MECH 206P: Design and Professional Skills 2

Reliability, Availability and Maintainability (RAM)

Failure Mode and Effects Analysis (FMEA)

&

Risk Assessment

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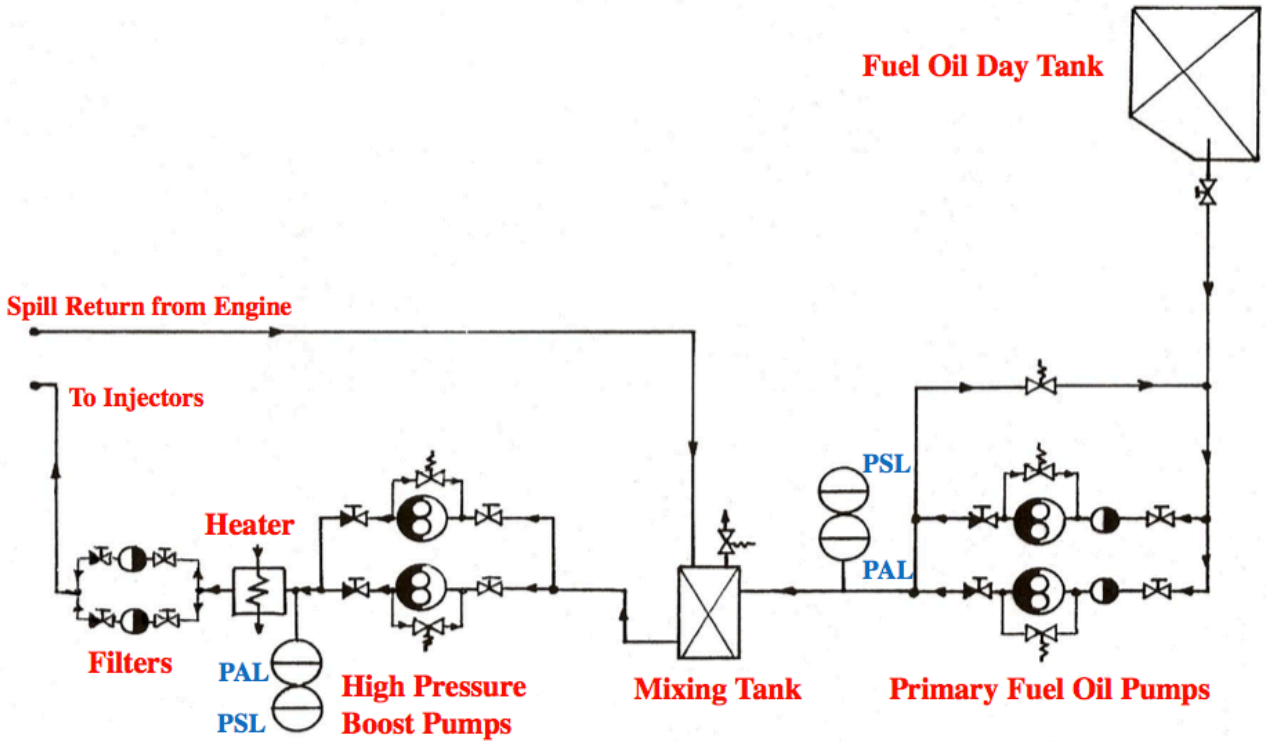
Task 1

The Fault Mode and Effect Analaysis (FMEA) worksheet is prepared below for a fuel oil system supplying to a large marine diesel engine. The FMEA risk assessment methodology is used to help identify potential failure modes and their associated risks, evaluate their causes and assess their impact in the fuel oil system of a ships diesel engine. The lifetime costs of a diesel engine as well as its reliability is dependent on and heavily influenced by the design and manufacturing phase. FMEA is carried out to address the consequences of the identified potenial failure modes by the effect analysis, and then to enforce favorable design rectifications to reduce risks and maintenace costs.



Identification: Fuel Oil System

Function: To supply clean fuel oil to the diesel engine and generators that is mixed in the appropriate (air to fuel ratio) AFR, at a particular favorable temperature and pressure.

