TABLE OF CONTENTS

PLANNED INDICATORS

PLANNED INDICATORS	DESCRIPTION
S•O•S℠ Services	S·O·S Services provide the best insight into internal component wear and potential failure.
Service Meter Hours	Operating and Maintenance Manual gives general guidelines for servicing based on service meter hours.
Experience –Observation & Discussion	Talking with your machine's operator can reveal many potential component problems.
Service History	Service history indicates how frequently routine maintenance is performed.
Fuel Consumption	Indicates when a piece of equipment is operating at less than optimum efficiency.
Site Operations Maintenance Advisor (SOMA)	SOMA is a software that assesses customers operating and maintenance practices and provides component life estimates.

ENGINE INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Excess Black Smoke at Full Load (Hot, Unburned Fuel)	• Dirty primary/secondary air cleaner • Operating in too high a gear • Overfueling • Overloading	• Faulty Turbocharger • Technical Analysis Inspection • Customer/Dealer Discussion	**Soot, Fe, Cr, Al**	• Dirty air filter • Piston rings • Liners
Increased Fuel Consumption	• Malfunctioning fuel nozzles/injectors • Malfunctioning turbocharger • Dirty air cleaner • Improper set point • Fuel leak	• Technical Analysis Inspection • Customer/Dealer Discussion • Tune-up	**Positive fuel contamination, decreased viscosity**	• Fuel leaking into oil from injectors • Shearing of the oil additives
Blue Smoke (Oil Consumption)	• Worn turbocharger seals • Worn rings/liners • Worn valve guides • Hours on engine	• S·O·S Fluid Analysis • Component Inspection/Repair • Repair Determination Inspection • Customer/Dealer Discussion	**Fe, Cr**	• Broken or stuck piston rings • Ether start-up • Running too cold or hot • Oil jet broken
White Smoke (Steam: Water in Combustion Chamber)	• Cracked head and/or liners • Leaking head gasket	• Technical Analysis Inspection	**Positive coolant contamination, Na, K, Si, Cu**	• Coolant entry
White Smoke (On Start-Up: Unburned Fuel)	• Incorrect starting procedure • Incorrect fuel injector timing • Faulty injector	• Customer/Dealer Discussion • Tune-up	**Positive fuel contamination, decreased viscosity**	• Fuel leaking into oil from injectors • Shearing of the oil additives

ENGINE INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Increased Oil Consumption (Excess Blow-By)	• Worn or broken rings/liners • Worn turbocharger seals • Worn valve guides • Hours on engine	• S·O·S Fluid Analysis • Component Inspection/ Repair • Repair Determination Inspection • Technical Analysis Inspection • Customer/Dealer Discussion	**Fe, Cr**	• Broken or stuck piston rings • Ether start-up • Running too cold or hot • Oil jet broken
Unusual Noises	• Malfunctioning fuel nozzles/injectors • Malfunctioning turbocharger • Worn piston pin bushings • Worn rod/main bearings • Too much valve lash	• Technical Analysis Inspection • Repair Determination Discussion • Customer/Dealer Discussion • Tune-up • Component Inspection Repair	**Positive fuel contamination, decreased viscosity, Cu, Pb, Al**	• Fuel leaking into oil from injectors • Shearing of the oil additives • Rod eye bushing • Piston pin bushing • Lower rod bearings
Lack of Power	• Incorrect adjustment of governor linkage • Malfunctioning fuel nozzles/injectors • Slipping torque converter • Improper set point • Dirty fuel filter • Dirty air cleaner • Low quality fuel	• Technical Analysis Inspection • Customer/Dealer Discussion • Tune-up	**Soot, Fe, Cr**	• Dirty air filter • Low quality fuel • Piston rings and liners

