



**Particle Physics Division
Mechanical Department Engineering Note**

Number: MD-ENG-306

Date: 27 December 2010

Project Internal Reference: 485-1.02.04.01

Project: Microboone

Title: Microboone Heat Exchanger Skid Assembly Pricing

Author(s): Mike Zuckerbrot

Reviewer(s):

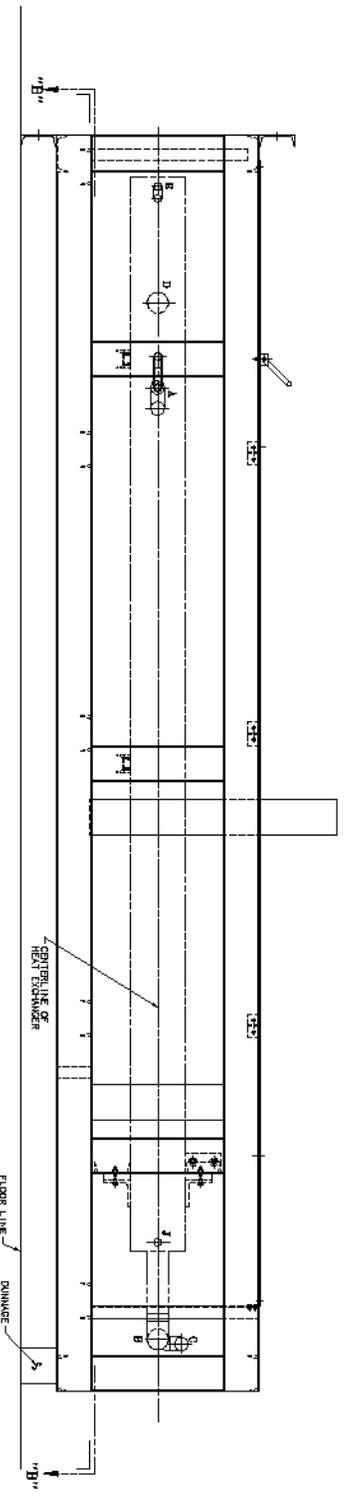
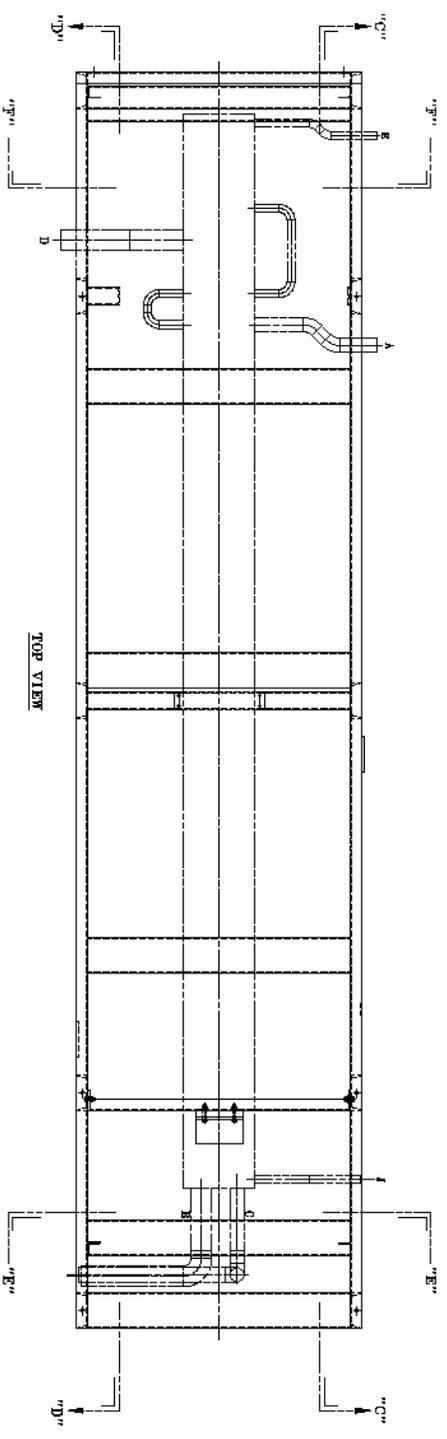
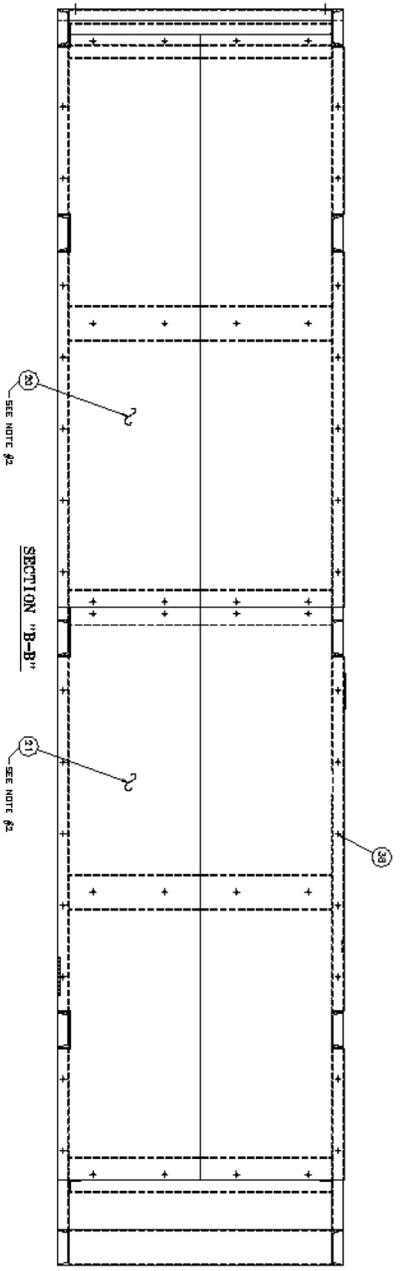
Key Words: Microboone, Heat exchanger skid

Applicable Codes:

Abstract Summary: This note reviews part and labor costs for assembling the Microboone heat exchanger skid in house at Fermilab. Pricing does not include any contingency.

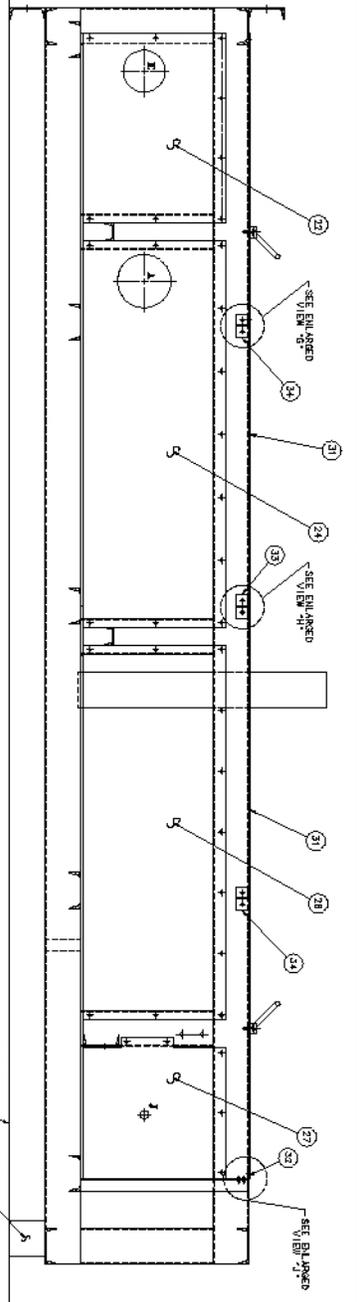
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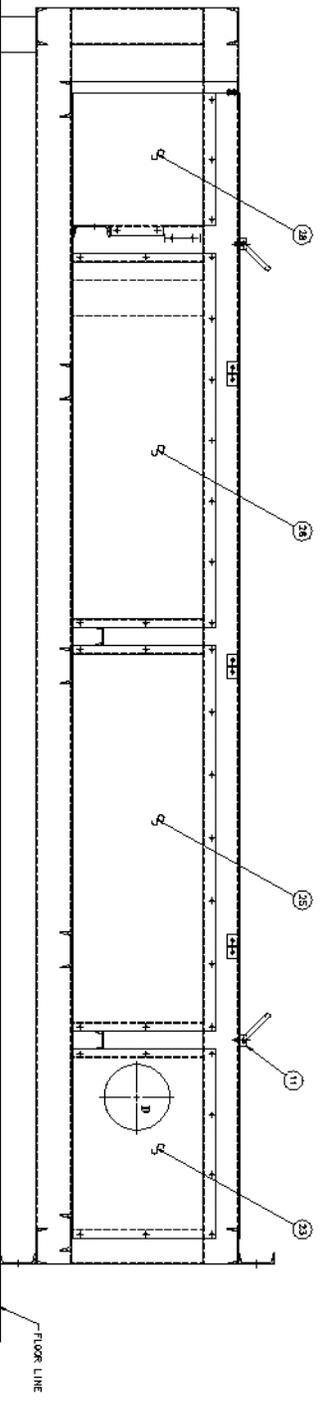


