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GUIDELINES ON ENGINE-ROOM OIL FUEL SYSTEMS

1 The Maritime Safety Committee, at its sixty-third session, in order to reduce the risk of fire in machinery spaces, approved MSC/Circ.647 containing recommendations for the design, construction, testing, installation, maintenance and inspection of systems containing flammable oils.

2 Since dissemination of MSC/Circ.647 there has been a continuing incidence of machinery space fires due to the leakage of oil fuel. Investigation of fire casualties, analysis of casualty statistics and technical research has revealed that leakages from the fuel system are due to the failure of worn, incorrectly fitted, slack, over-tightened or unsuitable components. Major contributing factors to failures of fuel system components have been found to be:

- the frequent partial dismantling and reassembly of the system for maintenance purposes;
- the effects of high frequency, short duration pressure pulses which are generated by the action of the fuel injection pumps and which are transmitted back into the fuel supply and spill rails; and
- vibration.

3 As the result of further research, the Committee, at its sixty-ninth session (11 to 20 May 1998), approved the Guidelines on engine-room oil fuel systems, as set out in the annex, to supplement the Guidance contained in MSC/Circ.647 by focussing on the importance of an accurate description of the interface between the various parties concerned and of adequate maintenance in reducing fuel system failures.

4 Member Governments are invited to bring the annexed Guidelines to the attention of shipowners, ship designers, shipbuilders, ship repairers, installers and all other parties concerned for appropriate action.

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ANNEX

GUIDELINES ON ENGINE-ROOM OIL FUEL SYSTEMS

1 Introduction

These Guidelines are intended to supplement the Guidance contained in MSC/Circ.647, by focussing on the importance of an accurate description of the interface between the various parties concerned and of adequate maintenance in reducing fuel system failures.

2 The causes of high pressure pulses in the fuel supply and spill systems

2.1 The most common fuel injection pumps (monobloc or "jerk" pumps) comprise a plunger moving up and down in a barrel which contains ports for fuel to enter and leave. The pump is designed to provide the variable fuel flow required for the engine to operate under fluctuating load or rpm, by adjustment of the plunger delivery stroke. At a point determined by the engine's fuel requirement, the plunger will uncover the ports and the internal pressures of between 800 bar and 1500 bar will be spilled back into the fuel supply and spill piping.

2.2 Each injection pump action generates high magnitude spill pressures followed by periods of reduced pressure. As a result, maximum pressure differences exist between successive injection pumps in the engine firing order. The pressure differences accelerate columns of fuel within the piping system and when combined with the action of the circulating pump relief valve, can cause cavitation and reflected pressure waves. Cavitation implosions occur quickly, and can induce very short duration pressure pulses in excess of 100 bar.

2.3 Tests have determined that the magnitude of pressure pulses in the fuel system of a typical medium speed engine installation is greatest at 40% to 60% engine load, and will reach 60 to 80 bar. The pulses are approximately 8 times the nominal pressure of the system. High-speed engines such as those installed on high-speed craft generate higher injection pressures and it is likely that the fuel system will experience correspondingly higher pressure pulses.

2.4 High pressure pulses lead to vibration and fatigue and are responsible for many failures of equipment such as thermostats, pressostats and mechanical dampers. The failure of fuel lines and their components will invariably involve fatigue and the initiation of fractures due to tensile stress.

3 Design considerations

3.1 It is essential that the fuel system is designed to accommodate the high pressure pulses which will be generated by the injection pumps. The engine manufacturer and/or the fuel installation manufacturer and the piping installer etc. must be consulted for an explicit statement of the fuel system parameters, including the maximum pressures which will be generated. Many engine manufacturers, aware of the potential risks due to high pressure pulses within the fuel system, now aim to limit the magnitude of the pulses to 16 bar at the engine fuel rail outlets.

3.2 The alternative approaches which may be considered by the designer are:

- design of the fuel system such that it is able to contend with the magnitude of pressure pulses which are generated. Piping systems should be designed and installed to an appropriate classification society or ISO specification;

- installation of pressure damping devices; or

- specification of injection pumps which are designed to eliminate or reduce high pressure pulses.

3.3 The fuel line between the fuel tank and the engine is made up of several parts from different suppliers. The fact that these suppliers are unaware of, and therefore do not take into account, the pressures that may be placed on their equipment by the other components of the system, is often the reason for the system's failure. It is recommended, therefore, that a single person is given responsibility for the co-ordination of the specification, design and installation of all components within the fuel system, so as to ensure that they are all suitable for the anticipated high pressure pulses. It is important that the co-ordinator ensures that the design intent is fully implemented at the time of on-board installation.