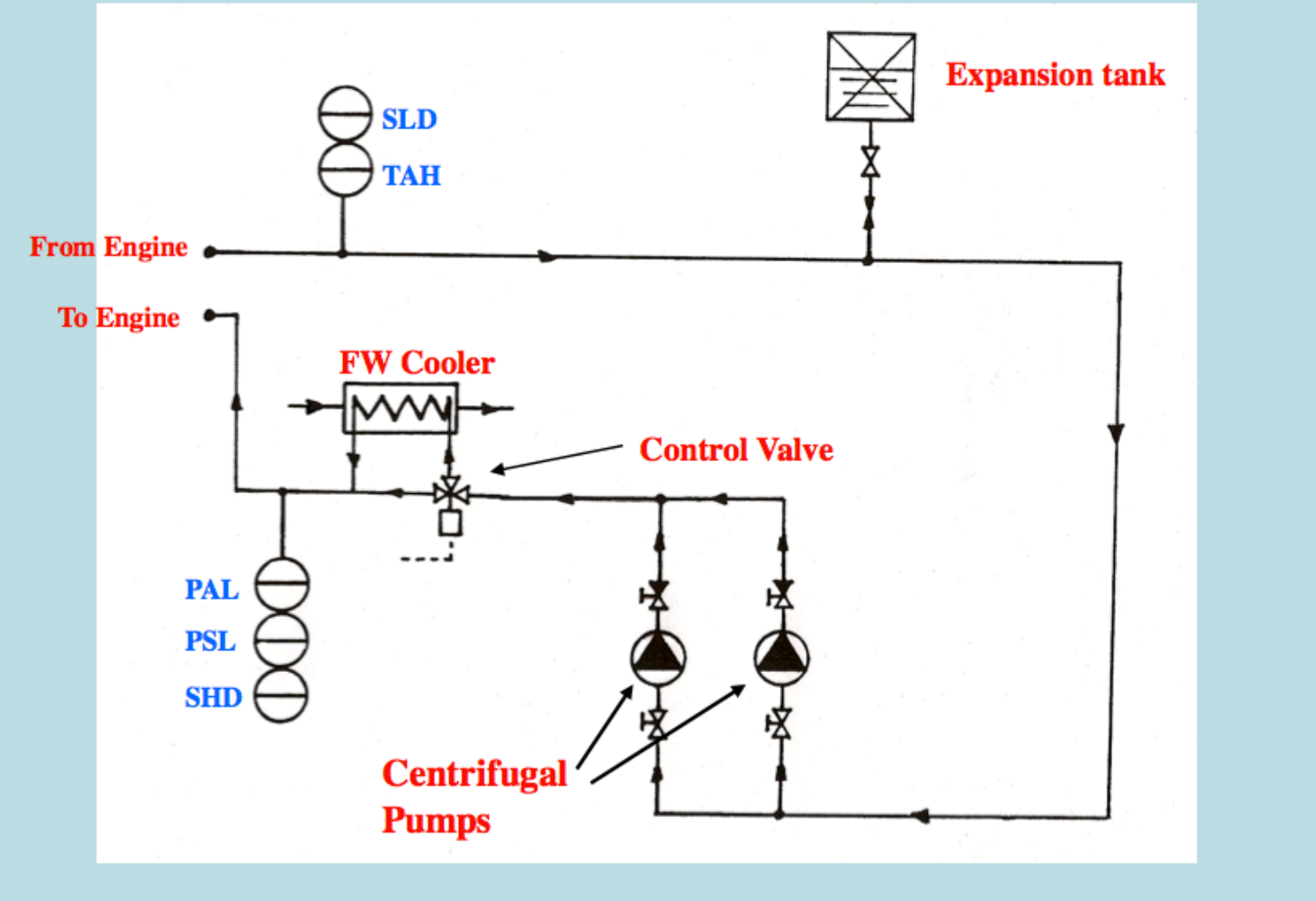
Item	Function	Failure Modes and Causes	Failure Effect		Failure Detection Method	Compensation Provisions	Severity X Likelihood	Remarks
			Local Effect	System Effect				
Primary Fuel Oil Pumps (positive displacement pump)	To increase the pressure of fuel oil from the fuel oil day tank to the mixing tank.	Pump seal leaking. Vibration and noise. Stalling because of no spinning or lack of capacity.	Damage to pumps. Disturbance to the fuel supply to the engine.	No power produced for propulsion, accessories and navigation systems. Engine liable to damage if kept running. Engine performance hindered.	Presure Switch Low(PSL). Pressure Alarm Low (PAL).	Direct Observation for irregularities and check the pressure indicator. Prompt invetsigation on detection by repairing/ changing in the case of minor/major damage. Tightening of the bolt fastener. Ensure power meets pump needs. Treatment to ensure right fuel viscosity. Replacement of impeller.	4 X 3 = 12 Critical	Severity =4 (in the absence of a reserve power supply 1 or 2) Likelihood=3
High Pressure Boost Pumps (positive displacement pump)	To deliver fuel oil at a high pressure from the mixing tank through the heaters and filters to the injectors.	Cavitation due to the entrance of particles distrupting the pump foundations (corrosion/errosion in the impeller). Sudden halting after spinning. Pump overloaded due to constant	Less overall pressure in the system. Pump overheats and impeller suffers damage due to heat deformation on account of the	Fuel discharge to main engine lacks/is completely halted. Disturbance/termination of fuel supply to the engine. Acceleration of wear and tear (worn out bearings)	Presure Switch Low(PSL), Pressure Alarm Low (PAL).	Check the flowmeter, voltage and pressure indicators. Stabilisation of supply voltage to cater to pumps power needs. Cleaning the filter, inlet and outlet valves.	4 X 3 = 12 Critical	Severity =4 (in the absence of a second engine) Likelihood=3