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3	1	SKID	EA
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5	1	SKID	EA
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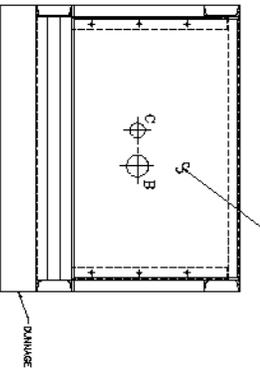
FEDERAL NATIONAL ACCREDITATION LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY
 6974-MICROBOONE - CRYOGENICS
 SUPPORT EQUIPMENT
 HEAT EXCHANGER SKID
 SCALE: 3/4" = 1'-0"
 DATE: 10/1/74
 DRAWN BY: [Name]
 CHECKED BY: [Name]
 APPROVED BY: [Name]



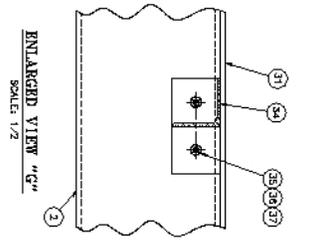
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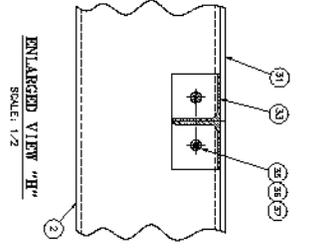
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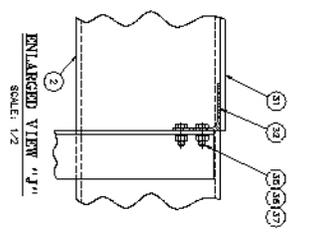
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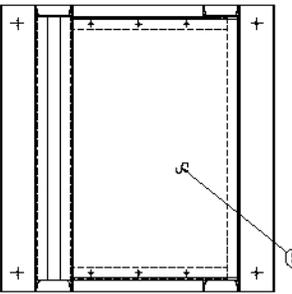
ENLARGED VIEW "G''
SCALE 1/2



ENLARGED VIEW "H''
SCALE 1/2



ENLARGED VIEW "I''
SCALE 1/2



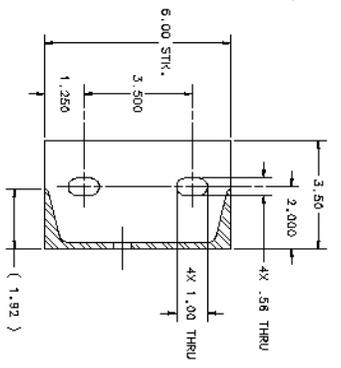
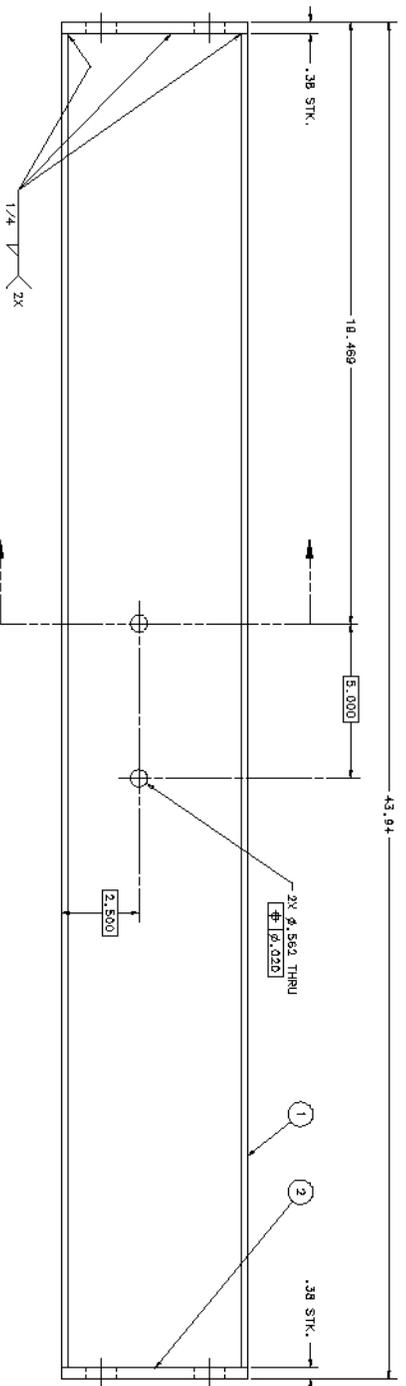
SECTION "F-F''

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99	SKID	ASSEMBLY	1
100	SKID	ASSEMBLY	1

FEDERAL BUREAU OF INVESTIGATION
 UNITED STATES DEPARTMENT OF JUSTICE
 LABORATORY
 400 ANDERSON DRIVE
 FORT MONROE, VIRGINIA 22034
 800-368-5848
 WWW.FBI-DOJ.GOV

1701 3441 00
 PARTS LIST
 DATE: 01/11/2013
 TIME: 10:00 AM
 DRAWN BY: J. M. BROWN
 CHECKED BY: J. M. BROWN
 SCALE: 1/2
 SHEET: 1 OF 1
 PROJECT: 3974.220-ME-486031
 TITLE: E874-MICROPHONE - CRYOGENICS SUPPORT EQUIPMENT HEAT EXCHANGER SKID

REV	DESCRIPTION	DATE
2		
1		



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
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1	CONL	3/8 THK. BAR OR PLATE	2
		C & X 5 3/8" ROLLER CHANNEL	1

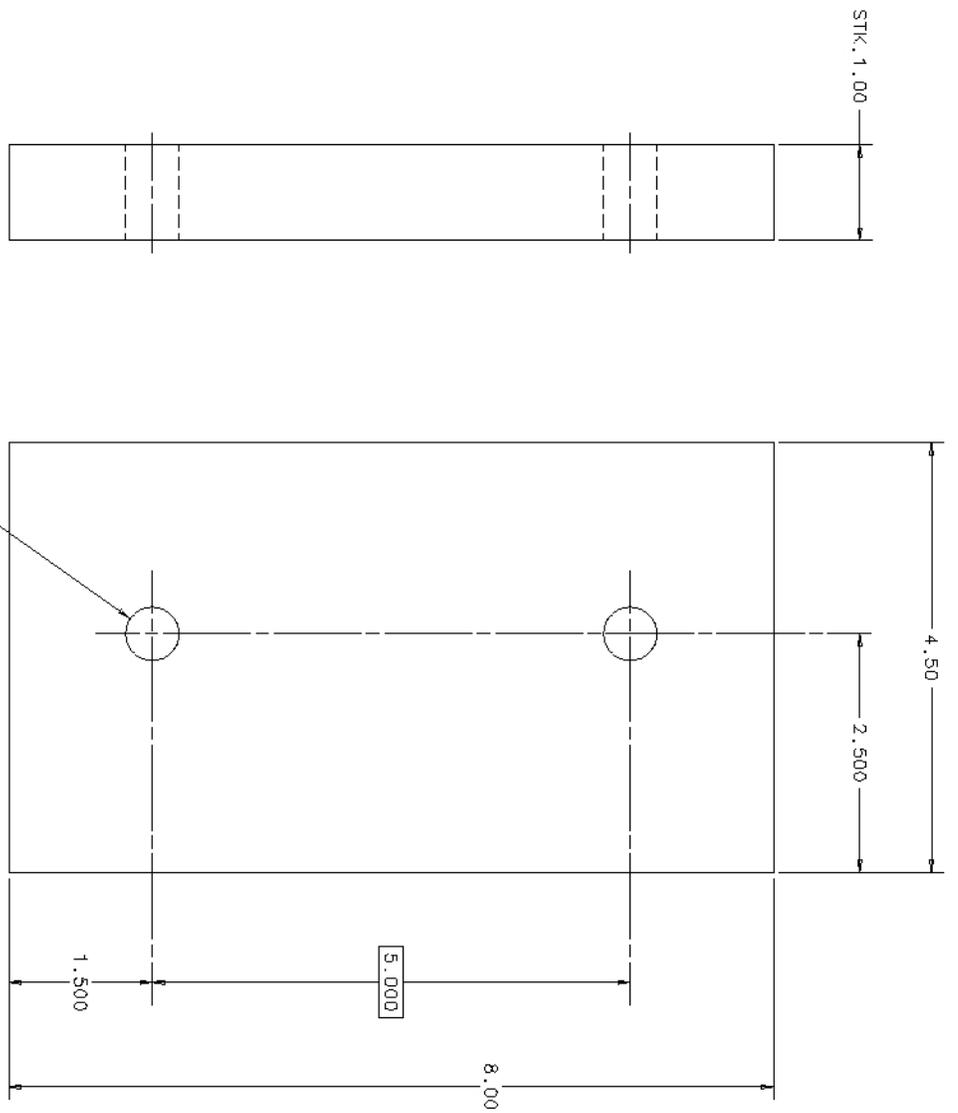
PARTS LIST		DATE
UNLESS OTHERWISE SPECIFIED	BY: SAUNDERS	22-04-2010
1. ROLLER CHANNEL	1. PARTS	22-04-2010
2. BAR	2. SAUNDERS	22-04-2010
3. CONL	3. SAUNDERS	22-04-2010
4. CONL	4. SAUNDERS	22-04-2010
5. CONL	5. SAUNDERS	22-04-2010
6. CONL	6. SAUNDERS	22-04-2010
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8. CONL	8. SAUNDERS	22-04-2010
9. CONL	9. SAUNDERS	22-04-2010
10. CONL	10. SAUNDERS	22-04-2010

FEDERAL NATIONAL ACCELERATOR LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY
 E974-MI OROBOONE - OROSENIOS
 SUPPORT EQUIPMENT
 BAR - HX-CROSSOVER-MOUNTING

SCALE	DRAWING NUMBER	SHEET	REV
1:2	3974-Z20-MD-486033	1 OF 1	
CREATED WITH:	ISSUED/REVISED BY:	DEPT:	PRO/MECHANICAL DEPARTMENT
2			1

- NOTE:
1. PAINT ONE (1) COAT RED OXIDE PRIMER.
 2. PRIOR TO PAINTING REMOVE WELD SLAG AND DEBRIS.