ENGINE INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Overheating	• Malfunctioning temperature regulator • Incorrect adjustment or worn belts/pulleys • Incorrect operator technique • Plugged radiator core (external and internal) • Low coolant level • Dirty air cleaner	• Technical Analysis Inspection • Customer/Dealer Discussion • Cooling system maintenance	**Oxidation increases, Fe, Pb, Al, Cu, soot**	• Liner • Gears • Valve train wear • Bearings • Cooler core leaching • Dirty air filter
Hard Starting (Engine Missing)	• Malfunctioning fuel nozzles/injectors • Improper starting technique • Worn fuel injector pump • Low cranking speed • Low quality fuel (low cetane rating or water in fuel)	• Customer/Dealer Discussion • Tune-up	**Soot, Fe, Cr**	• Dirty air filter • Low quality fuel • Piston rings and liners
Oil Level Over Full	• Coolant/fuel leak into crankcase • Improper oil fills	• S·O·S Fluid Analysis • Customer/Dealer Discussion	**Positive coolant contamination, Na, K, Si, Cu**	• Coolant Entry
Debris In Oil Filter	• Coolant/fuel leakage into crankcase • Extended oil change period • Damaged bearings • Wrong oil used • Dirt entry	• S·O·S Fluid Analysis • Customer/Dealer Discussion	**Positive coolant contamination, positive fuel contamination, oxidation increases, Si, Al**	• Coolant entry • Fuel leaking into oil from injectors • Overheating • Dirt contamination

FINAL DRIVE INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Brake Slippage	• Worn plates and discs • Wrong oil used • Linkage out of adjustment	• Technical Analysis Inspection • Repair Determination Discussion • Customer/Dealer Discussion	**Si increases, Fe increases, (Ca, P, Zn) levels change from trend**	• Worn disc • Worn plate • Wrong oil used
Unusual Noises	• Worn plates and discs • Dirt entry • Low fluid level	• Technical Analysis Inspection • Repair Determination Discussion • Customer/Dealer Discussion	**Si, Al, Fe**	• Dirt entry • Worn disc • Worn plate
Overheating	• Wrong oil used • Low fluid level • Worn or damaged seals	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services • Customer/Dealer Discussion	**Oxidation increasing, Water, Fe, Na, viscosity increasing**	• Wrong oil used • Low fluid level • Water entry

FINAL DRIVE INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Debris on Magnetic Plug	• Dirt entry • Wrong oil used • Extended oil change period • Disc disintegration • Worn gears/bearings	• S·O·S Services • Customer/Dealer Discussion	**(Si, Al), Fe, Cr, oxidation, viscosity increase, (Al, Cu, Fe)**	• Dirt entry • Worn gears/bearings • Sleeve bushing wear
Vibration	• Gear failure • Sprocket failure • Bearing failure	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services • Customer/Dealer Discussion	**Fe, Cr, (Si, Al), (Cu, Pb)**	• Gear failure • Bearing failure • Dirt entry • Thrust washer failure
Leaks	• Worn, hard, cracked seals • Sprocket failure • Bearing failure	• Repair Determination Discussion • Customer/Dealer Discussion	**Si, Al, Cr**	• Dirt entry from worn seals • Bearing failure

TRANSMISSION INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Hesitation/Slippage	• Worn plates and discs • Linkage out of adjustment • Low fluid level • Linkage not free • Incorrect pressure settings • Wrong oil used	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services • Customer/Dealer Discussion	**Si increases, Fe increases, (Ca, P, Zn) levels change from trend**	• Worn disc • Worn plate • Wrong oil used
Unusual Noises	• Worn gears/bearings • Dirt entry • Aeration/cavitation • Low fluid levels	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services • Customer/Dealer Discussion	**Fe, Cr, (Si, Al), (Ca, P, Zn) levels changed from trend, oxidation increases, viscosity increases**	• Gears • Bearings • Dirt entry from breather • Low fluid levels
Vibration	• Bent/damaged drive shaft • Gear failure • Bearing failure	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services • Customer/Dealer Discussion	**Fe, Cr**	• Bent drive shaft • Gear failure • Bearing failure

TRANSMISSION INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Overheating	• Wrong oil used • Plugged radiator • Worn pump/pressure relief valve • Worn or damaged seals • Low fluid level • Worn or dirty control valve	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services • Customer/Dealer Discussion	**Oxidation increase, coolant contamination (Na,K, Si, Cu) viscosity increase, (Si, Al), (Ca, P, Zn) levels changed from trend, Fe, Cr**	• Extended drain interval • Coolant entry • Dirt entry • Wrong oil used • Worn gears/bearings
Debris in Filter and/or on Magnetic Screen	• Dirt entry • Wrong oil used • Extended oil change period • Worn gears/bearings • Disc disintegration	• S·O·S Services • Customer/Dealer Discussion	**(Si, Al), (Ca, P. Zn) levels changed from trend, Fe, Cr**	• Dirt entry • Wrong oil used • Worn gears/bearings
Leaks	• Worn, hard, cracked seals	• Repair Determination Discussion • Customer/Dealer Discussion	**(Si, Al)**	• Dirt entry from seals

