MECHANICAL DATASHEET – SHELL & TUBE HEAT EXCHANGER

Doc. No. **MDS-E-101**

Item No.: **E-101** Service: Closed-loop hot water cooler (hot water / cooling water)

Rev. A

TEMA size / type: **508 / 2325 – BEU**, Class R; horizontal on 2 saddles; 1 shell per unit

Date: 2026-10-18

Design code: ASME VIII Div. 1 (2025 Ed.) + TEMA Class R; ASME "U" stamp + CRN (CSA B51)

Qty: 1

Reference: TEMA specification sheet HX-2026-0101 (process & configuration data)

A. DESIGN BASIS

	Shell Side	Tube Side
Fluid / service	Cooling tower water (treated), cold	Hot water, closed loop (inhibited), hot
Design pressure, internal – kPa(g)	**1,600**	**1,600**
Design pressure, external – kPa(g)	Nil (not vacuum rated)	Nil (not vacuum rated)
MAWP, hot & corroded	Calculate and stamp (UG-98)	Calculate and stamp (UG-98)
Design temperature – °C	**150**	**150**
MDMT – °C @ kPa(g)	**–45** @ 1,600	**–45** @ 1,600
Operating pressure / temperature	500 kPa(g) / 32 → 45 °C	900 kPa(g) / 85 → 71 °C
Shop hydrotest (horizontal)	UG-99(b): 1.3 × MAWP × LSR, per side	UG-99(b): 1.3 × MAWP × LSR, per side
Corrosion allowance – mm	**3.0** (tubesheet 3.0 on shell face)	**3.0** (tubes nil; partition 3.0 each side)
Joint efficiency E (UW-12)	Seamless 1.0; Cat. B Type 1, spot RT: 0.85	Seamless 1.0; Cat. B Type 1, spot RT: 0.85
Radiography	Spot RT – UW-11(a)(5)(b), Cat. B & C	Spot RT – UW-11(a)(5)(b), Cat. B & C
PWHT (UCS-56)	Not required (P-No. 1)	Not required (P-No. 1)
Service category	Non-lethal, non-cyclic, non-sour, no H_2	Non-lethal, non-cyclic, non-sour, no H_2
Impact testing (UG-84 / UCS-66)	SA-516 Gr 70N tubesheet, girth flanges & heads and SA-333 Gr 6 / SA-350 LF2 parts: Cv at –45 °C (base metal, HAZ, weld); SA-179 tubes per UCS-66(b)(3); SA-193 B7 / SA-194 2H bolting exempt to –48 °C	
Wind / seismic / snow; TEMA class	Per applicable building code and site data; saddle and anchor-bolt design per Zick analysis. TEMA Class R (RCB clearances, tie rods, baffle thickness, tolerances)	

B. PRESSURE PARTS, INTERNALS & ATTACHMENTS (dimensions in mm)

No.	Component	Qty	Size / description	Material (ASME)	CA	E	Basis
1	Shell	1	NPS 20 seamless pipe (508 OD) × 2,250 lg; TEMA E, single shell pass	SA-333 Gr 6	3.0	1.0	UG-27
2	Shell cover (head)	1	Torispherical, L = 425 / r = 77 (inside), 40 SF; one-piece seamless	SA-516 Gr 70N	3.0	1.0	UG-32
3	Shell girth flange	1	Plate ring, loose type, raised face; bolt holes straddle vertical centreline	SA-516 Gr 70N	3.0 (bore)	—	App. 2
4	Bonnet cylinder	1	NPS 20 seamless pipe (508 OD) × 286 lg	SA-333 Gr 6	3.0	1.0	UG-27
5	Bonnet head	1	As item 2 (integral bonnet, TEMA B)	SA-516 Gr 70N	3.0	1.0	UG-32
6	Bonnet girth flange	1	As item 3	SA-516 Gr 70N	3.0 (bore)	—	App. 2
7	Stationary tubesheet	1	Gasketed both sides (U-tube); 136 × Ø22 tube holes, 2 grooves per hole; partition groove 13 wide (R13 ends)	SA-516 Gr 70N	3.0 / face	—	UHX-12; TEMA RCB-7
8	Pass partition	1	Single horizontal plate, welded in bonnet; 2 tube passes	SA-516 Gr 70N	3.0 / side	—	TEMA RCB-9.13
9	Tubes (U)	68	21.3 OD × 3.73 wall; straight 2,325 (tubesheet rear face → bend tangent); bend radii (CL) 30 / 55 / 80 / 105 for 18 / 18 / 16 / 16 tubes	SA-179	nil	—	roller-expanded, 2 grooves; TEMA RCB-2
10	Baffles, segmental	6	Single segmental, horizontal cut 35 %; 3 window-up + 3 window-down, 303 c/c alternating; stations per section D	SA-516 Gr 70	—	—	TEMA RCB-4
11	Full support plate	1	Full-circle support at 2,222 from tubesheet, trimmed top and bottom to 360 high	SA-516 Gr 70	—	—	TEMA RCB-4
12	Tie rods & spacers	—	Number and size per TEMA RCB-4.71; spacer pipe between baffles	SA-36 rods; SA-106 Gr B pipe; SA-194 2H nuts	—	—	TEMA RCB-4.7
13	Nozzle necks N1–N4	4	NPS 4 seamless pipe; projection 580 from vessel CL to flange face; set-on, full penetration	SA-333 Gr 6	3.0	1.0	UG-37 / UG-45
14	Nozzle flanges N1–N4	4	4" Class 600 WN RF, ASME B16.5	SA-350 LF2 Cl.1	—	—	B16.5
15	Couplings V1–V4	4	1" NPS Class 3000 threaded half-coupling + round-head plug, one per nozzle neck, 100 from flange face	SA-350 LF2	3.0	—	B16.11
16	Shell drain D1	1	1" NPS Class 3000 threaded full coupling + hex-head plug; shell bottom, 649 from flange face	SA-350 LF2	3.0	—	B16.11
17	Shell gasket	1	Flat ring, full raised-face width	CNAF (non-asbestos)	—	—	m = 2.0, y = 11 MPa
18	Bonnet gasket	1	Flat ring, full raised-face width, with 13 wide partition rib	CNAF (non-asbestos)	—	—	m = 2.0, y = 11 MPa
19	Girth studs & nuts	—	Double-end UNC studs with heavy hex nuts; number and size per App. 2 flange design	SA-193 B7 / SA-194 2H	—	—	App. 2
20	Saddles	2	1 fixed + 1 sliding, 120° contact with wear plate; CL height 615; 1,250 c/c; 2 anchor bolts per saddle @ 440 c/c, slotted on sliding saddle	SA-36	—	—	Zick analysis
21	Lifting lugs	3	2 on shell top (300 and 1,700 from shell flange face) + 1 on bonnet; Ø60 shackle holes	SA-516 Gr 70	—	—	ASME BTH-1
22	Nameplate bracket	1	Rolled plate bracket 200 × 150 on shell top	SS 304	—	—	UG-116
23	Grounding lug	1	On fixed saddle, Ø20 hole	SA-36	—	—	