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



2X ϕ .562 THRU
 ϕ .030

UNLESS OTHERWISE SPECIFIED		ORIGINATOR	DATE
.XX	.XXX	R. SANDERS	20-JUL-2010
± .03	± .015	J. MATESKI	20-JUL-2010
	± 1°	J. RAUCH	30-NOV-2010
1. BREAK ALL SHARP EDGES		R. SANDERS	30-NOV-2010
2. DO NOT SCALE DRAWING			
3. DIMENSIONS BASED UPON			
4. MAX. ALLOWABLE SURFACES			
5. DRAWING UNITS: U.S. INCH			

FERMI NATIONAL ACCELERATOR LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY

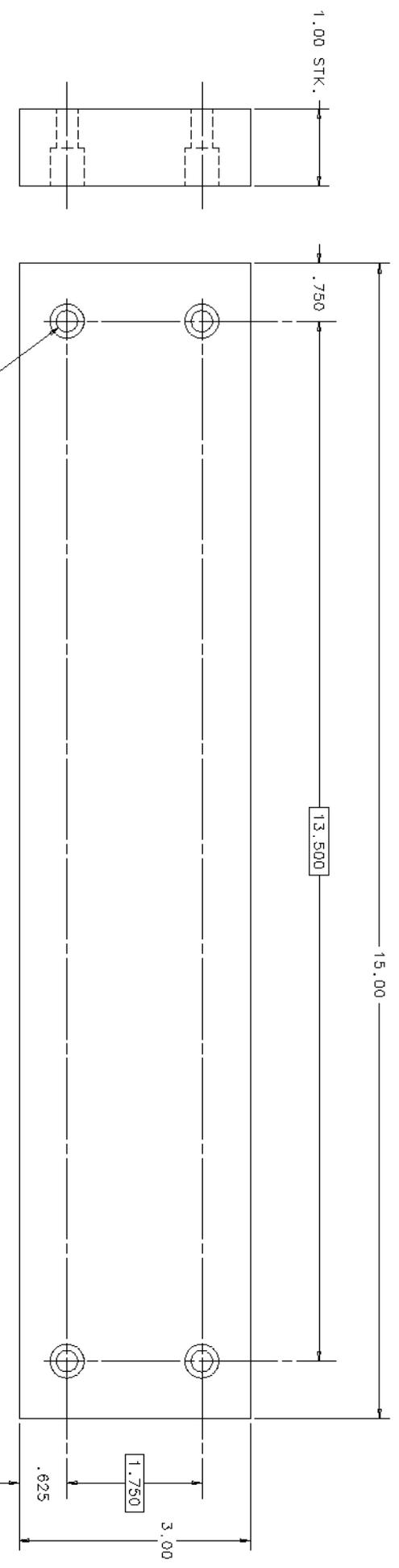
E974-MICROBONE - CRYOGENICS
 SUPPORT EQUIPMENT
 HX SPACER - 4.50 W. X 8.00 LG.

SCALE	DRAWING NUMBER	SHEET	REV
1:1	3974.220-MC-485124	1 OF 1	

NOTE:

1. PAINT ONE (1) COAT RED OXIDE PRIMER.
2. PRIOR TO PAINTING CLEAN AND DEGREASE.

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



- NOTE:
1. PAINT ONE (1) COAT RED OXIDE PRIMER.
 2. PRIOR TO PAINTING CLEAN AND DEGREASE.

UNLESS OTHERWISE SPECIFIED		ORIGINATOR	DATE
.XX	.XXX	R. SANDERS	20-JUL-2010
± .03	± .015	J. MATESKI	20-JUL-2010
	± 1°	J. RAUCH	30-NOV-2010
1. BREAK ALL SHARP EDGES		R. SANDERS	30-NOV-2010
2. DO NOT SCALE DRAWING			
3. DIMENSIONS BASED UPON			
4. MAX. ALLOW. SURFACES			
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5. DRAWING UNITS: U.S. INCH			
MATERIAL			G-10
USED ON		3974.220-ME-486031	



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UNITED STATES DEPARTMENT OF ENERGY

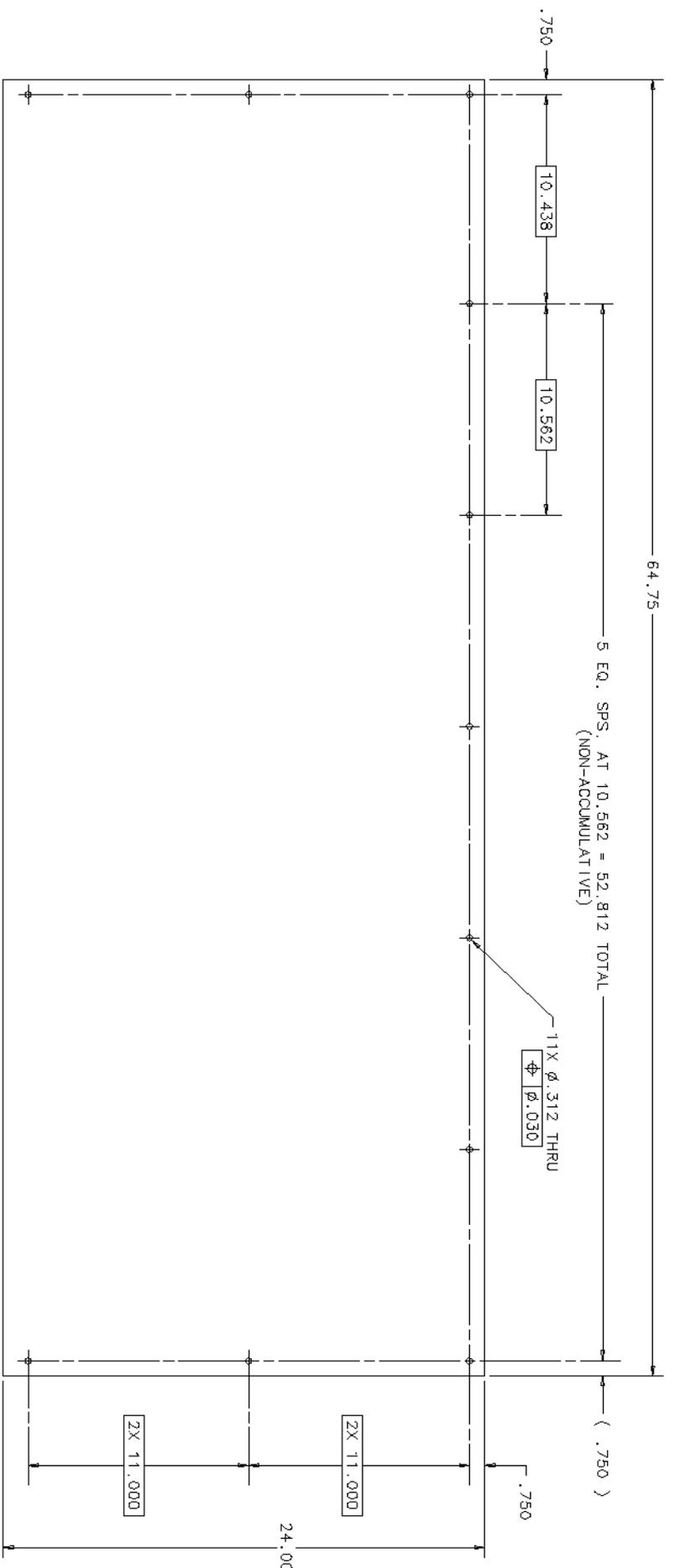
E974-MICROBONE - CRYOGENICS
SUPPORT EQUIPMENT
HX SPACER - 3.00 W. X 15.00 LG.

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GROUP: PPD/MECHANICAL DEPARTMENT

