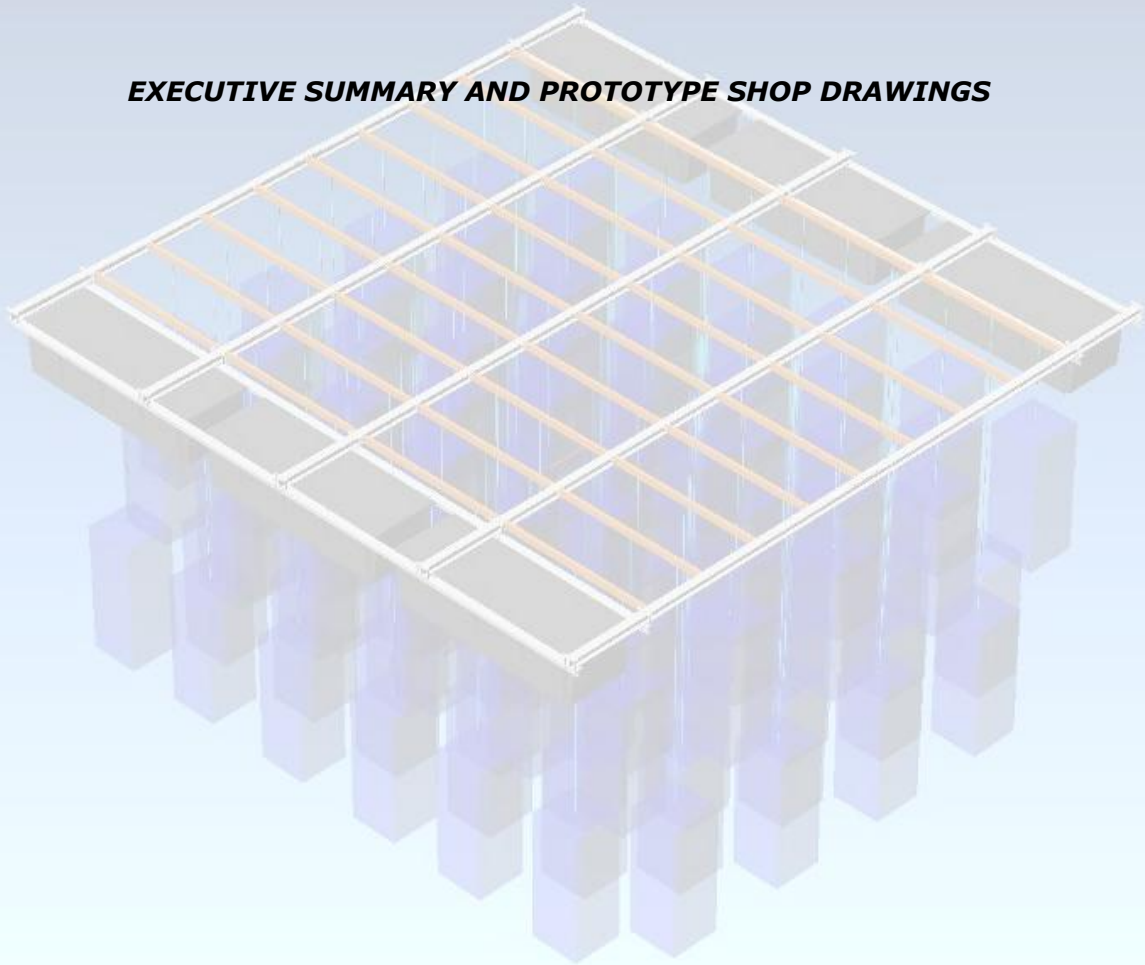


**DEVELOPMENT OF  
NEW RAFT TECHNOLOGIES  
FOR THE  
BC SHELLFISH AQUACULTURE INDUSTRY**

***EXECUTIVE SUMMARY AND PROTOTYPE SHOP DRAWINGS***





**DEVELOPMENT OF NEW RAFT TECHNOLOGIES  
FOR THE BC SHELLFISH AQUACULTURE INDUSTRY**

**Project Report**

**Date and Revision** October 14, 2010 Rev 3.1

**Submitted to:** **Fisheries and Ocean Canada**  
Attn: Sean Irvine  
Vancouver, BC

**BC Shellfish Growers Association**  
Attn: Tom Broadley, President  
Courtenay BC

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**Acknowledgements:** *This project was made possible by the Aquaculture Innovation and Market Access Program of Fisheries and Oceans Canada and we are extremely grateful for the support. The Innovation and Development Corporation at UVIC facilitated and support early portions of the work. This project was conducted with the BC Shellfish Growers Association in conjunction with ex R&D Manager Dave McCallum. We received significant input from individual BC Shellfish Growers as well as manufacturers and product suppliers, all of whom made this project a success.*



## Executive Summary

The necessity of creating better culture raft designs to effectively modernize the shellfish farming industry has been a significant priority to the BC shellfish culture industry. Recently, it has become apparent that the vast majority of industry infrastructure is in need of redesign, upgrades and new investment.

The goal of this project was to respond to industry need and to develop a new shellfish aquaculture raft design using current state-of-the-art materials and techniques. The resulting "open" design will hopefully create high quality rafts for the BC Shellfish Farming industry and improve industry economic profitability and environmental sustainability. Having long-life raft designs that will withstand significant loads from high wind and wave action will reduce industry's contribution of debris on beaches and subsequently save farmers time and money to replace lost and broken equipment.

The Centre for Shellfish Research conducted an open-source development process with industry, component manufacturers and experts. Two workshops were held, one at the beginning of the project to engage the industry and allow the opportunity for the exchange of ideas and needs to be incorporated into the design. The second industry workshop was held after preliminary designs were complete allowing the opportunity for feedback before final design decisions were made. In addition numerous conversations were conducted with industry members in BC and the US throughout the project.

Expert engineers (Dynamic Systems Analysis) were engaged to work with the project team to assist in developing prototype designs and to provide design recommendations to independent industry efforts. Virtual dynamic systems modelling was employed to simulate how various materials and structures would perform in a dynamic marine environment and greatly accelerated the range of materials and concepts that could be analyzed prior to physical prototyping.

Existing industry standard trimaran and catamaran rafts were modelled to determine weaknesses and safety factors and used as a guideline in new designs. A wide variety of materials were simulated to determine which would be most suitable as potential component materials in terms of both minimum strengths and cost effectiveness.

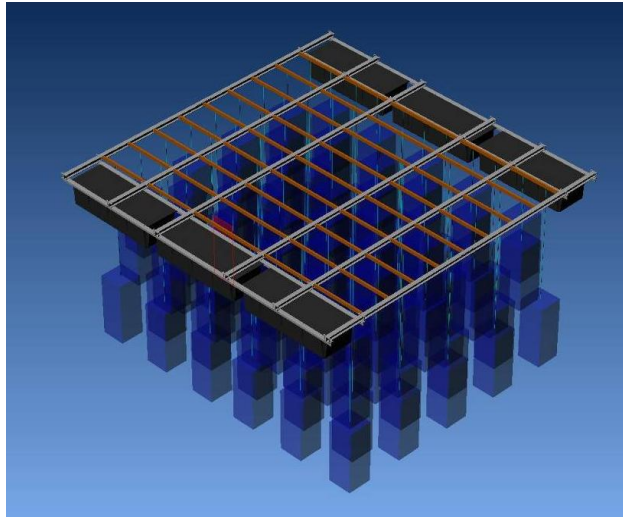
After testing more than 30 designs virtually, four final designs based on two styles (A & B) were developed for physical prototyping. Final designs use a combination of primary structural beams (steel) and secondary interstitial beams. The supporting structure of the rafts is a combination of galvanized steel 4" steel 'T' and 'I' beams, assembled with galvanized bolts in order that rafts can be bolted together onsite with simple tools. Standard steel stock comes in 40' lengths and to maximize the use of steel, the raft dimensions were extended to 27.6' x 27.6' (2/3d's) of a standard beam. Rotomolded dock floats (billets) manufactured by ACE Plastics were selected. A summary comparison is shown in the following table.



