ATMOSPHERIC STORAGE TANK

10 m³ milk tank T-102

SS316L · vertical · shop-built

PROJECT

Example dairy plant



SAMPLE
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INSIDE DIAMETER
2,050 mm

SHELL HEIGHT
2,950 mm

CAPACITY
10.0 m³

DESIGN BASIS
API 650, 13th ed.

PROJECT	Example dairy plant
EQUIPMENT	T-102 · milk storage tank
DOCUMENT NO.	ER-U7PW-62FS · Rev A
DATE	16 November 2026

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ENGINEERING · ESTIMATING · FABRICATION DATA

ENGINEERING AND ESTIMATE REPORT

Estimate summary

10 m³ milk tank · SS316L · vertical · shop-built

Tag **T-102** · Ref ER-U7PW-62FS · Rev A · 2026-11-16

Report ER-U7PW-62FS Rev A · Rev code RV-32D7-8LXZ · Project EP-2KVS-YA3H · Check KJ59-F392

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ESTIMATED DIRECT COST, SHOP-BUILT

AUD 59,950

Material + labour (shop AUD 110/h, engineering 150/h, NDT 160/h). Excl. contingency, markup, taxes, transport and site work.

Ex-works. Transport, unloading and site installation are not included in the price.

Price excludes (enter vendor quotations): Agitator top-entry 0.75 kW, about 40 rpm, Instrument LT-1 (LT) on N5, Instrument TT-1 (TT) on N6

MAN-HOURS

320 MH

engineering, shop, testing

DURATION

7 weeks

crew of 4, single shift

DESIGN CHECKS

6 open items

26 pass, 6 open items; full list in calculation section 11

WEIGHT, EMPTY, INSTALLED

1,341 kg

fabricated 1,283 kg · hydrotest 11,380 kg

GENERATED WITH

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Rates, markup and design inputs supplied by the user.

Contents

Estimate summary

Technical summary

Material take-off

Labour man-hours

Duration estimate

Basis of estimate: assumptions

Exclusions

This report is produced by the Estineer parametric tank model. Drawings, calculations, quantities and cost are generated from the same model inputs; check them together and against the open items in the calculation report.

1 Estimate summary

COST ITEM	MH	AUD
Plates, heads and structural		14,758
Nozzles, flanges and manway		3,573
Supports, lugs and access		1,723
Agitator mounting and cooling jacket		237
Consumables, surface treatment and finishing		724
Engineering, calculations and drawings	44	6,660
Shop fabrication	222	24,470
NDT (visual, radiography, penetrant)	39	6,188
Hydrotest and dimensional inspection	14	1,585
Estimated direct cost	**320**	**59,950**
Separate: site installation (setting, levelling, connection check)	36 MH	3,987

Material cost	AUD 21,014
Labour cost	AUD 38,903
Cost per m³	AUD 5,972
Cost per kg (empty)	AUD 44.71
Shop MH per tonne	166
Weld length / deposit	66 m / 9.7 kg
Contingency, 10 % of direct cost	AUD 5,995
Markup, 15 % of cost + contingency	AUD 9,892
Rounding up to the next 50	AUD 13
Indicative price (direct cost + contingency + markup + rounding)	AUD 75,850
Design checks	6 open items

Ex-works. Transport, unloading and site installation are not included in the price.

Price excludes (enter vendor quotations): Agitator top-entry 0.75 kW, about 40 rpm, Instrument LT-1 (LT) on N5, Instrument TT-1 (TT) on N6

Labour all-in: shop AUD 110/h, engineering 150/h, NDT 160/h. Direct cost only: contingency (10 %) and markup (15 %) are added in the indicative price in the key figures. Taxes and transport are not included.

2 Technical summary

SAMPLE
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Service	Milk
Capacity (geometric)	10.0 m³
Orientation	Vertical
Inside diameter	2,050 mm
Shell height	2,950 mm
Material	SS316L (plate 316L)
Bottom / top	Conical / 2:1 ellipsoidal head
Shell / bottom / top thickness	5 / 5 / 5 mm
Design code basis	API 650 13th ed. methods (J+S) + hygienic practice
Scope of code use	Selected design methods of API 650, 13th edition (Annexes J and S); this is not a claim of full API 650 compliance. API 650 covers tanks with a uniformly supported bottom: the suspended cone bottom on legs, the formed heads and their openings are outside that scope and are designed here by the methods shown in this report, for justification and approval by the responsible engineer.
Design pressure / temperature	Atmospheric, full of liquid / 95 °C
Corrosion allowance	0 mm
Supports	4 pipe legs nps 2-1/2
Finish	Internal polish Ra ≤ 0.8 µm, pickled and passivated
Agitator	Top entry 0.75 kW, about 40 rpm, on flange A1 NPS 4 (vendor supply)

NOZZLE SCHEDULE

MARK	SERVICE	SIZE	TYPE	LOCATION
N1	Inlet	NPS 2.0	CLAMP	top
N2	Outlet	NPS 2.0	CLAMP	bottom
N3	CIP spray ball	NPS 2.0	CLAMP	top
N4	Vent	NPS 3.0	CLAMP	top
N5	Level	NPS 1.5	CLAMP	top
N6	Temperature	NPS 1.0	CLAMP	shell
N7	Sample	NPS 0.5	CLAMP	shell
M1	Manway	457 mm	MANWAY	top
A1	Agitator	NPS 4	SO	top

INSTRUMENTS

LT-1 LT on N5

TT-1 TT on N6

3 Material take-off

COMPONENT	QTY	KG	AUD	BASIS
Shell plate	4 plate	759.9	9,028	2 course(s) x 2 plate(s), t=5 mm, +8 % cutting allowance
Top head (2:1 ellipsoidal)	1 ea	192.0	3,644	2:1 ellipsoidal head, t=5 mm; bought formed; blank 2570 mm
Cone bottom plate	1 ea	136.3	1,875	15 deg slope cone, t=5 mm, rolled from flat segments, +25 % development offcut
Cone junction compression ring	1 ea	14.8	211	flat bar ring, area 261 mm2 (junction check)
Nozzle N1 Inlet	1 ea	1.3	90	NPS 2 neck 10S (wall 2.77 mm) x 200 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to confirm), SS316L (catalogue)
Nozzle N2 Outlet	1 ea	1.4	90	NPS 2 neck 10S (wall 2.77 mm) x 205 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to confirm), SS316L (catalogue)
Nozzle N3 CIP spray ball	1 ea	1.3	90	NPS 2 neck 10S (wall 2.77 mm) x 200 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to confirm), SS316L (catalogue)
Nozzle N4 Vent	1 ea	2.2	145	NPS 3 neck 10S (wall 3.05 mm) x 225 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to confirm), SS316L (catalogue)
Nozzle N5 Level	1 ea	1.1	74	NPS 1-1/2 neck 10S (wall 2.77 mm) x 200 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to confirm), SS316L (catalogue)
Nozzle N6 Temperature	1 ea	0.8	62	NPS 1 neck 10S (wall 2.77 mm) x 205 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to confirm), SS316L (catalogue)

SAMPLE
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Nozzle N7 Sample	1 ea	0.5	52	NPS 1/2 neck 10S (wall 2.11 mm) x 205 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to confirm), SS316L (catalogue)
Manway M1 Manway	1 ea	20.6	2,648	Sanitary hinged manway 457 mm, 316L (budget price, vendor quote to confirm)
Nozzle A1 Agitator	1 ea	9.5	202	NPS 4 neck 40S (wall 6.02 mm) x 225 mm + slip-on flange Class 150 RF, SS316L (catalogue)
CIP spray ball	1 ea	1.5	324	316L static spray ball (budget price, vendor quote to confirm)
Agitator mounting pad 251 OD x 10 mm	1 ea	3.1	35	ring plate under the A1 flange, SS316L (plate rate)
Agitator top-entry 0.75 kW, about 40 rpm	1 ea	57.5	vendor	supply by vendor with gear motor, shaft, impeller and seal; weight estimated: price needed
Legs	4 ea	40.9	536	4 pipe legs NPS 2-1/2 x 1175 mm (catalogue) + adjustable feet
Leg pads	4 ea	8.3	91	4 pads 300 x 173 x 5 mm, SS316L (geometry)
Leg support rings (2)	2 ea	71.9	1,028	2 rings EA 75X75X5 rolled to shell OD, at 300 mm spacing (SS316L angle, catalogue CS weight x density ratio, priced at SS316L plate rate x 1.3 (vendor quote to confirm))
Lifting lugs + pads	2 ea	6.3	69	2 lugs 120 x 180 x 10 mm, hole 40, on pads 280 x 126 x 5 mm, SS316L (geometry)
Welding consumables	1 kg	10.9	483	weld register deposit 9.66 kg x 1.02 tack/repair allowance / deposition efficiency 0.9 (purchased filler, not tank weight)
Pickling / passivation chemicals	1 m2	0.0	241	allowance
Instrument LT-1 (LT) on N5	1 ea	0.0	vendor	supply by vendor: price needed (install MH from DB)
Instrument TT-1 (TT) on N6	1 ea	0.0	vendor	supply by vendor: price needed (install MH from DB)
TOTAL		1,342	21,014	

