District I
1625 N. French Dr., Hobbs, NM 88240
District II
811 S. First St., Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Form C-147
Revised April 3, 2017

Recycling Facility Only

Type of action: ☐ Permit ☒ Registration ☐ Modification ☐ Closure ☐ Other (explain) _____

Be advised that approval of this request does not relieve the operator of liability should operations result in pollution of surface water, ground water or the environment. Nor does approval relieve the operator of its responsibility to comply with any other applicable governmental authority's rules, regulations or ordinances.

1.
Operator: COG Operating LLC (For multiple operators attach page with information) OGRID #: 229137
Address: 600 W. Illinois Ave. Midland, Texas 79707
Facility or well name (include API# if associated with a well): Dominator 25 Fed Com O CTB Recycle Facility
OCD Permit Number: 1RF-439 (For new facilities the permit number will be assigned by the district office)
U/L or Qtr/Qtr O Section 25 Township 25 S Range 33 E County: Lea
Surface Owner: ☒ Federal ☐ State ☐ Private ☐ Tribal Trust or Indian Allotment

2.
☒ **Recycling Facility:**
Location of recycling facility (if applicable): Latitude 32.096648 Longitude -103.525092 NAD83
Proposed Use: ☐ Drilling* ☒ Completion* ☐ Production* ☐ Plugging *
The re-use of produced water may NOT be used until fresh water zones are cased and cemented
☐ Other, ***requires permit for other uses. Describe use, process, testing, volume of produced water and ensure there will be no adverse impact on groundwater or surface water.***
☒ Fluid Storage
☒ Above ground tanks ☐ Activity permitted under 19.15.17 NMAC explain type
☐ Activity permitted under 19.15.36 NMAC explain type: ☐ Other explain
☐ **Closure Report (required within 60 days of closure completion):** ☐ **Recycling Facility Closure Completion Date:**

3.
Variances:
Justifications and/or demonstrations that the proposed variance will afford reasonable protection against contamination of fresh water, human health, and the environment.
Check the below box only if a variance is requested:
☐ Variance(s): Requests must be submitted to the appropriate division district for consideration of approval. If a Variance is requested, include the variance information on a separate page and attach it to the C-147 as part of the application.
If a Variance is requested, it must be approved prior to implementation.

4.
Operator Application Certification:
I hereby certify that the information and attachments submitted with this application are true, accurate and complete to the best of my knowledge and belief.
Name (Print): Tim Reed Title: Water Resource Analyst
Signature: Tim Reed Date: 11/19/18
e-mail address: treed@concho.com Telephone: 432-238-8599

5.
OCD Representative Signature: Randolph Ponfis **Approval/Registration Date:** 20Nov18
Title: Hydrologist **OCD Permit Number:** 1RF-439
☐ OCD Conditions
☐ Additional OCD Conditions on Attachment

CONCHO RECYCLED PRODUCED WATER SYSTEM OVERVIEW

Water will be sent to the Dominator 25 Fed Com O CTB pad site into one 60,000 bbl Buffer AST. Water will flow from the Buffer AST to the treatment system consisting of chemical treatment to reduce bacteria, total iron, H_2S, TPH and TSS.

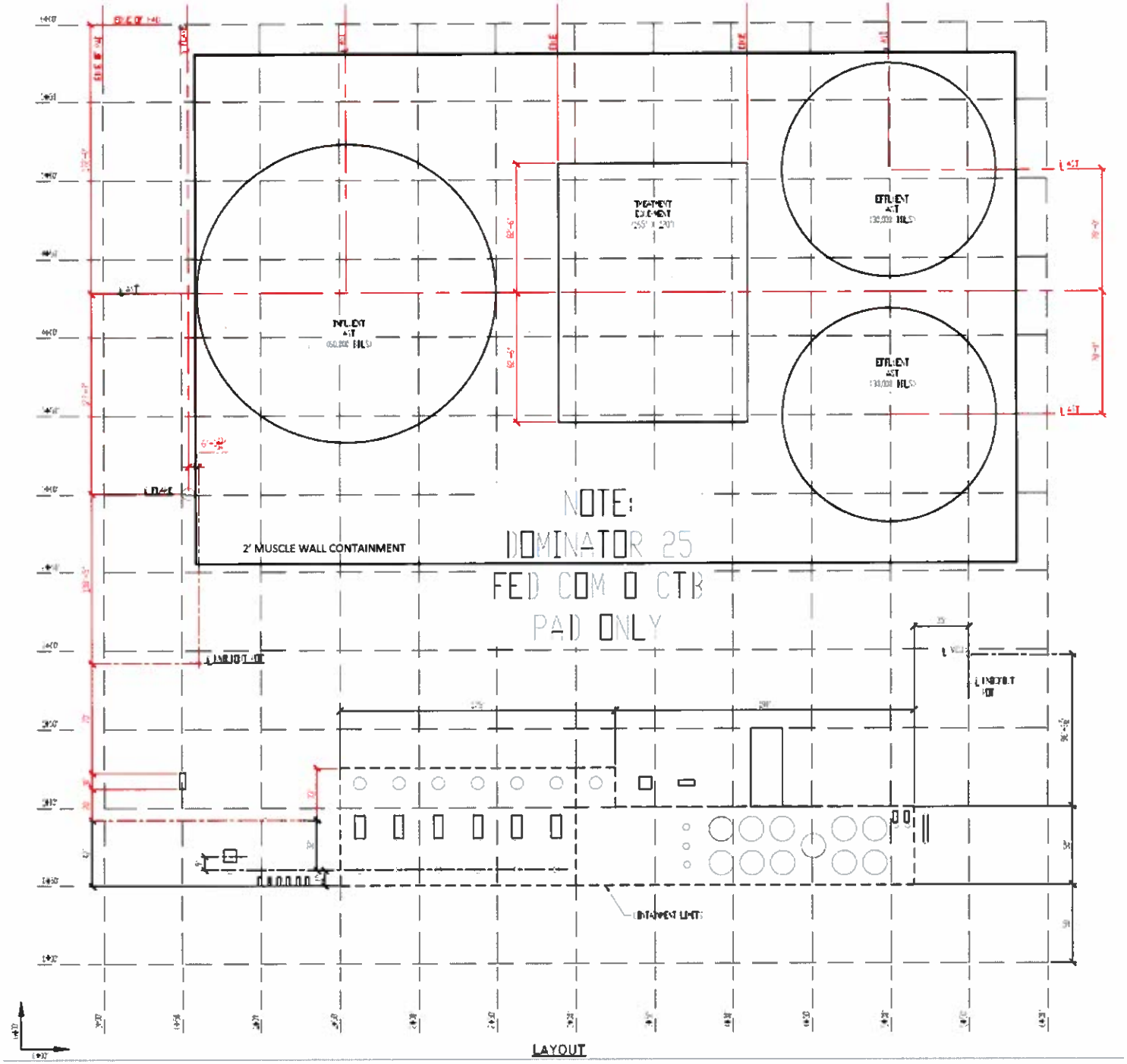
From there, the water will flow into a series of clarifier/solids control tanks and then through a series of weir tanks and final filtration before flowing into two 30,000 bbl Treated Water AST.

Both the Buffer Tank and the Treated Water Tanks will be double lined with 30 mil LLDPE liners equipped with an automated leak detection system. Both tanks will be placed on a protective cushion.

The entire treatment area including tanks, treating systems and blending manifold will be located inside a 30 mil LL lined containment measuring approximately 600' x 350' x 2'. The lined secondary containment system tank pad will have capacity in excess of the largest single tank with sufficient additional capacity to include a significant rainfall event.

The facility will be manned and monitored at all times during operation.

Used filters will be stored in a roll-off bin located at the tank pad and will be disposed of at an approved facility.


2' MUSCLE WALL CONTAINMENT
NOTE:
DOMINATOR 25
FED COM 0 CTB
PAD ONLY

LAYOUT

STEPHEN N. VALERO, P.E.
4010 New Chapel Hill Way, Cumming, GA 30041
P: 404-557-5884
E: svalero@Wall-Eval.com

March 19, 2015

Matt Smiley
General Manager -Fluids Management, Above-Ground Storage Tanks
Rockwater Energy Solutions
6000 Town Center Boulevard, Suite 165
Canonsburg, PA 15317

Subject: Transmittal - Analysis of Atlantis 48m +3, 18 Panel Above Ground Storage Tank

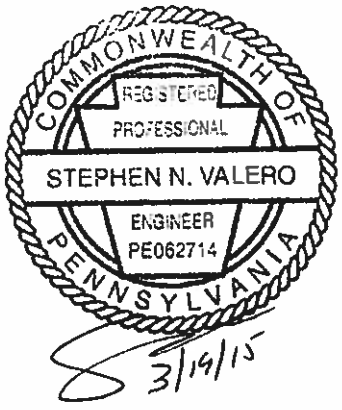
Dear Mr. Smiley:

As requested, I have analyzed the impact of adding three panels to the standard 48m Atlantis above ground storage tank such the resulting tank diameter is approximately 57.5m (188.6-ft). Results indicate that the loads imparted on the system by this configuration are within acceptable limits under the conditions analyzed. Key information related to this configuration is as follows:

- Minimum (Empty) Diameter: 188.46 ft
- Maximum (Full) Diameter: 188.60 ft
- Maximum (Full) Capacity: 59,721 BBL
- Capacity w/12-in Freeboard: 54,748 BBL
- Capacity w/24-in Freeboard: 49,774 BBL

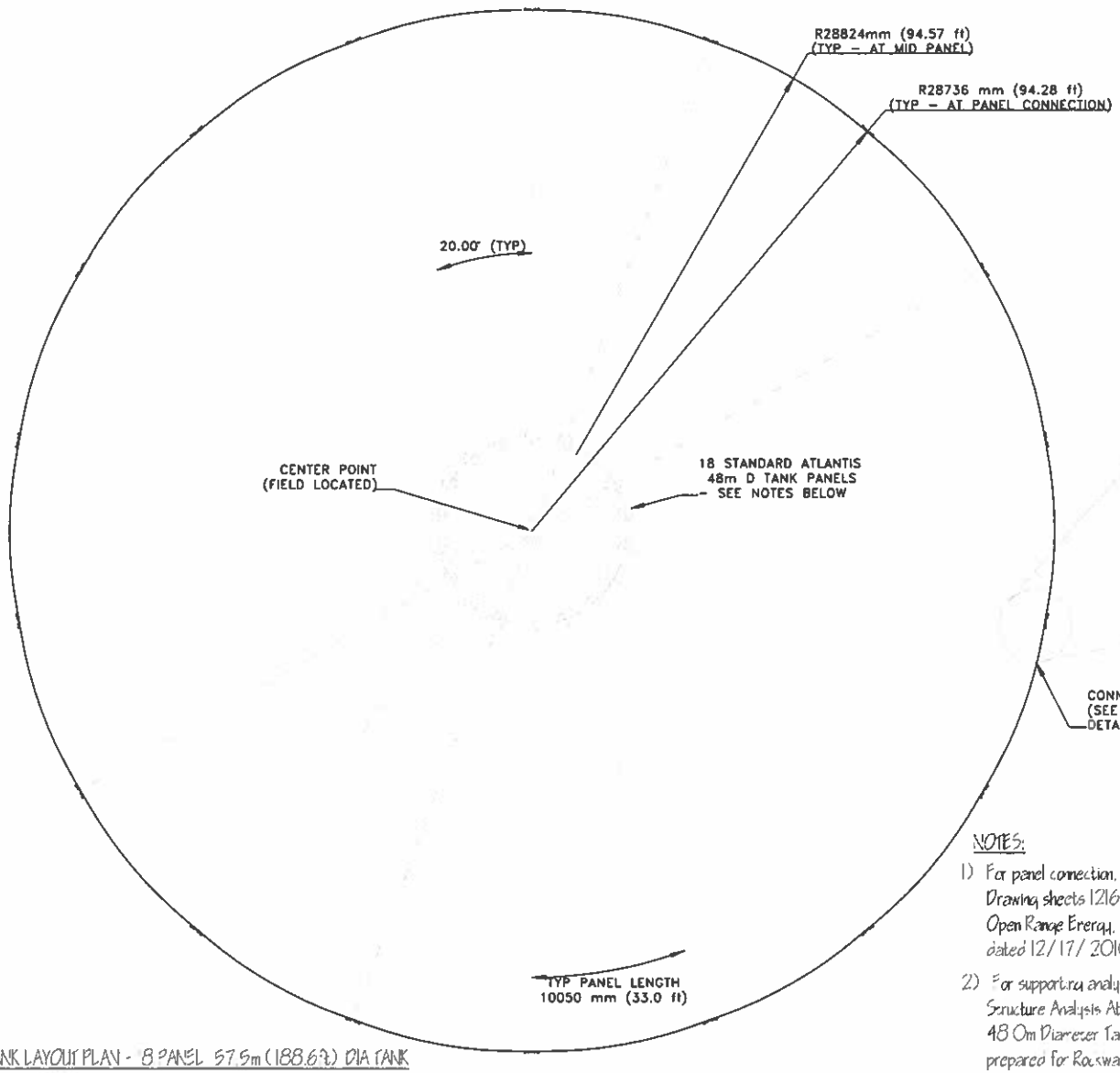
Supporting calculations and shop drawings listing the basis of the analysis, applicable codes and standards and limitations are provided in the Enclosure. Please review the analysis carefully to ensure that site specific conditions meet the limitations and assumptions of the analysis before installing this system. Thank you for the opportunity to work with you on this project. Please contact me if you have any questions or require additional information.

