PHENIX-LLNL-93-028

Bob Yamamoto

RHIC/PHENIX DETECTOR

PHENIX

TAC Baseline Review: Technical, Cost & Schedule Magnet Subsystem 5.1

Joel M. Bowers
James H. Thomas
Robert M. Yamamoto

representing the BNL, LANL and LLNL Design Team

November 8-10, 1993

PHENIX Magnet Subsystem - Agenda

- Engineering Overview

- CDR update - COILS:
  - changes from CDR; present design/fabrication status.

- CDR update - STEEL:
  - changes from CDR; present design/fabrication status.
  - FEA Results

- CDR update - Mu ID Steel.

- Cost:
  - baseline cost estimate.
  - contingency analysis.

- Schedule.

PHENIX Mag. Sys. - Dsgn Reviews & Site Visits

Date	Title
October, 1992	PHENIX Collaboration Meeting; Santa Fe, NM.
November, 1992	Coil Analysis Review; Steel Design Update.
February, 1993	TAC Review.
March, 1993	FDR: Central Magnet Outer Coils.
April, 1993	Visit to Japan: KEK + Coil Fabricator.
May, 1993	PDR: Central Magnet & Muon Magnet Steel.
June, 1993	Visit to Russia: Efremov/PNPI/Izhora Steel/LMZ.
August, 1993	FDR: Muon Magnet Coil.
August, 1993	FDR: Central Magnet & Muon Magnet Steel.

PHENIX Magnet Subsystem - Design Team

LLNL

- Joel Bowers
- Rudy Carpenter
- Brigitte Gim
- Art Harvey
- Bob Holmes
- Palmer House
- Marcus Libkind
- Dick Martin
- Julie McCreary
- Larry Mullins
- Joe Ryland
- Ross Schlueter (LBL)
- Winston Wong
- Bob Yamamoto

BNL

- Sam Aronson
- Ralph Brown
- Martin Howard
- Steve Kahn
- Chauncey Knapp
- Pete Kroon
- Jim Mills
- Jacques Negrin
- Irv Polk
- Richie Ruggiero
- Tom Shea

LANL

- Walt Sondheim

PHENIX Magnet Sys. - Engineering Overview

- Magnet subsystem divided into two magnet systems:
  - Central Magnet (CM) & Muon Piston Magnet (MM).
- Both magnets divided into two main areas: coils and steel.
- CM weights 500 tons and stands 9.5 meters tall.
  - assembled on-site and movable.
- MM weights 400 tons and stands 10 meters tall.
  - assembled in place in the detector hall.
- Mu ID Steel is comprised of 5 steel plate assemblies weighing over 600 tons and also standing 10 meters tall.
- Components are designed:
  - to meet all performance requirements.
  - to be made by US industry or by foreign sources.
  - for high reliability, low maintenance and long, steady state operation.
- All hardware will be "build to print" per LLNL drawings (except power supplies which will be build to spec.).
- Magnet subsystem on "critical path" of PHENIX detector.

PHENIX Magnet Subsystem - Design Summary

- Magnet Coils:
  - the CM Outer Coil design is complete. All detailed fabrication drawings have been sent to KEK for release to Japanese industry.
  - the CM Inner Coil drawings will be completed by the end of CY '93.
  - the MM Coil drawings are complete and in "final check" at LLNL.

- Magnet Steel:
  - the CM Steel drawings (except US fabricated items like the transporter frame) are complete and in "final check" at LLNL.
  - the MM Steel drawings (except US fabricated items like the hydraulically actuated access doors) are complete and in "final check" at LLNL.
  - all CM & MM Steel drawings required for Russian fabrication will be released as "fabrication drawings" to Russia by Dec. 1st.

- The Mu ID Steel is in the conceptual design phase; scheduled design completion (ready to release drawings for fabrication) is March '94.

PHENIX Magnet Sys. - Fabrication Summary

- All magnet fabrication (coils & steel) will be a "build to print" based on LLNL provided drawings.
- The CM Outer Coil will be fabricated in Japan. Fabrication of the MM Coil TBD. Fabrication of the CM Inner Coil will be deferred.
- The bulk of the magnet steel (for both CM & MM) will be fabricated in Russia with the balance being done in the US. Metric fasteners (US supplied) will be used throughout the entire steel assembly.
- Both Russian (steel) and Japanese (coils) potential vendors had on-site inspections to review their capability, qualifications, QA/QC, etc.
- A US rigging company (with the support of BNL personnel) will be used to assemble and install the magnet steel, coils and Mu ID steel in the detector hall.

PHENIX Magnet Subsystem - Magnetic Analysis

- PE2D, POISSON and TOSCA used for magnetic analysis.

- Analyses includes:
  - magnetic flux plots.
  - steel saturation levels.
  - forces on steel.

- Variables used to develop baseline:
  - coil geometry, location and cross-sectional area.
  - steel geometry, location and cross sectional area.
  - magnetic field requirements.

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PHENIX Magnet Subsystem - Thermal Analysis

- Two-dimensional finite element heat transfer analysis performed on the magnet subsystem using TOPAZ2D.
- Input variables include:
  - average coil temperatures.
  - ambient temperature.
  - surface emissivities.
  - heat transfer mechanism (radiation or convection).
  - contact resistance between the magnet and detector components.
- FEA results include subsystem temperature profiles, contour plots and heat flux vector plots.
- Results show that steady state magnet temperature is approx. the same as the average coil temperature.
  - minimizing coil temperature reduces temperature affects on all detector components (both CM & MM areas).

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PHENIX Magnet Subsystem - FEA

- FEA performed on the entire magnet subsystem.
  - full model developed for the CM & MM; Mu ID Steel to follow.
  - movement data provided to Muon group for interfacing with muon chamber design/mounting/etc.

- Software used from the Rasna Corporation:
  - Applied Structure.
  - Applied Thermal.
  - Applied Vibration.

- Modeling included:
  - modal analysis of full 3-D model.
  - static analysis of symmetric half-model (gravity, thermal, magnetic).
  - stress analysis.
  - vibration analysis using input forcing function (TBD).

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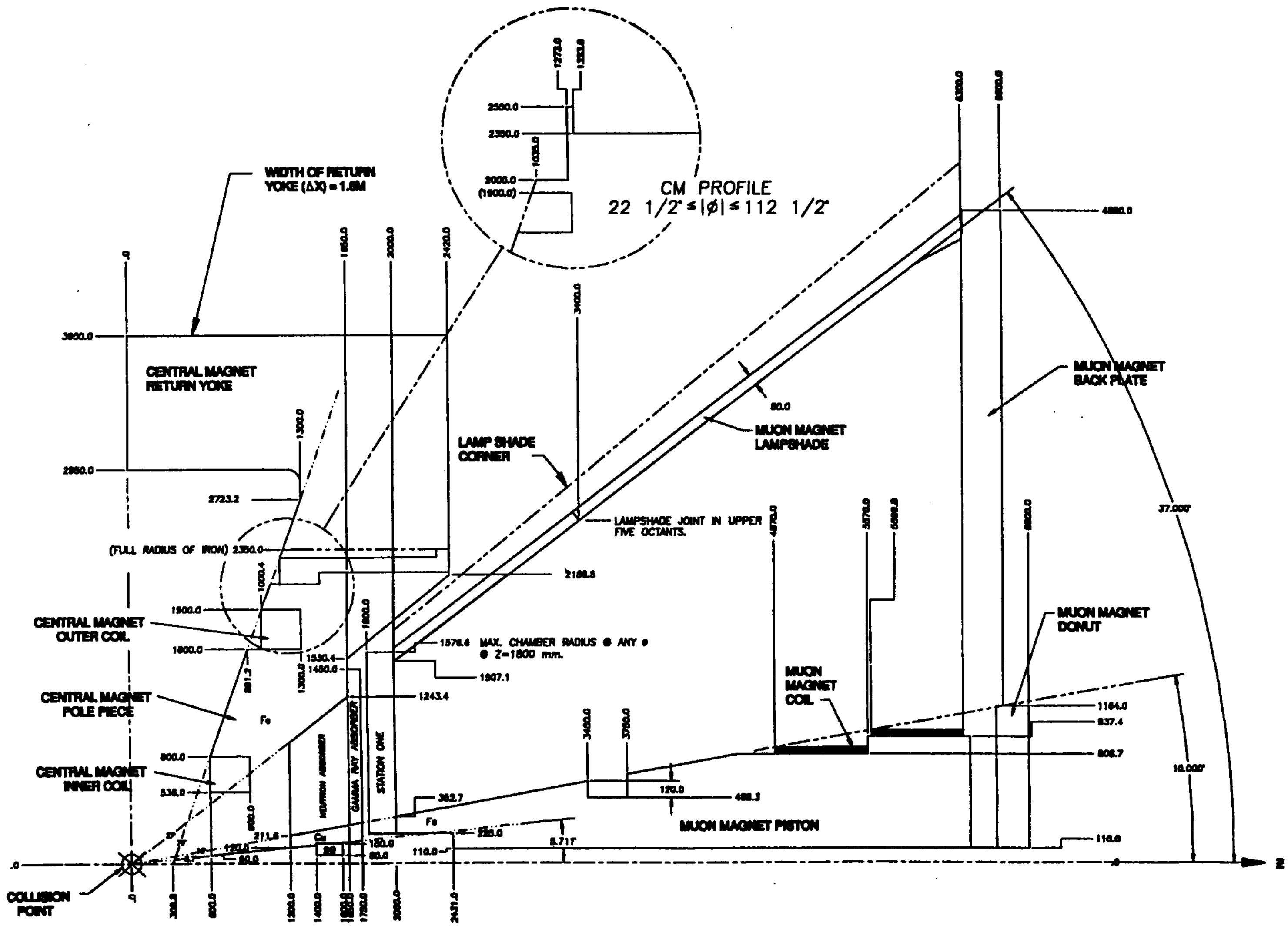
PHENIX Mag. Sys. - Configuration Control Dwg.



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PHENIX Coils - Design Philosophy

- Provide for high reliability and low maintenance coils.
- Provide "low tech" solution: proven design details + ease of fabrication = inexpensive & trouble free.
- Maximize conductor volume given severe coil cross-sectional area constraints (due to steel saturation affects and muon acceptance angle criteria). This increases B field capability and reduces power supply requirements.
- Minimize average coil temperatures by providing multiple coolant flow circuits (including bifilar construction).
- Provide for multiple checkout/testing points during fabrication to ensure coil quality and integrity prior to final installation, acceptance testing and magnetic mapping.

PHENIX Central Magnet Coils - CDR Update

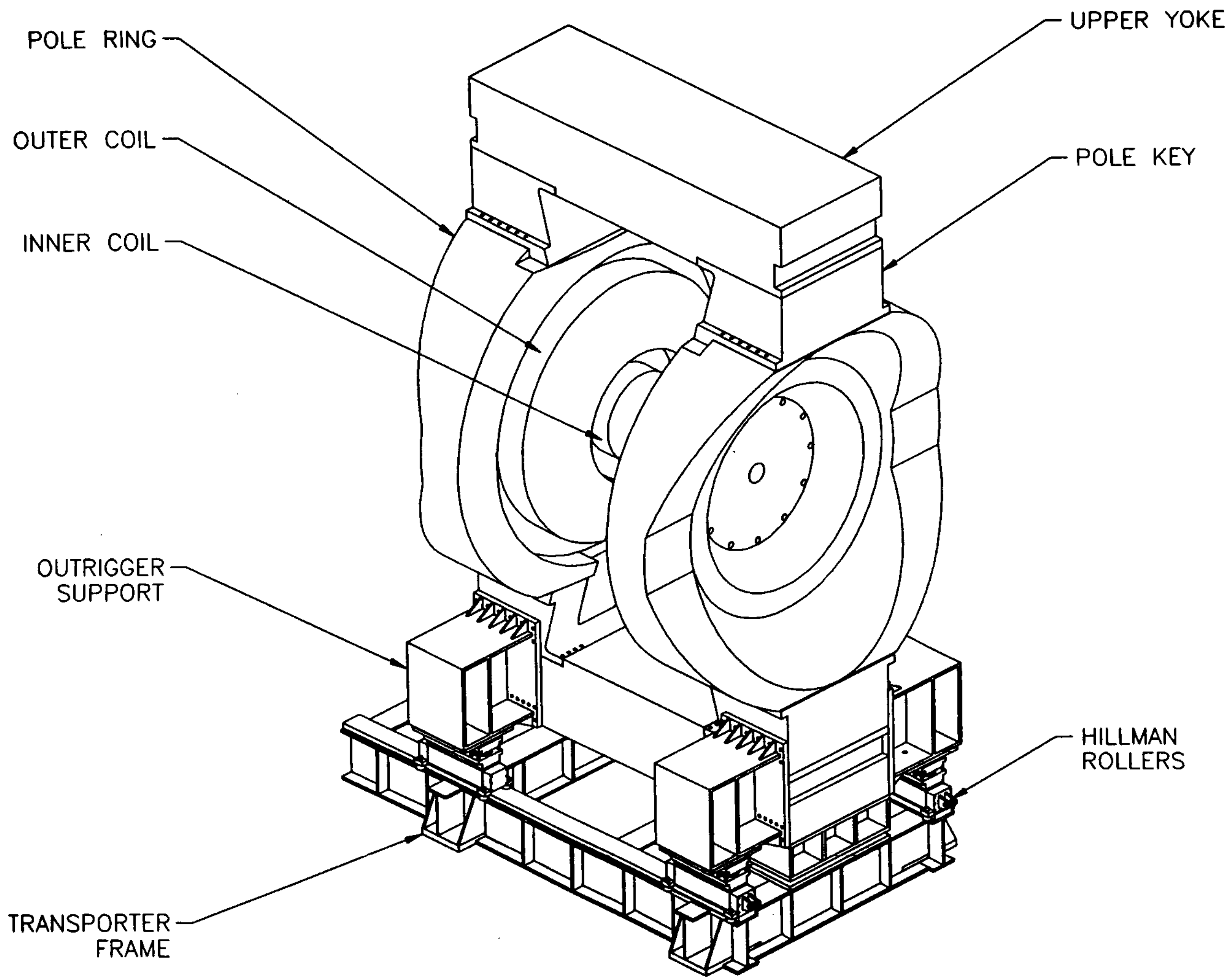
- CM Outer Coils: No changes.

- CM Inner Coils:
  - comprised of 6 (not 5) bifilar wound double pancakes.
  - all double pancake subassemblies are identical in configuration (not stepped).
  - ampere-turn requirement is 293,000 (vs. 280,000 before).
  - coil is 120 (vs. 150) turn conductor package. (20 turns per double pancake assembly X 6 double pancakes)
  - conductor size is 21.51 mm (vs. 17.8 mm).
  - conductor hole size is 13.66 mm ø (vs. 11.1 mm ø).
  - 12 water circuits per coil (vs. 10).
  - requires 2442 amps @ 67.1 volts (vs. 1867 amps @ 120 volts).
  - flow rate per coil is 99.2 GPM (vs. 30.9 GPM).
  - avg. coil temperature is 23.1°C (vs. 39.0°C).

PHENIX Central Magnet Coils - Design Summary

- Coils divided into 2 pairs: Inner Coils & Outer Coils, both resistive.
  - use conventional square hollow copper conductor.
  - circular in shape.
  - each coil consists of 6 identical bifilar wound double pancakes.
  - vacuum epoxy impregnated.
  - each coil pair is connected electrically in series and uses one power supply each; air cooled copper bus bars and 500 MCM cables bring current from power supply to the coils.
  - each coil is connected hydraulically in parallel utilizing counterflow water flow paths (12 water circuits per coil assembly).
  - design optimized for minimal operating temperature and power consumption given amp-turn and geometric requirements (max allowable steel saturation level is 15 kilogauss).

PHENIX CM Steel Assembly - Isometric



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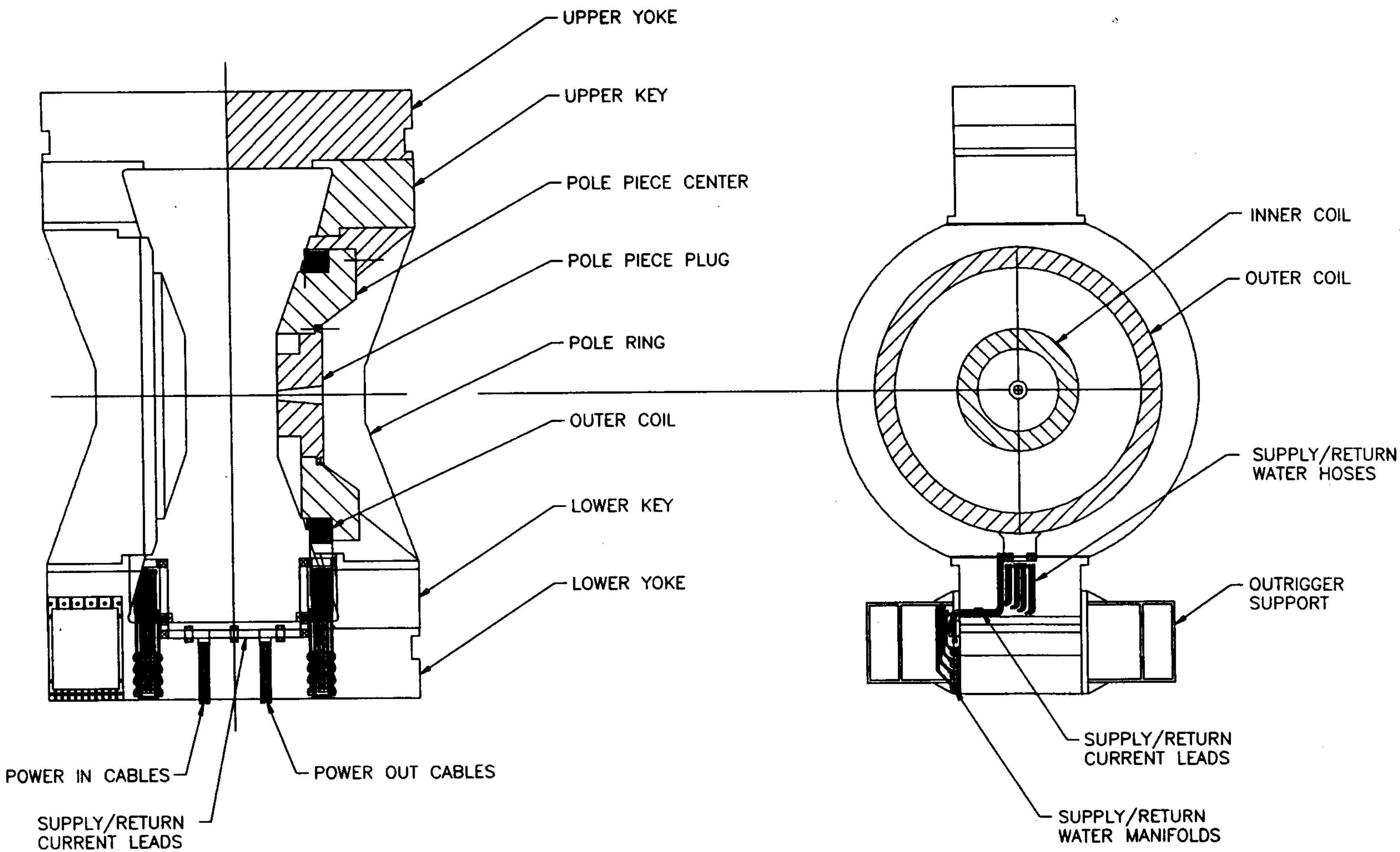
PHENIX Central Magnet - Overview



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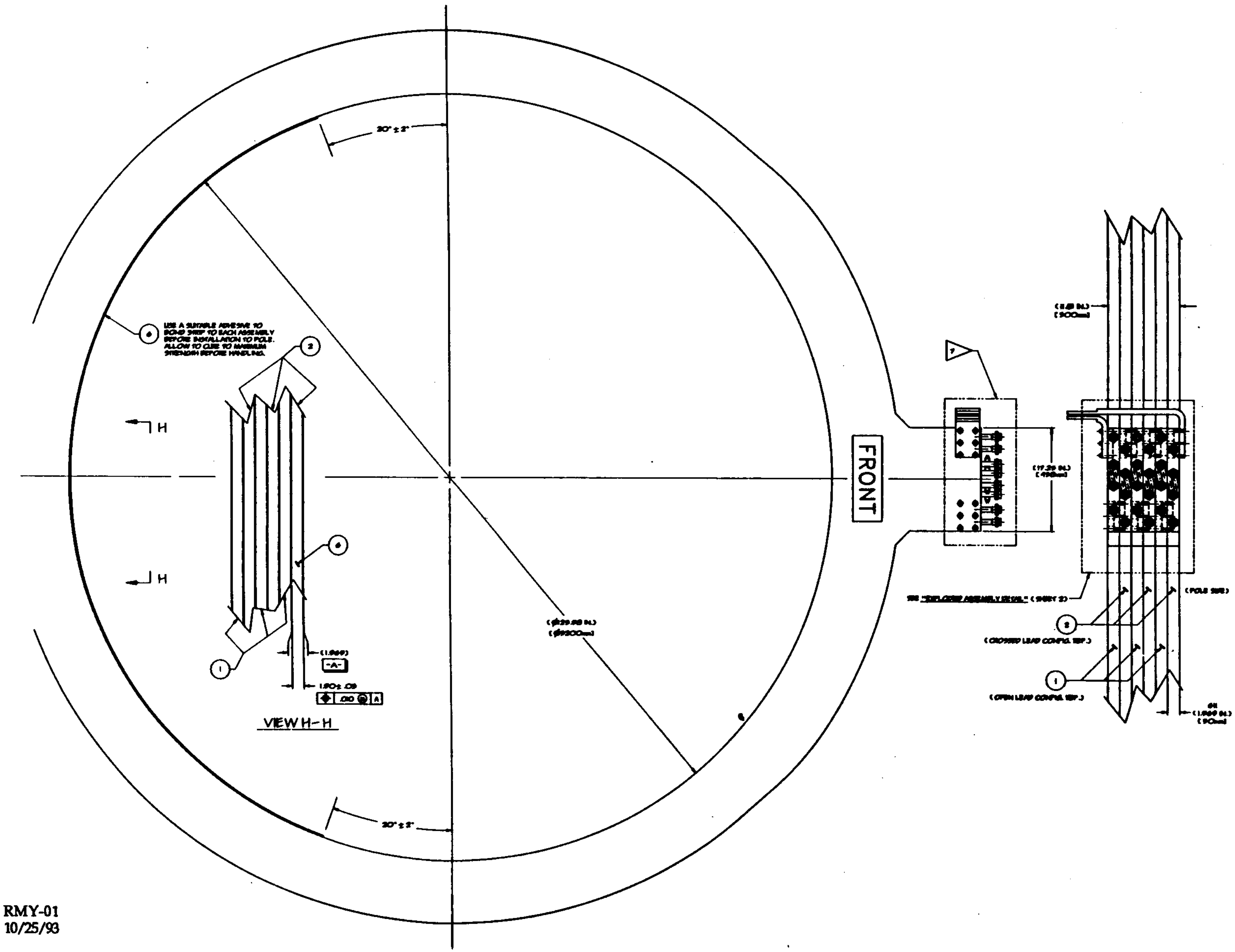
PHENIX CM Outer Coils - Coil Assembly



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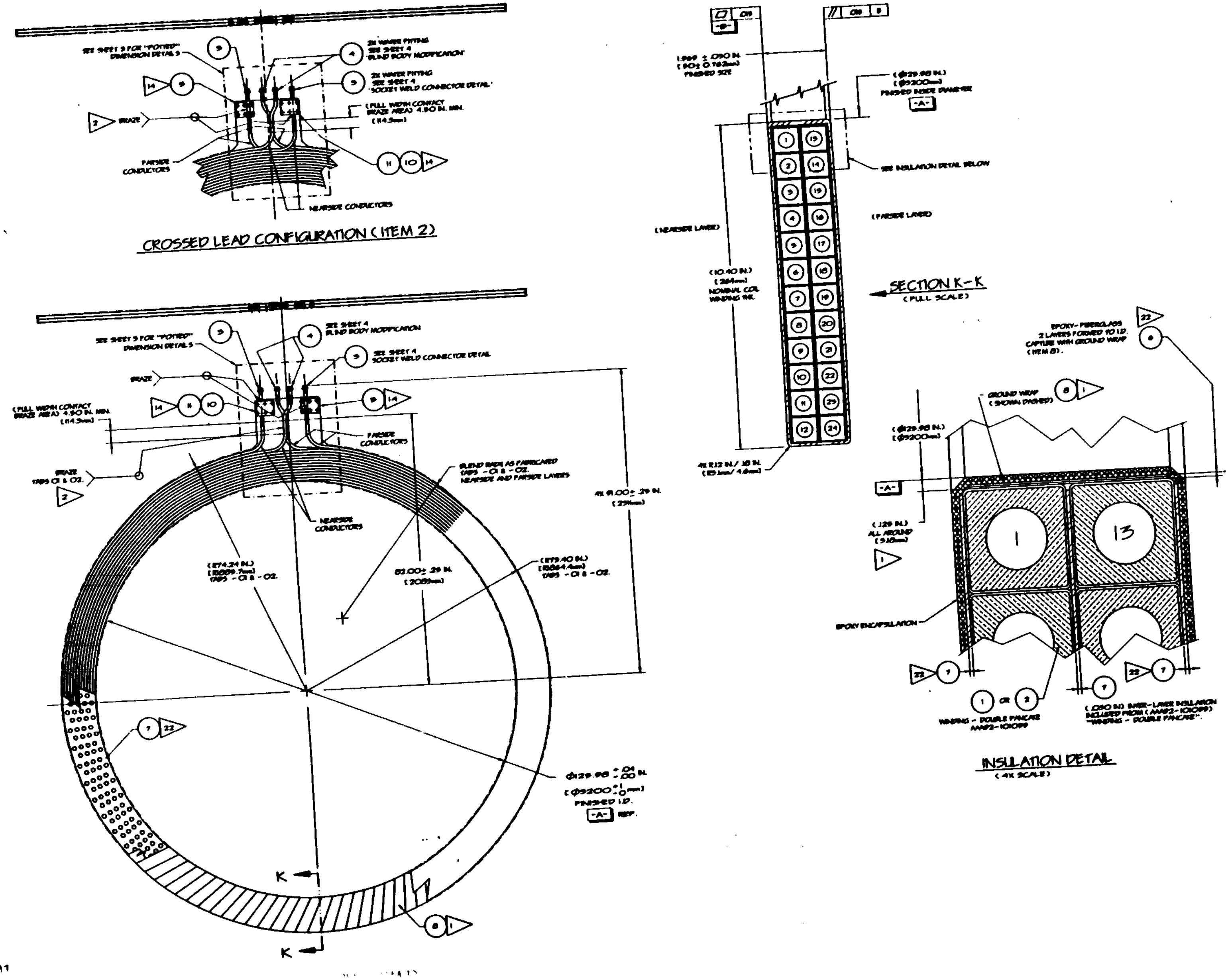
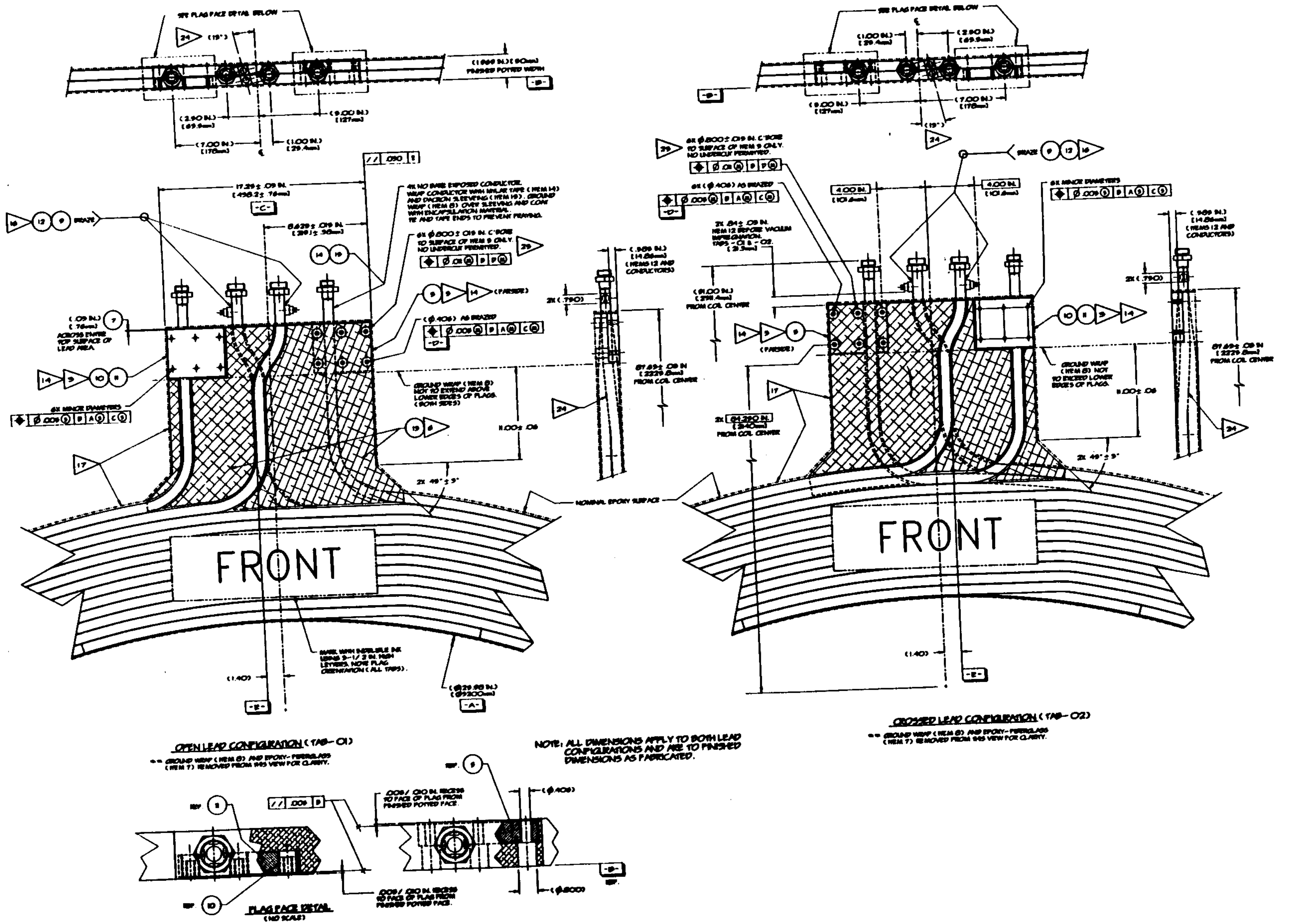
PHENIX CM Outer Coils - Double Pancake Assy.



PHENIX CM Outer Coils - Double Pancake Assy.



PHENIX CM Coils - Fabrication Schedule

- CM Coils (Inner and Outer) are NOT on the critical path.
- CM Inner Coil fabrication is deferred.
- CM Outer Coil fabrication begins Fall '93.
  - fabrication being done by TOKIN Corp (decision as of 10/24/93).
  - prototype Cu conductor (including dies) already made by Hitachi.
- CM Outer Coil fabrication will take approx. 12 months.
  - procurement cycle started in July '93.
  - conductor available by the end of Winter '93.
  - coil winding to commence Jan '94.
  - 6-8 months for actual coil fabrication.
- CM Outer Coil can be shipped to BNL around the Fall '94.
- CM Outer Coil can be tested/checked-out as early as the Summer '95.

PHENIX Muon Magnet Coils - CDR Update

- MM Coils: No changes.

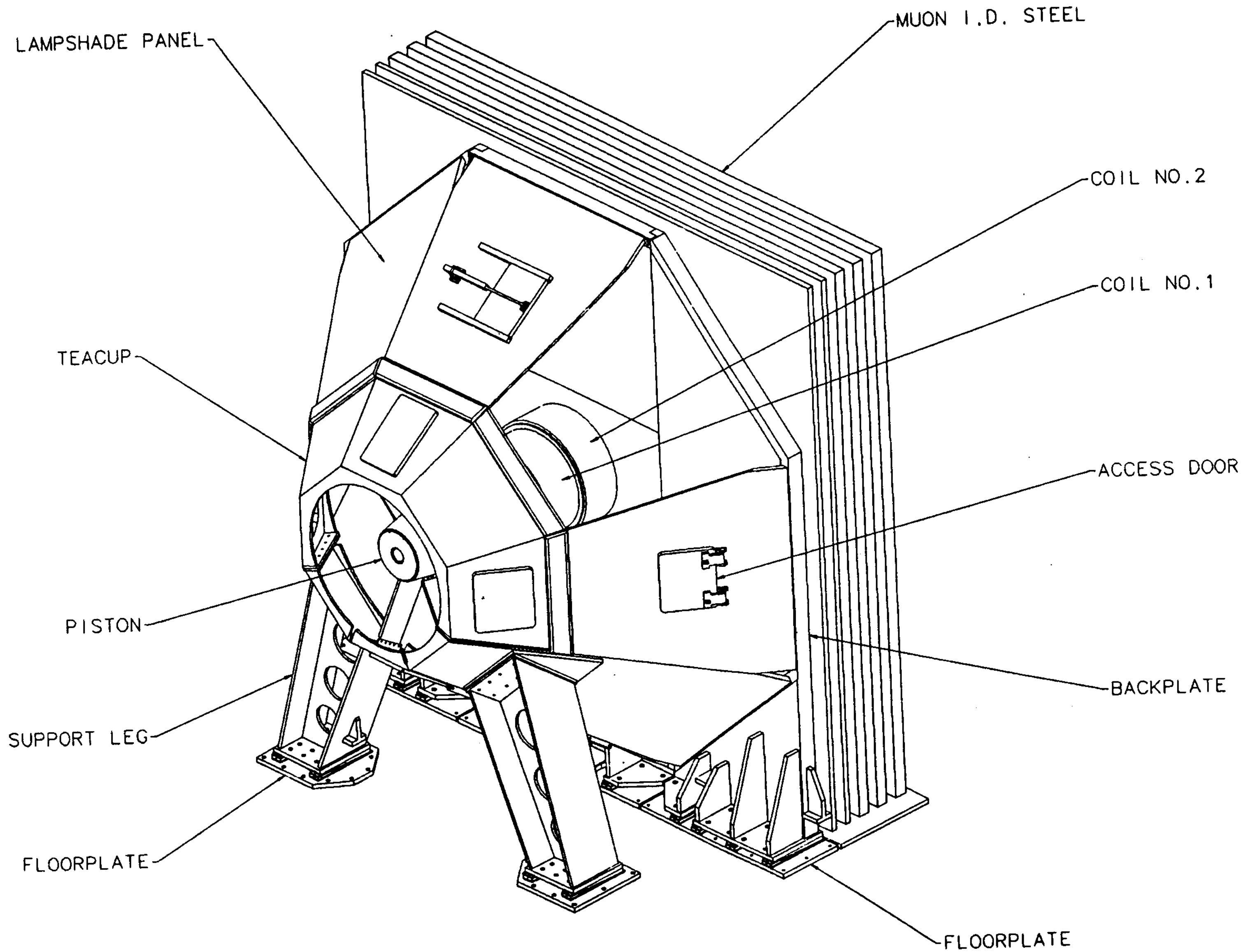
PHENIX Muon Magnet Coil - Design Summary

- Coil is made up of two individual solenoidal coils:
  - a small (#1) coil and a large (#2) coil.
- Coils are identical except for:
  - overall diameters.
  - detail of bus flags.
- Coils are:
  - made from square hollow copper conductor.
  - bifilar wound (two in-hand).
  - 2 layer solenoids.
  - cooled in parallel - 8 inlet & 8 outlet water fittings (each layer of coil cooled individually).
  - vacuum epoxy impregnated.

PHENIX Muon Magnet Coil - Design Summary

- Coils run electrically in series.
  - utilizes one power supply.
  - uses a single pair of water cooled leads. (actual coil conductor used - has its own independent cooling circuit).
  - inlet and outlet power physically attached to coils between the end of coil #1 and the beginning of coil #2.
  - power leads come from the bottom of the magnet at 22.5° from the vertical centerline (west side of magnet) and hides in the shadow of the muon chambers support structure.
  - an intermediate bus station (secured to MM steel lampshade) connects the 500 MCM cables coming from the power supply to the water cooled bus leads that attach to the coil flags (6 supply and 6 return power cables are required to carry the 3000 amperes of current to the coils).