4 Labour man-hours

ID	ACTIVITY	QTY	CREW	H / UNIT	MH
ENGINEERING					44.4
ENG	Calculation check + shop drawings + datasheet	1.0 tank	1	37.000	44.4
SHOP					222.5
CONE-B	Cone bottom: develop and cut segments	1.0 ea	2	4.050	9.7
CONE-BR	Cone bottom: roll segments (5 mm, 15 deg)	1.0 ea	2	4.050	9.7
AGI-PAD	Agitator mounting pad: mark, fit, check flange level	1.0 ea	1	2.000	2.4
LEGS	Leg fit and tack	4.0 leg	1	2.000	9.6
LRING	Roll angle rings, fit and stitch weld to shell	2.0 ring	2	4.012	19.3
LUGS	Lifting lugs and pads: fit and weld	2.0 ea	1	1.500	3.6
RECEIPT	Material receipt and handling	1.3 t	2	0.250	1.0
MARK	Plate marking	7.0 piece	1	0.133	1.3
CUT	Plate cutting (plasma)	66.4 m	1	0.033	3.2
ROLL	Shell plate rolling (5 mm, 3 passes)	4.0 plate	2	0.450	5.2
HOLES	Nozzle locate and cut opening	9.0 ea	1	0.300	3.9
FIT	Fit-up of seams	62.1 m	2	0.133	19.9
WELD	Welding: registered joints except those welded in their own activity (flanges, lugs, chairs, drain leg)	62.1 m	1	0.377	28.1

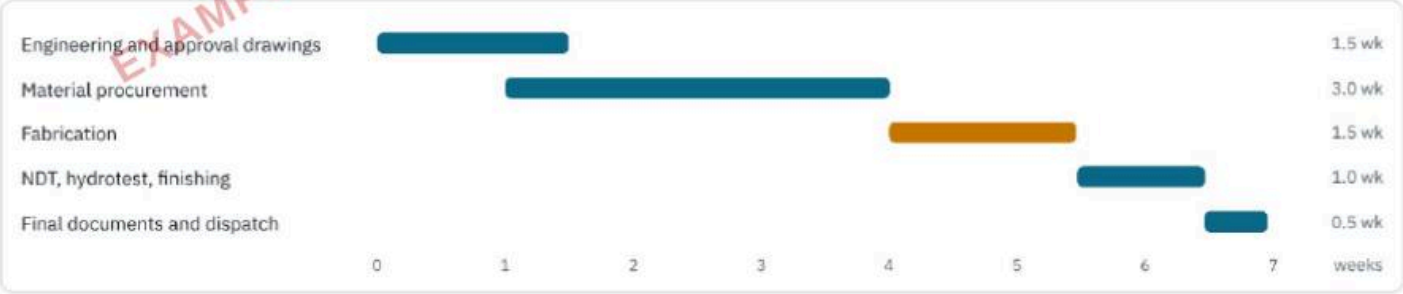
SAMPLE
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WELD-J	Extra per joint in WELD (purge, interpass)	41.0 joint	1	0.600	29.5
FLG-N1	Flange attach N1 NPS 2	1.0 ea	1	1.650	2.9
FLG-N2	Flange attach N2 NPS 2	1.0 ea	1	1.650	2.9
FLG-N3	Flange attach N3 NPS 2	1.0 ea	1	1.650	2.9
FLG-N4	Flange attach N4 NPS 3	1.0 ea	1	2.510	4.4
FLG-N5	Flange attach N5 NPS 1-1/2	1.0 ea	1	1.480	2.6
FLG-N6	Flange attach N6 NPS 1	1.0 ea	1	1.120	2.0
FLG-N7	Flange attach N7 NPS 1/2	1.0 ea	1	1.120	2.0
FLG-A1	Flange attach A1 NPS 4	1.0 ea	1	3.080	5.4
FINISH	Weld cleaning / finishing	62.1 m	1	0.033	3.7
POLISH	Internal polish (product contact)	27.2 m2	1	0.600	19.6
WPOLISH	Internal weld grind flush and polish	29.9 m	1	0.500	17.9
PICKLE	Pickling and passivation in + out	54.6 m2	1	0.150	9.8
TEST					53.1
VT	Visual weld inspection, every registered weld	66.4 m	1	0.025	2.0
RT	Spot radiography: 1 on vertical seams, 1 per 60 m of circumferential seams, 1 on cone bottom seams (every register joint marked RT; locations by the inspector; extent to be confirmed against the contract edition)	3.0 spot	1	2.370	8.5
PT	Penetrant test: every register weld marked PT (nozzle, ferrule/flange, pad, lug, agitator and dissimilar welds)	34.0 weld	1	0.690	28.2
DIM	Dimensional inspection	1.0 lot	1	4.000	4.8
HYDRO	Hydrotest (setup, fill, hold, drain)	1.0 test	2	4.004	9.6
SITE					36.2
AGI-INST	Agitator install, align shaft, first run (0.75 kW)	1.0 ea	2	2.750	6.6
SET	Offload, set and level on foundation	1.0 ea	1	21.601	25.9
INS-LT-1	Instrument LT-1 LT: install, calibrate, loop check	1.0 ea	1	1.550	1.9
INS-TT-1	Instrument TT-1 TT: install, calibrate, loop check	1.0 ea	1	1.550	1.9

MH = qty x crew x hours per unit x 1.2 allowance (set-up, handling, delays, personal time). Site work is shown separately and is not in the shop cost.

Material factor (stainless steel, database): handling x cutting x 1.2, welding x 1.46, plus 0.6 h per joint and 0.15 h per metre of seam, cleaning x 1.5. These are already inside the hours per unit of RECEIPT, MARK, CUT, ROLL, HOLES, WELD, WELD-J, FLG and FINISH.

5 Duration estimate



7 weeks from order and drawing approval, from 222 shop man-hours with a crew of 4 at 38.0 h/week. To be confirmed by the fabricator.

6 Basis of estimate: assumptions

The estimate is built from first principles: physical quantities from the tank model, times per unit of work, and the rates below. If an assumption does not hold, the estimate changes.

REF	ASSUMPTION

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QUANTITIES	
A1	Plate weights = developed area x thickness x density (7980 kg/m³), plus cutting allowance (shell +8 %, circular parts +12 %). Plate stock 1.50 x 6.0 m.
A2	Formed heads bought from a head maker; priced as blank weight x forming factor 1.6.
A3	Pipe, flanges and fittings at catalogue weights; nozzle necks per the nozzle schedule.
A4	Welding: 53 registered joints, 66 m, 9.7 kg deposited metal from joint geometry; consumables = deposit / 0.9.
LABOUR (FIRST PRINCIPLES)	
A5	Every operation = physical quantity x time per unit: marking per piece, cutting at 0.5 m/min over 66 m, shell rolling 3 passes at 2.0 m/min (more passes for thicker plate), fit-up 8 min/m with a crew of 2, weld finishing 2 min/m.
A6	Welding time = larger of deposit / 3.0 kg/h and length / 0.35 m/min of arc, divided by an operating factor 0.4 (arc-on share of the welder's hour), with position factors.
A7	Direct man-hours = productive hours x 1.2 (set-up, handling, delays, personal time).
A8	Result: shop 222 MH, testing and NDT 53 MH, engineering and drawings 44 MH.
A9	All-in labour rates (wages, employer costs, supervision, shop overheads, small tools; no markup): shop AUD 110/h, engineering AUD 150/h, NDT AUD 160/h. Hydrotest, dimensional inspection and site work at the shop rate.
A10	Contingency 10 % of direct cost and markup 15 % on cost plus contingency are entered by the user and applied only to the indicative price.
A11	Single shift, 38.0 h/week, crew of 4; no overtime or acceleration.
DESIGN AND TESTING	
A12	Design data as listed in section 2; code basis API 650 13th ed. methods (J+S) (Selected design methods of API 650, 13th edition (Annexes J and S); this is not a claim of full API 650 compliance. API 650 covers tanks with a uniformly supported bottom: the suspended cone bottom on legs, the formed heads and their openings are outside that scope and are designed here by the methods shown in this report, for justification and approval by the responsible engineer.); indoor installation, no wind load; roof live load 1.0 kPa; no seismic, snow or external pressure.
A13	Hydrotest full of water supplied by the shop, fill rate 20 m³/h, hold 4 h, water to drain.
A14	NDT: VT 100 %, RT spot per weld schedule, PT on stainless welds.
A15	Design, drawings and calculations are issued for review; one review cycle is included in engineering hours.
SHOP AND COMMERCIAL	
A16	Shop is covered, with plate rolls for 5 mm, plasma or flame cutting, and a crane of at least 2.0 t (fabricated weight 1,283 kg x 1.25).
A17	Plate prices at November 2026 supplier levels, excluding GST: SS316L plate AUD 11.00/kg; other material prices from the Estineer database at 2026 levels.
A18	Vendor items without a price in the database are listed under exclusions.

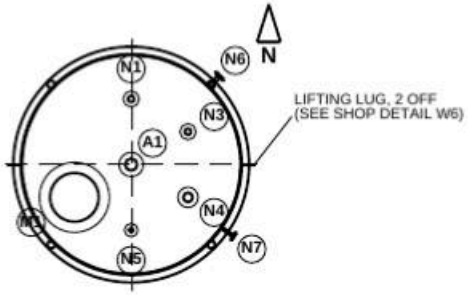
7 Exclusions

REF	NOT INCLUDED IN THIS ESTIMATE
X1	Foundation, civil works and anchor bolts setting
X2	Transport, unloading and erection (site installation shown separately)
X3	External piping, valves and electrical/instrument cabling
X4	Taxes, duties and third-party inspection fees
X5	Seismic design (site data not provided)
X6	Agitator top-entry 0.75 kW, about 40 rpm: priced at vendor quotation (not included in the price)
X7	Instrument LT-1 (LT) on N5: priced at vendor quotation (not included in the price)
X8	Instrument TT-1 (TT) on N6: priced at vendor quotation (not included in the price)
X9	Installation and alignment of the vendor's agitator at site (shown separately as site work, not in the price)
X10	Agitator supply, motor starter and electrical connection

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X11	Escalation and financing costs (contingency and markup are shown separately, on top of the direct cost)
X12	Overtime, double shift or schedule acceleration
X13	Design changes after drawing approval
X14	Third-party inspection, PMI and ferrite testing unless listed above
X15	Internal lining or special coatings unless listed above
X16	Engineer of record stamp or local authority approval
X17	Spare parts, special tools and commissioning
X18	Storage after completion
X19	Exchange-rate changes

