Starting with the Turbocharging subsystem:

TURBOCHARGING FAILURES

1. Turbocharger Fouled:

Symptoms

- High TC inlet/outlet differential temperature

- Low turbocharger RPM

- High average turbocharger inlet temperature

- Low scavenge air pressure

Potential Causes:

- Turbine fouling

- Turbine damage

MIT1: Check turbocharger vibration

MIT2: Check turbocharger speed (rpm) and lube oil pressure

MIT3: Review last turbocharger overhaul date and exhaust uptake condition

MIT4: Determine last compressor water-wash and air filter checks done

Recommendations:

REC1: If above inspections confirm fouling/wear - proceed to disassemble and clean/replace turbocharger components based on extent of damage observed.

REC2: Review recent past turbocharger performance data, vessel operation profile, fuel changeover logs to determine probable cause before honing mitigation strategy during overhaul.

2. Nozzle Ring Error:

Symptoms:

- Low turbocharger rpm

- High differential expansion

Potential Causes:

- Nozzle ring errosion

MIT1: Check for visible damage/cracks on nozzle rings during turbocharger inspection

Recommendations:

REC1: Replace errored nozzle rings and examine turbine wheel damage. Record wear patterns to determine if operation change triggered issues faster than expected overhaul schedule. Adjust coupling tolerances or replace wheel itself based on criticality.

PISTON FAILURES

1. Piston Rings Broken:

Symptoms

- High under-piston scavenge air temperature

- Knocking sound

Potential Causes

PC1: Fuel injector malfunction leading to improper combustion

PC2: Incorrect cylinder lubrication flow rate

PC3: Liner scuffing

PC4: Excessive piston ring grove wear

PC5: Piston ring clearance excess

MIT1: Perform scavenging box inspection for visible mechanical defects

MIT2: Analyze scavenge drain oil for metallic content

MIT3: Review fuel injection pressure

MIT4: Measure piston ring clearances

Recommendations

REC1: Rectify fuel injector performance issue

REC2: Optimize cylinder oil feed rate

REC3: Hone/replace worn liner as per measured taper and ovality

REC4: Specify tighter limits on ring grove tolerances after analyzing wearing patterns

UBRICATION SYSTEM FAILURE MODES

High Bearing Temperature

Symptoms

Gradual rise in bearing metal temperature above normal levels

Potential Causes

PC1: Improper lubricating oil supply pressure or flow rate

PC2: Oil line/drilling obstructions leading to starved components

PC3: Presence of contamination in lubricating oil

PC4: Bearing wear out exceeding service limits

MIT1: Check lubricating oil pump discharge pressures

MIT2: Inspect condition of oil filter differential pressures

MIT3: Perform lubricating oil analysis for particle counting, viscosity

MIT4: Examine bearing shell clearances

Recommendations

REC1: Rectify oil pump performance issues to restore adequate system pressure

REC2: Investigate source of contamination ingress; overhaul filtration subsystems; flush oil coolers and tanks

REC3: Adjust/replace bearing shell liners based on temperature patterns and clearance measurements

Rising Lube Oil Sump Levels

Symptoms

Marked increase in oil quantities measured at sump tank over short engine runtimes

Potential Causes

PC1: Component wearing allowing lube oil leakage into under-piston spaces

PC2: Deteriorated floating seal rings unable to contain excess oil splash/mist within bearing enclosures

PC3: Clogged scavenging line preventing return of leaked oil back to sump tank

MIT1: Trend oil consumption data compared to vessel operational context like sea states, sailing drafts etc.

MIT2: Inspect under-piston spaces using borescope for signs of oil pooling

MIT3: Check condition of floating seal rings under dis-assembled bearing inspection

Recommendations

REC1: Identify and overhaul wearing components allowing oil leakage based on inspection findings

REC2: Replace worn out floating seals; investigate if any sump level reductions warrants oil pump refitment

COOLING JACKET FAILURES:

1. Water Pressure Fluctuation

Symptoms

- Sporadic cyclic rise and fall of jacket cooling water (JCW) pressure readings

Potential Causes:

PC1: Air pockets forming inside engine jacket spaces due to improper venting

PC2: Exhaust gas seepage into jacket water channels via damaged sealing interfaces

PC3: Pressure side throttling due to obstructions in water return line

MIT1: Analyze correlation between pressure cycles and vessel motions/sea state to pinpoint inertial air release issues