PHENIX Muon Magnet Assembly - Isometric



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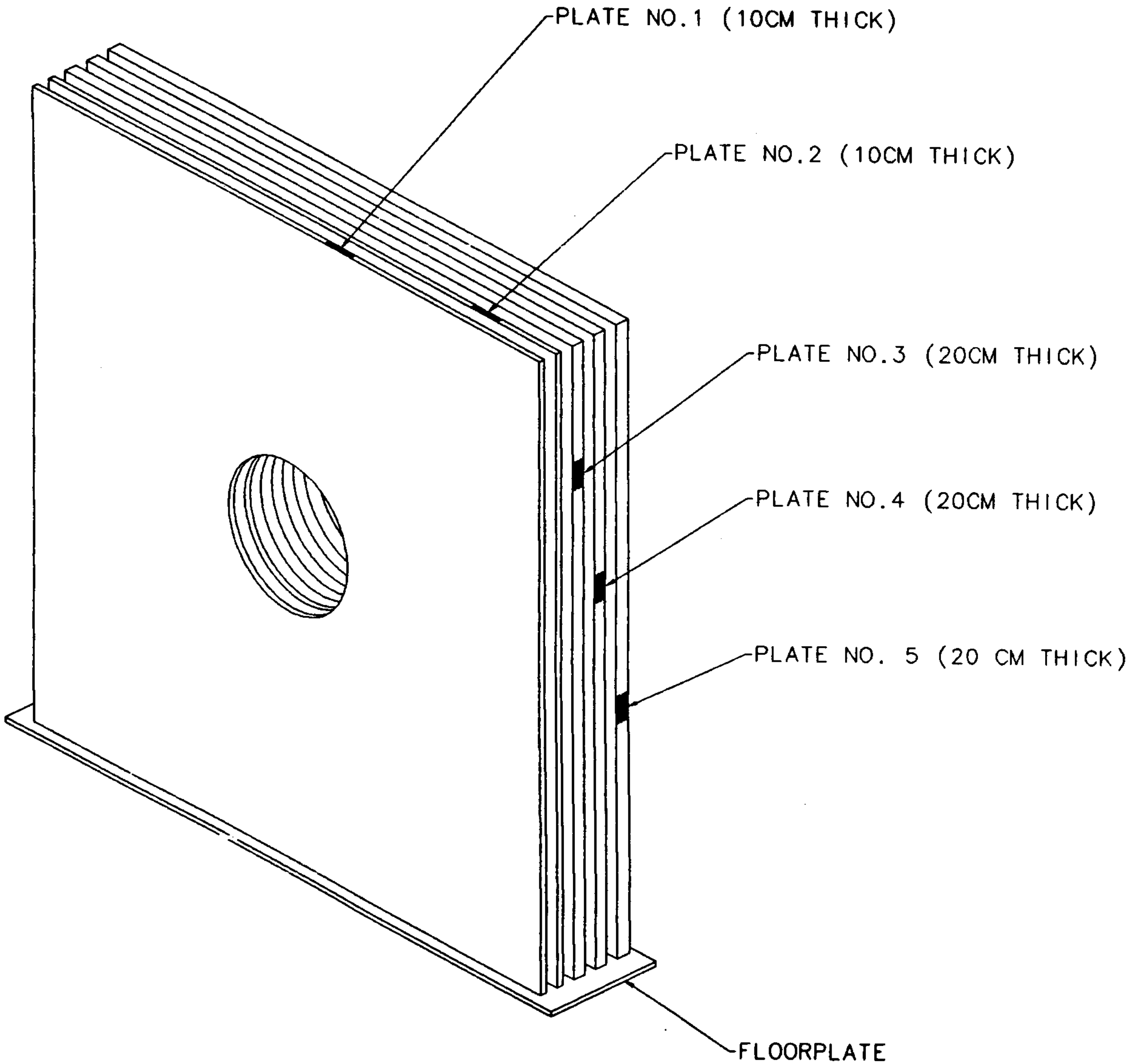
PHENIX Mu ID Steel Assembly - Isometric



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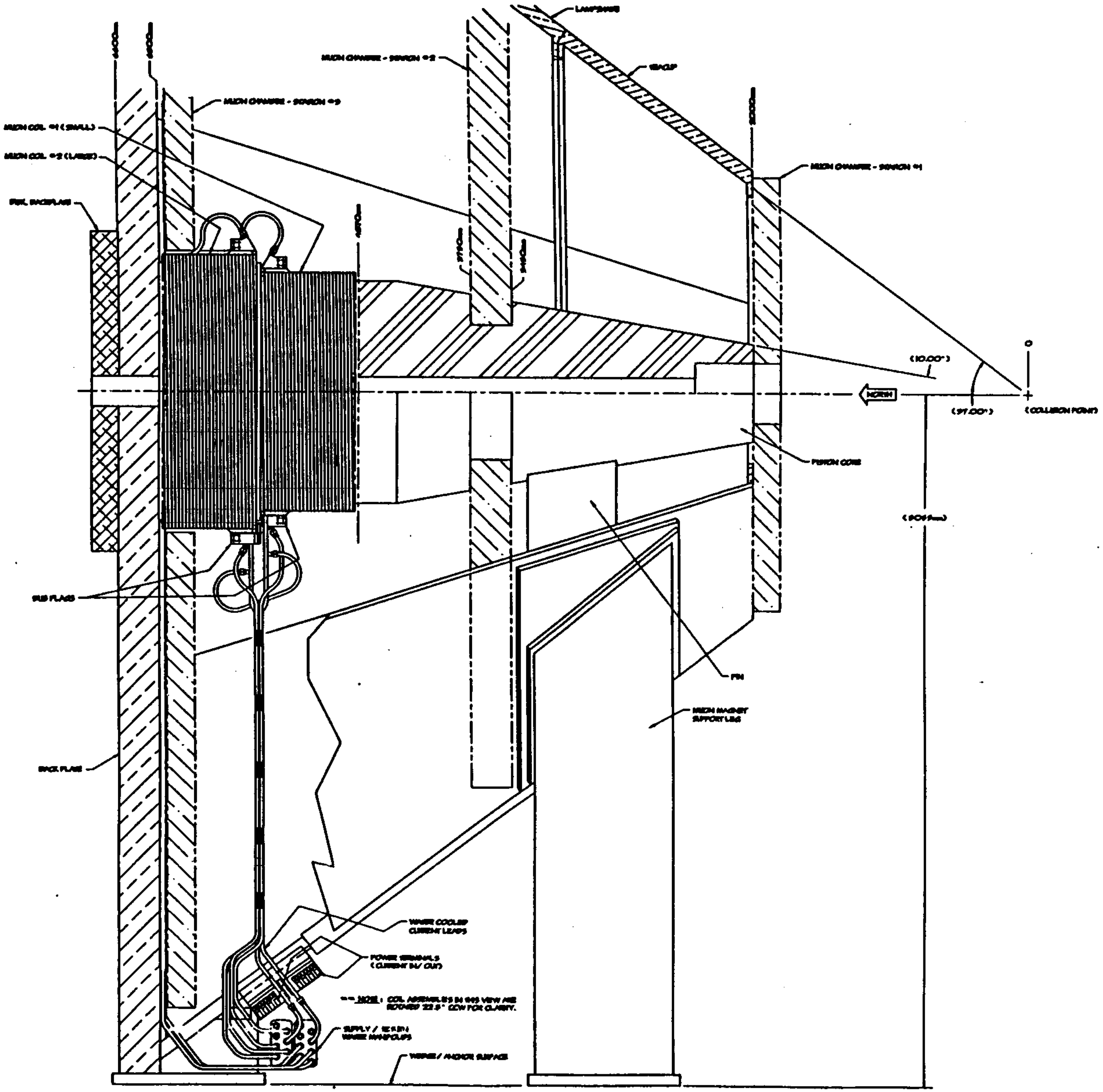
PHENIX Muon Magnet - Coil Installation



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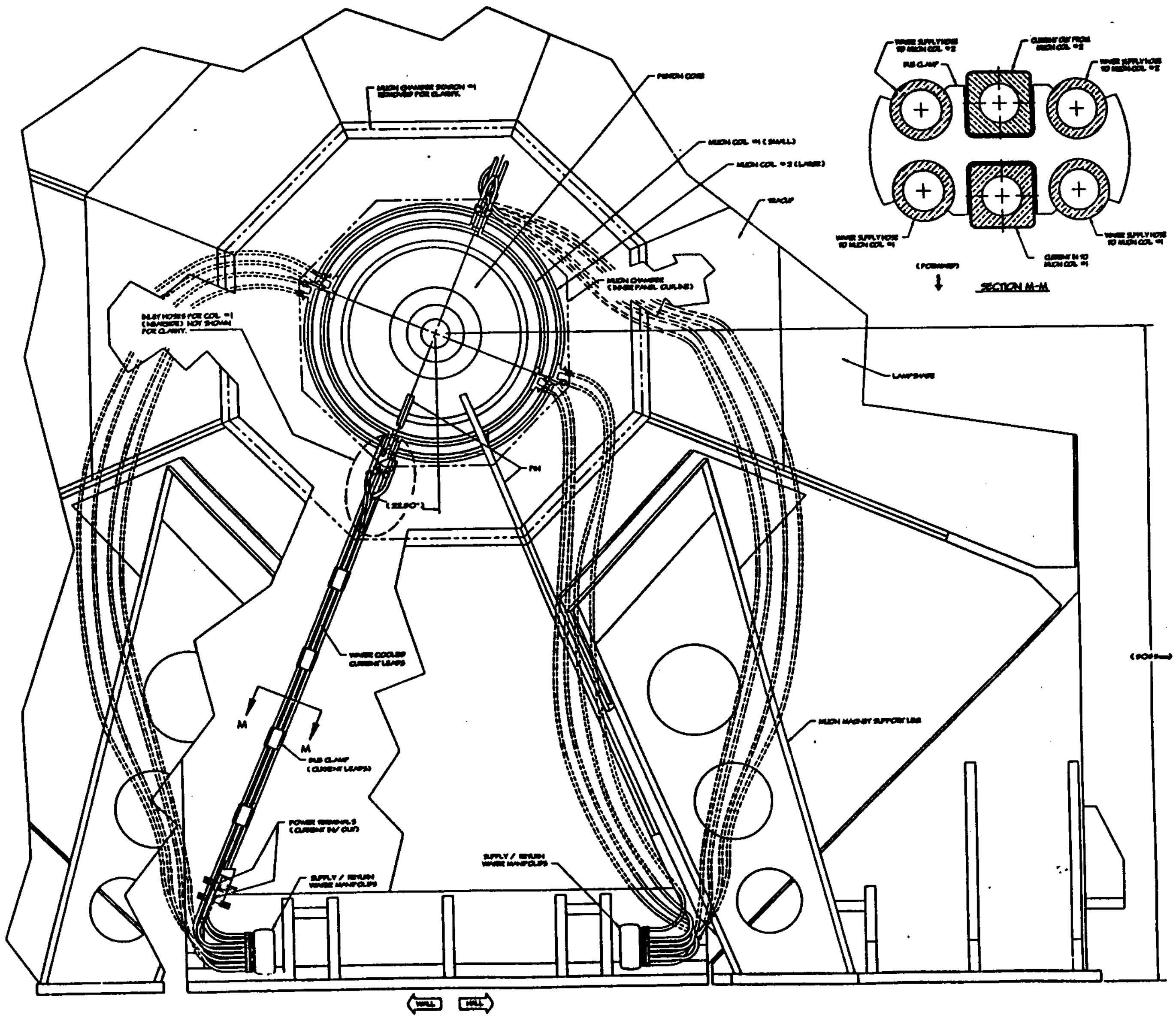
PHENIX Muon Magnet - Coil Installation



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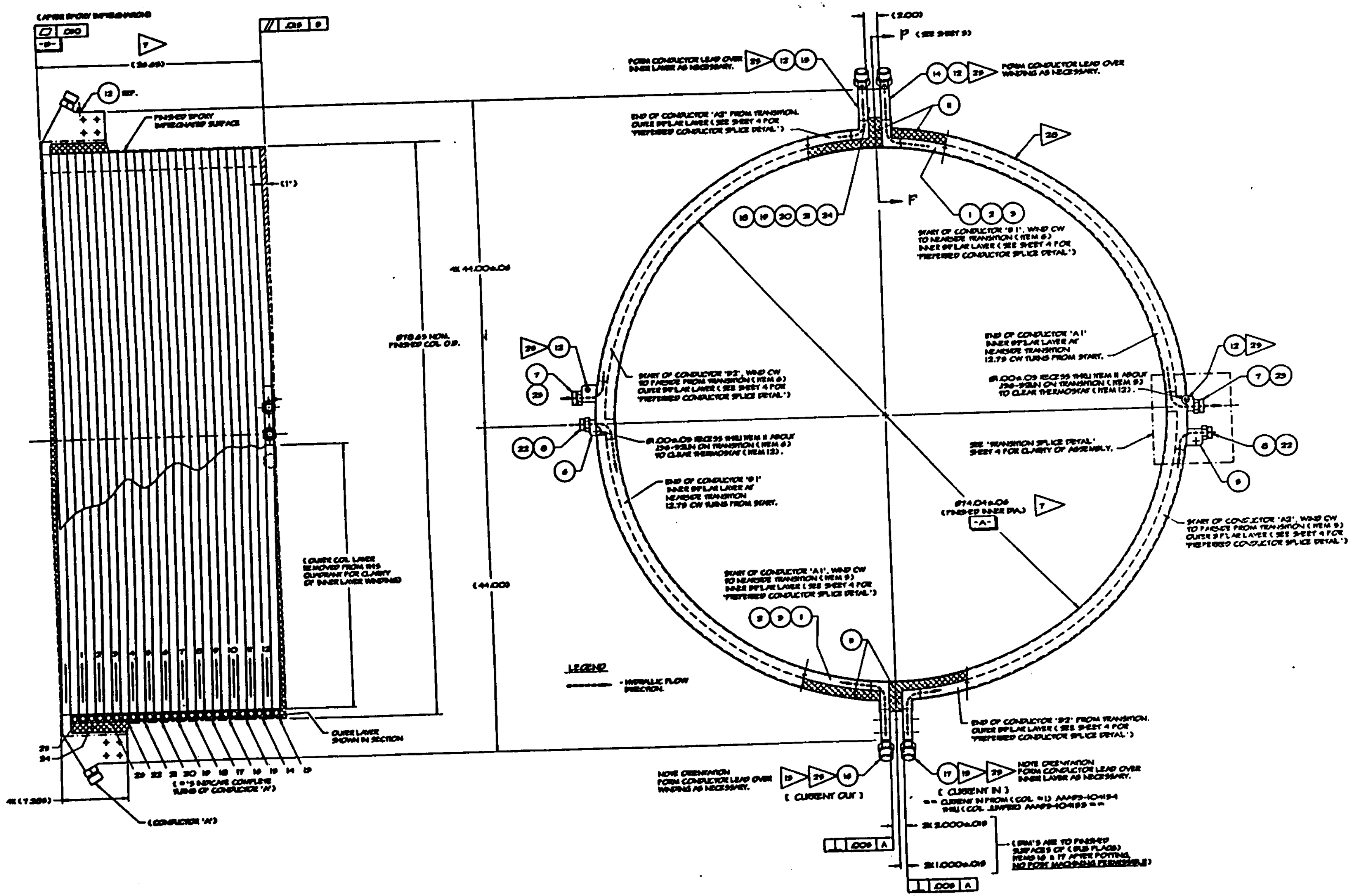
PHENIX Muon Magnet - Large (#2) Coil



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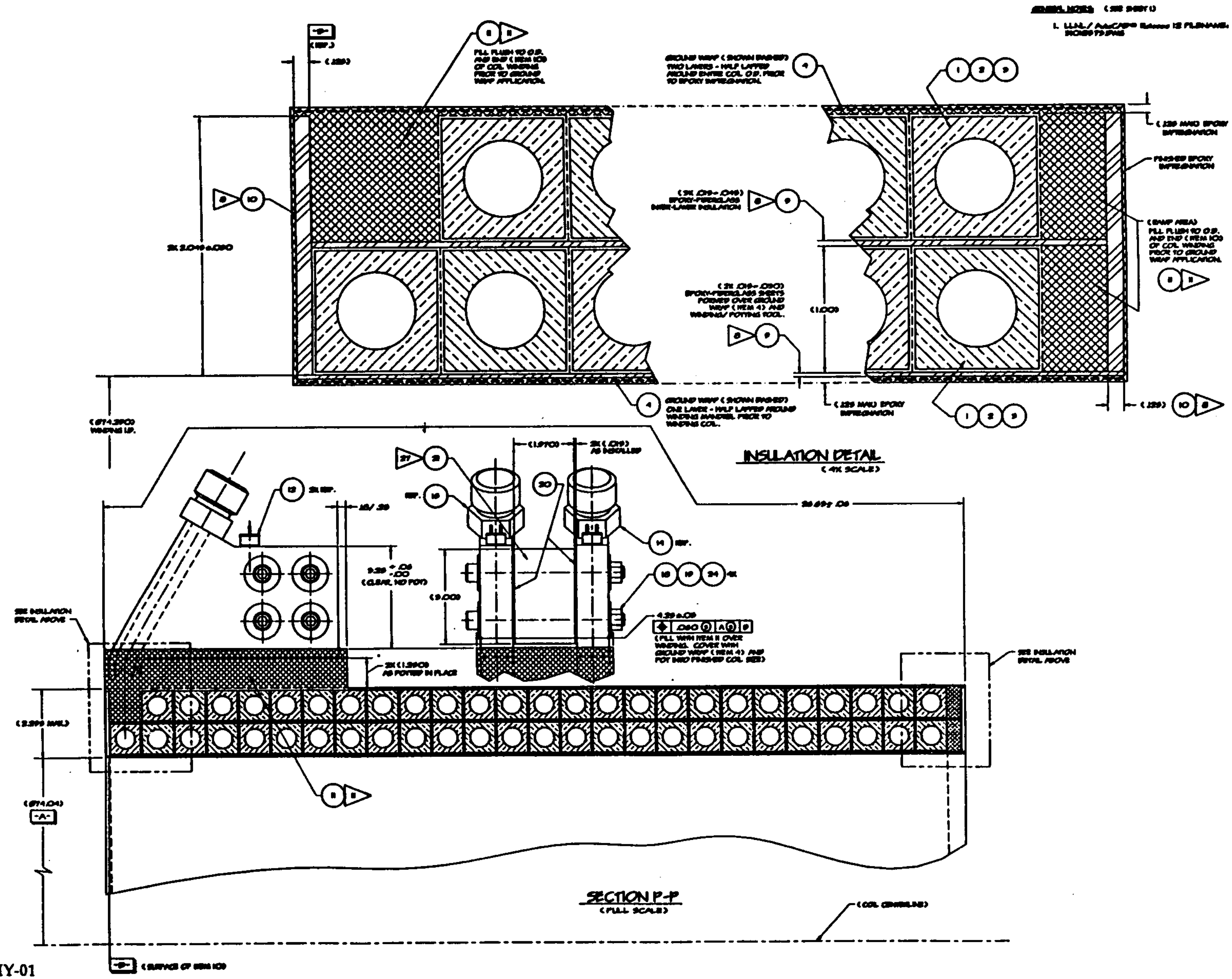
PHENIX Muon Magnet - Coil Cross-section



PHENIX MM Coil - Fabrication Schedule

- MM coil is NOT on the critical path.
- MM coil procurement can start Jan '94.
  - after Nov '93 cost and schedule review.
  - fabrication drawings are complete and in "final check" at LLNL.
- MM coil fabrication will take approx. 12-14 months.
  - 3 months for procurement cycle.
  - 2-3 months for conductor fabrication.
  - 6-9 months for coil fabrication.
- MM coil can be shipped to BNL as early as the Spring '95.
- MM coil can be tested/checked-out as early as the Summer/Fall '95.

SYSTEM: PHENIX Magnet Subsystem

PROJECT ENGINEER: R.M. Yamamoto

DATE: August 2-3, 1993

REVISION: 0

SUBSYSTEM: Muon Magnet Coil

1 COMPONENT		2 HAZARD						3 PREVENTATIVE ACTION
				CLASS				
NO.	DESCRIPTION	MODE	EFFECT	1	2	3	P**	
1	Break in water line	Normal operation	Overheating of coil or electrical shorting of coil creating a fire		X		L	Use of interlocked instrumentation: "Klixon" temperature switches and in-line flow switches
2	Electrical shock	Normal operation	Personnel could be electrically shocked and injured		X		L	All electrical areas on the coil & bus will be shielded; administrative control will be used to ensure that no personnel enter the detector area while the coils are energized
3	Magnetic field	Normal operation	Heart pace makers and some electronic devices become inoperative		X		L	Administrative control will be used to ensure that no personnel enter the detector area while the coils are energized

*HAZARD CLASS: 1-MINOR, 2-MODERATE, 3-MAJOR

**P=PROBABILITY: L=LOW, M=MEDIUM; H=HIGH

SYSTEM: PHENIX Magnet Subsystem

PROJECT ENGINEER: R.M. Yamamoto

DATE: August 2-3, 1993

REVISION: 0

SUBSYSTEM: Muon Magnet Coil

SHEET 2 OF 2

1 COMPONENT		2 HAZARD						3 PREVENTATIVE ACTION
				CLASS				
NO.	DESCRIPTION	MODE	EFFECT	1	2	3	P**	
4	Over pressure and rupture of water lines	Normal operation	Overheating of coil, flooding of detector hall		X		L	Use of interlocked instrumentation: multiple pressure relief valves; use of hoses/fittings which are rated much higher than normal operating pressure
5	High voltage in area by power supplies	Normal operation	Personnel could be electrically shocked and injured		X		L	Area to be secured and locked; grounding hooks supplied; proper safety training of personnel

*HAZARD CLASS: 1-MINOR, 2-MODERATE, 3-MAJOR

**P=PROBABILITY: L=LOW, M=MEDIUM; H=HIGH

PHENIX Muon Magnet Coil - Facility Interfaces

- Hydraulic Interfaces:
  - Required flow rate: approx. 70 gpm total.
  - Inlet pressure: 80 PSI.
  - Outlet pressure: 20 PSI (ΔP=60 PSI).

- Electrical Interfaces:
  - Approx. 3000 amp current carrying capability.
  - Requires 6 supply & 6 return 500 MCM power cables from power supply to intermediate bus station on MM Steel lampshade.

- System Interlocks:
  - Coil temperature sensors (Klixons).
  - Water pressure sensors.
  - Water flow switches.
  - Computer monitoring and control.

PHENIX Magnet Subsystem - Coil Parameters

	Central Magnet		Muon Piston
	Inner Coils (2)	Outer Coils (2)	Coil (1)
Amp-Turns	293,000	247,500	300,000
Configuration	6 Dbl. Pancakes	6 Dbl. Pancakes	Solenoids (2)
Cond Material	Copper	Copper	Copper
Inside Dia (m)	1.08	3.20	1.62/1.88
Outside Dia (m)	1.55	3.73	1.74/2.00
# of Turns	120	144	102
Cond Size (mm)	21.5 square	20.3 square	24.1 square
Cond Hole ø (mm)	13.7	12.8	15.5
Cond Length (m)	497	1578	581
Current (amps)	2442	1719	2941
Voltage (volts)	67	174	77
Power (kwatts)	164	300	225
Flow rate (gpm)	99.2	43.9	67.9
Weight (kg)	1408	4003	2047
Avg Coil Temp °C	23.1	32.8	25.6/27.1

PHENIX Mag Subsystem - Coil Parameters - Max

	Central Magnet		Muon Piston
	Inner Coils (2)	Outer Coils (2)	Coil (1)
Amp-Turns - Nominal	293,000	247,500	300,000
Amp-Turns - Maximum	883,924	367,200	587,739
% Increase	202	48	96
Current (amps)	7199	2550	5762
Voltage (volts)	218	274	164
Power (kwatts)	1573	699	944
Flow rate (gpm)	99.2	43.9	67.9
Avg Coil Temp °C	50.0	50.0	50.0

PHENIX Muon Magnet - Coil Parameters

	Muon Magnet	
	Small #1 Coil	Large #2 Coil
Amp-Turns	300,000	
Configuration	2 Layer Solenoid	2 Layer Solenoid
Cond Material	Copper	Copper
Inside Dia (mm)	1623.8	1880.6
Outside Dia (mm)	1740.4	1997.2
# of Turns	51	51
Cond Size (mm)	24.13 square	24.13 square
Cond Hole ø (mm)	15.49	15.49
Cond Length (m)	270	311
Current (amps)	2941	
Voltage (volts)	35.5	41.1
Power (kwatts)	225	
Flow rate (gpm)	35.3	32.6
Weight (kg)	951	1096
Avg Coil Temp °C	25.6	27.1

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PHENIX Coils - Power Supply Cable Analysis

Objective: to determine the proper size and quantity of electrical cables that will supply current from the power supplies to the coils.

- Assume each coil type (3 total) uses 1 power supply each (CM outer, CM inner & MM coil).
- Assume each set of power supply cables will run in its own individual cable tray (utilize de-rating correction factor "CF" based on number of layers and number of cables per layer).
- Assume electrical cables can operate at 90°C.
- Assume ambient air is at 40°C (conservative).
- Select 500 MCM electrical cables:
  - hypalon insulated
  - rated at 720 amps for a single cable
  - 1325 strands of #24 AWG
  - rated for 90°C @ 600 volts
  - 1.24"ø with insulation wall thickness of 0.109"
  - 1966 lbs per 1000 ft.

PHENIX Coils - Power Supply Cable Summary

Parameter	CM Outer Coils	CM Inner Coils	MM Coils
Current (amps)	1719	2442	2941
Voltage (volts)	348	134	77
Power (kwatts)	600	328	225
# of Layers	2	2	2
# of Cables/Layer	4	~~5~~ 4	~~6~~ 4
CF (de-rating) Factor	0.76	0.75	0.74
# of cables required	8	10	~~12~~ 6
Voltage drop per 1000 ft.	86	122	147
Kwatts per 1000 ft.	37	59	72
Maximum # of cables available at bus	~~16~~ 8	~~16~~ 8	~~16~~ 8

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PHENIX Coils - Power Supply Cable Summary

Parameter	CM Outer Coils	CM Inner Coils	MM Coils
Current (amps)	1719	2442	2941
Voltage (volts)	348	134	77
Power (kwatts)	600	328	225
# of Layers	2	2	2
# of Cables/Layer	4	5	6
CF (de-rating) Factor	0.76	0.75	0.74
# of cables required	8	10	12
Voltage drop per 1000 ft.	86	122	147
Kwatts per 1000 ft.	37	59	72
Maximum # of cables available at bus	16	16	16

PHENIX Coils - SC vs Copper vs. Aluminum

- Resistive coils able to meet B field requirements.
- SC coils require additional ancillary systems (vacuum + cryogenic); more maintenance and less reliability.
- SC coils have higher capital costs vs resistive coils but lower operating power costs. Cu coils designed to minimize power consumption and average coil temperature (large volume of Cu + multiple water circuits).
- SC coils have large reserve "ampere-turn" capacity but Cu coils have been designed to accommodate anticipated B field increases.
- Cu coils are "low tech"; can be made by many vendors and offer high reliability and low maintenance.
- Low "Z" properties of Aluminum not critical for PHENIX since coils do not interfere with detector's "line of sight" and radiation environment is not significant at their locations.
- Large power consumption increase using Al vs Cu coils.

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PHENIX CM Outer Coils - Trade Study

Parameter Change	Avg Coil Temp °C	Power (KW)	% Pwr Increase
Copper Conductor (baseline)	32.8	300	-
Aluminum Conductor	41.8	507	69%
Aluminum Conductor + Increase Water ΔP to 200 PSIG	30.6	486	62%
Aluminum Conductor + Increase Water ΔP to 200 PSIG + Decrease Conductor Hole Diameter (.50" to .48")	31.9	464	55%

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PHENIX MM Coils - Trade Study

Parameter Change	Avg Coil Temp °C	Power (KW)	% Pwr Increase
Copper Conductor (baseline for large coil)	27.1	225	-
Aluminum Conductor	31.6	375	67%
Aluminum Conductor + Increase Water ΔP to 200 PSIG	25.8	367	63%
Aluminum Conductor + Increase Water ΔP to 200 PSIG + Decrease Conductor Hole Diameter (.61" to .44")	31.5	304	35%

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RHIC/PHENIX Detector

CDR Update: Magnet Steel

Joel Bowers

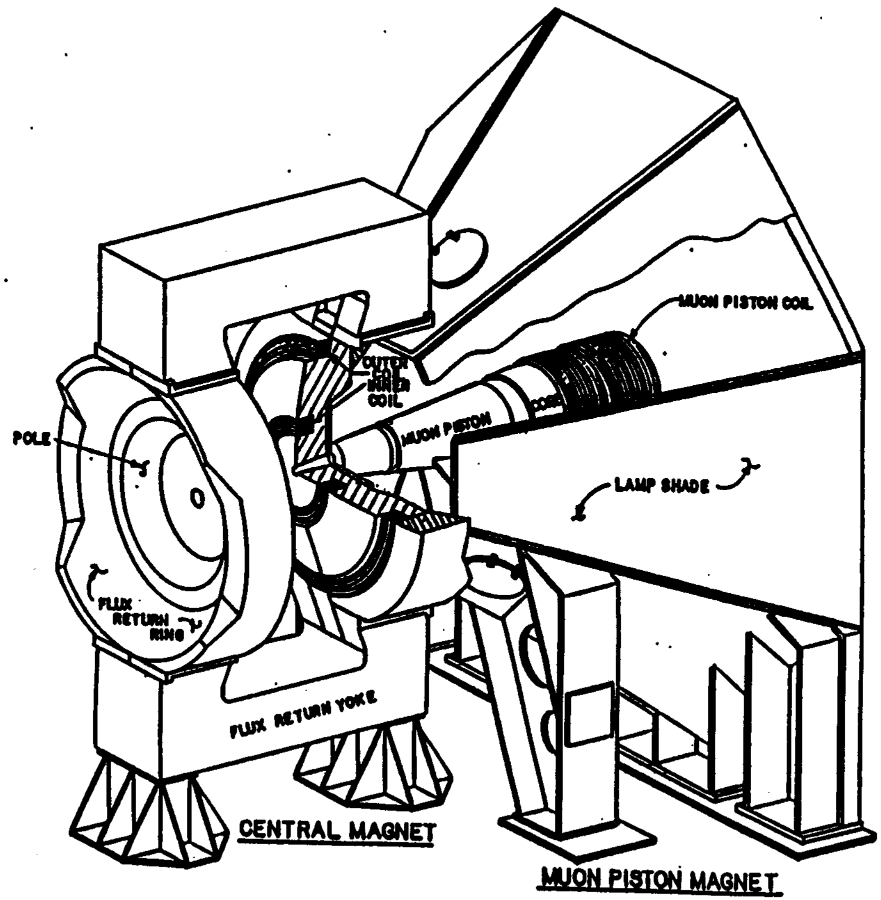
Lawrence Livermore National Laboratory
November 9, 1993

Design has progressed in several areas

- Central Magnet
- Muon Magnet
- Muon ID
- Procurement Plan
- Fabrication specification

PHENIX Magnet evolution

January CDR



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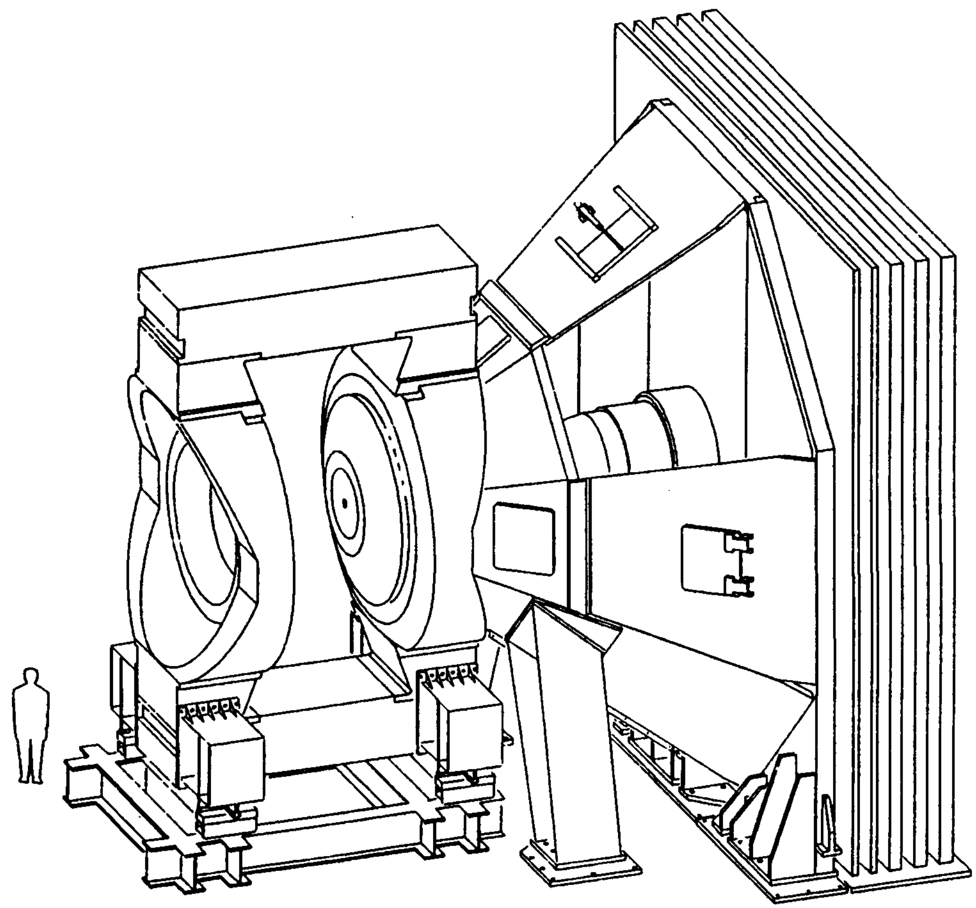


Steel design is ready

DETAIL DRAWINGS ARE COMPLETE

WE CAN START FABRICATION ON 12/1

Central Magnet changes since CDR

- **New transport and track system for precision motion**

  Permanent outriggers support magnet, sit on rollers
  Common track design for CM and RICH carriage
  1.5 meter retraction is quick and repeatable

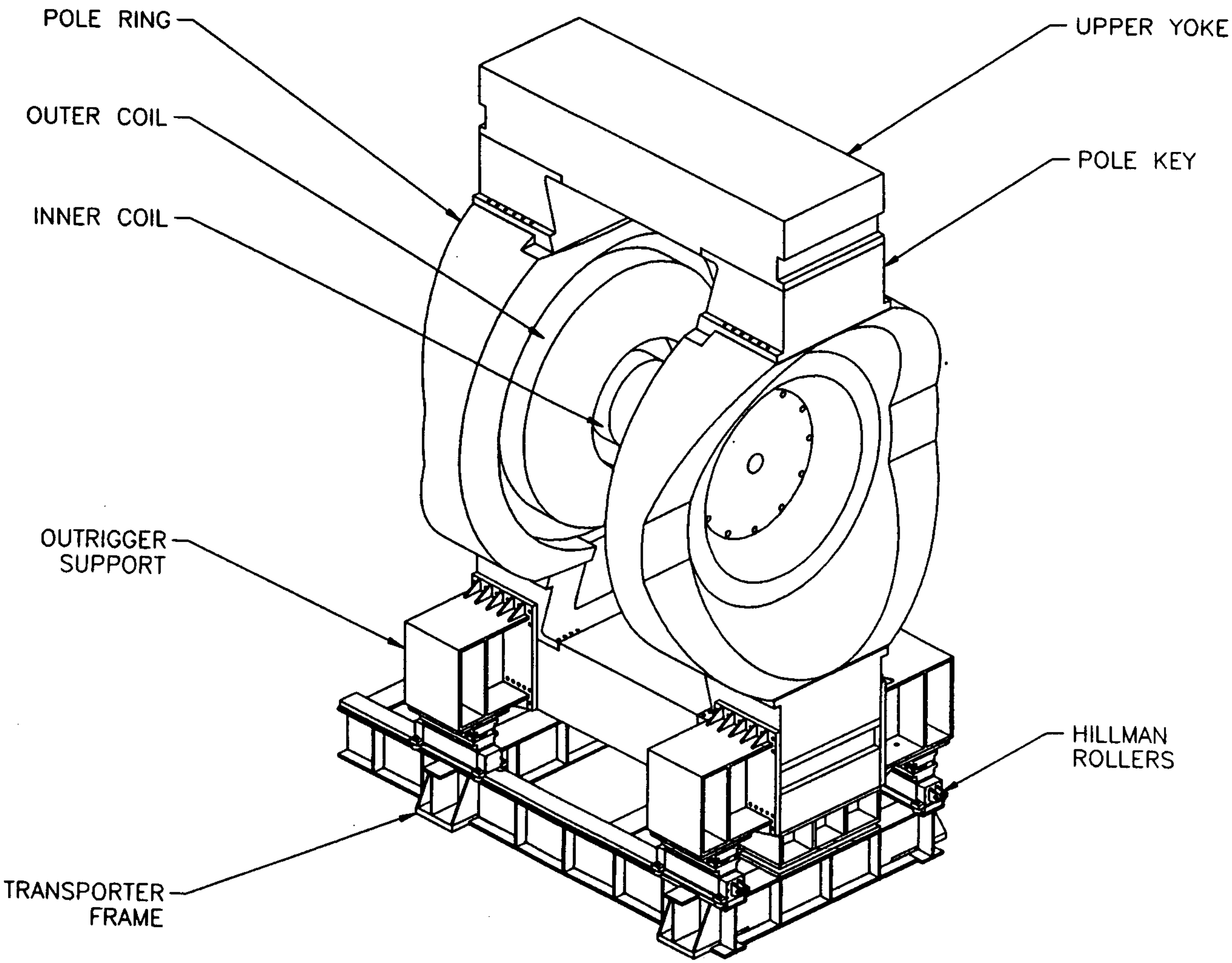
- **Notch provided in pole to allow clearance for RICH**