3.4 There are a number of pressure damping devices which have been fitted within fuel systems. Mechanical pressure accumulators and gas filled bellows have both been used, however in some cases, problems of slow response and failure due to fatigue and vibration have been experienced.

3.5 Fuel pipes should be of steel and supports should be adequate to prevent fatigue due to vibration through the structure from the engines and propellers. The support arrangements should also protect the system from vibration caused by high pressure pulses. Copper and aluminium-brass pipes should not be used as their inherent work hardening characteristics make them prone to failure when subjected to vibration.

3.6 Experience indicates that compression couplings require careful attention to tightening procedures and torques to avoid leaks or damage to the pipe when subjected to overtightening. They should not be used in the fuel supply line of the injection pumps and spill system. Flanged connections should be used in place of compression couplings.

3.7 In many cases several engines are supplied by a single fuel supply pump and if there is a leakage, the watchkeeper must stop all engines. However, there are occasions when promptly stopping the engine on which the leak has developed and isolating its fuel supply and spill lines would suffice. Therefore in multi-engine installations supplied from the same fuel source, means of isolating the fuel supply to and spill from individual engines should be provided. The means of isolation should be operable from the control position.

4 Installation

4.1 One person should be designated as responsible for co-ordinating the initial on-board installation of the complete fuel system.

4.2 The co-ordinator must be able to understand the overall design criteria and ensure that the design intent is fully implemented at the time of installation.

5 Maintenance and inspection procedures

5.1 The ship Safety Management System should contain procedures to identify vibration, fatigue, defects, poor components and poor fitting of the fuel system and ensure that proper attention to protecting hot surfaces is maintained. Check lists should be prepared to ensure that all procedures are followed at major overhauls and that all components, supports, restraints etc., are refitted on completion of such work. The installed system should be routinely inspected for:

- verifying the adequacy of its supports and the condition of its fittings;
- evidence of fatigue stresses to welded or brazed pipes and connections;
- assessing the level of vibration present; and

- the checking of the lagging or shielding of hot surfaces.

5.2 Components of the fuel system should be comprehensively examined, particularly threaded connections, at each dismantling.

5.3 Injection pump restraining bolts should be proved tight by testing with a torque spanner at frequent intervals (interval not to exceed 3 months).

5.4 The supports and retaining devices of the low pressure fuel system should be checked at regular intervals (interval not to exceed 6 months), to be proved tight and to provide adequate restraint. The lining of such devices should be examined for wear and renewed if they provide insufficient support.

5.5 Flexible pipes should be closely examined and renewed if signs of material cracking or deterioration are evident. Extra care should be exercised in the tightening of these pipe connections to ensure that they are not twisted when re-installed.

5.6 Flexible pipes should be pressure tested to their original design pressure at least at five yearly intervals. Alternatively, such pipes should be the subject of a study aimed at determining their finite life and then be automatically renewed before that has been reached. The views of engine and fuel system manufacturers should be sought and considered.

5.7 All gasket and seal ring materials, and any jointing compounds used, should comply with the requirements of the engine manufacturer.

5.8 Where already fitted, compression fittings should be carefully examined and if necessary tightened (but not over-tightened) with a torque spanner to the manufacturer's specification. Replacement with flanged connections should be considered.

5.9 Existing copper and aluminium-brass piping should be heat treated (annealed) and sufficient supports fitted to prevent damage from vibration. Replacement with steel piping should be considered.

5.10 All component locking devices, such as spring and tab washers, locking wires etc., should be present and in use. (It is recognised that it is impracticable to lock fuel pump vent screws with wire, due to their frequent use. However, wire loops containing a weight attached to each screw would prevent them unscrewing under the influence of vibration if they became slack.)

5.11 Spray or deflection plates and lagging should be correctly replaced after maintenance to reduce the possibility of fire in the event of fuel leakage.

5.12 The fuel system on existing ships should be checked for compatibility with the high pressure pulses which are generated by the fuel injection pumps.

6 Human element

Knowledge of the operation of engine fuel systems and the magnitude of pressures generated within them should be included in the training standards for engineer officers. The topic should receive detailed attention when candidates sit examinations for their Certificates of Competency.

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