall be "backed-up" by bilge level alarms which will sound in the event the pumps fail or are inadequate to control flooding. These alarms shall be independent of the pump control system. The alarm level sensors shall be in multiple for redundancy and to detect flooding at various angles of trim and heel.
- (c) In unattended machinery spaces the pumps shall be monitored to detect an excessive amount of operation in a specified time period. The intent is to detect excessive leakage which may be a prelude to a major casualty.
- (d) Automatic bilge pumps shall be equipped with an alarm and an automatic shut-down in the event oil is detected in the pump discharge. Manual operation may override this shut-down feature.
- (e) The bilge system required by Subchapter F, Marine Engineering regulations, shall be so arranged and/or located as to remain functional for a reasonable period of time after the sounding of the bilge flooding alarm.

5. Propulsion and Electrical Service Auxiliaries

- (a) For vessels with unattended machinery, pumps, systems or components essential for the operation of the propulsion or ships service electrical systems, such as feed pumps, condensate pumps, vacuum pumps, cooling water, etc., shall be fitted in duplicate and shall automatically start on failure of the operating unit.

6. Machinery Space Watertight Doors

- (a) Watertight doors, where required in machinery spaces, should be Class 3, as defined in Coast Guard Specification 163.001, when the centralized engine room control station is designed for operation by fewer than two men. Operating controls for such doors should be provided at the engine room console and at the required bridge control station.

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7. Instrumentation and Alarms

- (a) There should be adequate instrumentation and alarms at the centralized control station to provide all the information necessary to monitor and control within designed limits the operation of the propulsion, electrical, and emergency systems.
- (b) All alarmed temperatures and pressures should have a means of visual readout at the engineroom control station. If the display is not continuous, it should be some form of demand display. This display should be easily readable and available with a minimum of effort on the part of the watchstander.
- (c) Alarms should be both audible and visual. Means may be provided to silence the audible alarm; however, the system should be so designed that it cannot be in the silenced condition when the monitored system is normal.
- (d) Alarms should be of the self monitoring type; that is, an open circuit should cause an alarm condition.
- (e) Provision should be made for testing all audible and visual alarms and indicating lights except motor run lights.
- (f) Systems with remote reading instruments should have provision for the installation of direct reading instruments at the equipment.
- (g) Typewriters with movable carriages should not be used for printout devices.
- (h) The instrumentation and control systems shall not use illuminated push buttons and alarm lights of identical construction. There shall be an obvious difference between alarm or indicator lights and push buttons. This does not however prevent illuminating a push button as an alarm.
- (i) Table 1 is a recommended list of the minimum instruments and alarms that should be provided at the engineroom control station for steam turbine and diesel engine propulsion systems and auxiliaries. Other propulsion systems will be considered individually. Alternate instrumentation may be used; however, all systems listed should be effectively monitored. For continuously manned control stations, continuous displays may substitute for alarms.

Table 1

Minimum Instruments and Alarms

KEY: C - continuous display
D - demand or continuous display
RUN - indicating light when running

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LIMIT - An interlock to limit or prohibit operation under certain conditions.

* - Alarm required only for un-attended machinery operation

boilers

<u>Service</u>	<u>Display</u>	<u>Alarm</u>
Steam TEMP, S.H. Outlet	C	HIGH, for over 850°F
Steam PRES, S.H. Outlet	C	Low*
Steam PRES, Drum	C	
F.O. to burners, TEMP (Viscosity)	D	LOW (HIGH)
F.O. to burners, PRES	C	LOW
F.O. Service Pump	RUN	
F.O. Settling Tank Level		HIGH-LOW
Atonizing medium, PRES	D	LOW
Feed Pump Discharge, PRES	C	LOW
L.O. Feed Pump, TEMP	D	HIGH
Drum Water Level	C	HIGH-LOW LIMIT
Low-Low water		LIMIT
Force Draft		LIMIT
Flame failure		LIMIT
Control Power Supply		LOSS
Smoke Indicator		SMOKE*

