Title
PEP TRANSPORT BEND MAGNET 32B2600 (B19)

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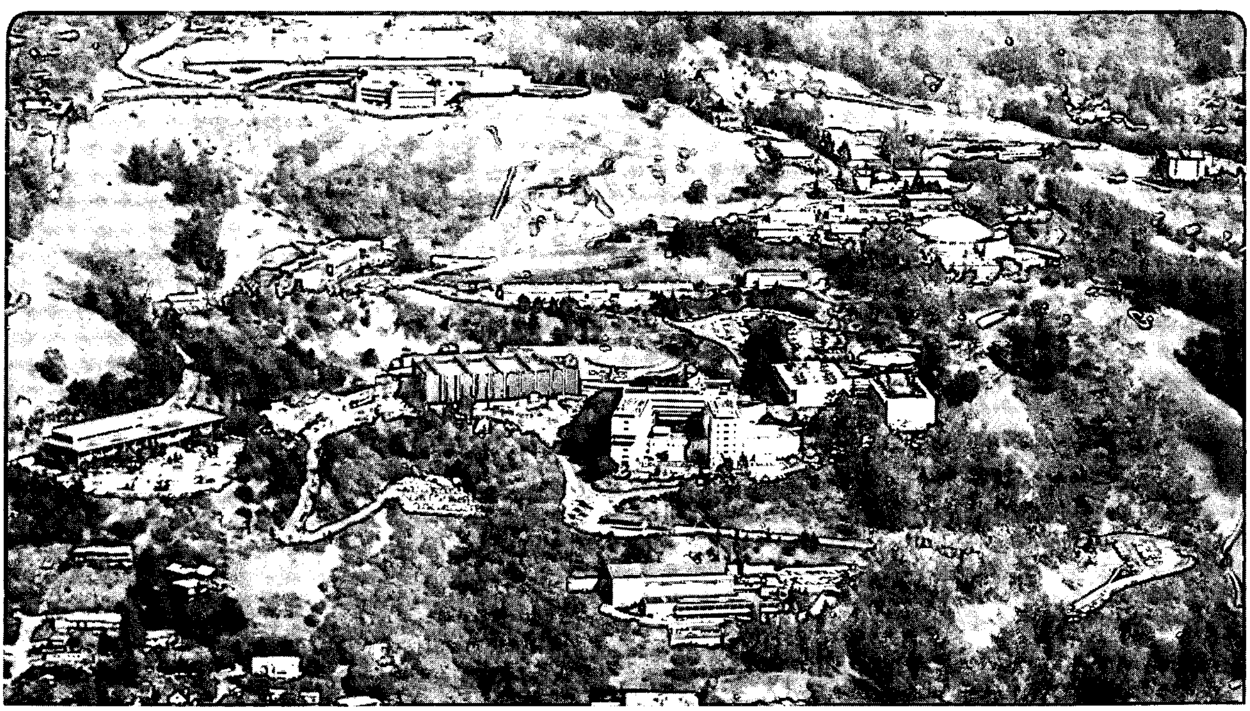
Publication Date
1979-11-01

Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA, BERKELEY

Engineering & Technical Services Division



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A. Lake/R. Reimers RMR	M.E.	Berkeley	Sept. 25, 1978

PROGRAM — PROJECT — JOB
PEP

INJECTION

TITLE
PEP TRANSPORT BEND MAGNET 32B2600 (B10)

Revision A-Update to agree w/msmts. R. Reimers 10-29-79 RMR
Reduce to 6 pages. Eliminate old p. 2.

1. Purpose

Short intense pulses of 4-18 GeV electrons and positrons will be injected into the PEP beam transport and injection systems by pulsed magnets. There will be two nearly identical systems connecting SLAC and the PEP ring; one will transport and inject electrons, the other positrons. The magnet described in this report bends the beam vertically as it enters the ring tunnel.

This report gives design parameters for operation at 15 GeV and 20 GeV beam energies.

