• OSR 45-24 (Rev 8-21-2006)

Calculation Cover Sheet

Project	Calculation Number	Project Number
	C-CLC-G-00364	N/A
Title Type I and II Waste Tank Cooling Coil to Tank Volume Ratios and Area Ratios	Functional Classification SC (PC-3)	Sheet 1 of 11
	Discipline Structural Integrity	
Calc Level [X] Type 1 Type 2	Type 1 Calc Status Preliminary [X] Confirmed	
Computer Program No. NA	Version/Release No. NA	
Purpose and Objective This calculation provides the cooling coil volume to tank volume ratios and cooling coil area to tank area ratios for Type I and Type II waste tanks in F/H Tank Farms.	DC/RO Date _____	

Summary of Conclusion

See Section 3.0

Revisions

Rev No.	Revision Description
0	Initial Issue

Sign Off

Rev No.	Originator (Print) Sign/Date	Verification/Checking Method	Verifier/Checker (Print) Sign/Date	Manager (Print) Sign/Date
0	John J Phillips John J. Phillips 03/21/07	Document review	A S Plummer 3/21/07	Gregory C Arthur 3/28/07

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OPEN ITEMS -------- NONE

RECORD OF REVISION				
Rev. No.	**Pages Superseded**	**Pages Added**	**Pages Revised**	**Description of Revisions**
0				New issue.

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1.0 PURPOSE

This calculation provides the cooling coil volume to waste tank volume ratios and cooling coil surface area to waste tank interior surface area for Type I and Type II tanks in F/H Tank Farms.

2.0 BACKGROUND/SCOPE

The Savannah River Site waste tanks located in F/H Tank Farms contain radioactive waste. There are cooling coils inside the tanks that provide for cooling of the waste where required. In the Type I and Type II tanks the cooling coils consist of carbon steel piping rigidly attached inside the tanks. The piping is nominal 2 inch pipe (2.375 inches actual outside diameter). The Type I tanks have 34 vertical coils and 2 horizontal (bottom) coils each with an inlet riser and an outlet riser for a total of 72 risers. The Type II tanks have 40 vertical coils and 4 horizontal (bottom) coils each with an inlet riser and an outlet riser for a total of 88 risers. The reference drawings are the design drawings and do not necessarily reflect the actual field dimensions. However the drawings closely represent the actual field layout.

This calculation will determine the volume that the cooling coils occupy inside the tanks and compare this volume with the inside volume of the tanks. Units will be specified in gallons to determine the ratios.

In addition, this calculation will determine the cooling coil surface area and the waste tank interior surface area and compare these areas. Units will be specified in square feet to determine the ratios. The tank tops will not be included in the tank surface area. The surface areas of the tanks and cooling coils will be calculated up to the overflow limit. (See reference 11.)

3.0 SUMMARY

The cooling coil volume to Type I tank volume ratio is 0.67 %.

The cooling coil area to Type I tank area ratio is 120 %.

The cooling coil volume to Type II tank volume ratio is 0.61 %.

The cooling coil area to Type II tank area ratio is 134 %.

4.0 CALCULATIONS

4.1 TYPE I WASTE TANKS

- Applicable to Tanks 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12.
- Length of cooling coils

  The cooling coils consist of 2 horizontal bottom coils (upper and lower) and 34 vertical coils. In addition, there are riser pipes (risers) to the top of the tank and lead pipes (leads) to connect the risers to the coils. The vertical coils consist of 604 vertical sections and 604 loops (half circle with 24 inch radius) that connect the vertical sections together. The

exact length of the vertical sections and bottom coils varies slightly for each tank. The values shown are determined from the reference drawings listed in section 5. Some tanks have bottom leads and some have top leads. In the calculation it is assumed that all are bottom leads. This is conservative because the vertical coil risers are longer for bottom leads.