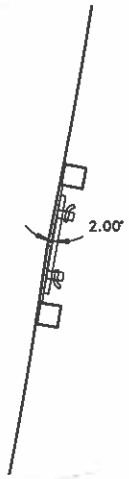
Sincerely,



Stephen N. Valero, P.E.
Enclosure: Supporting Calculations & Shop Drawings

Enclosure - Supporting Calculations & Shop Drawings





TANK LAYOUT PLAN - 18 PANEL 57.5m (188.6ft) DIA TANK

Scale 1" = 20'

NOTES:

1) For panel connection, assembly, and all other structural details refer to Drawing sheets 12167-S-001; 12167-S-002; and 12167-E-001 prepared for Open Range Energy, 48m Modular Water Tank by Beck Engineering, Ltd. dated 12/17/2010.

2) For supporting analysis of the tank configuration illustrated above refer to Tank Structure Analysis Atlantis 48m + 3 Tank - Constructed using 18 Standard Atlantis 48.0m Diameter Tank Panels for total Diameter of Approximately 57.5m (188.6ft) prepared for Rockwater Energy Soutions by Stephen N. Valero, P.E. dated 3/19/2015.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
STEPHEN N. VALERO
ENGINEER
PE062714
3/19/15

DESIGNED BY:
STEPHEN N. VALERO, P.E.

REVISION/ISSUE		
0	03/18/2015	SHOP DRAWINGS

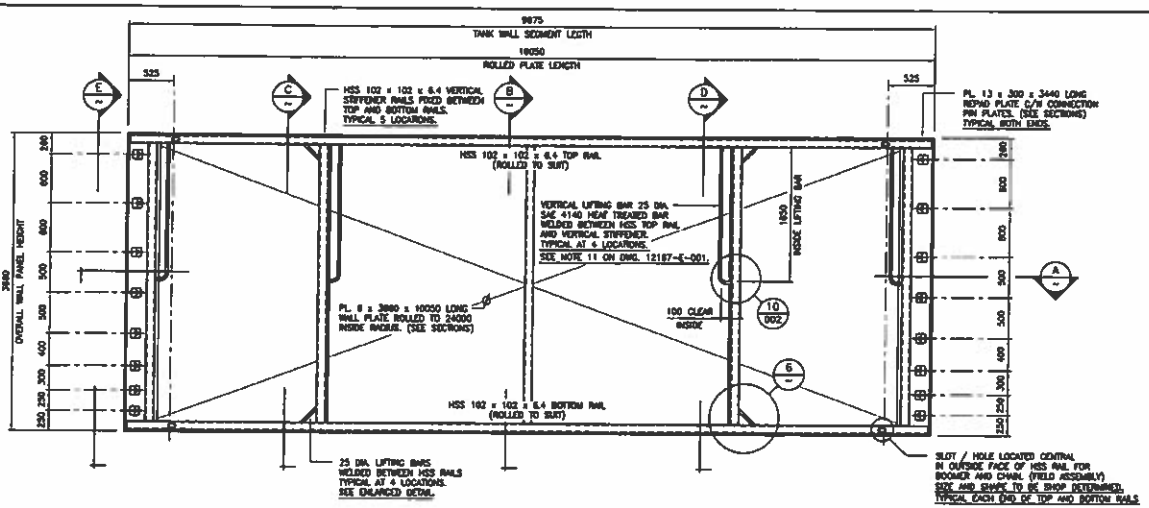
DESIGNED FOR:
ROCKWATER ENERGY SOLUTIONS
6000 Town Center Boulevard, Suite 165
Canonsburg, Pennsylvania 15317

Filename: 2014098 Drawings 03-01-15.TCW

Scale 1" = 20'	Project No. 2014098	Date Drawn 03/18/2015
Designed By SNV	Drawn By LDV	Checked By SNV

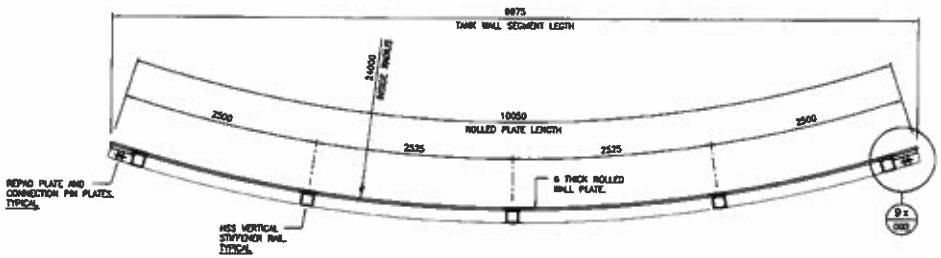
ATLANTIS 48M (+3) 18 PANEL TANK
57.5 m (188.6 ft) DIA
59,721 BBL MAX CAPACITY

TANK LAYOUT PLAN | SH1

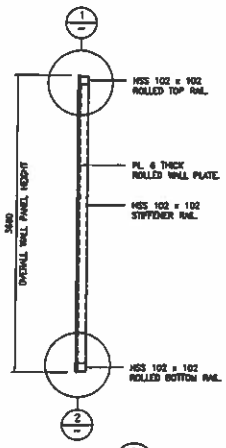


ELEVATION – SHOWING FRAMING TO OUTSIDE FACE OF WALL PANEL
SCALE 1 : 30

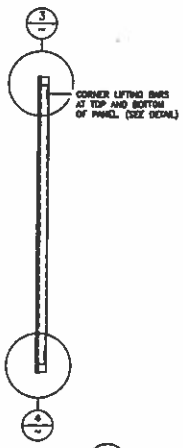
(x15 PANELS REQUIRED AS DRAWN)



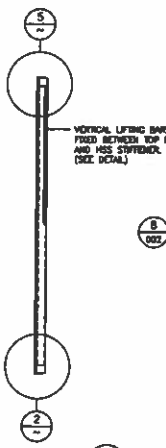
TYPICAL PLAN SECTION A
SCALE 1 : 30



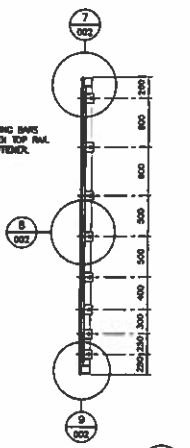
SECTION B
SCALE 1 : 30



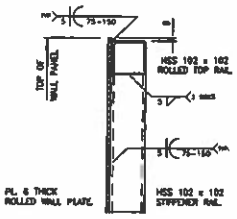
SECTION C
SCALE 1 : 30



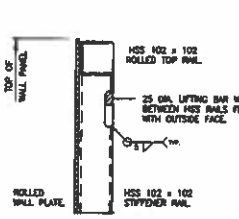
SECTION D
SCALE 1 : 30



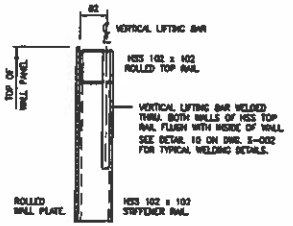
ELEVATION E
SCALE 1 : 30



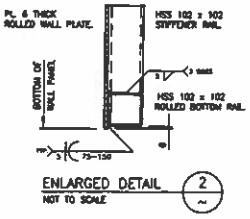
ENLARGED DETAIL 1
NOT TO SCALE



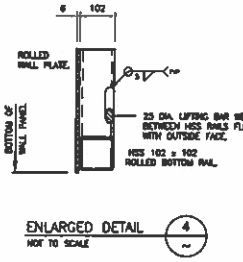
ENLARGED DETAIL 3
NOT TO SCALE



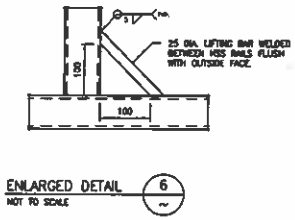
ENLARGED DETAIL 5
NOT TO SCALE



ENLARGED DETAIL 2
NOT TO SCALE



ENLARGED DETAIL 4
NOT TO SCALE



ENLARGED DETAIL 6
NOT TO SCALE

GENERAL NOTES :

1. STRUCTURAL STEEL DESIGN, FABRICATION AND ERECTION SHALL COMPLY WITH THE LATEST EDITION OF :
   - CSA-S16-01 LIMIT STATES DESIGN OF STRUCTURAL STEEL
   - CISC HANDBOOK OF STEEL CONSTRUCTION
   - CSA W59 WELDED STEEL CONSTRUCTION
2. MATERIALS SHALL CONFORM TO THE FOLLOWING GRADES OF CSA G40.21 :
   - HOLLOW STRUCTURAL SECTIONS – 350W
   - W SHAPES – 350W
   - C AND L SHAPES – 300W
   - PLATE AND ALL OTHER SECTIONS – 300W (Fy = 300 MPa / 44 KSI)
3. ALL WELDING SHALL BE IN ACCORDANCE WITH CSA W59-M 'WELDED STEEL CONSTRUCTION (METAL ARC WELDING)'.
4. FRAMING TO BE OF SOLID WELDED CONSTRUCTION (E-W000) COPE FRAMING MEMBERS INTO ONE ANOTHER.

PROFESSIONAL ENGINEER
PROVINCE OF ALBERTA
Beck

APEGGA PERMIT NO. 2042

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
12167-S-002	TANK WALL PANEL FRAMING DETAILS	A	ISSUED FOR REVIEW	14.12.10	RP	MH		
12167-E-001	TANK ASSEMBLY LAYOUT PLAN & SECTIONS	0	ISSUED FOR CONSTRUCTION	17.12.10	MH	MH		

FILE : 12167-S-001

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
MH	08.12.10	RP	11.12.10	MH	14.12.10

Client : OPEN RANGE ENERGY CORP

Project : 48m dia. MODULAR WATER TANK

TYPICAL TANK WALL PANEL
FRAMING PLAN, ELEVATION, SECTIONS & DETAILS

Job No.	Scale :	Dwg. No.	
12167	AS NOTED	12167-S-001	0

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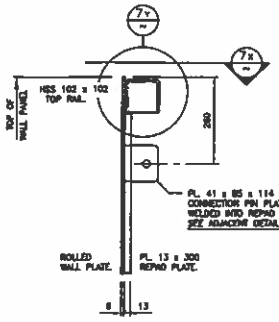
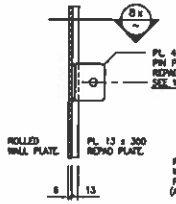
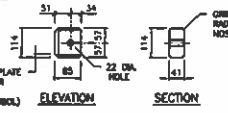
www.beckeng.ab.ca



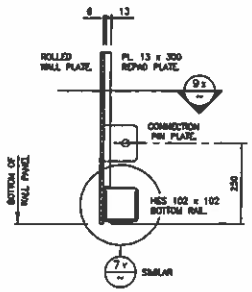
ENLARGED DETAIL 7 / 001
NOT TO SCALE



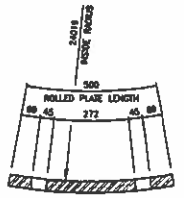
ENLARGED DETAIL 8 / 001
NOT TO SCALE



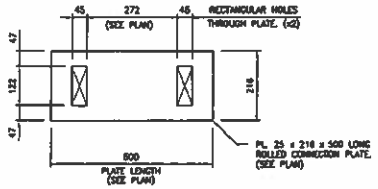
(x16 REQUIRED PER WALL PANEL)



ENLARGED DETAIL 9 / 001
NOT TO SCALE



PLAN
(EXAGGERATED SCALE)

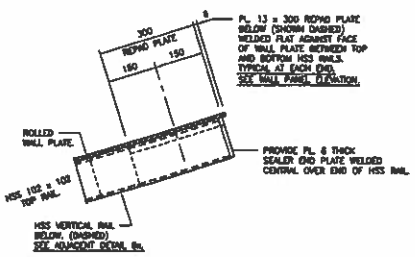


ELEVATION

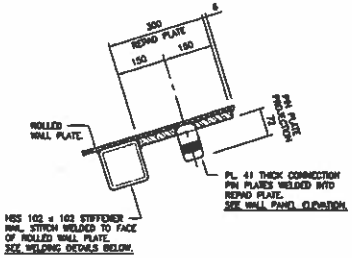
WALL PANEL CONNECTION PLATES

(x8 REQUIRED PER WALL PANEL)

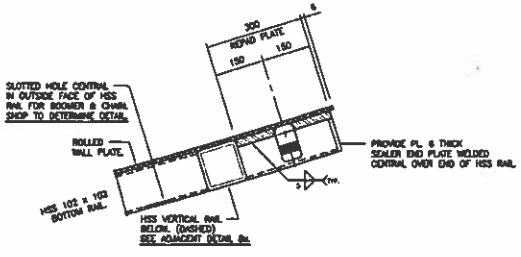
NOTE :
PAINT OUTSIDE FACE OF PLATE FOR IDENTIFICATION PURPOSES ONLY.