2. Aperture and Good-Field Region.

A minimum aperture is desirable. The good field region ($\frac{\Delta B}{B}$ < 0.4%) has a total width of 4.0 cm in the bending plane (vertical) at all energies of interest (< 20 GeV). The field quality analysis was done by R. Nissen and J. Peterson. The field uniformity is shown on PEP Dwg.-204-224-15. (A)

3. Personnel Involved in the Design.

R. Nissen, R. Reimers, A. Lake, R. Avery, J. Peterson, K. Brown (SLAC).

4. Magnet Design Values.

The design values are shown in Appendix A.

5. Drawings.

The design is shown on the following PEP Drawings:

Overall Assembly AD-204-224-00

6. Schedule.

Procurement is scheduled to begin October 1978.
Drawings and Specifications completed September 1978.
(A) Fabrication, testing, installn, & operation finished in 1979.

7. Cost.

Direct costs against PEP funds were:

MECHANICAL DESIGN	~$10,000	ED & I
CONSTRUCTION	28,800	ED & I
TESTING AND MEASUREMENTS	~ 1,600	B & H
Total	$40,400 (for 2 magnets)	

(A) 8. Testing & msmt. done by R. Main, D. Nelson (LBL).
(A) 9. New power supplies required for energy > 15 GeV.

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APPENDIX A - DESIGN VALUES

	SYMBOL	VALUE 15 GeV	VALUE 20 GeV	UNITS	FOOTNOTES
1. MAGNETIC VALUES					
A. Beam Energy	E	15	20		
B. Size of Good Field Required		27 ‖ gap x	35 ⊥ gap	mm	
C. Effective Length	l_{eff}	2632		mm	
Ⓐ D. Bend Angle	θ	.0418		radians	
E. Beam Stiffness	Bρ	500.4	667.2	kGauss-m	
Ⓐ F. Gap Field $= \theta B\rho / l_{eff}$	B_g	7.947	10.596	kGauss	(1)
Ⓐ G. Ampere Turns, total measured	NI	20,800	28,470	Ampere Turns	(3)
H. Yoke Field	B_y	12.4 max (1.24)	16.2 max (1.62)	kGauss (Teslas)	(2)
Ⓐ J. Magnet Efficiency	η	0.972	0.947		
Ⓐ K. Field Quality 20 mm From Center	ΔB/B	.004	.004		
2. CORE VALUES					
A. Vertical Gap	g	32		mm	
B. Core Length		2600		mm	
C. Core Width, overall		340		mm	
D. Core Height, overall		456		mm	
E. Core Material		C1010 to C1020 annealed			
F. Core Weight		1705		kg	
G. Total Magnet Weight		1950		kg	

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APPENDIX A - MAGNETIC DESIGN VALUES

	SYMBOL	VALUE 15 GeV	VALUE 20 GeV	UNITS	FOOTNOTES
3. COIL MECH VALUES					
A. Turn per Coil	N_{coil}	13		Turns	(3)
B. Conductor Material		Alum. Alloy 1060 F			
C. Conductor Dimension, Overall		80 x 8		mm	
D. Conductor I.D.		4.7 x 8.4, 3 holes		mm	
E. Conductor net Area		539		mm^2	
F. Conductor Length/Coil		80.12		meters	(11)
G. Conductor Weight/Coil		116.6		kg	(10)
H. Conductor Length/magnet		160.2		meters	
I. Conductor Weight/magnet		233.2		kg	
J. Coil Packing Factor		0.63			(12)
K. Coil Arrangement		Series Connected			
L. Coils/magnet		2			
M. Conductor Drawing		PF-204-221-28			
4. COIL ELECTRICAL VALUES					
A. Current Mode		DC			
B. Current/Magnet	I	795	1095	Amps. DC	Per Jung 9/2/79
C. Current Density	I/A	1.47	2.03	$Amps/mm^2$	(9)
D. Resistance/Coil @ 45°C	R_c	.00454		Ohms	
E. Resistance/Magnet @ 45°C	R	.00908		Ohms	
F. Voltage Drop/Coil	ΔV	3.61	4.97	Volts	(7)
G. Voltage Drop/Magnet	ΔV	7.22	9.94	Volts	

APPENDIX A - MAGNET DESIGN VALUES (CONT.)