Horizontal coils: $L_1 = 2 * \text{length} = 2 * 804 = 1608$ ft

Horizontal coil risers: $L_2 = 2 * \text{length lower (inches)} / 12 + 2 * \text{length upper (inches)} / 12$
$= (2 * 292 / 12) + (2 * 289 / 12) = 97$ ft

Vertical coil vertical sections: $L_3 = 604 * \text{length (inches)} / 12 = 604 * 222 / 12 = 11174$ ft

Vertical coil loops: $L_4 = 604 * \text{loop length (inches)} / 12 = 604 * 1 / 2 * \pi * 48 / 12$
$= 3795$ ft

Vertical coil risers: $L_5 = 68 * \text{length (inches)} / 12 = 68 * 286 / 12 = 1621$ ft

Vertical coil leads: $L_6 = 0.75 * 6000 = 4500$ ft (See ref 1 Eq. 11 and Eq. 34)

Total length: $L = 1608 + 97 + 11174 + 3795 + 1621 + 4500 = 22795$ ft

- Volume of Cooling Coils

The cooling coil piping is nominal 2 inch pipe which has an actual outside diameter of 2.375 inches.

Volume of cooling coils: $V = \pi / 4 * d^2 * L = \pi / 4 * (2.375 / 12)^2 * 22795 = 701\ ft^3$

Converting to gallons: $V = 701 * 7.48 = 5243$ gal

- Volume Ratio

The volume of Type I tanks is 793411 gal. (See ref 2)

Cooling coil volume to tank volume ratio: Ratio = 5243 / (793411 – 5243)
= 0.0067 or 0.67%

- Area of cooling coils up to overflow limit of 280.3 inches (23.36 feet)

Total area of cooling coils: $A_1 = \pi * d * L = \pi * (2.375 / 12) * 22795 = 14173\ ft^2$

Area of cooling coils above overflow limit: $A_2 = \pi * d * \#\ \text{risers} * L$
$= \pi * (2.375 / 12) * 72 * (24.5 - 23.36)$
$= 51\ ft^2$

Area of cooling coils up to overflow limit: $A = 14173 - 51 = 14122\ ft^2$

- Area of tank up to overflow limit of 280.3 inches (23.36 feet) (See Fig. 1& 2)

  Area of sidewall: $A_1 = \pi * D * h = \pi * 75 * (24.5 - 4 - 1) = 4595\ ft^2$
  Area of top curvature: $A_2 = H\ ratio * 1/4 * \pi * 2 * r * \pi * D$
  $= 45/90 * 1/4 * \pi * 2 * 4 * \pi * 75 = 740\ ft^2$

  Area of bottom curvature: $A_3 = 1/4 * \pi * 2 * r * \pi * D$
  $= 1/4 * \pi * 2 * 1 * \pi * 75 = 370\ ft^2$

  Area of bottom: $A_4 = \pi * R^2 - 12 * 1/4 * \pi * d^2$
  $= \pi * (37.5 - 1)^2 - 12 * 1/4 * \pi * 2^2 = 4148\ ft^2$

  Area of columns: $A_5 = 12 * \pi * d * h + 12 * \pi * (r + R) * L$ + gusset & plate area
  $= 12 * \pi * 2 * 22.28 + 12 * \pi * (1 + 0.71) * 1.01 + 160 = 1905\ ft^2$

  Total area of tank: $A = 4595 + 740 + 370 + 4148 + 1905 = 11758\ ft^2$

- Area ratio

  Cooling coil area to tank area ratio: Ratio = 14122 / 11758 = 1.20 = 120 %

4.2 TYPE II WASTE TANKS

- Applicable to Tanks 13, 14, 15 and 16

- Length of cooling coils

  The total length of cooling coils is 29400 ft. (See ref 3)

- Volume of cooling coils

  The cooling coil piping is nominal 2 inch pipe which has an actual outside diameter of 2.375 inches.