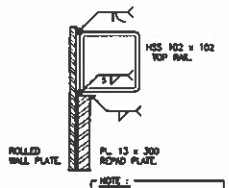
PLAN DETAIL 7X / ~
NOT TO SCALE



PLAN DETAIL 8X / ~
NOT TO SCALE

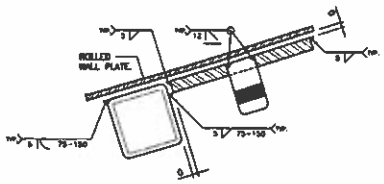


PLAN DETAIL 9X / ~
NOT TO SCALE

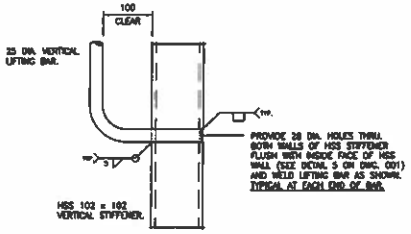


ENLARGED DETAIL 7Y / ~
NOT TO SCALE

EXPLODED TO SHOW WELD DETAILS.



ENLARGED TYPICAL PLAN – EXPLODED TO SHOW WELD DETAILS.
NOT TO SCALE



ENLARGED DETAIL 10 / 001
NOT TO SCALE

APEGGA PERMIT NO. 2042

NOTE :
REFER TO DRAWING 12167-S-001 FOR ALL MATERIAL SPECIFICATIONS AND CONSTRUCTION NOTES.

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
12167-S-001	TANK WALL PANEL FRAMING LAYOUTS	A	ISSUED FOR REVIEW	14.12.10	RP	MH		
		0	ISSUED FOR CONSTRUCTION	17.12.10	MH			

FILE : 12167-S-002

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
MH	08.12.10	RP	11.12.10	MH	14.12.10

Client : OPEN RANGE ENERGY CORP
Project : 48m dia. MODULAR WATER TANK
TYPICAL TANK WALL PANEL FRAMING SECTIONS AND DETAILS

Job No.	Scale :	Dwg. No.	
12167	AS NOTED	12167-S-002	0

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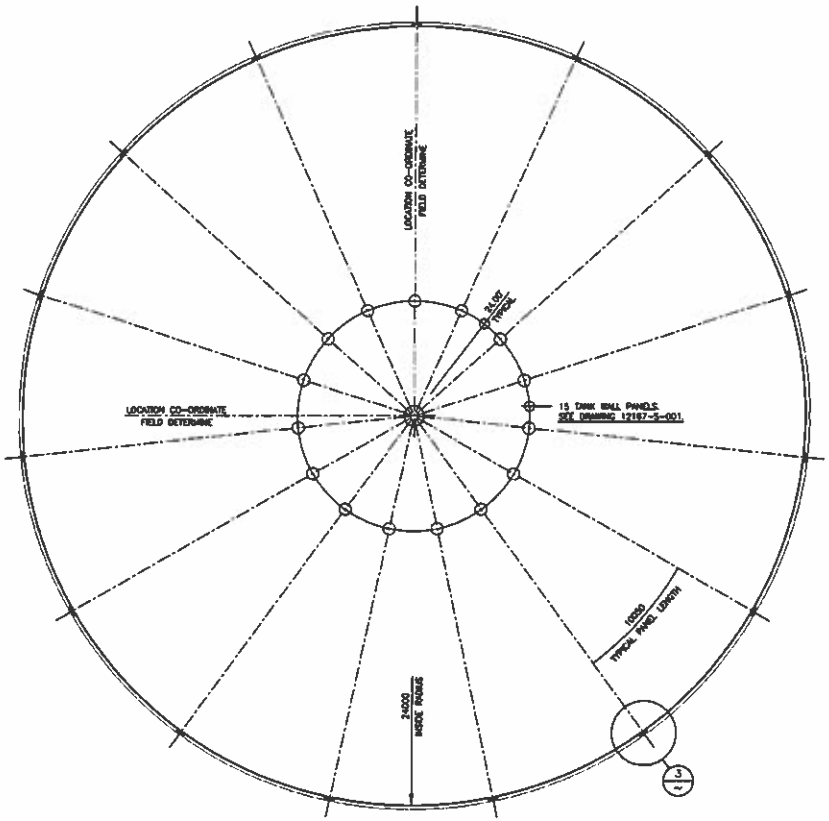
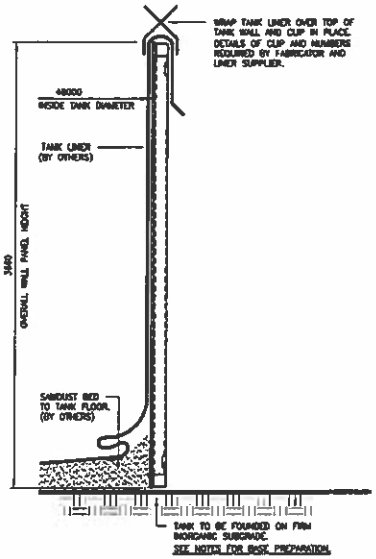
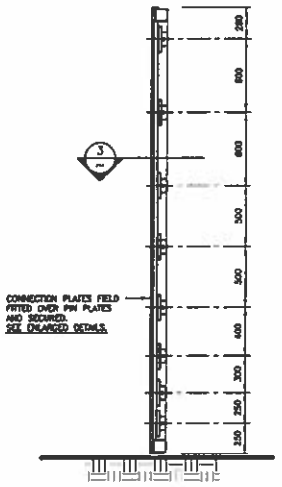


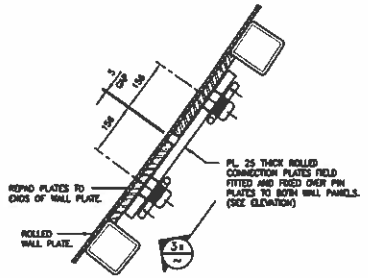
TANK LAYOUT PLAN
SCALE 1 : 75
A



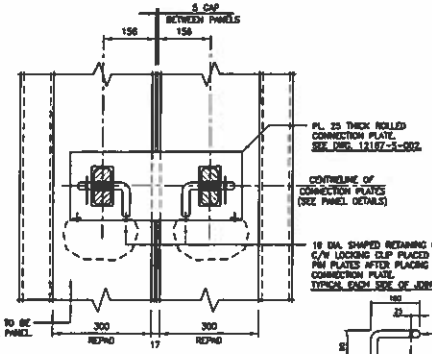
TYPICAL TANK WALL SECTION
SCALE 1 : 20
1



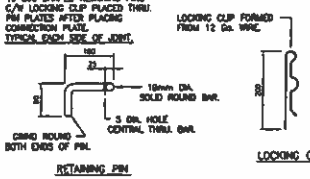
WALL SECTION AT PANEL JOINT
SCALE 1 : 20
2



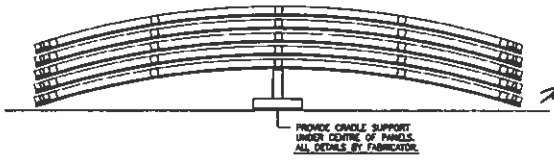
ENLARGED PLAN DETAIL
NOT TO SCALE
3



ENLARGED ELEVATION
NOT TO SCALE
3x



SUGGESTED PIN AND CLIP DETAILS
SHOP TO CONFIRM ALL DETAILS



TRANSPORT AND STORAGE DETAILS
NOT TO SCALE

APEGGA PERMIT NO. 2042

NOTES :

1. CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR THE STABILITY OF THE STRUCTURE AND FOR THE SAFETY OF ALL PERSONNEL DURING ASSEMBLY AND DISASSEMBLY. ALL WORK SHALL BE IN STRICT ACCORDANCE WITH OCCUPATIONAL HEALTH AND SAFETY REGULATIONS.
2. THE CONTRACTOR SHALL ENSURE ALL THE PANELS ARE ADEQUATELY SUPPORTED OR BRACED UNTIL THE ENTIRE STRUCTURE IS ASSEMBLED.
3. ALL TOPSOIL, ORGANICS, SOFT OR WET SOILS, DEBRIS OR OTHER DELETERIOUS MATERIALS SHALL BE REMOVED FROM THE TANK SITE.
4. THE FINISHED GRADES ALONG THE PERIMETER OF THE TANK SHALL BE LEVEL AND TRUE TO PLANE. THE MAXIMUM ELEVATION DIFFERENCE ACROSS ANY TWO DIAMETRICAL POINTS SHALL BE LESS THAN 250mm.
5. THE MAXIMUM DEVIATION FROM PLANE OVER ANY 3.0 METERS OF CIRCUMFERENCE SHALL BE LESS THAN 5mm AND LESS THAN 12mm OVER ANY 10.0 METERS OF CIRCUMFERENCE.
6. THE AREA SURROUNDING THE TANKS SHALL BE GRADED TO DIRECT SURFACE WATER AWAY FROM THE TANK.
7. THE EDGE OF ANY (EXCAVATED) SUMP SHALL BE A MINIMUM OF 900mm FROM THE EDGE OF THE TANK WALL.
8. THE PANELS SHALL BE ERECTED PLUMB. THE MAXIMUM OUT-OF-PLUMBNESS OF THE TOP OF THE PANEL RELATIVE TO THE BOTTOM SHALL BE LESS THAN 25mm.
9. THE MAXIMUM DEVIATION FROM THE THEORETICAL RADIUS SHALL BE LESS THAN 50mm AT ANY POINT ALONG THE TANK WALL.
10. THE LINER SHALL BE SECURELY FASTENED TO THE TOP OF EACH PANEL IN ACCORDANCE WITH THE LINER'S MANUFACTURER'S RECOMMENDATIONS. THE LINER SHALL BE INSTALLED WITH SUFFICIENT SLACK AT THE BASE OF THE PANEL TO PREVENT ANY TENSION IN THE LINER.
11. THE VERTICAL LIFTING BAR SHALL ONLY BE USED TO LIFT THE PANELS INTO THE VERTICAL POSITION. THE LIFT RIGGING MUST BE WITHIN 250mm OF THE TOP RAIL PRIOR TO LIFTING THE PANEL.

