INSTALLATION · COMMISSIONING · MAINTENANCE MANUAL

DHX / SHX / QXX Circulating Fluidised Bed Boilers

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This manual covers the circulating fluidised bed (CFB) family DHX, SHX and QXX: steam units from 10 t/h to 75 t/h and hot water units of 29 MW and 58 MW. It sets out the site services required before delivery, the erection and commissioning sequence, operating procedure from cold and from hot standby, the maintenance schedule with numeric acceptance limits, and fault-finding. It is written for boiler operators, plant engineers and maintenance planners responsible for a CFB unit burning coal gangue, washed coal, anthracite, biomass pellets or sludge blends.

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Applies to DHX10-1.6 to SHX75-3.82; QXX29 to QXX58 **Language** English

1. Scope and model coverage

All three series share one principle: a dense bed fluidised by primary air, a fast riser, a hot cyclone returning solids through a loop seal, and a convection pass with superheater, economiser and air preheater. Fuel is crushed to 0–8 mm with no more than 30% below 2 mm, and limestone is fed for in-furnace desulphurisation at Ca/S 1.8–2.2. Steam and hot water duties share the furnace platform, so spares and practice carry across the range.

Model	Capacity	Design pressure / outlet	Fuel	Typical duty
DHX10-1.6	10 t/h (≈7 MW)	1.6 MPa, saturated 204 °C	Coal gangue, washed coal	Factory process steam, two shifts
DHX20-2.5	20 t/h (≈14 MW)	2.5 MPa, saturated 226 °C	Coal gangue, anthracite	Plant steam, daily cycling
SHX35-2.5	35 t/h (≈24.5 MW)	2.5 MPa, 226 °C or 400 °C superheat	Washed coal, biomass pellets	Process steam and small CHP
SHX45-2.5	45 t/h (≈31.5 MW)	2.5 MPa, 226 °C or 400 °C superheat	Coal gangue with sludge co-firing	Chemical and paper steam

Model	Capacity	Design pressure / outlet	Fuel	Typical duty
SHX75-3.82	75 t/h (≈52.5 MW)	3.82 MPa rated (4.2 design), 450 °C	Washed coal, anthracite	Power and CHP, base load
QXX29-1.6/130/70	29 MW (≈41 t/h steam equivalent)	1.6 MPa, 130/70 °C water	Coal gangue, biomass pellets	District heating network
QXX58-1.6/130/70	58 MW (≈83 t/h steam equivalent)	1.6 MPa, 130/70 °C water	Coal gangue, washed coal	City heating, campus ring main

Excluded: site electrical works beyond the motor terminal boxes, civil and structural steel, the chimney and flue gas plant downstream of the boiler outlet, fuel yard handling before the day silo, and water treatment. The full boiler range and the coal-fired CFB steam boiler page give the commercial data behind this manual.

2. Site and utility requirements before delivery

Confirm every item before the foundation is poured. A CFB is taller and heavier than a packaged boiler of the same output and its ducts are large, so changes after erection are expensive. Return the signed utility schedule with the foundation approval.

Item	Requirement	Tolerance / notes
Foundation and plinth	Reinforced concrete to the general arrangement loading plan	Level ±5 mm overall, ±2 mm/m locally; bolts set from a template
Tube removal and access clearance	1.5 m at the front wall, 1.0 m at the side walls	Clear to full height; no pipes inside the zone
Bed gun swing	1.2 m clear in front of the burner	For gun withdrawal and nozzle cleaning
Boiler house ventilation	6 air changes per hour minimum	Burner platform ≤40 °C in summer
Feed water	Hardness ≤0.03 mmol/L, iron ≤0.1 mg/L, pH 8.5–9.5	Dissolved oxygen ≤0.05 mg/L after deaeration
Deaerator	Required above 6 t/h evaporation	104 °C, 0.02 MPa gauge, 20 min storage at rating
Fuel	0–8 mm crushed, below 2 mm no more than 30%	LHV 12–18 MJ/kg; moisture ≤12% at the feeder
Limestone	0–1 mm, $CaCO_3$ ≥90%	Dry, free-flowing, silo with 8 h buffer at full load
Flue and chimney	Balanced draught, induced draught fan sized at 1.2× calculated flow	Chimney height set by the dispersion study