DIFFERENTIAL INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Bent or Damaged Lines	• External damage	• Technical Analysis Inspection • Repair Determination Discussion • Customer/Dealer Discussion	**N/A**	• N/A
Unusual Noises (when traveling straight)	• Worn gears/bearings • Ring and pinion need adjustment • Dirt entry • Low fluid level	• Technical Analysis Inspection • Repair Determination Discussion • Customer/Dealer Discussion	**Fe, Cr, (Si, Al), oxidation, viscosity increase**	• Worn gears/bearings • Dirt entry • Low fluid level
Unusual Noises (when turning)	• Worn differential case assembly • Worn spider gears	• Technical Analysis Inspection • Repair Determination Discussion • Customer/Dealer Discussion	**Fe**	• Worn gears • Worn spider gears
Vibration	• Gear failure • Spider gear failure • Differential failure • Bearing failure • Bent/damaged drive shaft	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services	**Fe, Cr**	• Gear failure • Spider gear failure • Bearing failure

DIFFERENTIAL INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Debris on Magnetic Plug	• Contamination entry (dirt/debris) • Extended oil change period • Wrong oil used • Worn gears/bearings	• S·O·S Services • Customer/Dealer Discussion	**(Si, Al), Fe, Cr, oxidation, viscosity increase**	• Dirt entry • Worn gears/bearings • Extended oil change period
Leaks	• Worn/damaged seals (pinion/differential) • Worn bearings	• Repair Determination Discussion • Customer/Dealer Discussion	**(Si, Al), Cr**	• Dirt entry from seals • Worn bearings
Overheating	• Wrong oil used • Low fluid level • Worn or damaged seals	• Technical Analysis Inspection • Repair Determination Discussion • S·O·S Services • Customer/Dealer Discussion	**Oxidation increasing, (Ca, P. Zn) levels changed from trend, Water, Fe, Na, viscosity increasing**	• Wrong oil used • Low fluid level • Water entry

HYDRAULIC INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
Leaks	• System pressure too high • Scored/bent cylinder rod • Failed or incorrect seals • Improperly torqued hose connection • Worn or damaged hoses, tubes and fittings • Missing guards	• Technical Analysis Inspection II • S·O·S Services • Hose Service	**Cr, (Si, Al)**	• Scored cylinder rods • Dirt entry from wiper seals
Excessive cylinder drift	• Valve adjustment needed • Scored cylinder • Failed seal or seals • Scored valve • Contaminated oil	• Measure Drift • Technical Analysis Inspection II • S·O·S Services	**Cr, (Si, Al)**	• Scored cylinder rods • Dirt entry from wiper seals
Slow cycle times	• Engine performance • Faulty valve • Low fluid level • Worn system components • Contaminated oil	• Technical Analysis Inspection II • S·O·S Services	**Oxidation increases, (Si, Al)**	• Low fluid level • Dirt entry
Noisy operation	• Engine performance • Low fluid level • Restriction in system • Aeration • Worn system components • Faulty relief valve	• Technical Analysis Inspection I • S·O·S Services • Pump Cavitation • Loose or failed bearing	**Oxidation increases, (Cu, Cr, Fe), (Cu, Fe, Al)**	• Low fluid level • Vane pump • Piston pump

HYDRAULIC INDICATORS

PROBLEM INDICATOR	POSSIBLE CAUSES	OPTIONS	S•O•S INDICATOR	POSSIBLE CAUSES
System overheating	• Faulty oil cooler • Low fluid level • Plugged filter • Worn system components • Faulty relief valve • Wrong viscosity or contaminated oil • Restriction in system • Poor operator habits	• Technical Analysis Inspection I • S·O·S Services	**Positive coolant contamination (Na, K, Cu), (Si, Al), Oxidation increases, viscosity change from trend**	• Coolant entry from cooler core • Dirt entry • Wrong viscosity oil • Low fluid level
Loose cylinder joints	• Worn rod or cylinder eye/trunnion • Poor lubrication • Improper PM schedule	• Component Inspection/ Repair	**N/A**	• N/A
Blisters or abrasions in hose	• Pinhole leaks in liner material • Poor hose routing • External damage	• Technical Analysis Inspection I • Replace Hose	**N/A**	• N/A
Excessive hose movement	• Improper clamping or routing of hose	• Use proper clips and wire ties	**N/A**	• N/A