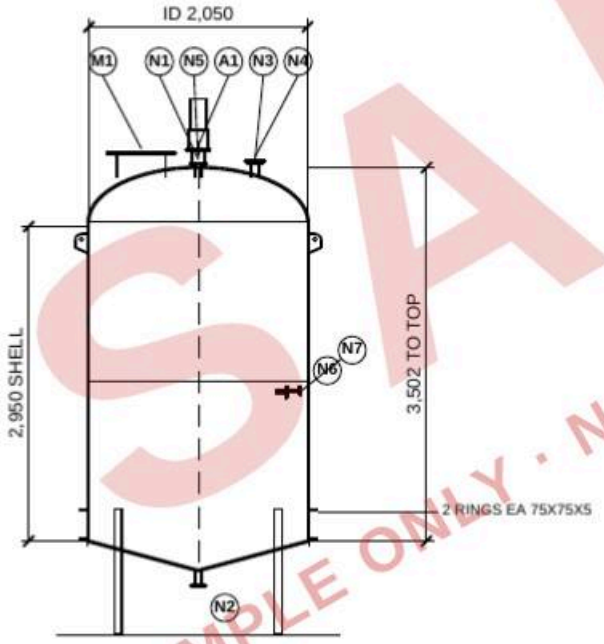
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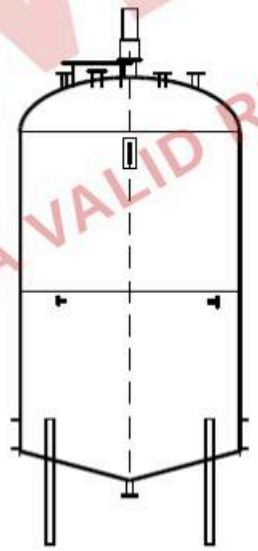
PLAN SCALE 1:71



ISOMETRIC VIEW (NOT TO SCALE)



FRONT ELEVATION SCALE 1:71



RIGHT SIDE VIEW SCALE 1:71

NOZZLE SCHEDULE

MARK	SERVICE	SIZE	TYPE	RATING	LOCATION	PROJ.
N1	Inlet	NPS 2	CLAMP	NOTE 5	TOP 0°	150
N2	Outlet	NPS 2	CLAMP	NOTE 5	BOTTOM	150
N3	CIP spray ball	NPS 2	CLAMP	NOTE 5	TOP 60°	150
N4	Vent	NPS 3	CLAMP	NOTE 5	TOP 120°	175
N5	Level	NPS 1.5	CLAMP	NOTE 5	TOP 180°	150
N6	Temperature	NPS 1	CLAMP	NOTE 5	SHELL 45°	150
N7	Sample	NPS 0.5	CLAMP	NOTE 5	SHELL 125°	150
M1	Manway	457 mm	MANWAY	-	TOP 240°	250
A1	Agitator (ON PAD)	NPS 4	SO	CL150	TOP 0°	175

DESIGN DATA

SERVICE	MILK
VOLUME TO SHELL TOP	10.0 m3
WORKING VOLUME	9.5 m3 (95 % FILL)
DESIGN BASIS	API 650 13TH ED. METHODS (J+S)
MATERIAL	SS316L
DESIGN PRESSURE	ATMOSPHERIC, FULL OF LIQUID
DESIGN TEMPERATURE	95 °C
LIQUID DENSITY	1030 kg/m3
CORROSION ALLOWANCE	0 mm
SHELL THICKNESS	5 mm
WEIGHT FAB / EMPTY / TEST	1,283 / 1,341 / 11,380 kg
HYDROTEST	FULL OF WATER, 4 h HOLD
FINISH	POLISH Ra<=0.8 um, PICKLE, PASSIVATE
INSULATION	NONE

NOTES

1. ALL DIMENSIONS IN mm UNLESS NOTED.
2. NOZZLE ANGLES CLOCKWISE FROM NORTH (PLAN).
3. PROJECTIONS FROM SHELL / HEAD OUTSIDE TO FLANGE FACE.
4. WELD DETAILS AND CUTTING LIST: SEPARATE SHEETS.
5. CLAMP NOZZLES: SANITARY WELD FERRULE + CLAMP + GASKET TO DIN 32676 / ISO 2852 (CLIENT TO CONFIRM). PRESSURE RATING BY THE FITTING VENDOR.
6. A1: TOP-ENTRY AGITATOR 0.75 kW, VENDOR SUPPLY; FLANGE NPS 4, ON PAD 251 OD x 10 mm.

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FOR REVIEW

GENERAL ARRANGEMENT

TANK T-102 10 m3 SS316L VERTICAL

DRAWING No.	REV	SCALE	SHEET	SIZE
ESTN-T-102-01	A	1:71	1 OF 2	A4

DRAWN	CHECKED	APPROVED	DATE
ESTINEER SOFTWARE			2026-11-16

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NOZZLE SCHEDULE

MARK	SERVICE	SIZE	TYPE	RATING	LOCATION	PROJ.
N1	Inlet	NPS 2	CLAMP	NOTE 5	TOP 0°	150
N2	Outlet	NPS 2	CLAMP	NOTE 5	BOTTOM	150
N3	CIP spray ball	NPS 2	CLAMP	NOTE 5	TOP 60°	150
N4	Vent	NPS 3	CLAMP	NOTE 5	TOP 120°	175
N5	Level	NPS 1.5	CLAMP	NOTE 5	TOP 180°	150
N6	Temperature	NPS 1	CLAMP	NOTE 5	SHELL 45°	150
N7	Sample	NPS 0.5	CLAMP	NOTE 5	SHELL 125°	150
M1	Manway	457 mm	MANWAY	-	TOP 240°	250
A1	Agitator (ON PAD)	NPS 4	SO	CL150	TOP 0°	175

DESIGN DATA

SERVICE	MILK
VOLUME TO SHELL TOP	10.0 m3
WORKING VOLUME	9.5 m3 (95 % FILL)
DESIGN BASIS	API 650 13TH ED. METHODS (J+S)
MATERIAL	SS316L
DESIGN PRESSURE	ATMOSPHERIC, FULL OF LIQUID
DESIGN TEMPERATURE	95 °C
LIQUID DENSITY	1030 kg/m3
CORROSION ALLOWANCE	0 mm
SHELL THICKNESS	5 mm
WEIGHT FAB / EMPTY / TEST	1,283 / 1,341 / 11,380 kg
HYDROTEST	FULL OF WATER, 4 h HOLD
FINISH	POLISH Ra<=0.8 um, PICKLE, PASSIVATE
INSULATION	NONE

NOTES

1. ALL DIMENSIONS IN mm UNLESS NOTED.
2. NOZZLE ANGLES CLOCKWISE FROM NORTH (PLAN).
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6. A1: TOP-ENTRY AGITATOR 0.75 kW, VENDOR SUPPLY; FLANGE NPS 4, ON PAD 251 OD x 10 mm.

SAMPLE
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GENERAL ARRANGEMENT: SCHEDULES

NOZZLE SCHEDULE, DESIGN DATA AND NOTES

TANK T-102 10.0 m3 SS316L

DWG ESTN-T-102-01-2 REV A 2026-11-16

SCALE NTS

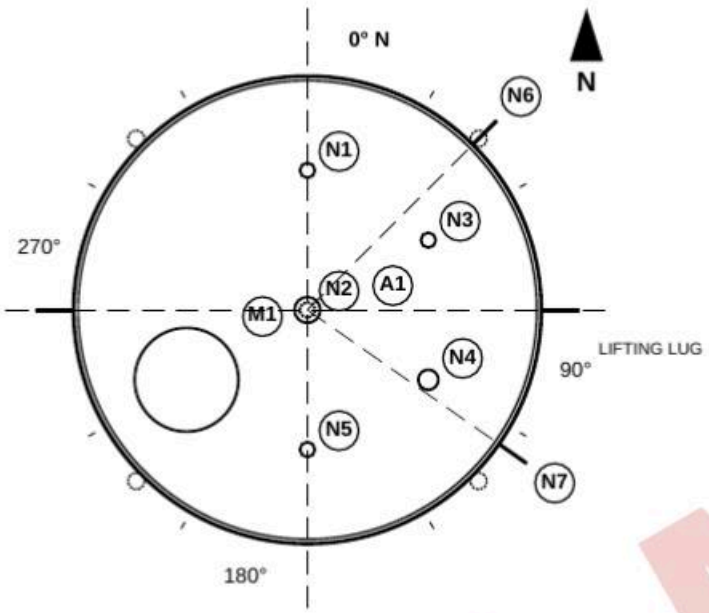
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SHEET 2 OF 2

FOR REVIEW

ORIENTATION PLAN (VIEW FROM ABOVE)

ROOF OPENINGS SOLID, BOTTOM OPENINGS DASHED



DEVELOPED SHELL (VIEW FROM OUTSIDE)



NOZZLE SCHEDULE

TAG	SERVICE	SIZE	CONNECTION	RATING	LOCATION	ANGLE	POSITION	PROJECTION	NECK / PAD
N1	Inlet	NPS 2.0	CLAMP	150	ROOF	0°	R 615 from centre	150	10S / 2.77 mm
N2	Outlet	NPS 2.0	CLAMP	150	BOTTOM	0°	centre	150	10S / 2.77 mm
N3	CIP spray ball	NPS 2.0	CLAMP	150	ROOF	60°	R 615 from centre	150	10S / 2.77 mm
N4	Vent	NPS 3.0	CLAMP	150	ROOF	120°	R 615 from centre	175	10S / 3.05 mm
N5	Level	NPS 1.5	CLAMP	150	ROOF	180°	R 615 from centre	150	10S / 2.77 mm
N6	Temperature	NPS 1.0	CLAMP	150	SHELL	45°	EL 1,400 above bottom	150	10S / 2.77 mm
N7	Sample	NPS 0.5	CLAMP	150	SHELL	125°	EL 1,410 above bottom	150	10S / 2.11 mm
M1	Manway	457 mm	MANWAY	150	ROOF	240°	R 615 from centre	250	vendor collar t5
A1	Agitator	NPS 4	SO FLG	150	ROOF	0°	R 0 from centre	175	40S / 6.02 mm