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
12167-S-001	TANK WALL PANEL FRAMING LAYOUTS	A	ISSUED FOR REVIEW	14.12.10	RP	MH		
12167-S-002	TANK WALL PANEL FRAMING DETAILS	0	ISSUED FOR CONSTRUCTION	17.12.10	MH			

FILE : 12167-E-001

ENGINEER AND PERMIT STAMPS

Designed	Date	Drawn	Date	Checked	Date
MH	08.12.10	RP	11.12.10	MH	14.12.10

Client : OPEN RANGE ENERGY CORP

Project : 48m dia. MODULAR WATER TANK

TANK INSTALLATION AND ASSEMBLY
LAYOUT PLAN, SECTIONS AND DETAILS

Job No.	Scale	Dwg. No.	
12167	AS NOTED	12167-E-001	0

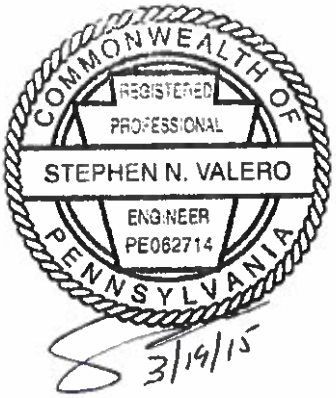
Beck
ENGINEERING (1992) LTD.
www.beckeng.ab.ca

Tank Structure Analysis
Atlantis 48m +3 Tank - Constructed using 18 Standard Atlantis 48.0m Diameter Tank Panels for total Diameter of Approximately 57.5m (188.6ft)

Date: 3/19/2015

Prepared for:

Rockwater Energy Solutions
6000 Town Center Blvd, Suite 165
Canonsburg, PA 15317



Prepared by:

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P: 404-557-5884 | F: 678-807-2902
E: svalero@Wall-Eval.com

PROBLEM STATEMENT:

Evaluate the feasibility of using standard panels designed for the Atlantis 48m diameter tank to construct a 51.2m diameter tank by adding 1 panel from the standard set up configuration (Atlantis 48m +1). The analysis that follows will consider the adequacy of the following parts of the tank configuration:

1) Wall shell capacity
2) Wall panel connection assembly capacity
3) Impact of difference in tank radius and panel radius of curvature on system

Adequacy of lifting hooks, etc. will not be evaluated as this is not changed from standard Atlantis 48m tank.

INPUT INFORMATION:

Tank & Panel Geometry

$L := 10050mm = 32.97\ ft$ Single wall panel length, per Ref 1

$H := 3.66m = 12.01\ ft$ Tank height, per Ref 1

$n := 18$ Number of Panels used to construct tank, per Ref 2

$Gap := 5mm = 0.02\ ft$ Gap between panel shells when tank is in service, per Ref 1

$\alpha_{org} := 24deg$ Original sector angle for panels in standard configuration, per Ref 1

$C_{org} := 9975mm = 32.73\ ft$ Chord length of panels, per Ref 1

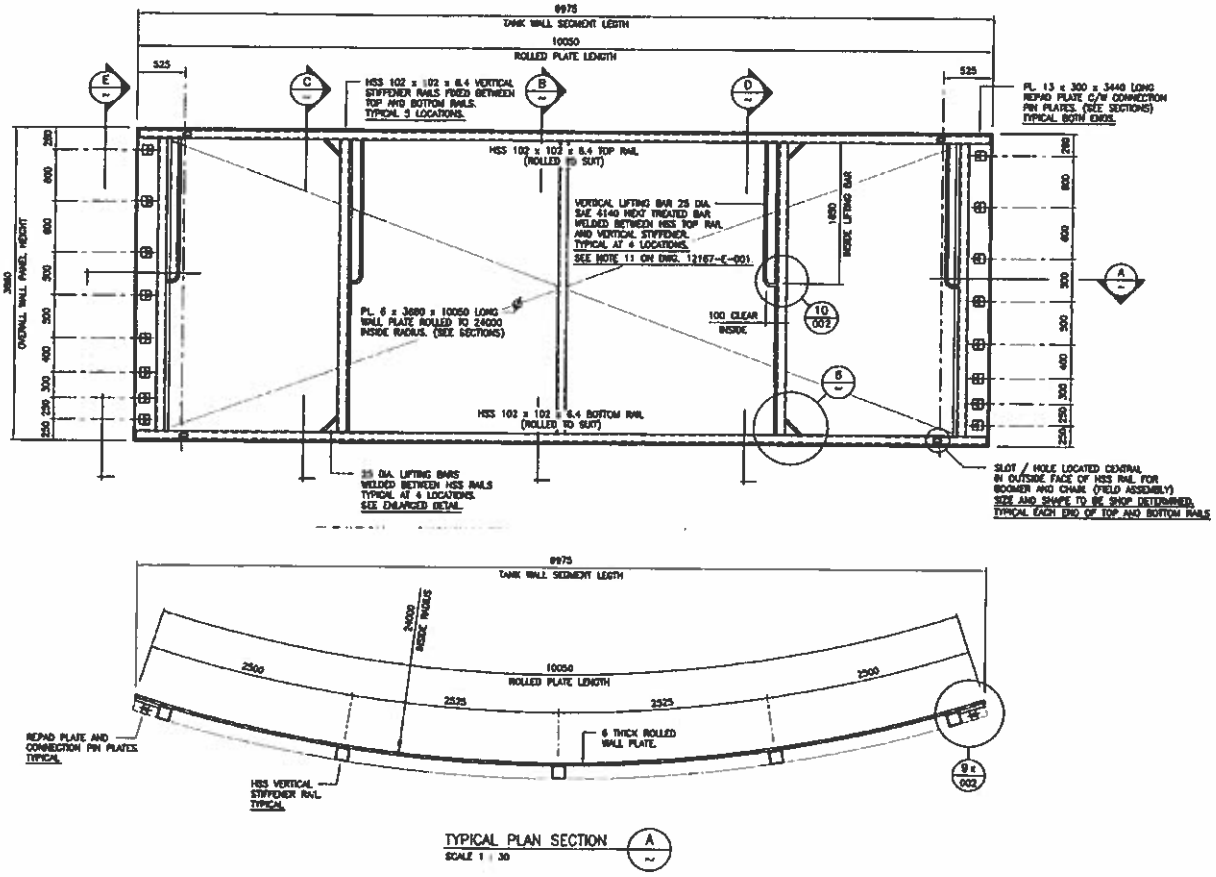
$c := 8$ Number of connection pin plates per panel side, per Ref 1

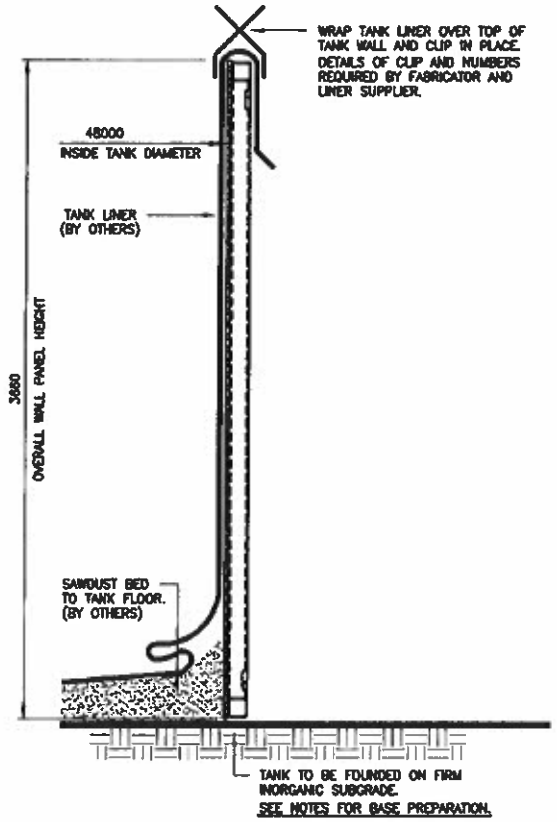
$i := 1 .. c + 1$

$d_i :=$ Vertical distances between connection pin points on panel, per Ref 1

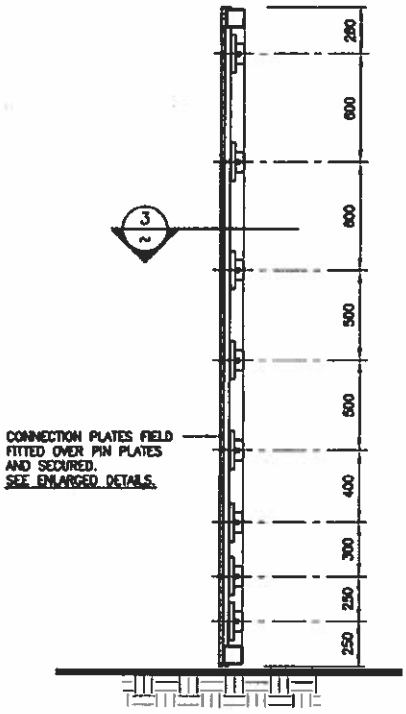
260mm	Top of Panel to Con 1
600mm	Con 1 to Con 2
600mm	Con 2 to Con 3
500mm	Con 3 to Con 4
500mm	Con 4 to Con 5
400mm	Con 5 to Con 6
300mm	Con 6 to Con 7
250mm	Con 7 to Con 8
250mm	Con 8 to Bottom of Panel

Tank Panel Layout and Connection Details are as follows, After Ref 1:

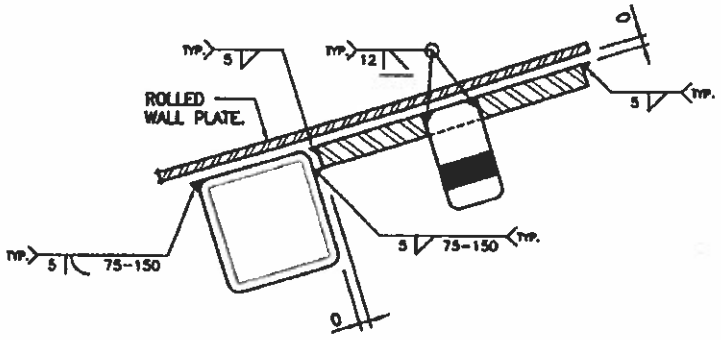




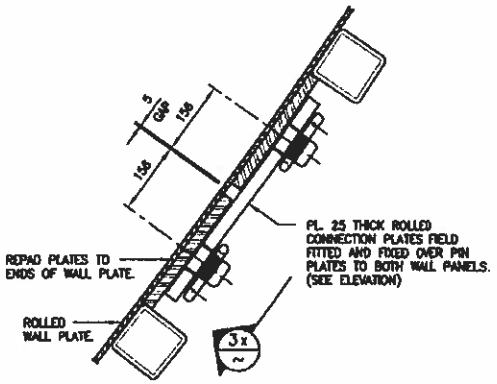
TYPICAL TANK WALL SECTION (1) SCALE 1 : 20



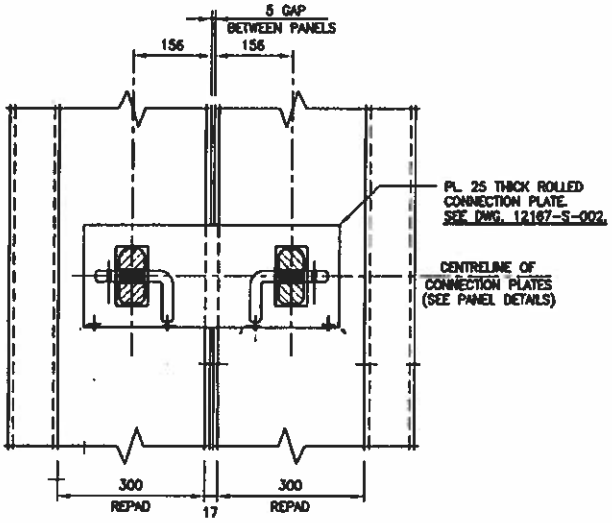
WALL SECTION AT PANEL JOINT (2) SCALE 1 : 20



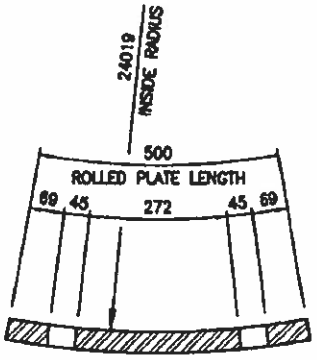
ENLARGED TYPICAL PLAN – EXPLODED TO SHOW WELD DETAILS.
NOT TO SCALE



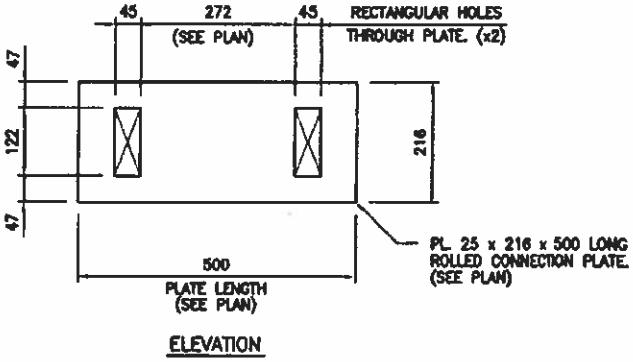
ENLARGED PLAN DETAIL 3 NOT TO SCALE



ENLARGED ELEVATION 3x NOT TO SCALE

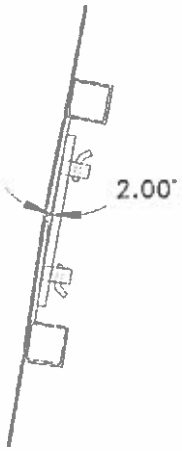


PLAN
(EXAGGERATED SCALE)



ELEVATION

WALL PANEL CONNECTION PLATES
(x8 REQUIRED PER WALL PANEL)



The figure to the right shows the impact on tank/connection roundness due to the difference in panel radius of curvature and tank curvature due to changing the number of standard panels used. By inspection, the impact of this geometry is insignificant with regard to mid-panel bending failure. However, the small angle between the connection plate and repad plate will be taken into consideration when calculating maximum stress to be carried by the connection assembly.