  Volume of cooling coils: $V = \pi / 4 * d^2 * L = \pi / 4 * (2.375 / 12)^2 * 29400 = 904\ ft^3$

  Converting to gallons: $V = 904 * 7.48 = 6762$ gal

- Volume Ratio

  The volume of Type II tanks is 1121357 gal. (See ref 2)

  Cooling coil volume to tank volume ratio: Ratio = 6762 / (1121357 – 6762)
  = 0.0061 or 0.61%

- Area of cooling coils up to overflow limit of 316.2 inches (26.35 feet)

Total area of cooling coils: $A_1 = \pi * d * L = \pi * (2.375 / 12) * 29400 = 18280\ ft^2$

Area of cooling coils above overflow limit: $A_2 = A_2 = \pi * d * \#\ risers * L$
$= \pi * (2.375 / 12) * 88 * (27 - 26.35)$
$= 36\ ft^2$

Area of cooling coils up to overflow limit: $A = 18280 - 36 = 18244\ ft^2$

- Area of tank up to overflow limit of 316.2 inches (26.35 feet) (See Fig. 1& 3)

Area of sidewall: $A_1 = \pi * D * h = \pi * 85 * (27 - 4 - 1) = 5875\ ft^2$

Area of top curvature: $A_2 = H\ ratio * 1 / 4 * \pi * 2 * r * \pi * D$
$= 56 / 90 * 1 / 4 * \pi * 2 * 4 * \pi * 85 = 1044\ ft^2$

Area of bottom curvature: $A_3 = 1 / 4 * \pi * 2 * r * \pi * D = 1 / 4 * \pi * 2 * 1 * \pi * 85$
$= 419\ ft^2$

Area of bottom: $A_4 = \pi * R^2 - 1 / 4 * d^2 = \pi * (42.5 - 1)^2 - 1 / 4 * \pi * 6.7^2 = 5375\ ft^2$

Area of column: $A_5 = \pi * d * h + \pi * (r + R) * L$
$= \pi * 6.7 * 19.1 + \pi * (3.35 + 10.6) * 10.28 = 853\ ft^2$

Total area of tank: $A = 5875 + 1044 + 419 + 5375 + 853 = 13566\ ft^2$

- Area ratio

Cooling coil area to tank area ratio: Ratio = 18244 / 13566 = 1.34 = 134%

5.0 REFERENCES

Reference	Document Number	Title
1	C-CLC-G-00355	Carbon Steel Components in Type I and II Tanks (U)
2	U-CLC-G-00001	Total Fill Volumes of High Level Waste Tanks (U)
3	W163593	Vertical Cooling Coils for 85' Dia. Waste Storage Tank (U)
4	W163658	Bottom Cooling Coils for 85' Dia. Waste Storage Tank (U)
5	D116048	Vertical Cooling Coils for Waste Storage Tank (U)
6	D116001	Bottom Cooling Coils for Waste Storage Tank (U)
7	W145573	Type I Waste Storage Tank Details (U)
8	W145379	Type I Waste Storage Tank Details (U)
9	W162672	Type II Waste Storage Tank Details (U)
10	W163018	Type II Waste Storage Tank Details (U)
11	WCS 1.5	Waste Characterization System WG17/WCS1.5PROD/WCS1.5

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APPENDIX A

Figure 1

Figure 1 shows the graphical determination of the H ratio for both Type I and Type II tanks.

Figure 2

Figure 2 shows the determination of the column parameters for the 12 columns in the Type I tanks.

Figure 3

Figure 3 shows the determination of the column parameters for the single column in the Type II tanks.

