

OWNER

Critical Lift Plans for H-101, V-101 and SK-110

Calculation



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1. OBJECTIVE

This calculation sets the engineering basis for the three heaviest lifts on the project: line heater H-101, filter separator V-101 and meter skid SK-110. It establishes the hook loads, selects a crane class and crane positions, sizes the rigging, and checks ground bearing under the outriggers on the site clay. It is the Owner's minimum requirement; the Contractor's lift engineer shall prepare the final plan for each lift with the actual crane, its certified load chart and the vendor-weighted equipment weights.

2. METHODOLOGY

TORUS took each item's empty weight from the mechanical equipment list and added a 10 % contingency, because the weights are calculated from geometry and have not yet been confirmed by vendor weigh tickets. Rigging, the spreader or lifting frame, the hook block and a load line allowance were added to give the hook load.

Crane positions were chosen on the plot plan so that the outriggers and their mats clear all equipment, piping and the receiving pipeline operator's right-of-way, and so that the geometric radius to each load is 35 ft or less. The planned radius used for selection is 35 ft for every lift. Three crane classes were compared against representative load chart capacities. A crane is acceptable when the hook load is no more than 75 % of the chart capacity at the planned radius, and no more than 85 % at 5 ft beyond it, to allow for positioning error and load swing. The capacities are typical of the class and are not taken from a specific manufacturer's chart.

Rigging for a four-point lift without an equalizing arrangement was sized on the assumption that two legs carry the full load. The maximum outrigger reaction was estimated with the planning rule that the most heavily loaded outrigger carries 75 % of the crane weight plus the hook load. Timber mats were then arranged in two layers and checked for bearing on the soil and for bending and shear as cantilevers from the loaded width.

3. DESIGN INPUTS

The inputs are listed in Table 3-1.

Table 3-1: Design Inputs

Input	Value	Source
H-101 empty weight and size	45,324 lb; 6.0 MMBtu/h, 96 in x 29 ft shell with 616 ft ² firetube, about 34 ft x 9.5 ft overall, bath empty, stack separate	MEC-DS-003; MEC-LST-002 (HOLD H-15)
V-101 empty weight and size	29,529 lb; 42 in ID x 15 ft, NPS 24 liquid barrel, 1.75 in shell	MEC-LST-002 (HOLD H-15)

Input	Value	Source
SK-110 weight and size	36,731 lb; 48 ft x 14 ft, canopy separate	MEC-LST-002 (HOLD H-15)
Equipment locations	V-101 (84, 40); SK-110 (84, 97); H-101 (191.5, 140), plot coordinates in ft	MEC-DWG-001, Plot Plan
Weight contingency	10 %	TORUS practice until weighed
Hook block; load line allowance	2,200 lb; 300 lb	Typical for crane class
Crane in lift configuration	280,000 lb (carrier and counterweight), outrigger spread 28 x 28 ft	Typical 200 US ton class (TBV)
Allowable soil bearing	2,000 psf	GEN-DB-001 (HOLD H-07)
Timber mats	4 ft x 12 in x 16 ft dense mixed hardwood; allowable bending 1,200 psi, shear 150 psi	Typical (TBV with mat supplier)
Outrigger float	2 x 2 ft equivalent	Typical

4. ASSUMPTIONS

1. Equipment weights are geometry-based. *Verification required: vendor certified weights (HOLD H-15). If a certified weight exceeds the value used by more than 10 %, this calculation shall be re-run before the lift.*
2. The crane capacities in Table 6-2 represent the 110, 150 and 200 US ton all-terrain classes with full counterweight, outriggers fully extended and a 60 to 70 ft main boom over 360°. *Verification required: the certified chart of the crane mobilized.*
3. The most heavily loaded outrigger carries 75 % of the crane weight plus the hook load. *Verification required: the manufacturer's outrigger load calculation for the actual configuration and slew range.*
4. The mats behave as rigid over the lengths used in the bending check.
5. The heater is lifted with its water bath empty and its stack removed.

