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PEP TRANSPORT BEND MAGNET 3B2600 (B19)

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# Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA, BERKELEY

## Engineering & Technical Services Division

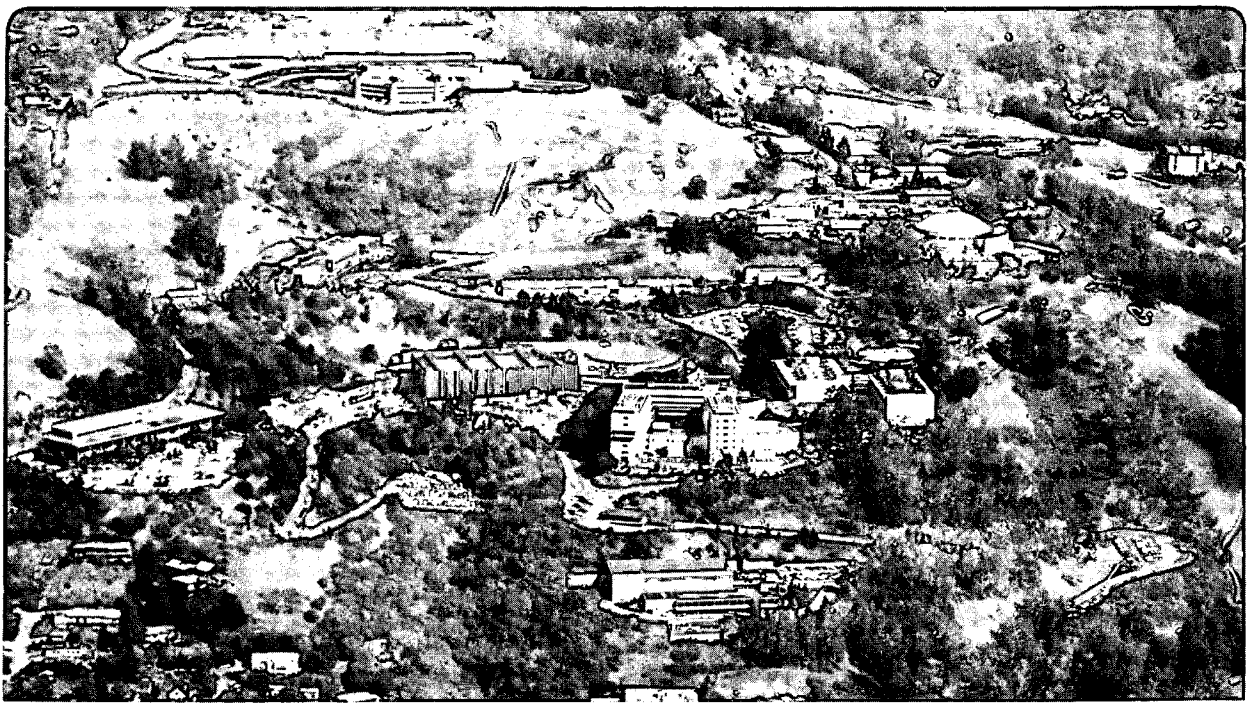
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**ENGINEERING NOTE**

CODE

PE0103

SERIAL

M5198A

PAGE

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AUTHOR

A. Lake/R. Reimers *RMR*

DEPARTMENT

M.E.

LOCATION

Berkeley

DATE

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.

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.  
Fabrication, testing, install, 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)

8. Testing & msmt. done by R. Main, D. Nelson (LBL).

9. New power supplies required for energy > 15 GeV.

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<b>APPENDIX A - DESIGN VALUES</b>					
	SYMBOL	15 GeV VALUE	20 GeV	UNITS	FOOTNOTES
<b>1. MAGNETIC VALUES</b>					
	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	$\theta$	.0418		radians
	E. Beam Stiffness	$B_p$	500.4	667.2	kGauss-m
A	F. Gap Field = $\theta B_p / l_{eff}$	$B_g$	7.947	10.596	kGauss (1)
A	G. Ampere Turns, total measured	NI	20800	28,470	Ampere Turns (3)
	H. Yoke Field	$B_y$	12.4 max (1.24)	16.2 max (1.62)	kGauss (Teslas) (2)
A	J. Magnet Efficiency	$\eta$	0.972	0.947	
A	K. Field Quality 20 mm From Center	$\Delta B/B$	.004	.004	
<b>2. CORE VALUES</b>					
	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		UNITS	FOOTNOTES
		15 GeV	20 GeV		
<b>3. COIL MECH VALUES</b>					
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			
<b>4. COIL ELECTRICAL VALUES</b>					
A. Current Mode		DC			
B. Current/Magnet	I	795	1095	Amps. DC	<i>Per JMC 9/2/79</i>
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	$\Delta V$	3.61	4.97	Volts	(7)
G. Voltage Drop/Magnet	$\Delta V$	7.22	9.94	Volts	

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APPENDIX A - MAGNET DESIGN VALUES (CONT.)

A

A

A

	SYMBOL	VALUE		UNITS	FOOTNOTES
		15 GeV	20 GeV		
H. Power/Coil	$P_c$	2.904	5.44	kWatts	(8)
I. Power/Magnet = $2P_c$	$P_m$	<del>5.808</del> 5.739	10.88	KW	
<b>5. COOLING</b>					
A. Medium		Low Cond. Water			
B. Arrangement		1 Circuit/Coil			
C. Design Press Drop Required	$\Delta P$	26.3	26.3	psig	
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	$\Delta T$	7.3	13.8	Degrees C.	
H. Water velocity	$V$	3.3	3.3	fps	

FOOTNOTES TO APPENDIX A

1.)  $B = \theta B_p / l_{eff} = .0417 \times 500 / 2 / 632 = 7.928 \text{ kG}$

2.) 1 Tesla = 10 kGauss

3.)  $NI (\text{Amp Turns}) = 79.5 B_g (\text{kGauss}) \times g (\text{mm}) / \eta$

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FOOTNOTES TO APPENDIX A (CONT.)

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

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

7.)  $\Delta V = IR$

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

9.)  $\text{Current Density} = I/A = J$

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:  $2 \times 2604 = 5208 \text{ mm}$

End Straight Pieces:  $2 \times 30 = 60 \text{ mm}$

Curved Pieces:  $\pi \times 95 \times 2 = \underline{895 \text{ mm}}$

$6163 \text{ mm}$

Length/Coil:  $6.163 \times 13 = \underline{80.12 \text{ m}}$

12.) Coil Packing Factor

Conductor Area:  $\frac{7007}{11048} = \underline{0.63}$

Coil Cross-Section:  $11048$



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TAB:E I - COOLING CALCULATIONS1. 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:  $\Delta P = 70$  psig (15 GeV) &  $\Delta P = 150$  psig @ 20 GeV

A. Length of conductor = length of each coolant circuit  
 = 80.12 meters = 263 ft.

B. Conductor actual hole dimensions:

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

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

$$= 1.577 \text{ mm.}$$

Equivalent diameter =  $4m = 4(1.577) = 6.28 \text{ mm} = .245''$

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

$\Delta P = 263 \times .10 = 26.3 \text{ psig}$

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