ESTINEER

NOZZLE ORIENTATION

ORIENTATION PLAN, DEVELOPED SHELL AND NOZZLE SCHEDULE

TANK T-102 10.0 m3 SS316L

DWG ESTN-T-102-NO REV A 2026-11-16

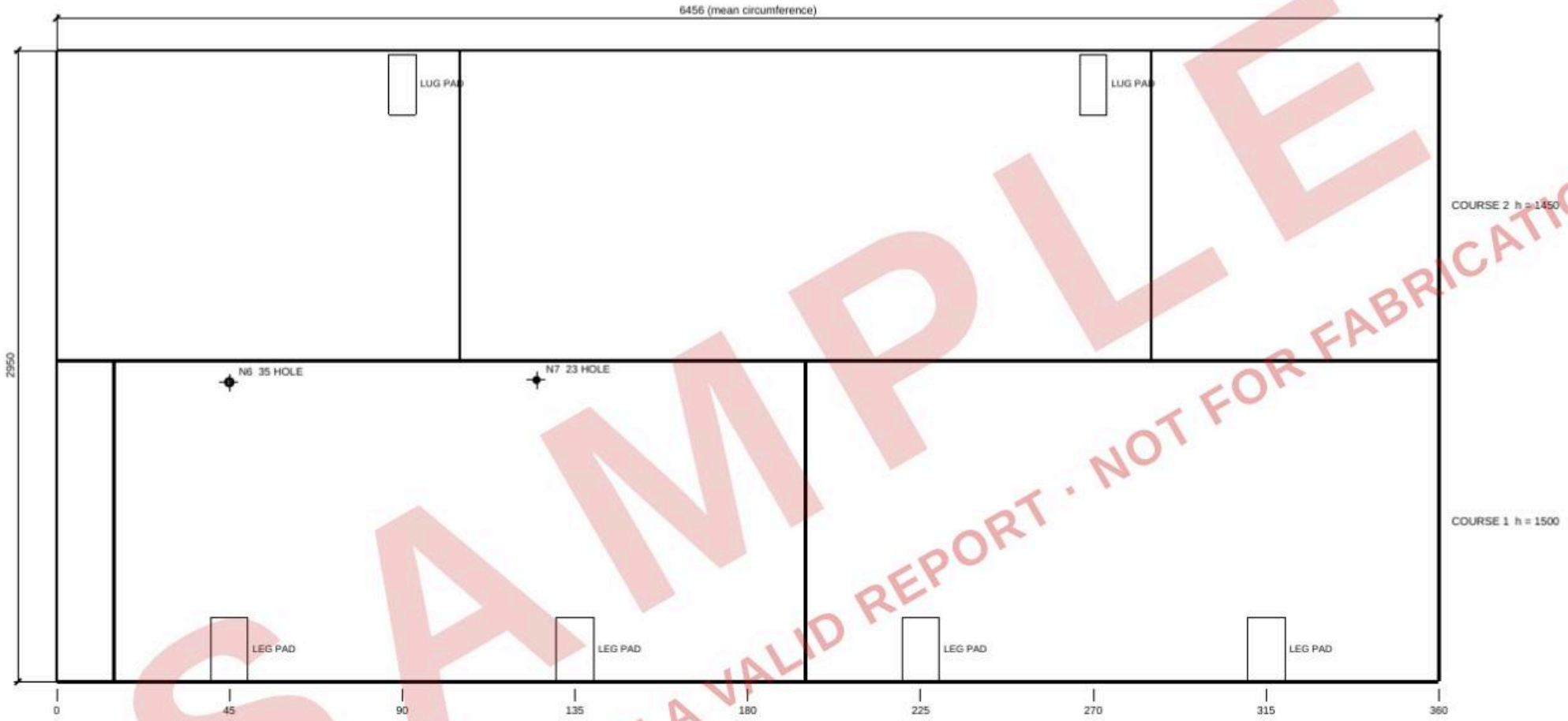
SCALE NTS

SIZE A4

SHEET 1 OF 1

FOR REVIEW

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION



DEVELOPED LENGTH (ANGLE CLOCKWISE FROM NORTH, VIEWED FROM OUTSIDE)

PLATE STOCK BASIS 1500 x 6000 mm; LONGITUDINAL SEAMS STAGGERED BETWEEN COURSES

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

ESTINEER	**SHELL DEVELOPMENT** DEVELOPED SHELL, COURSES AND OPENINGS TANK T-102 10.0 m3 SS316L DWG ESTN-T-102-S01 REV A 2026-11-16	SCALE 1:28 SIZE A4	SHEET **1 OF 8** **FOR REVIEW**

CUTTING AND MATERIAL LIST

MARK	DESCRIPTION	t	LENGTH	WIDTH	QTY	kg	CLASS	REMARK
S1-1	Shell plate	5	3228	1500	1	193.2	CUT	Roll to ID 2050
S1-2	Shell plate	5	3228	1500	1	193.2	CUT	Roll to ID 2050
S2-1	Shell plate	5	3228	1450	1	186.8	CUT	Roll to ID 2050
S2-2	Shell plate	5	3228	1450	1	186.8	CUT	Roll to ID 2050
-	Top head (2:1 ellipsoidal)	-	-	-	1	192.0	CUT	2:1 ellipsoidal head, t=5 mm; bought formed; blank 2570 mm
-	Cone bottom plate	-	-	-	1	136.3	CUT	15 deg slope cone, t=5 mm, rolled from flat segments, +25 % development offcut
-	Cone junction compression ring	-	-	-	1	14.8	CUT	flat bar ring, area 261 mm2 (junction check)
-	Nozzle N1 Inlet	-	-	-	1	1.3	BUY	NPS 2 neck 10S (wall 2.77 mm) x 200 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to…
-	Nozzle N2 Outlet	-	-	-	1	1.4	BUY	NPS 2 neck 10S (wall 2.77 mm) x 205 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to…
-	Nozzle N3 CIP spray ball	-	-	-	1	1.3	BUY	NPS 2 neck 10S (wall 2.77 mm) x 200 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to…
-	Nozzle N4 Vent	-	-	-	1	2.2	BUY	NPS 3 neck 10S (wall 3.05 mm) x 225 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to…
-	Nozzle N5 Level	-	-	-	1	1.1	BUY	NPS 1-1/2 neck 10S (wall 2.77 mm) x 200 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to…
-	Nozzle N6 Temperature	-	-	-	1	0.8	BUY	NPS 1 neck 10S (wall 2.77 mm) x 205 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to…
-	Nozzle N7 Sample	-	-	-	1	0.5	BUY	NPS 1/2 neck 10S (wall 2.11 mm) x 205 mm + sanitary clamp set: weld ferrule, clamp, EPDM gasket, blank cap (budget price, vendor quote to…
-	Manway M1 Manway	-	-	-	1	20.6	BUY	Sanitary hinged manway 457 mm, 316L (budget price, vendor quote to confirm)
-	Nozzle A1 Agitator	-	-	-	1	9.5	BUY	NPS 4 neck 40S (wall 6.02 mm) x 225 mm + slip-on flange Class 150 RF, SS316L (catalogue)
-	CIP spray ball	-	-	-	1	1.5	BUY	316L static spray ball (budget price, vendor quote to confirm)
-	Agitator mounting pad 251 OD x 10 mm	10	OD 251	-	1	3.1	CUT	ring plate under the A1 flange, SS316L (plate rate)
-	Agitator top-entry 0.75 kW, about 40 rpm	-	-	-	1	57.5	SITE	supply by vendor with gear motor, shaft, impeller and seal; weight estimated: price needed
-	Legs	-	-	-	4	40.9	BUY	4 pipe legs NPS 2-1/2 x 1175 mm (catalogue) + adjustable feet
-	Leg pads	5	300	173	4	8.3	CUT	4 pads 300 x 173 x 5 mm, SS316L (geometry)
-	Leg support rings (2)	L	6707	75X75X5	2	71.9	CUT	2 rings EA 75X75X5 rolled to shell OD, at 300 mm spacing (SS316L angle, catalogue CS weight x density ratio, priced at SS316L plate rate x 1.3…
-	Lifting lugs + pads	10/5	180/280	120/126	2	6.3	CUT	2 lugs 120 x 180 x 10 mm, hole 40, on pads 280 x 126 x 5 mm, SS316L (geometry)
-	Deposited weld metal (weld register)	-	-	-	1	9.7	WELD	per weld schedule

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

ESTINEER

CUTTING AND MATERIAL LIST

TOTAL FABRICATED WEIGHT 1,283 KG (EXCL. CONSUMABLES)

TANK T-102 10.0 m3 SS316L

DWG ESTN-T-102-S02 REV A 2026-11-16

SCALE NTS

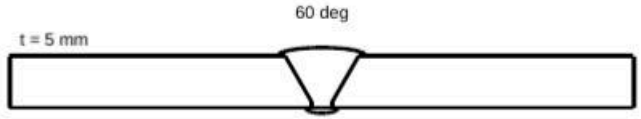
SIZE A4

SHEET **2 OF 8**

FOR REVIEW

DETAIL W1 SHELL LONG + CIRC SEAMS

NTS



FULL PENETRATION BUTT WELD (API 650 J.3.1.2)