		Clogged discharge and channel and closed suction valve. Reduction in supply voltage and fluctuations in electric voltage. Capacity Specification is not met. Extremely viscous fuel oil.	that seeped into the pump system.			Changing/servicing the impeller and foundations as necessary. Resetting the flow regulating valves. Opening the suctions valves. Adjusting fuel vicosity		
Mixing Tank	To mix the charge (air and fuel) in the correct ratio. Regulates the fuel oil flow from the day tank to the engine.	Pressure relief valve fails to regulate air (rich charge) and the PSL does not switch on in the scenario of low fuel (lean charge). Corrosion, rust cause leakage in the seal.	Chances of knock misfiring (higher in the case of a leaner mixture) Poor quality of fuel supplied to the engine.	Faulty air to fuel ratio collaboration could prove critically damaging to the performance and durability of the engine and its components. Engine starting could be slow and performance migth suffer when idle.	Direct Observation	Monitor engine performance. Inspect for knocking. Eliminate rust by painting. Replace worn out/ broken seals.	5 X 4 = 20 Marginal	Severity =5 (in the absence of a second engine 3 or 4) Likelihood=4
Filters	To remove fuel oil impurities, water,abrasive contanminants, dirt,etc.	Clogging of the filter	Non-functional filter and dirty fuel oil	Reduced/no supply to the engine due to obstructed flow/ clogging. Damage to fuel pumps, injectors and cylinder liner.	Pressure Alarm Low (PAL) will go off in the case of faulty filters preceding the primary fuel oil pumps, Affected fuel injection in the case of filters following the heater.	Watch the viscosity measuring instrument. Check the flow meter. Change the filter.	4 X 3 = 12 Critical	Severity =4 (in the absence of a reserve power supply 1 or 2) Likelihood=3
Fuel oil day tank	Storage tank that stores the fuel	Leaks, blocked, or cloggs leading to an empty /not completely filled Fuel Tank	Less/ no fuel to the engine if blocked/all fuel is drained if	No/reduced power to the engine, damage to filters by dirt accumulation due to reduced fuel in the lines.	Pressure Alarm Low (PAL) may set off in case of a blocked	Regular Checks to identify and instantly mitigate risks Identification and	3 X 3 = 9 Catastrophic	Severity =3 (in the absence of a reserve power supply 1 or 2) Likelihood=3