5. REFERENCES

1. 29 CFR 1926 Subpart CC, Cranes and Derricks in Construction: 1926.1402 ground conditions, 1926.1408 power line safety, 1926.1417 operation, 1926.1427 operator qualification.
2. ASME B30.5-2021, Mobile and Locomotive Cranes; ASME B30.9-2021, Slings; ASME B30.20-2021, Below-the-Hook Lifting Devices; ASME B30.26-2015, Rigging Hardware.
3. ASME BTH-1-2020, Design of Below-the-Hook Lifting Devices.

4. GEN-DB-001, Basis of Design.
5. MEC-LST-002, Mechanical Equipment List; MEC-DWG-001, Plot Plan.
6. SPC-SPC-001, General Requirements and Definitions (critical lift definition); SPC-SPC-017, Mechanical Equipment Setting.
7. CON-RPT-001, Construction Execution Plan; CON-RPT-003, Construction HSE Plan.

6. CALCULATION

6.1. HOOK LOADS

Table 6-1 builds up the hook load for each lift. For the heater:

$$HL = 1.10 \times 45,324 + 1,000 + 2,300 + 2,200 + 300 = 55,656 \text{ lb}$$

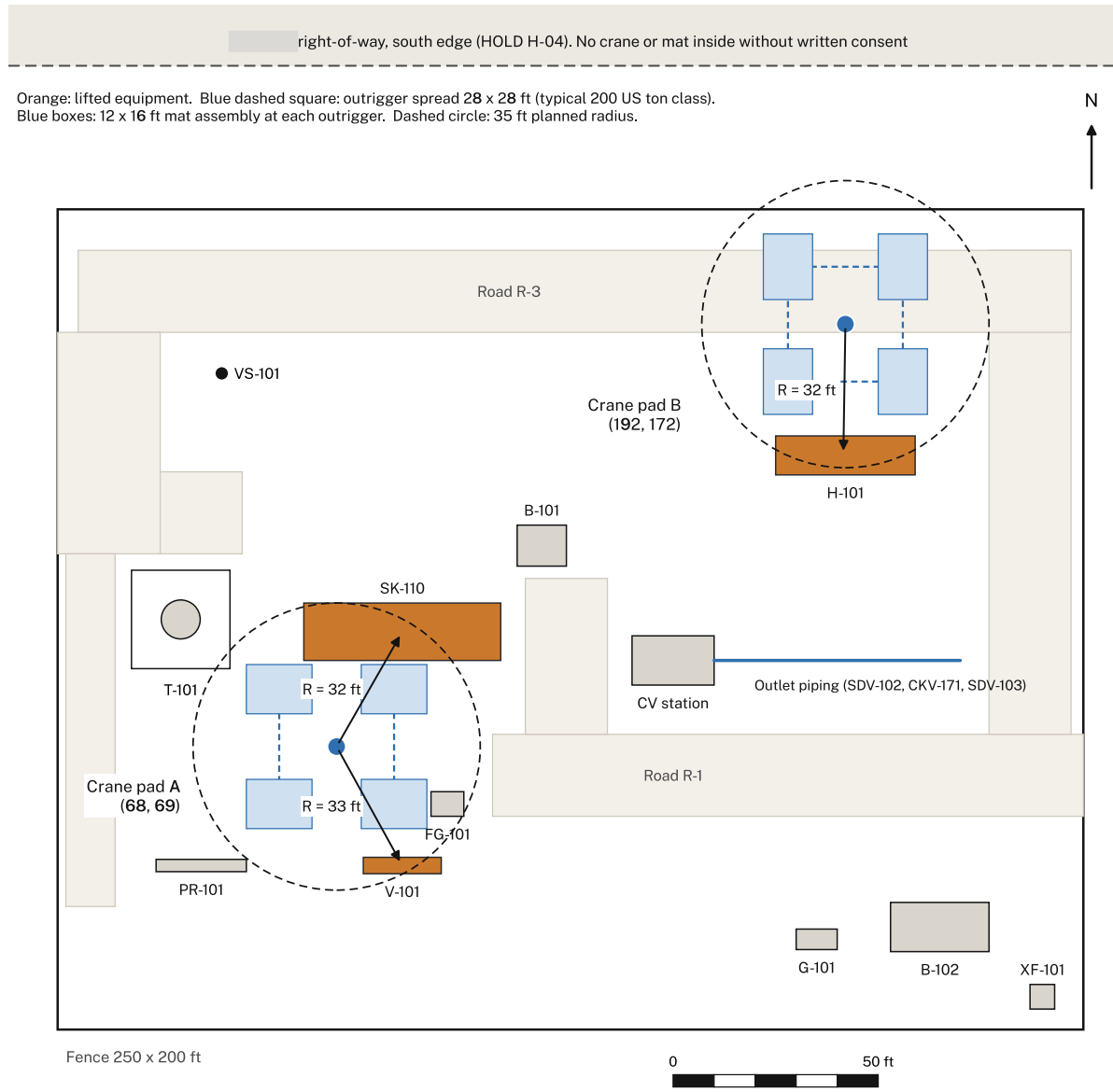
Table 6-1: Hook Loads

Lift	Empty weight, lb	With 10 % contingency, lb	Slings and shackles, lb	Spreader or frame, lb	Hook block and load line, lb	Hook load, lb
H-101	45,324	49,856	1,000	2,300 (26 ft beam)	2,500	55,656
V-101	29,529	32,482	600	900 (12 ft bar)	2,500	36,482
SK-110	36,731	40,404	1,000	3,500 (40 x 12 ft frame)	2,500	47,404

6.2. CRANE POSITIONS

Two crane pads serve the three lifts, as Figure 6-1 shows. Pad A, at (68, 69), serves V-101 at a 33 ft radius and SK-110 at 32 ft. It sits west of the fuel gas skid FG-101 and south of SK-110, so the mats clear both. V-101 shall be set first and SK-110 second, before the interconnecting piping