4 3 2 1

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



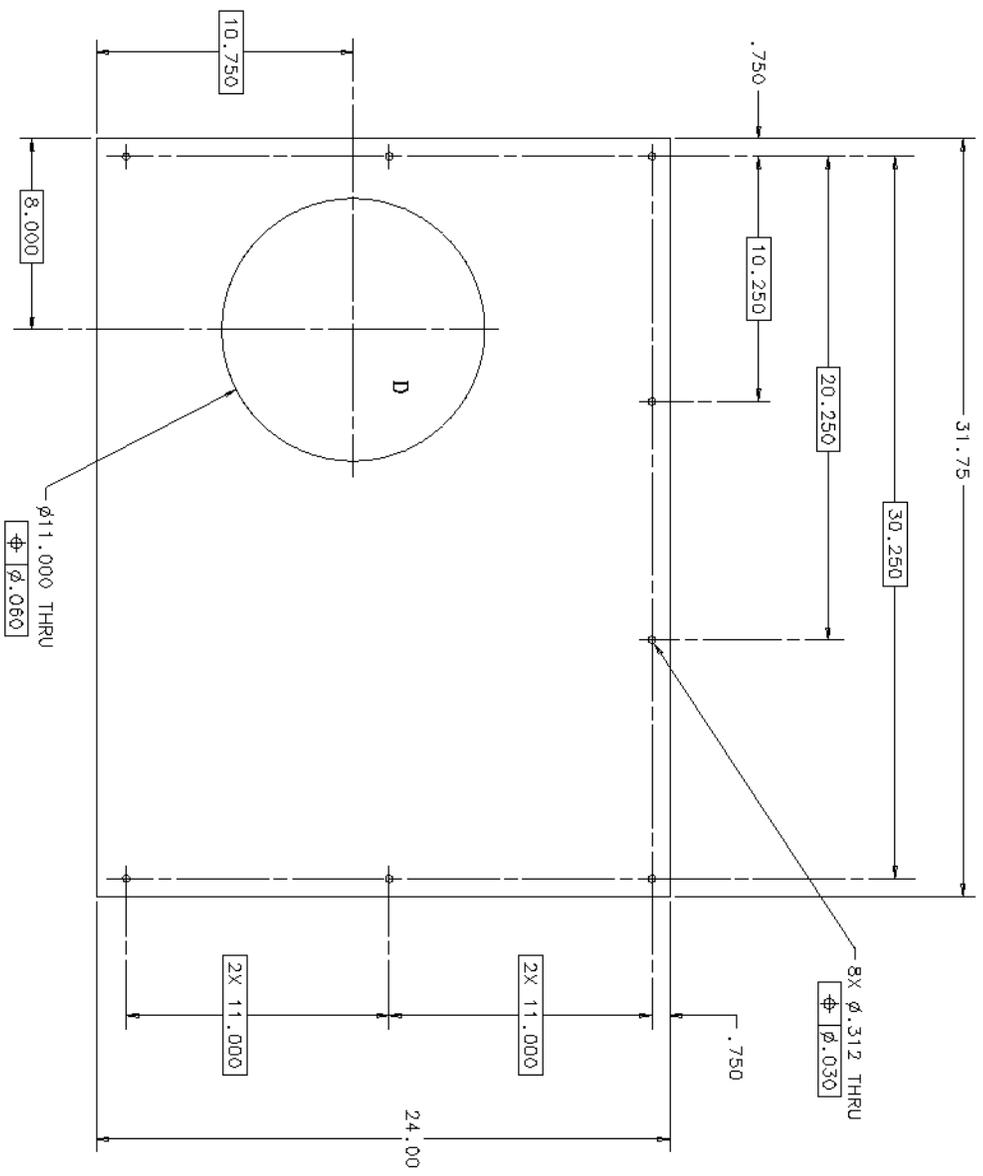
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UNLESS OTHERWISE SPECIFIED			
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± .03	± .010	± 1°	CHECKED
1. BREAK ALL SHARP EDGES TO 5 MAX	APPROVED	R. SANDERS	30-NOV-2010
2. DO NOT SCALE DRAWING. DIMENSIONS BASED UPON ASSE. AT THE SURFACES	USED ON	3974.220-ME-486031	
4. MAX. ALLOW. SURFACES 250	MATERIAL	6mm (.236) THK. POLYCARBONATE	
5. DRAWING UNITS: U.S. INCH			


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 UNITED STATES DEPARTMENT OF ENERGY

E974-MI CROBONE - CRYOGENICS
SUPPORT EQUIPMENT
HX SIDE PANEL - ITEM 25

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974.220-MC-485155	1 OF 1	
CREATED WITH: Ideas123vSeries GROUP: PPL/MECHANICAL DEPARTMENT			

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
PARTS LIST			
UNLESS OTHERWISE SPECIFIED			
.XX	.XXX	ANGLES	DRAWN
± .03	± .010	± 1°	CHECKED
1. BREAK ALL SHARP EDGES	APPROVED	R. SANDERS	30-NOV-2010
2. DO NOT SCALE DRAWING.	USED ON	3974.220-ME-486031	
3. DIMENSIONS BASED UPON			
4. MAX. ALLOW. SURFACES			
5. DRAWING UNITS: U.S. INCH			

ORIGINATOR	DRAWN	CHECKED	APPROVED	DATE
R. SANDERS	J. MATESKI	J. RAUCH	R. SANDERS	20-AUG-2010 30-NOV-2010 30-NOV-2010

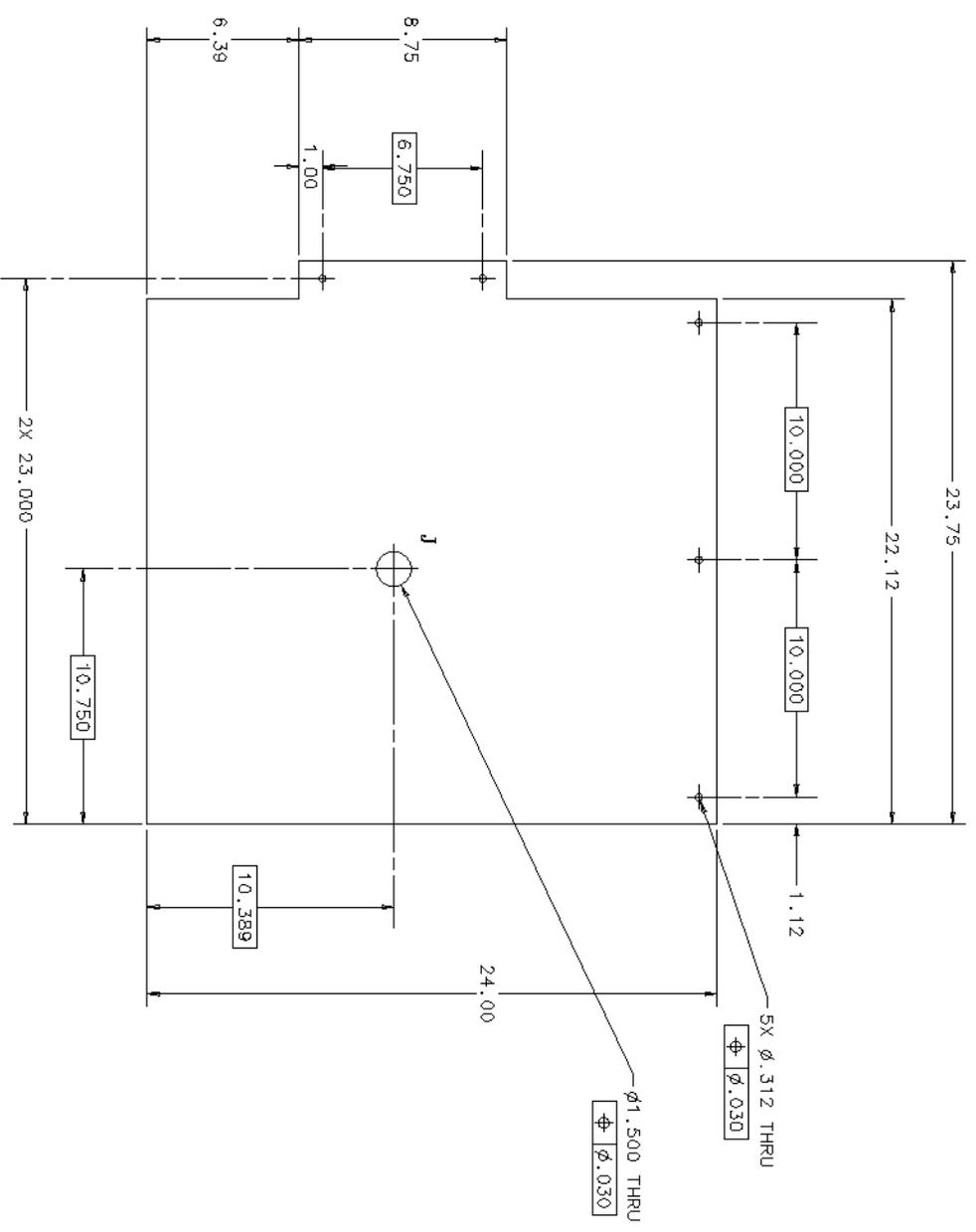
MATERIAL: 6mm (.236) THK. POLYCARBONATE


FERMI NATIONAL ACCELERATOR LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY

E974-M1 CARBONE - CRYOGENICS
 SUPPORT EQUIPMENT
 HX SIDE PANEL - ITEM 23

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974.220-MC-485154	1 OF 1	
CREATED WITH: Ideas12NXSeries		GROUP: PPD/MECHANICAL DEPARTMENT	

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
PARTS LIST			

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	DATE
.XX	R. SANDERS	20-AUG-2010
± .03	J. MATESKI	20-AUG-2010
± .010	J. RAUOH	30-NOV-2010
± 1°	R. SANDERS	30-NOV-2010

1. BREAK ALL SHARP EDGES
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON
DRAWING
4. MAX. ALLOWABLE SURFACES
250 /
5. DRAWING UNITS: U.S. INCH