- **Forging details accomodate Russian capabilities**

  Each pole made from three pieces to simplify fabrication
  Flux return yokes are smaller one piece forgings

- **Off site fit up and disassembly assures quality**

PHENIX CM Steel Assembly - Isometric



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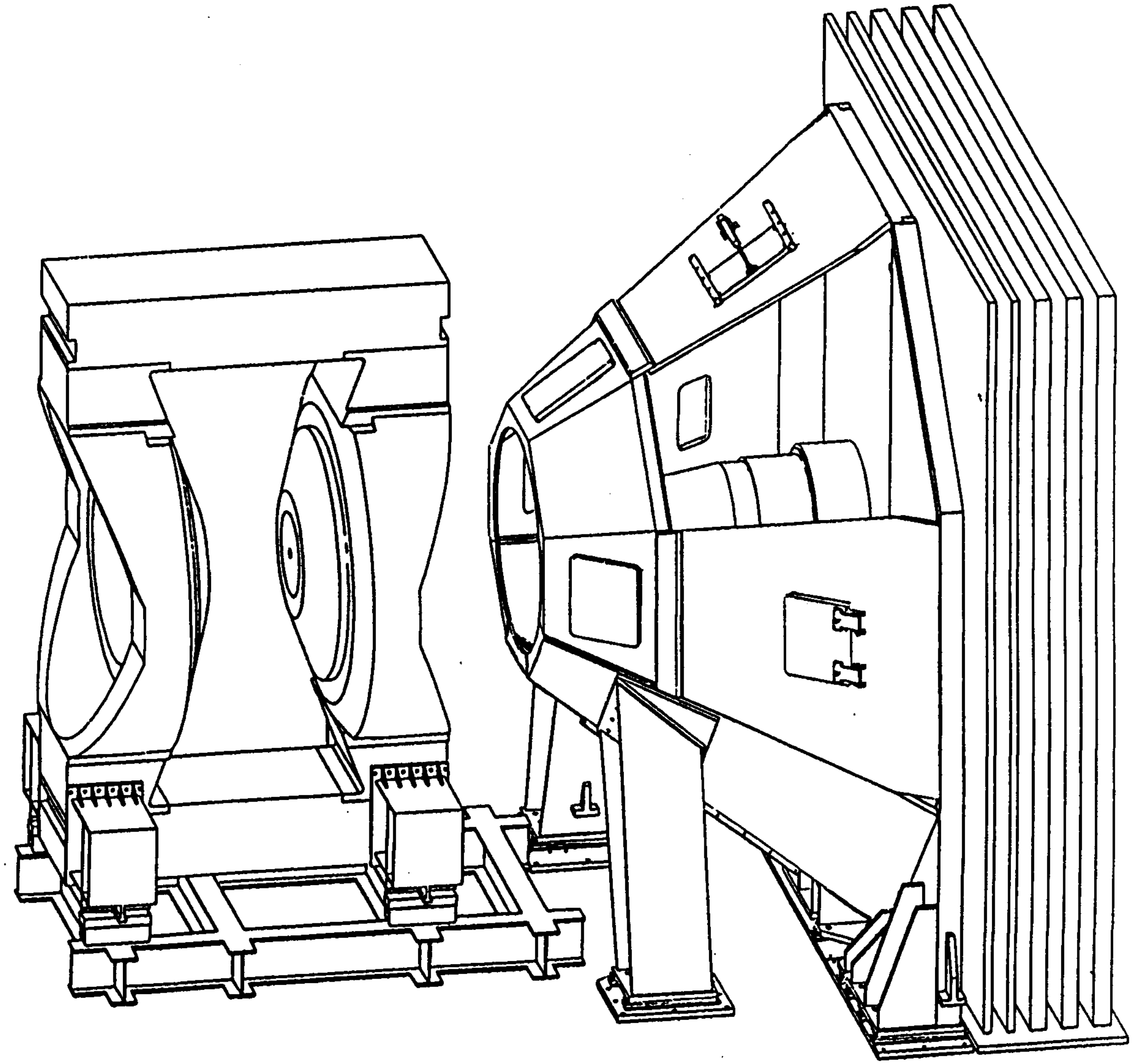
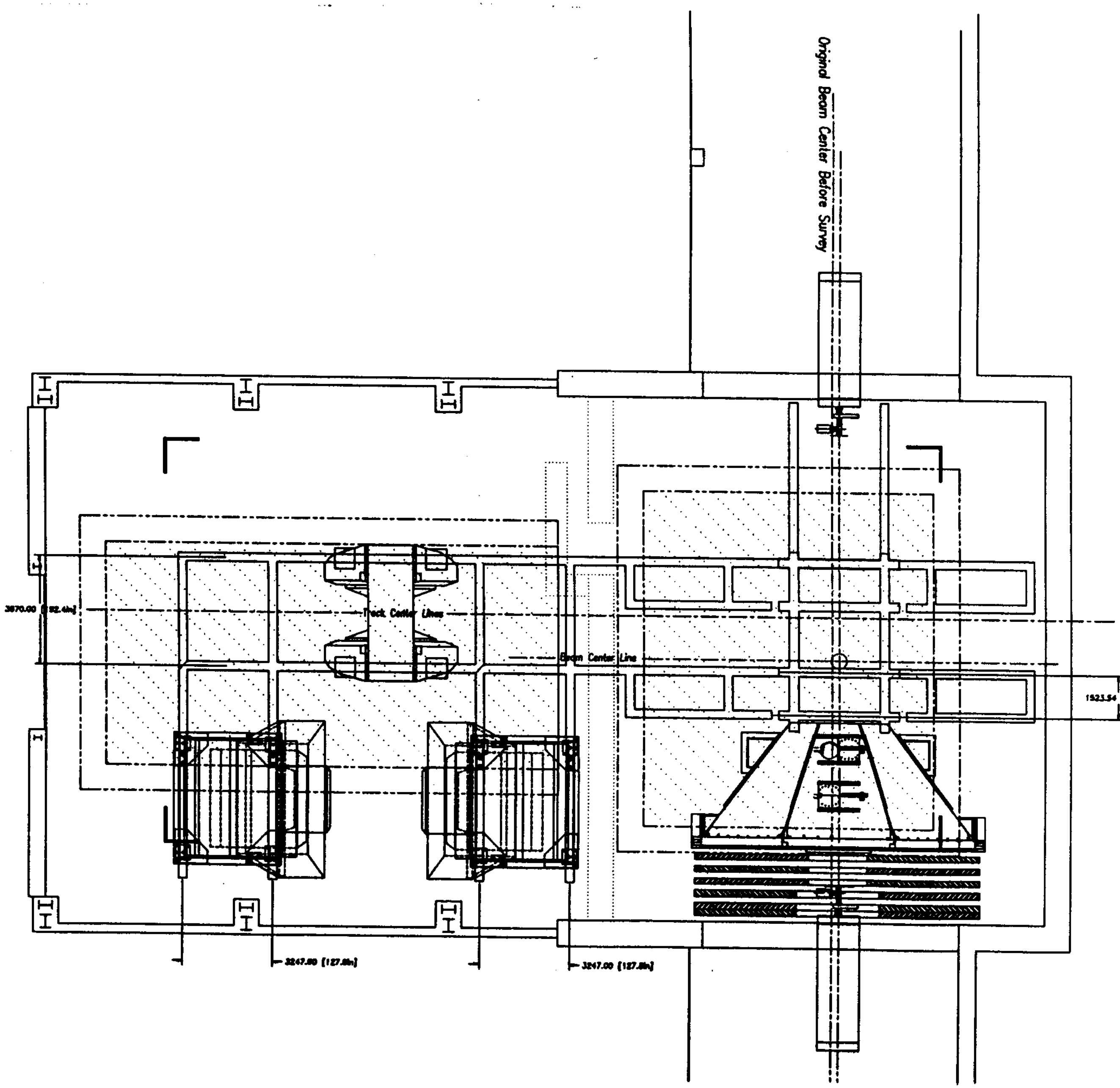
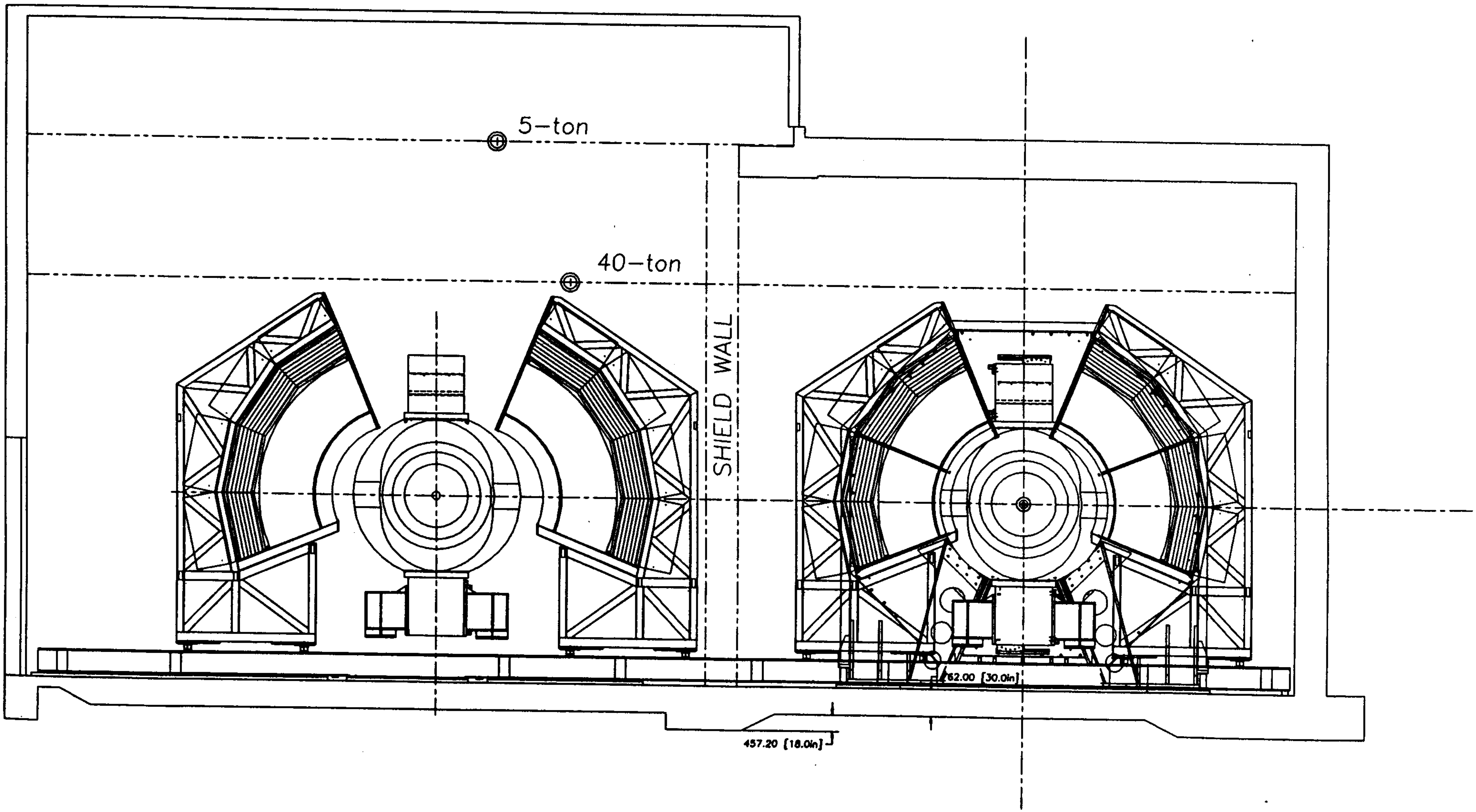
Central Magnet retracted 1.5 m



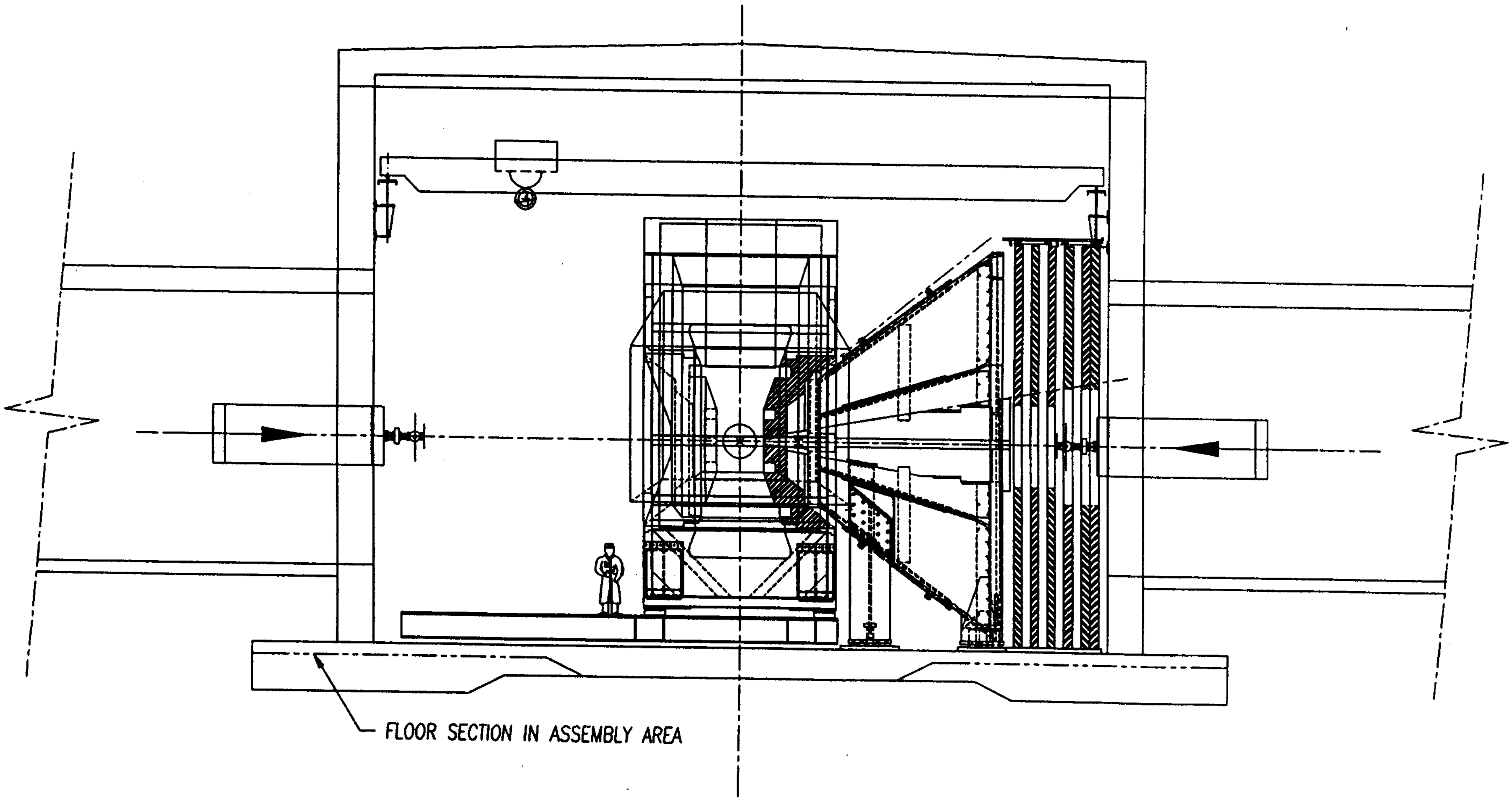
PHENIX hall track system



PHENIX hall track system (Z elevation)

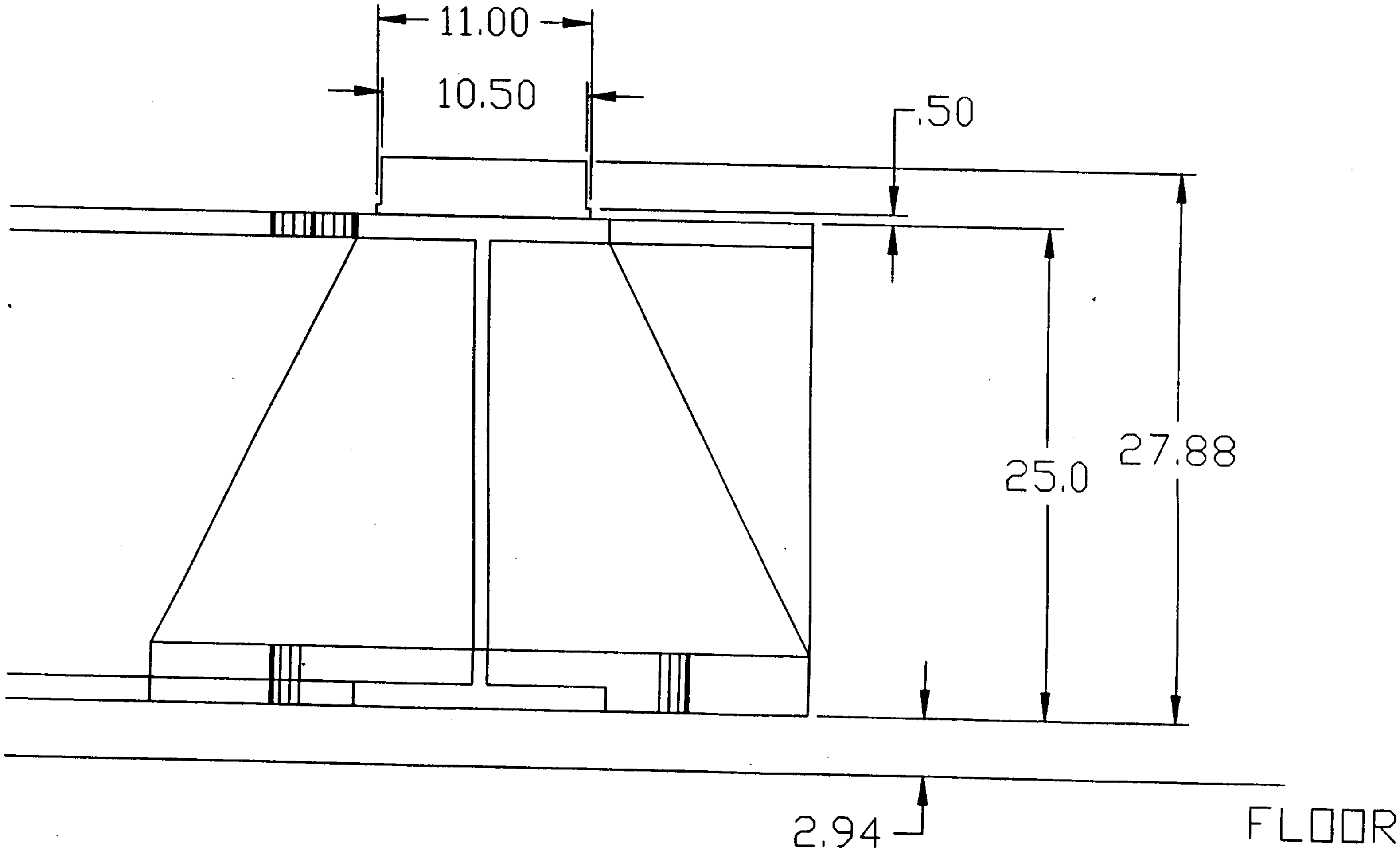


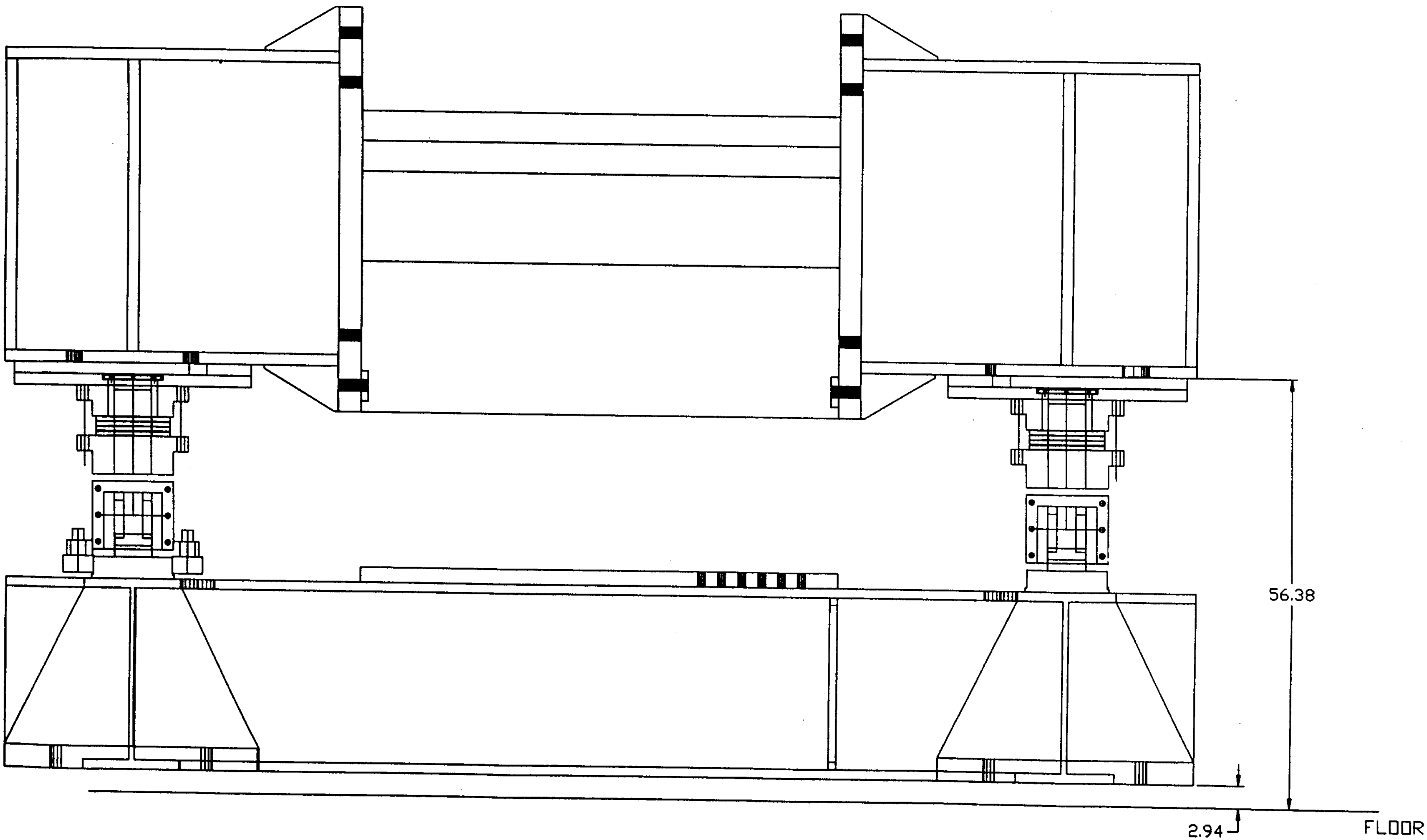
PHENIX hall track system (X elevation



Central magnet track design

- T1 hardened plate welded to a W24 beam section

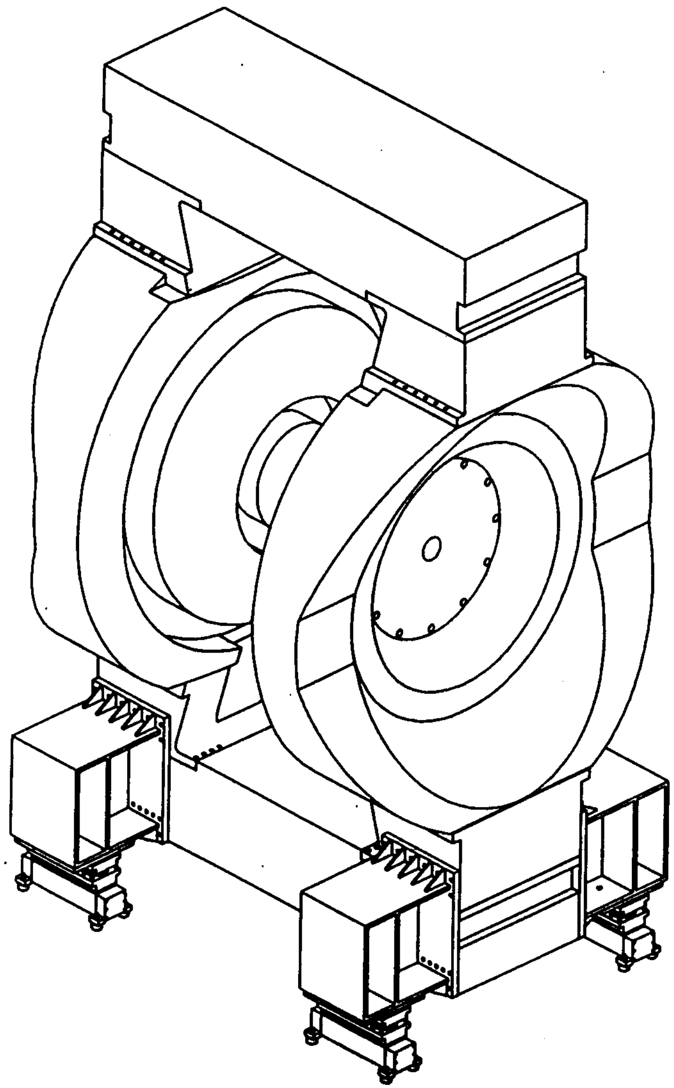




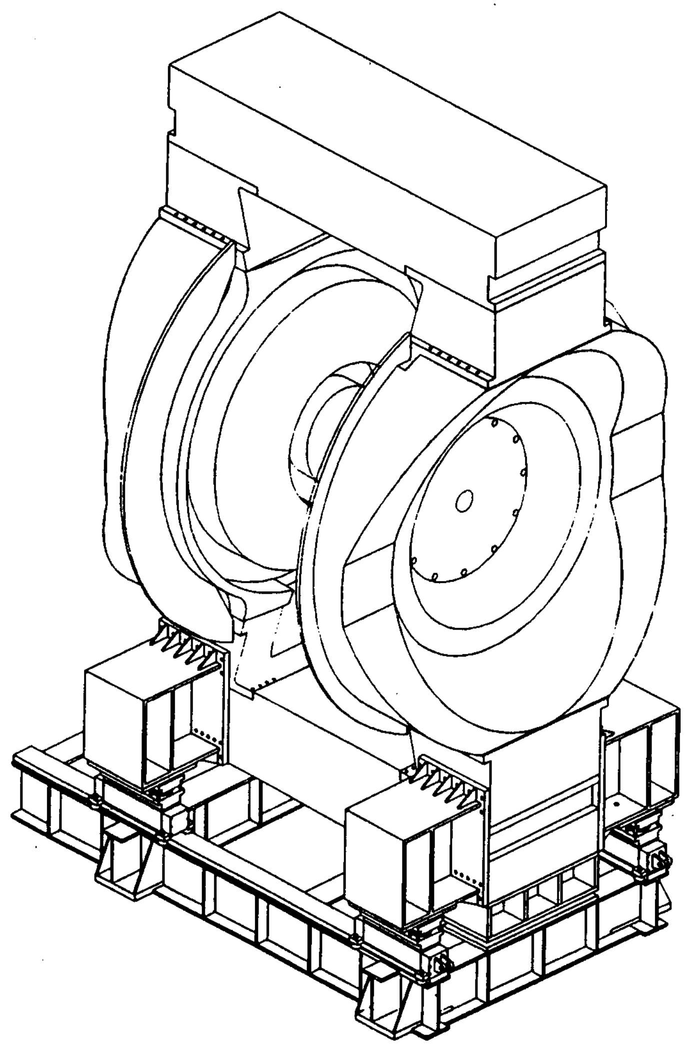
56.38
2.94
FLOOR

Central magnet notch design

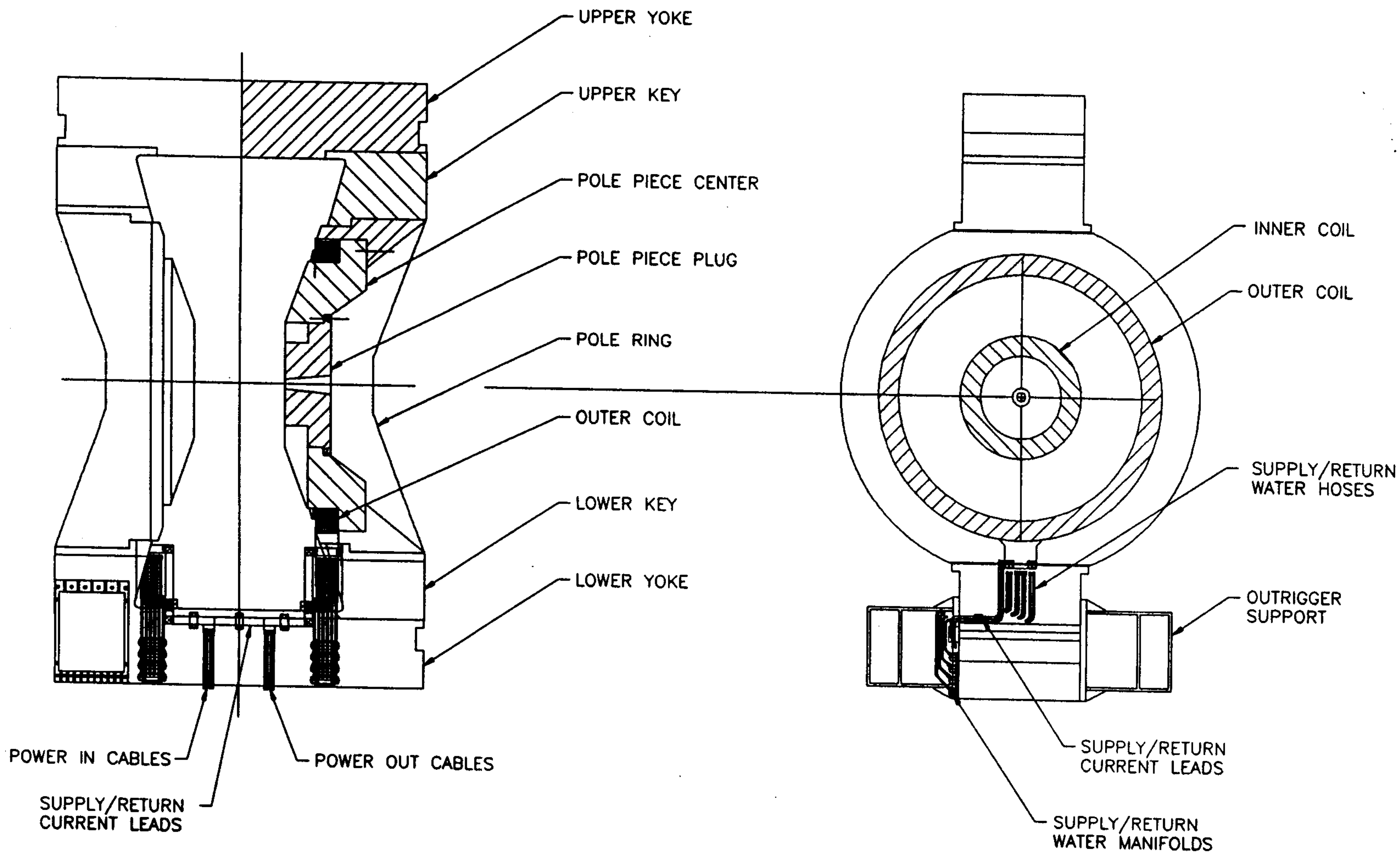
Before

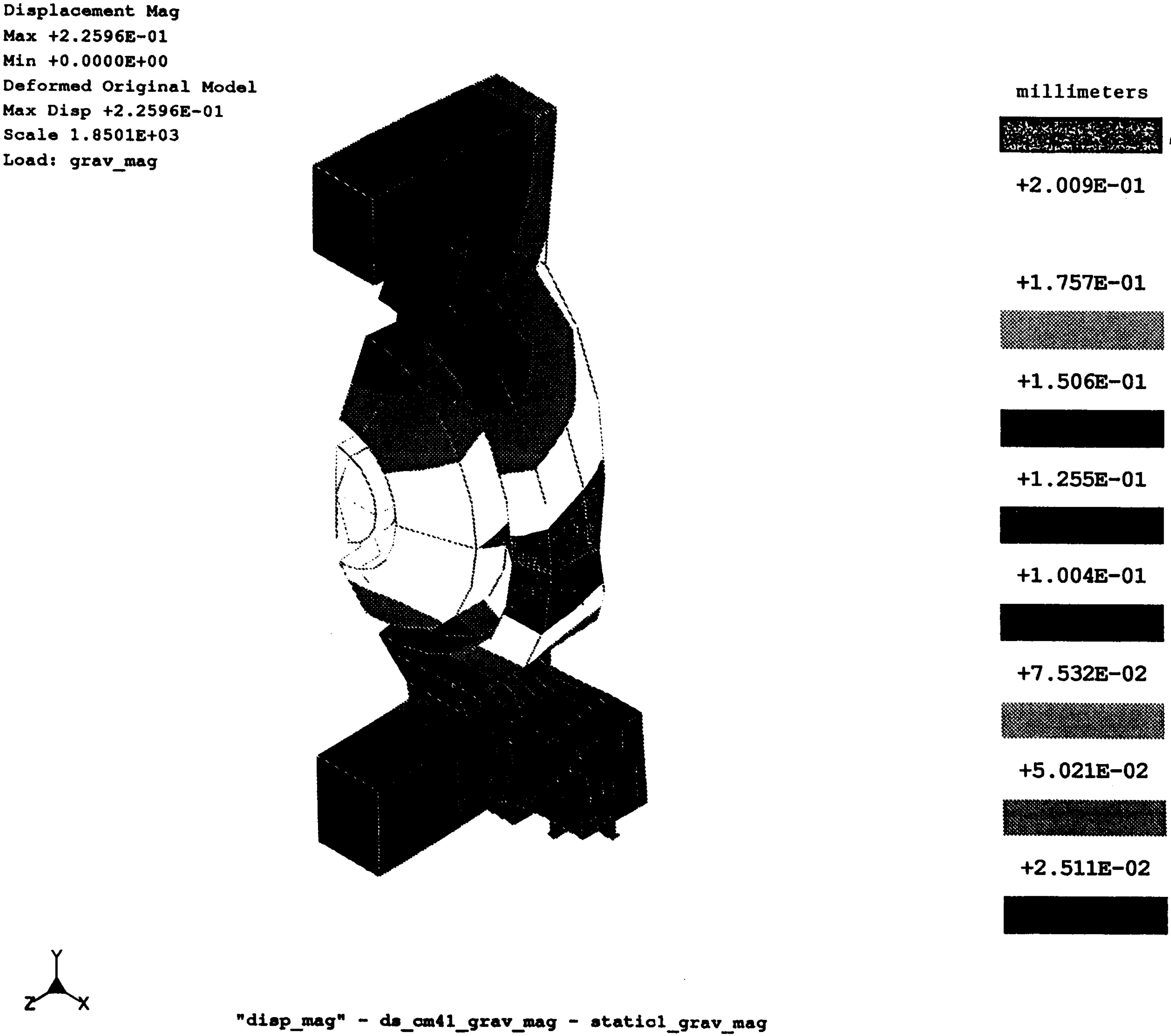


Now



PHENIX Central Magnet - Overview




Displacement Mag
Max +2.2596E-01
Min +0.0000E+00
Deformed Original Model
Max Disp +2.2596E-01
Scale 1.8501E+03
Load: grav_mag
millimeters
+2.009E-01
+1.757E-01
+1.506E-01
+1.255E-01
+1.004E-01
+7.532E-02
+5.021E-02
+2.511E-02
Y
Z
X
"disp_mag" - ds_cm41_grav_mag - static1_grav_mag