between them is installed, because that piping would run through the pad. Pad B, at (192, 172) on road R-3, serves H-101 at 32 ft. A pad south of the heater was rejected because a 28 ft outrigger spread there would land on the outlet piping at y = 90 (SDV-102, CKV-171 and SDV-103). The pad B mats stay more than 40 ft south of the right-of-way of the receiving pipeline operator.

Figure 6-1. Crane Setup Plan



Note 1: Plot coordinates in feet from the southwest fence corner, per MEC-DWG-001. Outrigger spread and mat sizes are typical for the crane class.

6.3. CRANE SELECTION

Table 6-2 gives the representative capacities, and Table 6-3 compares the hook loads with them at the 35 ft planned radius.

Table 6-2: Representative Crane Capacities

Crane class	25 ft, lb	30 ft, lb	35 ft, lb	40 ft, lb	45 ft, lb
110 US ton all-terrain	78,000	62,000	52,000	43,000	37,000
150 US ton all-terrain	110,000	90,000	76,000	64,000	55,000
200 US ton all-terrain	150,000	125,000	105,000	90,000	78,000

Table 6-3: Crane Utilization at 35 ft and 40 ft

Lift	Crane class	Chart at 35 ft, lb	Utilization at 35 ft	Chart at 40 ft, lb	Utilization at 40 ft	Result
H-101	150 US ton	76,000	73.2 %	64,000	87.0 %	Not acceptable
H-101	200 US ton	105,000	53.0 %	90,000	61.8 %	Acceptable
V-101	110 US ton	52,000	70.2 %	43,000	84.8 %	Acceptable
V-101	200 US ton	105,000	34.7 %	90,000	40.5 %	Acceptable
SK-110	150 US ton	76,000	62.4 %	64,000	74.1 %	Acceptable
SK-110	200 US ton	105,000	45.1 %	90,000	52.7 %	Acceptable

Note 1: The 110 US ton class fails H-101 (107 %) and SK-110 (91 %) at 35 ft and is not shown for them.