Item	Requirement	Tolerance / notes
Electrical supply	380 V, 50 Hz, three phase, neutral and earth	Voltage ±5%, frequency ±1 Hz, earth resistance ≤4 Ω
Drainage and blowdown pit	2 m^3 pit with quench connection	Discharge below 80 °C before entering the drain

Water chemistry drives tube life. Hold boiler water pH 10–12, total alkalinity within 8 mmol/L, and conductivity to 3 000 µS/cm at 2.5 MPa or 2 000 µS/cm at 3.82 MPa. Blow down from the lower drum header, recording conductivity before and after, so the cycle is set by measurement rather than habit.

Fuel varies widely across gangue, washed coal and biomass, and the bed tolerates that only while the size band holds. Fines below 2 mm burn in the riser and load the cyclone; oversize above 8 mm drains unburnt, so check the crusher screen monthly. For biomass and waste fuels, IEA ash and moisture data cross-checks supplier certificates, and the capacity and steam data pages give derating curves for high-moisture fuel.

3. Installation sequence

The sequence below assumes the foundation has cured and the boiler house roof is closed before pressure parts are set. Each step ends with a named acceptance check; do not start the next step until it is signed.

1. Unload and inspect. Check shock indicators on the drum and cyclone; record any refractory crack on the delivery note before the crane is released.
2. Set the boiler on its plinth. Align anchor bolts to the template, grout in one pour, level at ±2 mm/m and ±5 mm overall, and mark the 1.5 m front, 1.0 m side and 1.2 m gun-swing clearances.
3. Erect drum, headers and water walls. Set to drawing elevation, plumb walls to ±3 mm over full height, weld to the qualified procedure, and radiograph 10% of circumferential butt welds.
4. Fit the air distributor and bubble caps. Confirm every cap hole is clear and cap height within ±2 mm of drawing.
5. Install the loop seal and ash return leg. Check nozzle orientation and the return inlet gap before closing the access door.
6. Lay refractory to the supplier anchor layout. Keep expansion joints free of mortar and cure at 25 °C/h to 600 °C with holds.
7. Connect flue and air ducts. Set expansion joints at half cold travel, with no shear across the joint face.
8. Pipe feed water, blowdown and safety valves. Slope drains at 1:100 to the pit and support the safety valve outlet independently.

9. Install the bed gun and flame scanner. Set insertion depth to drawing, align the sight line on the flame root, and prove purge air.
10. Loop-check instruments and interlocks. Simulate each trip at the terminal, not in software, and record it on the interlock sheet.
11. Connect motors at the terminal boxes. Bump each fan for rotation, run 30 min uncoupled, and record vibration below 4.5 mm/s RMS.
12. Charge bed material and run the cold fluidisation test. Plot bed pressure drop against primary air flow and match the calculated curve within ±10%.
13. Hydrostatic test at 1.5 × design pressure for 30 min, then insulate and clad; casing surface ≤60 °C at 25 °C ambient.

Lifting and rigging

The drum and cyclone are not designed for slinging at the nozzles. Use the marked lifting lugs only, with a spreader beam, keeping the load clear of refractory-lined sections. Never lift the assembled boiler by ductwork or platform steel, and stop if wind exceeds 10 m/s at the hook.

Expansion and anchors

This is a bottom-supported boiler: the pressure parts grow upward by 60–80 mm between cold and full load. Set slides and guides so drum and downcomers move freely, leave the calculated cold gap at every restraint, and never weld platform steel to moving parts: one brace transfers expansion into the water wall and cracks the first tube weld.

The bed gun is a service item, not a permanent fixture. Keep the manufacturer's nozzle spanner and a spare swirl plate on site, and follow the start-up burner specification for oil or gas pressure at the gun.

4. Commissioning and handover

Hydrostatic test. Test at 1.5 times design pressure: 2.4 MPa for the 1.6 MPa units, 3.75 MPa for 2.5 MPa and 6.3 MPa for the 4.2 MPa design of the 3.82 MPa unit. Use water at ambient plus 5 °C and below 70 °C, fill from the bottom, vent every high point, and hold 30 min after stabilisation. Acceptance: no leak, no weeping at a welded seam, no permanent deformation. This follows GB/T 16508 and TSG G0001; third-party inspection is available on request and no other certification is implied.