MATERIAL: 6mm (.236) THK. POLYCARBONATE

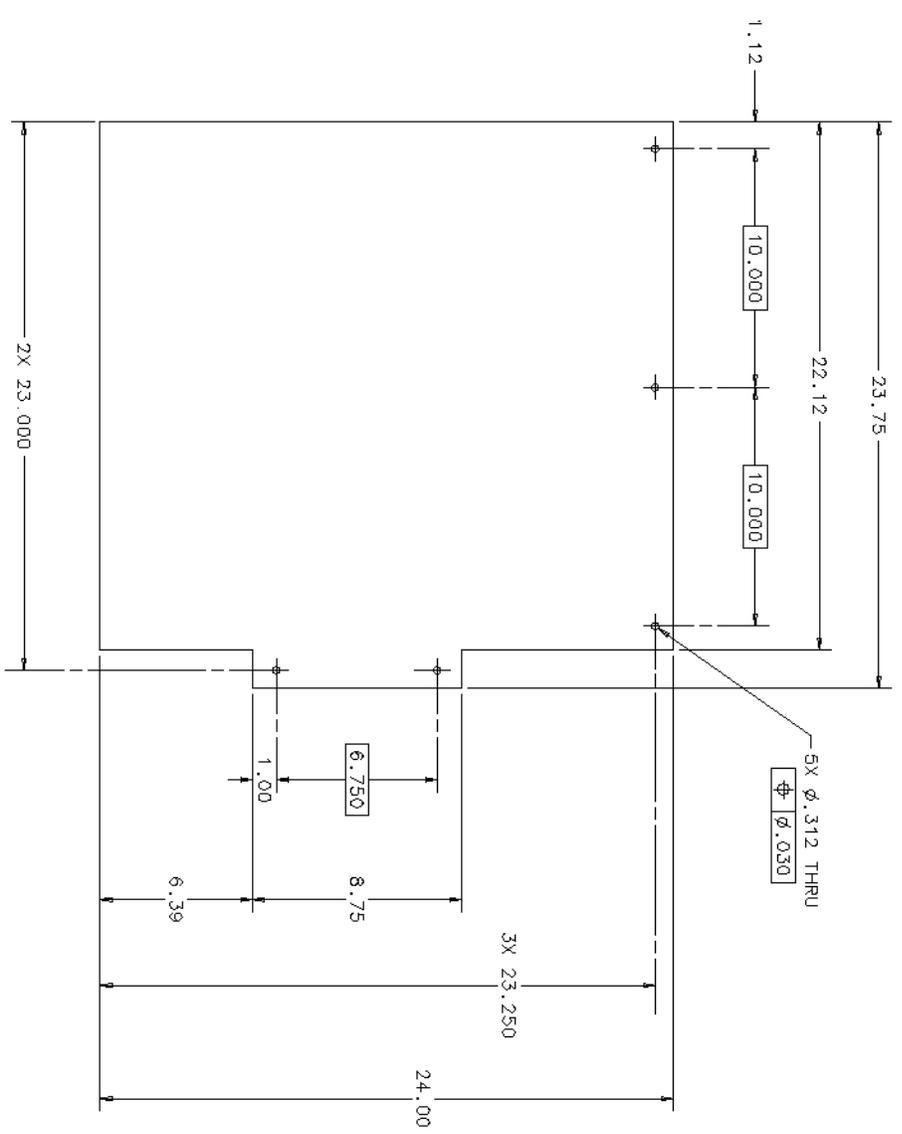
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UNITED STATES DEPARTMENT OF ENERGY

E974-MICROBONE - CRYOGENICS
SUPPORT EQUIPMENT
HX SIDE PANEL - ITEM 27

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974.220-MC-486158	1 OF 1	

GROUP: PRD/MECHANICAL DEPARTMENT
CREATED WITH: Ideas123xSeries

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
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PARTS LIST

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	DATE
.XX	R. SANDERS	20-AUG-2010
± .03	J. MATESKI	20-AUG-2010
± .010	J. RAJICH	30-NOV-2010
± 1°	R. SANDERS	30-NOV-2010

1. BREAK ALL SHARP EDGES
2. DO NOT SCALE DRAWING.
3. DIMENSIONS BASED UPON
4. MAX. ALLOW. SPREADS
5. DRAWING UNITS: U.S. INCH

APPROVED: R. SANDERS
USED ON: 3974-220-ME-486031

MATERIAL: 6mm (.236) THK. POLYCARBONATE



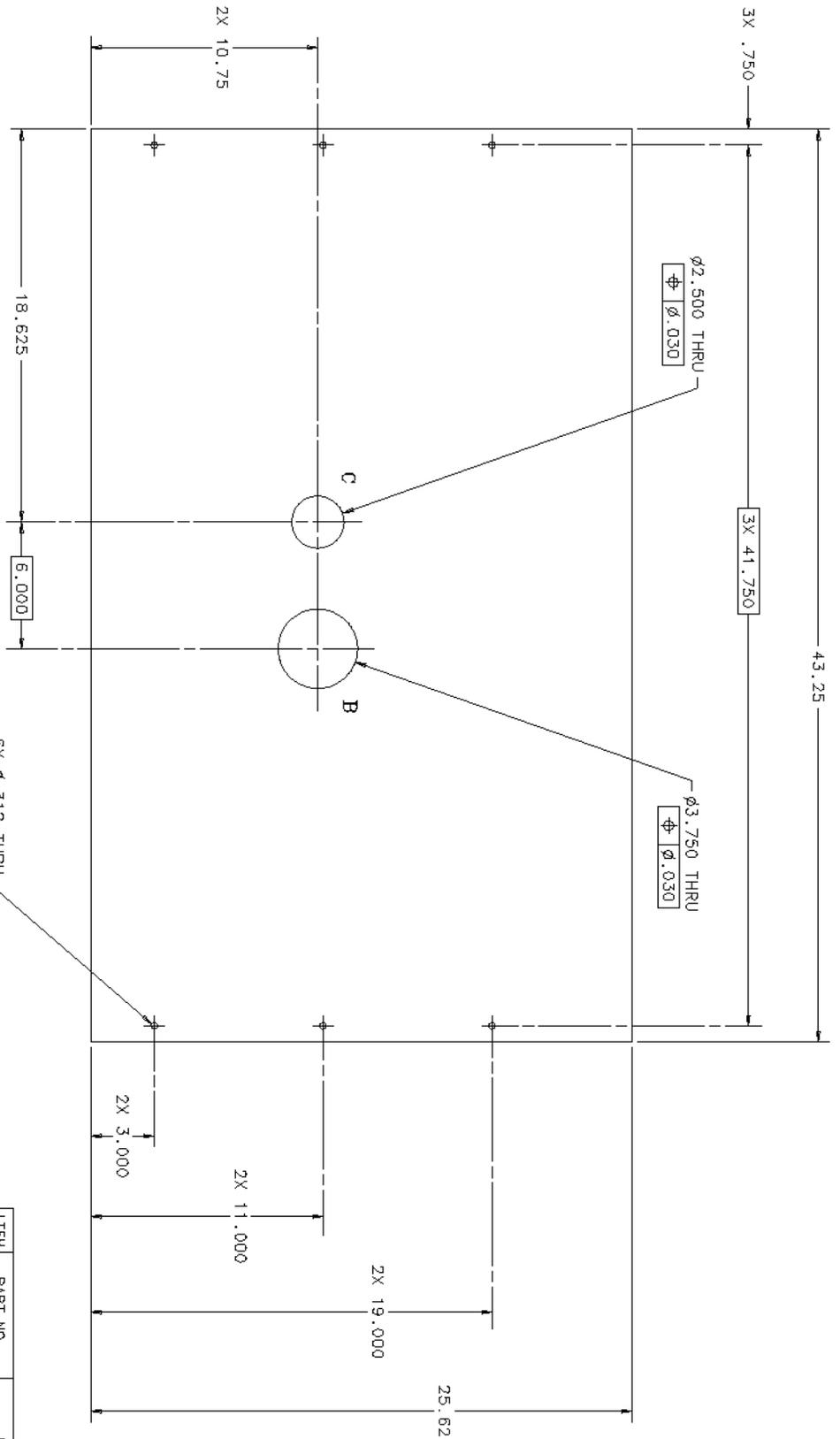
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UNITED STATES DEPARTMENT OF ENERGY

E974-MICROPHONE - CRYOGENICS
SUPPORT EQUIPMENT
HX SIDE PANEL - ITEM 28

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974-220-MC-486170	1 OF 1	

GROUP: PRD/MECHANICAL DEPARTMENT
CREATED WITH: Ideas123xSeries

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



6X ϕ .312 THRU
 ϕ .030

PARTS LIST

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
UNLESS OTHERWISE SPECIFIED	ORIGINATOR	R. SANDERS	20-AUG-2010
.XX	.XXX	ANGLES	J. MATESKI
± .03	± .010	± 1°	CHECKED
			J. RAJLOH
			APPROVED
			R. SANDERS
			USED ON
			3974.220-ME-486031

1. BREAK ALL SHARP EDGES
 2. DO NOT SCALE DRAWING.
 3. DIMENSIONS BASED UPON
 4. MAX. ALLOW. SPREADS
 290
 5. DRAWING UNITS: U.S. INCH