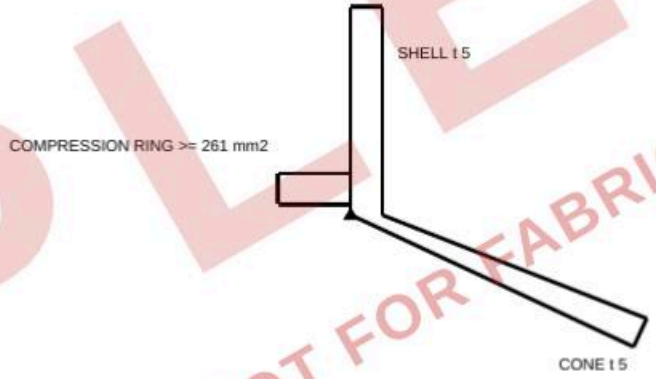
SINGLE-V 60 deg, ROOT FACE 1-1.5, GAP 2-3, BACK GOUGE + BACK WELD

INSIDE: GRIND FLUSH AND POLISH Ra <= 0.8 um

GTAW ER316L (argon back purge)

DETAIL W2 CONE BOTTOM TO SHELL

NTS



FULL PENETRATION BUTT WELD, CONE SLOPE 15 deg TO DRAIN

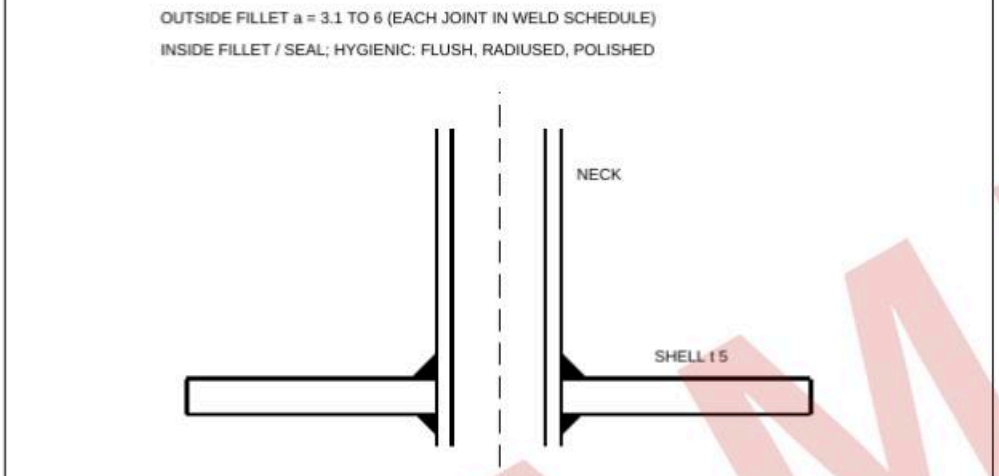
GTAW ER316L (argon back purge)

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

ESTINEER	**WELD DETAILS W1, W2** TYPICAL WELD DETAILS, NOT TO SCALE TANK T-102 10.0 m3 SS316L DWG ESTN-T-102-S03 REV A 2026-11-16	SCALE NTS SIZE A4	SHEET **3 OF 8** **FOR REVIEW**

DETAIL W3 NOZZLE NECK TO SHELL / HEAD

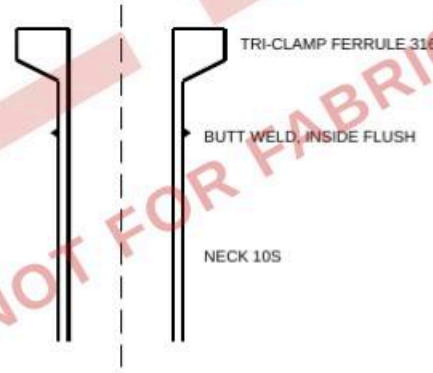
NTS



SET-IN NECK, FULL PENETRATION OR FILLET PER SCHEDULE

DETAIL W4 SANITARY CLAMP FERRULE

NTS



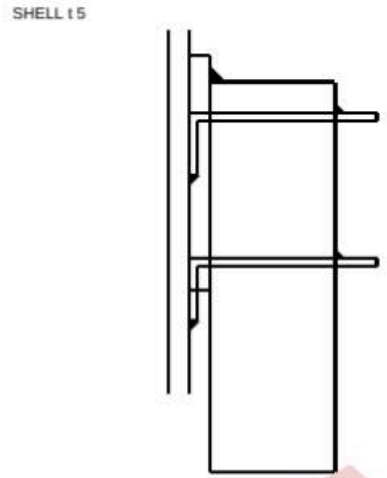
ORBITAL / GTAW BUTT WELD, ARGON PURGE

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

ESTINEER	**WELD DETAILS W3, W4** TYPICAL WELD DETAILS, NOT TO SCALE TANK T-102 10.0 m3 SS316L DWG ESTN-T-102-S04 REV A 2026-11-16	SCALE NTS SIZE A4	SHEET **4 OF 8** **FOR REVIEW**

DETAIL W5 LEG TO SHELL

NTS



PAD 300x173x5 SS316L, R25

PAD-SHELL: FILLET 5 ALL ROUND, SEALED

LEG: PIPE NPS 2-1/2

LEG-PAD: FILLET 5, 2 SIDES + END

2 RINGS EA 75X75X5 SS316L @ 300

RING-SHELL: FILLET 5, 50 @ 150 EACH SIDE

LEG-RING: FILLET 5 BOTH SIDES

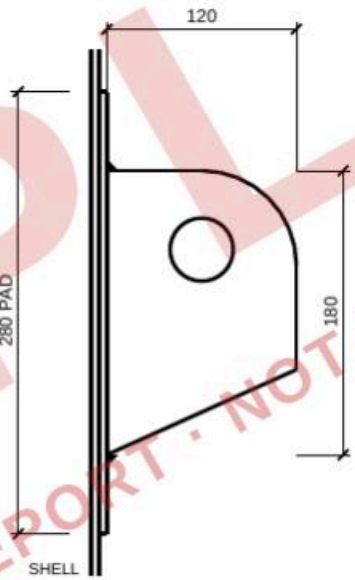
RING COPED ROUND LEG (CALC SEC. 7)

CLEARANCE UNDER TANK 600 mm

4 PIPE LEGS NPS 2-1/2 + ADJUSTABLE FOOT

DETAIL W6 LIFTING LUG

NTS



LUG 120 x 180 x 10, HOLE DIA 40

HOLE CENTRE 50 FROM LUG TOP EDGE

PAD 280 x 126 x 5, SS316L

LUG TO PAD: FILLET 8 BOTH SIDES

PAD TO SHELL: FILLET 5 ALL ROUND

PT OF LUG WELDS BEFORE FIRST LIFT

DRAWN IN TRUE PROPORTION

2 LUGS AT 180 deg, SS316L PLATE 120 x 180 x 10, HOLE 40 (CALC SECTION 8)

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

ESTINEER	**WELD DETAILS W5, W6** TYPICAL WELD DETAILS, NOT TO SCALE TANK T-102 10.0 m3 SS316L DWG ESTN-T-102-S05 REV A 2026-11-16	SCALE NTS SIZE A4	SHEET **5 OF 8** **FOR REVIEW**

1. WELDING: GTAW ER316L (argon back purge); WPS/PQR AND WELDERS QUALIFIED TO ASME IX.
2. ALL SHELL AND HEAD SEAMS FULL PENETRATION. NO WELD ON A SEAM CROSSING WITHOUT GRINDING FLUSH.
3. OPENINGS KEPT CLEAR OF SEAMS (API 650 5.7.3 PRACTICE; SEE GA / DEVELOPMENT).
4. NDT PER WELD SCHEDULE. HYDROTEST FULL OF WATER 4 h AFTER ALL WELDING.
5. HYGIENIC: PRODUCT-CONTACT WELDS GROUND FLUSH, POLISHED Ra <= 0.8 um, PICKLED AND PASSIVATED.
6. DIMENSIONS IN mm. TOLERANCES: SHELL ROUNDNESS +/- 0.5 % D, NOZZLE POSITION +/- 3 mm, ORIENTATION +/- 1 deg.
7. AGITATOR / NON-SANITARY NOZZLE SLIP-ON FLANGES (ASME B16.5 CL 150): FILLET INSIDE AT FACE (SET BACK t + 3) AND HUB FILLET 1.4 t OUTSIDE (NOT W4).