Summary of Displacements for CM

	Gravity Only	Magnetic Only	Gravity plus Magnetic
Magnitude (90° edge of eyebrow)	.11	.11	.22
Y-Axis (top of return yoke)	-.09	-.08	-.17
Z-Axis (90° edge of eyebrow)	-.08	-.12	-.20

Units are millimeters

Central magnet off site construction plan

- 100% of central magnet steel will be

Poured/Cast

Rolled

Welded

Forged

Heat treated

Machined

Assembled

Inspected

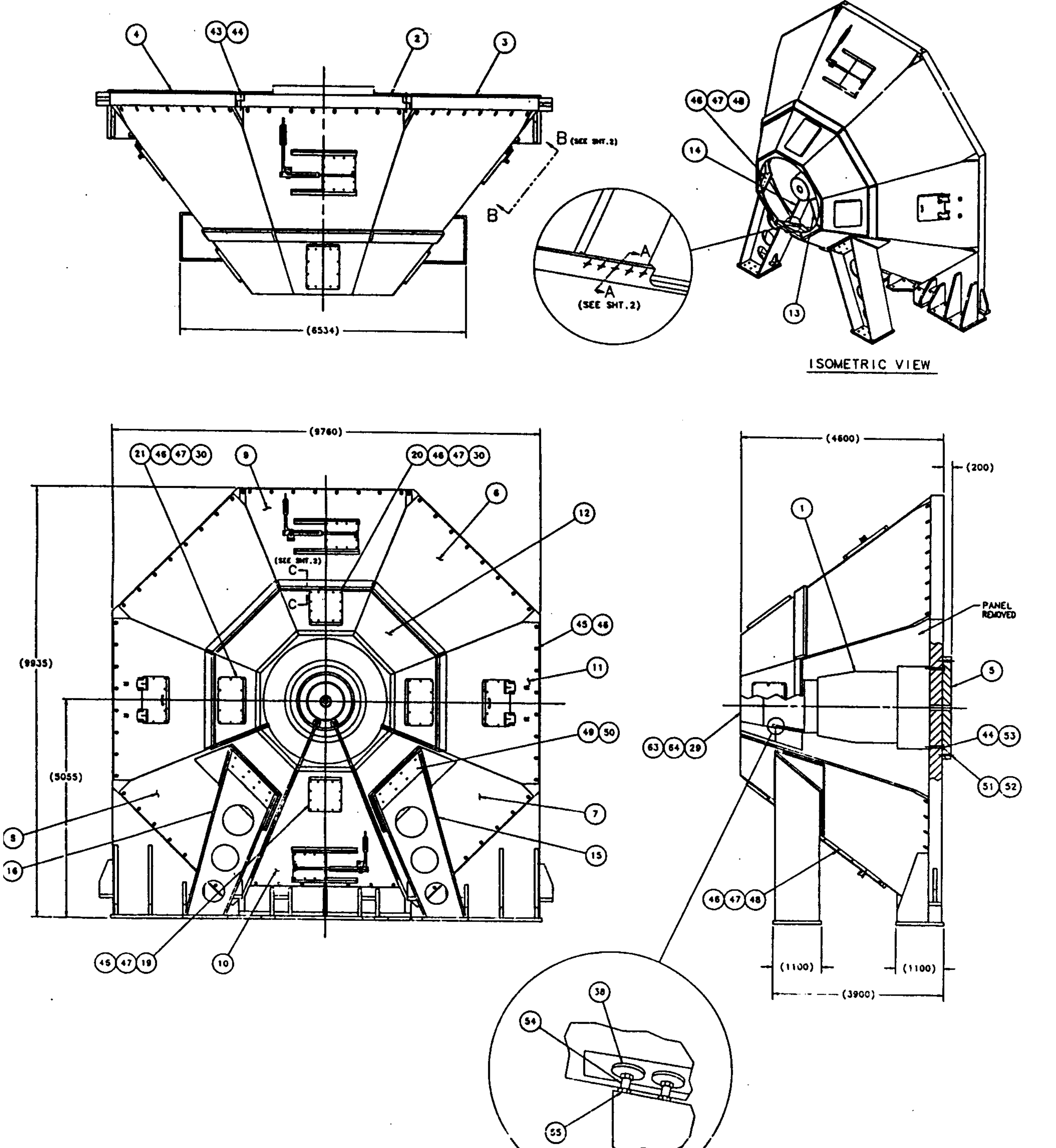
in St. Petersburg, Russia

Muon Magnet changes since CDR

- Top 5 plates (8 tons each) removable
- Semi-fixed section of top lampshade (tea cup)
- Hydraulic drive access doors on top and bottom plates
- Hinged access doors on side plates
- Removable stabilizer fins minimize muon piston motion
- Back plate design accommodates Russian plate rolling mill
- Bore of muon piston increased to 22 cm

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



NO REQD			PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
8				FLAT WASHER,STL.,ZINC PLATE,M20	DIN 125A	64
8				HEX.CAP SCREW,STL.,BLACK,M20X70	DIN 931 8.8	63
12				FLAT WASHER,STL.,ZINC PLATE,M12	DIN 125A	62
12				PAN HD.MACH.SCREW,PHILLIPS,ZINC PLATE,M5X16		61
8				HEX. CAP SCREW,STL.,BLACK,M12X50	DIN 931 8.8	60
40				HEX.FLAT WASHER,STL.,ZINC PLATE,M12	DIN 125A	59
32				HEX. CAP SCREW,STL.,BLACK,M12X90	DIN 931 8.8	58
30				SOC.HD. CAP SCREW,BLACK,M20X70	DIN 912 8.8	57
14			5310-21801	HEX. NUT,STNLS STL.,.750(INCH)-10		56
14				STUD,STNLS STL.,.750(INCH)-10 X 3" LG.		55
10				HEX. CAP SCREW,STL.,BLACK,M24X110	DIN 931 8.8	54
20				HEX. CAP SCREW,STL.,BLACK,M48X400	DIN 931 8.8	53
12				FLAT WASHER,STL.,ZINC PLATE,M36	DIN 7989 A	52
12				HEX. CAP SCREW,STL.,BLACK,M36X300	DIN 931 8.8	51
32				FLAT WASHER,STL.,ZINC PLATE,M30	DIN 7989 A	50
32				HEX. CAP SCREW,STL.,BLACK,M30X140	DIN 931 8.8	49
38				HEX. NUT,STL.,BLACK,M24	DIN 934 8	48
48				HEX. CAP SCREW,STL.,BLACK,M24X120	DIN 931 8.8	47
241				FLAT WASHER,STL.,ZINC PLATE,M24	DIN 7989 A	46
63				HEX. CAP SCREW,STL.,BLACK,M24X100	DIN 931 8.8	45
54				FLAT WASHER,STL.,ZINC PLATE,M48	DIN 125 B	44
34				HEX. CAP SCREW,STL.,BLACK,M48X200	DIN 931 8.8	43
						42
						41
						40
10			McMASTER CARR 91121A110	SPHERICAL WA. 1.06" I.D. X 2" O.D. X .5" THK.		39
14			CARR LANE CL-12-LF-S	LEVELING FEET,STNLS STL.,.750(INCH)-10		38
4			CARR LANE CL-16-T6	T-PIN, ø.75 INCH X 6 INCH LONG		37
8			SEAL MASTER NP-20R	PILLOW BLOCK, ø 1.25 INCH		36
2			McMASTER CARR 1402A46	DOOR PULL		35
						34
						33
						32
						31
3			93-104177	LOCATOR PIN		30
1			93-104212	PISTON NOSE CONE		29
8			93-104202	BASE, BEARING		28
4			93-104201	BRACKET, DOOR RESTRAINING		27
4			93-104203	SHAFT, DOOR HINGE		26
4			93-104208	STIFFENER, HINGE, OUTSIDE		25
4			93-104207	HINGE, PILLOW BLOCK		24
4			93-104206	STIFFENER, HINGE, INSIDE		23
2			93-104179	DOOR, HINGED		22
2			93-104180	DOOR, TEACUP SIDE		21
1			93-104178 TAB 02	DOOR, FIXED		20
1			93-104178 TAB 01	DOOR, FIXED		19
1			93-104176	SPACER BAR		18
5			93-104175	SPLICE BAR		17
1			93-101887 TAB 02	SUPPORT LEG,R.H.		16
1			93-101887 TAB 01	SUPPORT LEG,L.H.		15
1			93-104157 TAB 02	SUPPORT FIN,R.H.		14
1			93-104157 TAB 01	SUPPORT FIN,L.H.		13
1			93-104173	TEACUP		12
2			93-104174	LAMPSHADE PANEL NO.5		11
1			93-101892 TAB 02	LAMPSHADE PANEL ASSY.,LOWER		10
1			93-101892 TAB 01	LAMPSHADE PANEL ASSY.,UPPER		9
1			93-101891 TAB 02	LAMPSHADE PANEL NO.3,R.H.		8
1			93-101891 TAB 01	LAMPSHADE PANEL NO.3,L.H.		7
2			93-101890	LAMPSHADE PANEL NO.2		6
1			93-101864	DISK,BACKPLATE		5
1			93-101886 TAB 02	BACKPLATE,SIDE,R.H.		4
1			93-101886 TAB 01	BACKPLATE,SIDE,L.H.		3
1			93-101885	BACKPLATE,CENTER		2
1			93-101860	PISTON CORE		1

C	RHH		TEACUP ADDED
B	RHH		REVISED
A	RHH		REVISED

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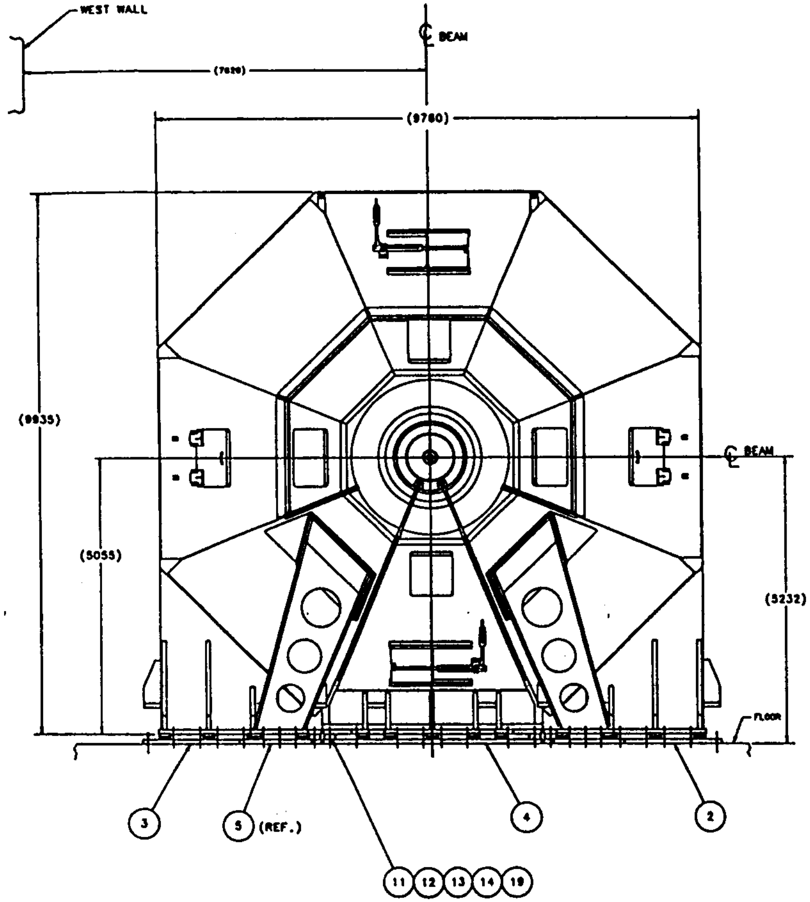
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

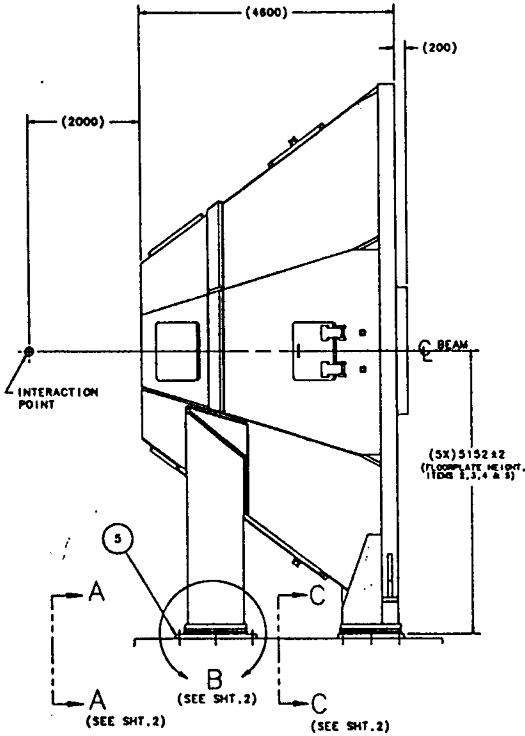
RELATIVISTIC HEAVY ION COLLIDER (RHIC)
PHENIX MUON PISTON MAGNET
MUON PISTON MAGNET ASSEMBLY

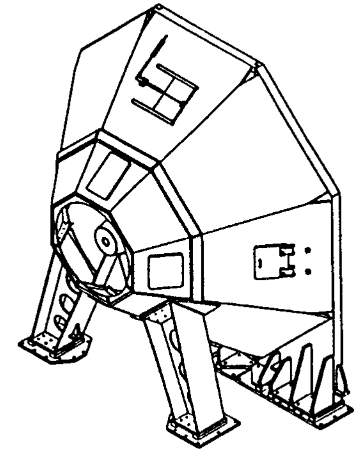
DRAWING NO AAA93-101858-0C

SCALE NONE SHEET 1 OF 2

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. CHIP OUT EXISTING FLOOR TO PROVIDE SPAC FOR GROUT AND WRENCH CLEARANCE FOR HEIG ADJUSTMENT OF FLOORPLATE.
5. DRILL HOLES, INJECT EPOXY, INSERT STUDS AND CURE PER MANUFACTURERS INSTRUCTIONS
6. FILL WITH GROUT AND CURE PER MANUFACTURER INSTRUCTIONS. FULL CONTACT BETWEEN GROU AND PLATE/FLOOR IS ESSENTIAL TO INSURE LOAD DISTRIBUTION. 1 1/4" NPTF HOLES PROVIDED IN FLOORPLATES FOR GROUT INJECTION







ISOMETRIC VIEW

NO REQD			PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO
A/R			UNISORB V-100, OR EQUIV.	EPOXY	
A/R			UNISORB V-1, OR EQUIV.	GROUT	
2				NUT, STEEL, ZINC PLATE, 1.25(INCH)-7	
58				STUD, 4140 STL, ZINC/CAD PLT, 1.25(INCH)-7 X 24(INCH) LONG	
60				HEX. CAP SCREW, BLACK, M36 X 300	DIN931 8.8
A/R			93-104172 TAB 03	SPACER, FLOORPLATE	
A/R			93-104172 TAB 02	SPACER, FLOORPLATE	
4			93-104172 TAB 01	SPACER, FLOORPLATE	
176			93-104213	WASHER, 110 O.D. X 38 I.D. X 30 THICK	
A/R			93-104165 TAB 03	SHIM (10MM THICK)	
A/R			93-104165 TAB 02	SHIM (4MM THICK)	
A/R			93-104165 TAB 01	SHIM (2MM THICK)	
17			93-104184	WEDGEPLATE, LOWER	
17			93-104183	WEDGEPLATE, UPPER	
2			93-104158	FLOORPLATE, FRONT	
1			93-104166	FLOORPLATE, REAR, CENTER	
1			93-104159 TAB 02	FLOORPLATE, REAR, SIDE	
1			93-104159 TAB 01	FLOORPLATE, REAR, SIDE	
1			93-101858	MUON PISTON MAGNET ASSEMBLY	

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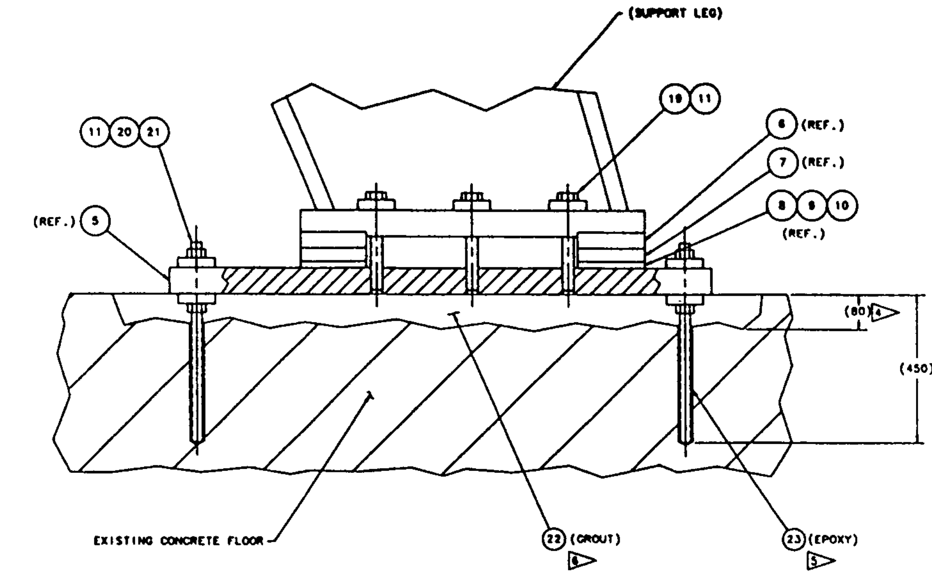
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

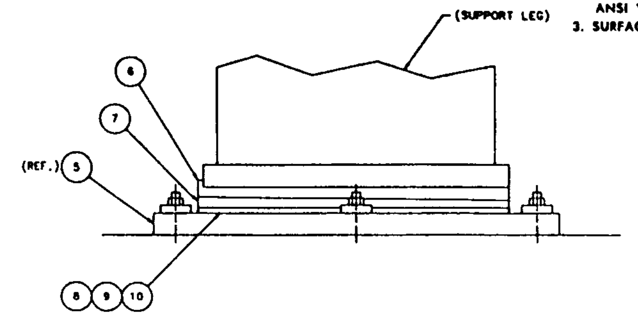
MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUBASSY: PHENIX MUON PISTON MAGNET
DETAIL: MUON PISTON MAGNET INSTALLATION
DRAWING NO: AAA93-104171-0
SCALE: NONE
SHEET 1 OF

1. ALL DIMENSIONS ARE IN ~~INCHES~~MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



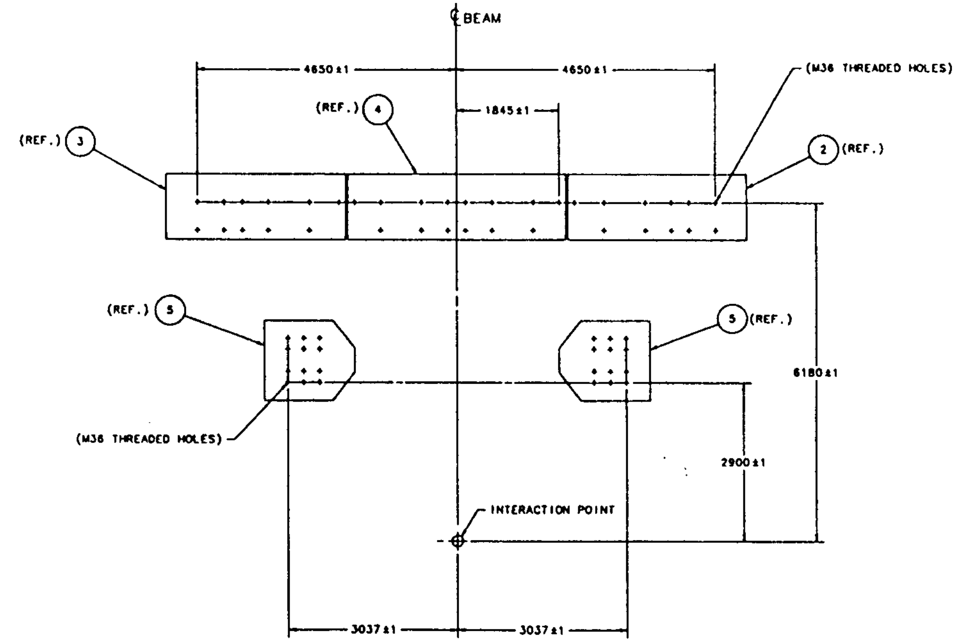
VIEW A-A

(FROM SHEET 1)



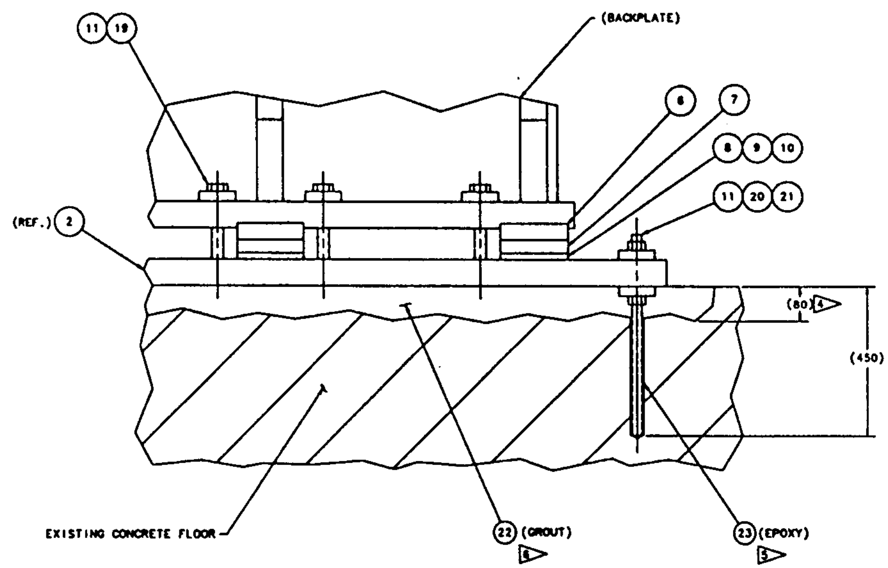
DETAIL B

(FROM SHEET 1)



FLOORPLATE LOCATIONS

(PLAN VIEW)



VIEW C-C

(FROM SHEET 1)

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO

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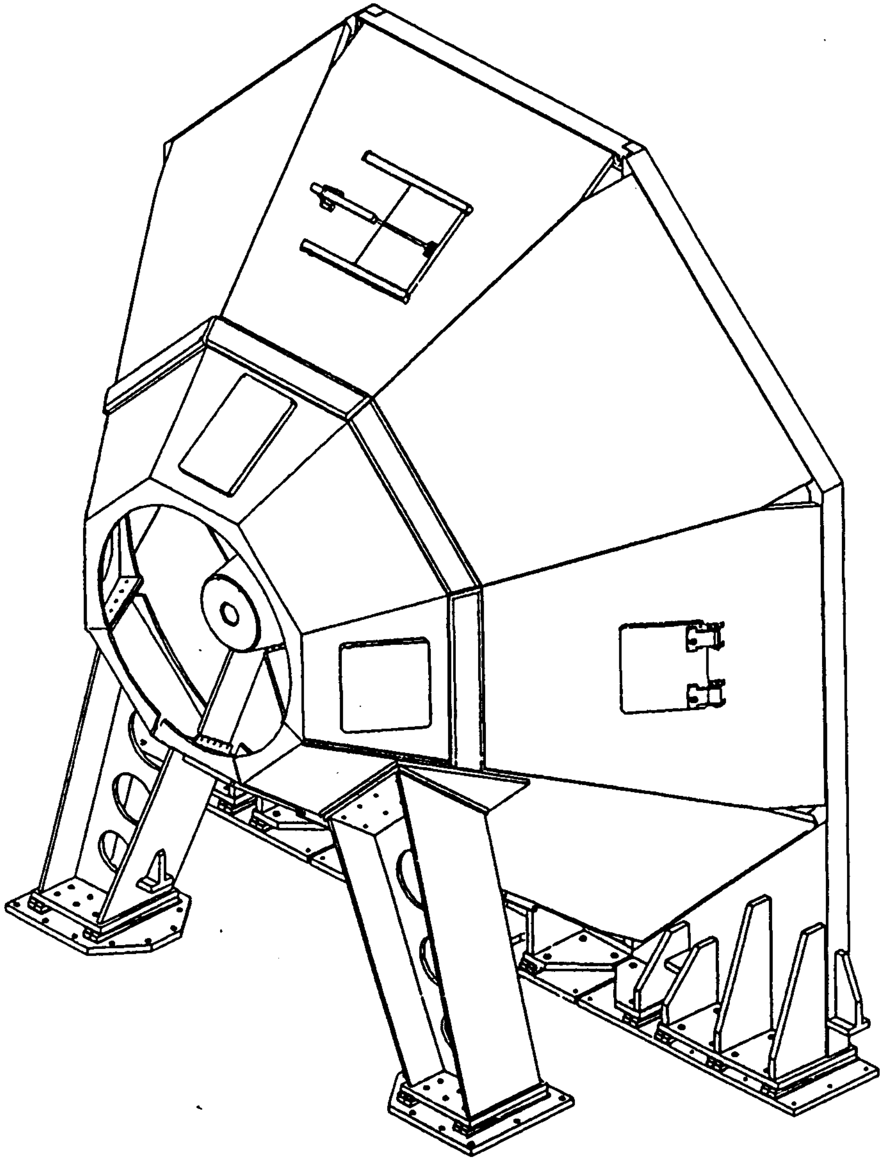
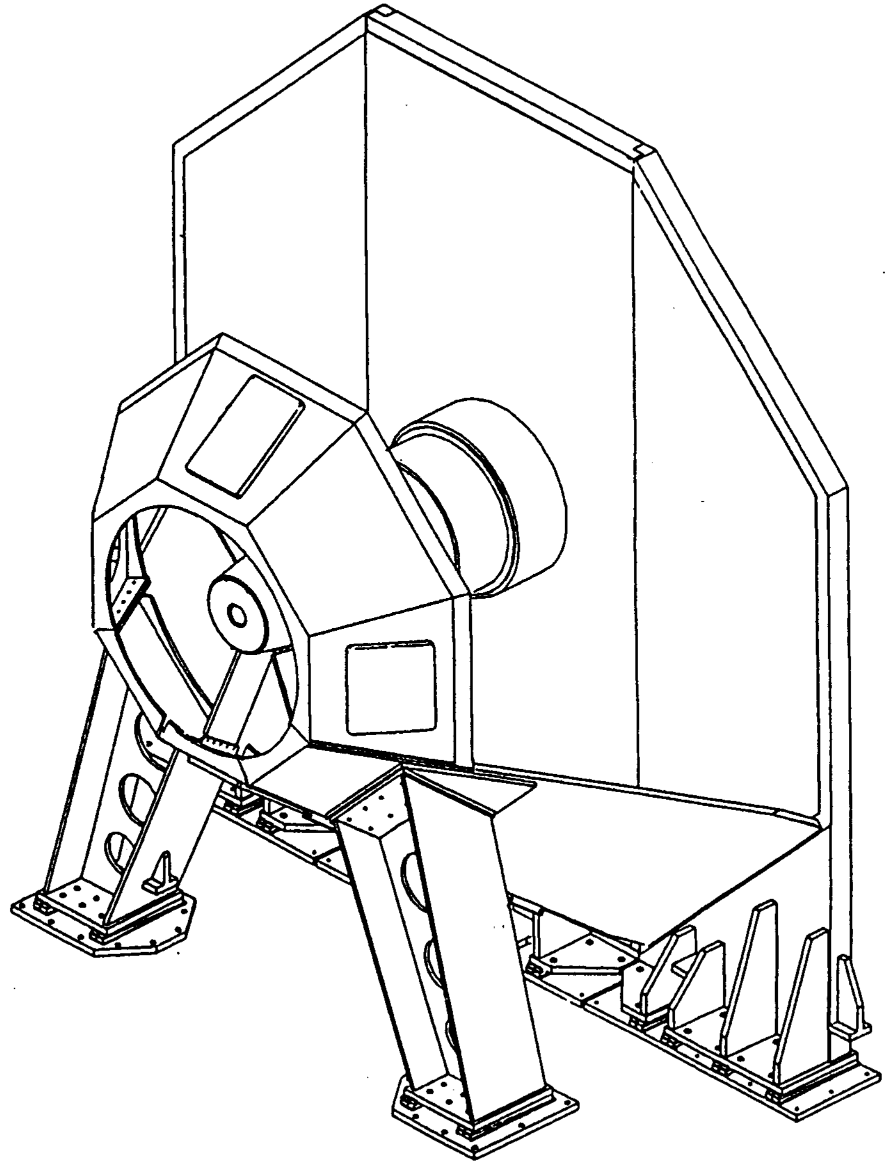
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

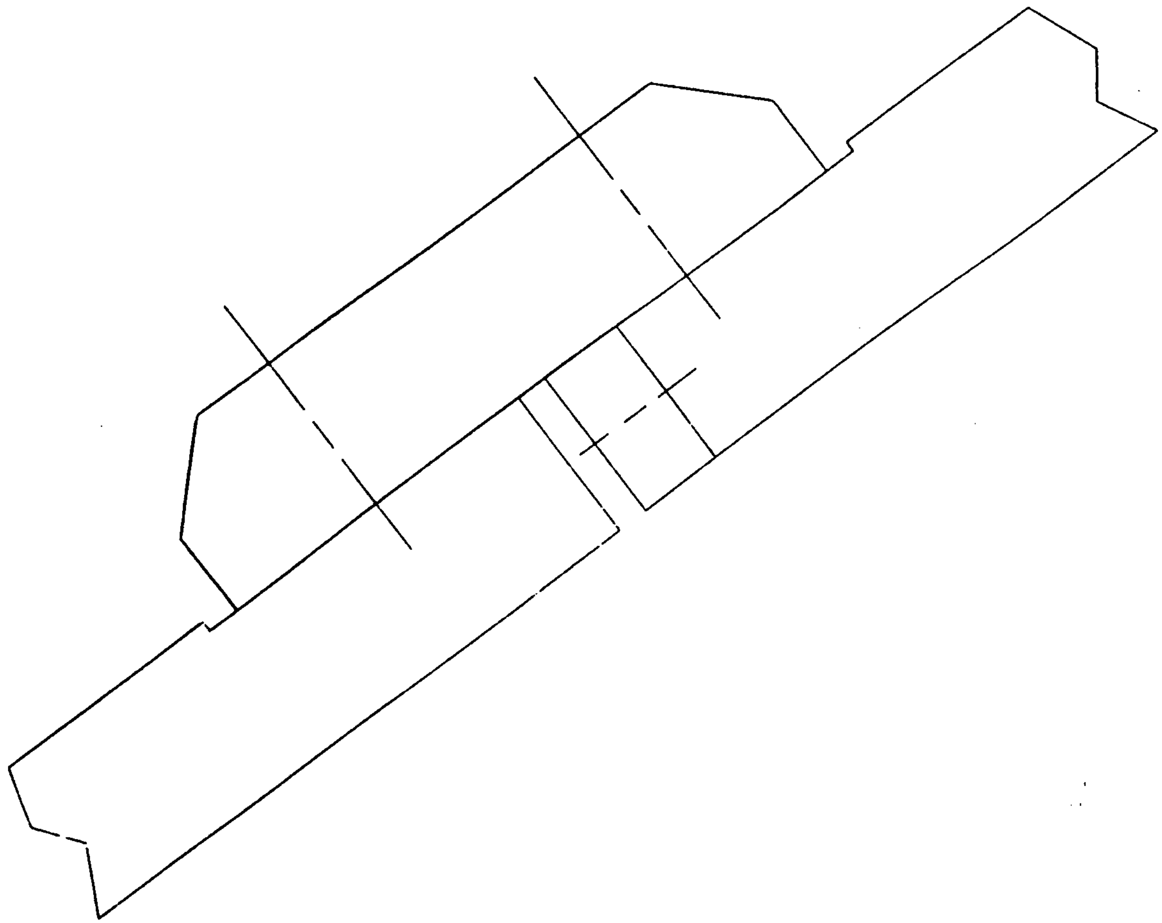
MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUBASSY: PHENIX MUON PISTON MAGNET
DETAIL: MUON PISTON MAGNET INSTALLATION
DRAWING NO: AAA93-104171-0(
SCALE NONE
SHEET 2 OF 2