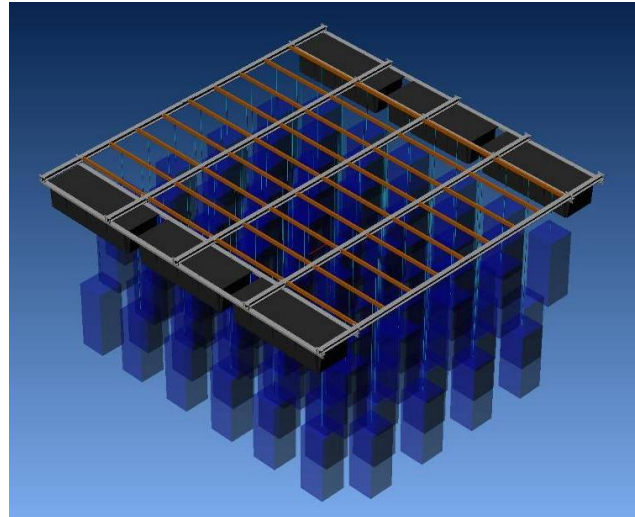


### Comparison of styles.

Main cross beam component	Raft dimension (feet)	Main beam dimension (in x in x ft)	# Main cross beams	# Floats	Min # Drop lines	Max # Drop lines	% Submergence (Max)	% Submergence (Min)
A -galvanized I beam unequal spacing	27x27	4x4x27	6	6	77	121	87	64
B -galvanized I beam equal spacing	27x27	4x4x27	5	6	96	144	97	72



**Raft "A" – 6 Beam raft CAD image**



**Raft "B" – 5 Beam raft CAD image**

Overall, we believe we have been successful in achieving the project objectives. The prototype designs meet the project goals and criteria established during industry discussions. Both raft styles are approximately 1m x 1m larger than existing designs (8m x 8m), with more capacity (>80 tray droppers and >12,000 lbs floatation).

In summary these designs:

- May be able to be moored in a similar fashion to existing designs
- Are as simple as possible with few "custom parts" and structures that could be assembled by farmers with a minimum of tools on-site.
- Have integral structure constructed from non biodegradable materials virtually tested to be capable of withstanding normal to significant weather conditions.
- Isolate the structure of the raft from the components that physically suspend the culture stock so that failure of components suspending stock does not contribute to overall raft failure.
- Have durable components that do not degrade and/or can be maintained or repaired *in situ*.
- Have commercially available plastic foam filled billets as floatation that will not degrade in the marine environment if damaged.

Prototypes are now being tested and demonstrated at the Deep Bay Field Station in Baynes Sound, BC. Shop drawings of prototypes are available to industry for construction, further testing and continuing advancement.



**Appendix 4: Raft Plan documents**

(attached as PDF)

***PLEASE NOTE*** : *The designs which follow are prototypes still under testing and are provided "as is" and without warranties of any kind whether express or implied. Vancouver Island University disclaims all warranties express or implied and does not make any warranties or representations regarding the use of the designs in terms of the in terms of their correctness, accuracy, adequacy, usefulness, timeliness, reliability or otherwise.. Vancouver Island University may not be held liable for any damages (including, without limitation, incidental and consequential damages, personal injury/wrongful death, lost profits, or damages resulting from the use of these designs.*





REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED

**Description:**

These drawings are for the fabrication of prototype shellfish cultivation rafts. There are two raft designs, Raft A, and Raft B.

Because the only difference between the raft designs are the layout of the "Frame Beams," the only raft-specific parts are the "T Beams" that have the bolt holes for Frame beam mounting. To save on material costs, the rafts utilize structural members that are 2/3 of standard 40ft lengths. Extra 1/3's of the 40ft lengths are utilized by splicing two 1/3 lengths into 2/3 lengths. The Frame beam splice is a welded joint with caps on the flanges.

All material is to be galvanized. Assembled onsite.

For Technical Questions Please Contact  
 Scott Beatty, Research Engineer,  
 Dynamic Systems Analysis,  
 250 472 4323,  
 scott@dsa-ltd.ca

For Administrative Questions Please Contact  
 Joy Wade  
 Centre for Shellfish Research  
 Vancouver Island University  
 250 740-6399  
 Joy.Wade@viu.ca

**Numbering Scheme:**

##A denotes a drawing specific to Raft A,  
 ##B denotes a drawing specific to Raft B,  
 ## denotes a drawing shared by both Rafts.

**RAFT A Specific Drawings:**

- 00A\_Raft\_A\_Bill\_of\_Materials
- 00A\_Raft\_A\_Overview
- 06A\_TBeam\_Basic
- 07A\_TBeam\_Spliced

**RAFT B Specific Drawings:**

- 00B\_Raft\_B\_Bill\_of\_Materials
- 00B\_Raft\_B\_Overview
- 06B\_TBeam\_Basic
- 07B\_TBeam\_Spliced

**Drawings Shared by Raft A and Raft B**

- 01\_Basic\_Frame\_Beam
- 02\_Spliced\_Frame\_Beam\_Assy
- 03\_Splice\_Flange\_Plate
- 05\_FB\_Clamp\_Plate

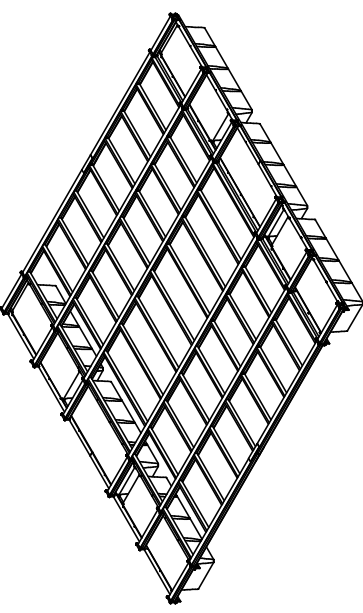
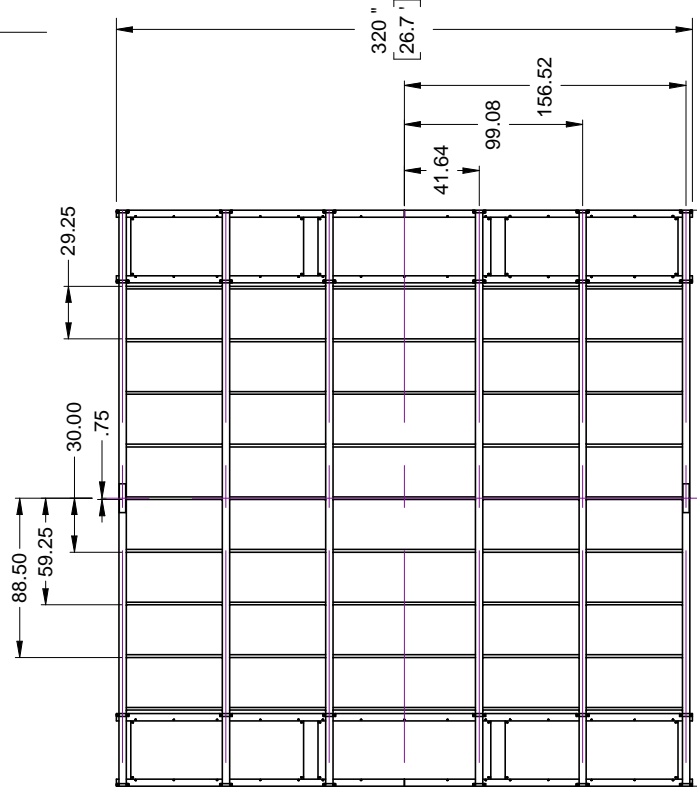
Item Number	Quantity	Part Name	Revision	Comment
1	4	Frame Beam Half (W4x13 Structural Steel)	2.0	
18	4	Frame Beam Full (W4x13 Structural Steel) 26.67ft - 2/3 of a 40ft length.	2.0	As Per Dwg 01-Basic Frame Beam
6	4	Frame_Beam_Splice_Cap	2.0	As Per Drawing: 03-Splice Flange Plate
8	24	Frame Beam Clamp Plate	2.0	As Per Drawing: 05 - Clamp PLate
16	3	T Beam Basic 26.67ft (2/3 of 40ft length)	2.0	As Per Drawing: 06A - TBeam Basic
2	1	T Beam Spliced (spliced from two 13.3ft T Beams)	2.0	As Per Drawing 07A - TBeam Spliced
4	90	Weld On Tabs	2.0	As Per Drawing: 01-Basic Frame Beam