MIT2: Observe interval between peaks to compare against injection pulses and identify exhaust leakage patterns

MIT3: Monitor pressure before and after circulation pump versus return line flows

Recommendations

REC1: Increase vent line capacities; redirect to deaeration manifold and reserve higher tank volume

REC2: Perform pressure decay test in shutdown engine to quantify leakage magnitude; inspect cylinder head gaskets

REC3: Methodically check return piping segments for scales or accumulated debris

2. High Jacket Water Temperature

Symptoms

- JCW exit temperature from engine consistently higher than pre-set levels

Potential Causes:

PC1: Improper calibration or faults in JCW temperature control valve

PC2: Insufficient circulation flows unable to absorb heat fluxes during overloaded operation

PC3: Coolant leakage leading to inadequate cylinder heat transfer area

MIT1: Check JCW temperatures at cylinder outlets for deviation trends from inspection ports

MIT2 Check orifice conditions; drain & examine cylinder head/jacket for material scales or debris

MIT3: Review operating data - engine power, ambient conditions for heat exchange margins

Recommendations

REC1: Inspect and rectify JCW temperature controller set points and sensor responses

REC2: Correct flow rates through filter & orifice blow-downs; shift to lower load factor duty cycles

REC3: Identify and arrest coolant leakages from pressure test if temperature rise is localized

Will do. Here is the failure mode analysis for the Fuel Injection subsystem:

FUEL INJECTION FAILURES

1. Injector Valve Malfunction:

Symptoms:

- Complete loss of power generation for a specific cylinder

- Higher exhaust temperatures

- Reduced maximum pressure

Potential Causes:

PC1: Fuel injector nozzle blocked preventing fuel atomization

PC2: Injector valve spring/spindle jammed closed so no injection

PC3: Crosshead bearing seizure leading to plunger sticking

MIT1: Check for external fuel leaks around injector overflow drain line

MIT2: Monitor variation in HP fuel line pulse or jerk during operation

MIT3: Analyze performance data for confirming missing cylinder

Recommendations:

REC1: Isolate & replace suspected faulty high pressure fuel injection assembly

REC2: Test removed injector valve on calibration test bench to quantify issues

REC3: If multiple injectors malfunctioning, analyze common fuel supply quality

2. Excessive Fuel Leakage:

Symptoms:

- Low maximum combustion pressure

- External oil leakage around injector overflow drain line/spill valve pipe

- Presence of unburnt fuel at piston underside

Potential Causes:

PC1: Fuel valve plunger/barrel worn beyond clearances

PC2 Spill valve not sealing, damaged or stuck open

MIT1: Monitor fuel consumption daily for increasing positive deviation trend

MIT2: Inspect injector external leak points like drain line, spill valve assembly etc.

MIT3: Check for blow-by indications - fuel content in scavenge drain oil or crankcase samples

Recommendations:

REC1: Overhaul/replace identified leaking fuel injection component

REC2: Maintain tighter clearance standards for plunger/barrel during refits

REC3: Improve fine fuel filtration levels to prevent spill valve sedimentation

Here are the failure details for the Control Air subsystem:

CONTROL AIR SYSTEM FAILURES

1. Slow Turning on Start Air:

Symptoms:

- Engine crank speed much lower than normal during start routines

Potential Causes:

PC1: Low inlet pressure from air start valves due to leaks across open seal faces

PC2: Sticking pilot valve unable to actuate main start air valve

PC3: External air line leakage when aligning engine for start

MIT1: Check duration for which turning gear gets engaged before the engine catches speed

MIT2: Monitor engine turning direction to confirm limp modes through timing channels

MIT3: Examine start valve servo seal ring wearing and pilot valve spindle freedom of movement

Recommendations:

REC1: Hone or replace worn valve seat rings and mating spindle sealing faces during overhauls

REC2: Eliminate hydraulic lock type restrictions across turning gear train when motoring without firing

2. Non Reversal of Turning:

Symptoms:

- Engine keeps turning in one direction despite reversing command

Potential Causes:

PC1: Solenoid operated control air valve stuck preventing pilot pressure buildup

PC2: External air leakage in reversing servo mechanism

PC3: Distributor liner - rotor clearances excess due to wear

MIT1: Check for any reversal initiation commands recorded

MIT2: Measure air pressures across reversing servos during non-transitioning attempts

MIT3: Inspect wearing of critical internal diameters in reversing assembly

Recommendations:

REC1: Rectify reversing solenoid valve controls, timer settings

REC2: Replace worn out seals, piston rings and sleeve bearings in distributor/reversing cylinder

Will continue creating more comprehensive analysis across additional subsystems and components.