The larger heater settles the crane class. On the 150 US ton class, H-101 would use 73.2 % of chart at 35 ft, just inside the 75 % limit, but 87.0 % at 40 ft, outside the 85 % limit that covers positioning error, load swing and a pick from the delivery trailer at a longer radius than the set. The 200 US ton class is therefore selected for all three lifts. One crane class for all lifts costs less than mobilizing a second crane for the lighter items. For the governing lift:

$$U = \frac{55,656}{105,000} = 53.0 \% \leq 75 \%, \quad U_{+5 \text{ ft}} = \frac{55,656}{90,000} = 61.8 \% \leq 85 \%$$

The margin also allows the heater to be picked from its trailer at up to 45 ft (71 % of chart), so the trailer can stand on road R-3 west of the crane.

6.4. RIGGING

Figure 6-2 shows the H-101 rigging. The 29 ft shell needs a 26 ft spreader beam so that the four drops land on the skid lugs vertically; a shorter beam would put the drops at an angle and load the lugs sideways. With two of the four drops carrying the load below the spreader, each drop sees $50,356 / 2 = 25,178$ lb. The two bridle legs above the spreader, at 60° from horizontal, each carry:

$$T = \frac{53,156}{2 \sin 60^\circ} = 30,690 \text{ lb}$$

Figure 6-2. H-101 Rigging Arrangement

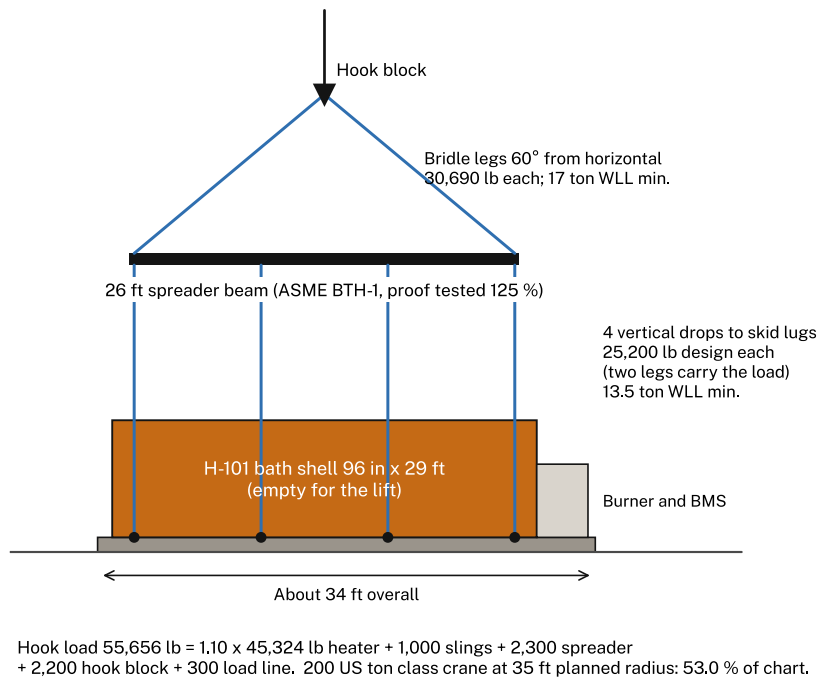


Table 6-4 gives the design tension and the minimum working load limit (WLL) for each lift.

Table 6-4: Rigging Design Tensions

Lift	Vertical drop tension, lb	Minimum WLL per drop	Bridle leg tension, lb	Minimum WLL per bridle leg
H-101	25,178	13.5 ton	30,690	17 ton
V-101	16,391	8.5 ton	19,619	12 ton
SK-110	20,452	12 ton	25,925	17 ton

Note 1: Spreader beams and the SK-110 lifting frame shall be designed to ASME BTH-1, Design Category B, Service Class 0, and proof tested at 125 % of rated load before use. Equipment lifting lugs are the vendor's design and are a submittal under SPC-SPC-017.