SIZE <b>A</b>	FSCM NO.	DWG NO. 00A - Raft A Overview - BOM	REV 3.0
SCALE	SJB 2009:12.09		SHEET

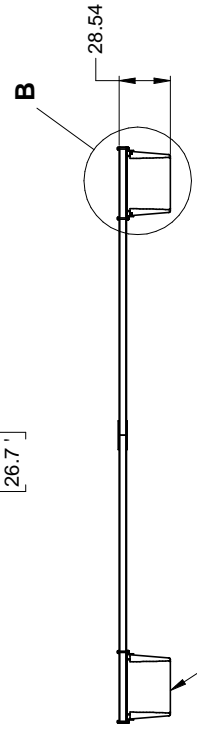
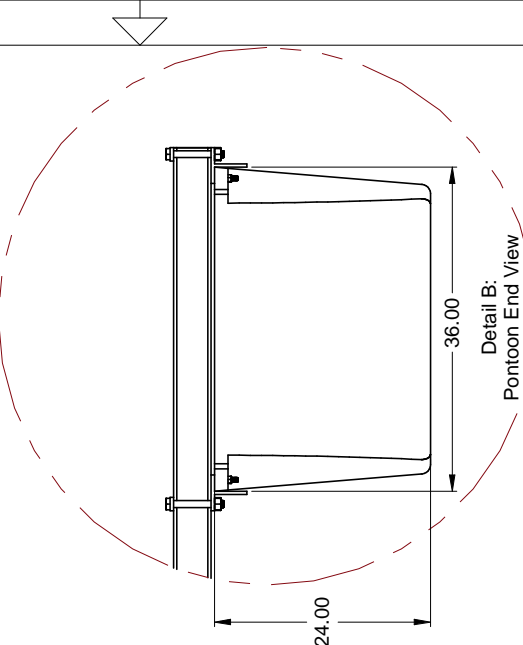
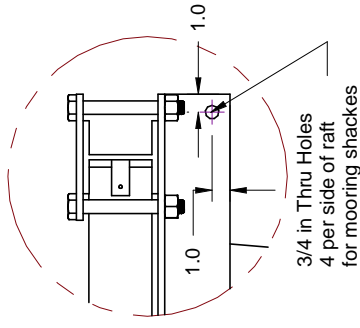


REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Updated to reflect series of changes	2009.12.09	
	R3	Added location dims for shackie hole in Detail A	2009.12.09	



Detail A:  
Frame Beam  
Connection



Barr Plastics Float Drums x 6  
Part Number: 3624-96

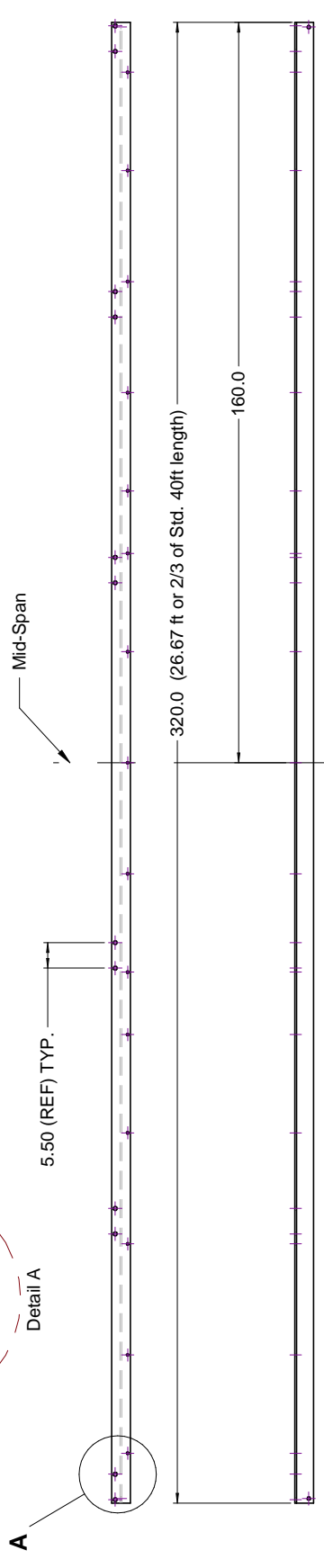
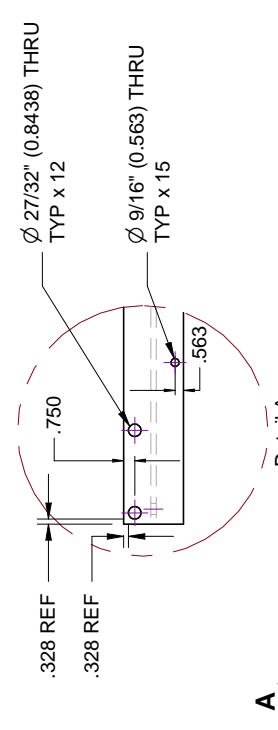
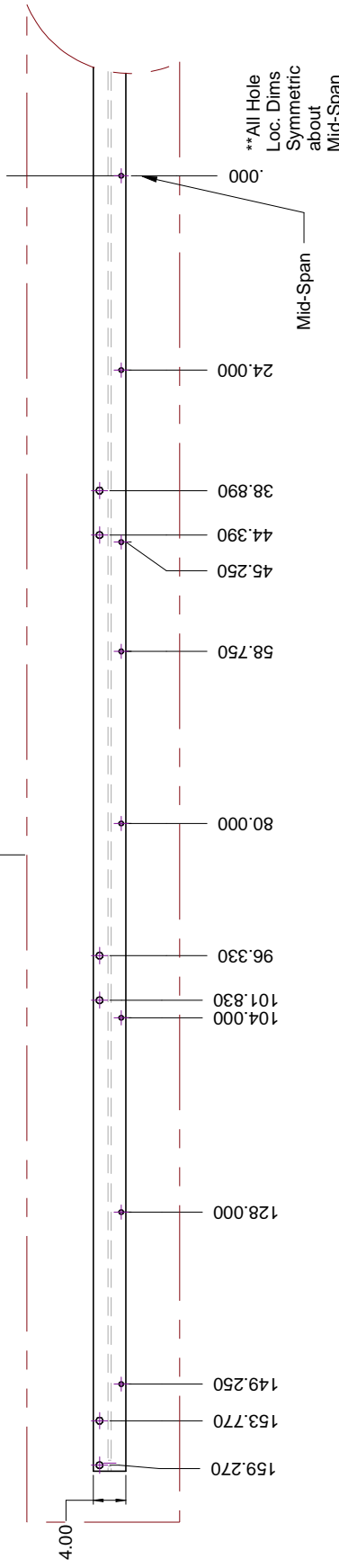
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A		00A - Raft A Overview	R3
SCALE	SJB 2009.12.09		SHEET