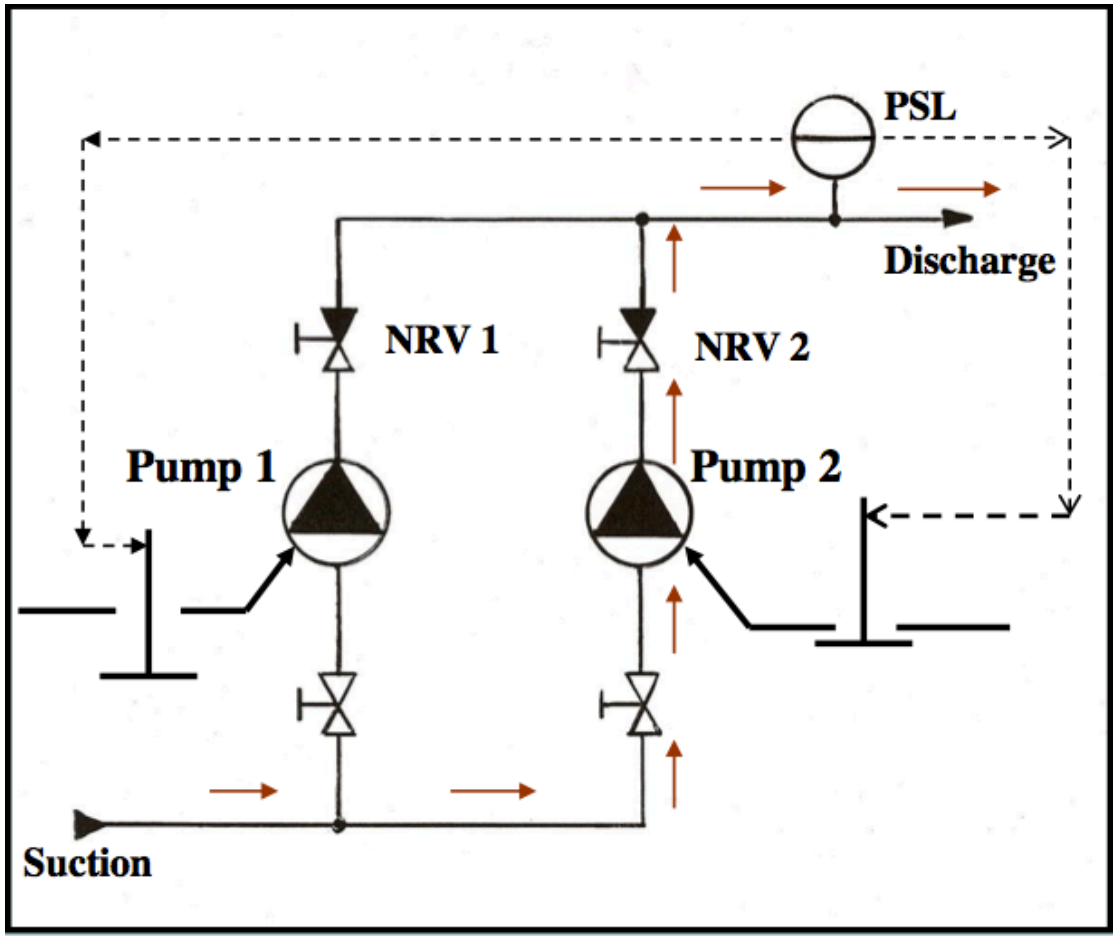
			excess charge in the tank if clogged up.	Fuel is lost in a leakage, fire hazard and danger of explosion is present.		leakage(patching plates that leak) and provision for continual surveillance.		
PSL & PAL	PAL goes off on low pressure in the system and activates the PSL.	Faulty installaton/ lack of maintainace	Switching of pumps cannot be facilitated	This is a fault to the detection mode which could lead to imbalance in the whole system as regulation has failed	Direct Observation and monitoring.	Observe if unacceptable component and system low pressures are not alarmed.	4 X 4 =16 Marginal	Severity =4 (in the absence of a reserve power supply 2 or 3) Likelihood=4
Valves – Pressure Relief Valve (PRV) Screw Down Valve (SDV) Screw Down No Return Valve (SDNRV)	PRV keeps the pressure constant. SDV enables flow regulation. SDNRV impedes the flow of fuel in the reverse direction.	Faulty installaton/ lack of maintainace, Wear and tear due to excessive usage	Spillages if the valves leak.	The flow of the entire oil system could be disturbed if the valves fail to operate as required	Direct Observation and monitoring.	Ensure valves are securely screwed down where required, constant condition checks should be carried out	3 X 4 =12 Critical	Severity = 3 (in the absence of a reserve power supply 1 or 2) Likelihood=4

Task 2

A fresh water circulation system



Health and Safety Executive (HSE) risk assessment form for the removal of the faulty centrifugal pump 1 while pump 2 is still running in the fresh water circulation system.