Muon Magnet lampshade design



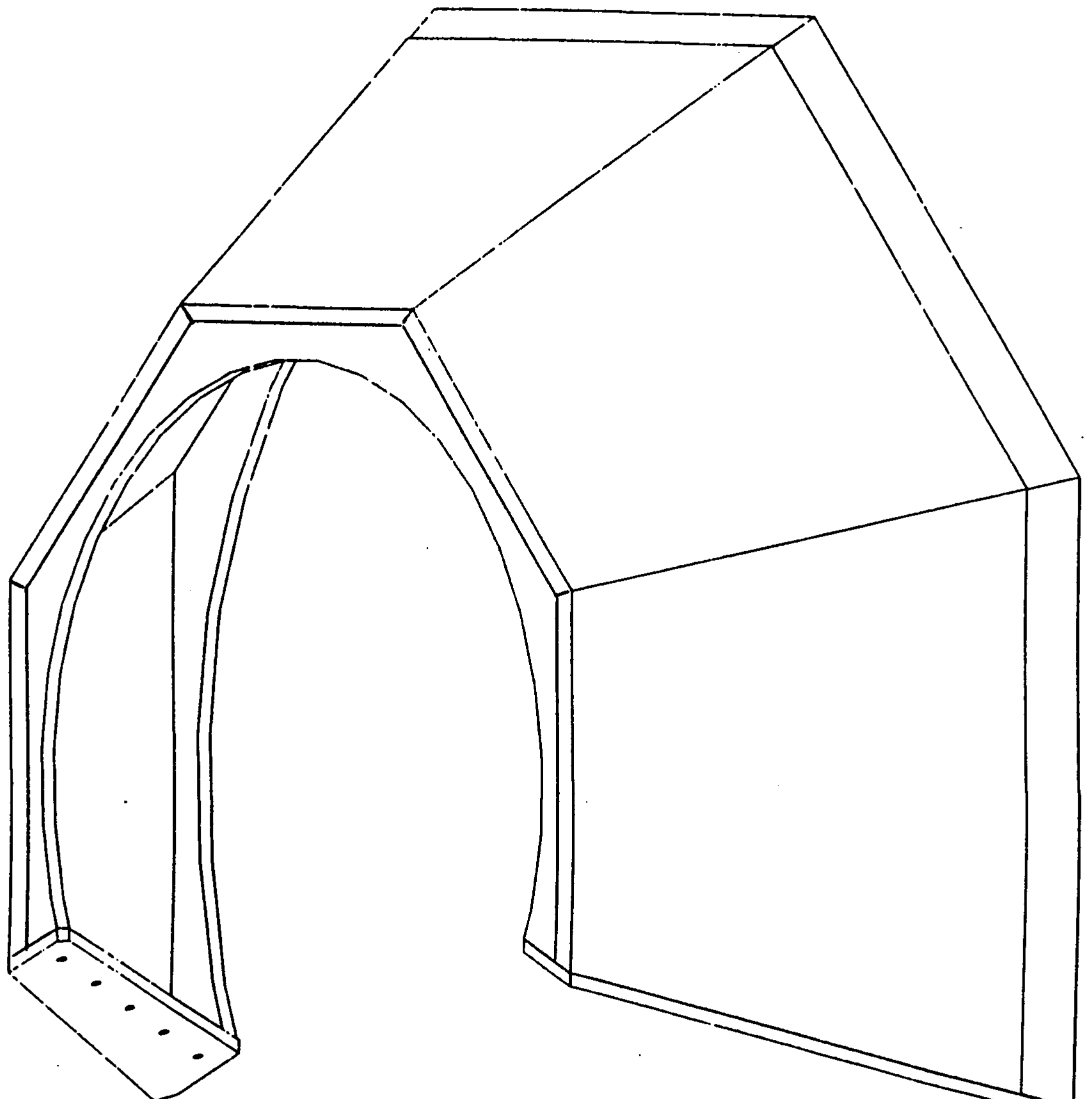


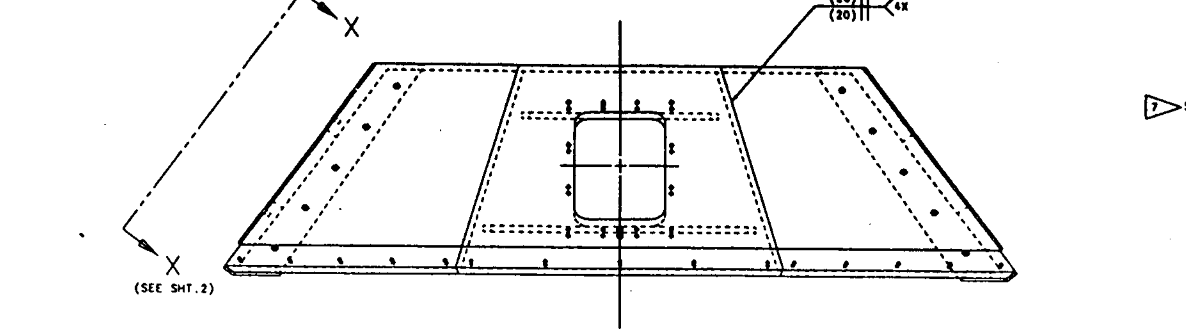
Lampshade-teacup connection

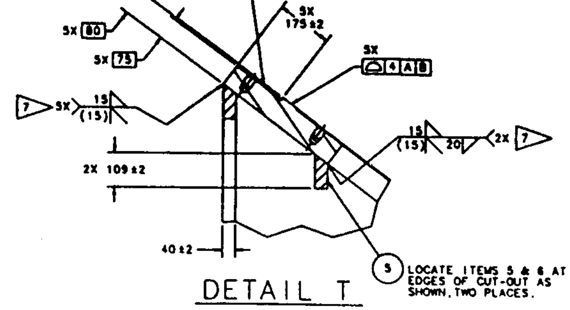


JMB
7/29/93

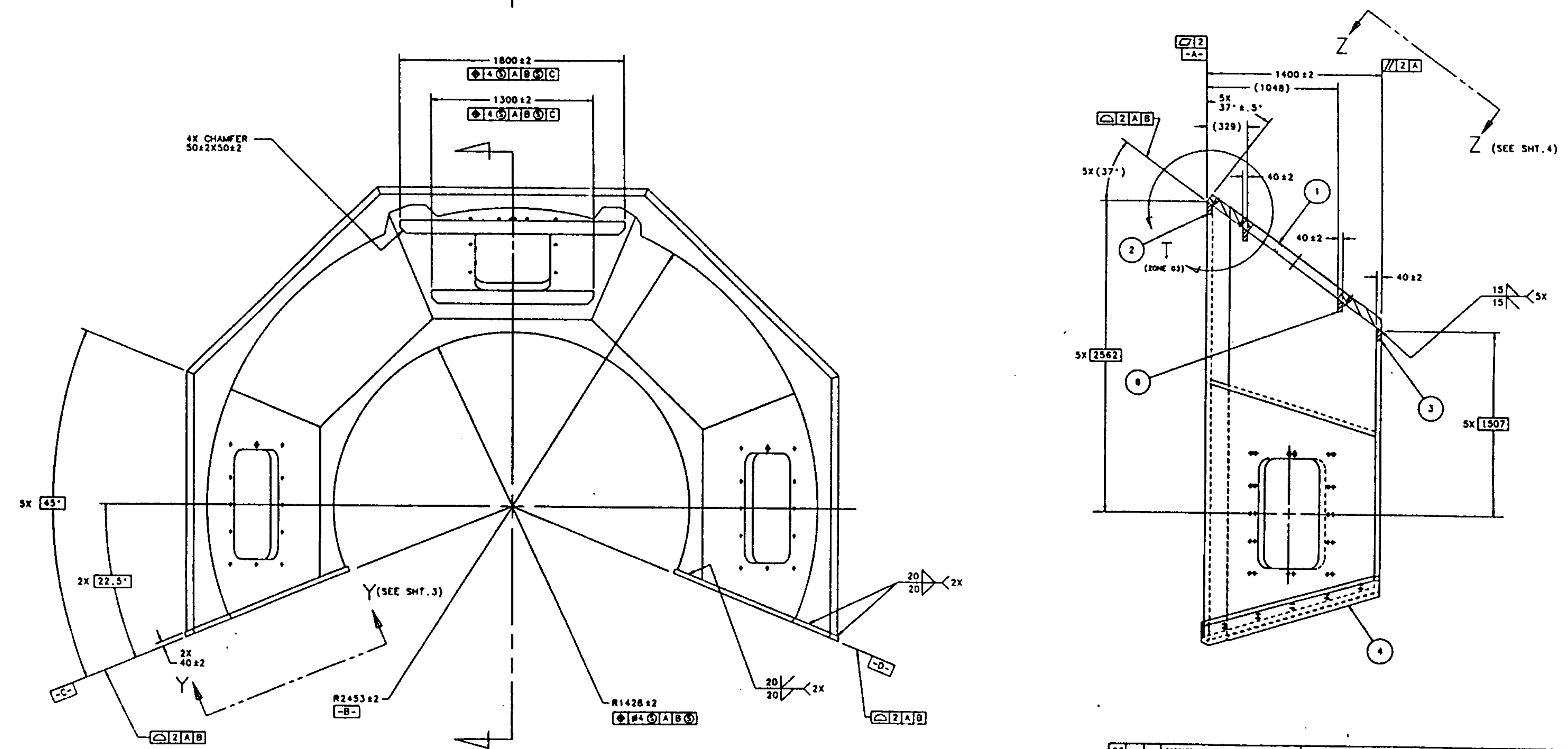
Muon teacup weldment







1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2/ALL MACHINED SURFACES.
5. BREAK SHARP EDGES, CHAM. OR R 1 TO 2MM
6. WELD SYMBOLS PER AWS 2.4, 1979.
7. WELDS PER ANSI/AWS D1.1, USE STNLS. STL. TYPE 308L ROD AT JOINTS NOTED.
8. ALL WELDS TO BE MAGNETIC PARTICLE TESTED
9. PRIME AND PAINT PER LLNL SPECIFICATIONS
10. DO NOT PRIME OR PAINT THIS SURFACE. (SEE VIEW X-X, SHT.2, AND SECTION R-R, SHT.4)



63			BOSSARD NO. BN 902 M24 OR EQUIV.	THREAD INSERT, STL., SELF TAPPING, M24 (ENSAT TYPE 302)		8
						7
1				STNLS. STEEL, TYPE 304L OR EQUIV.		6
1				STNLS. STEEL, TYPE 304L OR EQUIV.		5
2				STEEL, AISI 1006 OR EQUIV.		4
1				STNLS. STEEL, TYPE 304L OR EQUIV.		3
1				STNLS. STEEL, TYPE 304L OR EQUIV.		2
5				STEEL, AISI 1006 OR EQUIV.		1
NO REQD			PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

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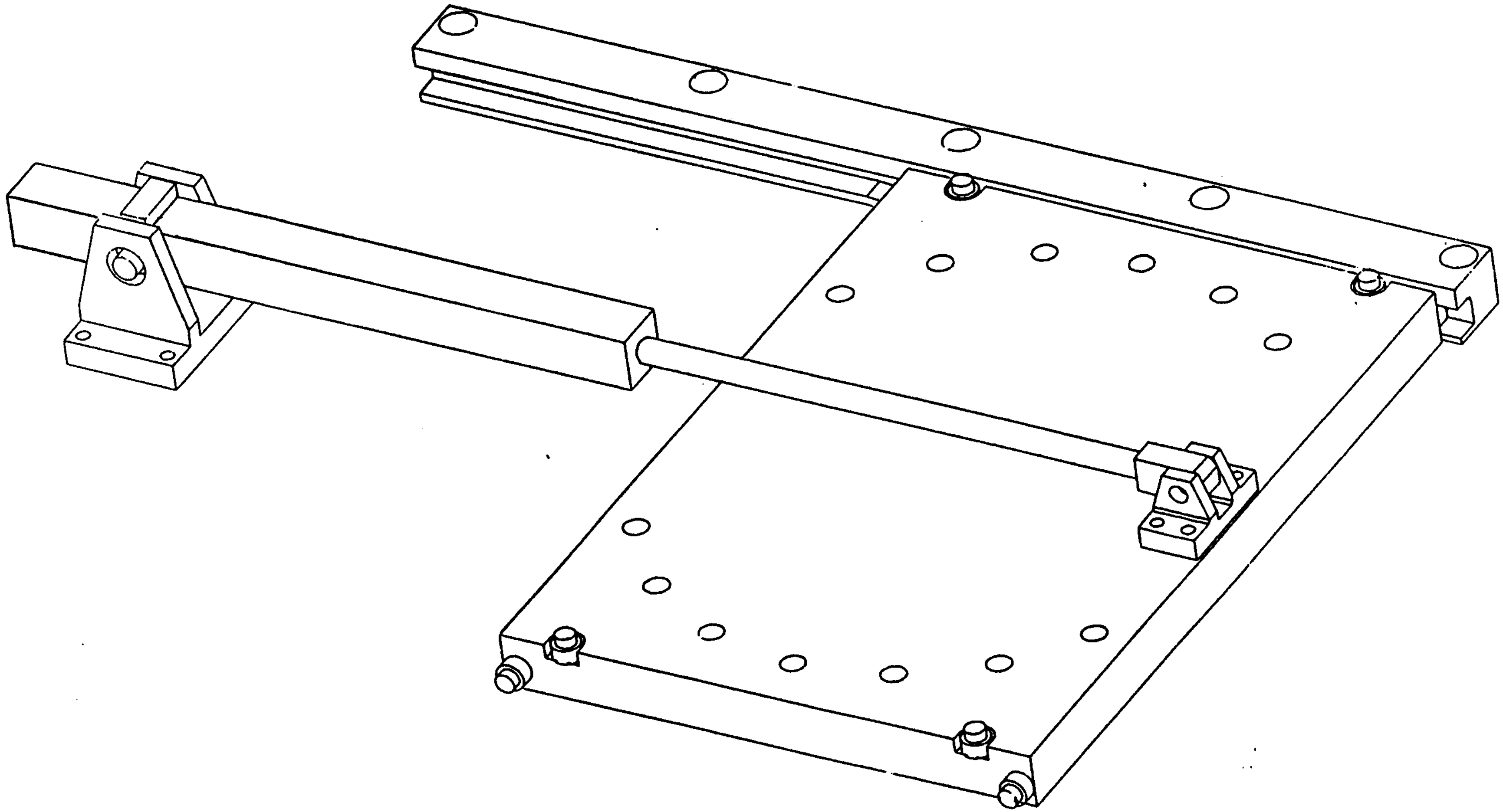
UNIVERSITY OF CALIFORNIA

MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUBASSY: PHENIX MUON PISTON MAGNET
DETAIL: TEACUP
93-101850
DRAWING NO: AAA93-104173-00
SCALE: NONE
SHEET 1 OF 4

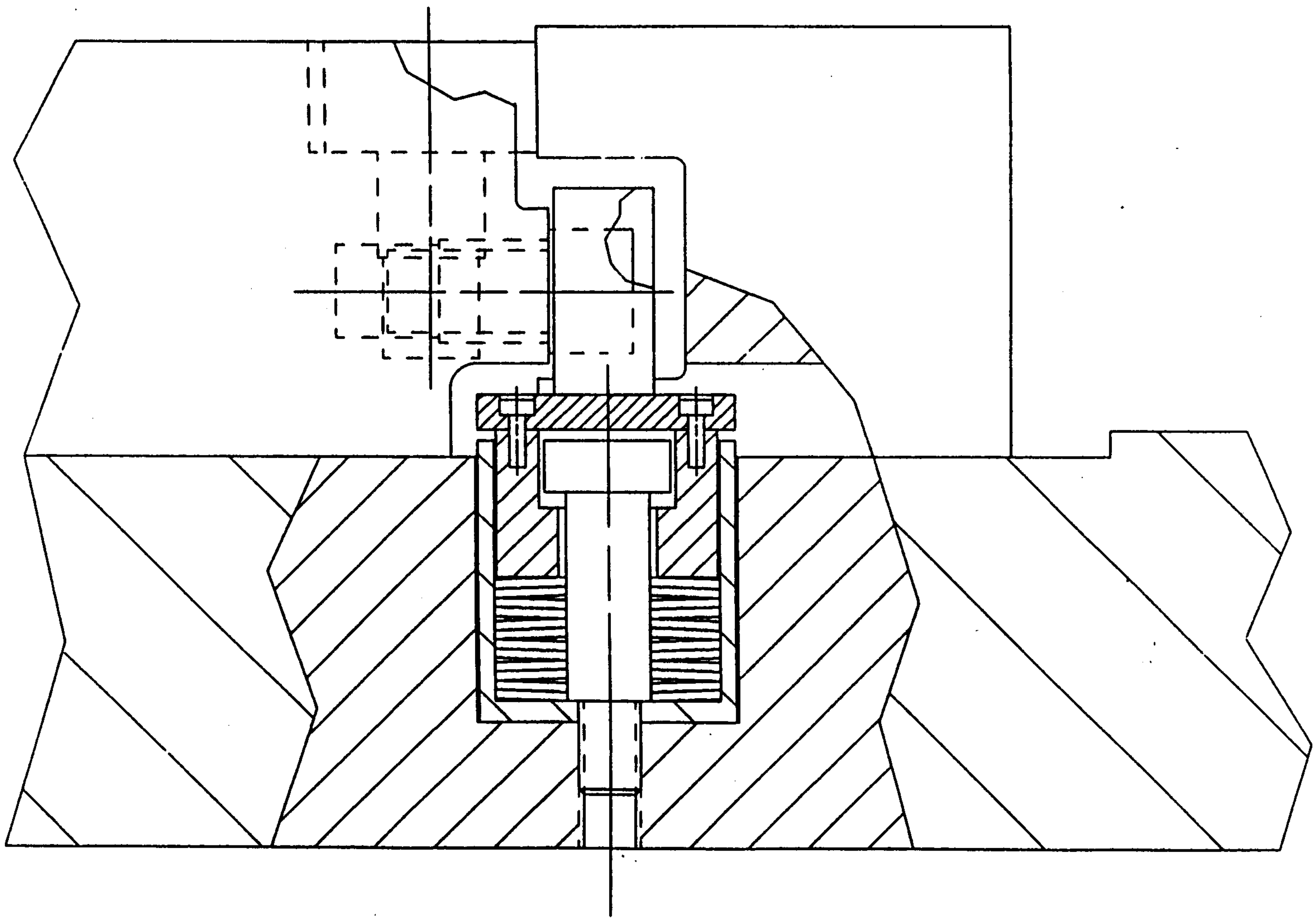
Cam roller guided door



JMB-12
4/30/93

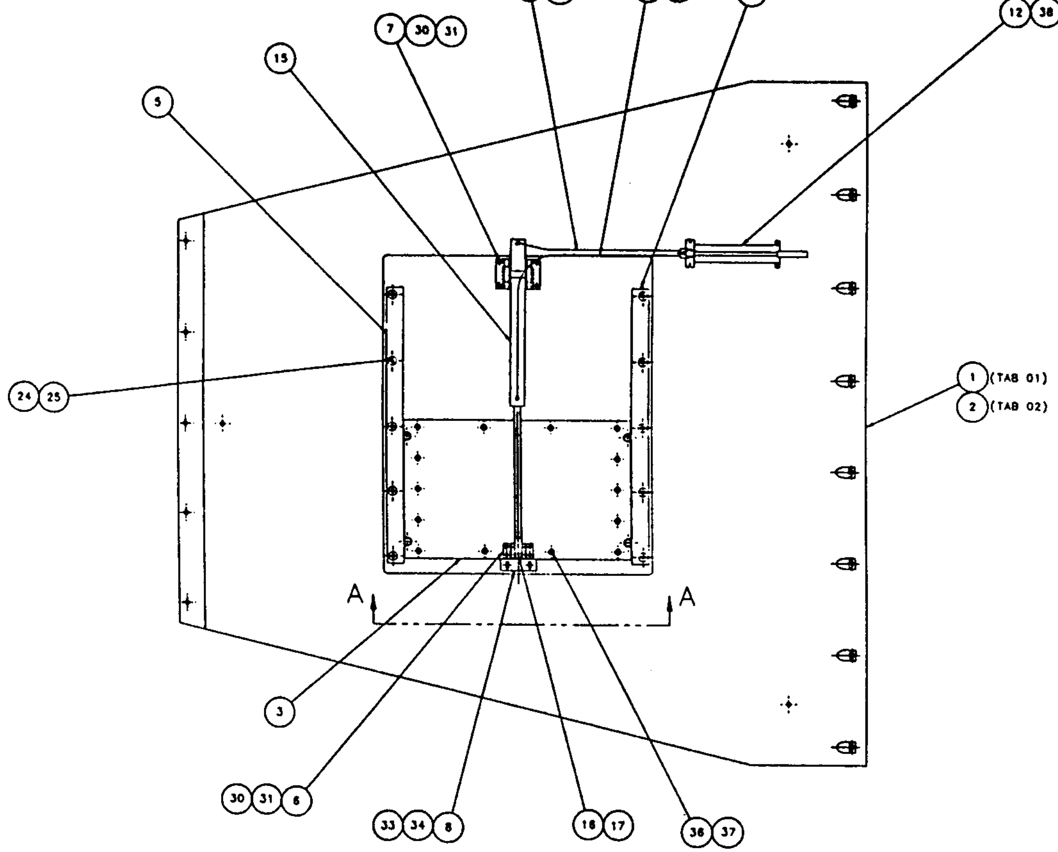
Cam roller guided door: compression detents

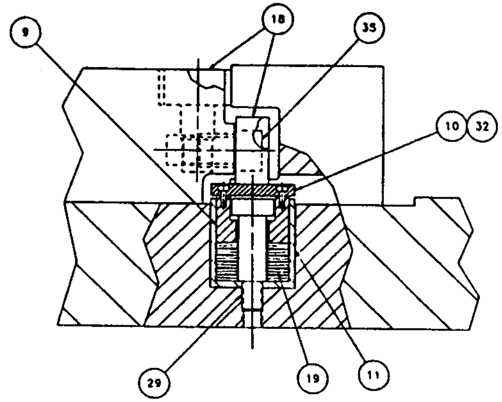
- Spring loaded plate allows rollers to sink below the track
- Magnetic contact between the door and lampshade is assured



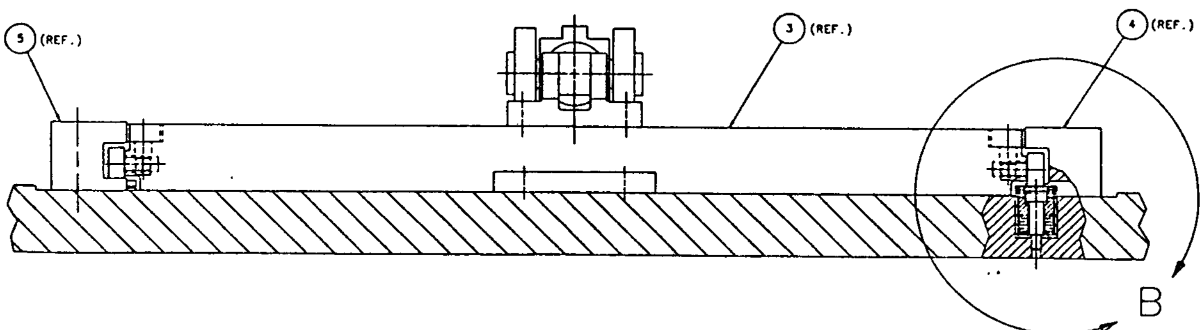
JMB
7/28/93

1. ALL DIMENSIONS ARE IN INCHES
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.





DETAIL B



SECTION A-A

TAB NO.	REMARKS
01	LAMPSHADE ASSY., UPPER (SHOWN)
02	LAMPSHADE ASSY., LOWER

TAB 01	TAB 02		PART / IDENT NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
4	4			FLAT WASHER,STL.,ZINC PLATE,M8	DIN125A	39
4	4			HEX. CAP SCREW,STL.,BLACK,M8X30	DIN933 8.8	38
14	14			FLAT WASHER,STL.,ZINC PLATE,M24	DIN125A	37
14	14			HEX. CAP SCREW,STL.,BLACK,M24X120	DIN933 8.8	36
4	4			SOCKET HEAD CAP SCREW,STL,BLACK,M16X25	DIN912 8.8	35
2	2			FLAT WASHER,STL.,ZINC PLATE,M16	DIN125A	34
2	2			HEX. CAP SCREW,STL.,BLACK,M16X55	DIN933 8.8	33
8	8			SOCKET HEAD CAP SCREW,STL.,BLACK,M3X10	DIN912 8.8	32
14	14			FLAT WASHER,STL.,ZINC PLATE,M12	DIN125A	31
24	24			HEX. CAP SCREW,STL,BLACK,M12X60	DIN933 8.8	30
4	4			SOC. HD. SHLDR. SCREW,STL.,BLACK,ø16XM12X40LG.	ISO7379 12.9	29
						28
						27
						26
						25
						24
1	1		IMPERIAL EASTMAN J4-MA06-06MCX06HJ-59	HOSE ASSY.,3/8"I.D.X59"LG. (3/8"MNPT-3/8"TUBE)	SAE 100R2 TYPE AT	23
1	1		IMPERIAL EASTMAN J4-MA06-06MCX06HJ-32	HOSE ASSY.,3/8"I.D.X32"LG. (3/8"MNPT-3/8"TUBE)	SAE 100R2 TYPE AT	22
						21
2	2		IMPERIAL EASTMAN 849-FS-06X08	37°FLARED 90°ELBOW,STL,3/8"O.D.TUBEX1/2"MNPT		20
48	48		BOSSARD NO. BN806	DISC SPRING ø40 O.D.Xø16.3 I.D.X1.75 THK.		19
8	8		McGILL NO. MCF-40-SXB	CAMROL BEARING ø40 X 20 WIDE		18
1	1		WABCO NO. J800019	PIN, ROD EYE		17
1	1		WABCO NO. J800011	FEMALE ROD EYE		16
1	1		WABCO NO. MT4-HH-C	CYLINDER ASSY.,2"BOREX30"STROKE,13/8"øROD 1-14 MALE THRD.		15
						14
						13
1	1		93-104160	PUMP, HYDRAULIC, REWORK		12
4	4		93-104161	CUP		11
4	4		93-104162	COVER PLATE		10
4	4		93-101860	PLUNGER		9
1	1		93-101867	BRACKET, DOOR STOP		8
2	2		93-101866	BRACKET NO.2, CYL. MTG.		7
1	1		93-101865	BRACKET NO.1, CYL. MTG.		6
1	1		93-101894 TAB 02	RAIL, R.H.		5
1	1		93-101894 TAB 01	RAIL, L.H.		4
1	1		93-101889	DOOR		3
—	1		93-101893	LAMPSHADE PANEL NO.4		2
1	—		93-101888	LAMPSHADE PANEL NO.1		1
NO REQD			PART / IDENT NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

ONE DOOR REMOVED

DWN R.HOLMES 6/17/93
CHK
APVD
DATE

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

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RELATIVISTIC HEAVY ION COLLIDER (RHIC)

PHENIX MUON PISTON MAGNET

LAMPSHADE PANEL ASSY.

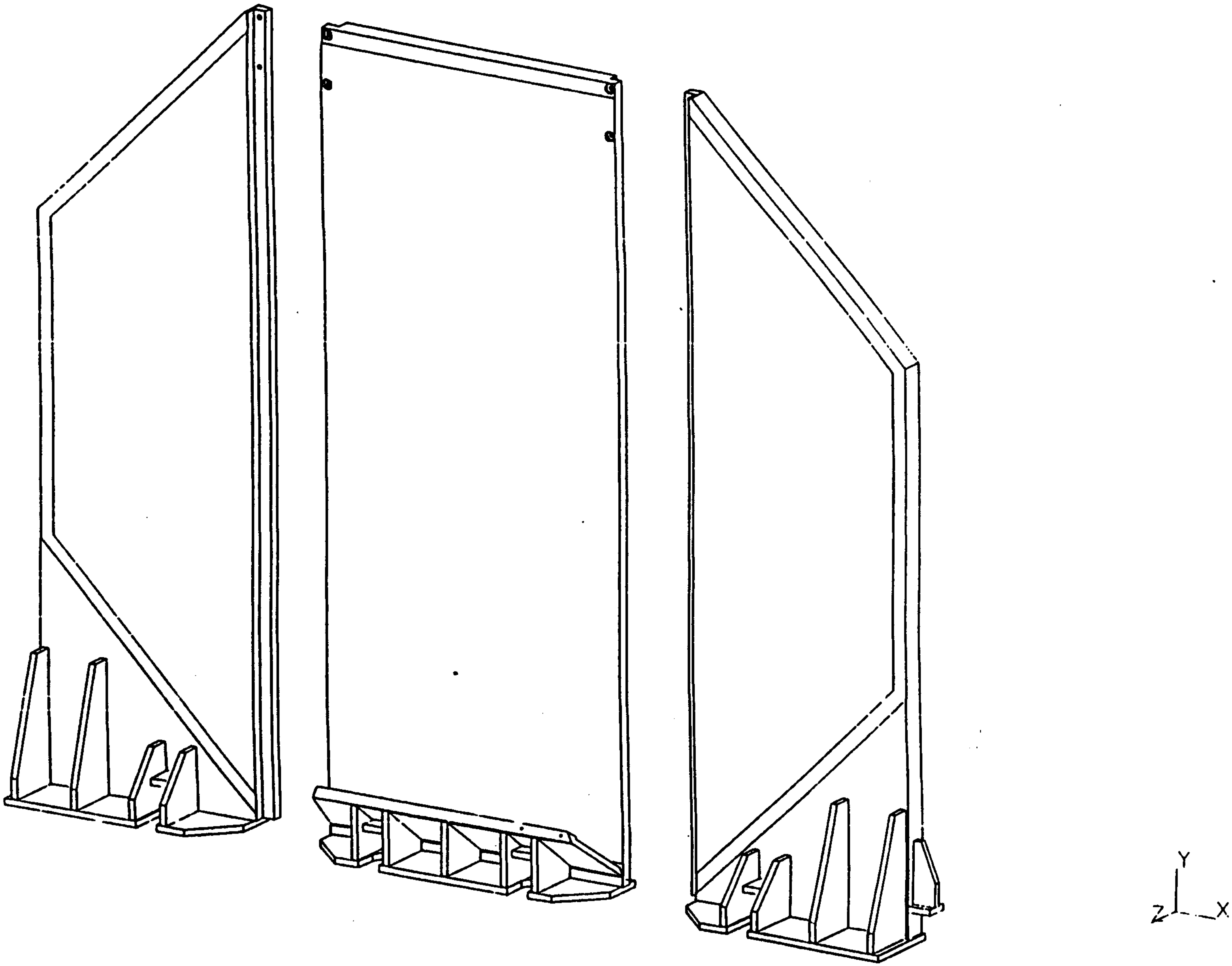
93-101959

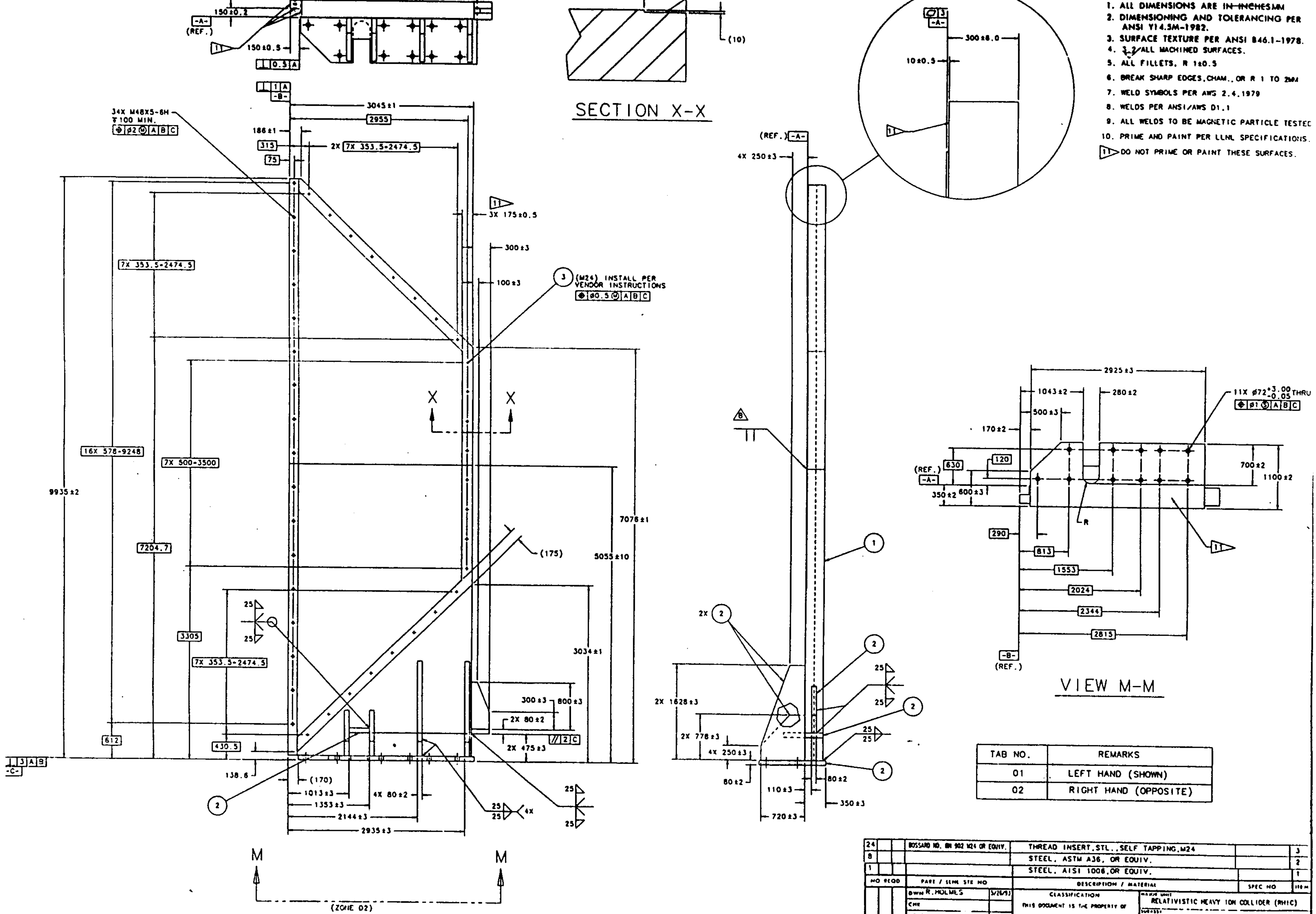
DRAWING NO AAA93-101892 0A

SCALE

SHEET 1 OF 1

Back plate design





1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2/ ALL MACHINED SURFACES.
5. ALL FILLETS, R 1±0.5
6. BREAK SHARP EDGES, CHAM., OR R 1 TO 2MM
7. WELD SYMBOLS PER AWS 2.4,1979
8. WELDS PER ANSI/AWS D1.1
9. ALL WELDS TO BE MAGNETIC PARTICLE TESTED
10. PRIME AND PAINT PER LLNL SPECIFICATIONS.

11: DO NOT PRIME OR PAINT THESE SURFACES.

TAB NO.	REMARKS
01	LEFT HAND (SHOWN)
02	RIGHT HAND (OPPOSITE)

NO REQD	PART / IDEN STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
24	BOSSARD NO. BN 902 M24 OR EQUIV.	THREAD INSERT, STL., SELF TAPPING, M24		3
8		STEEL, ASTM A36, OR EQUIV.		2
1		STEEL, AISI 1006, OR EQUIV.		1

B	WELD JOINT ADDED	
A	REVISED	

DWN R. HOLMES 3/26/93

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RELATIVISTIC HEAVY ION COLLIDER (RHIC)

PHENIX MUON PISTON MAGNET

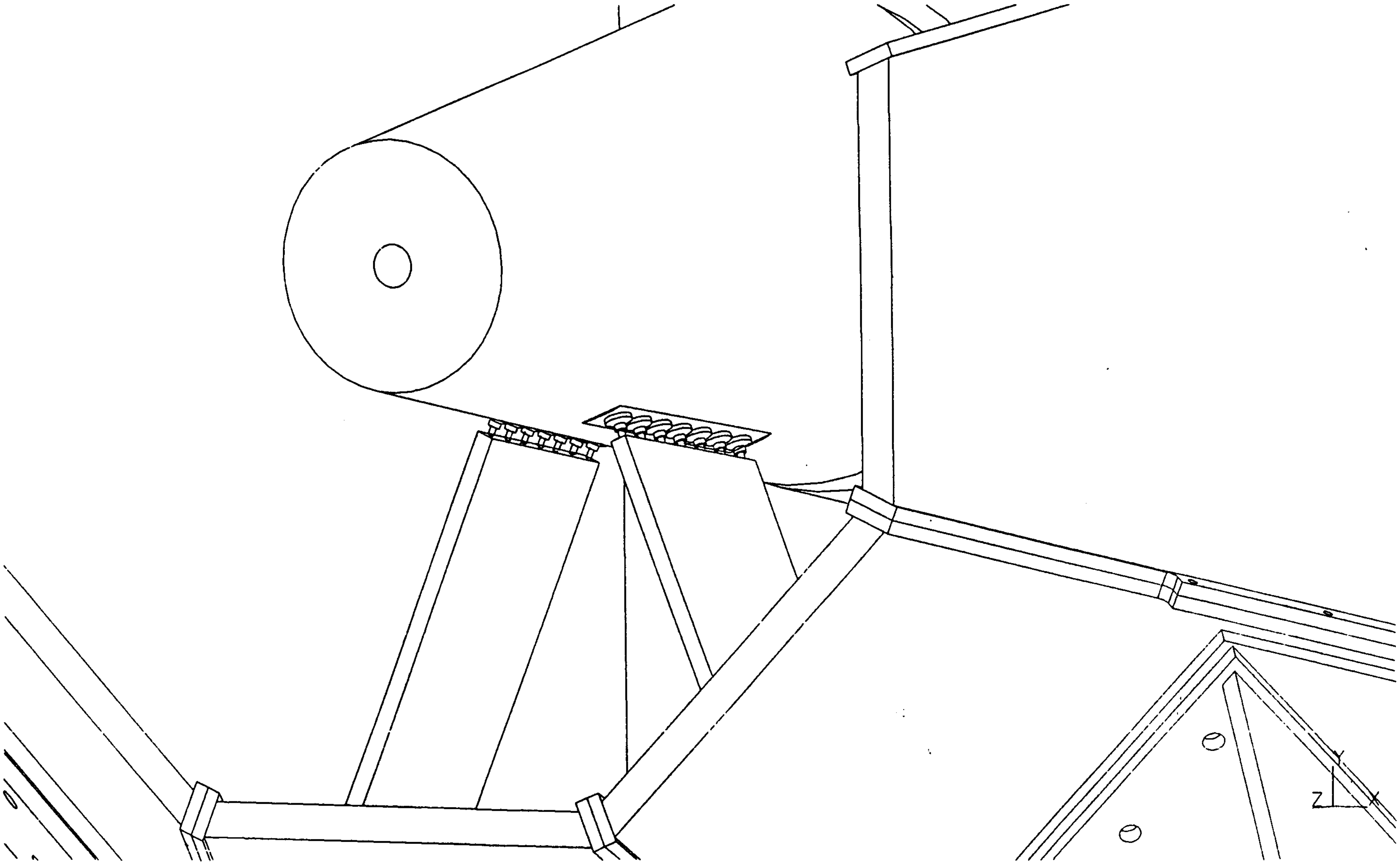
BACKPLATE, SIDE

DRAWING NO AAA93-101886-0B

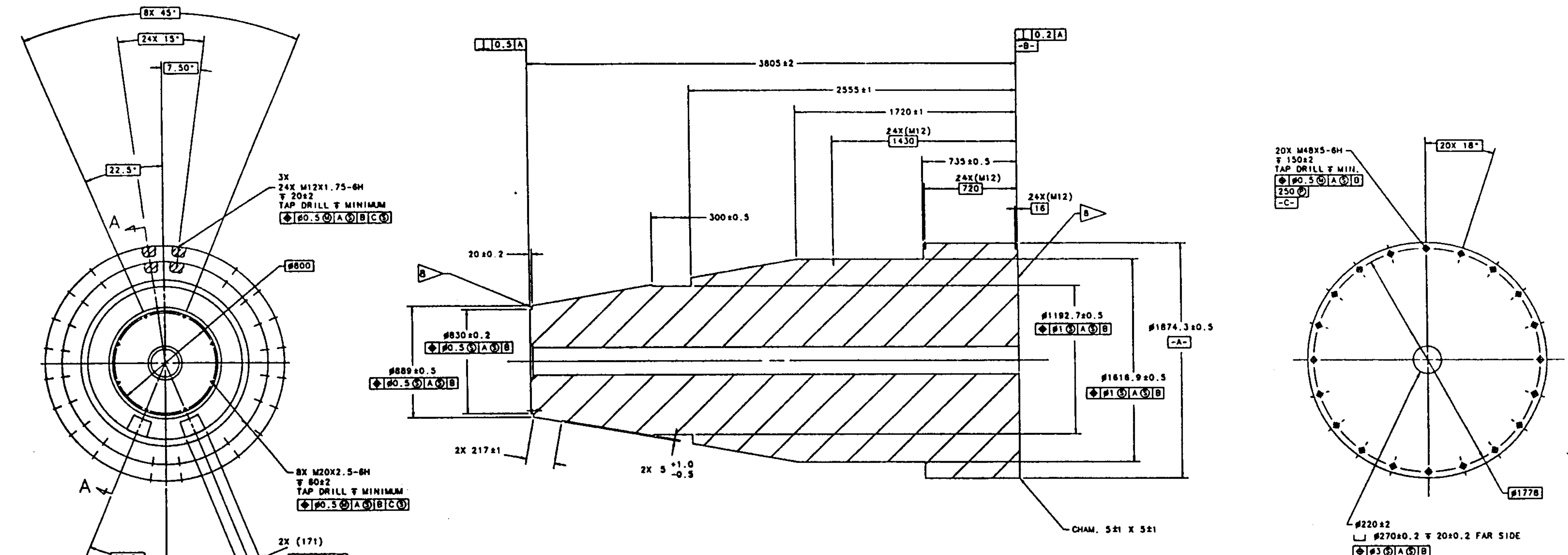
SHEET 1 OF 1

Stabilizer fin design

- 50 mm thick 310 stainless steel
- 0.6 m long in Z direction
- Two fins required, both removable
- Piston is self supporting without fins (sags 3mm)


Y
Z
X

2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 ALL MACHINED SURFACES.
5. ALL FILLETS, R 1±0.5
6. BREAK SHARP EDGES, CHAM. OR R 1 TO 2 MM
7. PRIME AND PAINT PER LLNL SPECIFICATIONS
8. DO NOT PRIME OR PAINT THESE SURFACES.