ALL DIMS IN INCHES UNLESS OTHERWISE SPECIFIED



REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	12 FB clamp holes diameter increased to 27/32" 15 Float mount holes specified to 9/16" drill Reference dims for hole to edge clearance given in Detail A	2009.08.29	SJB



SIZE	FSCM NO.	DWG NO.	REV
A		06A - T Beam Basic	R2

SCALE	SUB	DATE	SHEET
	SUB 2009.12.09		

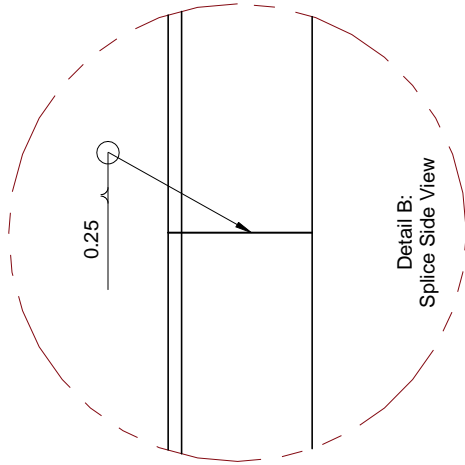
MAT'L: Hot Rolled ASTM A572 GR50/A992  
Wide Flange W8x13 split into T Beam

ALL DIMS IN INCHES UNLESS OTHERWISE SPECIFIED

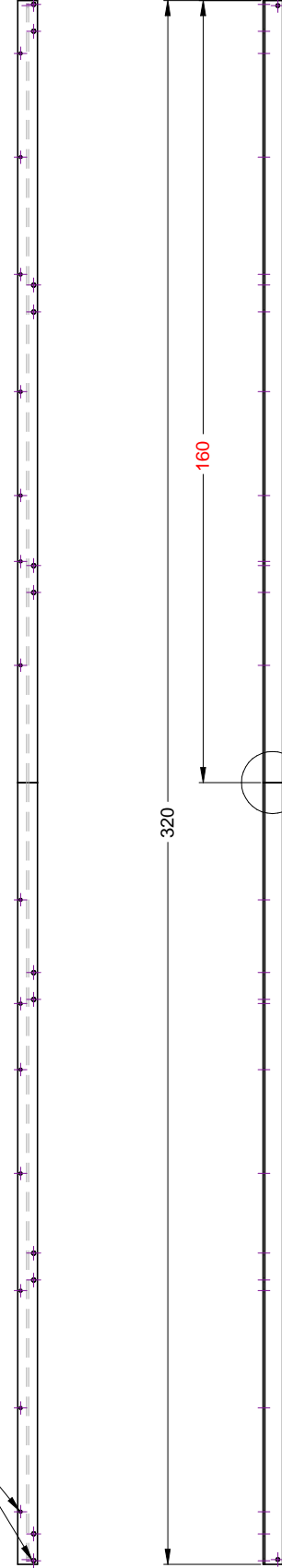


REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Flange and Web Splice Plates removed Splice Joint as butt weld all around.	2009.10.05	SJB



Hole Locations and Sizes  
Identical As per Drawing 06A



SIZE	FSCM NO.	DWG NO.	REV
A		07A - TBeam Spliced	R2

SCALE	SHEET
	SJB 2009.12.09

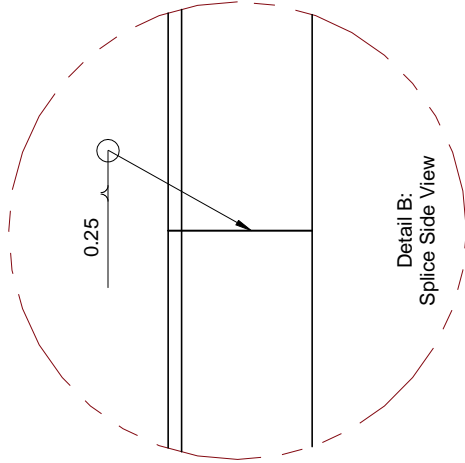
MATL: Hot Rolled ASTM A572 GR50/A992  
Wide Flange W8x13 split into T Beam

ALL DIMS IN INCHES UNLESS OTHERWISE SPECIFIED



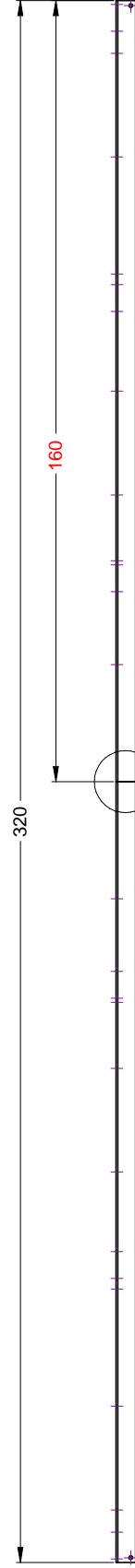
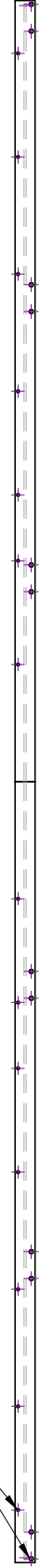
REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Flange and Web Splice Plates removed Splice Joint as butt weld all around.	2009.10.05	SJB



Detail B:  
Splice Side View

Hole Locations and Sizes  
Identical As per Drawing 06A



SIZE	FSCM NO.	DWG NO.	REV
A		07A - TBeam Spliced	R2

SCALE	SHEET
	SJB 2009.12.09

MATL: Hot Rolled ASTM A572 GR50/A992  
Wide Flange W8x13 split into T Beam

ALL DIMS IN INCHES UNLESS OTHERWISE SPECIFIED



**Description:**  
 These drawings are for the fabrication of prototype shellfish cultivation rafts. There are two raft designs, Raft A, and Raft B. Because the only difference between the raft designs are the layout of the "Frame Beams," the only raft-specific parts are the "T Beams" that have the bolt holes for Frame beam mounting. To save on material costs, the rafts utilize structural members that are 2/3 of standard 40ft lengths. Extra 1/3's of the 40ft lengths are utilized by splicing two 1/3 lengths into 2/3 lengths. The Frame beam splice is a welded joint with caps on the flanges. All material is to be galvanized. Assembled onsite.

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REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
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**Numbering Scheme:**

##A denotes a drawing specific to Raft A,  
 ##B denotes a drawing specific to Raft B,  
 ## denotes a drawing shared by both Rafts.