$\beta := 2.0\text{deg}$ Angle between connection plate and repad plate for this tank configuration

Tank shell, Repad Plate, Connection Pin Plate and Connection Plate Steel Specifications

$Steel := "CSA\ G40.21\ 300W\ Steel"$ Steel specification, per Ref 1

$Fu := 450MPa = 65266.98\,psi$ Ultimate strength, per Ref 3

$Fy := 300MPa = 43.51 \cdot ksi$ Yield strength, per Ref 3

Tank shell/rail specifications:

$t_{shell} := 6mm = 0.24 \cdot in$ Thickness, per Ref 1

$d_{rail} := 102mm = 4.02 \cdot in$ Depth of top/bottom rails connected to shell

Repad plate specifications:

$t_{rpad} := 13mm = 0.51 \cdot in$ Thickness, per Ref 1

$de_{rpad} := 129.5mm = 5.1 \cdot in$ Distance from connection pin plate hole to outside edge of plate, per Ref 1

$b_{rpad} := 300mm = 11.81 \cdot in$ Width of repad plate, per Ref 1

$d_{rpad} := 3440mm = 135.43 \cdot in$ Length of repad plate, per Ref 1

$s_{rpad} := 5mm = 0.2 \cdot in$ Weld leg dimension for fillet welds between repad plate and shell, per Ref 1

Connection pin plate specifications

$t_{pin} := 41mm = 1.61 \cdot in$ Thickness, per Ref 1

$h_{pin} := 114mm = 4.49 \cdot in$ Height, per Ref 1

$dph_{pin} := 27mm = 1.06 \cdot in$ Distance from repad to inside of retaining pin hole, Per Ref 1

Connection plate specifications:

$t_{cplate} := 25mm = 0.98 \cdot in$ Thickness, per Ref 1

$h_{cplate} := 216mm = 8.5 \cdot in$ Height, per Ref 1

$de_{cplate} := 69mm = 2.72 \cdot in$ Distance from pin hole to outside edge of plate, per Ref 1

$h_{pinhole} := 122mm = 4.8 \cdot in$

$w_{pinhole} := 45mm = 1.77 \cdot in$ Dimensions of pin hole slots in connection plate, per Ref 1

ASSUMPTIONS:

The following assumptions were required in order to complete this analysis:

$Freeboard := 0ft$ Maximum permissible liquid depth (overflow condition)

$G_s := 1.0$ Specific gravity of contained liquid, assumed to be fresh water

$\gamma_{water} := 62.4pcf$ Unit weight of water

Resisting forces are provided by hoop tension in the wall panels/connections only.

$F_{E60} := 413MPa = 59.9 \cdot ksi$ 60 ksi electrodes used for all arc welding

The applied liquid pressure is considered a dead load as its maximum depth is limited by the maximum height of the tank walls. It is highly unlikely that the tank would remain full to the struck capacity for an extended period. Therefor, the following load factor will apply throughout these calculations

$LF := 1.4$

The only load applied to the system is due to the contained liquid. This analysis does not consider:

- Ice load
- Wind load
- Impact load
- Seismic load
- or any other potential internal/external load.

It is assumed that the tank is installed properly, on firm, level ground and that all steel, welds, etc. are in good condition.

REFERENCES:

1) Drawing sheets 12167-S-001; 12167-S-002; and 12167-E-001 prepared for Open Range Energy, 48m Modular Water Tank by Beck Engineering, Ltd. dated 12/17/2010.

2) CSA G40.20-13/G40.21-13 - General requirements for rolled or welded structural quality steel / Structural quality steel.

3) AISC Manual of Steel Construction, 13th Ed.

CALCULATIONS:

1) Determine the average (design) diameter of the tank:

$\alpha := \frac{360deg}{n} = 20 \cdot deg$ Sector angle for each panel

$C_{tot} := C_{org} + Gap = 32.74\ ft$ Total segment length for each panel

$R := \frac{C_{tot}}{\sqrt{2 - 2\cos(\alpha)}} = 94.28\ ft$ New radius of tank constructed with n panels

$D := 2 \cdot R = 188.56\ ft$ Inside diameter of tank

2) Check stress level vs. capacity of tank shell:

$z_{cpshell} := H - Freeboard - d_{rail} = 140.08 \cdot in$ Depth from top of tank to top of bottom rail, critical unsupported point of tank shell

$\gamma := LF \cdot G_s \cdot \gamma_{water} = 87.36 \cdot pcf$ Factored unit weight of contained liquid

$Pcp_{shell} := (z_{cpshell} - Freeboard) \cdot \gamma = 7.08\ psi$ Maximum internal tank pressure at critical unsupported point in shell (between vertical stiffener rails and just above bottom rail).

$\sigma_{shell} := \frac{Pcp_{shell} \cdot D}{2 \cdot t_{shell}} = 33917.21\ psi$ Use diameter Equation to estimate hoop tensile stress in shell at critical point (valid since tshell/tank radius << 0.10)

$Ta_{shell} := \min(0.9 \cdot Fy, 0.75 \cdot Fu) = 39160.19\ psi$ Allowable axial tensile stress per Ref 4

$Check_{shell} := if(\sigma_{shell} < Ta_{shell}, "OK", "Shell thickness is insufficient")$

$Check_{shell} = "OK"$ Check shell thickness

3) Check stress level vs. capacity of panel connection assembly:

The connection assembly consists of: Repad plate welds to shell; repad plate, connection pins and connection plates.

3a) Check sufficiency of welds between repad plate and tank shell:

$Pmax_{rpad} := (H - Freeboard)\cdot\gamma = 7.28\,psi$

Maximum internal tank pressure at critical unsupported point in shell (between vertical stiffener rails and just above bottom rail).

$Tmax_{rpad} := \frac{\frac{1}{2}\cdot Pmax_{rpad}\cdot H\cdot D}{2} = 593786.38\,lbf$

Use Young-Laplace Equation to estimate total hoop tension to be transferred from shell to repad plate (valid since tshell/tank radius << 0.10)

$M_{rpad} := \left(\frac{H}{2} - \frac{H}{3}\right)\cdot Tmax_{rpad} = 14260223.97\cdot lbf\cdot in$

Torque on line welds transferring stress from shell to repad (5mm fillet along both sides)

$C := \frac{\sqrt{b_{rpad}^{2} + d_{rpad}^{2}}}{2} = 67.97\cdot in$

Distance from neutral axis to extreme fibers of welds

$J_w := \frac{H}{6}\cdot\left(3b_{rpad}^{2} + d_{rpad}^{2}\right) = 450550.26\cdot\frac{in^4}{in}$

Polar moment of inertia of line welds

$f := \frac{M_{rpad}\cdot C}{J_w} = 2151.41\cdot\frac{lbf}{in}$

Force of extreme fibers of welds

$f_t := 0.75\left(0.6F_{E60}\right)\cdot\left(s_{rpad}\cdot 0.707\right) = 3751.45\cdot\frac{lbf}{in}$

Maximum allowable stress of welds

$Check_{rpadwelds} := if\left(f < f_t, "OK", "Welds\ insufficient"\right)$

$Check_{rpadwelds} = "OK"$

Check repad plate welds

3b) Determine critical connection pin location and load:

$j := 2 .. c - 1$

$z_0 := 0in \qquad z_1 := d_1 + \frac{d_2}{2}$

$z_j := z_{j-1} + \left(\frac{d_j + d_{j+1}}{2} \right)$

Depth from top of wall panel to the bottom of contributory load area carried by each connection plate/pin set:

$z_8 := z_7 + \frac{d_8}{2} + d_9$

$j := 0 .. c$

$z_j =$

0	in	Top of tank
22.05		Bottom of contributory area where load is carried by Connection 1
45.67		
67.32		
87.01		
104.72		
118.5		
129.33		
144.09		Bottom of contributory area where load is carried by Connection 8

$P_j := \text{if}\left[z_j - \text{Freeboard} > 0in, \gamma \cdot \left(z_j - \text{Freeboard} \right), 0psi \right]$

$P_j =$

0.00	psi	Top of tank
1.11		Con 1
2.31		Con 2
3.40		Con 3
4.40		Con 4
5.29		Con 5
5.99		Con 6
6.54		Con 7
7.28		Con 8

Pressure distribution inside tank at the bottom of contributory area carried by each connection point

$k := 1 .. c$

$$T_{con_k} := \left[P_{k-1}\cdot\left(z_k - z_{k-1}\right) + \frac{1}{2}\left(P_k - P_{k-1}\right)\cdot\left(z_k - z_{k-1}\right)\right]\cdot\frac{D}{2} = \ldots$$

Use Young-Laplace Equation to estimate total hoop tension to be transferred from repad plate to each connection (valid since tshell/tank radius << 0.10)

T_{con_k} =

13900.94	lbf	Con 1
45745.43		Con 2
69970.12		Con 3
86880.86		Con 4
97142.56		Con 5
87966.87		Con 6
76735.53		Con 7
115444.06		Con 8

Estimate of total tension carried at each connection point (actual load distribution is likely more evenly spread from repad plate to connections reducing total load carried by bottom connections). For this analysis, bottom connection will be considered critical and analyzed vs. total contribution load (conservative).

$T_{con} := T_{con_c} = 115444.06\ \text{lbf}$ Critical connection load, bottom connection

$T_{con} := \frac{T_{con}}{\cos(\beta)} = 115514.42\ \text{lbf}$ Effect of load vector due to change in geometry at connection point induced by difference in tank radius and radius of curvature of panels

$d_{rpad} := z_c - z_{c-1} = 14.76\cdot\text{in}$ Contributory length of repad plate carrying critical load

3c) Check the repad plate for sufficient strength to transfer critical load to connection pins:

$Ag_{rpad} := d_{rpad}\cdot t_{rpad} = 7.56\cdot\text{in}^2$ Theoretical gross section area subject to tension

$An_{rpad} := \left(d_{rpad} - h_{pin}\right)\cdot t_{rpad} = 5.26\cdot\text{in}^2$ Theoretical net section area subject to tension

$Ans_{rpad} := 2\cdot de_{rpad}\cdot t_{rpad} = 5.22\cdot\text{in}^2$ Theoretical net section area subject to shear (tear out)

$Tn_{rpad} := \min\left[0.9\cdot Fy\cdot Ag_{rpad}, 0.75\cdot Fu\cdot An_{rpad}, 0.75\cdot(0.6\cdot Fu)\cdot Ans_{rpad}\right] = 153278.67\ \text{lbf}$

Allowable tension on the repad considering yielding on the gross section, fracture on the net section and tear out.

$Check_{rpad} := \text{if}\left(T_{con} < Tn_{rpad}, \text{"OK"}, \text{"Repad insufficient"}\right)$

$Check_{rpad} = \text{"OK"}$ Check on thickness of repad plate

3d) Check the connection pin plates for sufficient strength to transfer critical load to connection plates.