SECTION A-A

D						LENGTH SHORTENED 45MM	
C						REVISED	
B						REVISED	
A						REVISED	
LTR				APVD	DATE	CHANGE	

		STEEL, AISI 1006 OR EQUIV.	
NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO

DWN R. HOLMES 1/21/93
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RELATIVISTIC HEAVY ION COLLIDER (RHIC)
PHENIX MUON PISTON MAGNET
PISTON CORE
93-101858
DRAWING NO AAA93-101860-0
SCALE NONE SHEET 1 OF 1

Muon Magnet finite element analysis

Modal, stress, and displacement analyses

Four cases, three complete

1) Gravity

2) Thermal expansion of muon piston

3) Magnetic forces

4) Ambient vibration (in progress)

Muon Magnet maximum displacements

units: mm

			GRAVITY	THERMAL	MAGNETIC
Maximum (magnitude)			0.75	0.33	0.10
Teacup	Station 1	Max. X	0.15	0.03	0.01
		Max. Y	0.37	0.02	0.02
		Max. Z	0.30	0.04	0.02
Teacup	Station 2	Max. X	0.13	0.03	0.01
		Max. Y	0.29	0.05	0.01
		Max. Z	0.27	0.06	0.02
Vertical Plate	Station 3	Max. X	0.00	0.11	0.00
		Max. Y	0.03	0.20	0.00
		Max. Z	0.42	0.23	0.03

COLOR
6-10

Muon Magnet displacements

angles from top: 22.5-67.5 deg

units: mm

STATION	AXIS	22.5 deg Gravity	22.5 Thermal	22.5 Magnet	22.5 Total	67.5 Gravity	67.5 Thermal	67.5 Magnet	67.5 Total
1 Front of teacup	Mag	0.38	0.05	0.03	0.46	0.38	0.03	0.02	0.43
	X	0.05	0.00	0.00	0.05	0.15	-0.03	-0.01	0.11
	Y	-0.37	0.02	0.02	-0.33	-0.20	0.00	0.01	-0.19
	Z	0.18	0.04	-0.01	0.21	0.30	0.02	-0.02	0.30
2 Back of teacup	Mag	0.38	0.08	0.02	0.48	0.38	0.05	0.02	0.45
	X	0.02	0.00	0.00	0.02	0.13	-0.03	-0.01	0.09
	Y	-0.29	0.05	0.01	-0.23	-0.15	0.02	0.01	-0.12
	Z	0.24	0.06	-0.02	0.28	0.27	0.02	-0.02	0.27
3 Front of plate	Mag	0.42	0.33	0.03	0.78	0.23	0.24	0.02	0.49
	X	0.00	0.04	0.00	0.04	0.00	0.11	0.00	0.11
	Y	-0.03	0.20	0.00	0.17	-0.02	0.13	0.00	0.11
	Z	0.42	0.23	-0.03	0.62	0.23	0.18	-0.02	0.39

Muon Magnet lampshade displacements

angles from top: 112.5-157.5 deg

units: mm

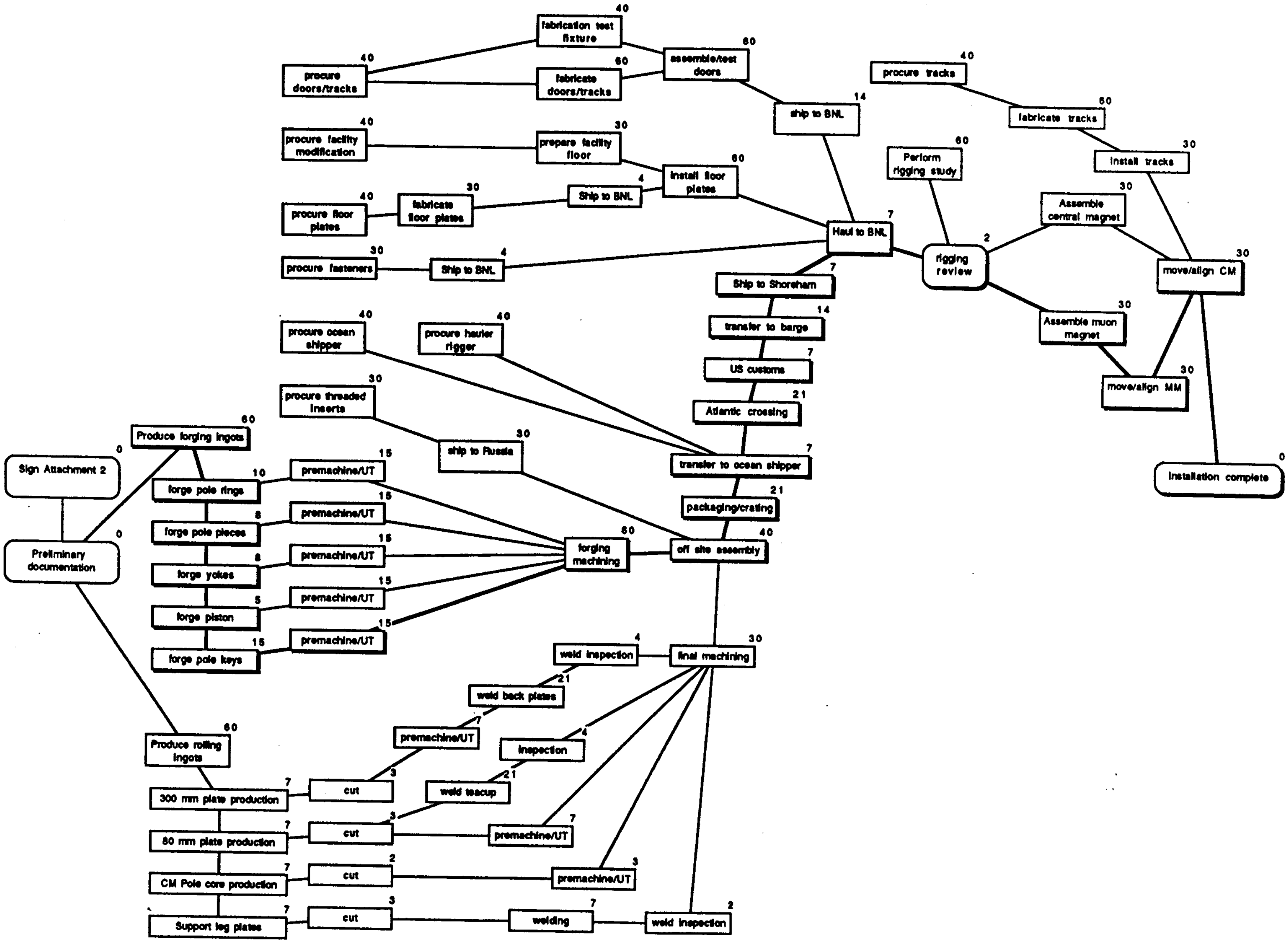
STATION	AXIS	112.5 Gravity	112.5 Thermal	112.5 Magnet	112.5 Total	157.5 Gravity	157.5 Thermal	157.5 Magnet	157.5 Total
1 Front of teacup	Mag	0.25	0.02	0.02	0.29	0.13	0.02	0.01	0.16
	X	0.07	-0.02	0.00	0.05	0.00	0.00	0.00	0.00
	Y	-0.16	0.00	0.01	-0.15	-0.12	0.00	0.01	-0.11
	Z	0.18	0.00	-0.01	0.17	0.09	0.02	-0.01	0.10
2 Back of teacup	Mag	0.17	0.03	0.01	0.21	0.13	0.01	0.01	0.15
	X	0.02	-0.02	0.00	0.00	-0.03	0.00	0.00	-0.03
	Y	-0.08	0.00	0.01	-0.07	-0.12	0.00	0.01	-0.11
	Z	0.12	0.00	-0.01	0.11	0.06	0.00	0.00	0.06
3 Front of plate	Mag	0.07	0.11	0.01	0.19	0.00	0.00	0.00	0.00
	X	0.00	0.08	0.00	0.08	0.00	0.00	0.00	0.00
	Y	-0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	Z	0.07	0.07	-0.01	0.13	0.00	0.00	0.00	0.00

Muon Magnet FEA piston displacements

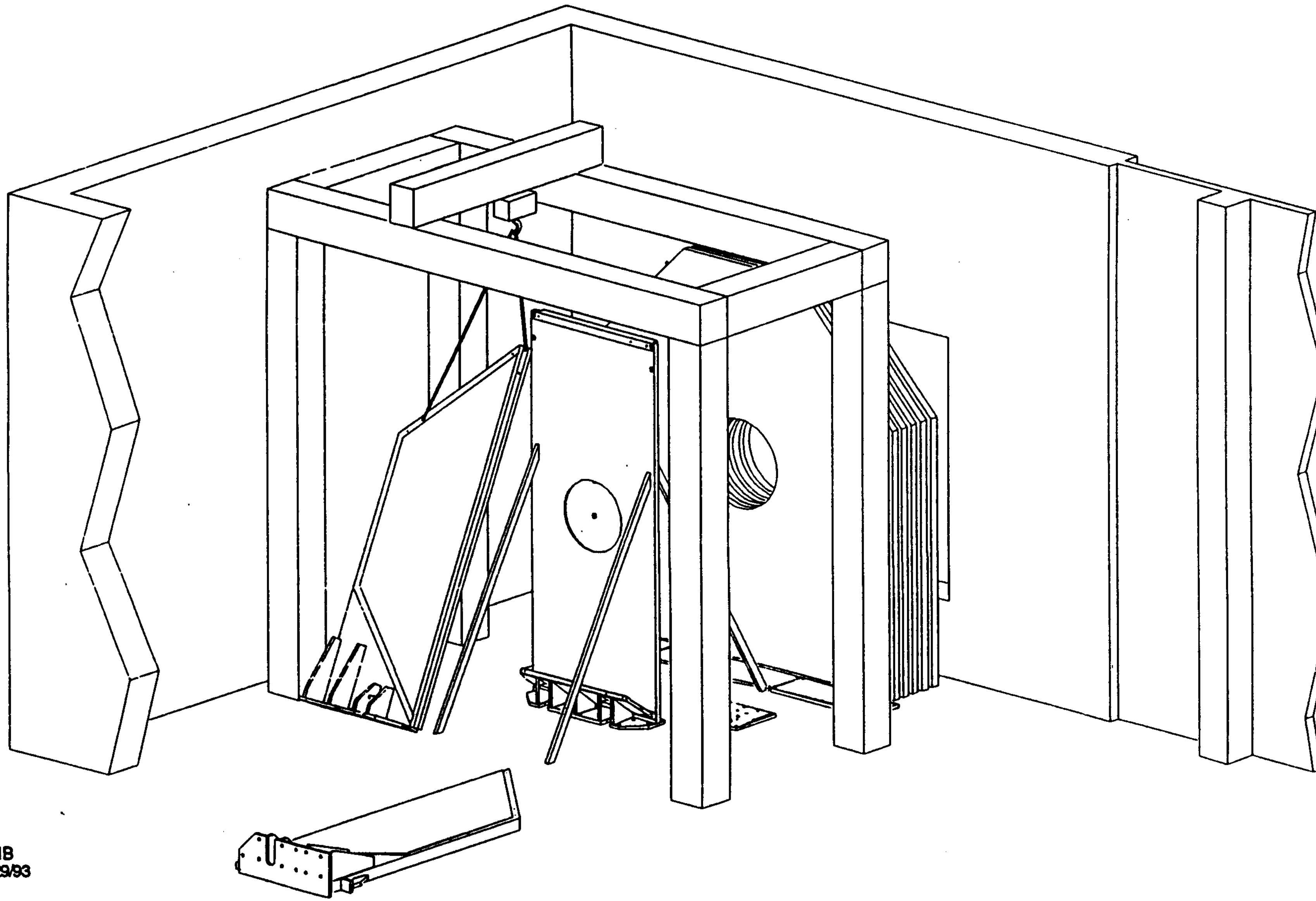
units: mm

STATION	AXIS	Center Gravity	Center Thermal	Center Magnet	Center Total
1 Front of teacup	Mag	n/a	n/a	n/a	n/a
	X	n/a	n/a	n/a	n/a
	Y	n/a	n/a	n/a	n/a
	Z	n/a	n/a	n/a	n/a
2 Back of teacup	Mag	0.22	0.27	0.01	0.50
	X	0.00	0.05	0.00	0.05
	Y	-0.14	0.16	0.00	0.02
	Z	0.17	0.21	-0.01	0.37
3 Front of plate	Mag	0.14	0.12	0.01	0.27
	X	0.00	0.00	0.00	0.00
	Y	-0.02	0.11	0.00	0.09
	Z	0.14	-0.02	-0.01	0.11

Simplified steel fabrication sequence



Hall Assembly: Muon back plate erection



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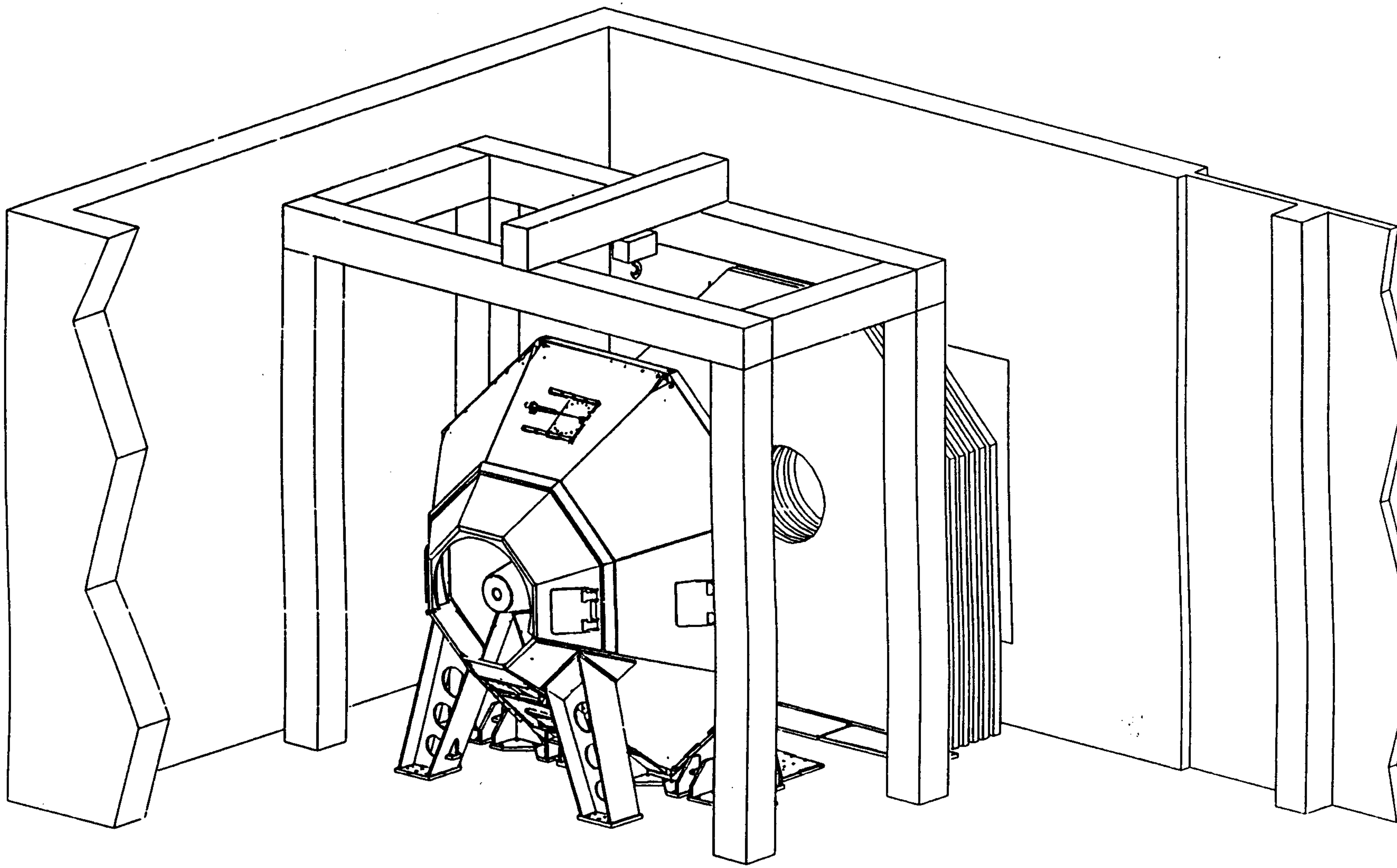
7/29/93

Hall Assembly: Complete muon system



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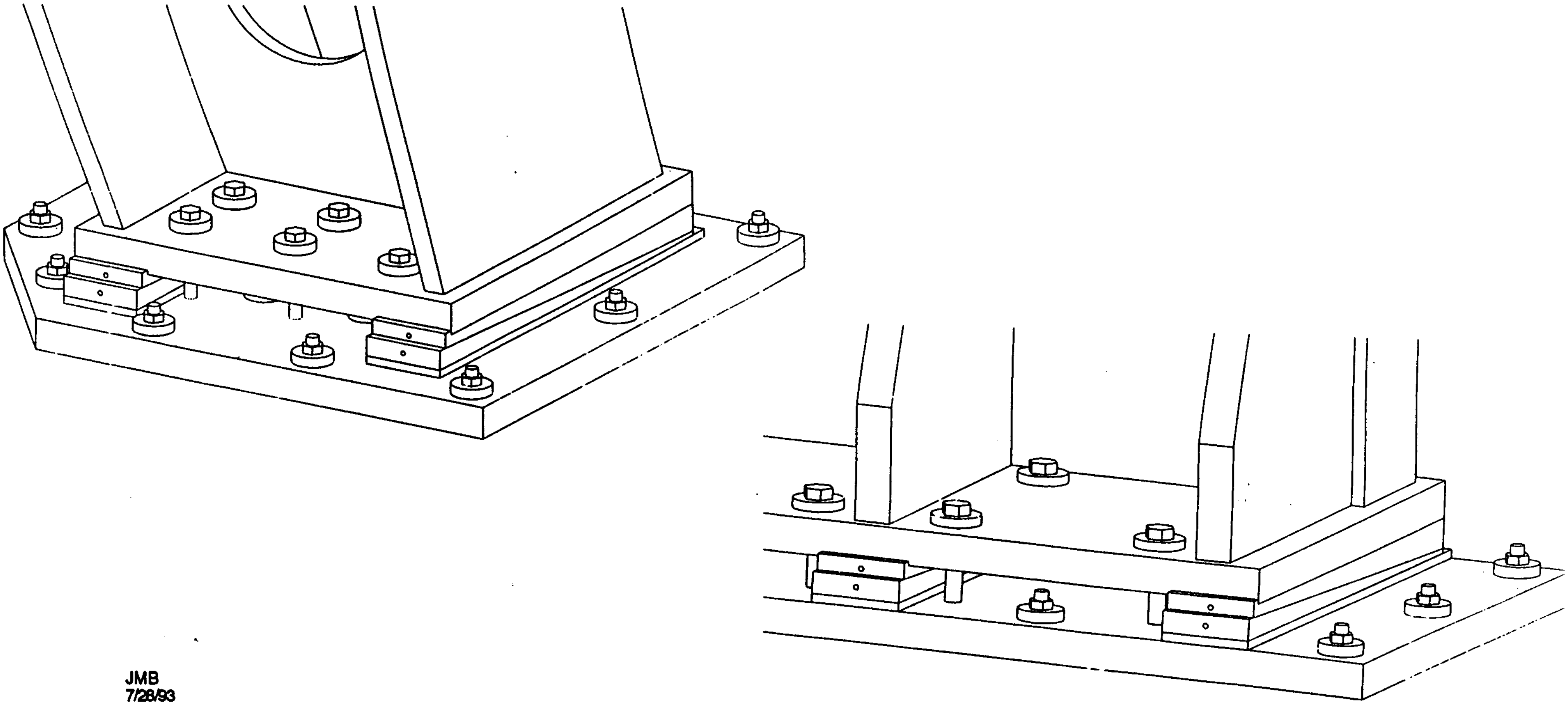
Muon system floor anchorage

- Foundation plates anchored and grouted to floor
- Tapped holes provided to mount detector on studs
- Detector shimmed to foundation plates with wedges

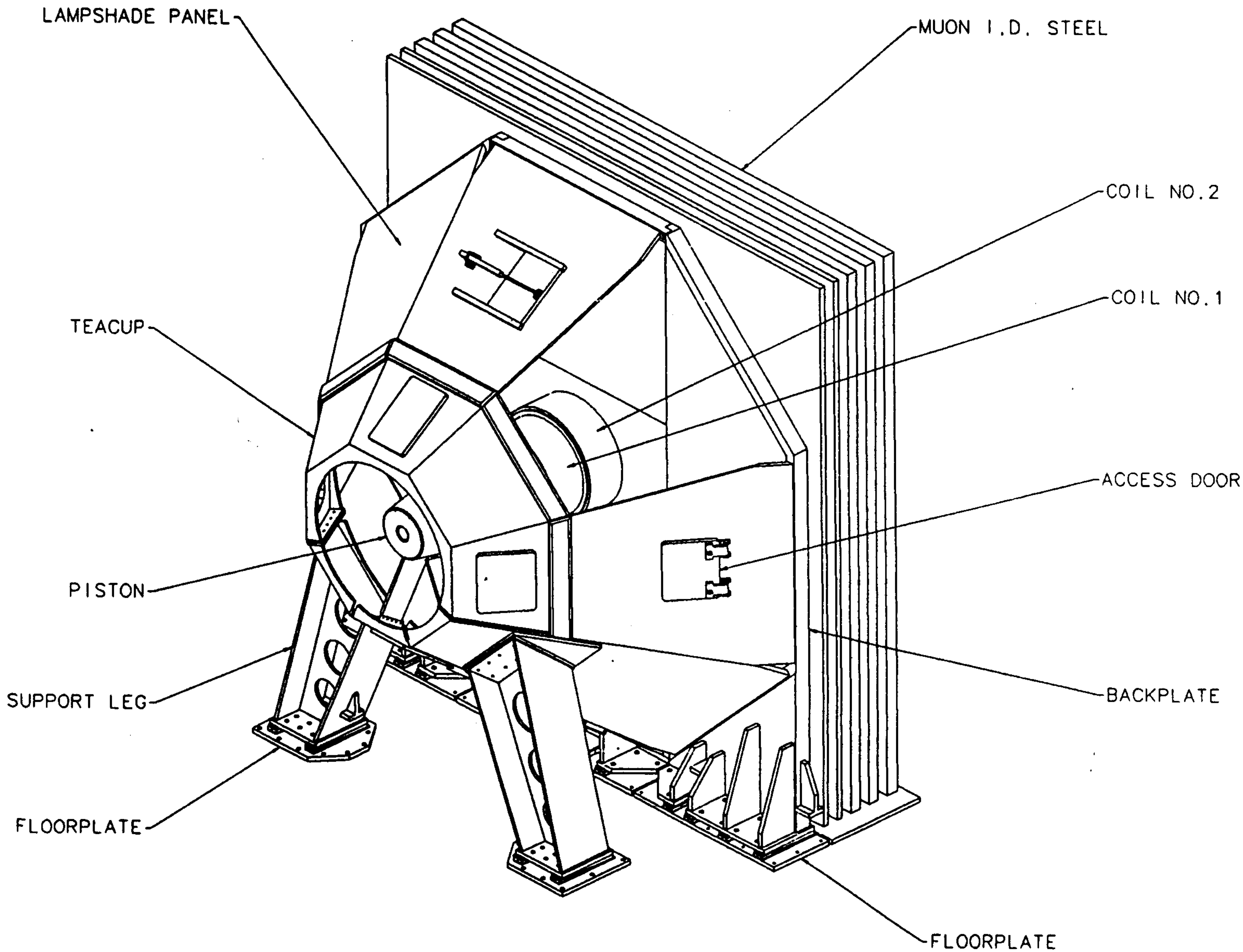


JMB
7/28/93

Muon ID changes since CDR

- Muon absorber is now steel instead of concrete
- Muon absorber layers are now 10, 10, 20, 20, 20 cm thick
- Space allowed for muon ID panels is 20 cm between absorber plates
- Non certified steel will be used to reduce cost. No guarantees on impurity content or alloying elements

PHENIX Muon Magnet Assembly - Isometric



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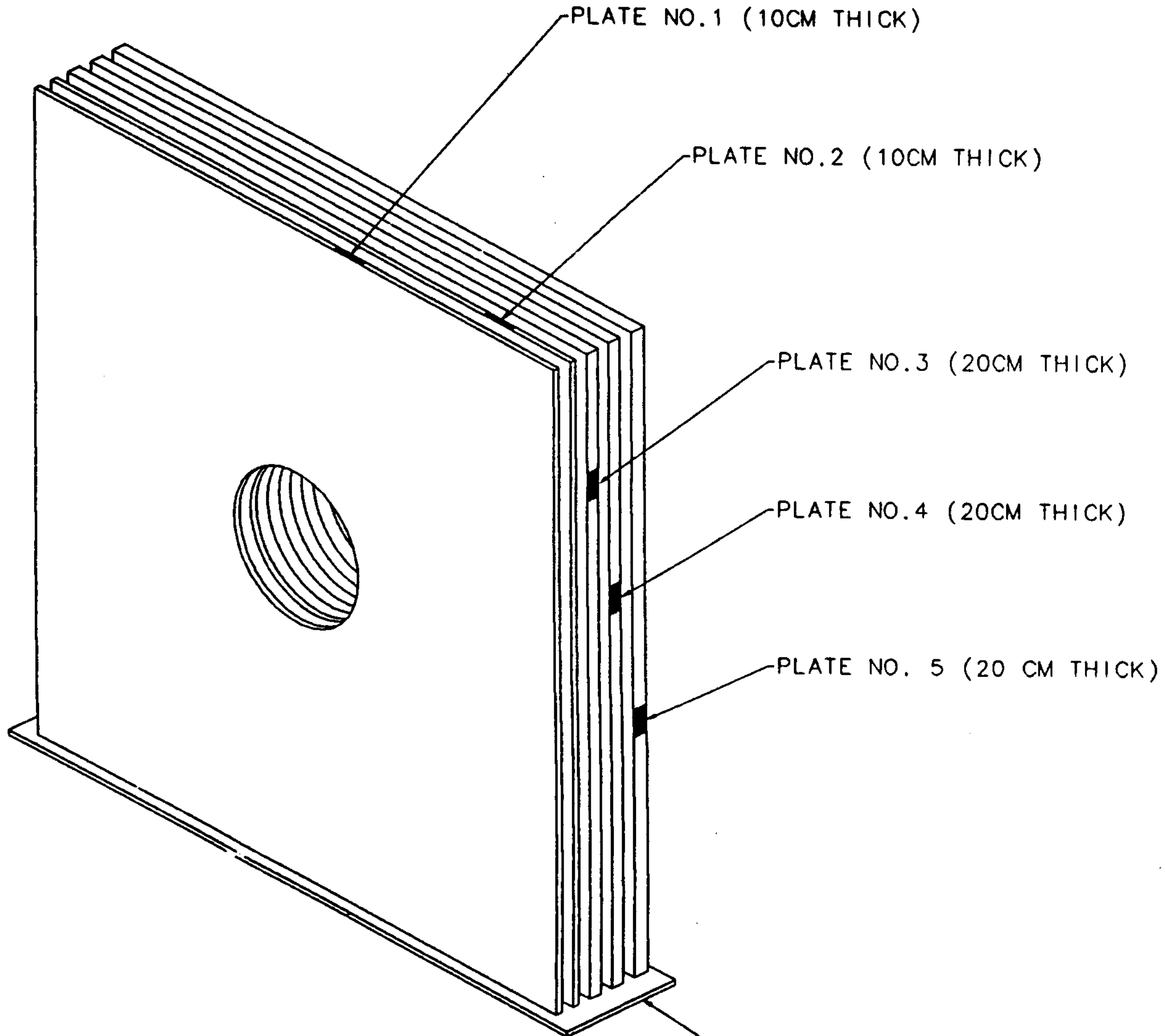
PHENIX Mu ID Steel Assembly - Isometric



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Procurement Plan

- The plan has been optimized to:

  Exploit opportunities for cost savings

  Minimize technical risk

- Five categories of construction activities:

1) Russia Hardware
2) U.S. Hardware
3) U.S. labor in the U.S.
4) U.S. labor in Russia
5) Russian labor in Russia

Procurement Plan: Russian Hardware

Petersburg Nuclear Physics Institute (PNPI)
(principal scientific and financial liaison)

D. V. Efremov Scientific Research Institute
(responsible for fabrication)

Muon piston magnet core (1)
Muon detector back plates (3)
Muon lampshade plates (8)
Muon piston support fins (2)
Muon system support legs (2)
Muon teacup weldment (1)

Central detector return yokes (2)
Central detector pole rings (2)
Central detector pole keys (4)
Central detector pole pieces (2)
Central detector pole cores (2)
Central detector outrigger weldments (4)

Procurement Plan: U.S. Hardware

Some items should be procured domestically, for various reasons:

Item	Reason
Alloy steel cap screws, nuts, and washers	Safety risk
Wide flange beams and structural angles	English units
Concrete anchor studs	Safety risk
Weld studs	English units
Muon Doors and tracks	Local testing
Door operating cylinders	Spare parts
Door hydraulic hand pumps	Spare parts
Door guide rollers	Quality
Door belleville washers	Quality
Door pillow blocks	Quality/Safety
Transporter rollers (300 ton)	Safety risk
Lifting jacks	Safety risk
Other rigging equipment (shackles, wire rope, pulley blocks etc)	Safety risk

U.S. labor in the U.S.

- Fabricate muon doors, tracks, test fixture (US shop)
- Operate muon doors on test stand (LLNL)
- Fabricate Central magnet support frame (US shop)
- Prepare PHENIX high bay for magnet installation (BNL/LLNL)
- Off load major components from trans ocean carrier (Contractor)
- Ship components by barge from port of entry to Shoreham Nuclear Facility (Contractor)
- Off load major components at Shoreham (Contractor)
- Haul major components to BNL (Contractor)
- Erect central magnet and Muon Magnet (Contractor)
- Perform final alignment of magnet (LLNL/BNL/Contractor)

U.S. labor in Russia

- Witness steel production chemical analysis
- Witness mechanical, magnetic, and chemical coupon testing
- Audit welding QA records
- Witness ultrasonic inspection
- Perform dimensional inspection on parts
- Perform weld inspection
- Witness assembly
- Perform dimensional inspection on assembly
- Witness packaging for shipment

Russian labor in Russia

Items included on steel purchase order:

- Steel production
- Analysis and material testing
- Preparation of test reports (CMTR's, UT, etc)
- Maintenance of PHENIX fabrication quality assurance records
- Fabrication and machining
- In house ultrasonic testing, dimensional and weld
- Assembly and off site rigging
- Packaging for shipment
- Transfer and loading to ocean carrier

Accountability of Russian procurements

- LLNL fabrication specification (Attachment 2)
- Specific milestone hold points on the construction schedule included in Attachment 2
- Construction progress payments are tied directly to completion of each milestone
- LLNL will provide coordinator/inspector/quality assurance personnel to perform these services
- Approximately one year of construction support
- Several trips by various specialists for QA inspections

Shoreham facility option

- Consulting with Long Island Lighting Company (LILCO) to contract use of their dock facility at the Shoreham nuclear power plant

- Talking with rigger who has experience shipping to the Shoreham facility (Lockwood Brothers, Virginia)

- Close proximity to BNL makes this an ideal option

- Approximate shipping time of February is good because ground is likely to be frozen.

PHENIX Mag Sys. - Cost Estimate Overview

- Basis of Estimates (BOE's) were generated for all level 3 WBS elements of 5.1 Magnet Subsystem.
  - estimate is "bottoms-up" type.
  - vendor estimates were used wherever prudent to do so.

- A total of 6 BOE's were developed for:
  - 5.1.1 CM Outer Coil
  - 5.1.2 CM Inner Coil
  - 5.1.3 CM Steel
  - 5.1.4 MM Coil
  - 5.1.5 MM Steel
  - 5.1.6 Mu ID Steel

- BOE's include technical description of element and cost estimates for:
  - EDIA
  - Prototype
  - Fabrication
  - Assembly/Installation
  - Testing

PHENIX Mag Sys. - Cost Estimate Overview

- Contingency analysis using Risk Factors were performed for all level 3 WBS elements.
- Magnet Subsystem estimate costed in FY '93 $$$'s.
- BOE information was transferred into MS Project format for inclusion into the overall PHENIX management database.

