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SDC
SOLENOIDAL DETECTOR NOTES

FINAL REPORT ON COST ESTIMATE OF FORWARD SUPERCONDUCTING AIR CORE TOROID

December 1992

T. Fields
Argonne National Laboratory

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Abstract

An independent cost-estimate for key components of the forward superconducting air core toroid (ACT) was obtained in May 1992 from an experienced manufacturer of large cryogenic vessels. This new cost estimate is summarized in this report. It implies that a suitably designed ACT may have a cost which is approximately equal to that of the presently designed SDC forward iron core toroid.

Introduction

The SDC decision to use an iron core toroid (ICT) rather than a superconducting ACT for the forward angle region was based on cost and physics benefit issues which have been described in an SDC note (ref. 1). That SDC note also emphasized the large uncertainties in the cost of the ACT. These uncertainties drove the choice toward the ICT, despite the better physics capabilities of an ACT. Main sources of these uncertainties included:

1. Two radically different ACT conceptual designs were made, and their estimated cost differed by a factor of 4.

2. The (lower cost) design made by Advanced Cryo Magnetics (ACM) (described in ref. 2) incorporated several novel design features which were designed to minimize costs. However, no independent cost estimate was available.

A logical next step to clarify these cost matters was to obtain an independent, more detailed cost estimate for the ACM design. For this purpose, a contract was let in early 1992 from ANL to Pitt-Des Moines, Inc. (PDM), a company with extensive experience in the design, cost-estimating, and fabrication of very large, aluminum (welded) cryogenic vessels. PDM was supplied with the ACM conceptual design report (with all ACM cost estimate information omitted).

In the remainder of this note, we first summarize the independent cost estimate report from PDM, then we compare that estimate to the original ACM cost estimate, and finally we give some conclusions.

PDM Report

The report from PDM, dated May 12, 1992, is a 30 page document. Copies of it can be obtained from the present author (email THF@ANLHEP).

The report first notes that the ACM conceptual design report (ref. 2) is not detailed enough to support pricing at the fabrication and welding level. Therefore, additional design work was done by PDM before they made their cost estimate. Furthermore, only 4 major components of the toroid were estimated: toroid former, helium vessel, heat shield, and vacuum vessel. These

particular components were chosen because their design and fabrication features are well matched to PDM's capabilities and experience.

Appendix A is a spreadsheet from the PDM report. It shows that the PDM total estimate for these four components is $2.9M. Appendix B shows the construction time schedule given in the PDM report.

Comparison with ACM Estimate

The total cost of the above-mentioned four components in the ACM estimate (ref. 2) is given as $5.1M. Thus the cost estimating from ACM seems conservative, as was stated by ACM.

Averaging the above two estimates gives $4.0M. To this I shall add $5.4M, which is the cost estimate from ACM of all items (including a liquifier system) which are not included in the PDM study. This yields a new estimate of the total cost per toroid of $9.4M. This is about 10% less than the ACM estimate.

Conclusions

My conclusions are these:

1. A more reliable cost estimate of $9.4M per ACT is now available.

2. This can be compared to the present cost estimate of $8.0M for each iron toroid which can be deduced from ref. 3.

3. The comparative physics advantages of the 100 ton ACT versus those of the 2400 ton ICT stand as described in ref. 1.

4. Independent cost analysis has supported the ACM claim that their design incorporates economical construction and assembly methods.

5. The ACM design also emphasizes high stability against quenches . Independent documented review of this and other fundamental design features would be desirable before more detailed engineering design work were carried out.

6. In view of the cost estimate comparisons discussed in this note, the use of superconducting toroids in the forward angle region should continue to be seriously considered for high energy collider detectors.

Acknowledgment

The help and advice of Norm Hill is much appreciated.

References

1. Report of the SDC ACT Task Force, SDC-91-00046.

2. Superconducting Toroidal Magnet Conceptual Design Report, SDC-90-130.

3. SDC Project Cost/Schedule Summary Book, SDC-000021 (Rev. B) (Oct. 1992).

PITT-DES MOINES INC — SHORT FORM ESTIMATE SHEET

CONTRACT NUMBER: 60120 INQUIRY NUMBER: FILE: SSC\DETECEST DATE: 4/20/92
PRODUCT DESCRIPTION: SSC Detector Vacuum Vessel
LOCATION: Waxahatchie, TX PURCHASER: Argonne National Laboratory OWNER: U.S. D.O.E.
SALESMAN:RNS PRODUCT Cl/Tp: 24/90 Estimate Type:

	BRANCH
ENGR	Pit /T.P.
DRAFT	Pit /T.P.
PROJ M	Pit /T.P.
FABR	CLIVE

CC	DESCRIPTION		LB/MH	COST	SUBTOTAL
011	MATERIALS - PLATES/SHAPES		160,572	321,144	
012	- FREIGHT IN-PLATES & SHAPES			0	
021	MATERIALS - NET WEIGHT		127,339		
031	MATERIALS - WELD CONSUMABLES	$6.00 / Lb.	8,042	48,250	
041	- BUY OUT ITEMS		721	11,153	
051	- PAINT-WEIGHT & COST		0	0	
	MATERIALS - NET WEIGHT & COST		136,102	XXXXXXXX	380,547
111	ENGR - LABOR-DIRECT	$ 23.20 /MH	1,600	37,120	
131	- OVERHEAD-APPLIED	118.00%		40,832	
133	-EXPENSES			0	77,952
211	DRAFT - LABOR-DIRECT	$ 16.60 /MH	3,000	49,800	
221	- OVERTIME	10.00%		4,980	
231	- OVERHEAD-APPLIED	120.00%		59,760	
241	- SUBLET #1			0	114,540
361	PROJ MGT-LABOR-DIRECT	$ 26.75 /MH	2,000	53,500	
381	-O'HEAD-APPLIED	105.00%		56,176	
385	-EXPENSES	35.00%		18,724	128,400
311	FABR - LABOR-DIRECT	$ 11.300 /MH	15,602	176,301	
321	-OVERTIME	2.00%		3,526	
331	- O'HEAD-APPLIED	165.00%		290,897	
341	- SUBLET #1			0	
342	- SUBLET #2			0	
361	- SPECIAL MACH-PLANT			0	
381	- SPECIAL SUPPLIES			11,241	
391	- JIGS & FIXTURES			23,000	
441	-OUTSIDE INSPECTION			0	504,965
461	- FRT OUT MTL	$3.40 / CWT		29,094	29,094
431	TRANS - MEN TO SITE + TRUCK ALLOWANCE			6,000	
491	- EQUIP-TO INCOUNTRY/BETWEEN SITES			6,000	12,000
511	FIELD - LABOR-DIRECT	$ 16.405 /MH	21,614	354,578	
521	- O'TIME-DIRECT	2.00%		7,091	
541	- PAYROLL TAXES	10.50%	317.6	37,975	
551	- LIABILITY INSURANCE	16.35%	MH / Ton	57,974	
561	- MERIT / UNION FRINGES	$ 3.14 /MH		67,867	
571	- LOCAL TRVL & SUBSIST	$ 40.62 /DAY		109,745	
581	- O/HEAD-APPLIED	$ 3.850 /MH		83,213	
582	- SMALL TOOLS	$ 3.000 /MH		64,842	
591	- LOCAL BILLS	$ 2.000 /MH		43,228	
601	- EQUIP RENT-PDM INC.	$ 5.000 /MH		108,070	
603	-OTHERS	CRANE		40,000	
681	- SPECIAL SUPPLIES (WELD GASES)			29,188	
691	- JIGS & EQUIPMENT (VACUUM TEST)			20,000	1,023,771
711	FIELD - G.C. LABOR	$ 16.405 /MH	1,840	30,184	
731	- OVERHEAD	$ 28.54 /MH		52,523	
733	- EXPENSES			0	
739	- SPECIAL SUPPLIES			0	
741	- OUTSIDE INSPECTION			0	82,707
751	SUBLET - FOUNDATIONS & SITE			0	
771	- PAINTING			0	
781	- ELECTRICAL			0	
791	- MECHANICAL			0	
801	- INSULATION			0	0
	MANUFACTURING & CONSTRUCTION FLAT COST				2,353,976
910	GENERAL & SALES-ADMINISTRATION	12.00%			282,477
	MANUFACTURING & CONSTRUCTION FULL COST				2,636,453
921	GENERAL - TAXES	0.00% Cost of Mat'l.	(EXEMPT)	0	
931	- BONDS			0	
990	PROFIT	10.00%		263,645	263,645
FORM 3	2/07/89	SALES PRICE			2,900,098
					2,891,150

Bid Date:
Est. By: Date:
Chk. By: Date:
Sold By.: Date:
Rev. No.:
Est. By: Date:
Sold By.: Date:

FABRICATE AT CLIVE — Shop Base Rate $11.30; Escalation 0.0% $0.00; TOTAL Shop $11.30

* Unload @ 3.00 MH/Ton

FABR DIRECT 15361 MH
FABR UNLOAD 241 MH*
TOTAL FABR 15602 MH

229.3 MH / Ton

Chk. By: Date:
Erect By: Texas Prevail. Wage

Field Base Wage: $15.875
Esc. @ 0.00% $0.000
Crew Average: $0.530
ESTIMATED WAGE => $16.405

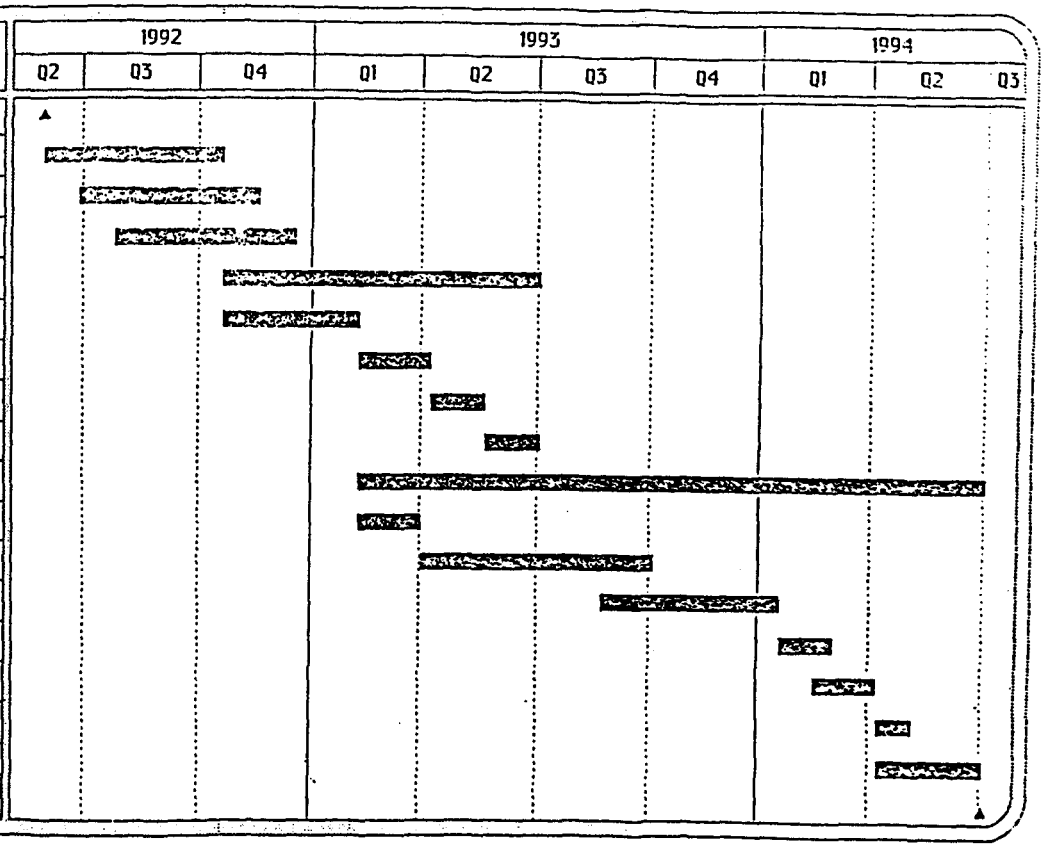
Good to:

$21.31 / Lb.