C. NOZZLE SCHEDULE

Mark	Service	NPS	Rating / facing	Proj.	Location / station (from flange face)	Notes
N1	Tube-side inlet (hot water in)	4	Cl. 600 RF (B16.5)	580	Bonnet, top (0°), 194 from bonnet flg. face	ρV² 1,880
N2	Tube-side outlet (hot water out)	4	Cl. 600 RF (B16.5)	580	Bonnet, bottom (180°), 194 from bonnet flg. face	
N3	Shell-side inlet (CW in)	4	Cl. 600 RF (B16.5)	580	Shell, top (0°), 230 from shell flg. face	ρV² 2,040
N4	Shell-side outlet (CW out)	4	Cl. 600 RF (B16.5)	580	Shell, bottom (180°), 2,049 from shell flg. face	
V1–V4	Vent / drain / instrument	1	Cl. 3000 thd. half-cplg + plug	—	On N1–N4 necks, 100 from nozzle flange face	B16.11
D1	Shell drain	1	Cl. 3000 thd. full cplg + hex plug	—	Shell bottom (180°), 649 from shell flg. face	B16.11

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TEMA size / type: **508 / 2325 – BEU**, Class R; horizontal on 2 saddles; 1 shell per unit		Date: 2026-10-18
Design code: ASME VIII Div. 1 (2025 Ed.) + TEMA Class R; ASME "U" stamp + CRN (CSA B51)		Qty: 1
Reference: TEMA specification sheet HX-2026-0101 (process & configuration data)		Sheet 2 of 2
D. BUNDLE & INTERNALS GEOMETRY (mm)		
Shell: NPS 20 seamless pipe, **508 OD**; TEMA E, single shell pass	Bundle envelope: **446 wide × 231 high** (8 tube rows)	
Tube holes: **136 × Ø22**, 2 grooves per hole	Tube rows: **±30 / ±55 / ±80 / ±105** from the horizontal pass lane	
In-row pitch 25; row spacing 25; stagger 12.5 (30°-type staggered)	Tubes per row (inner → outer): **18 / 18 / 16 / 16** = 68 per pass	
Pass lane: 13 groove (R13 ends) in tubesheet; single horizontal partition	U-bend radii (CL): **30 / 55 / 80 / 105**; bend tangent 2,325 from TS rear face	
Baffle cut: horizontal, **35 % of ID**; baffle pitch **303 c/c** alternating	Inlet space TS → 1st baffle: 350; last baffle → support plate: 350	
Baffle stations from TS rear face, window-up: **350 / 956 / 1,563**	window-down: **653 / 1,259 / 1,866**; full support plate: **2,222**	
Bundle overall length: 2,441 from TS rear face	Tube-to-tubesheet joint: roller-expanded, 2 grooves (TEMA R)	
Shell inlet nozzle ρV^2 2,040 kg/(m·s²): no impingement plate; no seal strips	Surface: **22.1 m²** gross outside (straight 316.2 m + bends 14.1 m)	
Flow areas: tubes/pass 0.0102 m²; cross-flow 0.022 m²; window 0.039 m²	Tube-side velocity 1.0 m/s; shell cross-flow velocity 0.5 m/s	
E. OVERALL DIMENSIONS, SUPPORTS & LIFTING (mm)		
Overall length (bonnet head → shell head): **3,029**	Bonnet 514.6 (flange face → head); shell 2,478.6 (flange face → head)	
Nozzle projection: **580** from vessel CL to flange face (N1–N4)	Nozzle stations: N1/N2 194 (bonnet flg.); N3 230, N4 2,049 (shell flg.)	
Saddles: 2 off, **1,250 c/c**; fixed @ 470, sliding @ 1,720 from shell flange face	Saddle CL height **615**; 2 anchor bolts/saddle @ 440 c/c (slotted, sliding)	
Lifting lugs: shell 2 × Ø60 @ 300 & 1,700 from flg. (top); bonnet 1 × Ø60	Bundle removal clearance: 2,500 at bonnet end	
Grounding lug on fixed saddle; D1 drain @ 649; nameplate bracket on top	Heads: torispherical L425 / r77 inside, 40 SF (shell cover and bonnet head)	
F. FABRICATION, NDE & TESTING		