PHENIX Magnet Subsystem - Cost Summary

WBS Category	Element	Baseline Cost ($k)
5.1	Magnet Subsystem	6182
5.1.1 + 5.1.2 + 5.1.3	CM Outer & Inner Coil + Steel	3055
5.1.4 + 5.1.5	MM Coil + Steel	2134
5.1.6	Mu ID Steel	993

PHENIX Magnet Subsystem - CM Cost Summary

WBS Category	Element	Baseline Cost ($k)
5.1	Central Magnet	3055
5.1.1	CM Outer Coil	926
5.1.1.1	EDIA	203
5.1.1.2	Prototype	0
5.1.1.3	Fabrication	625
5.1.1.4	Assy/Installation	28
5.1.1.5	Testing	70
5.1.2	CM InnerCoil	470
5.1.2.1	EDIA	111
5.1.2.2	Prototype	0
5.1.2.3	Fabrication	325
5.1.2.4	Assy/Installation	14
5.1.2.5	Testing	20
5.1.3	CM Steel	1659
5.1.3.1	EDIA	348
5.1.3.2	Prototype	0
5.1.3.3	Fabrication	1110
5.1.3.4	Assy/Installation	201
5.1.3.5	Testing	0

PHENIX Magnet Subsystem - MM Cost Summary

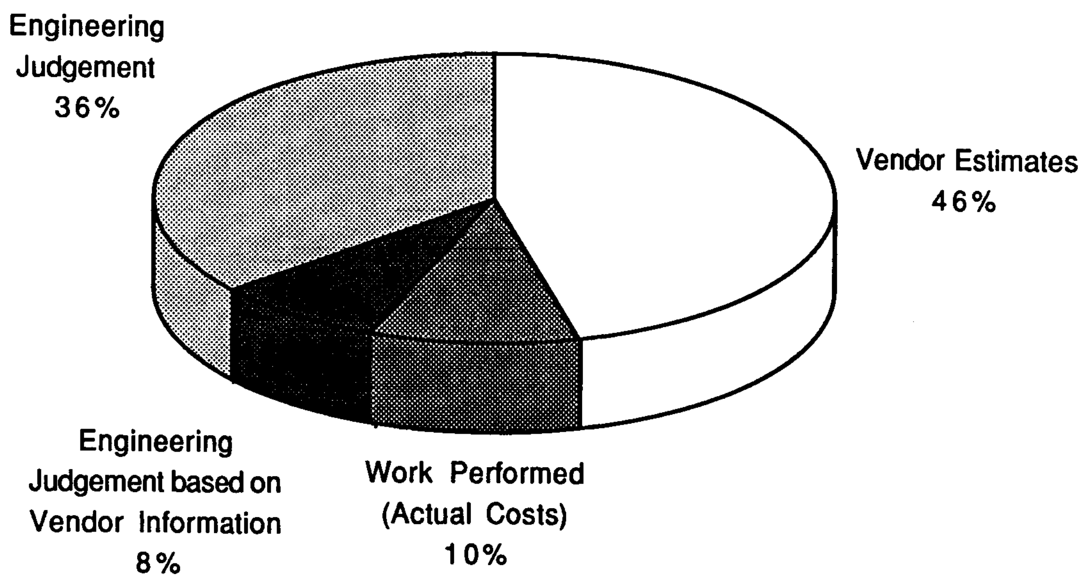
WBS Category	Element	Baseline Cost ($k)
5.1	Muon Magnet	2134
5.1.4	Muon Coil	474
5.1.4.1	EDIA	149
5.1.4.2	Prototype	10
5.1.4.3	Fabrication	225
5.1.4.4	Assy/Installation	20
5.1.4.5	Testing	70
5.1.5	Muon Steel	1660
5.1.5.1	EDIA	360
5.1.5.2	Prototype	0
5.1.5.3	Fabrication	1116
5.1.5.4	Assy/Installation	184
5.1.5.5	Testing	0

PHENIX Mu ID Subsystem - Steel Cost Summary

WBS Category	Element	Baseline Cost ($k)
5.1.6	Mu ID Steel	993
5.1.6.1	EDIA	139
5.1.6.2	Prototype	0
5.1.6.3	Fabrication	412
5.1.6.4	Assy/Installation	442
5.1.6.5	Testing	0

PHENIX Magnet Subsys. - Type of Estimate (%)

Total Baseline Cost: $6182k



PHENIX Magnet Subsys. - Type of Estimate (%)

Estimate Type	Baseline Cost ($k)	Cost (%)
Work Performed (Actual Costs)	$604	10%
Vendor Estimates	$2836	46%
Engineering Judgement based on Vendor Info	$488	8%
Engineering Judgement	$2254	36%
Totals:	$6182	100%

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10/20/93

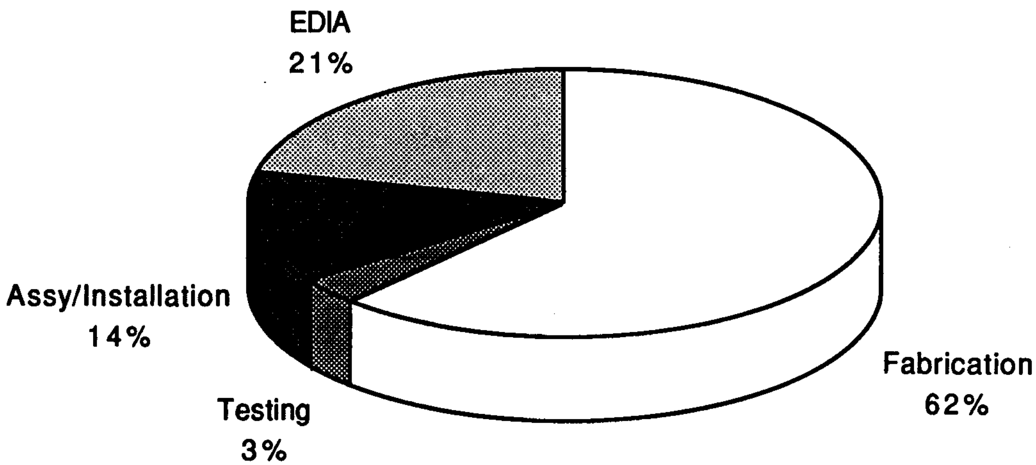
PHENIX Magnet Subsys. - Type of Estimate ($k)

Estimate Type	CM Coils[1]	CM Steel	MM Coil	MM Steel	Mu ID Steel	
Work Performed (Actual Costs)	113 + 42	170	99	170	10	[604]
Vendor Estimates	568+ 325	811	225	907	0	[2836]
Engineering Judgement based on Vendor Info	0 + 0	38	0	38	412	[488]
Engineering Judgement	245 + 103	640	150	545	571	[2254]
Totals:	$1396	$1659	$474	$1660	$993	[6182]

1 5.1.1 + 5.1.2 CM Outer & Inner Coils

PHENIX Magnet Subsys. - WBS Level 4 Summary

Total Baseline Cost: $6182k



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10/25/93

PHENIX Magnet Subsys. - WBS Level 4 Summary

WBS Category	Element	Baseline Cost ($k)	% of Total Baseline Cost
5.1.X.1	EDIA	1310	21%
5.1.X.2	Prototype	10	0%
5.1.X.3	Fabrication	3813	62%
5.1.X.4	Assy/Installation	889	14%
5.1.X.5	Testing	160	3%
	Totals:	$6182	100%

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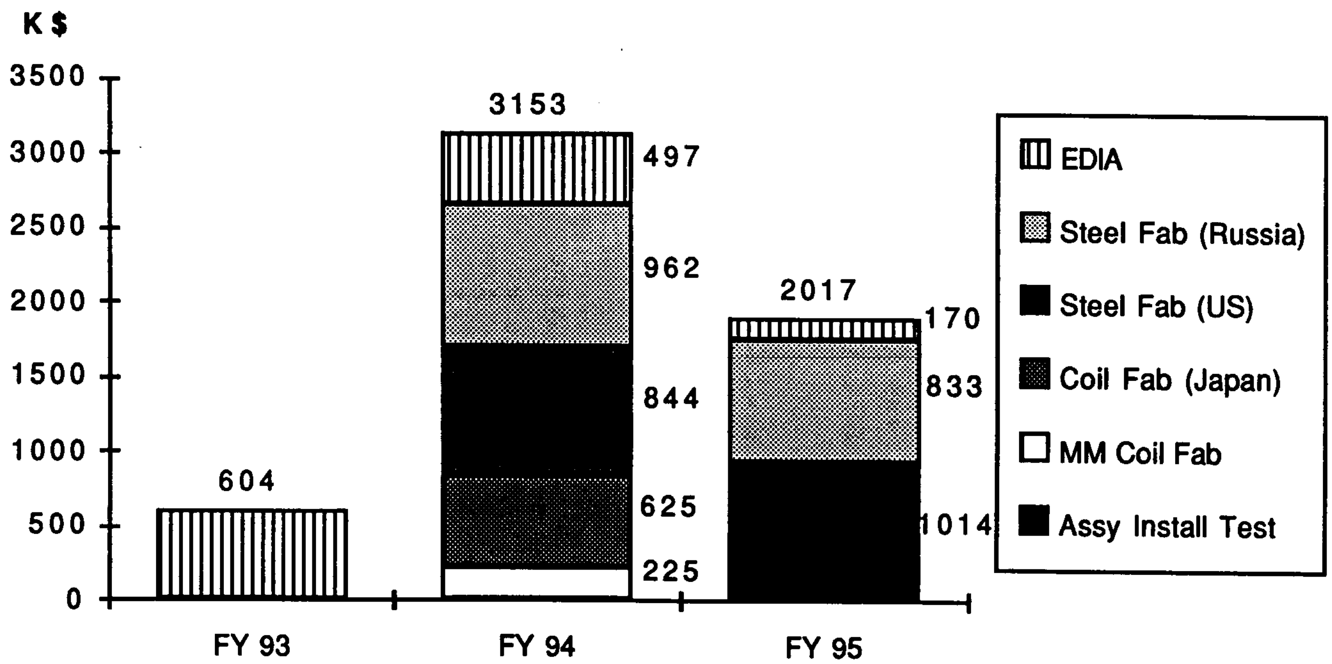
PHENIX Magnet Subsystem - Funding Profile

Total Baseline Cost: $6182k



Defer: CM Inner Coil Fab ($408k)

RMY-01
10/28/93

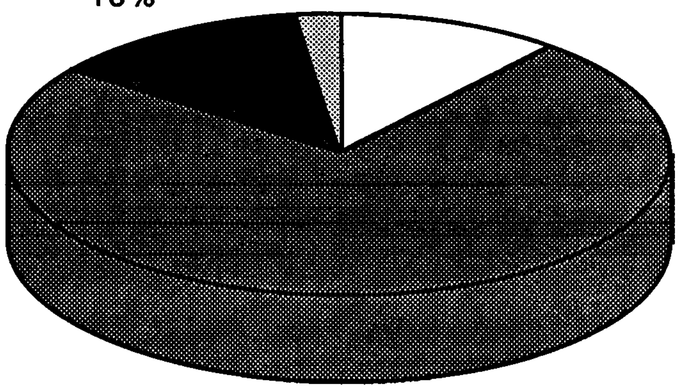
PHENIX Mag. Sys. - Baseline (Russian) vs US Costs

WBS Category	Element	Baseline Cost ($k)	US Cost ($k)
5.1.1	CM Outer Coil	926	926
5.1.2	CM Inner Coil	470	470
5.1.3	CM Steel	1659	2648
5.1.4	MM Coil	474	474
5.1.5	MM Steel	1660	2755
5.1.6	Mu ID Steel	993	993
	Totals:	$6182	$8266

RMY-01
10/21/93

PHENIX Mag. Subsys. - WBS Level 4 US Summary

Total Baseline Cost: $8266k



RMY-01
10/26/93

PHENIX Magnet Sys. - WBS Level 4 US Summary

WBS Category	Element	US Cost ($k)	% of Total US Cost
5.1.X.1	EDIA	1051	13%
5.1.X.2	Prototype	10	0%
5.1.X.3	Fabrication	6156	74%
5.1.X.4	Assy/Installation	889	11%
5.1.X.5	Testing	160	2%
	Totals:	$8266	100%

RMY-01
10/21/93

PHENIX Magnet Subsystem - Program Savings

- LLNL contributed $130k to magnet subsystem EDIA.
  ($120k EDIA + $10k MM coil prototype).

- PHENIX Japanese Collaboration contributing $470k to CM Outer Coil.
  ($400k coil fabrication + $70k for shipping).

- Effective Russian contribution is $2084k.
  ($988k for Central Magnet steel & $1096k for Muon Magnet steel).

- Total Program Savings: <u>$2684k</u>.

PHENIX Magnet Subsystem - Cost Justification

- Magnet subsystem costs have increased since the CDR cost estimate. These cost increases can be attributed to the following reasons:

  - Initial coil & steel fabrication costs were estimated on a $ per lb basis and rough sketches. Subsequently, preliminary drawings were sent out to perspective vendors and vendor estimates were received. These estimates were higher than the CDR estimate.

  - Changes in scope required more components and complexity.

  - The $ to ¥ exchange rate has dropped from ¥125 per $1 to ¥100 per $1 since the initial CM Outer Coil estimate was made. In addition, shipping costs for the coil from Japan to BNL have been included in the cost estimate for the first time.

PHENIX Magnet Subsystem - Cost Justification

- EDIA costs have increased due to several reasons:
  Design completion date has slipped from Spring '93 to Dec '93 because of changes in scope brought about by the evolution of physics requirements.
  Fabrication of the steel in Russia has been decided. Changes in the design were required to complement the fabrication capabilities of the Russians. In addition, more oversight of QA/QC activities is required to ensure the desired end product.

PHENIX Magnet Subsystem - Cost Comparison

WBS Category	Element	Baseline Cost ($k) 11/93	Cost ($k) CDR
5.1	Magnet Subsystem	6182	6352 (4904 + 248 + 1200)[1,2]
5.1.1 + 5.1.2 + 5.1.3	CM Outer & Inner Coil + Steel	3055	2937
5.1.1	CM Outer Coil	926	1293
5.1.2	CM Inner Coil	470	included in 5.1.1
5.1.3	CM Steel	1659	1644
5.1.4 + 5.1.5	MM Coil + Steel	2134	1967[1]
5.1.4	MM Coil	474	258[1]
5.1.5	MM Steel	1660	1709
5.1.6	Mu ID Steel	993	(1200)[2]

[1] 5.1.4 MM Coil fab + Power Supply deferred ($248k) @ CDR

[2] 5.1.6 Mu ID used concrete instead of steel @ CDR ($1200k)

RMY-01
10/21/93

PHENIX Mag Subsystem - Contingency Analysis

- Provide for a systematic and uniform methodology in developing contingency for level 3 WBS items.
- Methodology adopted from work done for the GEM detector at the SSC.
- Contingency is calculated by multiplying a Risk Factor by the appropriate Risk Percentage using the following table:

Risk Percentage Table

	Condition	Risk Percentage
Technical	Design OR manufacturing concerns	2%
	Design AND manufacturing concerns	4%
Cost	Material cost OR labor rate concern	1%
	Material cost AND labor rate concern	2%
Schedule		1%

PHENIX Mag Subsystem - Risk Factor Table

Risk Factor Table

Risk Factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
1 0	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
1 5	New design way beyond the current state-of-the-art	Engineering judgment	not used

PHENIX Mag Sys. - Contingency Computation

- **Example of calculating contingency:**

  Risk Factors for the 5.1.1 CM Outer Coil:

  Technical: 4 Basis: New design based on established, well-proven technology.
  Cost: 2 Basis: Cost based on vendor estimates.
  Schedule: 2 Basis: Fabrication delay does not affect overall Magnet completion.

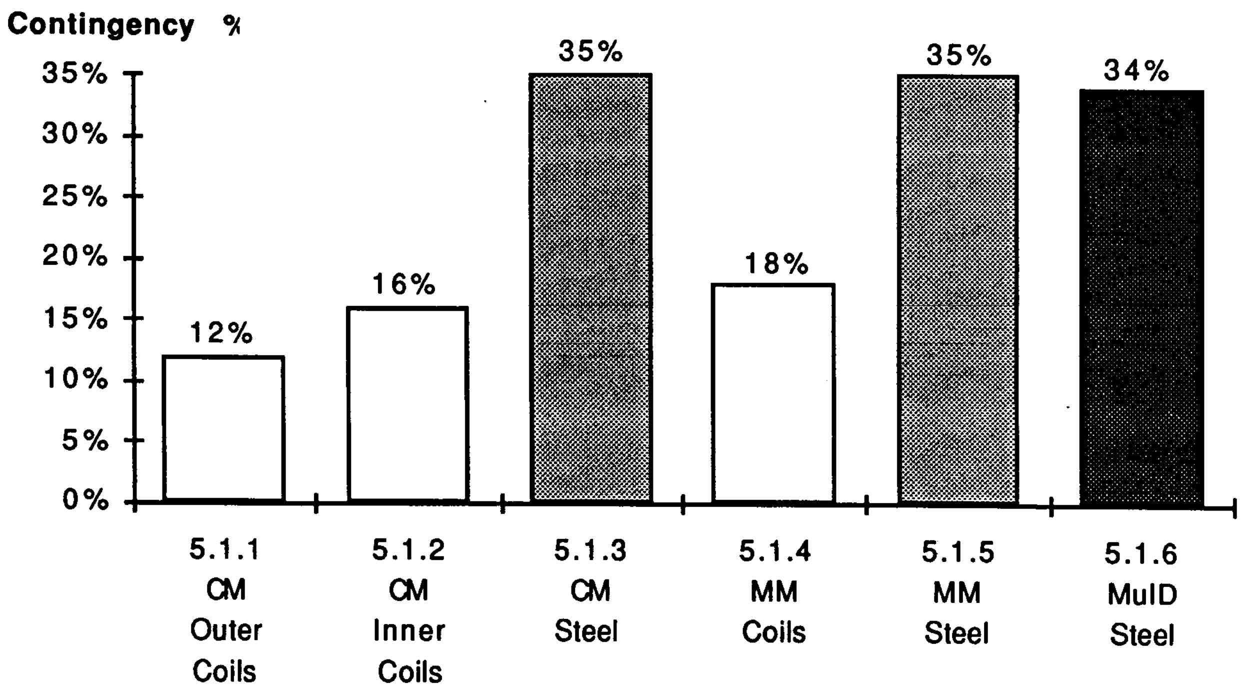
- **Contingency (%) = [Technical Risk Factor X Risk Percentage] + [Cost Risk Factor X Risk Percentage] + [Schedule Risk Factor X Risk Percentage]**

- **Contingency (%) = [4 X 2%] + [2 X 1%] + [2 X 1%] = 12%**

- **Maximum contingency allowed using this method is 98%: [15 X 4%] + [15 X 2%] + [8 X 1%] = 98%**

PHENIX Mag Subsystem - Contingency Profile

Total 5.1 Magnet Subsystem Contingency is 29%.



RMY-01
10/28/93

PHENIX Magnet Subsystem - Contingency

WBS	Element	Baseline Cost ($k)	Cont. (%)	Cont. ($k)	Total
5.1	Magnet + Mu ID Steel	$6182	29%	$1774	$7956
5.1.1	CM Outer Coil	926	12%	107	1033
5.1.2	CM Inner Coil	470	16%	75	545
5.1.3	CM Steel	1659	35%	587	2246
5.1.4	MM Coil	474	18%	85	559
5.1.5	MM Steel	1660	35%	583	2243
5.1.6	Mu ID Steel	993	34%	337	1330

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10/20/93

PHENIX Mag Sys. - Contingency Justification

- Overall 5.1 Magnet Subsystem contingency is 29%:
  - Magnet Coils + Steel contingency is 28%.
  - Mu ID Steel contingency is 34%.

- Magnet Coils contingency is low (12 to 18%) because:
  - design is well proven and purposely designed to be "low tech".
  - fabrication uses standard industry practices.
  - discussions with vendors reinforce low contingency values.
  - fabrication delay does not affect overall magnet installation schedule.

PHENIX Mag Sys. - Contingency Justification

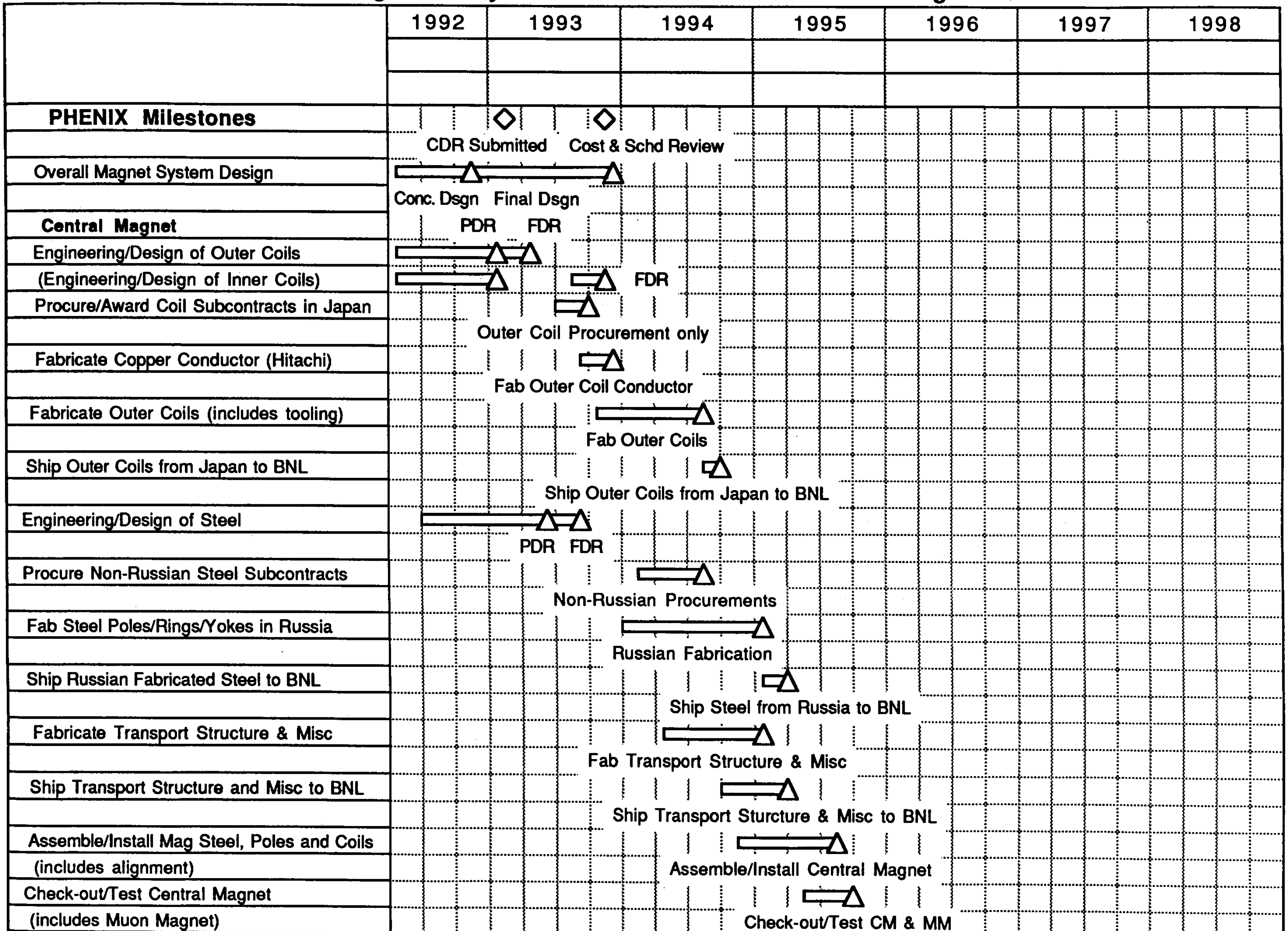
- Magnet Steel contingency is above normal (35%) because:
  - fabrication is being done in Russia which requires more oversight of QA/QC activities.
  - general communication is more difficult due to language/cultural and distance/time concerns.
  - some steel fabrication (forgings) because of weight limitation are at industry limit.
  - fabrication delay affects overall magnet subsystem completion.

- Mu ID Steel contingency is above normal (34%) because:
  - design is very conceptual in nature.
  - estimated cost based on discussion with vendors using preliminary steel dimensions.
  - received no credible estimates for shipping or assembly of the steel.
  - fabrication delay affects overall magnet subsystem completion.

PHENIX Magnet Subsystem - Schedule Highlights

- Magnet Subsystem on critical path of PHENIX Detector.
- Engineering/Design of magnet subsystem will be completed by 4th quarter of CY '93.
- Mu ID Steel is the critical path item of magnet subsystem:
  - installation in detector hall is required before magnets can be installed and tested (Spring '95).
- Muon Magnet (MM) Steel next critical path item:
  - Russian fabrication scheduled to be completed by Spring '95.
- Central Magnet (CM) & Muon Magnet (MM) will be installed with magnetic field mapping completed by Fall '95.

PHENIX Magnet Subsystem - 5.1.1 + 5.1.2 + 5.1.3 Central Magnet Rev 'B'



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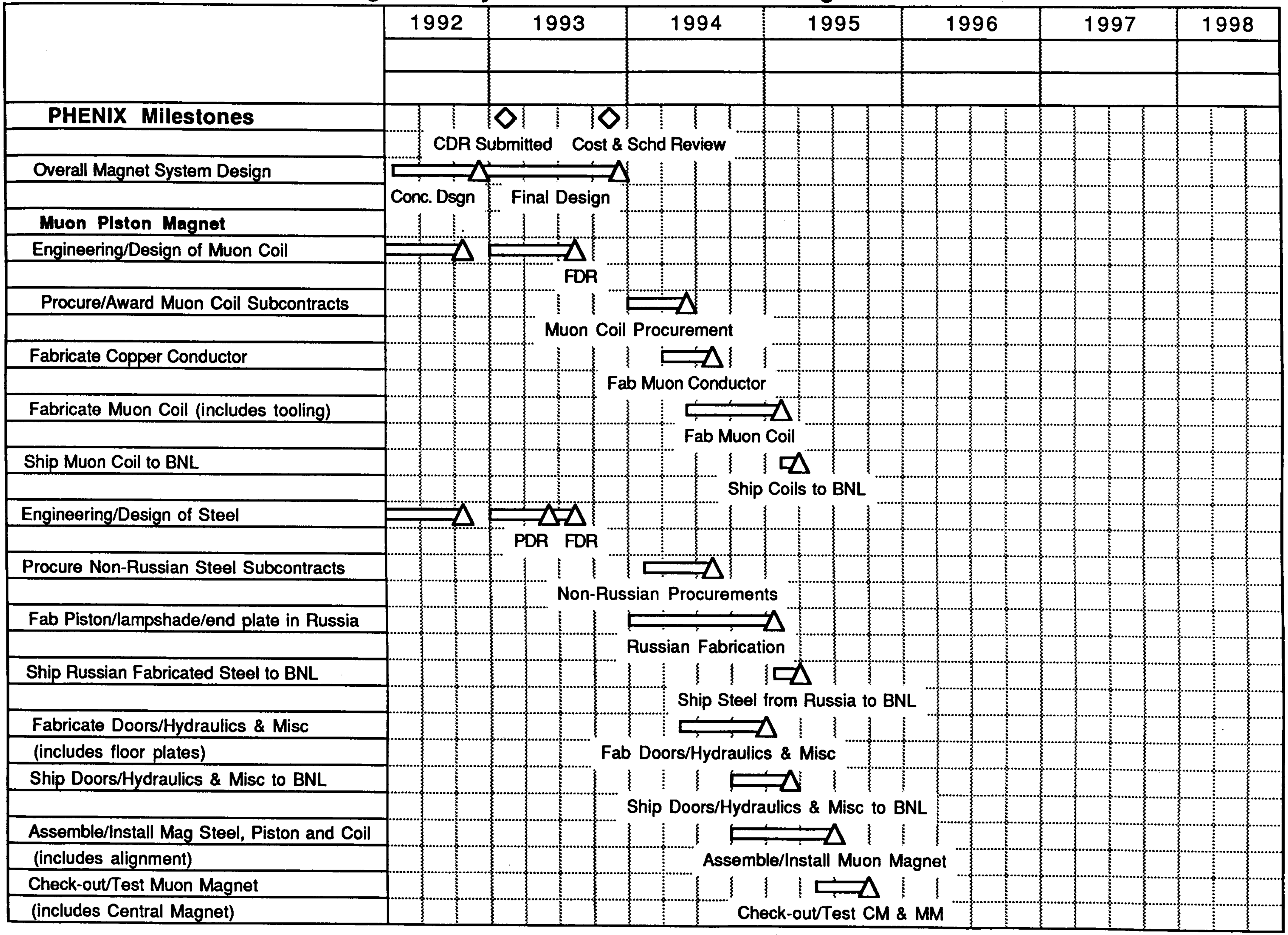
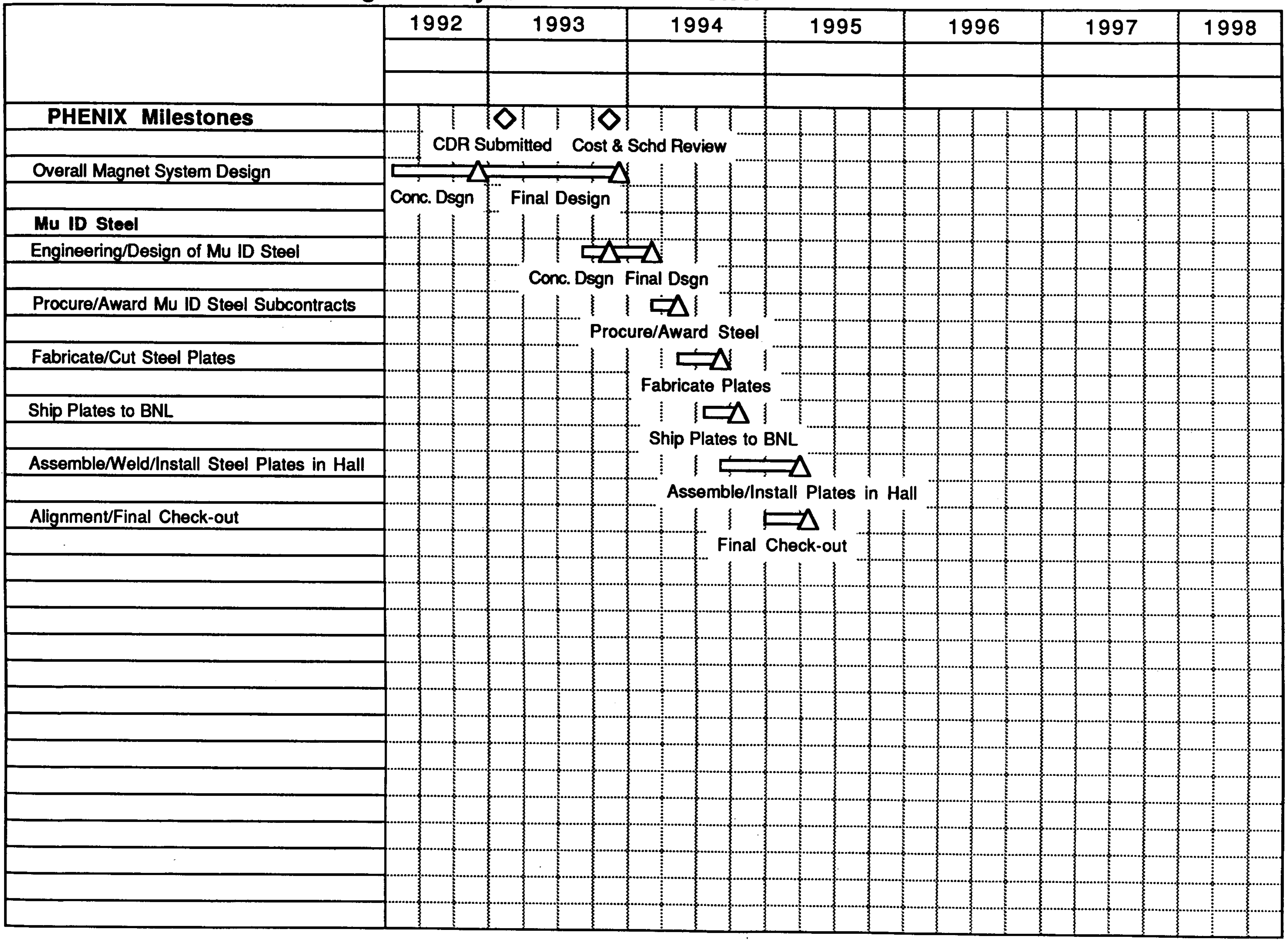
PHENIX Magnet Subsystem - 5.1.4 + 5.1.5 Muon Magnet Rev 'B'



Thursday, October 28, 1993

PHENIX Magnet Subsystem - 5.1.6 Mu ID Steel



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PHENIX Magnet Subsystem - Appendix

- Basis of Estimates (BOE's)
  - 5.1.1 CM Outer Coil
  - 5.1.2 CM Inner Coil
  - 5.1.3 CM Steel
  - 5.1.4 MM Coil
  - 5.1.5 MM Steel
  - 5.1.6 Mu ID Steel
- Magnet Steel Fabrication Specification (for Russia). (Inter Laboratory Collaborative Agreement - Attachment 2).
- Magnet Assembly Study - Statement of Work.
- Central Magnet Outer Coil Fabrication Specification (for Japan).
- Drawings:
  - Central Magnet Outer Coils.
  - Central Magnet Steel.
  - Muon Magnet Coils.
  - Muon Magnet Steel.

WBS 5.1 PHENIX Magnet Subsystem Contingency 10/05/93

WBS	Element	US Cost	Russian Cost	% cont	$ cont.	Total
5.1	**Magnet + Mu ID Steel**	**8266.6**	**6182.7**	**29%**	**1774.4**	**7957.1**
5.1.1	**CM Outer Coil**	**926.5**	**926.5**	**12%**	**107.4**	**1033.9**
5.1.1.1	EDIA	203.0	203.0	10%	20.3	223.3
5.1.1.2	Prototype	0.0	0.0	0%	0.0	0.0
5.1.1.3	Fabrication	625.3	625.3	10%	62.5	687.8
5.1.1.3.1	Coils	528.0	528.0	10%	52.8	580.8
5.1.1.3.2	Power Supplies	97.3	97.3	10%	9.7	107.0
5.1.1.4	Assy/Installation	28.0	28.0	25%	7.0	35.0
5.1.1.5	Testing	70.3	70.3	25%	17.6	87.9
5.1.2	**CM Inner Coil**	**470.0**	**470.0**	**16%**	**75.5**	**545.5**
5.1.2.1	EDIA	111.1	111.1	10%	11.1	122.2
5.1.2.2	Prototype	0.0	0.0	0%	0.0	0.0
5.1.2.3	Fabrication	324.6	324.6	17%	55.8	380.4
5.1.2.3.1	Coils	233.6	233.6	20%	46.7	280.3
5.1.2.3.2	Power Supplies	91.0	91.0	10%	9.1	100.1
5.1.2.4	Assy/Installation	14.0	14.0	25%	3.5	17.5
5.1.2.5	Testing	20.3	20.3	25%	5.1	25.4
5.1.3	**CM Steel**	**2647.6**	**1659.6**	**35%**	**586.6**	**2246.2**
5.1.3.1	EDIA	224.5	348.5	28%	97.6	446.1
5.1.3.2	Prototype	0.0	0.0	0%	0.0	0.0
5.1.3.3	Fabrication	2222.0	1110.0	35%	388.5	1498.5
5.1.3.4	Assy/Installation	201.1	201.1	50%	100.6	301.7
5.1.3.5	Testing	0.0	0.0	0%	0.0	0.0
5.1.4	**MM Coil**	**474.0**	**474.0**	**18%**	**85.0**	**559.0**
5.1.4.1	EDIA	148.6	148.6	10%	14.9	163.4
5.1.4.2	Prototype	10.0	10.0	0%	0.0	10.0
5.1.4.3	Fabrication	224.8	224.8	21%	47.5	272.3
5.1.4.3.1	Coils	166.8	166.8	25%	41.7	208.5
5.1.4.3.2	Power Supplies	58.0	58.0	10%	5.8	63.8
5.1.4.4	Assy/Installation	20.3	20.3	25%	5.1	25.4
5.1.4.5	Testing	70.3	70.3	25%	17.6	87.9
5.1.5	**MM Steel**	**2755.1**	**1659.2**	**35%**	**583.1**	**2242.3**
5.1.5.1	EDIA	224.5	359.6	28%	100.7	460.3
5.1.5.2	Prototype	0.0	0.0	0%	0.0	0.0
5.1.5.3	Fabrication	2347.0	1116.0	35%	390.6	1506.6
5.1.5.4	Assy/Installation	183.6	183.6	50%	91.8	275.4
5.1.5.5	Testing	0.0	0.0	0%	0.0	0.0
5.1.6	**Mu ID Steel**	**993.3**	**993.3**	**34%**	**336.8**	**1330.1**
5.1.6.1	EDIA	139.0	139.0	25%	34.8	173.8
5.1.6.2	Prototype	0.0	0.0	0%	0.0	0.0
5.1.6.3	Fabrication	412.0	412.0	25%	103.0	515.0
5.1.6.4	Assy/Installation	442.3	442.3	45%	199.0	641.3
5.1.6.5	Testing	0.0	0.0	0%	0.0	0.0

Basis of Estimate

WBS: 5.1.1 Item: PHENIX - Central Coils: Outer
Date: October 4, 1993 Rev: 0K By: R. Yamamoto

Element Scope:

This element covers the entire cost of the engineering, design, fabrication, assembly, installation and testing of the outer coils (2) for the Central Magnet (CM).