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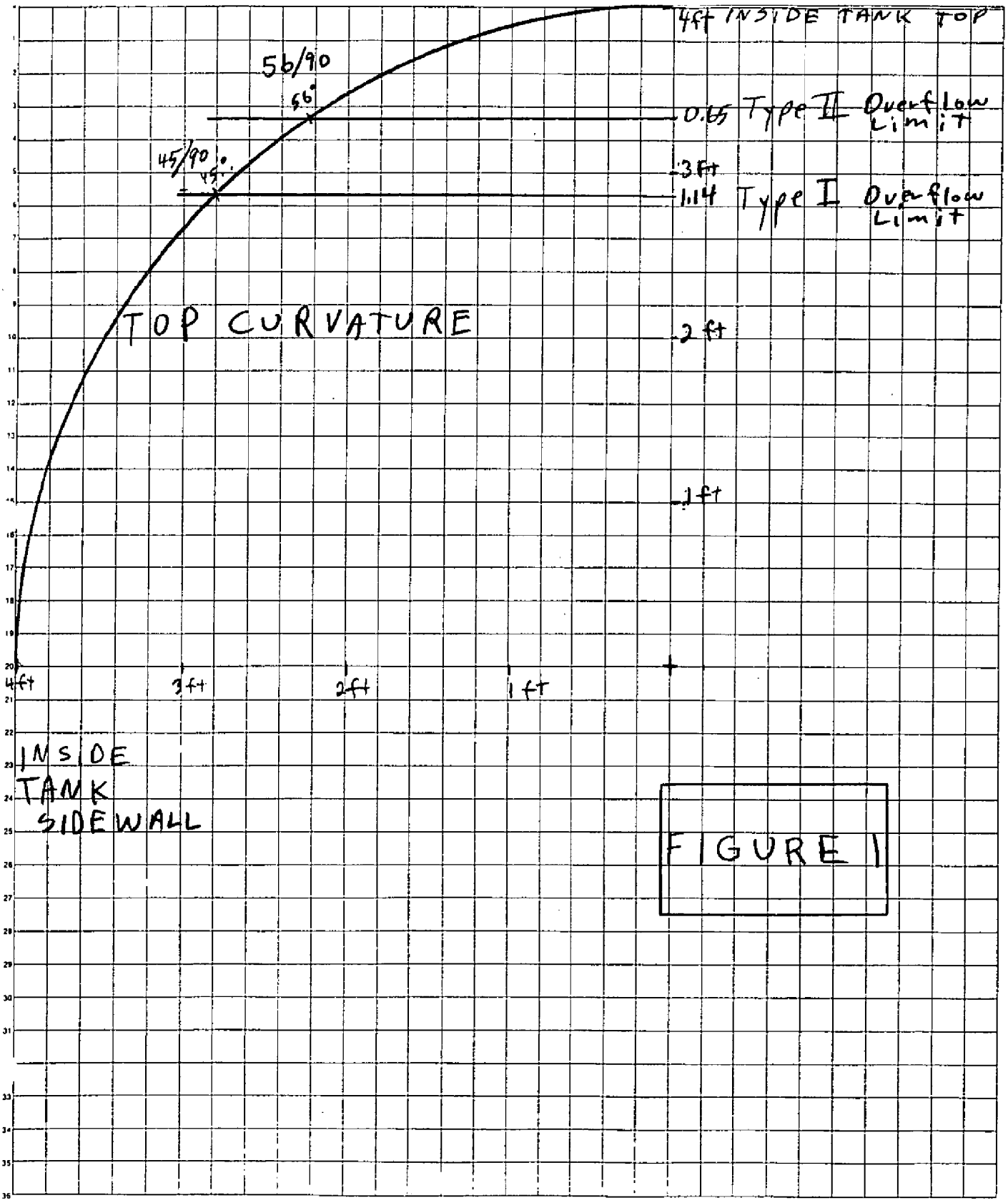