**RAFT A Specific Drawings:**

00A\_Raft\_A\_Bill\_of\_Materials  
 00A\_Raft\_A\_Overview  
 06A\_TBeam\_Basic  
 07A\_TBeam\_Spliced

**RAFT B Specific Drawings:**

00B\_Raft\_B\_Bill\_of\_Materials  
 00B\_Raft\_B\_Overview  
 06B\_TBeam\_Basic  
 07B\_TBeam\_Spliced

**Drawings Shared by Raft A and Raft B**

01\_Basic\_Frame\_Beam  
 02\_Spliced\_Frame\_Beam\_Assy  
 03\_Splice\_Flange\_Plate  
 05\_FB\_Clamp\_Plate

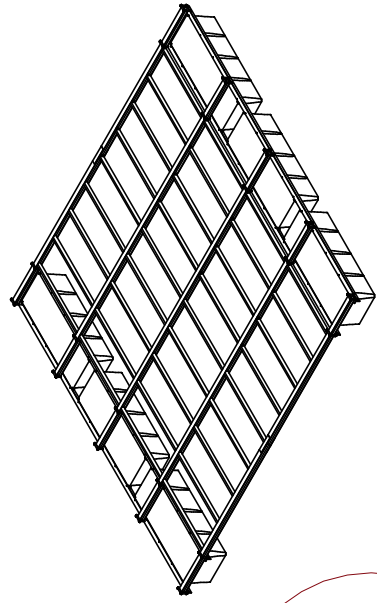
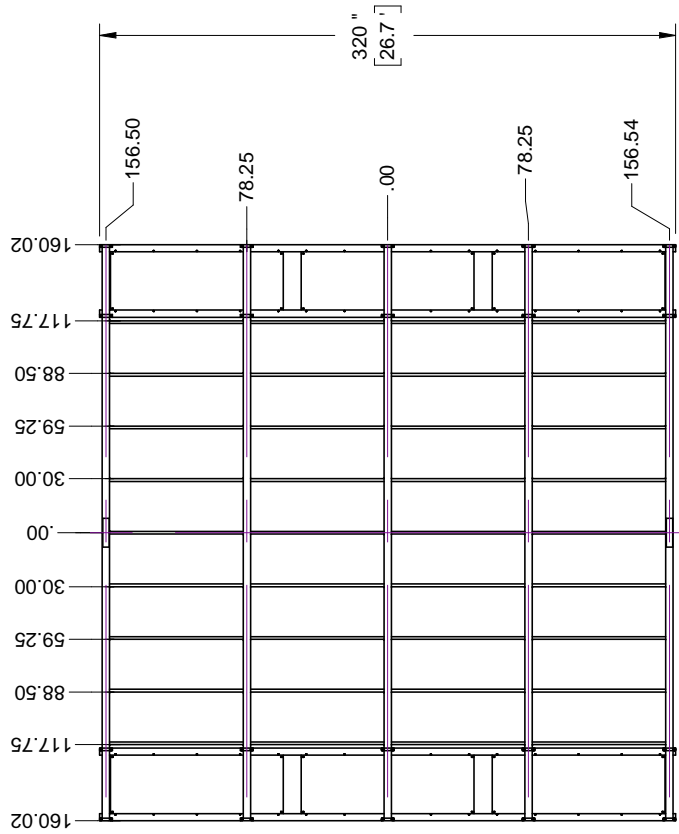
Item Number	Quantity	Part Name	Revision	Comment
1	4	Frame Beam Half (W4x13 Structural Steel)	2.0	
18	3	Frame Beam Full (W4x13 Structural Steel) 26.67ft - 2/3 of a 40ft length.	2.0	As Per Dwg 01-Basic Frame Beam
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8	20	Frame Beam Clamp Plate	2.0	As Per Drawing: 05 - Clamp PLate
16	3	T Beam Basic 26.67ft (2/3 of 40ft length)	2.0	As Per Drawing: 06B- TBeam Basic
2	1	T Beam Spliced (spliced from two 13.3ft T Beams)	2.0	As Per Drawing 07B_ TBeam Spliced
4	72	Weld On Tabs	2.0	As Per Drawing: 01-Basic Frame Beam

SIZE <b>A</b>	FSCM NO.	DWG NO. 00B- Raft B Overview - BOM	REV 3.0
SCALE	SJB 2009.12.09		SHEET

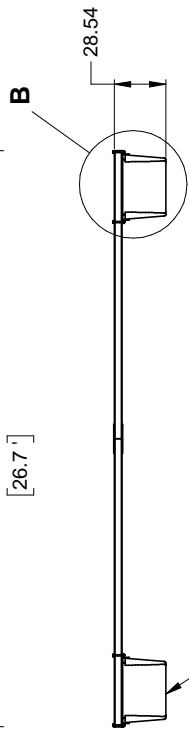
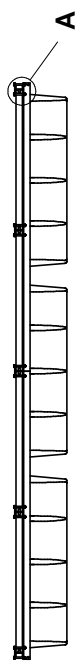
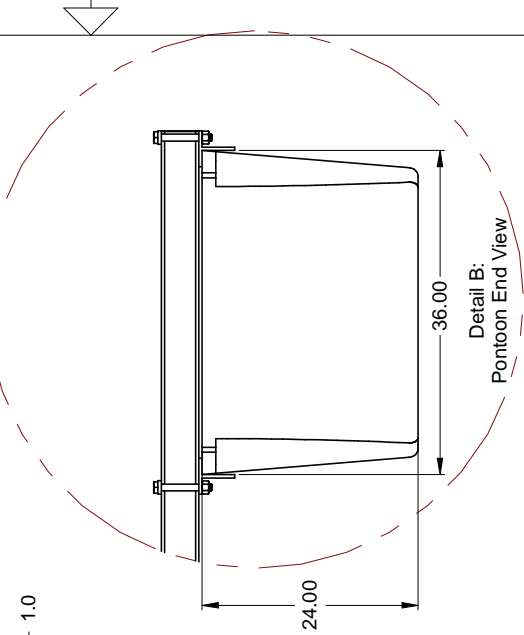
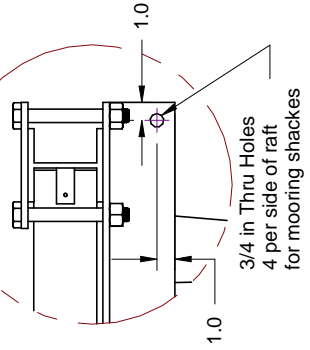


REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Design updated significantly See revisions to all component dwgs	2009.12.09	
	R3	Added loc dims for mooring shackle holes in Det. A	2010.01.04	



Detail A:  
Frame Beam  
Connection



Barr Plastics Float Drums x 6  
Part Number: 3624-96

SIZE	FSCM NO.	DWG NO.	REV
A		00B - Raft B Overview	R3

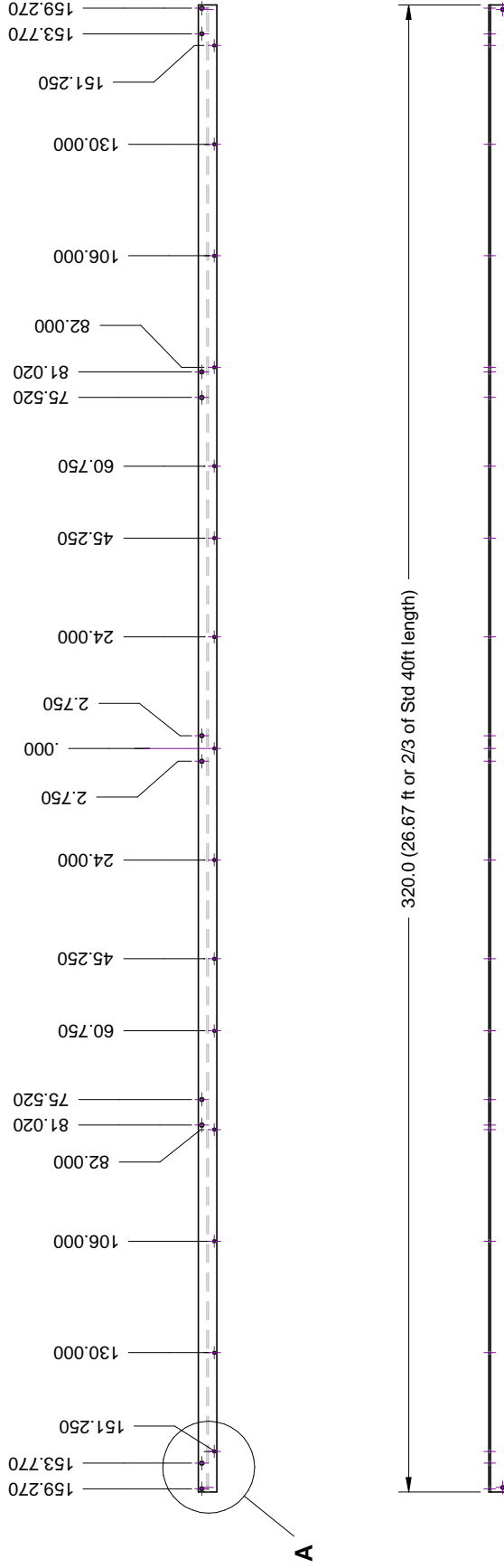
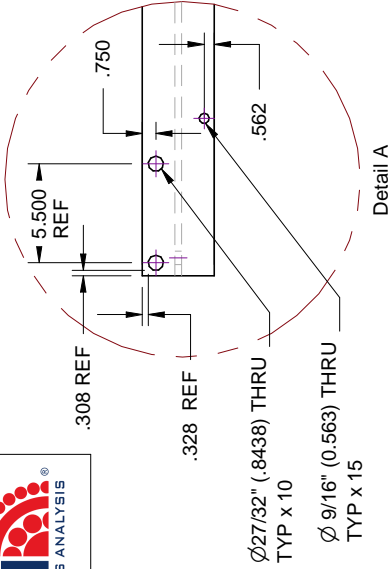
ALL DIMS IN INCHES UNLESS OTHERWISE SPECIFIED