	SYMBOL	VALUE 15 GeV	VALUE 20 GeV	UNITS	FOOTNOTES
A H. Power/Coil	P_c	2.904	5.44	kWatts	(8)
A I. Power/Magnet = $2P_c$	P_m	~~5.808~~ 5.739	10.88	kW	
5. COOLING					
A. Medium		Low Cond. Water			
B. Arrangement		1 Circuit/Coil			
C. Design Press Drop Required	ΔP	26.3	26.3	psig	
A D. Press. Drop Available		100	150	psig	
E. Design Flow/Coil	F_c	1.5	1.5	gpm	
F. Design Flow/Magnet	F_T	3.0	3.0	gpm	
G. Design Temp. Rise Across Coil	ΔT	7.3	13.8	Degrees C.	
H. Water velocity	v	3.3	3.3	fps	

FOOTNOTES TO APPENDIX A

1.) $B = \Theta B\rho / l_{eff} = .0417 \times 500/2/632 = 7.928$ kG

2.) 1 Tesla = 10 kGauss

3.) NI (AmpTurns) = 79.5 B_g (kGauss) x g(mm)/η

FOOTNOTES TO APPENDIX A (CONT.)

6.) $R = \frac{\rho L}{A} = \frac{30.53 \times 10^{-6} \text{ Ohm-mm} \times 80120}{539 \text{ mm}^2}$

$R = \underline{.00454 \text{ Ohms}}$ @ 45°C (per Coil)

A 7.) $\Delta V = IR$

A 8.) Power/Coil = $\Delta V \times I \times 10^{-3}$ kW

A 9.) Current Density = $I/A = J$

10.) Conductor Weight/Coil

$80119 \text{ mm} \times 539 \text{ mm}^2 \times 2.7 \times 10^{-6} \text{ kg/mm}^3 = \underline{116.6 \text{ kg}}$

11.) Conductor Length/Coil

Length of Average Conductor

Straight Pieces: 2 x 2604	=	5208 mm	
End Straight Pieces: 2 x 30	=	60 mm	
Curved Pieces: π x 95 x 2	=	895 mm	
		6163 mm	
Length/Coil: 6.163 x 13	=		80.12 m

12.) Coil Packing Factor

$$\frac{\text{Conductor Area: } 7007}{\text{Coil Cross-Section: } 11048} = \underline{0.63}$$

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TAB:E I - COOLING CALCULATIONS

1. Heat into Coolant

Assume all power in magnet is converted into heat to be removed by coolant.

A. Power/Coil = 2.79 kW (15 GeV)

= 6.145 kW (20 GeV)

2. Coolant Flow

Max Available: ΔP = 70 psig (15 GeV) & ΔP = 150 psig @ 20 GeV

A. Length of conductor = length of each coolant circuit

= 80.12 meters = 263 ft.

B. Conductor actual hole dimensions:

$$m = \text{hydraulic radius} = \frac{\text{area}}{\text{wetted perimeter}}$$

$$= \frac{\frac{\pi}{4}(4.65)^2 + 3.75(4.65)}{4.65\pi + 2(3.75)}$$

= 1.577 mm.

Equivalent diameter = 4m = 4(1.577) = 6.28 mm = .245"

C. Maximum temperature rise in coolant 20 C @ 20 GeV.

Flow required = $q = \frac{3.8P}{\Delta T}$ (from LBL Mech. Dept. Design Sheets 10 & 57)

P = power (heat) to be remove by coolant, kW

q = flow/circuit, gpm

20 GeV $q = \frac{3.8\ (6.14)}{(3)\ 20}$ = .39 gpm/hole

ΔP = 263 x .10 = 26.3 psig