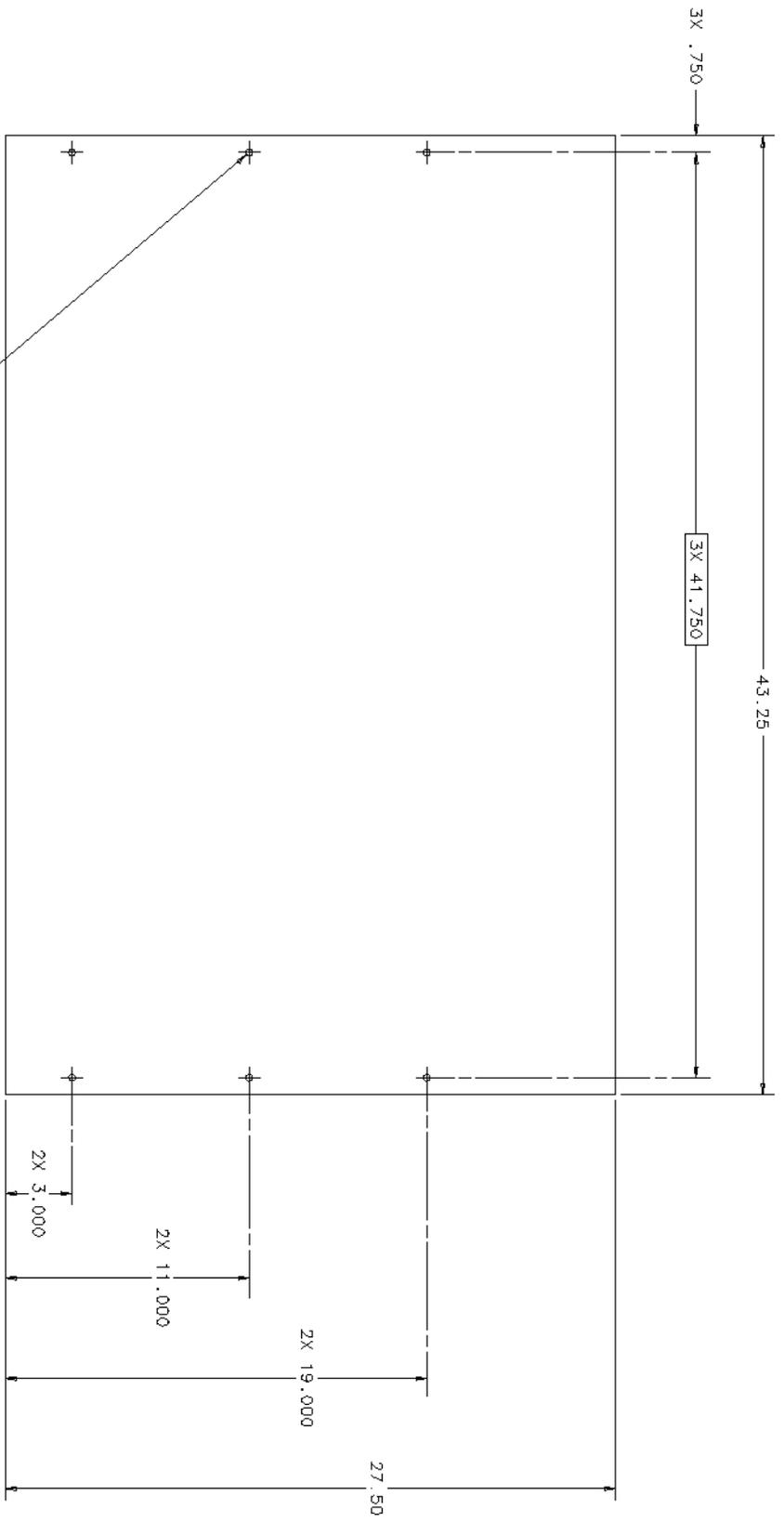
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 UNITED STATES DEPARTMENT OF ENERGY

E974-MICROPHONE - CRYOGENICS
 SUPPORT EQUIPMENT
 HX END PANEL - ITEM 29

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974.220-MC-486172	1 OF 1	

GROUP: PRD/MECHANICAL DEPARTMENT
 CREATED WITH: Ideas123xSeries

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



6X Ø.312 THRU
 Ø.050

PARTS LIST

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
UNLESS OTHERWISE SPECIFIED ORIGINAL			
.XX	.XXX	ANGLES DRAWN	R. SANDERS 20-AUG-2010
± .03	± .010	± 1°	J. MATESKI 20-AUG-2010
		CHECKED	J. RAUOH 30-NOV-2010
		APPROVED	R. SANDERS 30-NOV-2010
		USED ON	3974.220-ME-486031
MATERIAL		HX END PANEL - ITEM 30	
5. DRAWING UNITS: U.S. INCH			



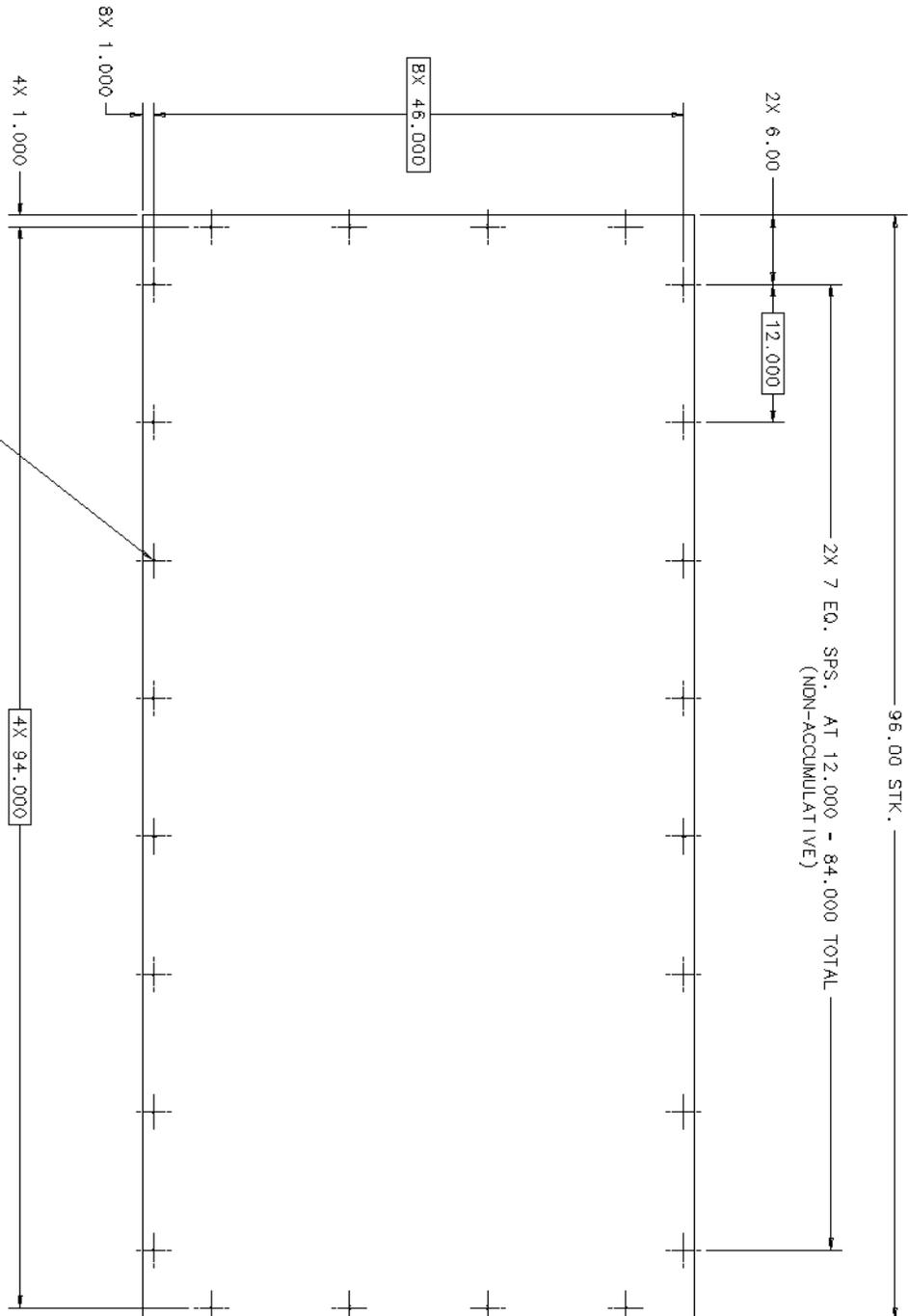
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 UNITED STATES DEPARTMENT OF ENERGY

E974-MICROPHONE - CRYOGENICS
 SUPPORT EQUIPMENT
 HX END PANEL - ITEM 30

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974.220-MC-486175	1 OF 1	

GROUP: PRD/MECHANICAL DEPARTMENT
 CREATED WITH: Ideas123xSeries

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



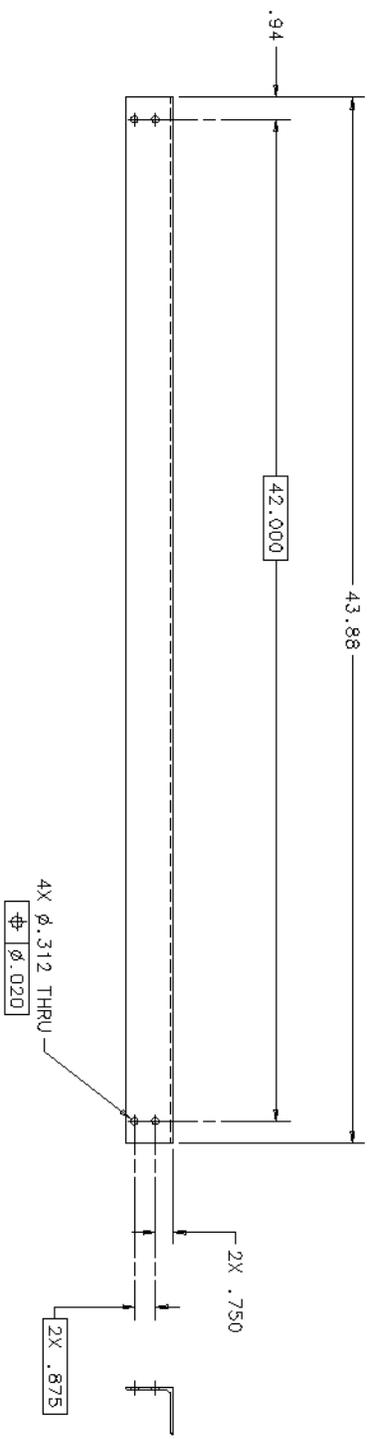
ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
PARTS LIST			
UNLESS OTHERWISE SPECIFIED	ORIGINATOR	R. SANDERS	20-AUG-2010
.XX	ANGLES DRAWN	J. MATESKI	20-AUG-2010
± .03	± .010	± 1°	30-NOV-2010
1. BREAK ALL SHARP EDGES	CHECKED	J. RAJLOH	30-NOV-2010
2. DO NOT SCALE DRAWING.	APPROVED	R. SANDERS	30-NOV-2010
3. DIMENSIONS BASED UPON	USED ON	3974-220-ME-486031	
4. MAX. ALLOW. SPREADS	MATERIAL	6mm (.236) THK. POLYCARBONATE	
5. DRAWING UNITS: U.S. INCH			