SJ/B 2009.12.09 SHEET



REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Drilled Through hole sizes updated See Detail A	2009.12.09	SJB
	R3	Fixed small error in Ordinate Dimensions For frame beam clamp holes. Dimes are now symmetric about midspan	2010.01.15	SJB



SIZE <b>A</b>	FSCM NO.	DWG NO. 06B-TBeam Basic	REV R3
SCALE	SJB 2009.12.09		SHEET

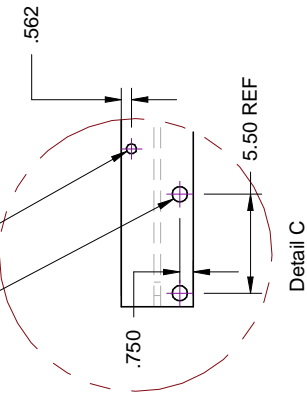
MAT'L Hot Rolled ASTM A572 GR50/A992  
Wide Flange W8x13 Split into T Beam

ALL DIMS IN INCHES UNLESS OTHERWISE SPECIFIED

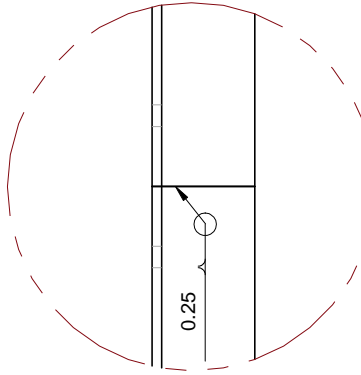


Ø 9/16" (0.563) THRU  
TYP x 15 Holes

Ø 27/32" (0.8438) THRU  
TYP x 10



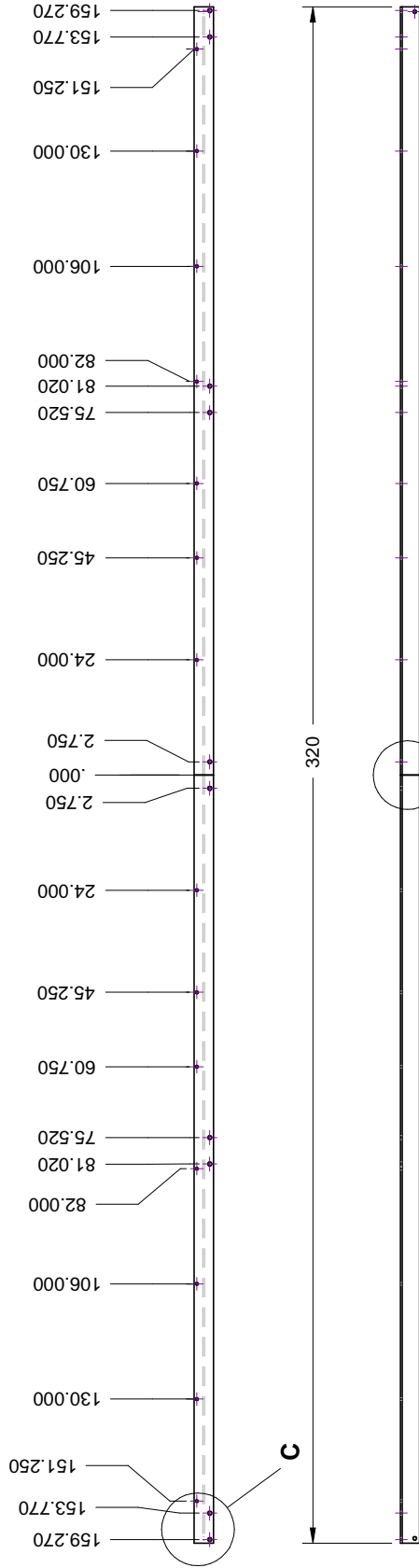
Detail C



Detail B:  
Splice Side View

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Flange and Web splice plates removed, replaced with butt weld all around (see Detail B) Drilled hole sizes increased (see Detail C)	2009.12.09	SJB
	R3	Fixed small error in frame beam clamp holes: Ordinate dimensions are now symmetric about mid-span as intended	2010.01.15	SJB



B

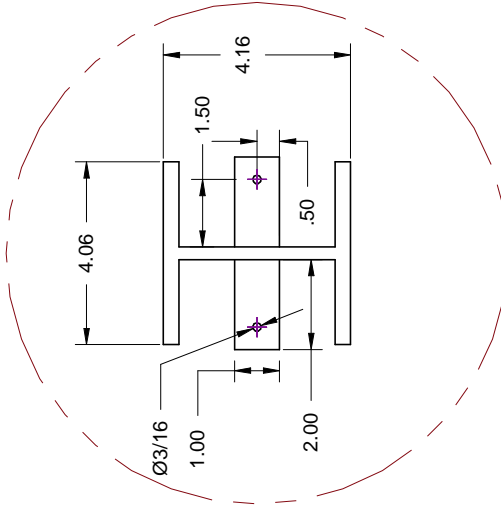
C

SIZE <b>A</b>	FSCM NO.	DWG NO. 07B - TBeam Spliced	REV R3
SCALE		SJB 2009.12.09	SHEET