Main Turbine

<u>Service</u>	<u>Display</u>	<u>Alarm</u>
Steam, Ahead Chest, PRES	C	
Steam, Astern Chest, PRES	C	
Gland Seal, PRES	D	
L.O. to Turbine, PRES	D	LOW-LIMIT
L.O. to Turbine, TEMP	D	HIGH-LOW
Turbine Bearings (individual), TEMP	D	HIGH
L.O. to Reduction Gear, PRES	D	LOW
L.O. to Reduction Gear, TEMP	D	HIGH-LOW
Reduction Gear Bearings (individual), TEMP	D	HIGH
L.O. Sump Level		LOW
L.O. Gravity Tank Level		LOW
L.O. Service Pump	RUN	
Condensate Pump Discharge, PRES	C	
Main Condensate Pump	RUN	
Main Condenser Vacuum	C	LOW
Condensate Level		HIGH
Main Circulator	RUN	
Turning Gear	ENGAGED	LIMIT
Vibration		EXCESSIVE*
Rotor Axial Displacement		EXCESSIVE*

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Turbine Generator

<u>Service</u>	<u>Display</u>	<u>Alarm</u>
L.O. to Turbine, PRES	D	LOW
L.O. to Turbine, TEMP	D	HIGH-LOW
Turbine Bearings (individual), TEMP	D	HIGH
Vacuum, Auxiliary Condenser	C	
Auxiliary Condensate Pump	RUN	
L.O. Pump	RUN	
Auxiliary Circulator	RUN	

Main Diesel Engine

<u>Service</u>	<u>Display</u>	<u>Alarm</u>
Starting Air, PRES	D	LOW
Raw Water, PRES	D	
J.W. Out, TEMP	C	HIGH
L.O. to Engine, PRES	C	LOW
L.O. to Turbo-charger, PRES	D	LOW
L.O. to Reduction Gear, PRES	D	LOW
L.O. to Engine, TEMP	C	HIGH
L.O. to Turbo-charger, TEMP	D	HIGH
L.O. to Reduction Gear, TEMP	D	HIGH
Exhaust TEMP (individual cylinders and combined)	D	
Jacking Gear	ENGAGED	LIMIT
L.O. Service Pump	RUN	
Fuel Oil Day Tanks, LEVEL		HIGH-LOW

Diesel Generator

<u>Service</u>	<u>Display</u>	<u>Alarm</u>
Starting Air	D	LOW
Raw Water, PRES	D	
J.W. Out, TEMP	C	HIGH
L.O. to Engine, PRES	C	LOW
L.O. to Engine, TEMP	C	HIGH
Exhaust TEMP (individual cylinders and combined)	D	

Miscellaneous

<u>Service</u>	<u>Display</u>	<u>Alarm</u>
Steering Gear Feeder C.B. (ref. 46 CFR 111.65-55(e)).		OPEN
Steering Gear (ref. 46 CFR 111.65-55(e)).	RUN	
Steering Gear Motor Overload (ref. 46 CFR 111.45-5(p)).		OVERLOAD
Emergency Generator	RUN	

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Miscellaneous continued

<u>Service</u>	<u>Display</u>	<u>Alarm</u>
Shaft Alley Door	OPEN-CLOSED	
Fire Pumps	RUN	
Fire Main, PRES	C	LOW*
Bilge Pumps	RUN	EXCESSIVE OPERATION*
Bilge Water Level		HIGH*
Ship Service Generator, Voltage	C	LOW*
Ship Service Generator, Amperage	C	HIGH*
Propeller RPM	C	
Propeller Direction	Ahead-Astern	Wrong Direction
Propeller Pitch	C	
Control Air	C	LOW
Line Shaft Bearing TEMP	D	HIGH