What are the hazards? Identification of Hazards: Anything that can cause harm	**Who might be harmed and how?** Decision of WHO might be harmed and HOW	**What are you already doing?** Evaluation of the risks and decision on precautions	**Do you need to do anything else to control this risk?** Record of findings and implementation
Non-Return Valve 1 (NRV) leaks (Leading to back flow)	Who: Technicians (who are changing the pump) as well as staff within close proximity of the engine room. How: Slipping due to spillage. Electric shock danger (if leak takes place during through the replacement).	Ensuring that the valve is safely locked and the non-return aspect is functional.	Regular checks to ensure no disturbance is caused to the replacement process and no one is physically harmed
Screw Down Valve (SDV) for pump 1 fails (Leading to certain proportion of the flow diverted towards pump 1 after suction)	Who: Technicians undertaking the operation with Pump 1 as well as staff in the engine room. How: Slipping due to spillage. Electric shock danger (if leak takes place during through the replacement)	Ensuring that the valve is securely screwed down.	Constant precautions and checks to ensure that the replacement process is not hindered and no one is physically harmed

Electrical Switch Gear for Pump 1 makes contact on Signal from PSL (Electric Hazard)	Who: Technicians undertaking the operation How: While the pump is removed, electric wires and circuits are bound to be left exposed. Harm: Large spark discharge/Electric shocks/ electrocution, extreme danger if contact with water is made.	Careful replacement is carried out and electric wires are coated with non-conductive materials like rubber/plastic.	Ensure no electric circuits are exposed during the replacement. Implementation of a sequential replacement procedure with necessary precaution steps to be adhered to by tecINhnicians.
Incompetent, Inadequately trained Maintenance staff and Technicians (Human Error)	Who: Anyone accessing the engine room and on board the vessel. How: Potential damage to the vessel and harm caused due to glitches/errors like misaligning of the replacement pump leading to overheating, setting of the wrong motor direction, over tightening, incorrectly torqued bolts,etc.	Only appropriately and adequately qualified staff is employed. Servicing/replacement jobs are allocated as per expertise and experience demanded.	Educating the relevant people involved about the engine room environment, correct equipment to be used, recent condition history, operation instructions and safety measures.

Engine Room Clutter	Who: Anyone working in the engine room Harm: Physical Injury due to tripping over tools. Scattered obstructions causing Disruption to work flow processes by making the work environment more susceptible to danger.	Staff regularly organize and maintain the design layout of the engine room	Enforce rules to keep the working environment always in order to mitigate the harm that clutter can cause.
Failure of safety critical systems	Who: Anyone working in the engine room How: No containment/ avoidance of hazards that arise are possible as the necessary systems that are responsible for it are non-functional.	Regular proof checks to ensure risks are within acceptable proportions	Implement maintenance regime and a proof check schedule to ensure reliability of safety systems.
Chemicals and gases	Who: Anyone working in the engine room How: Exposure to hazardous and harmful chemicals and gases released as a byproduct/ as exhaust could cause irritation to eyes, skin, and cause breathing difficulties.	Ensure protective gear is worn like gloves, glasses, boiler suits.	A sensing system to identify threats and prompt immediate action.
Corrosion	Who: Anyone working in the engine room How: Contact with corroded metal can lead to infectious bruises and cuts.	Application of a protective paint coating layer, sealant or use of an anti rust agent.	Periodical maintenance to ensure rust is absent and all metallic surfaced that are exposed are safe to handle.

Fire	Who: Everyone How: sources of ignition like flammable spillage interacting with electric connections and supply. Extremely dangerous as a fire in the engine room has the potential to spread rapidly.	Fire extinguisher and fire blankets at accessible locations. Clear fire exit maps and fire proof doors.	Fire proofing of the engine room ensuring that ignition equipment and flammable substances are separated. Running of fire drills to test emergency protocols and ensuring that the alarm system sounds.
Noise and Displacement	Who: Anyone working in the engine room How: Harm to hearing because of the large magnitude of sound surrounding the engine. Physical harm due displacement of equipment on account of ship's rocky movement and loss of balance.	Earmuffs are used by staff. Equipment is strapped in place to avoid calamity.	Sound proofing areas where staff are extensively exposed. Adding in handlebars so that staff can use to steady themselves.