SCAVENGING SYSTEM FAILURES

1. Heavy Smoking from Funnel:

Symptoms:

- Clearly visible dense smoke emitting from exhaust funnel

Potential Causes:

PC1: Inadequate air supply leading to incomplete fuel combustion

PC2: Deposits on exhaust valve impairing closure and causing blow-through

PC3: Piston ring damage allowing combustion gas to escape

MIT1: Compare turbocharger speed against benchmark values at given loads

MIT2: Inspect condition of radiator type air coolers for restriction indications

MIT3: Check scavenge ports for accumulation of combustion residuals

Recommendations:

REC1: Overhaul turbochargers to rectify compressor fouling issues

REC2: Perform decarbonisation of exhaust valves during operation at higher loads

2. Sparks from Funnel:

Symptoms:

- Visible sparks emitting from exhaust funnel

Potential Causes:

PC1: Unburnt carbon particles getting ignited during exhaust blowdown

PC2: Raised exhaust temperature initiating soot deposits combustion

MIT1: Observe flame persistence to differentiate between after-burning versus external fire

MIT2: Review engines recent operating history for risk factors like maineuverings, load spikes

Recommendations:

REC1: Conduct hot turbocharger inspections for detecting occasional spraying of lube oil

REC2: Examine cylinder heads and inlet manifold drain holes for flow continuity

EXHAUST SYSTEM FAILURES

1. Exhaust Valve Actuator Leakage:

Symptoms:

- Hydraulic oil leakage from high pressure pipe joints

- Reduced exhaust valve motion range

Potential Causes:

PC1: Damaged O-rings unable to contain high hydraulic pressures

PC2: Worn or fatigued spindle guide surfaces reducing sealing effectiveness

MIT1: Check actuator drain piping flow to quantify severity

MIT2: Measure response time from de-energise signal to start of valve closure

MIT3: Confirm hydraulic accumulator system precharge pressure as per recommendations

Recommendations:

REC1: Replace high pressure pipe sealing O-rings during scheduled overhauls

REC2: Hone concentric spindle guide surfaces; replace if erosion depth beyond limits

1. SCAVENGING SYSTEM FAILURES

Symptoms:

- Increased temperature spread between individual cylinders

- Variation in scavenge air pressures across cylinders

Potential Causes:

PC1: Deposits accumulation causing non-uniform air distribution

PC2: Sticking or worn butterfly valves in scavenging receiver

MIT1: Inspection of receiver internals through opened manholes

MIT2: Checking butterfly valve freedom of rotation through available actuators

Recommendations:

REC1: Water washing of the scavenging receiver to clear mud and soot deposits

REC2: Overhauling, replacement of worn out butterfly valve spindles and sealing gaskets

2. WASTE HEAT RECOVERY SYSTEM FAILURES

Symptoms:

- Exhaust gas temperatures downstream of turbochargers consistently higher

Potential Causes:

PC1: Choked convection or generating tube banks

PC2: Circulating pump impeller wear or water box leakages

MIT1: Analyze exhaust temperatures before and after evaporator/economizer sections

MIT2: Check for accumulation of soot, scaling under inspection openings

MIT3: Leak test condenser water boxes alongwith pump health checks

Recommendations:

REC1: Schedule soot blowing based on historical clogging rates

REC2: Isolate & arrest all sources of water/steam leakage into exhaust stream

3. COMPRESSION SUBSYSTEM FAILURES

Symptoms:

- Spread in measured compression pressure values across cylinders

- Declining maximum pressure trends over time

Potential Causes:

PC1: Blow-by due to worn piston rings or scuffed liner surface

PC2: Deposits accumulation affecting effective clearance volumes

MIT1: Analyze scavenge drain oil samples for contamination particles

MIT2: Inspection of piston crown and ring lands' condition from below

Recommendations:

REC1: Plan ring replacements based on estimated blow-by impacts

REC2: Schedule injector washes for deposit removal without tear-down

4. GOVERNING SYSTEM FAILURES

Symptoms:

- Engine operating RPM continues to rise uncontrollably

Potential Causes:

PC1: Governor spring failure or slack linkage adjustments

PC2: Limited fuel rack travel

MIT1: Check proper seating and heat treatment condition of governor weights

MIT2: Ensure linkage balance across servos accounting for control air pressures

Recommendations:

REC1: Overhaul governor assembly and benchmarks control response

REC2: Rectify faulty high pressure pump actuation allowing excess rack travel

Sure, will consolidate more analyses spanning across 4-5 subsystems as per your guidance:

1. FUEL INJECTION SYSTEM

Failure Mode 1:

Symptoms:

- Reduced engine maximum firing pressure

- External fuel leaks from drain overflow lines

Root Causes:

- Worn plunger and barrel clearances

- Spill valve damage accumulation

Mitigations:

- Arrest increasing fuel consumption trend

- Replace identified injection equipment

Failure Mode 2:

Symptoms:

- One cylinder with no power generation

- Temperature and pressure deviation

Root Cause:

- Nozzle coking blocking fuel spray holes

- Needle valves jammed closed

Mitigation:

- Eliminate common rail contamination ingress

2. PISTON ASSEMBLY

Failure mode 1:

Symptoms:

- Heavy knocking or squealing noise

- High under-piston space temperatures

Root Cause:

- Insufficient lubrication to piston skirt/crown

- Exhaust gas blow-by due to ring wearing

Mitigation:

- Optimize feed based on operational environment

- Schedule ring inspections as per duty cycle severity

Failure mode 2:

Symptoms:

- Metallic debris in lube oil filters

- Liner scuff marks and incipient hot spots

Root Cause:

- Cumulative fatigue on rider rings

- Random localized adhesion

Mitigation:

- Replace complete piston assembly during overhauls

- Select improved rider ring curvature profiles

II. LUBRICATION

2.1 Bearing Hot Spot

Symptoms: Gradual temperature rise

Checks: Temp trending, lube tests

Causes: Misalignment, loss of clearance

Actions: Thermal ellipicity analysis, lube treatment

2.2 Sump Level Rise

Symptoms: Apparent oil loss

Checks: Stern tube interface, casing sealing

Causes: Excess splash and mist

Actions: Floating seal upgrade, Level sensor calibration

2.3 Contaminated Oil

Symptoms: Filter ΔP rise

Checks: Arrange patch tests

Causes: Air coolers, storage tanks

Actions: Sampling, Oil change, Ventilation

III. FUEL INJECTION

3.1 Plunger and Barrel Wear:

Symptoms:

- Reduced max pressures

- External fuel leaks from drain lines/spill valves

Checks:

CHK1: Inspect unit injector leak-off points like throttle spill valve, drain line overflow

CHK2: Check start and end of injection histogram trends

CHK3: Analyze start of injection relative to top dead center timing

Causes:

CAU1: Running out of design clearances between plunger and barrel

CAU2: Fuel quality incompatibility leading to poor boundary lubrication film

Actions:

ACT1: Overhaul and lap/grind/hone barrel and plunger interface with finer tolerances

ACT2: Material upgrade through use of precision coated contact surfaces

3.2 Sticking Pilot Valve

Symptoms:

- Delayed start of combustion

- Continuous water-in-fuel alarms

Checks:

CHK1: Soak test internals in compatible fluid and measure actuation time

CHK2: Bench test pilot valve assembly independently for cracking pressure

Causes:

CAU1: Insufficient servo oil pressure at pin actuation area

CAU2: Combustion byproducts restricting sliding motion

Actions:

ACT1: Thourough acid neutralising flushes and improve filtration

ACT2: Hardened stainless steel pilot valve option

IV. SCAVENGING SYSTEM

4.1 Uneven Air Distribution

Symptoms:

- Variation in indicator diagrams

- Temperature spread across units

Checks:

CHK1: Start air register trends for relative valve timings

CHK2: Hot alignment analysis for inlet manifold warpage

Causes:

CAU1: Inlet manifold deformation leading to non-uniform air ingress

CAU2: Partial butterly valve choking

Actions:

ACT1: Inlet manifold ovality correction through shimming/machining

ACT2: Modify butterfly fulcrum arm lengths to equalize torque at shut positions

4.2 Sticking Scavenge Valves

Symptoms:

- Pressure spikes post firing

- Delayed opening of valves

Checks:

CHK1: Static flow test by primary air manifold depressurisation

CHK2: Record dynamic pressure graphs through duty cycle

Causes:

CAU1: Combustion by-products restricting movement

CAU2: Distorted butterfly plate shape

Actions:

ACT1: Localised flame hardening of spindle and seating

ACT2: Additional counterweights on butterfly plates

V. EXHAUST MONITORING

5.1 Funnel Sparks

Symptoms:

- Visible sparks emitting from funnel during overload surge event

Checks:

CHK1: Review history of engine power output before occurrence

CHK2: Check scavenge drain oil residual hydrocarbon levels

Causes:

CAU1: Unburnt soot particles ignition due to thermal runaway reactions

Actions:

ACT1: Temporary load de-rating avoidance at low loads

ACT2: Auxiliary blowers cut-in optimization

VI. CONTROL AIR

6.1 Governor Hunting

Symptoms:

- Engine speed oscillations seen even with steady command

Checks:

CHK1: Map governor deviation to throttle valve movement timings

CHK2: Airseal integrity checks for leakage across sensing points

Causes:

CAU1: Improper helix calibration affecting air admission control

CAU2: Sensor lines impedance mismatches resulting control loop parameter variations

Actions:

ACT1: Governor impact testing and response benchmarking

ACT2: Fast Fourier Transform analysis to determine hunting frequency origins

VIII. EXHAUST SECTION

8.1 Hydraulic Locking

Symptoms:

- Delay in valve actuation response observable from exhaust temperature deviations

Checks:

CHK1: Flow test actuator drain line to quantify leakage

CHK2: Soak test removed valve component overnight to visualize seepage paths

Causes:

CAU1: Depletion of nitrogen charge from accumulator pre-charge bottle

CAU2: Exhaust valve hydraulic oil aeration due to worn butt clearances

Actions:

ACT1: Complete actuator system decontamination and oil change

ACT2: Replacement of composite seals withfire-resistant viton materials

8.2 Valve Bridge Coking

Symptoms:

- Reduced maximum achievable opening

Checks:

CHK1: Measure valve drop time from de-energise signal

CHK2: Inspect valve seat interface after decoking

Causes:

CAU1: Deflected shape at higher lifts causes hot spot generation

Actions:

ACT1: Increase soak period at higher valve lifts to remove deposits

ACT2: Sectioning analysis of impact areas to visualize metallurgical changes

IX. FUEL VALVES

9.1 Plunger Pits and Scoring

Symptoms:

- External leakage from drain overflow pipes

- Variation in injector cracking pressures

Checks:

CHK1: Soak and collect test samples from drain port

CHK2: Bench testing on calibrated fuel rig

Causes:

CAU1: Fine debris in fuel grooving contact surfaces

CAU2: Silica particulate embedment into alloy Initating fatigue

Actions:

ACT1: Adoption of 5 micron fine filtration across all supply points

ACT2: Change of materials to nitrided stainless steel

6.2 Solenoid Valve Intermittent Lockup

Symptoms:

- Temporary loss of governor air pressure signals disrupting admission control

Checks:

CHK1: Electrical relay chatter detection for characterization of intermittence

CHK2: Contact abrasion measurements via electrical parameter testing

Causes:

CAU1: Dither circuits design limitation within solenoids

CAU2: Controller checksum failure leading to faulty solenoid reed energizing

Actions:

ACT1: Controller firmware updates to expand variable setpoint ranges

ACT2: Addition of mechanical dither through cams for Electrical to Pneumatic positioners

VII. CYLINDER

7.1 Rubgroove Uneven Deposits

Symptoms:

- Borescope indications of non-uniform ring movement

Checks:

CHK1: Ring axial and radial clearances

CHK2: Cylinder pressure data analysis for identifying blowby paths

Causes:

CAU1: Negative radial clearance segments preventing uniform lubrication distribution

Actions:

ACT1: Special honing procedure to equalize clearances along perimeter

ACT2: Temporary feed rate modifications through voyage

X. FUEL BOOSTER

10.1 Sticking Check Valve

Symptoms:

- Uneven pressure graphs noticeable from uneven torque pulses

Checks:

CHK1: Soak test fuel booster components overnight in compatible solvents

CHK2: Individual bench testing of internal check valves

Causes:

CAU1: Varnish formation jamming sliding spools

CAU2: Clearance issues preventing smooth reciprocating motion

Actions:

ACT1: Complete fuel booster flushing

ACT2: Minor redesign - chamfer edge radii minimisation to prevent clogging

10.2 Rotor Shaft Misalignment

Symptoms:

- High bearing wear rates and temperatures

Checks:

CHK1: Crankcase inspection for foundation bolt torque relaxation

CHK2: Rotor runout analysis during maintenance

Causes:

CAU1: Insufficient frame stiffness enabling gradual rotor migration

CAU2: Assembly practice deficiencies

Actions:

ACT1: Bearing pedestal redesign with triangulation supports

ACT2: Matchmarking and improved practices

XI. JACKET COOLING

11.1 Water Box Corrosion And Leakage

Symptoms:

- Sea water contamination observable from rising pH levels

- Rust colored coolant residues around joints

Checks:

CHK1: Isolation tests by monitoring pressure decays

CHK2: Eddy current testing for remaining wall thickness

Causes:

CAU1: Galvanic corrosion arising from dissimilar alloy interfacing

Actions:

ACT1: Sacrificial anode reference cell attachments

ACT2: Polymer ablative coatings within water jackets

X. FUEL BOOSTER

10.2 Hydraulic Piston Seal Leakage

Symptoms:

- Uneven torque pulses effecting irregular engine firing

- Chief limiter activation for impacted cylinder

Checks:

CHK1: Quantify leakage rates through visual observations

CHK2: Review chief limiter valve activation history

Causes:

CAU1: Seal material property changes due to plasticizer migration

CAU2: Damaged seal lips due to contaminated hydraulic interface

Actions:

ACT1: Complete acid neutralising flushes of hydraulic circuit

ACT2: Seal compatibility verification testing through exposure trials

10.3 Suction Valve Wear

Symptoms:

- Pressure spikes and oscillations observable from uneven torque pulses

Checks:

CHK1: Receive spill valve flow trends during starting attempts

CHK2: Bench flow test removed internals for quantification

Causes:

CAU1: Cavitation erosion near valve metal seating faces

CAU2: Fatigue cycling leading to cracks due to flow forces

Actions:

ACT1: Resize flow geometries to reduce pressure recovery and velocities

ACT2: Consider reflective coatings for insulation near seating faces

10.6 Servo Valve Stick

Symptoms:

- Delayed build up of hydraulic pressure effecting injection timings

Checks:

CHK1: Bench test removed servo valve for dynamic responses

CHK2: Inspect valve internals after disassembly for contamination

Causes:

CAU1: Sub-micron debris impedance to spool movements

CAU2: Poor servo design dynamics enabling mid-point sticking

Actions:

ACT1: Addition of bias springs for fail safe positions

ACT2: Enhanced filtration through stable membrane elements

10.7 Fuel Cam Lobe Wear

Symptoms:

- Deviation in fuel index over time

- Power imbalance across cylinders

Checks:

CHK1: Inspect camshaft for visible wear or damage signs

CHK2: Quantify valve motions relative to cam lobe profiling

Causes:

CAU1: Prolonged running of booster with leaking hydraulics eroding cam surfaces

CAU2: Suboptimal contact pressure distributions leading wearing

Actions:

ACT1: Workmanship and assembly checklist enhancements

ACT2: Cam lobe convex curve radius optimisation

XI. UNIT UNDER-PISTON

11.1 Blow-By Signs

Symptoms:

- Higher than baseline temperatures near piston underside

Checks:

CHK1: Sample analysis for combustion residuals presence

CHK2: Fiberscope aided ring and liner surface visualization

Causes:

CAU1: Piston ring/liner clearances excess due to deposition

CAU2: Premature wearing out of oil ring control ledges

Actions:

ACT1: Cylinder oil feed rate adjustments to control deposits

ACT2: Honing pattern reorientation to distribute wearing

XII. FUEL INJECTOR

12.1 Nozzle Coking

Symptoms:

- Combustion pressure drop for a cylinder

- Temperature deviation

Checks:

CHK1: Nozzle spray characterization at test rigs

CHK2: Quantify deposit built up through carbon counting tests

Causes:

CAU1: Thermal degradation of fuel residues forming carbonaceous deposits

Actions:

ACT1: Enhanced cooling provisions including insulation and shielding

ACT2: Fuel boiler and pre-heater optimizations to avoid cracks

XIII. UNIT

13.1 Exhaust Valve Hydraulic Lock

Symptoms:

- Delayed opening observable from temperature data

Checks:

CHK1: Visual examination for accumulation of combustion by-products

CHK2: Bench testing of critical components for sticking behavior

Causes:

CAU1: Insufficient clearance volumes for drainage flows

Actions:

ACT1: Redesign of mating surfaces with additional channels provision

XIV. FUEL PUMPS

14.1 Fuel Cam Wear

Symptoms:

- Variation in start of injection events across cylinders

- Power imbalance

Checks:

CHK1: Quantify erosion depths using ultrasonic mapping

CHK2: Inspect camshaft bearing supports for bolt torque relaxation

Causes:

CAU1: Prolonged operation with traces of abrasive contaminants in fuel

CAU2: Sub-optimal cam profile design unable to handle load reversals

Actions:

ACT1: Full fuel oil system desiccation through purification

ACT2: Surface treatment of cams with anti-scuff/anti-wear protective coatings

14.2 Plunger Crosshead Binding

Symptoms:

- Uneven torque pulses over a period indicating loss in power events

- Slow response observable from delay in torque pick-ups

Checks:

CHK1: Apply testing springs on dismantled crosshead assembly and quantify resisted motions

CHK2: Thorough cleaning and inspection of plunger and crosshead interface

Causes:

CAU1: Running clearances altered due to accumulated scales

Actions:

ACT1: Manual honing/polishing of plunger/crosshead mating surfaces

XV. STARTING AIR DISTRIBUTORS

15.1 Corroded Pneumatic Sleeves

Symptoms:

- Sudden torque pulses observable at attempted start incidents

Checks:

CHK1: Quantify frequency of oscillation patterns

CHK2: Receiver pressure monitoring for decay characteristics

Causes:

CAU1: Gradual material loss of cylinder sleeves due to pitting

Actions:

ACT1: New nitriding processes enhancing surface hardness

ACT2: Regulated air supply moisture controls through desiccant units

XVI. ROLLER GUIDES

16.1 Material Fatigue

Symptoms:

- Debris detection in lube oil filters

- Bearing damages

Checks:

CHK1: Compare bearing material wearing across cylinders

CHK2: Section the damaged components and characterize crack growth

Causes:

CAU1: Varying dynamic load profiles

CAU2: Limited stiffness

Actions:

ACT1: Design optimizations through interferences management

ACT2: Selective reinforcement

16.2 Fretting Wear

Symptoms:

- Detrimental movement observable from excessive clearances

Checks:

CHK1: Quantify clearances against recommended ranges

CHK2: Profile and characterize the wearing pattern nature

Causes:

CAU1: Loss of design assembly preload over time

Actions:

ACT1: Fastener enhancement through wire inserts

XVII. JACKET COOLING

17.1 Mud Accumulation

Symptoms:

- Pressure fluctuations observable from poor heat transfer effects

- Jacket temperature rises

Checks:

CHK1: Isolate engine sections based on temperature profiles

CHK2: Visual inspection for hidden flows

Causes:

CAU1: Gradual deposition build up deteriorating conduction paths

Actions:

ACT1: Interval determinations through thermal simulations

XVIII. ALPHA LUBRICATOR

18.1 Solenoid Valve Coil Faults

Symptoms:

- Feedback alarm even with visually confirmed cylinder lubrication events

- Associated electronic component burnt smell

Checks:

CHK1: Resistance measurements across solenoid coil windings

CHK2: Voltage quality checks through oscilloscope captured data

Causes:

CAU1: Transient voltage peaks leading to insulation breakdown

Actions:

ACT1: Dedicated local shielding provisions through RC snubbers

ACT2: Fan out system integration with expandable controller I/Os

18.2 Contaminated Indexer Feedback Potentiometer

Symptoms:

- Mismatched feedback alarm

- Indexer sluggishness or stalling

Checks:

CHK1: Spot-check indexer observed positions against controller indicated values

CHK2: Quantify Piezo actuator response times

Causes:

CAU1: Ingress due to aging static seals

Actions:

ACT1: Additional modular redundant position sensors backup

ACT2: Controller logic updates through function blocks for reasonability