FIGURE 1

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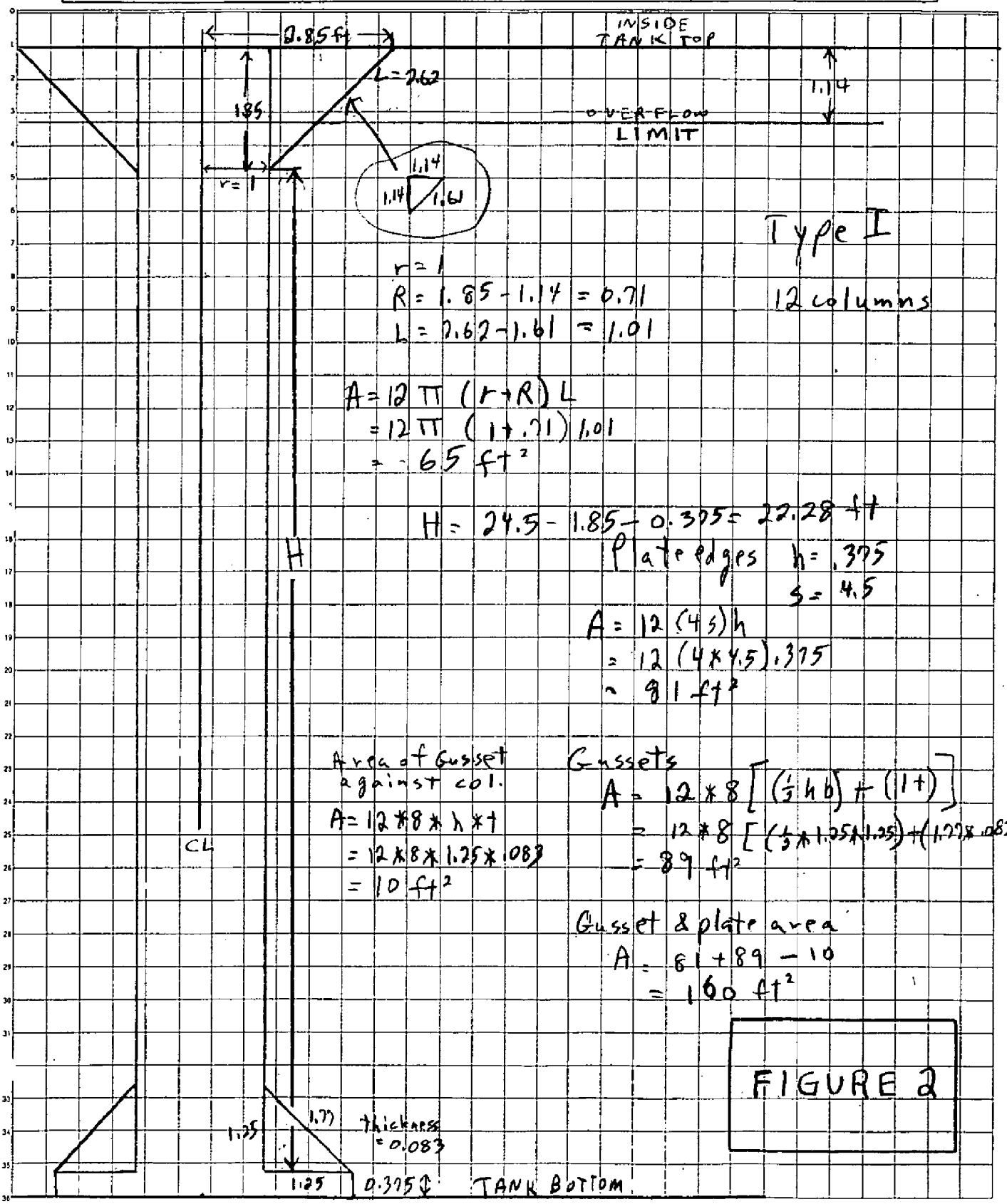

Type I

12 columns

$r = 1$

$R = 1.85 - 1.14 = 0.71$

$L = 2.62 - 1.61 = 1.01$

$A = 12\pi(r+R)L$

$= 12\pi(1+.71)1.01$

$= 65\ ft^2$

$H = 24.5 - 1.85 - 0.375 = 22.28\ ft$

Plate edges $h = .375$

$s = 4.5$

$A = 12(4s)h$

$= 12(4 \times 4.5).375$

$= 81\ ft^2$

Area of Gusset against col.

