Appendix H: Lubrication

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Appendix H: Lubrication Schedules and Specifications

H.1 Linear Motion Lubrication

H.1.1 Linear Guide Rail Lubrication

Lubricant Type: ISO VG 32 hydraulic oil (standard), NLGI Grade 2 lithium grease (enclosed environments)

Lubrication Schedule:

Operating Conditions	Interval	Method
Clean environment, light duty	Every 100 km travel or 6 months	Manual (grease nipple, 2-3 drops oil)

Operating Conditions	Interval	Method
Moderate dust, medium duty	Every 50 km travel or 3 months	Automatic single-shot lubricator
Heavy duty, high speed	Every 20 km travel or monthly	Centralized auto-lube system
Dirty environment (wood dust, coolant)	Weekly inspection, lube as needed	Manual + dust covers/bellows

Recommended Lubricants:

Brand	Product	Type	Viscosity	Applications
Mobil	DTE 24	Hydraulic Oil	ISO VG 32	General linear guides
Shell	Tellus S2 M 32	Hydraulic Oil	ISO VG 32	Standard CNC
THK	AFE-CA	Grease	NLGI #2	THK linear guides (OEM spec)
HIWIN	Lubricant A	Grease	NLGI #2	HIWIN guides (OEM spec)
Mobilith	SHC 220	Synthetic Grease	NLGI #2	High temp, long life

H.1.2 Ball Screw Lubrication

Lubricant Type: Lithium-based grease with EP (extreme pressure) additives, NLGI Grade 2

Re-greasing Procedure: 1. Clean old grease from nut exterior and screw shaft 2. Inject fresh grease via Zerk fitting (grease gun, 2-3 pumps) 3. Manually cycle axis 10-20 times (distribute grease throughout nut) 4. Wipe excess grease from shaft 5. Verify smooth motion

Lubrication Schedule:

Load Factor	Speed (RPM)	Re-grease Interval (hours)
Light (<30% C_a)	<1000	500
Light (<30% C_a)	1000-2000	300
Medium (30-60% C_a)	<1000	200
Medium (30-60% C_a)	1000-2000	100
Heavy (>60% C_a)	<1000	100
Heavy (>60% C_a)	1000-2000	50 (or oil mist system)

Oil Mist Systems (High-Speed Applications): - Minimum oil flow: 0.01-0.02 cc/min per 100mm screw length - Oil type: ISO VG 32-68 - Compressed air: 0.3-0.5 MPa (3-5 bar)

Recommended Greases:

Brand	Product	EP Rating	Temp Range (°C)	Applications
Mobilux	EP 2	High	-20 to +130	General ball screws
Shell	Gadus S2 V220	High	-30 to +120	Standard CNC
THK	AFJ-LF	Medium	-40 to +100	Low-friction, long life
Kluber	Isoflex NBU 15	Very High	-40 to +150	Heavy load, high speed

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H.2 Spindle Bearing Lubrication

H.2.1 Grease-Lubricated Spindles

Grease Type: High-speed bearing grease, NLGI Grade 1.5-2, polyurea or lithium complex base

Re-greasing Intervals (by DN factor):

DN Factor = Bearing bore diameter (mm) × RPM

DN Factor	Re-grease Interval
<300,000	Every 2000 hours or annually
300,000-500,000	Every 1000 hours or 6 months
500,000-1,000,000	Every 500 hours or 3 months
>1,000,000	Oil-mist or oil-air system required

Example: 80mm bore bearing at 10,000 RPM

$$DN = 80 \times 10,000 = 800,000$$

Re-grease every 500 hours (or consider oil-air system for extended life)

Recommended Spindle Greases:

Brand	Product	Base	Max Speed (DN)	Temp Range (°C)
Kluber	Isoflex Topas NB 52	Polyurea	1,500,000	-40 to +160
SKF	LGMT 2	Lithium	500,000	-40 to +120
Castrol	Longtime PD 2	Lithium Complex	750,000	-30 to +140
Mobil	Polyrex EM	Polyurea	1,200,000	-35 to +180

H.2.2 Oil-Mist and Oil-Air Lubrication

Oil-Mist System: - Continuous mist delivery (air + oil droplets) - Oil flow: 0.005-0.01 cc/min per bearing - Air pressure: 0.15-0.3 MPa (1.5-3 bar) - Suitable for DN <1,500,000

Oil-Air System: - Precise oil + air pulses (programmable intervals) - Oil flow: 0.01-0.05 cc/min per bearing (adjustable) - Air pressure: 0.5-0.8 MPa (5-8 bar) - Suitable for DN >1,000,000 (high-speed spindles up to 40,000 RPM)

Recommended Oils:

Brand	Product	Viscosity (ISO VG)	Max Temp (°C)	Applications
Mobil	Velocite Oil No. 6	10	80	Low-speed spindles
Shell	Morlina S1 B 10	10	90	General spindles
Kluber	Klüberoil 4 UH1-68 N	68	120	Medium/high speed
Castrol	Ilocut EDM 24	24	100	High-speed spindles (>20,000 RPM)