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

ESTINEER	**WELDING NOTES** GENERAL NOTES FOR ALL WELD DETAILS TANK T-102 10.0 m3 SS316L DWG ESTN-T-102-S06 REV A 2026-11-16	SCALE NTS SIZE A4	SHEET **6 OF 8** **FOR REVIEW**

WELD SCHEDULE

JOINT	DESCRIPTION	TYPE	SIZE	L m	DETAIL	NDT
L11,L12,L21,L22	Shell long seam	BUTT	5	5.90	W1	VT 100 % + RT spot, inside ground flush
C1	Shell circ seam 1	BUTT	5	6.44	W1	VT 100 % + RT spot, inside ground flush
H-Top	Top head to shell	BUTT	5	6.44	W2	VT 100 %, ground flush inside
CB1,CB2	Cone bottom radial seam	BUTT	5	2.12	W1	VT 100 % + RT spot, inside ground flush
H-Bot	Cone bottom to shell	BUTT	5	6.44	W2	VT 100 % + RT spot, inside ground flush
CR	Compression ring to junction	FILLET	a5	12.88	W2	VT
N1 to N3,N5 to N7 -sh	Nozzles: neck to parent, outside	FILLET	a4	0.89	W3	VT + PT
N1 to N3,N5 to N7 -in	Nozzles: neck to parent, inside (ground flush, polished)	FILLET	a3	0.79	W3	VT + PT
N1 to N3,N5,N6 -fl	Nozzles: ferrule to neck (orbital butt)	BUTT	2.77	0.82	W4	VT + PT
N4-sh	N4 neck to parent, outside	FILLET	a5	0.28	W3	VT + PT
N4,A1 -in	Nozzles: neck to parent, inside (ground flush, polished)	FILLET	a4	0.58	W3	VT + PT
N4-fl	N4 ferrule to neck (orbital butt)	BUTT	3.05	0.28	W4	VT + PT
N7-fl	N7 ferrule to neck (orbital butt)	BUTT	2.11	0.07	W4	VT + PT
M1,A1 -sh	Nozzles: neck to parent	FILLET	a6	1.80	W3	VT + PT
A1-fl	A1 slip-on flange to neck (2 fillets)	FILLET	a8	0.72	NOTE 7	VT + PT
A1-pad	Agitator pad outer fillet	FILLET	a7	0.79	W3	VT + PT
LEG1 to LEG4	Leg to pad (2 vertical fillets + end)	FILLET	a5	2.86	W5	VT
LEGP1 to LEGP4	Leg pad to shell (all round)	FILLET	a5	3.78	W5	VT + PT
LR	Leg rings to shell (stitch 50 long at 150 pitch, each side)	FILLET	a5	8.94	W5	VT
LEGR1 to LEGR4	Leg to rings (2 rings, fillets both sides across the ring outstand)	FILLET	a5	1.20	W5	VT
LUG1,LUG2	Lifting lug 1 to pad (2 fillets a8)	FILLET	a8	0.72	W6	VT + PT (before first lift)
LUGP1,LUGP2	Lifting lug pad 1 to shell (all round)	FILLET	a5	1.62	W6	VT + PT (before first lift)

TOTAL WELD LENGTH 66.4 m | DEPOSIT 9.7 kg

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

ESTINEER	**WELD SCHEDULE** JOINTS, PROCESS, NDT AND DEPOSIT TANK T-102 10.0 m3 SS316L DWG ESTN-T-102-S07 REV A 2026-11-16	SCALE NTS SIZE A4	SHEET **7 OF 8** **FOR REVIEW**

NOZZLE DETAIL SCHEDULE

MARK	SIZE	NECK OD x t	FLANGE / END	PAD t	LOC	ORIENT	POSITION	PROJ
N1	NPS 2	60.3 x 2.77	SANITARY CLAMP FERRULE (VENDOR)	-	TOP	0	R 615	150
N2	NPS 2	60.3 x 2.77	SANITARY CLAMP FERRULE (VENDOR)	-	BOTTOM	0	-	150
N3	NPS 2	60.3 x 2.77	SANITARY CLAMP FERRULE (VENDOR)	-	TOP	60	R 615	150
N4	NPS 3	88.9 x 3.05	SANITARY CLAMP FERRULE (VENDOR)	-	TOP	120	R 615	175
N5	NPS 1.5	48.3 x 2.77	SANITARY CLAMP FERRULE (VENDOR)	-	TOP	180	R 615	150
N6	NPS 1	33.4 x 2.77	SANITARY CLAMP FERRULE (VENDOR)	-	SHELL	45	EL 1400	150
N7	NPS 0.5	21.3 x 2.11	SANITARY CLAMP FERRULE (VENDOR)	-	SHELL	125	EL 1410	150
M1	457 mm	VENDOR	SANITARY HINGED MANWAY (VENDOR)	-	TOP	240	R 615	250
A1	NPS 4	114.3 x 6.02	SLIP-ON FLANGE CLASS 150 RF	10 (OD 251)	TOP	0	R 0	175

SAMPLE
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ESTINEER

NOZZLE DETAIL SCHEDULE

NECKS, FLANGES, PADS AND POSITIONS

TANK T-102 10.0 m3 SS316L

DWG ESTN-T-102-S08 REV A 2026-11-16

SCALE NTS

SIZE A4

SHEET **8 OF 8**

FOR REVIEW

ESTINEER

ENGINEERING · ESTIMATING · FABRICATION DATA

Engineering Calculation

Shop-built atmospheric storage tank · Milk service

Tag **T-102** · ER-U7PW-62FS-CALC · Rev A

Report ER-U7PW-62FS Rev A · Rev code RV-32D7-8LXZ · Project EP-2KVS-YA3H · Check KJ59-F392

Verify this report at www.estineer.com/verify

SAMPLE
EXAMPLE ONLY · NOT A VALID REPORT · NOT FOR FABRICATION

CAPACITY	INSIDE DIAMETER	SHELL HEIGHT	MATERIAL
10.0 m³	2,050 mm	2,950 mm	SS316L

SHELL THICKNESS	DESIGN BASIS	EMPTY WEIGHT	HYDROTEST WEIGHT
5 mm	API 650 13th ed. methods (J+S)	1,341 kg	11,380 kg

Preliminary: 26 calculated checks pass, 6 open

Shell, heads, nozzles, supports, lifting, wind and hydrotest. Open points are listed in section 10.

i Document control

Document	ER-U7PW-62FS-CALC
Revision	A
Date	2026-11-16
Status	Issued for review
Code basis	API 650 13th ed. methods (J+S) + hygienic practice
Related	ESTN-T-102-S01 onward (GA and shop drawings)

ii Approval

ROLE	NAME	SIGNATURE	DATE
Prepared	Estineer software for		2026-11-16
Checked			
Approved			

Contents

1. Design data
2. Shell thickness
3. Heads, bottom and roof
4. Nozzles, manways and reinforcement
5. Weights and centre of gravity
6. Wind load
7. Support legs
8. Lifting lugs
9. Agitator mounting and cooling jacket
10. Hydrostatic test
11. Code compliance checklist and open points

Summary of checks

CHECK	VALUE	LIMIT	RESULT
Shell hoop stress ratio (corroded)	**0.06**	1.00	OK
Cone bottom thickness	**5.00 mm**	1.17 mm	OK
Cone/shell junction area	**819.72 mm2**	819.72 mm2	OK
N2 bottom opening reinforcement	**335.62 mm2**	4.15 mm2	OK
M1 manway in top head (local load)	**0.28 MPa**	58.83 MPa	OK
Leg axial (full of product to design level)	**0.68**	1.00	OK
Leg axial + bending (full of product + wind)	**0.68**	1.00	OK
Leg-to-pad fillet welds	**17.55 MPa**	144.00 MPa	OK
Shell shear at leg pad	**9.55 MPa**	58.83 MPa	OK
Leg support ring bending	**83.62 MPa**	97.08 MPa	OK
Leg-to-ring welds	**7.92 MPa**	144.00 MPa	OK
Ring-to-shell stitch welds	**32.90 MPa**	144.00 MPa	OK
Shell bearing at the lower leg ring	**11.20 MPa**	132.38 MPa	OK
Leg uplift, empty + wind (no anchors needed)	**-3.29 kN**	0.00 kN	OK
Lifting lug 120 x 10 plate and welds	**OK**	SF 4 on ultimate	OK
Lug pad weld and shell shear	**0.13**	1.00	OK
Local shell bending at lifting lugs	**not calculated**	engineer	OPEN
Agitator mount	**OK**	pad on wall	OK
Hydrotest shell stress	**5.93 MPa**	131.75 MPa	OK

1 Design data

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Tag / service		**T-102 / Milk**		
Design code		**API 650, 13th edition (selected methods)**		
Design basis		**API 650 13th ed. methods (J+S)**		

SAMPLE
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Scope of code use	Selected design methods of API 650, 13th edition (Annexes J and S); this is not a claim of full API 650 compliance. API 650 covers tanks with a uniformly supported bottom: the suspended cone bottom on legs, the formed heads and their openings are outside that scope and are designed here by the methods shown in this report, for justification and approval by the responsible engineer.		
Elevated temperature (S.3.6.1 / Annex M)	design temperature above 40 C (stainless) / 93 C (CS)	**95**	C
Shell allowable Sd at temperature	API 650 Table S.2, interpolated	**130**	MPa
Modulus ratio E(20) / E(T)	applied to self-supporting roof thickness formulas `= 195000 / 189375`	**1.03**	-
Yield at temperature fy(T)	used for legs, bottom plate and beams `= fy(40 C) 170`	**147**	MPa
Orientation		**vertical**	
Material		**SS316L (plate 316L)**	
Inside diameter D		**2,050**	mm
Shell height H (T/T or bottom to top angle)		**2,950**	mm
Bottom / top		**cone / ellipsoidal**	
Geometric capacity V		**10.04**	m3
Design liquid level (from lowest point)		**3,225**	mm
Design liquid level above the shell bottom	datum for shell courses and shell nozzles	**2,950**	mm
Design specific gravity G	max(1.0, density / 1000) `= density 1030 kg/m3`	**1.03**	-
Design pressure		**atmospheric (open vent), full of liquid**	
Design temperature		**95**	C
Corrosion allowance CA		**0**	mm
Joint efficiency E	spot radiography	**0.85**	-
Allowable design stress Sd	CS: Annex A 145 MPa; SS: Table S.2a at design temperature	**130**	MPa
Basic wind speed V (site input)	0 = installed indoors	**0**	km/h

2 Shell thickness

One-foot method: td = 4.9 D (H - 0.3) G / (Sd E) + CA ; tt = 4.9 D (H - 0.3) / (St E). H is the design liquid level above the bottom of each course (m), D in m, result in mm. The 0.3 m reduction is used only where a flat bottom restrains the shell foot; with a formed or cone bottom, or a horizontal tank, the full head is used.