VACUUM VESSEL			HEAT SHIELD (EXCLUDES - Supply & Installat'n of Superinsulation on Heat Shield)			HELIUM VESSEL (EXCLUDES - Supply & Installat'n of Carbon Loops)			TOROID FORMER (EXCLUDES - Insulation & Winding of Coils on Toroid Former)		
UNIT	COST	SUBTOTAL	UNIT	COST	SUBTOTAL	UNIT	COST	SUBTOTAL	UNIT	COST	SUBTOTAL
44,756	89,512		20,175	40,350		64,496	128,992		31,145	62,290	
	0			0			0			0	
36,691			14,976			53,241			22,431		
1,343	8,056		1,381	8,286		3,160	18,960		2,158	12,948	
281	4,321		165	2,926		275	3,906		0	0	
0	0		0	0		0	0		0	0	
38,315	XXXXXXXX	101,889	16,522	XXXXXXXX	51,562	56,676	XXXXXXXX	151,858	24,589	XXXXXXXX	75,238
500	11,600		300	6,960		500	11,600		300	6,960	
	12,760			7,656			12,760			7,656	
	0	24,360		0	14,616		0	24,360		0	14,616
800	13,280		600	9,960		1,000	16,600		600	9,960	
	1,328			996			1,660			996	
	15,936			11,952			19,920			11,952	
	0	30,544		0	22,908		0	38,180		0	22,908
500	13,375		500	13,375		500	13,375		500	13,375	
	14,044			14,044			14,044			14,044	
	4,681	32,100		4,681	32,100		4,681	32,100		4,681	32,100
2,489	28,126		2,792	31,550		3,154	35,640		6,926	78,264	
	563			631			713			1,565	
	46,408			52,058			58,806			129,136	
	0			0			0			0	
	0			0			0			0	
	0			0			0			0	
	0			1,701			0			9,540	
	5,000			3,000			5,000			10,000	
	0	80,097		0	88,940		0	100,159		0	228,505
	2,605	2,605		562	562		1,927	1,927		24,000	24,000
	0			0			3,000			3,000	
	0	0		0	0		3,000	6,000		3,000	6,000
5,639	92,508		3,691	60,551		9,952	163,263		2,332	38,256	
	1,850			1,211			3,265			765	
294.4	9,908		446.8	6,485		351.2	17,485		189.7	4,097	
MH / Ton	15,125		MH / Ton	9,900		MH / Ton	26,694		MH / Ton	6,255	
	17,706			11,590			31,249			7,322	
	28,632			18,741			50,531			11,841	
	21,710			14,210			38,315			8,978	
	16,917			11,073			29,856			6,996	
	11,278			7,382			19,904			4,664	
	28,195			18,455			49,760			11,660	
	10,000			10,000			10,000			10,000	
	7,000			5,200			15,800			1,188	
	5,000	265,829		5,000	179,798		5,000	461,122		5,000	117,022
480	7,874		280	4,593		800	13,124		280	4,593	
	13,701			7,993			22,836			7,993	
	0			0			0			0	
	0			0			0			0	
	0	21,575		0	12,586		0	35,960		0	12,586
	0			0			0			0	
	0			0			0			0	
	0			0			0			0	
	0			0			0			0	
	0	0		0	0		0	0		0	0
		558,999			403,071			851,666			532,975
		67,080			48,369			102,200			63,957
		626,079			451,440			953,866			596,932
	0			8			0			0	
	0			0			0			0	
	62,608	62,608		45,144	45,144		95,387	95,387		59,693	59,693
		688,687			496,584			1,049,253			656,625

$ / Sq. Ft $135

Task Name	Start Date	Duration	End Date
AWARD OF CONTRACT	1-Jun-92	0.0	1-Jun-92
ENGINEERING	1-Jun-92	20.0 w	22-Oct-92
DRAFTING	29-Jun-92	20.0 w	20-Nov-92
MATERIAL PROCUREMENT	28-Jul-92	20.0 w	21-Dec-92
FABRICATION:	22-Oct-92	35.0 w	6-Jul-93
TOROID FORMER	22-Oct-92	15.0 w	11-Feb-93
HELIUM VESSEL	11-Feb-93	8.0 w	9-Apr-93
HEAT SHIELD	9-Apr-93	6.0 w	21-May-93
VACUUM VESSEL	21-May-93	6.0 w	6-Jul-93
CONSTRUCTION:	11-Feb-93	70.0 w	5-Jul-94
TOROID FORMER	11-Feb-93	7.0 w	2-Apr-93
WIND COILS (ANL)	2-Apr-93	26.0 w	6-Oct-93
HELIUM VESSEL	24-Aug-93	20.0 w	20-Jan-94
INSTALL CARBON TIES (ANL)	20-Jan-94	6.0 w	4-Mar-94
HEAT SHIELD	17-Feb-94	7.0 w	8-Apr-94
INSTALL SUPERINSULATION (ANL)	8-Apr-94	4.0 w	6-May-94
VACUUM VESSEL	8-Apr-94	12.0 w	5-Jul-94
PROJECT COMPLETE	5-Jul-94	0.0	5-Jul-94



PRELIMINARY SCHEDULE

SSC - AIR CORE SUPERCONDUCTING TOROID

for ARGONNE NATIONAL LABORATORY

PDM CONTRACT 60120

ARGONNE P.O. 061188

May 13, 1992