H.3 Rack and Pinion Lubrication

Lubricant Type: Open-gear grease (tacky, water-resistant) or spray lubricant

Lubrication Schedule:

Environment	Method	Interval
Indoor, clean	Spray (PTFE dry lube)	Weekly or 100 km travel
Outdoor, exposed	Open-gear grease	Weekly or 50 km travel
High load, continuous	Automatic spray system	Daily or per operating hour

Recommended Products:

Brand	Product	Type	Applications
Mobilgear	OGL 461	Open Gear Grease	Heavy-duty racks, outdoor
WD-40	Specialist Dry Lube	PTFE Spray	Indoor racks, low dust
Kluber	Barrierta L 55/2	Spray Grease	Precision racks, moderate load
CRC	Sta-Lube Open Gear Lube	Aerosol Grease	General racks, easy application

Application Procedure: 1. Clean rack teeth (remove old grease, chips) 2. Apply thin coat of grease to tooth faces (not roots) 3. Cycle axis to distribute lubricant 4. Wipe excess (prevents chip attraction)

H.4 Coolant and Cutting Fluid Maintenance

H.4.1 Water-Soluble Coolant (Emulsion)

Concentration: 5-10% (1:20 to 1:10 dilution) for most machining

Testing and Maintenance:

Parameter	Target Range	Test Method	Frequency
Concentration	+/-1% of target	Refractometer	Daily
pH	8.5-9.5	pH test strips	Daily
Bacteria/Fungi	<10^5 CFU/mL	Dip slide test	Weekly
Tramp oil	<5%	Visual (skim surface)	Daily

Coolant Life Extension: - Add biocide if bacteria count >10^6 CFU/mL (foul odor, skin irritation) - Skim tramp oil daily (prevents anaerobic bacteria growth) - Top-off with pre-mixed coolant (not concentrate) to maintain concentration - Full changeout every 3-6 months (or when odor/contamination cannot be controlled)

Disposal: Contact local waste management (coolant = hazardous waste in most jurisdictions)

H.4.2 Straight Cutting Oil (Mineral Oil)

Viscosity: ISO VG 15-32 for most CNC operations

Maintenance: - Filter continuously (10 micron nominal filtration) - Change when dark/cloudy (oxidation, contamination) - Typical life: 6-12 months with filtration

Fire Safety: Flashpoint >200°C typical, but hot chips can ignite oil mist. Use coolant mist collector.

H.5 Pneumatic System Maintenance

H.5.1 Compressed Air Quality (ISO 8573-1)

Particulate Class: 1-7 (Class 1 = <0.1 mum, 0.1 mg/m^3 max) **Water Content:** 1-10 (Class 4 = -40°C pressure dew point typical for CNC) **Oil Content:** 1-5 (Class 3 = 1 mg/m^3 max)

CNC Recommendation: Class 4 or better (dew point -40°C, 1 mg/m^3 oil, 5 mum particles)

H.5.2 FRL (Filter-Regulator-Lubricator) Maintenance

Filter: - Check weekly, replace element when pressure drop >0.5 bar - Drain condensate daily (automatic drain recommended)

Regulator: - Set to 6 bar (0.6 MPa) typical for CNC pneumatics - Check gauge accuracy annually

Lubricator: - Fill with ISO VG 32 pneumatic oil - Adjust drip rate: 1 drop per 1000 actuations (visible in sight glass) - Check weekly

Note: Some modern pneumatic components are pre-lubricated and do NOT require FRL lubricator (check manufacturer spec).

H.6 Way Oil (for Sliding Surfaces)

Applications: Box ways (Bridgeport-style mills), dovetail slides (older CNC)

Lubricant Type: Tacky way oil with stick-slip additives, ISO VG 68-220

Recommended Products:

Brand	Product	Viscosity (ISO VG)	Tackiness	Applications
Mobil	Vactra Oil No. 2	68	Medium	Horizontal slides
Mobil	Vactra Oil No. 4	220	High	Vertical slides, heavy load
Shell	Tonna S3 M 68	68	Medium	General ways
Castrol	Magna BD 220	220	High	Heavy machine tools

Lubrication Schedule: - Manual oiling: Before each use (few drops on ways) - One-shot system: Every 50-100 cycles (adjustable)

H.7 Grease Compatibility Chart

Mixing Incompatible Greases: Can cause separation, hardening, or loss of lubricity.

Lithium	Calcium	Aluminum	Polyurea	Silicone
OK	Caution	Caution	OK	NO
Caution	**OK**	NO	Caution	NO
Caution	NO	**OK**	NO	NO
OK	Caution	NO	**OK**	Caution
NO	NO	NO	Caution	**OK**

Legend: - **OK:** Compatible (can mix) - **Caution:** Limited compatibility (purge old grease before switching) - **NO:** Incompatible (flush completely before switching)

Recommendation: When changing grease type, purge old grease by cycling axis 50+ times with new grease, then re-grease normally.

End of Lubrication Schedules and Specifications Appendix