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Course 1: design level H	liquid level above shell bottom - course bottom `= 2.950 - 0.000`	**2.95**	m	
Course 1: td	4.9 D (H-0) G / (Sd E) + CA `= 4.9 x 2.050 x (2.950-0) x 1.03 / (130 x 0.85) + 0`	**0.28**	mm	
Course 1: tt	4.9 D (H-0) / (St E) `= 4.9 x 2.050 x (2.950-0) / (155 x 0.85)`	**0.22**	mm	
Course 1: adopted	plate stock >= max(td, tt, minimum)	**5**	mm	OK
Course 2: design level H	liquid level above shell bottom - course bottom `= 2.950 - 1.500`	**1.45**	m	

SAMPLE
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Course 2: td	4.9 D (H-0) G / (Sd E) + CA = 4.9 x 2.050 x (1.450-0) x 1.03 / (130 x 0.85) + 0	**0.14**	mm	
Course 2: tt	4.9 D (H-0) / (St E) = 4.9 x 2.050 x (1.450-0) / (155 x 0.85)	**0.11**	mm	
Course 2: adopted	plate stock >= max(td, tt, minimum)	**5**	mm	OK
Minimum nominal thickness	API 650 S.3.2.1.1 / 5.6.1.1	**5.00**	mm	OK
Corroded hoop stress / allowable (worst course)	4.9 D (H-0) G / (tn - CA) / (Sd E)	**0.06**	-	OK

3 Heads, bottom and roof

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Conical bottom	slope 15 deg to centre drain, half apex angle b = 75 deg			
Hydrostatic pressure at apex P	rho g H (design level (water if heavier)) = 1030 x 9.81 x 3.225	**32.57**	kPa	
Required thickness th	P D / (2 cos b Sd E) + CA = 0.0326 x 2050 / (2 x 0.259 x 130 x 0.85) + 0	**1.17**	mm	
Adopted cone thickness	max(above, shell minimum), plate stock	**5**	mm	OK
Junction ring force Q	P R / 2 x tan b (inward pull of the cone at the shell) = 0.0326 x 1025 / 2 x 3.73	**62.30**	N/mm	
Compression area required	Q R / (0.6 Sd) = 62.3 x 1025 / (0.6 x 130)	**820**	mm2	
Area available (cone + shell)	0.78 sqrt(R t) t for each, corroded	**558**	mm2	
Added compression ring	flat-bar ring at the junction (see MTO and detail W2)	**261**	mm2	OK
Top 2:1 ellipsoidal head	same profile, no hydrostatic load; minimum + CA	**5**	mm	OK

4 Nozzles, manways and reinforcement

Shell openings larger than NPS 2 need reinforcement (API 650 5.7.2.1). Area required = hole diameter x required corroded shell thickness. Area available = excess shell + neck within 4 tn of the shell + pad. Roof/top openings carry no hydrostatic load (Table 5.14a details). Openings in a formed or cone bottom are below the liquid and are checked by area replacement at the pressure of the lowest point; top openings are checked for a local load.

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
N1 NPS 2.0 in the top (top)	above the design liquid level: no hydrostatic pressure, so no pressure reinforcement; checked for a local load			
N1: punching shear of the top plate	W / (pi OD (t - CA)) <= 0.4 fy, W = 1.5 kN = 1500 / (pi x 60 x 5.0)	**1.58**	MPa	OK
N2 NPS 2.0 in the conical bottom (below the liquid)	pressure at the lowest point (design level (water if heavier)) = 1030 x 9.81 x 3.225 / 1e6	**0.03**	MPa	
N2: required head thickness at the opening	P Dl / (2 cos b Sd E), Dl = 2 d (reinforcement limit), b = 75 deg = 0.0326 x 121 / (2 x 0.259 x 130 x 0.85)	**0.07**	mm	
N2: area required (area replacement)	d x t_r = 60 x 0.069	**4.15**	mm2	
N2: area available	d (t_b - CA - t_r) + 2 x 2.5 min(t_b, t_n) x (t_n - CA - t_rn) + pad = 297 + 38 + 0	**336**	mm2	OK
N2: neck hoop stress	P (OD - t_n) / (2 (t_n - CA)) <= Sd = 0.0326 x 57.5 / (2 x 2.77)	**0.34**	MPa	OK
N3 NPS 2.0 in the top (top)	above the design liquid level: no hydrostatic pressure, so no pressure reinforcement; checked for a local load			
N3: punching shear of the top plate	W / (pi OD (t - CA)) <= 0.4 fy, W = 1.5 kN = 1500 / (pi x 60 x 5.0)	**1.58**	MPa	OK

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N4 NPS 3.0 in the top (top)	above the design liquid level: no hydrostatic pressure, so no pressure reinforcement; checked for a local load			
N4: punching shear of the top plate	W / (pi OD (t - CA)) <= 0.4 fy, W = 1.5 kN = 1500 / (pi x 89 x 5.0)	**1.07**	MPa	OK
N5 NPS 1.5 in the top (top)	above the design liquid level: no hydrostatic pressure, so no pressure reinforcement; checked for a local load			
N5: punching shear of the top plate	W / (pi OD (t - CA)) <= 0.4 fy, W = 1.5 kN = 1500 / (pi x 48 x 5.0)	**1.98**	MPa	OK
N6 NPS 1.0 shell	API 650 5.7.2.1: NPS 2 and smaller, no reinforcement required = neck 105 / 2.77 mm	**exempt**		OK
N7 NPS 0.5 shell	API 650 5.7.2.1: NPS 2 and smaller, no reinforcement required = neck 105 / 2.11 mm	**exempt**		OK
M1 manway in the top (top)	above the design liquid level: no hydrostatic pressure, so no pressure reinforcement; checked for a local load			
M1: punching shear of the top plate	W / (pi OD (t - CA)) <= 0.4 fy, W = 1.5 kN + 0.5 kN cover = 2000 / (pi x 457 x 5.0)	**0.28**	MPa	OK
A1 agitator nozzle (top)	above the design liquid level: no hydrostatic pressure; mounting loads (torque, bending, weight) checked in the agitator section with the pad	**see section 9**		OK

5 Weights and centre of gravity

Weights from the model material take-off (catalogue items and plate geometry) plus deposited weld metal; purchased filler is a consumable and is not tank weight. Lifting and support checks use the installed empty weight (conservative). Elevations from the shell bottom (tangent line for formed bottoms, cone/shell junction for cone bottoms); the centre of gravity is approximate.

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Fabricated (shipping / lifting) weight	material take-off + deposited weld metal; excl. filler wastage and site-installed vendor items	**1,283**	kg	
Vendor items installed at site	agitator (vendor estimate)	**57.50**	kg	
Empty weight, installed	fabricated + site-installed vendor items	**1,341**	kg	
Operating weight	empty + V x fill 0.95 x density	**11,164**	kg	
Full of product (design level)	empty + V x 1030	**11,681**	kg	
Hydrotest weight	empty + V x 1000 (water to the design level)	**11,380**	kg	
Welding filler purchased (not tank weight)	deposited 9.66 kg x 1.02 / efficiency 0.9	**10.94**	kg	
CoG empty (elevation)	sum(w z) / sum(w)	**1,465**	mm	
CoG operating (elevation)	incl. liquid at fill level / 2	**1,409**	mm	

6 Wind load

API 650 5.2.1(k): 0.86 kPa on the projected area of cylindrical surfaces and 1.44 kPa uplift on the horizontal projected roof area, for 190 km/h, scaled by (V/190)^2.

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Design wind pressure, shell Pws	0.86 (V/190)^2 = 0.86 x (0/190)^2	**0.00**	kPa	
Roof uplift pressure Pwr	1.44 (V/190)^2 = 1.44 x (0/190)^2	**0.00**	kPa	
Wind force Fw	Pws x projected area = 0.000 x 2.060 x 3.777	**0.00**	kN	
Support base elevation	leg foot plates	**-875**	mm	

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Overturning moment at support base Mw	Fw x arm + roof uplift moment = 0.00 x 2.49 + 0.00	**0.00**	kN m

7 Support legs

Each leg is a cantilever from the shell attachment, effective length KL = 2 x free length (clearance under the head + head depth). Allowable axial load A fy / (1.67 (1 + lambda^2)), lambda = KL / (r pi) sqrt(fy / E), E at design temperature. Wind shear shared equally by the legs; overturning adds 4 Mw / (n Dc) to the most loaded leg.

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Load case: Empty	W g / n = 1,341 x 9.81 / 4	**3.29**	kN per leg	
Load case: Operating (fill 95%)	W g / n = 11,164 x 9.81 / 4	**27.37**	kN per leg	
Load case: Full of product to design level (1030 kg/m3)	W g / n = 11,681 x 9.81 / 4	**28.64**	kN per leg	
Load case: Hydrotest (water, full)	W g / n = 11,380 x 9.81 / 4	**27.90**	kN per leg	
Governing gravity case	max(full of product, hydrotest)	**Full of product to design level (1030 kg/m3)**		
Legs		**4 x pipe OD 73.0 x 3.05 mm, SS316L; fy at 95 C**		
Leg area A / radius of gyration r		**663 mm2 / 24.8 mm**		
Free leg length	clearance under head + head depth = 600 + 275	**875**	mm	
Effective length KL	2 x free leg length = 2 x 875	**1,749**	mm	
Slenderness lambda	KL / (r pi) sqrt(fy/E) = 1749 / (24.8 pi) sqrt(147/189375)	**0.63**	-	
Allowable axial load per leg	A fy / (1.67 (1 + lambda^2))	**41.91**	kN	
Load per leg, governing gravity case	W g / n = 114.6 / 4	**28.64**	kN	OK
Overturning load per leg (wind)	4 Mw / (n Dc), Dc = shell diameter (conservative) = 4 x 0.00 / (4 x 2.050)	**0.00**	kN	
Wind shear / bending per leg	V = Fw / n ; M = V x free leg length = 0.00 kN x 0.87 m	**0.00**	kN m	
Bending stress fb	M / Z = 0.000e6 / 11253	**0.00**	MPa	
Interaction (full of product + wind)	P / Pall + fb / (0.66 fy) = 28.6/41.9 + 0.0/97	**0.68**	-	OK
Uplift on windward leg (empty)	4 Mw / (n Dc) - W_empty / n	**-3.29**	kN	OK
Leg attachment	leg overlaps a pad 300 x 173 x 5 mm on the shell; two vertical fillets a = 5 mm			
Design load per leg Pd	max(governing gravity, full + wind)	**28.64**	kN	
Eccentricity e	leg OD / 2 + pad = 36.5 + 5	**41.50**	mm	