6.5. OUTRIGGER REACTION AND MATS

The governing outrigger reaction and the bearing under an unmatted float are:

$$P_{out} = 0.75 (280,000 + 55,656) = 251,742 \text{ lb}, \quad q = \frac{251,742}{2 \times 2} = 62,900 \text{ psf}$$

This is 31 times the allowable bearing, so mats are required. Table 6-5 compares two-layer arrangements. Three top mats laid under the float, over three bottom mats at right angles, spread the load over 12 x 16 ft. For the top mats, the load per foot and the cantilever from the float edge are:

$$w = \frac{251,742}{3 \times 12} = 6,993 \text{ lb/ft}, \quad a = \frac{12 - 2}{2} = 5.0 \text{ ft}$$

$$f_b = \frac{wa^2/2}{S} = \frac{6,993 \times 5.0^2/2 \times 12}{1,152} = 911 \text{ psi} \leq 1,200 \text{ psi}$$

and the bearing pressure is $251,742 / 192 = 1,311 \text{ psf}$.

Table 6-5: Mat Arrangements per Outrigger

Top mats	Bottom mats	Bearing area, ft ²	Bearing, psf	Top mat bending, psi	Top mat shear, psi	Result
1	2	128	1,967	1,475	246	Not acceptable
2	2	128	1,967	738	123	Acceptable, minimum
3	3	192	1,311	911	91	Acceptable, selected
4	3	192	1,311	683	68	Acceptable

The two-by-two arrangement passes but uses 98 % of the assumed bearing capacity. The three-by-three arrangement is selected because it keeps 34 % margin on a bearing value that is itself an assumption (HOLD H-07) and on red-bed clay that loses strength when wet.

7. RESULTS AND CONCLUSIONS

Table 7-1 summarizes the three lifts. All three are critical lifts under SPC-SPC-001, because each exceeds 20,000 lb and each item is named there.

Table 7-1: Lift Summary

Item	H-101	V-101	SK-110
Hook load, lb	55,656	36,482	47,404
Crane pad and geometric radius	B, 32 ft	A, 33 ft	A, 32 ft

Item	H-101	V-101	SK-110
Utilization, 200 US ton class at 35 ft	53.0 % (governs)	34.7 %	45.1 %
Rigging	26 ft spreader, 4 drops	12 ft spreader bar, 2 drops	40 x 12 ft frame, 4 drops
Mats per outrigger	3 over 3, 4 ft x 12 in x 16 ft	Same	Same
Bearing under mats, psf	1,311	1,311 or less	1,311 or less

TORUS draws the following conclusions:

1. One 200 US ton class all-terrain crane with full counterweight will make all three lifts. The heater, now 45,324 lb and about 34 ft long, governs at 53.0 % of chart at 35 ft. A 150 US ton class crane is no longer acceptable because the heater would use 87 % of its chart at 40 ft.
2. Each outrigger shall stand on three top mats over three bottom mats, 4 ft x 12 in x 16 ft, giving about 1,310 psf on the soil.
3. Each crane pad shall be built on proof-rolled subgrade with 12 in of compacted aggregate base under SPC-SPC-002 and SPC-SPC-005, level within 1 %, drained, and kept at least 10 ft (or 1.5 times the depth) from any open excavation. The lift supervisor shall confirm the ground condition on the day of each lift, and no lift shall be made on saturated clay.
4. The sequence shall be V-101, then SK-110 from pad A before the piping between them is installed, then H-101 from pad B, then the H-101 stack and the SK-110 canopy as ordinary lifts.
5. No crane shall work within 20 ft of an energized power line. The utility service to transformer XF-101 shall stay de-energized, or be routed underground, until the heavy lifts are complete (HOLD H-10).
6. Lifting shall stop at 20 mph sustained wind or 25 mph gusts, or at the manufacturer's lower limit for the sail area of the load.

The Contractor's lift plan for each lift, with the certified chart, outrigger load calculation, mat design, rigging certificates, certified weights and personnel certifications, shall be submitted 14 days before the lift and released by the Owner before the lift (hold point HP-CAL-01 in SPC-SPC-019). Open items are the vendor weights (HOLD H-15) and the geotechnical bearing value (HOLD H-07).