FERMI NATIONAL ACCELERATOR LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY

E974-MICROPHONE - CRYOGENICS
SUPPORT EQUIPMENT
 HX TOP PANEL - ITEM 31

SCALE	DRAWING NUMBER	SHEET	REV
1:8	3974-220-MC-486179	1 OF 1	
CREATED WITH : Ideas123xSeries		GROUP : PPD/MECHANICAL DEPARTMENT	

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
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PARTS LIST

UNLESS OTHERWISE SPECIFIED	ORIGINATOR	DATE
.XX	R. SANDERS	20-AUG-2010
± .03	J. MATESKI	20-AUG-2010
± .010	J. RAJLOH	30-NOV-2010
± 1°	R. SANDERS	30-NOV-2010

1. BREAK ALL SHARP EDGES
 2. DO NOT SCALE DRAWING.
 3. DIMENSIONS BASED UPON ASSE Y14 20-1994
 4. MAX. ALLOW. SURFACES 290 ✓
 5. DRAWING UNITS: U.S. INCH

USED ON: 3974.220-ME-486031
 MATERIAL: ANGLE 2 X 2 X 1/8 HRS
 ASTM A-36

FERMI NATIONAL ACCELERATOR LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY

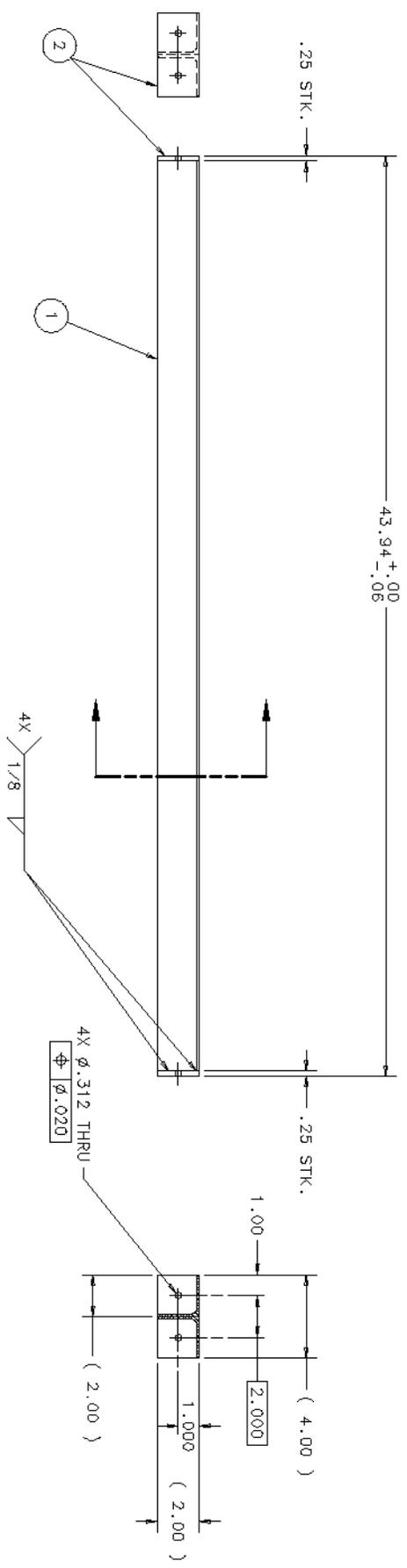
E974-MICROBONE - CRYOGENICS
 SUPPORT EQUIPMENT
 HX END SUPPORT BAR

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974.220-MC-486180	1 OF 1	

GROUP: PPD/MECHANICAL DEPARTMENT
 CREATED WITH: Ideas123XSeries

- NOTE:
1. PAINT ONE (1) COAT RED OXIDE PRIMER.
 2. PRIOR TO PAINTING CLEAN AND DEGREASE.

REV	DESCRIPTION	DRAWN	DATE
		APPROVED	DATE



ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.
2	CDML	BAR 1/4 THK X 2.00 W X 43.00 LG. H.R.S. ASTM-A36	2
1	CDML	ANGLE, 2 X 2 X 1/8 H.R.S. ASTM-A36	2

PARTS LIST			
UNLESS OTHERWISE SPECIFIED	ORIGINATOR	DATE	
.XX	R. SANDERS	20-AUG-2010	
± .03	J. MATESKI	20-AUG-2010	
± .010	J. RAJICH	30-NOV-2010	
1. BREAK ALL SHARP EDGES	R. SANDERS	30-NOV-2010	
2. DO NOT SCALE DRAWING.			
3. DIMENSIONS BASED UPON			
4. MAX. ALLOW. SPREADS			
290			
	3974-220-ME-486031		
	USED ON		
	MATERIAL		
	SEE PARTS LIST ABOVE		

- NOTE:
1. PAINT ONE (1) COAT RED OXIDE PRIMER.
 2. PRIOR TO PAINTING REMOVE WELD SLAG AND DEBRIS.



FERMI NATIONAL ACCELERATOR LABORATORY
 UNITED STATES DEPARTMENT OF ENERGY

E974-MICROBONE - CRYOGENICS
 SUPPORT EQUIPMENT
 HX MID SUPPORT BAR

SCALE	DRAWING NUMBER	SHEET	REV
1:4	3974-220-MC-486182	1 OF 1	

CREATED WITH : Ideas123xSeries GROUP : PPD/MECHANICAL DEPARTMENT

Ila. Heat Exchanger

Copied below is an e-mail conversation between Fermilab and AUAI, containing the budgetary information on the heat exchanger.

From: AUAI/EEEE [mailto:auai@q.com]
Sent: Friday, December 18, 2009 12:16 PM
To: Glenn A. Morgan
Cc: 'DEBLANGEY Arnaud'
Subject: RE: FERMILAB / BUDGET QUOTATION OF BAHX CORE
Importance: High

HELLO GLENN,

ATTACHED ARE DATA SHEET, SKETCH AND COOLING CURVES FOR THE REQUESTED HEAT EXCHANGER ITEM. PER OUR PHONE CONVERSATION, THESE DOCUMENTS ARE CONSIDERED TO BE **PROPRIETARY**. THEY SHOULD **NOT** BE INCLUDED IN THE FORMAL INQUIRY DOCUMENTS THAT FERMILAB WILL LIKELY ISSUE WITHIN THE NEXT FEW MONTHS.

THE BUDGET SELECTION IS ONE [1] BAHX CORE 305 X 235 X 4500 mm AT A BUDGET PRICE OF 63,450 EURO (= US\$92,000 @ 1.45US\$/EURO) EX WORKS GOLBEY, FRANCE. THE ESTIMATED DRY WEIGHT IS 900 LB. SHIPMENT EX WORKS GOLBEY, FRANCE IS 40 WEEKS AFTER RECEIPT OF ORDER.

THE ESTIMATED COST OF SHIPMENT AND U.S. CUSTOMS DUTY TO FERMILAB IS US\$5,500 TO US\$6,000.

THANKS FOR YOUR COMMUNICATION. PLEASE ADVISE IF FURTHER INFORMATION SHOULD BE REQUIRED.

REGARDS,

DEE

****New conversion 63,450 euro @ current conversion rate (1/7/11) 1.304 \$/eu = \$82,739**

****Total for heat exchanger with shipping = \$88,739 (check current conversion rate)**

II. Heat Exchanger Frame Parts Pricing

Item #- Description	Source	Part Number	Quantity	Price (each)
#1- Structural channel, C6 x 8.2 x 210.5 long	Metals Depot	C2682	4 (4 – 20 foot lengths)	\$125.80
#2- Structural channel, C6 x 8.2 x 22 long	Metals Depot	C2682	10 (1- 20 foot length)	\$125.80
#3- Structural channel, C6 x 8.2 x 44 long	Metals Depot	C2682	9 (2- 20 foot lengths)	\$125.80
#4- Structural channel, C6 x 8.2 x 210.5 long	Metals Depot	C2682	2 (1- 6 foot length)	\$59.04
#5- Structural channel, C3 x 4.1 x 47 long	Metals Depot	C2341	2 (1- 10 foot length)	\$36.90
#6- Angle, Hot rolled, 2 x 2 x 1/8 x 27.25 long	Metals Depot	A12218	4 (1- 10 foot length)	\$17.80
#7-Half couple, 1/4 NPT steel, McM # 4513K71	McMaster Carr	4513K71	2	\$1.05

Heat exchanger frame parts total cost: $125.80(4) + 125.80 + 125.80(2) + 59.04 + 36.90 + 17.80 + 1.05(2) = \mathbf{\$996.44}$

III. Heat Exchanger Skid Parts Pricing

The heat exchanger skid is seen in engineering drawing 486031. *Items 20-31 are 6mm thick polycarbonate panels, machined to different configurations. The Sundance Supply Company has the cheapest pricing on polycarbonate sheets with a list price of \$1.35 per square foot. These items will be priced by square foot.