F. AUTOMATIC MAIN BOILERS

1. General.

- (a) Automatic main boilers should be capable of meeting steam demand from standby conditions to full load without the need for manual adjustment or manipulation. Automatic operation should include burner management, combustion control, feed water control, and safety limits. The boiler control equipment should be designed to prevent unsafe operation of the boiler. Any failure of the burner management or safety systems should prevent continued operation of the affected burner or boiler and cause the fuel supply to be cut off.
- (b) Control systems of the electrical (relay) type shall be designed to operate via an isolation transformer. One side of the secondary shall be grounded and all coils shall be connected between the grounded side and the operating contacts. All over current devices, switches and contacts shall be connected to the ungrounded or hot side of the circuit. Electronic (tube and solid state) systems shall be designed to similarly prevent false signals or safety by-passing as a result of system electrical grounds.
- (c) A fully automatic burner management system is normally required on systems designed for less than two watchstanders. On systems with a single licensed watchstander with the control station located immediately adjacent to the boiler firing area, installed locally operated ignition systems with manually operated air registers may be considered.

2. Combustion Control System. The boiler should be equipped with automatic combustion control to provide stable boiler pressure and temperature outlet conditions and a satisfactory fuel to air ratio throughout the range from standby to full load. The system may employ any of the following methods:

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- (1) Wide range fuel atomizers.
- (2) Steam dump.
- (3) Burner sequencing.

Unattended machinery systems shall provide a smoke detection alarm.

3. Feed Water Controls.

- (a) Each boiler should be equipped with at least an automatic two-element feed water regulator sensing water level and steam flow.

4. Fuel Oil System.

- (a) A master fuel oil cut-off valve should be provided in the fuel supply to each boiler. The master fuel oil cut-off valve should be automatically closed under the following conditions:

- (1) Flame failure of all burners in the boiler.
- (2) Whenever the combustion control system or boiler limit control system requires that the master fuel oil cut-off valve be closed.

- (b) Each fuel oil atomizer should be fitted with a safety coupling which will close valves in the oil line and the atomizing medium line whenever the burner is not fully seated or in place.

5. Flame Safeguard Control System

- (a) A flame safeguard control system should be provided for each burner to close the burner fuel oil cut-off valve in the event of flame failure and to close the master fuel oil valve in the event of loss of all flame in the boiler. The flame safeguard control should be capable of closing the burner fuel oil valve in not more than 4 seconds after a flame failure.
- (b) Whenever the flame safeguard control has operated, it should be alarmed and manual reset of the control should be required for restart. However, on systems with a fully automatic burner management system the flame safeguard control system may permit automatic re-ignition of a failed burner provided, at least one burner in the boiler has a satisfactory flame. The alarm system shall hold the flame failure alarm until operator acknowledged and shall indicate the automatic re-ignition.
- (c) The flame safeguard control should be so designed that the failure of any component will cause a safety shut-down of the burner and prevent automatic restarting.
- (d) Means to temporarily bypass the flame safeguard control system during a trial-for-ignition period should be limited to 15 seconds. A push-and-hold (spring-return-to-normal) type switch may be used for flame safeguard control ignition by-pass on two-man watch systems.

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- (e) Except for the trial for ignition period there shall be no means provided to by-pass one or more of the burner flame safeguard systems unless the boiler is being manually fired. Maintenance of the burner flame safeguard systems shall be made with the burner secured or with the boiler in a supervised manual control mode of operation.
- (f) It is recommended that ultra-violet flame detectors have a self checking feature which will close the burner fuel oil cut-off valve when a malfunction is detected.

6. Burner Management Systems

- (a) Burners which are automatically sequenced on and off should be provided with an automatic ignition system.
- (b) An automatic prepurge and ignition system should be provided when the system is designed to light the initial burner automatically or when the system permits lighting the initial burner from a location remote from the boiler front. On flame failure of all burners in the boiler, the system should go to a purge condition.
- (c) The prepurge should consist of a purge of the combustion chamber and convecting spaces for a sufficient duration to assure a minimum of four changes of air, but not less than 15 seconds. Sufficient air flow or the position of the air registers and dampers should be proven before the prepurge period commences.
- (d) Ignition of the fuel oil may be accomplished by an electric spark igniting a light oil pilot or by a high energy electric spark igniting the fuel oil directly.
- (e) The ignition system should be energized before or simultaneously with the opening of the pilot oil or fuel oil valve, and should remain energized during the trial-for-ignition period.
- (f) A low fire interlock should be provided to insure that the initial burner is ignited in a low fire position. No other burners should enter an ignition program until flame is proven at the initial burner.
- (g) The flame safeguard control system should provide a trial-for-ignition period of not more than 15 seconds during which fuel oil may be supplied to the burner. If flame is not established within this period, the fuel oil supply to the burner should be immediately closed.
- (h) Where a light oil pilot is used, the flame safeguard control system should provide a trial-for-ignition period for the pilot of not more than 15 seconds. If flame is not established within this period the light oil supply to the pilot should be immediately closed. The fuel oil supply to the main burner should be opened only after the pilot flame has been proven. The 15 seconds trial-for-ignition period described in paragraph (g) above should then be followed.