$Rn_{pin} := 0.75 \cdot (0.6 \cdot Fu) \cdot h_{pin} \cdot t_{pin} = 212778.29\ lbf$ Allowable shear load on pin plate

$M_{pin} := T_{con} \cdot \left(dph_{pin} - \frac{t_{cplate}}{2} \right) = 65943.27 \cdot lbf \cdot in$ Factored maximum moment on pin plate at intersection with repad plate (critical point) under worst case conditions (plate contacts retaining pin)

$Mn_{pin} := 0.9 \cdot \frac{h_{pin} \cdot t_{pin}^{2}}{6} \cdot Fy = 76324.67 \cdot lbf \cdot in$ Allowable bending moment on pin plate

$Check_{pin} := if\left(T_{con} < Rn_{pin}, if\left(M_{pin} < Mn_{pin}, "OK", "Pin Insufficient"\right), "Pin Insufficient"\right)$

$Check_{pin} = "OK"$ Check on pin dimensions

3e) Check the connection plate for sufficient strength to transfer critical load from connection pins to next panel:

$Ag_{cplate} := h_{cplate} \cdot t_{cplate} = 8.37 \cdot in^2$ Gross section area subject to tension

$At_{cplate} := \left(h_{cplate} - h_{pinhole}\right) \cdot t_{cplate} = 3.64 \cdot in^2$ Net section area subject to tension

$Anbs_{cplate} := \left(de_{cplate} + \frac{h_{cplate} - h_{pinhole}}{2} \right) \cdot t_{cplate} = 4.5 \cdot in^2$ Net section area subject to block shear (tear out)

$Avg_{cplate} := \left(de_{cplate} + \frac{w_{pinhole}}{2} \right) \cdot t_{cplate} = 3.55 \cdot in^2$ Gross section area subject to shear yield

$Atg_{cplate} := \left(\frac{h_{cplate}}{2} \right) \cdot t_{cplate} = 4.19 \cdot in^2$ Gross section area subject to tensile yield

$Ans_{cplate} := de_{cplate} \cdot t_{cplate} = 2.67 \cdot in^2$ Net section area subject to shear fracture

$Ant_{cplate} := \left(\frac{h_{cplate} - h_{pinhole}}{2} \right) \cdot t_{cplate} = 1.82 \cdot in^2$ Net section area subject to tensile fracture

$Tngen_{cplate} := \min\left(0.9 \cdot Fy \cdot Ag_{cplate}, 0.75 \cdot 1.0Fu \cdot At_{cplate}\right) = 178301.59\ lbf$ Allowable general yield/fracture limit tension

$Tnbs_{cplate} := 0.75 \cdot (0.6 \cdot Fu) \cdot Anbs_{cplate} = 132019.05\ lbf$ Allowable block shear tension

$Tnsy_{cplate} := \min\left[0.75 \cdot \left(0.6Fy \cdot Avg_{cplate} + Fu \cdot Ant_{cplate}\right), 0.75 \cdot \left(0.6Fu \cdot Ans_{cplate} + Fy \cdot Atg_{cplate}\right)\right] = 158574.61\ lbf$

Allowable yield/fracture tension

$Tn_{cplate} := \min(Tngen_{cplate}, Tnbs_{cplate}, Tnsy_{cplate}) = 132019.05\ lbf$ Block shear controls

$Check_{cplate} := if(T_{con} < Tn_{cplate}, "OK", "Connection plate insufficient")$

$Check_{cplate} = "OK"$ Check on dimensions of connection plate

4) Summary of final Capacity and Dimensions

$D = 188.56\ ft$ Design inside diameter of tank

$\alpha = 20 \cdot deg$ Arc intersected by each panel

$D_{min} := \frac{2C_{org}}{\sqrt{2 - 2\cos(\alpha)}} = 188.46\ ft$ Minimum inside diameter of tank when empty

$D_{max} := \frac{2\left[C_{tot} + \left(\frac{w_{pinhole} - t_{pin}}{2}\right)\right]}{\sqrt{2 - 2\cos(\alpha)}} = 188.60\ ft$ Maximum inside diameter of tank when full

$Freeboard = 0 \cdot in$ Design freeboard used in analysis

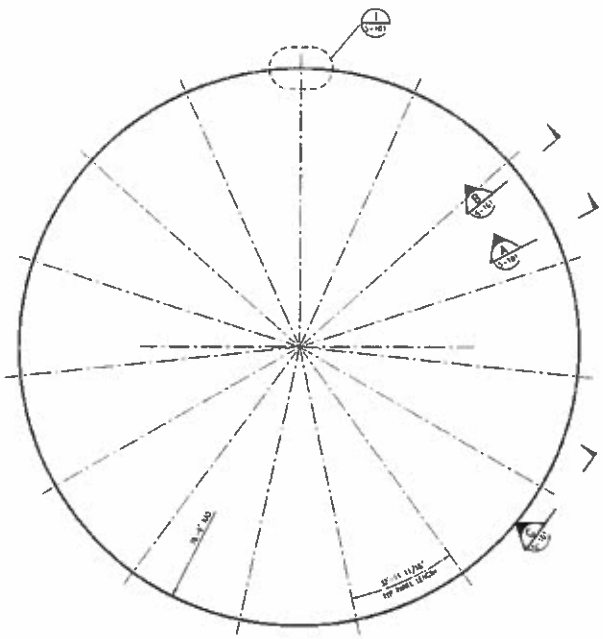
$V_{design} := (H - Freeboard) \cdot \frac{\pi \cdot D^2}{4} = 59721 \cdot BBL$ Design capacity (No freeboard)

$V_{max} := H \cdot \pi \cdot \frac{D^2}{4} = 59721 \cdot BBL$ Maximum capacity (filled to top)

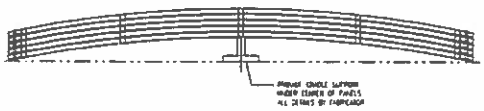
Design capacity (with varying freeboard):

$Freeboard := 12in$ $V_{design} := (H - Freeboard) \cdot \frac{\pi \cdot D^2}{4} = 54748 \cdot BBL$

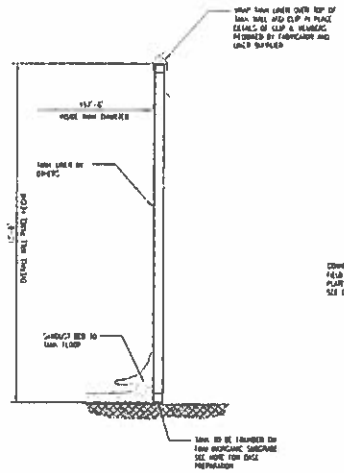
$Freeboard := 24in$ $V_{design} := (H - Freeboard) \cdot \frac{\pi \cdot D^2}{4} = 49774 \cdot BBL$



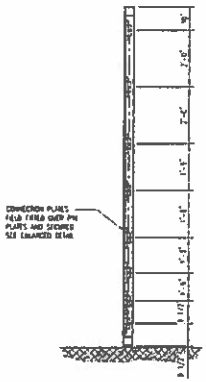
TANK LAYOUT PLAN
1/16"=1'-0"



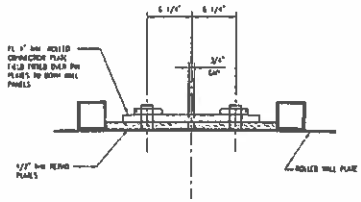
TRANSPORT AND STORAGE DETAILS
1/4"=1'-0"



A TYPICAL TANK WALL SECTION
1/2"=1'-0"

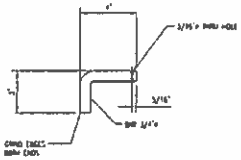


B SECTION AT WALL PANEL JOINT
1/2"=1'-0"

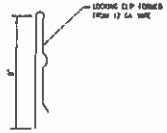


1 DETAIL AT WALL PANEL JOINT
1 1/2"=1'-0"

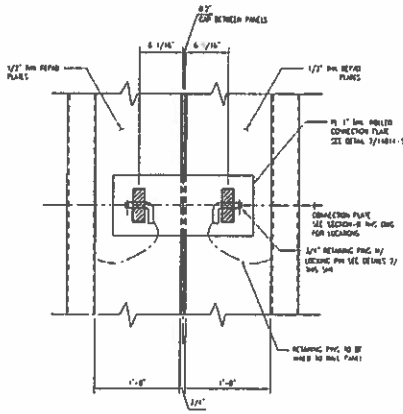
2/14/14
COLORADO LICENSED
KIM GAZDIK
47107
PROFESSIONAL ENGINEER



2 DETAIL RETAINING PIN
3"=1'-0"
16 REQUIRED PER PANEL



3 DETAIL LOCKING CLIP
3"=1'-0"
16 REQUIRED PER PANEL



C ENLARGED SECTION AT WALL PANEL JOINT
1 1/2"=1'-0"

NOTES:
1. CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR THE STRUCTURE AND FOR THE SAFETY OF ALL PERSONS DURING ASSEMBLY AND DISASSEMBLY. ALL WORK SHALL BE IN ACCORDANCE WITH OSHA.
2. THE CONTRACTOR SHALL ENSURE ALL THE PANELS ARE ADEQUATELY SUPPORTED OR BRACED UNTIL THE ENTIRE STRUCTURE IS ASSEMBLED
3. ALL TOPSOIL ORGANICS SOFT OR WET SOIL DEBRIS OR OTHER DELETERIOUS MATERIALS SHALL BE REMOVED FROM THE TANK SITE.
4. THE FINISHED GRADES ALONG THE PERIMETER OF THE TANK SHALL BE LEVEL AND TRUE TO PLANE. THE MAXIMUM ELEVATION DIFFERENCE ALONG ANY TWO CONSECUTIVE POINTS SHALL BE LESS THAN 1/8".
5. THE MAXIMUM DEVIATION FROM PLANE OVER ANY 10'-0" OF CIRCUMFERENCE SHALL BE LESS THAN 1/4" AND LESS THAN 1/2" OVER ANY 32'-0" OF CIRCUMFERENCE
6. THE AREA IMMEDIATELY INSIDE THE TANK SHALL BE GRADED TO DIRECT SURFACE WATER AWAY FROM TANK.
7. THE EDGE OF ANY EXCAVATION SUMP SHALL BE A MINIMUM OF 3'-0" FROM THE EDGE OF THE TANK WALL
8. THE PANELS SHALL BE CHECKED PLUMB, THE MAXIMUM OUT-OF-PLUMBNESS OF THE TOP OF THE PANEL RELATIVE TO THE BOTTOM SHALL BE LESS THAN 1"
9. THE MAXIMUM DEVIATION FROM THE HORIZONTAL WORKS SHALL BE LESS THAN 3" AT ANY POINT ALONG THE WALL
10. THE LINER SHALL BE SECURELY FASTENED TO THE TOP OF EACH PANEL IN ACCORDANCE WITH THE LINER'S MANUFACTURER'S RECOMMENDATIONS. THE LINER SHALL BE INSTALLED WITH SUFFICIENT SLACK AT THE BASE OF THE PANEL TO PREVENT ANY TENSION ON THE LINER
11. THE VERTICAL LIFTING BARS SHALL ONLY BE USED TO LIFT THE PANELS AND THE VERTICAL PORTION, THE LIFT HOLE BE WITHIN 18" OF THE TOP EAR PRIOR TO LIFTING THE PANEL
12. A MINIMUM 12" FREEBOARD SHALL BE PROVIDED WHEN TANK IS FILLED FOR NORMAL FLUID DEPTH OF 11'

NOTES:
1. ALL PLATE SHALL CONFORM TO ASTM A-36 SPECIFICATION
2. STRUCTURAL TUBING SHALL CONFORM TO ASTM A-500 GRADE B SPECIFICATION
3. STRUCTURAL WELDING SHALL CONFORM TO AWS D1.1 STRUCTURAL WELDING SPECIFICATION

NO	DESCRIPTION	DATE	BY	APP
0	ISSUED FOR CONSTRUCTION	02/14/14	JAZ	PS

Behrent Engineering Company

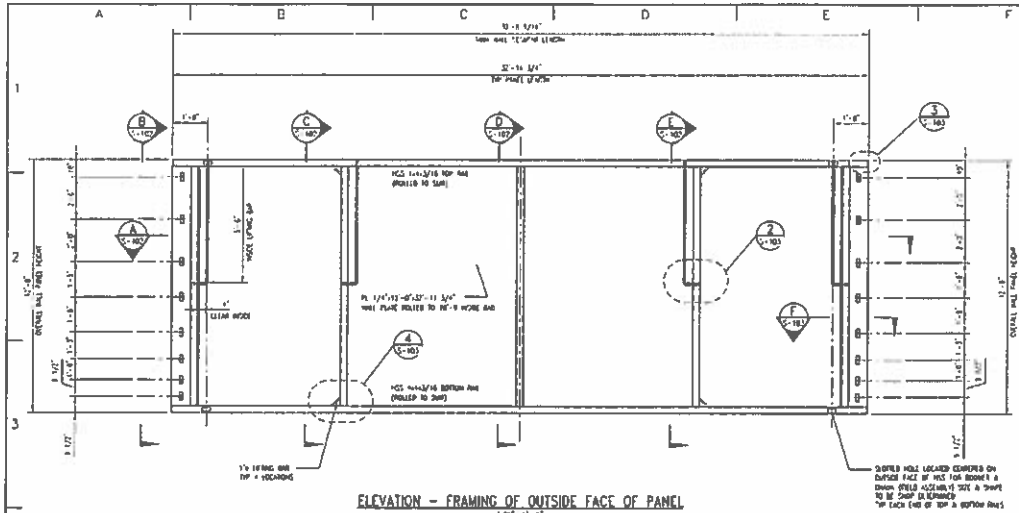
ROCKWATER ENERGY SOLUTIONS

ROCKWATER ENERGY
CANONSBURG, PA.