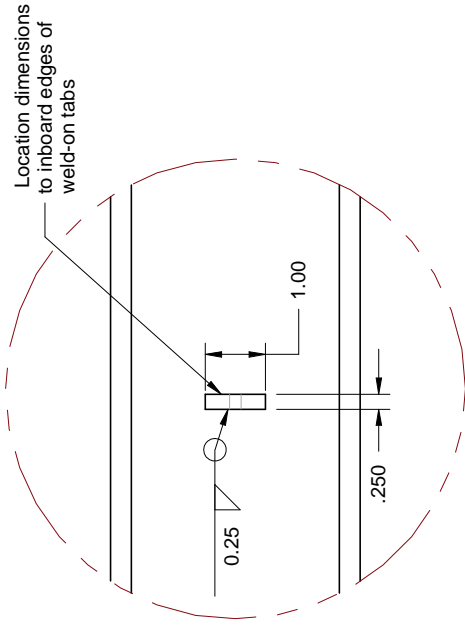


REVISIONS

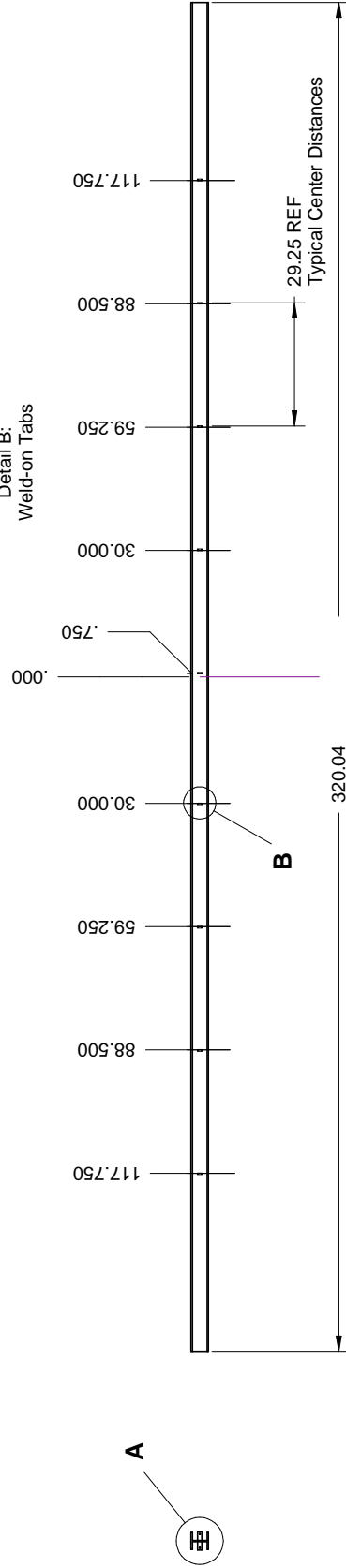
ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Weld tab design changed to smaller mat'l, drill hole size reduced from .25 to .1875, weld updated to all-around type	2009.12.09	SJB



Detail A:  
Frame Beam End-View



Detail B:  
Weld-on Tabs



Weld-on Tabs placed on both sides of web (as per Detail A)  
 Fillet Welds all around web/tab interface (sealed for galvanization).  
 Tab locations dimensioned to inboard edges.  
 18 Tabs, 18 Fillet Welds

MAT'L: Hot Rolled W4x13 Steel Beam

\*DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

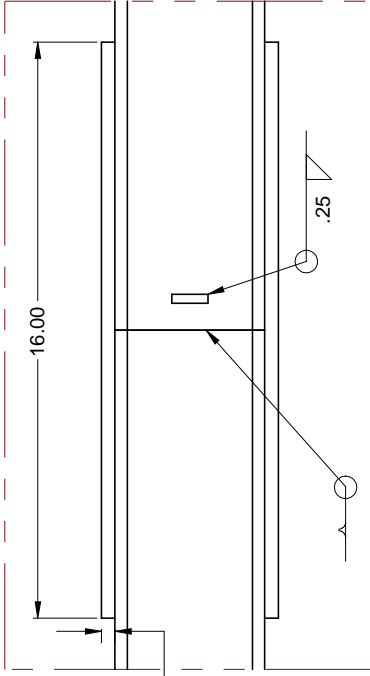
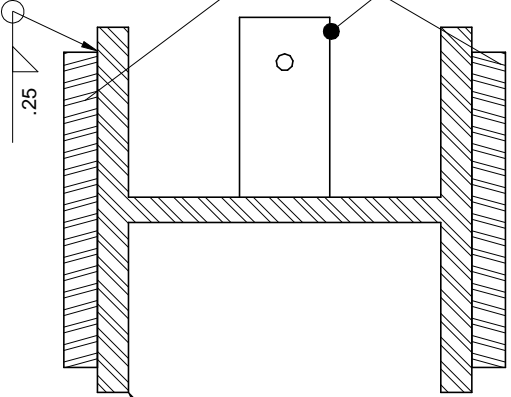
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A		01 - Basic Frame Beam	R2

SCALE: SJB 2009.10.05 SHEET



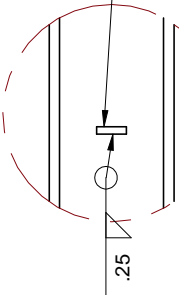
REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Bolted splice changed to a welded splice, Web splice plates removed, Flange splice plates reduced to 3.5in width	2009.12.09	SJB

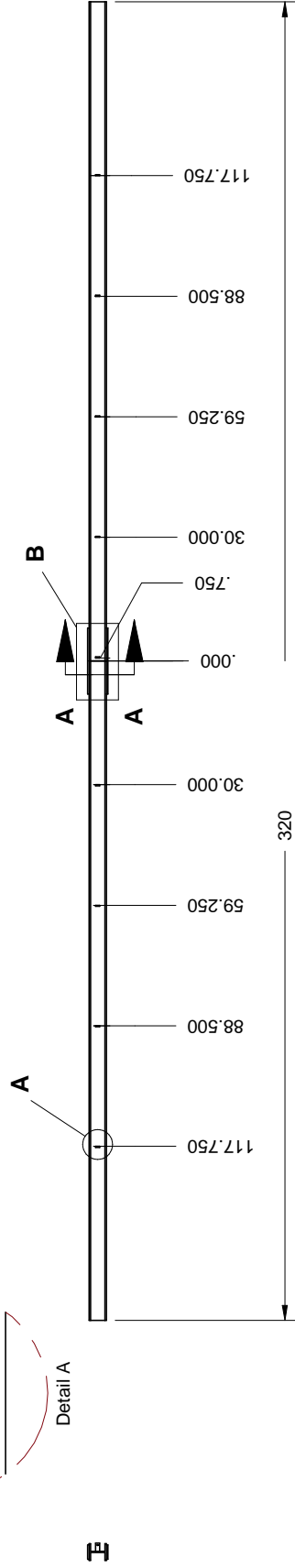


**Detail B: Beam Splice**  
 Welded butt joint: beveled edges with a 1/8" root gap  
 100% weld penetration with back grinding.  
 Welded Splice plates on flanges: 1/4" fillet all around

Section A-A



Weld-on tab locations  
 given to inboard edges  
 Placement symmetric about  
 mid-span



320  
 Two W4x13 x 160in  
 segments spliced at  
 midspan.

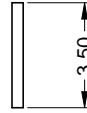
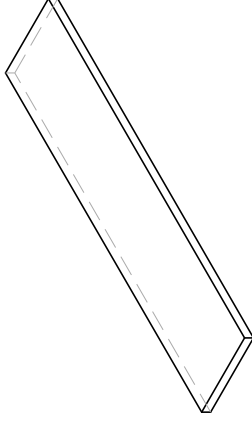
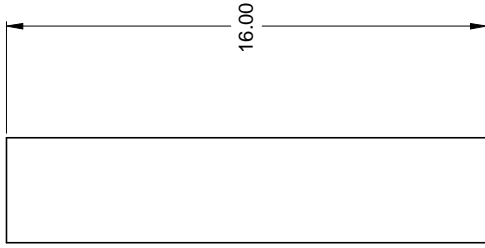
\*ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

SIZE	FSCM NO.	DWG NO.	SHEET	REV
A		02-Spliced Frame Beam-Assembly	2009.12.09	R2



REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R1	All drilled holes removed, material width reduced from 4.5 to 3.5in to accommodate fillet weld	2009.08.29	SJB



\*ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

SIZE	FSCM NO.	DWG NO.	REV
A		03-Splice Flange Plate	R1
SCALE	SJB 2009.12.09		SHEET