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- (1) On boiler trips resulting in severe reductions in boiler pressure or temperature or on start-up of a cold boiler, the burner management system shall have a programmed release from low firing rates to the normal combustion control system. This program should prevent over firing and thermal stressing of a cold or cool boiler. As an alternative, transfer of the combustion control system from manual to automatic control outside of set boiler pressure and/or temperature limits shall be alarmed.

7. Boiler Limit Control System

- (a) Boiler limit controls should be provided as listed in this section. These limit controls should prevent start-up and cause shut-down when the unsafe firing conditions exist. The limit controls should close each burner fuel oil cut-off valve and the master fuel oil cut-off valve. Manual resetting of the control system should be required before the boiler can be restarted.
- (b) A low water limit should be provided. This limit should be set to operate when the water level falls to a minimum safe level, but at a level no lower than that visible in the gage glass. To avoid nuisance alarms and shut-downs due to ship motion, the low level detection system should preferably use a level integrating type sensor. A time delay may be used if it is set so as not to effectively lower the level tripping point. Normally the time delay should not exceed a quarter of the roll period or about 3 to 5 seconds for an average vessel. The water level sensing devices for the low water cut-off (limit) and the low water alarm should be independent and should be connected to separate drum nozzles. Using these level sensing devices for feed-water control or remote water level indicators is acceptable.
- (c) A loss of forced draft limit should be provided. This limit should be set to operate when the air flow is inadequate to support satisfactory combustion. This limit may be operated by the air flow signal of the combustion control system.
- (d) For vessels with unattended machinery, the boiler limit control system may permit one automatic attempt at re-ignition after a total flame out condition. The system shall permit re-ignition only after all limits have returned to their normal range. The alarm system shall hold the tripping limit alarm until acknowledged by an operator and shall indicate the success or failure of the automatic re-ignition attempt.
- (e) Other boiler limit controls such as oil pressure, oil temperature, etc., may be provided subject to approval by the Commandant.

8. Boiler Instruments and Alarms

- (a) The boiler instruments and alarms should meet the general requirements of section E.7.
- (b) Each boiler limit control provided under section F.7 should be alarmed.

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- (c) A low water alarm should be provided. This alarm should be independent of and set higher than the low water cut-off described in paragraph F.7 (b).
- (d) Flame failure of each burner should be alarmed.
- (e) Loss of the boiler control system power supply (electric, hydraulic, and pneumatic) should be alarmed.
- (f) The instruments and alarms listed for boilers in Table 1 of section E.7 should be provided.
- (g) In cases where the Commandant has permitted the engineroom control station to be located remote from the boiler firing area, the alarms and instruments required by this section should be provided at both the engineroom control station and the boiler fronts.

G. Ships Electrical Systems.

- 1. Ships Service Generators shall comply with the existing regulations. Additionally the units should be designed for a minimum number of manual operations to start and place the generators in service.
- 2. For vessels with a single licensed engineering watchstander, the generators shall be capable of being started and placed in service from a single location. This location shall be at the engineering console, switchboard, or remote control room as applicable.
- 3. For vessels with unattended machinery, a standby generator shall be provided and capable of automatically assuming the ships service load within 30 seconds after running generator failure.
 - (a) For vessels with identical ship's service generators, each unit shall have an automatic starting capability if either may serve as the standby generator.
 - (b) For vessels with a single propulsion boiler, the standby generator shall be other than steam driven.
 - (c) The standby generator may be any onboard unit including the emergency generator which has sufficient capacity to carry all auxiliaries necessary to maneuver the vessel, to provide adequate ship instrumentation and interior illumination, and which is able to comply with the previous requirements of this section.