$A = 12 * 8 * h * t$

$= 12 * 8 * 1.25 * .083$

$= 10\ ft^2$

Gussets

$A = 12 * 8\left[\left(\frac{1}{2}hb\right) + (lt)\right]$

$= 12 * 8\left[\left(\frac{1}{2} * 1.25 * 1.25\right) + (1.77 * .083)\right]$

$= 89\ ft^2$

Gusset & plate area

$A = 81 + 89 - 10$

$= 160\ ft^2$

FIGURE 2

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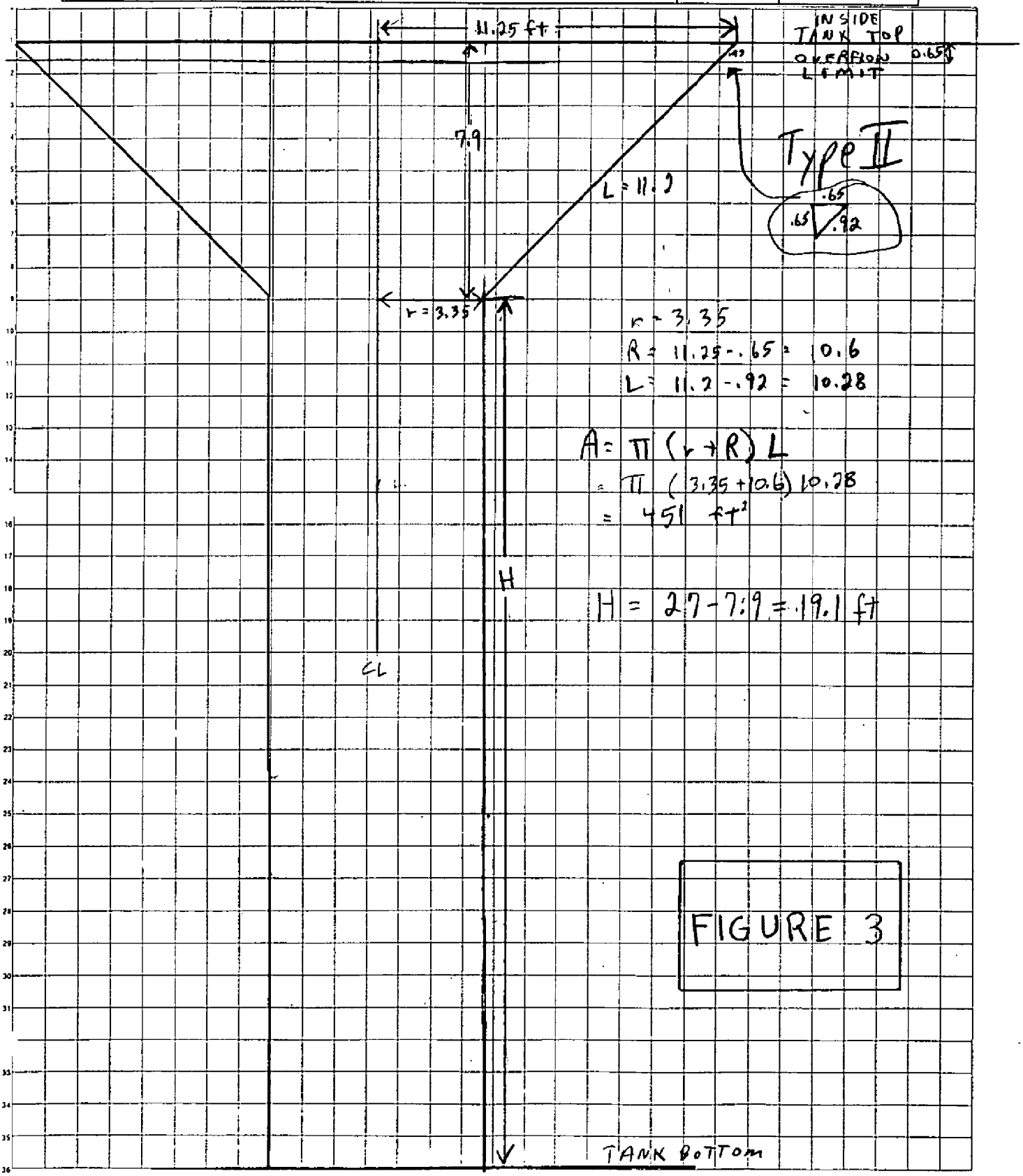

$r = 3.35$

$R = 11.25 - .65 = 10.6$

$L = 11.2 - .92 = 10.28$

$A = \pi (r + R) L$

$= \pi (3.35 + 10.6) 10.28$

$= 451 \text{ ft}^2$

$H = 27 - 7.9 = 19.1 \text{ ft}$

FIGURE 3