1. Welds: Cat. A – none (seamless pipe, one-piece heads); Cat. B – head-to-shell and flange-to-shell (shell and bonnet): full-penetration Type 1, spot RT; Cat. D – nozzles set-on, full-pen + fillet; WPS/PQR per Sec. IX.		
2. Girth flanges: loose-type plate rings welded to the pipe ends (App. 2 Fig. 2-4 sketch 1a); raised faces machined after welding; flatness/parallelism per TEMA RCB-1; bolt holes straddle vertical centreline.		
3. Tubesheet: 136 × Ø22 tube holes with 2 grooves per hole; partition groove 13 wide; tie-rod tappings per TEMA RCB-4.71; gasket faces machined; ligament efficiency per UHX.		
4. Bundle: U-bends cold formed, wall after bending per TEMA RCB-2.33; tubes roller-expanded (2–3 % wall reduction), ends flush with tubesheet face; baffles de-burred; bundle inserted horizontally.		
5. NDE: spot RT per UW-11(a)(5)(b); PT on nozzle and coupling welds; MT on lug, saddle and wear-plate welds; 100 % visual; no hardness survey (non-sour).		
6. Testing: shop hydrotest per UG-99(b) each side separately, hold ≥ 30 min, water ≥ 16 °C (UG-99(h)); tube-to-tubesheet joints examined under shell-side test; no pneumatic test.		
7. Impact tests: UG-84 Cv on SA-516 Gr 70N tubesheet, girth flanges and heads at –45 °C (base metal, HAZ, weld metal); SA-333 Gr 6 and SA-350 LF2 certified per their specifications.		
8. Documentation: MDR (Form U-1), CRN registration, NDE and hydrotest reports, EN 10204 3.1 certificates, as-built drawings, nameplate rubbing; painting per TEMA sheet; nameplate and bracket SS 304.		
G. NOTES		
1. Thermal duty 587 kW: hot water 36,000 kg/h, 85 → 71 °C (tube side, 2 passes); cooling water 38,000 kg/h, 32 → 45.3 °C (shell side, 1 pass); fouling 0.18 / 0.35 (m²·°C)/kW; required surface 19.0 m², installed 22.1 m² (16 % excess).		
2. Design pressure 1,600 kPa(g) at 150 °C on both sides; MDMT –45 °C at design pressure; shell side and tube side designed independently (no differential-pressure design); MAWP calculated and stamped.		
3. Mechanical design per ASME VIII Div. 1 (2025) and TEMA R: shell and bonnet per UG-27, heads per UG-32, girth flanges per App. 2 (loose-type plate rings, RF), tubesheet per UHX-12, nozzles per UG-37 / UG-45, saddles per Zick, lifting lugs per ASME BTH-1.		
4. Nozzle flanges ASME B16.5 Class 600 RF, all nozzles NPS 4; couplings ASME B16.11 Class 3000 threaded, NPS 1; nozzle necks seamless pipe set-on with full-penetration welds.		
5. Shell-side inlet nozzle ρV^2 2,040 kg/(m·s²): no impingement protection; no seal strips; U-bends supported by the full support plate at 2,222 from the tubesheet.		
6. Materials per ASME II-D, P-No. 1 carbon steel: SA-333 Gr 6 pipe, SA-516 Gr 70N plate (impact tested to –45 °C), SA-350 LF2 forgings, SA-179 tubes, SA-193 B7 / SA-194 2H bolting; gaskets CNAF, m = 2.0, y = 11 MPa.		
7. Tube layout and baffle geometry per section D; tubes roller-expanded into 2-groove holes, ends flush with the tubesheet face; baffle and support-plate thickness and clearances per TEMA R.		
8. Hydrotest per UG-99(b) each side separately with test water ≥ 16 °C; CRN registration per CSA B51; MDR, NDE and material certification per section F.		
9. This datasheet together with TEMA specification sheet HX-2026-0101 defines the design input for item E-101. Dimensions in mm, pressures in kPa(g), temperatures in °C.		