H. Fire Protection.

- 1. The ship shall be equipped with the fire detection and extinguishing systems specified by the regulations. For ships with unattended machinery spaces, the following additional systems are required:
 - a. A fire detection system shall be installed throughout the machinery spaces. The system shall be carefully selected based upon its sensitivity and compatibility with the environment. Final location of the detectors shall be established by consultation with the equip-

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ment engineers, by an inspection of the completed installation, and by such tests as are deemed necessary by the Coast Guard.

- b. Control of all systems or functions relating to fire protection of the machinery space should be centralized in a single accessible location outside the machinery casing. This station should be able to control the fixed fire extinguishing system, the machinery space ventilation, fuel pumps and fuel tank valves subject to a fuel head pressure, the remote fire pump, and the bilge system.

I. Maintenance.

The key to successful automation is a continuous and comprehensive maintenance program. Experience has shown that marine machinery plants can not operate indefinitely without some attention and care. In particular the continued satisfactory performance of an "unattended machinery" plant is dependent upon a routine inspection and maintenance program. Therefore, the unattended machinery concept presently implies that the plant may operate unattended for extended periods (hours) but that inspection and maintenance personnel will be routinely present during the normal working hours.

Although system failures can not be predicted, routine and systematic inspections of equipment will eliminate or minimize many casualties. Inspection and maintenance check-off lists are recommended to eliminate the human errors of omission, such as failure to clean the strainers or fill the fuel oil day tank.

Prior to leaving the plant unattended each day, a routine inspection procedure should be established to ascertain that; all loose gear is secured, all standby equipment is in a ready condition, fire or flooding hazards have been minimized, and that the machinery is functioning properly.

Therefore, an operation and maintenance program for all unattended machinery plants must be approved by the Coast Guard prior to the certification for unattended operation.

It is assumed that for attended enginerooms the watchstanders will have assigned routine inspection and maintenance duties.

J. System Tests and Inspections.

1. General. The automated systems shall be subjected to routine tests and inspections by the operator and the Coast Guard to verify the operational condition of the system, the alarms, and the safety devices and/or interlocks. To assist in this evaluation, a test procedure shall be provided and approved for all complex systems (e.g. burner management systems) and vital systems, alarms or safety devices. A vital alarm system or safety device is one specifically required by this guide other than in Table 1. This is not intended to degrade the need or importance of the other alarms or systems; however the need and particularly the method of testing of the other systems should be readily apparent. A typical, but not necessarily all inclusive, list of systems to be included in the test procedure is:

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- a. Burner Management System.
- b. Boiler water level alarms and fuel oil cut-off.
- c. Flame safeguard systems.
- d. Throttle control overrides and control transfer.
- e. Propulsion and generator L.O. alarms and pump transfer.
- f. Fire detection system if not included in the general fire protection system.
- g. Bilge flooding detection and automatic bilge pump systems.
- h. Automatically started generators.

2. Test Procedure Details.

- a. The test procedure shall be in a step by step or check-off list format. Each test instruction should specify the equipment status, functions necessary to accomplish the test, and the expected test results. It should be sufficiently detailed and explicit that engineering personnel unfamiliar with the details of the particular system can use it. However, it should not contain long narrative explanations which make it inconvenient to use.
 - b. The test procedure shall not simulate conditions by mis-adjustment, artificial signals, improper wiring or other revision or tampering of the installed alarm or safety system.
 - c. The test procedure shall be available and used during initial trials of the installation to verify the test procedure correctness and adequacy.
3. The test procedure shall be approved and retained on board the vessel in a systems operation and maintenance manual.
4. All tests and inspections to comply with Coast Guard requirements shall be conducted by the ship's personnel and witnessed as specified by Coast Guard personnel.