Item #-Description	Source	Part Number	Quantity	Price (each)	
#1- Heat exchanger, Applied UA inc., sketch AUAI 091215-01 or equiv.	Applied UA inc.	Sketch 091215-01 or equiv.	1	\$88,739	
#2- Frame (drawing 486032)	See section II	See section II	1	\$996.44	
#3- Spacer, G10 grade Garolite, 8 x 4.5 x 1 thick	McMaster Carr	9910T55	2 (covered by item # 10)	See item # 10	
#4- Bar, crossover-mounting (drawing 486033)	Structural channel, C6 x 8.2 x 44 long	Metals Depot	C2682	1	\$39.36
	A36 steel bar, 3.5 x 6 x 3/8 thick	Metals Depot	F2386	2 (1- 3/8 thick x 6 wide x 12 long flat)	\$10.32
#5- Washer, flat, 1/2, 18-8 stainless steel	McMaster Carr	98125A443	8 (1- pack of 10)	\$6.90	
#6- Nut, hex head, 1/2-13unc, 18-8 stainless steel	McMaster Carr	91845A310	8 (1- pack of 25)	\$5.25	
#7- Screw, hex head, 1/2-13unc x 1.38, 18-8 stainless steel	McMaster Carr	92240A716	4 (1- pack of 10)	\$11.31	
#8- Screw, hex head, 1/2-13unc x 2.5, 18-8 stainless steel	McMaster Carr	92240A722	4 (1- pack of 5)	\$7.01	
#9- Screw, socket head, 1/4-20unc x .75, type 18-8 SS	McMaster Carr	93705A540	8 (1- pack of 25)	\$7.71	
#10- Spacer (drawing 486125), grade G10 Garolite, 3 x 15 x 1 thick	McMaster Carr	9910T56	1 (1- 24 x 24 x 1 thick sheet, provides enough for item # 3)	\$352.00	
#11- Hoist ring, McM # 3070T51 or equiv.	McMaster Carr	3070T51	4	\$115.42	

#12- Bar, A36, 6 x 41.5 x 3/8	Metals Depot	F2386	1 (1- 3/8 x 6 x 8 foot bar)	\$82.56
#13- Bar, A36, 6 x 22 x 3/8	Metals Depot	F2386	1 (covered by item #12)	See item # 12
#14- Bar, A36, 2 x 5.62 x 1/4	Metals Depot	F2142	1 (1- 1/4 x 2 x 2 foot bar)	\$4.68
*#15- Flex hose, single braid, 2 id x 22 live length, 2 IPS schedule 10 beveled end pipe fittings, Hose Master or equiv	Hose Master (Motion Industries)	N/A	1	\$120
*#16- Flex hose, single braid, 3 id x 24 live length, 3 IPS schedule 10 beveled end pipe fittings, Hose Master or equiv	Hose Master (Motion Industries)	N/A	1	\$200
*#17- Flex hose, single braid, 1 id x 14.25 live length, 1 IPS schedule 10 beveled end pipe fittings, Hose Master or equiv	Hose Master (Motion Industries)	N/A	2	\$75
*#18- Flex hose, single braid, 3 id x 84 live length, 3 IPS schedule 10 beveled end pipe fittings, Hose Master or equiv	Hose Master (Motion Industries)	N/A	1	\$200
*#19- Flex hose, single braid, 2 id x 41 live length, 2 IPS schedule 10 beveled end pipe fittings, Hose Master or equiv	Hose Master (Motion Industries)	N/A	1	\$160
#20- Bottom panel, 6mm thick polycarbonate, 48 x 96	Sundance Supply Company	N/A	1 (4 x 8 feet at \$1.35/sq. foot)	\$43.20
#21- Bottom panel, 6mm thick polycarbonate, 48 x 96	Sundance Supply Company	N/A	1 (4 x 8 feet at \$1.35/sq. foot)	\$43.20
#22- Hx side panel, 6mm thick polycarbonate, 31.75 x 24	Sundance Supply Company	N/A	1 (2.65 x 2 feet at \$1.35/sq. foot)	\$7.16
#23- Hx side panel, 6mm thick polycarbonate, 31.75 x 24	Sundance Supply Company	N/A	1 (2.65 x 2 feet at \$1.35/sq. foot)	\$7.16

#24- Hx side panel, 6mm thick polycarbonate, 64.75 x 24		Sundance Supply Company	N/A	1 (5.4 x 2 feet at \$1.35/sq. foot)	\$14.57
#25- Hx side panel, 6mm thick polycarbonate, 64.75 x 24		Sundance Supply Company	N/A	1 (5.4 x 2 feet at \$1.35/sq. foot)	\$14.57
#26- Hx side panel, 6mm thick polycarbonate, 62.75 x 24		Sundance Supply Company	N/A	2 (5.3 x 2 feet at \$1.35/sq. foot)	\$28.24
#27- Hx side panel, 6mm thick polycarbonate, 23.75 x 24		Sundance Supply Company	N/A	1 (1.99 x 2 feet at \$1.35/sq. foot)	\$5.34
#28- Hx side panel, 6mm thick polycarbonate, 23.75 x 24		Sundance Supply Company	N/A	1 (1.99 x 2 feet at \$1.35/sq. foot)	\$5.34
#29- Hx side panel, 6mm thick polycarbonate, 25.62 x 43.25		Sundance Supply Company	N/A	1 (2.135 x 3.6 feet at \$1.35/sq. foot)	\$10.39
#30- Hx side panel, 6mm thick polycarbonate, 27.5 x 43.25		Sundance Supply Company	N/A	1 (2.29 x 3.6 feet at \$1.35/sq. foot)	\$11.14
#31- Hx top panel, 6mm thick polycarbonate, 48 x 96		Sundance Supply Company	N/A	2 (4 x 8 feet at \$1.35/sq. foot)	\$86.40
#32- End support bar, A36 hot rolled angle, 2 x 2 x ¼ x 43.88 long		Metals Depot	A12218	1 (1- 20 foot length)	\$28.40
#33- Mid support bar	A36 angle, 2 x 2 x ¼ x 43.88 long	Metals Depot	A12218	1 (Covered by item # 32)	Covered by item # 32
	A36 bar, ¼ x 2 x 6		F2142	2 (1- ¼ x 2 x 4 foot long bar)	\$9.36
#34- Intermediate support bar	A36 angle, 2 x 2 x ¼ x 43.88 long	Metals Depot	A12218	2 (Covered by item # 32)	Covered by item # 32
	A36 bar, ¼ x 2 x 6		F2142	4 (Covered by item # 33)	Covered by item # 33
#35- Screw, hex head, ¼-20unc x ½ long, type 18-8 SS		McMaster Carr	92240A537	16 (1- pack of 50)	\$4.88

#36- Lock washer, 1/4, type 18-8 SS	McMaster Carr	92146A029	16 (1- pack of 100)	\$4.03
#37- Hex nut, 1/4-20, type 18-8 SS	McMaster Carr	91845A29	16 (1- pack of 100)	\$4.49
#38- Screw, self tapping TEK type with Neoprene seal washer, #10/16 x 3/4 long, Greenhouse Megastore #GA-1009 or equiv.	Greenhouse Megastore	GA-1009	182 (2- packs of 100)	\$20.00

*Item # 15-19 are unofficial estimates extrapolated from previous estimates on lengths of 3/4 hose with schedule 10 end fittings.

Heat exchanger skid parts total: $88,739 + 996.44 + 39.36 + 10.32 + 6.90 + 5.25 + 11.31 + 7.01 + 7.71 + 352.00 + 115.42(4) + 82.56 + 4.68 + [830 \text{ (unofficial estimate of all hose assemblies)}] + 43.20 + 43.20 + 7.16 + 7.16 + 14.57 + 14.57 + 28.24(2) + 5.34 + 5.34 + 10.39 + 11.14 + 86.40(2) + 28.40 + 9.36 + 4.88 + 4.03 + 4.49 + 20.00(2) = \mathbf{\$92,093.21}$

IV. In House Labor Cost

Description	Time (hours)	Base wage	Total
Technician	96	\$51.00 / hour	\$4,896.00
Welder	32	\$51.00 / hour	\$1,632.00
Total / [Total +15%]	128 / [147]		\$6,528 / \$7,497

Total in house labor cost: \$6,528

Total in house labor cost +15%: \$7,497

\$7,497 will be used as the total in house

V. Total in house part and assembly costs

Description	Cost x quantity(if applicable)	Total Cost
Heat Exchanger	\$88,739 x 1	\$88,739
Heat Exchanger Frame	\$996.44 x 1	\$996.44
Heat Exchanger Skid Parts	\$2,356.77 x 1	\$2,356.77
In house labor cost	-	\$7,497
Total		\$99,589.21

Total in house assembly and parts: \$99,589.21

*The next section would typically be a comparison against outside quotes for full fabrication; however no such estimates currently exist. With the cost of the heat exchanger itself accounting for a large majority of the cost of the skid, outside quotes may be of little value, and will almost certainly be higher on account of higher labor charges.

No contingency has been accounted for in this estimate, however 15% has been added to the total labor cost per John Voirin's recommendation.