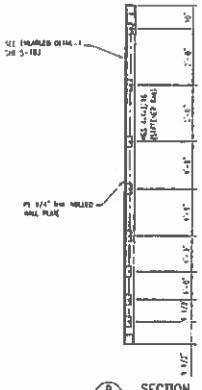
ATLANTIS TANK
157'-6" DIA x 12'-0" HIGH

DRAWN	JAZ	01/29/14
CHK	KHG	02/06/14
APP	PS	02/14/14
SCALE	AS NOTED	

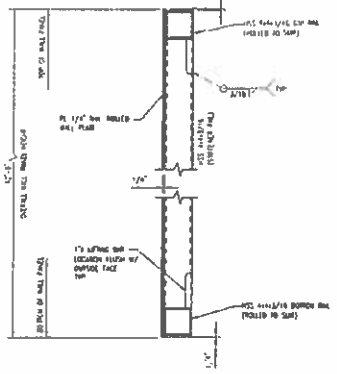
DRAWING NUMBER: 14014-S-101
REV: 0



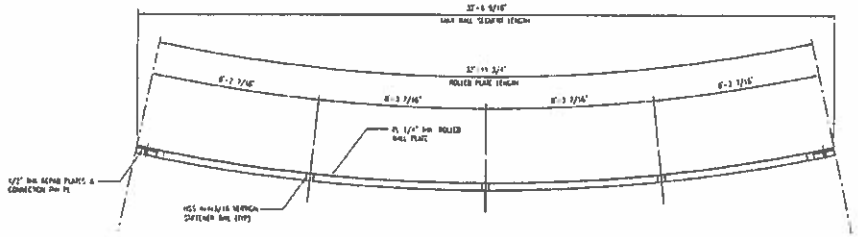
ELEVATION – FRAMING OF OUTSIDE FACE OF PANEL
3/8"=1'-0"
15 PANELS REQUIRED



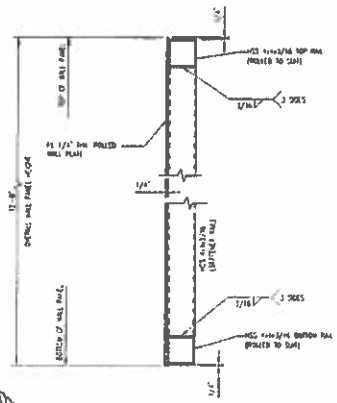
B SECTION
1/2"=1'-0"



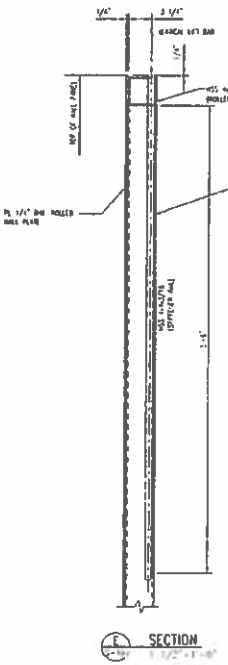
C SECTION
1 1/2"=1'-0"



A SECTION
1/2"=1'-0"



D SECTION
1 1/2"=1'-0"



F SECTION
1 1/2"=1'-0"

NOTES:
1. ALL PLATE SHALL CONFORM TO ASTM A-36 SPECIFICATION
2. STRUCTURAL TUBING SHALL CONFORM TO ASTM A-500 GRADE B SPECIFICATION
3. STRUCTURAL WELDING SHALL CONFORM TO AWS D1.1 STRUCTURAL WELDING CODE-STEEL

2/14/14
COLORADO LICENSED
KIM GAZDIK
47107
PROFESSIONAL ENGINEER

NO	ISSUE FOR CONSTRUCTION	DATE	BY	APP
0		02/14/14	JMF	PS

REVISION RECORD

Bakerel Engineering Company

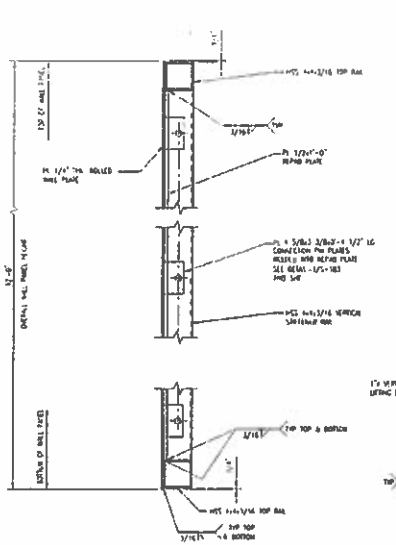
ROCKWATER ENERGY SOLUTIONS

ROCKWATER ENERGY
CANONSBURG, PA.

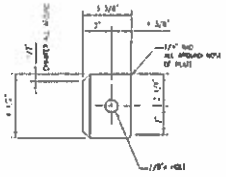
ATLANTIS TANK
157'-6" DIA x 12'-0" HIGH

DRAWN	JMF	01/29/14
CHK	KMG	02/06/14
APP	PS	02/14/14
SCALE	AS NOTED	

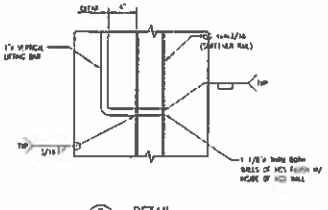
DRAWING NUMBER: 14014-S-102
REV: 0



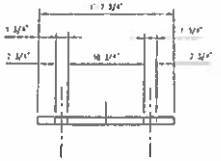
1 S-103 DETAIL - ENLARGED DETAIL
1/2" = 1'-0"

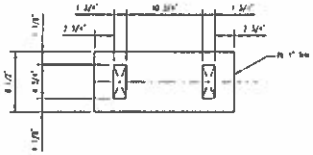


1 S-103 DETAIL - PIN PLATE
3" = 1'-0"

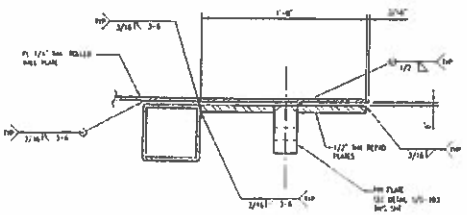


2 S-103 DETAIL
1 1/2" = 1'-0"

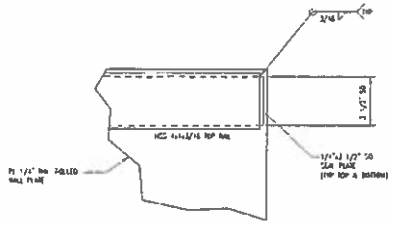




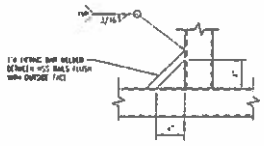
2 S-103 DETAIL - WALL PANEL CONNECTION PLATE
1 1/2" = 1'-0"
8 REQUIRED PER WALL CONNECTION



5 S-103 SECTION
3" = 1'-0"



3 S-103 DETAIL
3" = 1'-0"



4 S-103 DETAIL
1 1/2" = 1'-0"

NO	REVISION RECORD	DATE	BY
0	ISSUED FOR CONSTRUCTION	02/14/14	MP

Behrent Engineering Company

ROCKWATER ENERGY SOLUTIONS

ROCKWATER ENERGY
CANONSBURG, PA.

ATLANTIS BANK
157'-6" DIA x 12'-0" HIGH

DRAWN	JMZ	02/13/14
CHK	KMG	02/06/14
APP	PJS	02/14/14
SCALE	AS NOTED	

DRAWING NUMBER: 14014-S-103 REV: 0

2/14/14
COLORADO LICENSED
KIM GAZDIK
47107
PROFESSIONAL ENGINEER

SKAPS TRANSNET™
HDPE GEONET TN 220

SKAPS INDUSTRIES
571 Industrial Pkwy,
Commerce, GA 30529
Phone: (706) 336-7000
Fax: (706) 336-7007
E-Mail: contact@skaps.com

SKAPS TRANSNET™ geonet consists of SKAPS Geonet made from HDPE resin.

PROPERTY	TEST METHOD	UNIT	VALUE	QUALIFIER
Thickness	ASTM D 5199	mil	200	MAV[3]
Carbon Black	ASTM D 4218	%	2.0	MAV
Tensile Strength	ASTM D 7179	lb/in	45	MAV
Melt Flow	ASTM D 1238[2]	g/10 min	1.0	Maximum
Density	ASTM D 1505	g/cm^3	0.94	MAV
Transmissivity[1]	ASTM D 4716	gal/min/ft (m^2/sec)	9.67 (2.0×10^{-3})	MAV

Notes:

(1) Transmissivity measured using water at 21 ± 2 °C (70 ± 4 °F) with a gradient of 0.1 and a confining pressure of 10,000 psf between steel plates after 15 minutes. Values may vary with individual labs.

(2) Condition 190/2.16

(3) Minimum average value

HYDRAFLEX™ HT30

CO-EXTRUDED TEXTURED LLDPE

RAVEN

PRODUCT DESCRIPTION

HydraFlex™ HT30 is a co-extruded one-side textured linear-low-density polyethylene (LLDPE) geomembranes containing carbon black and ultraviolet inhibitors to ensure protection against harmful UV degradation. HT-Series one-side textured LLDPE provides increased friction, elongation, and flexibility. Available in black and black/gray color options with the gray side providing a cooler surface against contrasting colors and a vital function for ease of damage detection during installation.

PRODUCT USE

HydraFlex™ HT30 is used in applications demanding increased friction resistance characteristics in sloped areas. These highly flexible geomembranes will conform to uneven subgrades.

SIZE & PACKAGING

HydraFlex™ HT30 can be fabricated into panels up to 35,000. sq. ft. All panels are accordion folded and rolled on a heavy duty core for ease of handling and time saving installation.