Fill and vent. Fill through the economiser with the drum vents open until water runs clear, then close and bring the drum to normal level. Confirm the level responds within 30 s to a 10 mm gauge glass change before lighting the bed gun.

Bed gun set-up. Light on minimum fire with 30% primary air, then set combustion: O_2 3–5% and CO_2 11–13% at the gun outlet, CO below 50 ppm, stack 160–180 °C. Prove the scanner sees flame within 3 s and drops the gun within 1 s on simulated flame loss. Heat the bed at no more than 100 °C/h and hold at 600 °C through the refractory cure curve.

Interlock	Simulated condition	Expected result
Drum low water	Level signal at −75 mm	Fuel and secondary air trip, alarm, induced draught purge for 5 min
Drum high water	Level signal at +75 mm	Feed pump stops, alarm; fuel stays on until the level recovers
Furnace pressure high	+1.5 kPa at the furnace outlet	Induced draught fan to maximum, then master fuel trip at +2.5 kPa
Bed temperature high	Thermocouple at 1 020 °C	Coal feed stops, primary air stays on, alarm and trend capture
Primary air fan trip	Contactor opened	Master fuel trip, bed gun off, 5 min purge, no coal until air is restored
Bed gun flame failure	Scanner signal lost	Gun valve closes within 1 s, purge 30 s, alarm
Safety valve	Pressure raised to set point	Valve lifts at ≤ design pressure, accumulation ≤10%, reseats without simmer

Trial runs. Run 4 h each at 50%, 75% and 100% load, logging bed temperature, bed pressure drop, output, stack temperature and emissions every 15 min. Then run 24 h at the plant's real load, including a shift change and one soot-blowing cycle. Acceptance: bed at 850–950 °C above 40% load, steam temperature within ±10 °C of set point, efficiency 88–91% on the design fuel.

Handover documents. Supply as-built drawings, material and welding records with radiographs, refractory cure record, cold fluidisation curve, interlock test sheets, safety valve certificates, the 4 h and 24 h logs, and this manual with the serial number entered. The efficiency and fuel consumption pages give the trial run reference figures.

5. Normal operation

Cold start. Charge bed material to the drawing height, typically 450–600 mm, and run the cold fluidisation check. Start the induced draught fan, purge 5 min at 30% air, light the bed gun, and raise bed temperature at 100 °C/h to 600 °C. Start coal at 550–650 °C with the gun supporting and hold 20–30% load until the bed is stable at 850 °C. Withdraw the gun, then raise load at 5% per minute at most. A cold start takes 6–10 h.

Hot standby. Keep the bed above 700 °C on minimum coal, 30% air and the gun at low fire where ash fusion allows. Restart within 30 min by restoring air, then coal. Below 600 °C treat the unit as a cold start: never force coal into a cooling bed, because unburnt fuel accumulates and can cause a pressure excursion on re-light.

Running log. Log every two hours against these bands at steady load.

Parameter	Normal band	Action if outside
Bed temperature	850–950 °C, target 900 °C	Adjust coal or air; gun support below 800 °C
Bed pressure drop	7–10 kPa at rating, ±0.5 kPa stable	Drain or add bed material; check bubble caps
Furnace outlet pressure	−0.1 to −0.3 kPa	Tune induced draught; check for a tube leak
Superheated steam temperature	Set point ±10 °C	Attemperator or soot blowing
O_2 at economiser outlet	3–5%	Trim secondary air; check air preheater leakage
Loop seal temperature	850–950 °C, within 20 °C of bed	Check loop seal air and dipleg flow
Ash cooler outlet	Below 200 °C	Check water flow and ash discharge rate
Stack NOx / SO_2 / dust	NOx ≤50, SO_2 ≤35, dust ≤10 mg/Nm^3	Trim SNCR, limestone feed or bag cleaning

Normal shutdown. Reduce load at 5% per minute to 30%, stop coal and keep air on 5 min to burn out the bed. Stop the gun, then the primary air fan once the bed is below 400 °C. Cool at no more than 100 °C/h; never spray water on hot refractory.

Emergency shutdown. Trip on drum level below −75 mm, loss of both air fans, furnace pressure above +2.5 kPa, a confirmed tube leak, or fire in the ducting. Keep the induced draught fan on 5 min to purge, then isolate fuel, limestone and ash at the local isolator.