MATERIAL: HOT ROLLED 3/8 x 4.5 ASTM A-36 Steel

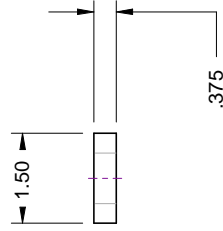
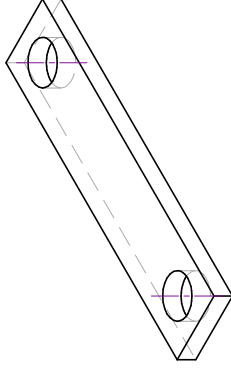
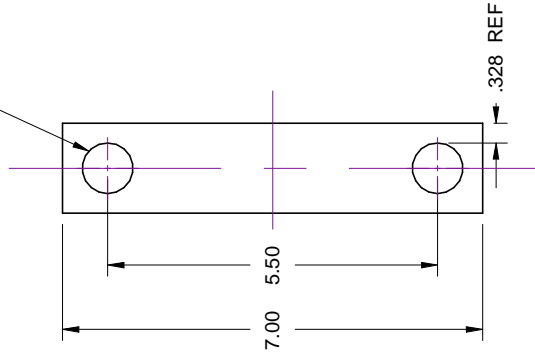


REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	R2	Drilled hole sizes increased from 0.75 CLR to 27/32 to accommodate galvanization thickness	2009.12.09	SJB

Drilled hole sizes increased from 0.75 CLR to 27/32 to accommodate galvanization thickness

Ø27/32" (0.8438) THRU  
TYPICAL x 2



MAT'L:  
HOTROLLED ASTM A-36  
3/8 X 1.5 STEEL

ALL DIMENSIONS IN INCHES

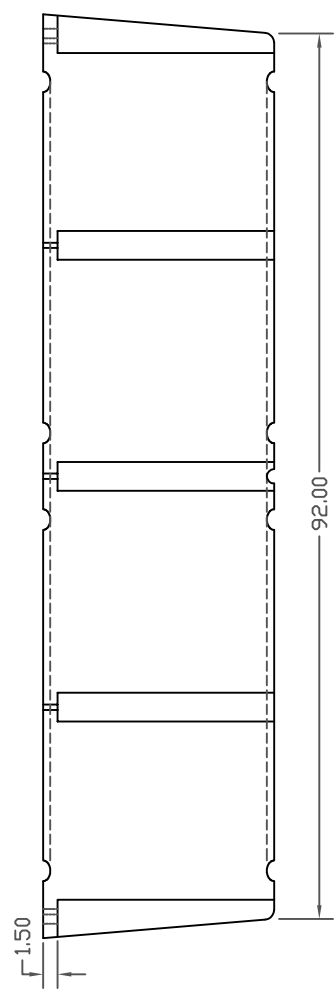
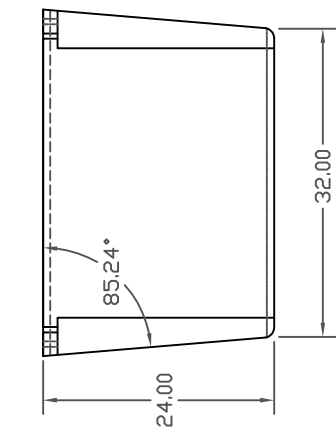
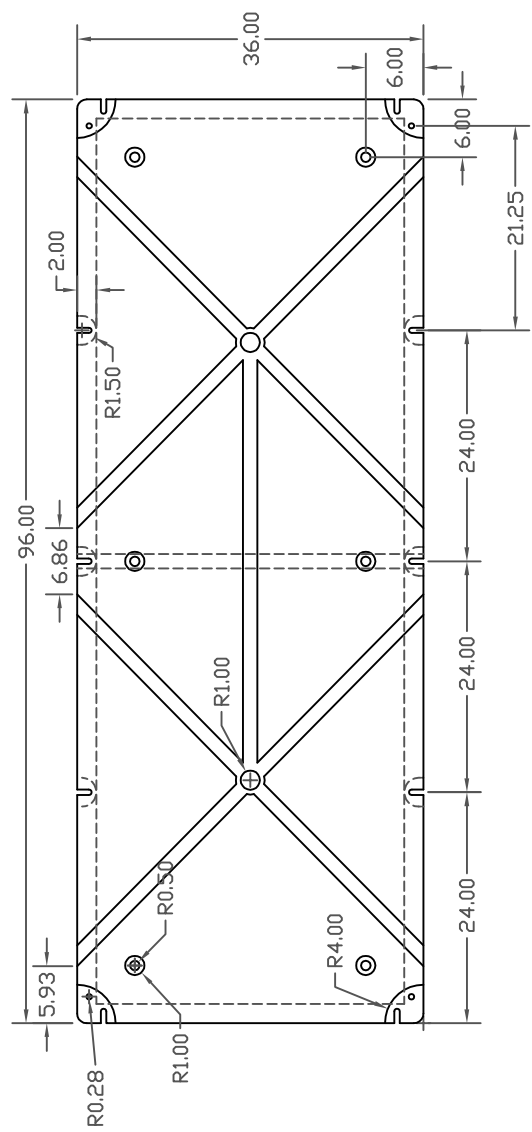
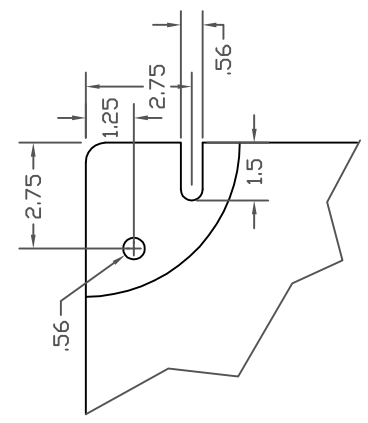
SIZE	FSCM NO.	DWG NO.	REV
A		05 - Clamp Plate	R2
SCALE		SJB 2009.12.09	SHEET

3696-24

PROPRIETARY DATA

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CORNER DETAIL



<p><b>Ace Roto-Mold</b> A DIVISION OF DEN HARTOG INDUSTRIES, INC. 4018 HWY. 60 BLVD., BOX 421, HOSPERS, IOWA 51238</p>		<p>CLIENT / DESCRIPTION <b>3696-24 FLOAT</b></p>	
<p>MATERIAL MDPE OR EQUIVALENT REFERENCE MATERIAL DATA SHEET FOR SPECIFIC PROPERTIES.</p>		<p>SCALE N.S.</p>	
<p>NOTES: 1. FDAM FILLED 129 LBS. 2. SHOT WEIGHT 81LBS. 3. WALL = .125 MIN. / .180 AVE.</p>		<p>PART NO. <b>3696-24</b></p>	
<p>REV</p>	<p>DESCRIPTION</p>	<p>DATE</p>	<p>APPROD</p>
<p>ALL DIMENSIONS ARE IN DECIMAL INCHES TOLERANCES UNLESS OTHERWISE SPECIFIED + 1% @ 68° F -</p>		<p>DRAWN / DATE DHJ 11/29/06</p>	<p>APPROD. / DATE REH 4/6/07</p>
<p>THIRD ANGLE PROJECTION ANSI 14.5H</p>		<p>PROPERTY OF ACE ROTO-MOLD MFG., INC. INFORMATION FURNISHED HEREIN IS THE PROPERTY OF ACE ROTO-MOLD MFG., INC. AND SHALL NOT BE USED, DISCLOSED TO OTHERS, OR COPIED WITHOUT THE EXPRESSED WRITTEN CONSENT OF ACE ROTO-MOLD MFG., INC. ALL RIGHTS RESERVED.</p>	