HydraFlex
CONTAINMENT SOLUTIONS

Reservoir Liner

PRODUCT	PART #
HydraFlex™	HT30B
HydraFlex™	HT30BG

APPLICATIONS

- Oilfield Pit Liners
- Well Pad Liners
- Secondary Containment
- Waste Lagoon Liners
- Farm Ponds
- Soil Remediation Liners
- Leachate Collections Ponds
- Brine Ponds
- Canal and Frac Reservoir Liners
- Landfill Caps
- Golf Course Ponds
- Frac Reservoir Liners

HYDRAFLEX™ HT30

CO-EXTRUDED TEXTURED LLDPE

PRO-FORMA DATA SHEET

		HYDRAFLEX™ HT30			
		IMPERIAL		METRIC	
PROPERTIES	TEST METHOD	MINIMUM	TYPICAL	MINIMUM	TYPICAL
Appearance		Black & Black/Gray		Black & Black/Gray	
Thickness, Average	ASTM D5994	27 mil	28.5 mil	0.69 mm	0.72 mm
Weight		146 lbs/msf		713 g/m^2	
Asperity Height	ASTM D7466	10 mil	14 mil	0.25 mm	0.36 mm
Tensile Strength at Break	ASTM D6693	50 ppi	80 ppi	88 N/cm	140 N/cm
Tensile Elongation at Break	ASTM D6693	300 %	600 %	300 %	600 %
Tear Resistance	ASTM D1004	14 lbs	18 lbs	62 N	80 N
Puncture Resistance	ASTM D4833	39 lbs	57 lbs	173 N	254 N
Standard OIT or High Pressure HPOIT	ASTM D3895 ASTM D5885	100 min 400 min	150 min 600 min	100 min 400 min	150 min 600 min
Carbon Black (black layers only)	ASTM D4218	2.0 - 3.0 %	2.5 %	2.0 - 3.0 %	2.5 %
Hydraulic Conductivity		2.4 x 10^{-10} cm/sec			
Maximum Static Use Temperature		180° F		82° C	
Minimum Static Use Temperature		-70° F		-57° C	
FACTORY SEAM REQUIREMENTS					
Bonded Seam Strength	ASTM D6392	45 lbf/in width	63 lbf/in width	200 N	280 N
Seam Peel Adhesion	ASTM D6392	38 lbf/in width	48 lbf/in width	169 N	214 N

PRO-FORMA Sheet Contents. The test values listed in this Pro-Forma data sheet are representative of initial production runs. These values may be revised at anytime without notice as additional test data becomes available.

HydraFlex™ HT30 is a co-extruded one-side textured linear-low-density polyethylene (LLDPE) geomembranes containing carbon black and ultraviolet inhibitors to ensure protection against harmful UV degradation. HT-Series one-side textured LLDPE provides increased friction, elongation, and flexibility. Available in black and black/gray color options with the gray side providing a cooler surface against contrasting colors and a vital function for ease of damage detection during installation.

Note: To the best of our knowledge, unless otherwise stated, these are typical property values and are intended as guides only, not as specification limits. Chemical resistance, odor transmission, longevity as well as other performance criteria is not implied or given and actual testing must be performed for applicability in specific applications and/or conditions. RAVEN INDUSTRIES MAKES NO WARRANTIES AS TO THE FITNESS FOR A SPECIFIC USE OR MERCHANTABILITY OF PRODUCTS REFERRED TO, no guarantee of satisfactory results from reliance upon contained information or recommendations and disclaims all liability for resulting loss or damage. Limited Warranty available at www.RavenEFD.com

RAVEN ENGINEERED FILMS
P.O. Box 5107 Sioux Falls, SD 57117-5107
Ph: +1 (605) 335-0174 • TF: +1 (800) 635-3456
efdsales@ravenind.com
www.ravenefd.com

Raw Material — Linear Low Density Polyethylene

A geomembrane manufactured from maximum quality linear low density polyethylene LLDPE resins, duly contrasted, that comply with the most rigurous requirements established for their use.
Contains 97,5% of pure polymer, and approximately 2,5% of Carbon Black, antioxidants and thermal stabilizers. The product does not contain plasticizers or fillers that can migrate over time.
The geomembrane is manufactured under permanent quality controls.

Surface	Smooth	Colour	Black
		RAL Code	-

Raw Material Identification

Tested Property	Unit	Test Method	Value
Density of Raw Material	g/cm³	ASTM D 792	0.915-0.926
Density of Geomembrane	g/cm³	ASTM D 792	0.925-0.939
Melt Flow Index	g/10 min	ASTM D 1238 (190°C/2,16 Kg)	< 1,0
Carbon Black Content	%	ASTM D 4218	2,0 - 2,5
Carbon Black Dispersion	-	ASTM D 5596	Note (3)

Durability

Oxidative Induction Time (OIT) Standard OIT High Pressure OIT	min	ASTM D 3895 (200°C) ASTM D 5885	≥ 100 ≥ 400
Oven aging at 85°C HP O.I.T. % retained after 90 days	%	ASTM D 5721 ASTM D 5885	≥ 60
UV Resistance. HP OIT, % retained after 1600 hrs	%	ASTM D 5885	≥ 35

Functional Properties

Tested Property	Unit	Test Method	Value
Low Temperature Brittleness (t°: -40°C)	-	ASTM D 746	No cracks
Water Permeability	m³/m²·day	EN 14150	< 1·10⁻⁶
Coefficient of Linear Thermal Expansion	1/K	ASTM D 696	2,15·10⁻⁴
Water Absorption	%	ASTM D 570 (24h)	≤ 0,2
		ASTM D 570 (6 days)	≤ 1

Strength Characteristics Quality of Final Product

Tested Property	Unit	Test Method	Value					
Thickness	mils	ASTM D 5199	30	40	60	80	100	120
Tolerance	%		-10					
Mechanical Properties								
Tensile strength at Break[1]	lb/in	ASTM D 6693 (Type IV), lo 2 in	125 (108)	171 (148)	256 (222)	342 (296)	428 (371)	513 (445)
Elongation at Break	%		≥ 800					
Tear Resistance	lb	ASTM D 1004	≥ 15	≥ 21	≥ 32	≥ 43	≥ 53	≥ 64
Puncture Resistance	lb	ASTM D 4833	≥ 42	≥ 56	≥ 84	≥ 112	≥ 140	≥ 168
2% Modulus	lb/in	ASTM D 5323	≤ 1800	≤ 2400	≤ 3600	≤ 4800	≤ 6000	≤ 7200
Axi-Symmetric Break Resistance Strain	%	ASTM D 5617	≥ 30					
Dimensional Stability	%	ASTM D 1204 (100°C, 1h)	± 1,5					

PRESENTATION (Standard Sizes)

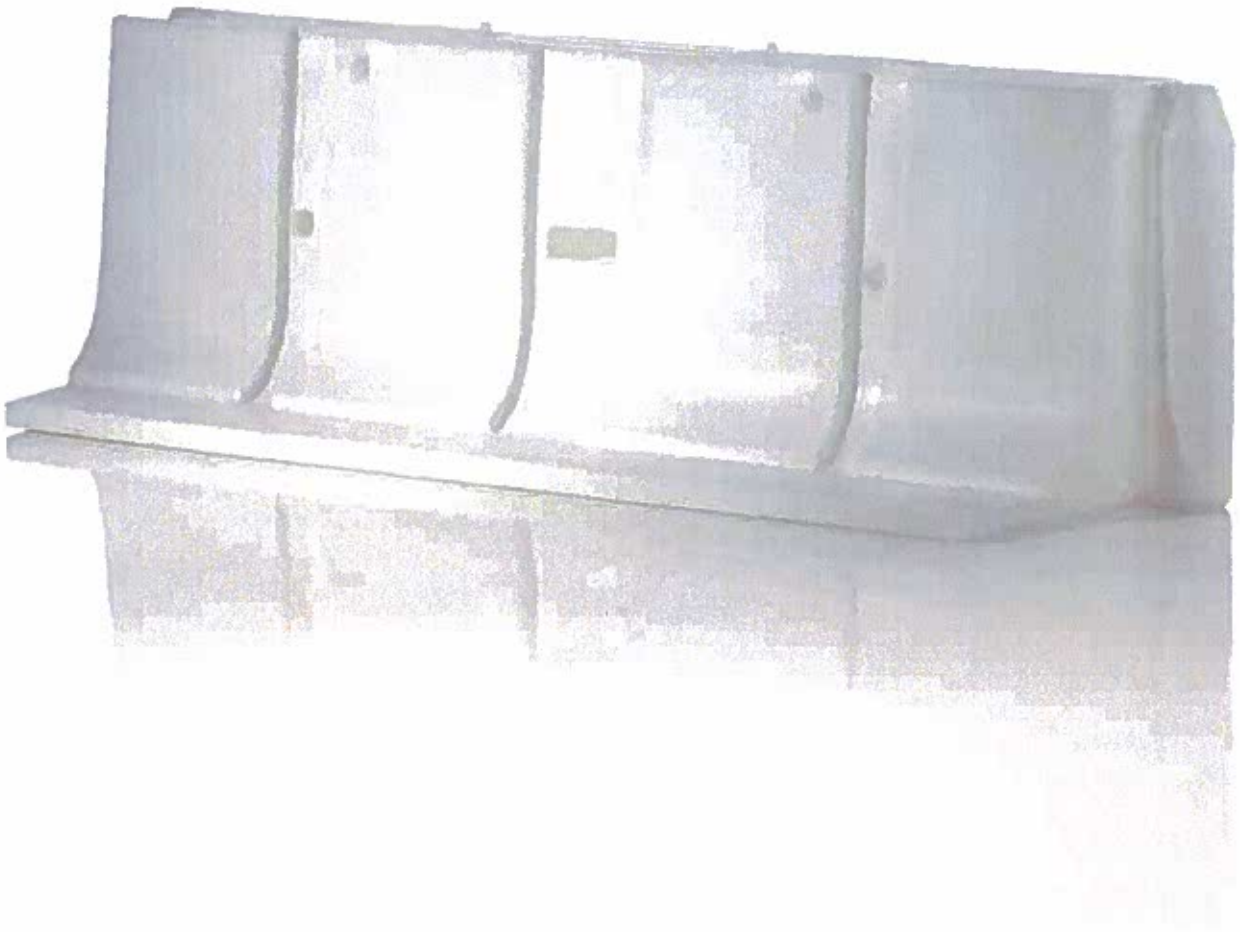
Parameter	Units	30	40	60	80	100	120
Roll width[4]	ft	19.7					
Roll Length[4]	ft	1,332	999	666	498	399	333
Surface	ft²	26,240.4	19,680.3	13,120.2	9,810.6	7,860.3	6,560.1

280717

[1] Values indicated are medium. In brackets minimum values.
[2] Certificates belonging to the Environmental and Quality Integrated System of ITI.
[3] Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3
[4] Roll lengths and widths have a tolerance of ±1%.

U.S. Fabrication & Distribution Centers

Moses Lake, Washington . . . 4172 North Frontage Road E, Moses Lake, WA 98837 • 800.346.7744 • Fax 509.766.0414
Fostoria, Ohio . . . 1600 North Main Street, Fostoria, OH 44830 • 888.377.5640 • Fax 419.436.6007
Odessa, Texas . . . 8784 W. Interstate 20, Odessa, TX 79763 • 432.272.9413



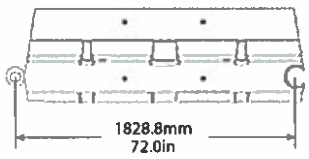
MUSCLEWALL®

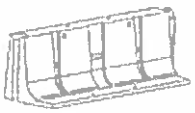
Specifications:

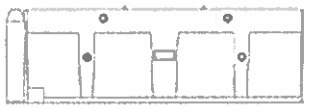
- Material
  - Low density polyethylene
  - Elongation to yield: 20%
  - Impact strength: 190 ft-lb
  - Tensile strength at yield: 2600 psi
- All Season Compatible
  - Temperature range: -40° F to 180° F
  - 10 year UV rated
- Portable
  - Weight per unit (empty): 55lbs
  - Weight per unit (filled): 650lbs
  - Units nest together for transportation
- Ground Pressure
  - Empty: 0.0333 psi
  - Filled: 0.3939 psi
- Dimensions
  - Minimum polyethylene thickness: 0.25"
  - Footprint on ground: 11.5 ft^2
  - 6 ft. wide x 2 ft. deep x 2 ft. high
  - Installed in 6 ft. sections
  - Fit 256 units on one 48 ft. flatbed trailer

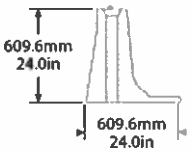
2 Foot System

MUSCLE WALL®









Features:

- Walls interconnect
- Connection acts like a hinge allowing for 22° of motion
- Corner piece allows 90° turns
- Ratchet straps restrain adjacent panels
- Tongue and groove panel interface for easy staking
- Patent Protected
  - US 8.313.265 B2
  - USD 631977
  - US 634443

Contact us:

Please contact us with any questions you have regarding Muscle Wall and how we can help you with your water management needs.

Email – info@musclewall.com
Toll-free – 1.800. 801.8739
Fax – 435.514.6707
Mail – 675 North 600 West Suite 1
Logan, UT 84321
Web – www.musclewall.com