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Weld: direct shear f1	Pd / (2 Lp) = 28638 / (2 x 300)	**47.73**	N/mm	
Weld: bending f2	Pd e / (Lp^2 / 3) = 28638 x 41.5 / (300^2 / 3)	**39.62**	N/mm	
Weld throat stress	sqrt(f1^2 + f2^2) / (0.707 a) <= 0.3 x 480	**17.55**	MPa	OK
Shell shear along pad edges	Pd / (2 Lpad (t - CA)) <= 0.4 fy, Lpad = pad length = 28638 / (2 x 300 x 5.0)	**9.55**	MPa	OK
Leg support rings	two continuous EA 75X75X5 rings around the shell at the top and bottom of the leg attachment, spacing hr = 300 mm; the eccentric moment Pd e is carried as a radial couple by ring bending, so no local shell bending at the leg pad			
Radial couple force per ring F	Pd (e + t/2) / hr, to the shell mid-wall = 28638 x 44.0 / 300	**4.20**	kN	
Ring radius R	shell outside radius	**1,030**	mm	
Ring moment M (n equal radial loads)	F R / 2 x max(1/a - cot a, 1/sin a - 1/a), a = pi / n = 4200 x 1030 x 0.1366	**0.59**	kN m	
Ring hoop force N	F / 2 x cot a	**2.10**	kN	
Ring stress (EA 75X75X5, angle alone)	M / Z + N / A = 591058 / 7322 + 2100 / 725	**83.62**	MPa	OK
Allowable	0.66 fy at design temperature	**97.08**	MPa	
Leg-to-ring welds (each ring)	F / (0.707 a x 2 b): fillets both sides of the leg across the ring outstand b = 4200 / (0.707 x 5.0 x 2 x 75)	**7.92**	MPa	OK
Ring-to-shell welds, stitch 50 long at 150 pitch (alternate path: full Pd through the rings)	Pd / (0.707 a x 2 rings x 2 sides x Le x 0.33), Le = OD + 2 x 0.78 sqrt(R (t - CA)) = 28638 / (0.707 x 5.0 x 246)	**32.90**	MPa	OK
Shell bearing under the lower ring (inward F)	F / ((t - CA) b) <= 0.9 fy = 4200 / (5.0 x 75)	**11.20**	MPa	OK

8 Lifting lugs

Two lugs (API 650 J.3.8: at least two) on pads, lug and pad in the tank material (SS316L). Design load = 2 x installed empty weight shared by the lugs, sling at 60 deg to the horizontal; allowable stresses = ultimate / 4 (safety factor 4). The pad spreads the lug load into the shell; the shell is checked in shear around the pad.

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Design load per lug (along sling)	2 W_empty g / n / sin 60 = 2 x 1341 x 9.81 / 2 / 0.866	**15.18**	kN	
Components	Fv = F sin 60, Fh = F cos 60	**Fv 13.15 kN, Fh 7.59 kN**		
Lug plate	b x h x t, hole d, edge a	**120 x 180 x 10 mm, hole 40, edge 50, SS316L (Fu 485 MPa)**		
Net tension	F / ((b - d) t) <= Fu/4	**18.98**	MPa	OK
Tear-out shear	F / (2 (a - d/2) t) <= 0.6 Fu/4	**25.31**	MPa	OK
Pin bearing	F / (d t) <= 1.5 Fu/4	**37.96**	MPa	OK
Moment on the lug welds	M = Fv b/2 + Fh |h/2 - a| = 13151 x 60 + 7592 x 40	**1.09**	kN m	
Lug-to-pad welds (2 fillets 8 mm x 180)	sqrt((Fv/Aw)^2 + (Fh/Aw + M/Sw)^2) <= 0.6 Fe/4 = Aw 2036 mm2, Sw 61085 mm3	**22.56**	MPa	OK

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Pad		**280 x 126 x 5 mm, SS316L, fillet a5 all round**		
Pad-to-shell weld group	Mp = Fv (b/2 + tp) + Fh |h/2 - a|; sqrt((Fv/Aw)^2 + (Fh/Aw + Mp/Sw)^2) <= 0.6 Fe/4 = Aw 2870 mm2, Sw 217096 mm3, Mp 1.16 kN m	**9.20**	MPa	OK
Shell shear around the pad	F / (2 (L + W) (t - CA)) <= 0.4 fy = 15185 / (2 x 406 x 5.0)	**3.74**	MPa	OK
Local shell bending under the lug pad (moment Fh e)	radial-load method (WRC 537) or FEA: not calculated by this tool	**open**		OPEN
Weld procedure	same-material welds (lug, pad and shell all SS316L); filler as the shell procedure			

9 Agitator mounting and cooling jacket

The agitator and its loads come from the agitator vendor; the values below are declared estimates for sizing the mounting pad only. The jacket is checked for its design pressure; cooling duty and chiller sizing are by the process / refrigeration supplier.

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Agitator		**Top entry, 0.75 kW, about 40 rpm, flange A1 NPS 4**		
Shaft torque	T = 9550 P / n = 9550 x 0.75 / 40	**179**	N m	
Side moment at the mount (assumed)	M = 2 T	**358**	N m	
Agitator weight (estimate)	35 + 30 P kg	**0.56**	kN	
Mounting pad	ring plate welded all round	**251 OD x 10 mm, fillet 7 mm**		
Weld stress	√((M/(π r² a) + W/(2π r a))² + (T/(2π r² a))²) ≤ 0.6 Fe / 4	**1.64**	MPa	OK
Local wall stress, indicative (head 5 mm - CA 0)	M/(π r² (t-CA)) + W/(2π r (t-CA)) ≤ Sd	**1.58**	MPa	OK
Local loads at the agitator nozzle	WRC 107 / WRC 297 or FEA with the vendor's final loads (AS 1210 App N method)	**open: engineer to confirm**		

10 Hydrostatic test

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
Test medium / level		**water, full to top of shell**		
Shell stress at test (new, no CA)	4.9 D (H-0) / tn = 4.9 x 2.050 x (2.950-0) / 5	**5.93**	MPa	OK
Allowable test stress	St x E = 155 x 0.85	**132**	MPa	
Hold time / acceptance		**4 h hold, no leaks (alt. API 650 J.4.2.2 air test of welds)**		

11 Code compliance checklist and open points

ITEM	FORMULA / BASIS	VALUE	UNIT	RESULT
API 650 J.1.1	Diameter <= 6 m for shop assembly			OK

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API 650 J.3.1.2	All shell joints full-penetration butt welds (weld details W1/W2)		SPECIFIED
API 650 J.3.1.5	Bottom joints: conical bottom seams and the junction to the shell are full-penetration butt welds (W2)		SPECIFIED
API 650 J.3.2.3 / 5.1.5.7	Flat-bottom projection and shell-to-bottom fillets: not applicable, the bottom is a conical joined to the shell by a butt weld		N/A
API 650 J.3.8	Minimum 2 lifting lugs, design load 2 x empty weight, SF 4 (calc section 8)		OK
API 650 J.3.9	Overturning by wind checked (calc sections 6-7); anchors where uplift		OK
API 650 J.5.2	Spot RT: vertical and horizontal joints, E = 0.85 (weld register and RT activity)		SPECIFIED
API 650 S.3.3.1	SS nozzle necks: <= NPS 2 Sch 80S, NPS 3-4 Sch 40S, > NPS 4 6 mm		OK
API 650 S.4.14.2	PT of nozzle, neck-to-flange and attachment welds (weld register, Inspection column)		SPECIFIED
Hygienic	Product-contact surface Ra <= 0.8 um, polished		SPECIFIED
Hygienic	Product-contact welds continuous, ground flush and polished inside (W3 hygienic detail)		SPECIFIED
Hygienic	Self-draining bottom, outlet at lowest point		OK
Hygienic	No threads / crevices in product zone; sanitary fittings		SPECIFIED
Hygienic	300-series stainless steel product contact		OK
Hygienic	Leg clearance under tank >= 150 mm for cleaning		OK
Hygienic	Applicable 3-A / EHEDG criteria, CIP spray coverage (flow, pressure) and vent sizing for filling, draining and CIP temperature changes: process data needed	**open**	OPEN
API 650 S.3.6.1 / Annex M	Stainless at 95 C: Sd from Table S.2 at temperature; roof and structural checks with E and fy at temperature (E ratio 1.030)		OK
API 650 Table 5.3a/5.4a	Shell manhole tables: not applicable, sanitary vendor manway		N/A
NDT basis	Spot radiography only on butt welds that carry liquid head: shell vertical and circumferential seams, bottom head / cone to shell, cone bottom seams and horizontal-tank head seams (API 650 8.1 spot rules, E = 0.85). Roof and top head seams (above the liquid) and flat-bottom plate seams: VT 100 %, no radiography		SPECIFIED
Open point	Sanitary clamp sets, manway and CIP spray ball priced at budget values: confirm with vendor quotes	**open**	OPEN
Open point	Agitator: supply, loads and seal by the agitator vendor; electrical connection not included	**open**	OPEN
Open point	Instrument supply prices not in DB: vendor quotes needed	**open**	OPEN
Seismic	Seismic design (API 650 Annex E) not included: site seismic data needed	**excluded**	

SAMPLE
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