Lay-up over 30 days. Wet: fill with condensate or demineralised water at pH 10.5, add oxygen scavenger to 200 mg/L, circulate monthly. Dry: drain, dry with warm air, place desiccant in the drum, hold relative humidity below 30%. Seal access doors and keep rainwater out of bed and cyclone.

6. Maintenance schedule

The bed, cyclone and loop seal carry the wear. Every row has an acceptance figure; a row without a recorded value is not complete.

6.1 Daily (each shift)

Task	What to check / acceptance	Tool or reference	Who
Bed pressure profile	Five taps within ±0.5 kPa of the load baseline; no step above 1.0 kPa	Inclined manometer, log sheet	Operator
Bed temperature survey	850–950 °C; spread across the width ≤40 °C	Calibrated thermocouples	Operator

Task	What to check / acceptance	Tool or reference	Who
Furnace and cyclone draught	Furnace outlet −0.1 to −0.3 kPa; cyclone inlet within design	Panel gauge	Operator
Loop seal and return leg	850–950 °C and no more than 20 °C above bed temperature	Infrared thermometer	Operator
Drum level and blowdown	Level ±25 mm; blowdown to the conductivity target	Sight glass, conductivity meter	Operator
Limestone feed	Ca/S 1.8–2.2; SO_2 trend flat; silo above 30%	Feeder dial, analyser	Operator
Soot blowing	Convection pass ΔP stable; blow only above 60% load	Soot blower controller	Operator
Ash discharge and stack	No visible dust; ash cooler outlet below 200 °C	Visual check, infrared thermometer	Operator

6.2 Monthly

Task	What to check / acceptance	Tool or reference	Who
Cyclone and loop seal internal check	Cracks below 3 mm wide; no spall above 0.05 m^2; anchors covered	Access door, boroscope, steel rule	Mechanical fitter
Bed pressure mapping	Weekly full profile; monthly bed ΔP within ±10% of the design curve at 50, 75 and 100%	Manometer set, baseline file	Shift engineer
Air preheater leakage	O_2 rise across the preheater ≤1.5 percentage points	Portable analyser	Instrument technician
Safety valve check	Manual lifting lever free; set pressure within ±3%	Lifting gear, calibration record	Shift engineer
Feeder calibration	Coal and limestone within ±2% of set rate	Weigh scale, stopwatch	Instrument technician
Fan vibration and bearings	≤4.5 mm/s RMS; bearing temperature below 75 °C	Vibration meter, contact probe	Mechanical fitter

6.3 Quarterly / semi-annual

Task	What to check / acceptance	Tool or reference	Who
Cyclone wear survey	Refractory loss ≤5 mm since the last survey; no exposed anchors	Depth gauge, photo grid	Refractory contractor
Tube erosion shields	Shield thickness ≥70% of 6 mm, replace at 4 mm	Ultrasonic thickness gauge	Boiler inspector

Task	What to check / acceptance	Tool or reference	Who
Expansion measurement	Cold-to-hot movement within ±5 mm of calculated; slides free	Dial gauge, reference marks	Mechanical fitter
SNCR system	Nozzle spray pattern even; NSR 1.2–1.8; urea concentration 20%	Nozzle test rig, refractometer	Commissioning engineer
Refractory crack and gap survey	Cracks below 3 mm; expansion gaps clear of debris	Feeler gauge, torch	Refractory contractor
Instrument calibration	Bed thermocouples, pressure taps and O_2 analyser within ±1% of span	Calibrator, certificate	Instrument technician

6.4 Annual shutdown inspection

Task	What to check / acceptance	Tool or reference	Who
Refractory thickness survey	Grid at 500 × 500 mm; remaining ≥70% of 80 mm design, replace below 50 mm	Depth gauge, survey drawing	Refractory contractor
Tube thickness survey	Water wall and superheater at 3-year interval; retire at 80% of nominal	Ultrasonic gauge, thickness map	Boiler inspector
Cyclone and loop seal rebuild	Anchors sound, new refractory to the cure curve, gaps set cold	Supplier procedure	Refractory contractor
Safety valve overhaul	Set pressure within ±3%, accumulation ≤10%, reseat clean	Test bench, certificate	Valve technician
Air preheater cleaning and leak test	Gas-side ΔP back to design; no cross-leak above 5%	Water wash, analyser	Mechanical fitter
Fan overhaul	Bearing clearance per supplier, impeller wear ≤3 mm, alignment ≤0.05 mm	Micrometer, laser alignment	Mechanical fitter
Drum internal inspection	Separator vanes intact, no scale above 0.3 mm, chemical clean if exceeded	Boroscope, scale sample	Boiler inspector
Hydrostatic test after major repair	1.5 × design pressure, 30 min, no leak	Test pump, calibrated gauge	Shift engineer

Records

Keep log sheets, thickness maps, interlock sheets and refractory surveys for three years, and the last two annual surveys as the wear-rate baseline. Escalate any measurement moving more than twice the previous year's rate within one shift: a doubled wear rate is the earliest sign of a bed or air problem, long before a tube fails.

7. Troubleshooting

Read the bed pressure profile and temperature survey together before changing a set point.

Symptom	Likely cause	Check	Remedy
Bed temperature falls below 800 °C	Wet or low-grade fuel, excess air, limestone overfeed	Feeder rate, fuel moisture, O_2, limestone dial	Support with the bed gun, cut excess air, restore coal quality
Bed temperature above 1 000 °C	High calorific fuel, low air, low ash fusion	Fuel certificate, air/fuel ratio, bed sample	Increase air, reduce coal, drain agglomerated bed material
Bed pressure drop rises steadily	Bed inventory growth, agglomerates, slag	Pressure mapping, drained sample	Increase ash extraction, drain bed, check fuel size
Bed pressure drop collapses	Fan trip, blocked bubble caps, bed drain open	Fan current, distributor ΔP, drain valve	Restore air, re-fluidise; never feed coal to a defluidised bed
Loop seal temperature high or ash return stops	Loop seal air low or blocked, dipleg plug	Loop seal air 1.5–2% of total, dipleg ΔP	Clear the blockage, restore air, then raise load
Stack dust above 10 mg/Nm^3	Bag failure, cyclone efficiency loss	Bag ΔP, opacity, cyclone survey	Replace bags, repair cyclone refractory and dipleg seal
SO_2 above limit at normal Ca/S	Limestone quality or size, feed point blocked	$CaCO_3$ certificate, 0–1 mm screen, feeder	Raise Ca/S to 2.2, correct size, clear the feed line
Drum level falls with rising make-up	Tube leak in water wall or economiser	Furnace pressure, acoustic check, feed flow balance	Shut down, isolate, repair; do not chase the leak with make-up

8. Spare parts and service

Hold the following for the first year; double the wear items for a unit on high-ash gangue.

PRESSURE AND BED

Bubble caps (10% of total), two bed thermocouples, drum level electrode set, lower-furnace erosion shields, access door gaskets.

REFRACTORY

Two tonnes of cyclone and loop seal castable, 200 kg anchor steel, 20 m ceramic fibre blanket, curing compound.

ROTATING AND FEED

One coal feeder belt, one limestone feeder screw, fan bearing set, coupling element, one set of air preheater gaskets.

COMBUSTION AND CONTROL

One bed gun nozzle and swirl plate, flame scanner, one set of analyser filters, spare pressure transmitter.

Consumables: limestone, bed sand, urea for SNCR, soot blower lane gaskets and the specified bearing grease. Order by model, serial number and drawing number, quoting the general arrangement item position. DHX and SHX units share the burner and instrument set; refractory shapes differ between the 2.5 MPa and 3.82 MPa cyclones.

Service: remote diagnosis within one working day, site attendance within three working days in the region, and a commissioning engineer for the annual inspection. Keep the manual library copy current and run any fuel change through the fuel and air calculator before it reaches the feeder.

9. Document control

Rev	Date	Change
A	2026-11	First issue for the DHX, SHX and QXX family
B	2026-11	Added SNCR checks and the 3-year tube thickness interval
C	2026-11	Refractory acceptance criteria revised to the 70% rule

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This manual covers the family. Your unit has its own serial number, fuel analysis and drawing set, and the site-specific manual carries those figures.

Request the site-specific manual with the boiler serial number and the fuel certificate.