Technical design description:

Outer Coil:
The outer coils (2 required) are conceptually identical in design to the inner coils. They are made up of 6 identical (except for the electrical flag connections) bifilar wound double pancake coils with each double pancake assembly being individually vacuum epoxy impregnated. They have an inside diameter of 3200 mm (125.98 in) and a nominal outside diameter of 3729 mm (146.8 in). Nominal coil assembly width is 300 mm (11.81 in). There is a 6 mm clearance between the ID of the coil and the inside surface of the counterbore (to allow for coil installation onto the steel poles). LLNL drawing AAA93-101878-0A shows the North Pole coil stack. As in the inner coil, the six double pancake assemblies that make up the outer coil are nested together side by side and rest on the circular counterbore machined into the iron pole pieces of the Central Magnet.

The outer coils have a design value of 247,500 amp-turns and also utilizes a copper conductor which is 20.32 mm (0.800 in) square with a 12.83 mm (0.505 in) hole. The coil configuration is a 144 turn conductor package (24 turns per double pancake times 6 double pancakes). Total conductor length is 1578 meters (5176 ft) per coil resulting in a coil weight of 4003 kg (8826 lbs). Maximum outlet water temperature rise is 45.6°C (inlet water temperature is 20°C) which corresponds to an average conductor temperature of 32.8°C. Required water flow rate is 43.9 gallons/minute per coil.

The outer coil requires 1719 amps @ 174 volts for a power supply requirement of 300 kwatts (247,500 amp-turns) per coil. The coil can theoretically achieve 367,200 amp-turns (48% increase) by allowing the outlet water temperature to rise to 80°C (vs. 45.6°C) and using a power supply of 699 kwatts (2550 amps @274 volts) per coil.

Eng/Dsgn/Ins/Adm (mm): 15.75[1] Cost ($k): 203k Dur: 4/92-10/95

5.1.1.1 CM Outer Coils:
This estimate for EDIA is based upon recent design experience resulting from the design of several conventional coil magnet subsystems and from the experience gained in the design and specification of the GEM magnet subsystem The manpower for this effort is divided into two categories: effort required for the engineering/design/analysis (Dsgn Phase) of the coil (11/92 through 4/93; 6 months) and effort required for the purchase/fabrication/assembly/installation/test (Fab Phase) of the coil (the present plan shows that the CM outer coil will be fabricated in Japan and be completed and shipped to BNL around the beginning of summer '94). As of the end of July, '93, approx. $78K has been spent on the final design and analysis of the CM outer coils. In addition to the estimate below, LLNL has contributed **$30k** to the preliminary engineering design of the CM outer

coils during the early stages of the PHENIX program. This amount is included in the EDIA total shown above.
The estimate is based upon actual LLNL charge rates for each individual and averaged by category type and is estimated as follows:

WBS	Name	Type	Salary $av/mo	Design m-m's	Design total k$	Fab m-m's	Fab total k$	total K$
5.1.1.1.1	Bob Yamamoto	Eng	9,281	2.00	$18.56	2.50	$23.20	$41.76
5.1.1.1.2	Ross Schlueter	Eng	9,281	0.50	$4.64	0.00	$0.00	$4.64
5.1.1.1.3	Art Harvey	Eng	9,281	1.50	$13.92	0.00	$0.00	$13.92
5.1.1.1.7	Winston Wong	Des	6,506	4.00	$26.00	1.00	$6.51	$32.51
5.1.1.1.8	Brigitte Gim	Des	6,506	1.00	$6.51	1.00	$6.51	$13.02
5.1.1.1.11	Rudy Carpenter	Cord	6,506	0.75	$4.88	1.00	$6.51	$11.39
5.1.1.1.12	Checker	Des	6,506	0.50	$3.25	0.00	$0.00	$3.25
			totals:	**10.25**	**$77.76**	**5.50**	**$42.73**	**$120.49**

5.1.1.1.13 LLNL contribution: preliminary engineering design: **$30k**

5.1.1.1.14 Travel:
Estimate travel to coil vendor in Japan to be 4 trips for the duration of the coil fabrication (inspect conductor & winding fixture/start of winding, inspect potting mold/start of vacuum impregnation, electrical and hydraulic testing of coil subassemblies, final assembly fit check/shipping). Cost of each trip is $4k per person. Assume 2 people per trip.
Cost is: (4 trips) X (2 people) X ($4k/trip) = $32k.
[reduce this cost by half ($2k/trip) which totals $16k if the fabrication was to be done in the US].

Estimate travel to BNL for facilities interfacing, rigging, etc. and final installation of the outer coil onto the magnet steel and testing to be 4 trips from now through the fall of '95. Assume 2 people per trip @ $2k average cost per trip.
Cost is: (4 trips) X (2 people) X ($2k/trip) = $16k.

Total travel cost is $32k + $16k = **$48k**

Based upon the last 6 months, the following items incurred real costs on the PHENIX program at LLNL. These cost are estimated for the duration of the task:

5.1.1.1.15 TID (Technical Information Department) which includes photocopying, color reproduction, making design review booklets, etc. An average cost of $700/mo were incurred for the entire PHENIX program at LLNL. It is estimated that these costs will decrease over the life of the program. These costs are estimated at $200/mo. for the total PHENIX project or $50/mo per major task (CM coils + steel & MM coils + steel). For the CM coils, the cost is shared between the inner & outer coils. Cost per month is: $50/ 2 coils = $25/mo
TID cost is: ($25/mo) X (24 months) = **$0.60K**

5.1.1.1.16 Computer support (includes upgrading AutoCad revisions, quickmail troubleshooting, etc) is:
$5/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$2.6k**

5.1.1.1.17 FED X and office supplies is:
$2.5/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$1.3k**

Total CM Outer Coil EDIA cost:
$120.49k + $30.0k + $48k + $0.60k + $2.6k + $1.3k = **$203k**

[1]plus travel and other related expenses

Prototype ($k): 0 k Dur: X/9X-X/9X

5.1.1.2 No prototype work was done on the CM Outer Coil

Fabrication ($k): 528.00 + 97.25 = 625.25k Dur: 9/93-6/94

5.1.1.3 CM Outer Coils:

The fabrication of the CM Outer Coils will be a build to print from LLNL provided drawings. The winding mandrel and the potting fixture will be specified by LLNL. The detail design of this support hardware will be the responsibility of the coil vendor with the design being approved by LLNL.

5.1.1.3.1 At this time, it is assumed that a Japanese company will fabricate the outer coil. This includes the purchase of the copper conductor and the fabrication of the coil. It does not include any of the coil support hardware, water manifolds, etc. The estimate to provide the completed outer coils from Japan is **$400K** (@¥100=$1)

Coil hardware fabrication cost including installation fixturing, water manifolds, supports, etc. is estimated to be $58K, the same as the CM inner coil.

Cost of shipping the coils from the Japanese coil fabricator to BNL is estimated by the Japanese to be $70k (@¥100=$1).

Total CM Outer Coil costs: 400.0k + $58.0k + $70.0k = **$528.0k.**

5.1.1.3.2 Power Supplies: Outer Coil (1):

The power supply specified is the nominal amount required to achieve the baseline operating field of the magnet system. It includes extra capacity to account for voltage drop through the electrical bus system and some safety margin. The pair of outer coils will be run in series by a single power supply to eliminate any power fluctuations between coils that might occur if two separate power supplies were used. This effect would create a non uniform magnetic field which is very undesirable. Provided is the following table which reflects both baseline and maximum operating coil conditions (maximum coil operating set by limiting the exit cooling water temperature to 80°C):

Coil type	amp-turns baseline	reqd power supply baseline	amp-turns maximum	reqd power supply maximum
outer	247,500	600 kwatts	367,200	1398 kwatts

The power supplied specified for the CM Outer Coil is:
2500 amps @400 volts which equals 1000 kwatts
(Baseline coil requirement is 1719 amps @348volts)

Nominal power supply requirements include:
Input Voltage 13.8 kv (or 480 volt) - 3 phase

Rectifier Configuration	12 phase
Output Voltage Ripple	5 volts (use output filter)
Long Term Reproducibility	0.1% (one year)
One Hour Stability	0.01%
One Minute Stability	0.001%
Control and Status Interface	Digital (Optional)
Trim Input Analog Range	1%
Input Tap Switch Settings	100%, 50% and 25%, (Optional)
Reversing Switch	Mechanical (Optional)

Two budgetary estimates were received from US Companies:

Estimate #1: $102k
Estimate #2: $92.5k

Average CM Outer Coil Power Supply cost: **$97.25k**

Total fabrication costs: $528k + $97.25k = **$625.25k**

Assy/Installation (mm): 4.82 Cost ($k): 28k Dur: 3/95-6/95

5.1.1.4 CM Outer Coils:

This includes installing the two CM outer coils onto the pole pieces in the detector hall. It includes all of the electrical and LCW (low conductivity water) hook-ups and doing all system integration checkouts. Once completed, the CM is ready for test operation. The engineering supervision for this task is included in 5.1.1.1, the EDIA for this portion of assy/installation.

The total outer coil assembly consists of 12 double pancakes assemblies, each pole having 6 double pancake coil subassemblies each. I estimate it will take approx. 3 technicians 1/2 week to completely assemble and install a double pancake coil subassembly onto the pole pieces. This would include all of the fixturing and preparation required for this installation as well as hook up of electrical and hydraulic interfaces. The coil subassemblies will come from the vendor ready for coil installation. Little work will need to be done to the coils on site in preparation of this task. Total manpower required for the central magnet outer coils is: 3 technicians X 1/2 week per subassembly X 12 double pancake subassemblies = 18 man-weeks. (720 man-hours). Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 0.40 man-years and accounts for items such as vacation, sick leave, holidays, etc. The dollar rate used assumes that BNL staff will be used to support this task.

Cost = 0.4 man-years * $70k/yr = **$28k**

Testing (mm): 3.0 **Cost ($k):** 70.29k[2] **Dur:** 7/95/10/95

5.1.1.5 CM Outer Coils:

This includes running the CM outer coils at full rated current, magnetically mapping the magnetic field produced in the gap and other key locations around the magnet as required and checking all instrumentation and system performance. The engineering supervision for this task is included in 5.1.1.1, the EDIA for this testing.

It is estimated that it will take 3 technicians 1 month to test and map a coil pair (including reverse polarity).

Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 10.35 mm per man year to account for items such as vacation, sick leave, holidays, etc. The dollar rate used assumes that BNL staff will be used to support this task.

Cost = 3 man-months/10.35 man-months * $70/yr = **$20.29k**

[2]Estimated cost for the magnetic mapper, data acquisition system and misc hardware is $100.0k but cost is shared equally between the Central Magnet Outer Coils and the Muon Piston Coil so that the cost to the CM Outer Coil is **$50.0k**

Total cost is $20.29k + $50.0k = **$70.29k**

Unit type: ea **Number of units:** 1 pair

Estimate Type: Bottoms Up (BU)

Risk Factors:

Technical: 4 Basis: New design based on established, well-proven technology

Cost: 2 Basis: Cost based on vendor estimates.

Schedule: 2 Basis: Fabrication delay does not affect overall Magnet completion.

Definitions for use of the Risk Factors are as follows:

Risk Factor Table

Risk Factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
10	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
15	New design way beyond the current state-of-the-art	Engineering judgment	not used

Contingency is calculated using the above Risk Factors and the Risk Percentage Table. The following is the Risk Percentage Table:

Risk Percentage Table

	Condition	Risk Percentage
Technical	Design OR manufacturing concerns	2%
	Design AND manufacturing concerns	4%
Cost	Material cost OR labor rate concern	1%
	Material cost AND labor rate concern	2%
Schedule		1%

Contingency is calculated by multiplying the Risk Factor by the appropriate Risk Percentage using the table above.

Contingency (%) = [Technical Risk Factor X Risk Percentage] + [Cost Risk Factor X Risk Percentage] + [Schedule Risk Factor X Risk Percentage]

As an example, the maximum contingency allowed by this process is:
Maximum contingency = [15 X 4%] + [15 X 2%] = [8 X 1%] = 98%

Values greater than 98% contingency can be used at the discretion of the estimator. Additional justification must be included to warrant these higher contingency values.

Contingency: [4 X 2%] + [2 X 1%] + [2 X 1%] = **12%**

(The 12% contingency value is low because the Japanese are taking full responsibility for coil fabrication).

Misc Comments:

Basis of Estimate

WBS: 5.1.2 Item: PHENIX - Central Coils: Inner

Date: October 4, 1993 Rev: 0K

By: R. Yamamoto

Element Scope:

This element covers the entire cost of the engineering, design, fabrication, assembly, installation and testing of the inner coils (2) for the Central Magnet (CM).

Technical design description:

Inner Coil:
The inner coils (2 required) are made up of 6 bifilar wound double pancake coils which are vacuum epoxy impregnated in three sets of two double pancake assemblies each. All three pancake assemblies are identical in size and configuration. The nominal inside diameter (ID) of the coil is 1084.7 mm (42.7 in) which leaves a 6 mm clearance between the ID of the coil and the inside surface of the counterbore (to allow for coil installation onto the steel poles). The nominal outside diameter (OD) of the coil is 1553.5 mm (61.2 in). Nominal coil assy width is 300 mm (11.81 in). When installed, the three sets of two double pancake assemblies are nested together side by side and rest on the circular counterbore machined into the iron pole pieces of the Central Magnet.

The inner coils have a design value of 293,000 amp-turns. It utilizes a square, hollow, copper magnet conductor which is nominally 21.51 mm (0.847 in) square with a 13.66 mm (0.538 in) hole. The coil configuration is a 120 turn conductor package (40 turns per two double pancake assembly times 3 assemblies). Total conductor length required is 497 meters (1630 ft) per coil resulting in a coil weight of 1408 kg (3105 lbs). 12 water circuits corresponding to 4 circuits per potted pancake subassembly (bifilar wound) provide a pressure drop of 60 psig with a maximum water temperature of 26.2°C (inlet water temperature is 20°C) which corresponds to an average conductor temperature of 23.1°C. The copper conductor will first be insulated with a "half-lap" of mylar tape, then enclosed in a continuous dacron sheath, wound on a coil winding form, ground wrapped with wide dacron cloth tape and epoxy impregnated under vacuum in a potting mold. Both before and after vacuum impregnation, the coil will be electrically checked for shorts and hydrostatically pressure checked and flow checked through each of the 12 water circuits. Required water flow rate is approx. 99.2 gallons/minute for each coil assembly.

The inner coil requires 2442 amps @ 67.1 volts for a power supply requirement of 164 kwatts (293,000 amp-turns) per coil. The coil can theoretically achieve 883,924 amp-turns (195% increase) by allowing the outlet water temperature to rise to 80°C (vs. 26.2°C) and using a power supply of 1573 kwatts (7199 amps @218.4 volts) per coil.

Eng/Dsgn/Ins/Adm (mm): 11.25[1] Cost ($k):111.11k Dur: 6/92-X/9X

5.1.2.1 CM Inner Coils:
This estimate for EDIA is based upon recent design experience resulting from the design of several conventional coil magnet subsystems (including the CM Outer Coils) and from the experience gained in the design and specification of the GEM magnet subsystem The

manpower for this effort is divided into two categories: effort required for the engineering/design/analysis (Dsgn Phase) of the coil (11/92 through 1/93 + 8/93 through 10/93; 6 months) and effort required for the purchase/fabrication/assembly/installation/test (Fab Phase) of the coil (the present plan is that the CM inner coil will not be available on "Day 1" of the PHENIX experiment; hence the fabrication schedule is based on relative time, not absolute calendar time; it is estimated that it will take approx. 12 months to procure and fabricate the CM inner coils and that the fabrication is done somewhere in the United States). As of the end of July, '93, approx. $20K has been spent on the final design and analysis of the CM inner coils. In addition to the estimate below, LLNL has contributed **$12k** to the preliminary engineering design of the CM inner coils during the early stages of the PHENIX program. This amount is included in the EDIA total shown above.
The estimate is based upon actual LLNL charge rates for each individual and averaged by category type and is estimated as follows:

WBS	Name	Type	Salary $av/mo	Design m-m's	Design total k$	Fab m-m's	Fab total k$	total K$
5.1.2.1.1	Bob Yamamoto	Eng	9,281	1.00	$9.28	2.00	$18.56	$27.84
5.1.2.1.2	Ross Schlueter	Eng	9,281	0.50	$4.64	0.00	$0.00	$4.64
5.1.2.1.3	Art Harvey	Eng	9,281	0.50	$4.64	0.00	$0.00	$4.64
5.1.2.1.7	Winston Wong	Des	6,506	3.00	$19.52	1.00	$6.51	$26.03
5.1.2.1.8	Brigitte Gim	Des	6,506	0.50	$3.25	1.00	$6.51	$9.76
5.1.2.1.11	Rudy Carpenter	Cord	6,506	0.75	$4.88	0.50	$3.25	$8.13
5.1.2.1.12	Checker	Des	6,506	0.50	$3.25	0.00	$0.00	$3.25
			totals:	**6.75**	**$49.46**	**4.50**	**$34.83**	**$84.29**

5.1.2.1.13 LLNL contribution: preliminary engineering design: **$12k**

5.1.2.1.14 Travel: Estimate travel to coil vendors to be a total of 3 trips for the duration of the job. Total relative time required to complete this task is 3 mo (for design) + 12 months (for fabrication) which equals 15 months. This does not include any foreign travel as it is assumed that the fabrication will be done in the United States. It also does not include any trips to BNL since this effort is being deferred and will not be available on Day 1. Assume 2 people per trip @ $2k average cost per trip.
Total travel cost is: (3 trips) X (2 people) X ($2k/trip) = **$12k**

Based upon the last 6 months, the following items incurred real costs on the PHENIX program at LLNL. These cost are estimated for the duration of the task:

5.1.2.1.15 TID (Technical Information Department) which includes photocopying, color reproduction, making design review booklets, etc. An average cost of $700/mo were incurred for the entire PHENIX program at LLNL. It is estimated that these costs will decrease over the life of the program. These costs are estimated at $200/mo. for the total PHENIX project or $50/mo per major task (CM coils + steel & MM coils + steel). For the CM coils, the cost is shared between the inner & outer coils. Cost per month is: $50/ 2 coils = $25/mo
TID cost is: ($25/mo) X (15 months) = **$.375K**

5.1.2.1.16 Computer support (includes upgrading AutoCad revisions, quickmail troubleshooting, etc) is:
$5/day X 5 days/wk X 52 wk/yr x 15 mo/12 mo per year = **$1.63k**

5.1.2.1.17 FED X and office supplies is:
$2.5/day X 5 days/wk X 52 wk/yr x 15 mo/12 mo per year = **$0.813k**

Total CM Inner Coil EDIA cost:
$84.29k + $12k + $12k + $.375k + $1.63k + $.813k = **$111.11k**

[1]plus travel and other related expenses

Prototype ($k): 0 k **Dur: X/9X-X/9X**

5.1.2.2 No prototype work was done on the CM Inner Coil

Fabrication ($k): 233.6 + 91.0 = 324.6k **Dur: X/9X-X/9X**

5.1.2.3 CM Inner Coils:

The fabrication of the CM Inner Coils will be a build to print from LLNL provided drawings. The winding mandrel and the potting fixture will be specified by LLNL. The detail design of this support hardware will be the responsibility of the coil vendor with the design being approved by LLNL. Based on vendor estimates, it will take 4 months to procure the copper conductor and 8 months to fabricate the coils. The fabrication cost estimate is based on actual cost data from a similar type of epoxy impregnated coil built at LLNL (3/91). Some of the cost data has been modified (downward) due to recent vendor estimates on the cost of the conductor and economy of scale. The engineering supervision provided by LLNL for this task is included in 5.1.2.1, the EDIA for fabrication by a vendor. Historical single coil costs includes:

materials, fixtures, labor	$9.0k	
copper conductor	$1.8k	($4.00/lb for conductor + excess)
misc hardware, supplies	$1.2k	
water manifolds, supports	$3.0k	
Total:	$15.0k	per 450 lb complete coil assembly

5.1.2.3.1 Inner Coil (2):
CM inner coil cost estimate on a per lb basis:
Inner Coil total weight: 3105 lbs times 2 coils = 6210 lbs
Coil Fabrication cost: 6210 lbs times $15k/450 lbs = $207.0k

In addition, 2 budgetary estimates from vendors were received:

Estimate #1: (from KEK/Japanese company): $200K (@¥125=$1) which includes the copper conductor + coils only.
Cost for misc. hardware + manifolds, etc: [$1.2k + $3.0k] X 6210/450 lbs = $58k
Total cost: $200k + $58k = $258k

Estimate #2: (from US company): $153k which includes the coils only.
Cost for copper conductor + misc. hardware + manifolds, etc: [$1.8k + $1.2k + $3.0k] X 6210/450 lbs = $82.8k
Total cost: $153k + $82.8k = $235.8k

Average CM Inner Coil costs: [207.0k + $258.0k + $235.8K]/3 units = **$233.6k.**

5.1.2.3.2 Power Supplies: Inner Coil (1):

The power supply specified is the nominal amount required to achieve the baseline operating field of the magnet system. It includes extra capacity to account for voltage drop through the electrical bus system and some safety margin. The pair of inner coils will be run in series by a single power supply to eliminate any power fluctuations between coils that might occur if two separate power supplies were used. This effect would create a non uniform magnetic field which is very undesirable. Provided is the following table which reflects both baseline and maximum operating coil conditions (maximum coil operating set by limiting the exit cooling water temperature to 80°C):

Coil type	amp-turns baseline	reqd power supply baseline	amp-turns maximum	reqd power supply maximum
inner	293,000	330 kwatts	863,924	3146 kwatts

The power supplied specified for the CM Inner Coil is:
3000 amps @300 volts which equals 900 kwatts
(Baseline coil requirement is 2442 amps @135volts)

Nominal power supply requirements include:
Input Voltage 13.8 kv (or 480 volt) - 3 phase

Rectifier Configuration	12 phase
Output Voltage Ripple	5 volts (use output filter)
Long Term Reproducibility	0.1% (one year)
One Hour Stability	0.01%
One Minute Stability	0.001%
Control and Status Interface	Digital (Optional)
Trim Input Analog Range	1%
Input Tap Switch Settings	100%, 50% and 25%, (Optional)
Reversing Switch	Mechanical (Optional)

Two budgetary estimates were received from US Companies:

Estimate #1: $90k
Estimate #2: $92k

Average CM Inner Coil Power Supply cost: **$91k**

Total fabrication costs: $233.6k + $91k = **$324.6k**

Assy/Installation (mm): 2.41 Cost ($k): 14.0k Dur: X/9X-X/9X

5.1.2.4 CM Inner Coils:

This includes installing the two CM inner coils onto the pole pieces in the detector hall. It includes all of the electrical and LCW (low conductivity water) hook-ups and doing all system integration checkouts. Once completed, the CM is ready for test operation. The engineering supervision for this task is included in 5.1.2.1, the EDIA for this portion of assy/installation.

The inner coil assembly consists of six sets of two double pancakes assemblies, each pole having 3 sets of coil subassemblies each. I estimate it will take approx. 3 technicians 1/2 week to completely assemble and install a single two double pancake coil subassembly onto the pole pieces. This would include all of the fixturing and preparation required for this installation. The coil subassemblies will come from the vendor ready for coil installation. Little work will need to be done to the coils on site in preparation of this task. Total manpower required for the central magnet coils is: 3 technicians X 1/2 week per subassembly X 6 subassemblies = 9 man-weeks. (360 man-hours). Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 0.20 man-years and accounts for items such as vacation, sick leave, holidays, etc. The dollar rate used assumes that BNL staff will be used to support this task.

Cost = 0.2 man-years * $70k/yr = **$14.0k**

Testing (mm): 3.0 **Cost ($k):** **20.3k**[2] **Dur:** X/9X-X/9X

5.1.2.5 CM Inner Coils:

This includes running the CM inner coils at full rated current, magnetically mapping the magnetic field produced in the gap and other key locations around the magnet as required and checking all instrumentation and system performance. The engineering supervision for this task is included in 5.1.2.1, the EDIA for this testing.

It is estimated that it will take 3 technicians 1 month to test and map a coil pair (including reverse polarity).

Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 10.35 mm per man year to account for items such as vacation, sick leave, holidays, etc. The dollar rate used assumes that BNL staff will be used to support this task.

Cost = 3 man-months/10.35 man-months * $70k/yr = **$20.3k**

[2]Estimated cost for the magnetic mapper, data acquisition system and misc hardware is $100.0k but cost is shared equally between the Central Magnet Outer Coils and the Muon Piston Coils. Since the magnetic mapper will already be available when the inner coils are installed, the cost to the CM Inner Coil is **$0.0k**

Total cost is **$20.3k**

Unit type: ea **Number of units:** 1 pair

Estimate Type: Bottoms Up (BU)

Risk Factors:
Technical: 4 Basis: New design based on established, well-proven technology.
Cost: 3 Basis: Cost based on vendor estimates.
Schedule: 2 Basis: Coil will not be available at Detector start-up.

Definitions for use of the Risk Factors are as follows:

Risk Factor Table

Risk Factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
10	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
15	New design way beyond the current state-of-the-art	Engineering judgment	not used

Contingency is calculated using the above Risk Factors and the Risk Percentage Table. The following is the Risk Percentage Table:

Risk Percentage Table

	Condition	Risk Percentage
Technical	Design OR manufacturing concerns	2%
	Design AND manufacturing concerns	4%
Cost	Material cost OR labor rate concern	1%
	Material cost AND labor rate concern	2%
Schedule		1%

Contingency is calculated by multiplying the Risk Factor by the appropriate Risk Percentage using the table above.

Contingency (%) = [Technical Risk Factor X Risk Percentage] + [Cost Risk Factor X Risk Percentage] + [Schedule Risk Factor X Risk Percentage]

As an example, the maximum contingency allowed by this process is:
Maximum contingency = [15 X 4%] + [15 X 2%] = [8 X 1%] = 98%

Values greater than 98% contingency can be used at the discretion of the estimator. Additional justification must be included to warrant these higher contingency values.

Contingency: [4 X 2%] + [3 X 2%] + [2 X 1%] = 16%

Misc Comments:

Basis of Estimate

WBS: 5.1.3 Item: PHENIX - Central Magnet Steel

Date: Oct 5, 1993 Rev: 0K By: J. Bowers

Element Scope:

This element covers the entire cost of the engineering, design, fabrication, assembly, installation and testing of the central magnet steel and its associated support structure for the Central Magnet.

Technical design description:

The basic magnet steel structure will consist of two poles, two large flux returns, and a support structure. All magnetic material will be ASTM 1006, or equivalent. The large size of these poles exceeds world fabrication capacity, so each is split into three concentric parts. The outermost part, called the pole ring (AAA93-101850), has a finished weight of 60 tons and interfaces the flux returns. The pole piece (AAA93-101853) fits into the pole ring and weighs 61 tons. The center element of the pole, which surrounds the RHIC beam pipe, is made from thick rolled plate and weighs seven tons. Machined circular grooves in the pole assemblies accept the inner and outer coils. The two poles will be separated by a nominal gap of 1.2 meters, and will resist an attractive force of approximately 170,000 lb. The two facing poles will be magnetically and structurally tied together with two large flux return yokes(approx. 3.2 M^2 cross section), attached to the top and bottom of the poles. The large size of these return yokes dictates that they be split into smaller pieces. Each yoke subassembly consists of two pole keys and a yoke. Total weight of the each yoke subassembly is 90 tons. The entire pole assembly will be supported on a rigid steel structure. This structure will be designed to allow the Central Magnet to translate a short distance (1.5m) along the beam axis (z direction) and then move horizontally transverse to the beam (x direction) several meters into the working area of the detector hall. A transporter system consisting of Hilman rollers, hydraulic jacks, and steel plate is planned for this purpose. Primary loadings on the magnet assembly include seismic excitation, magnetic forces, and thermal expansion. Each of these is addressed in the design details.

Entire magnet assembly, excluding the transport system, will be fabricated and prefit in Russia. Design will accomodate shipping constraints, and allow 100% bolt up assembly at BNL. A strict quality assurance program will be implemented in Russia to minimize risk to the program. An installation study will be performed by an experienced rigging company to determine equipment, manpower, space, time and logistics requirements. A contract will be negotiated with Long Island Lighting Company (LILCO) for use of their docking facility at Shoreham Nuclear Power Station, which is in close proximity to BNL. This facility will be used to off load major steel components from barges to be transported over local roads using multiaxis, self jacking trailers.

Eng/Dsgn/Ins/Adm (mm): 35.30[1] Cost ($k):348.48 Dur: 4/92-10/95

5.1.3.1 Central Magnet Steel:

This estimate for EDIA is based upon recent LLNL design experience resulting from the design and specification of a magnet subsystem for another large particle detector(SSCL/GEM). The manpower for this effort is divided into two categories: effort required for the engineering/design/analysis (Dsgn Phase) of the steel (11/92 through 10/93; 12 months) and effort required for the purchase/fabrication/assembly/installation/test (Fab Phase) of the steel (11/93 through 10/95; 24 months). As of the end of July, '93, approx. **$108K** has been spent on the final design and analysis of the central magnet steel. In addition to the estimate below, LLNL has contributed **$24k** to the preliminary engineering design of the central magnet steel during the early stages of the PHENIX program. This amount is included in the EDIA total shown above. A rigging study will cost approximately $30k, and will be subcontracted at a fixed price to an outside vendor. This cost will be shared by the muon steel and the central magnet steel, at **$15k** each.

EDIA costs for Russia are calculated in the charts below, and are in addition to the cost estimated if all work was done in the US. These additional costs are due to estimates of project management and quality assurance associated with construction in Russia, as well as lost time inherent in the inefficient nature of both travel to Russia and communication delays of critical information. These activities are also included in the Muon Magnet steel EDIA (5.1.5), but costs are not double counted. Purchasing expenses are for smaller items, such as nuts and bolts. The estimate is based upon actual LLNL charge rates for each individual and averaged by category type and is estimated as follows:

Design phase labor costs:

WBS	Name	Type	Salary $av/mo	Design m-m's	Design total k$	Russia des m-m's	Russia des total k$	total K$
5.1.3.1.1	Bob Yamamoto	Eng	9,281	0.8	$7.42	0.5	$4.64	$12.07
5.1.3.1.4	Joel Bowers	Eng	9,281	2	$18.56	1	$9.28	$27.84
5.1.3.1.5	Palmer House	Eng	9,281	0.5	$4.64	0	$0.00	$4.64
5.1.3.1.6	Metallurgist	Eng	9,281	0.5	$4.64	1	$9.28	$13.92
5.1.3.1.9	Marcus Libkind	Eng	9,281	2	$18.56	0	$0.00	$18.56
5.1.3.1.12	Dwg Checker	Des	6,506	1	$6.51	0	$0.00	$6.51
5.1.3.1.10	Purchasing	Pur	6,506	0	$0.00	0	$0.00	$0.00
5.1.3.1.13	Larry Mullins	Des	6,506	2	$13.01	1	$6.51	$19.52
5.1.3.1.15	Coord/QA	Cord	6,506	0.75	$4.88	0.75	$4.88	$9.76
			totals:	9.55	$78.23	4.25	$34.59	$112.82

Fabrication phase labor costs:

WBS	Name	Type	Salary $av/mo	US Fab m-m's	US Fab total k$	Russia Fab m-m's	Russia Fab total k$	total K$
5.1.3.1.1	Bob Yamamoto	Eng	9281	1	$9.28	0.5	$4.64	$13.92
5.1.3.1.4	Joel Bowers	Eng	9281	1.5	$13.92	1.5	$13.92	$27.84
5.1.3.1.5	Palmer House	Eng	9281	1.5	$13.92	0	$0.00	$13.92
5.1.3.1.6	Metallurgist	Eng	9281	0.5	$4.64	1	$9.28	$13.92
5.1.3.1.9	Marcus Libkind	Eng	9281	0	$0.00	0	$0.00	$0.00
5.1.3.1.12	Dwg Checker	Des	6506	0	$0.00	0	$0.00	$0.00
5.1.3.1.10	Purchasing	Pur	6506	2	$13.01	0	$0.00	$13.01
5.1.3.1.13	Larry Mullins	Des	6506	1	$6.51	1	$6.51	$13.01
5.1.3.1.15	Coord/QA	Cord	6506	2	$13.01	2	$13.01	$26.02
			totals:	9.5	$74.29	6	$47.36	$121.66

5.1.3.1.16 LLNL contribution: preliminary engineering design: **$24k**

5.1.3.1.17 Rigging study contract: **$15k**

total manpower for US estimate = $78.23k + $74.29k = $152.52k
additional cost if procured in Russia = $34.59k + $47.36k = $81.95k

total manpower cost if procured in Russia = $112.82k + $121.66k = **$234.48k**

5.1.3.1.18 Travel: During the design phase, estimated travel to domestic steel vendors and trips to BNL to be a total of 1 per 2 months, which equals 6 trips. Assume 2 people per trip @ $2k average cost per trip. An additional trip to Russia cost $6k, divided between the central magnet and the muon magnet. During the fabrication phase, estimated travel to BNL totals 6 trips. Approximately 6 additional trips to Russia at $6k per trip. All trips are divided between the central magnet and the muon magnet.

design phase domestic travel: (6 trips) X (2 people) X ($2k/trip)/2 = $12k
design phase trip to Russia: (1 trip) X (2 people) X ($6k/trip)/2 = $6k
(this trip not required if all fabrication is done in the US)

fabrication phase domestic travel:(6 trips) X (2 people) X ($2k/trip) /2 = $12k fabrication phase trips to Russia: (6 trips) X (2 people) X ($6k/trip)/2 = $36k

Total travel cost is: $12k + $6k + $12k + $36k = **$66k**

Based upon the last 6 months, the following items incurred real costs on the PHENIX program at LLNL. These cost are estimated for the duration of the task:

5.1.3.1.19 TID (Technical Information Department) which includes photocopying, color reproduction, making design review booklets, etc. An average cost of $700/mo were incurred for the entire PHENIX program at LLNL. It is estimated that these costs will decrease over the life of the program. These costs are estimated at $200/mo. for the total PHENIX project or $50/mo per major task (CM coils + steel & MM coils + steel).
TID cost is: ($50/mo) X (24 months) = **$1.2K**

5.1.3.1.20 Computer support (includes upgrading AutoCad revisions, quickmail troubleshooting, etc) is:
$10/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$5.2k**

5.1.3.1.21 FED X and office supplies is:
$5/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$2.6k**

Total CM steel EDIA cost:
$24.0k + $15k + $234.48k + $66k + $1.2k + $5.2k + $2.6k = **$348.48k**

[1]plus travel and other related expenses

Prototype ($k): **0 k** Dur: n/a

5.1.3.2 No prototype work is planned for the central magnet steel.

Fabrication ($k): **$1110k** Dur: **1/94-1/95**

5.1.3.3 Central Magnet Steel:

The fabrication of the Central Magnet steel and structure will be a build to print from LLNL provided drawings. The large pole pieces (approx. 105 tons each) will be either cast or forged due to its large size and weight. In addition, magnetic performance is enhanced (the fewer the joints the better) and assembly time minimized by making the poles in single units. Based on vendor estimates, it will take approx. 12 months to fabricate, machine and transport to BNL the two large pole pieces. The fabrication cost estimate for the poles is provided in the form of a vendor estimate made for budgetary purposes. The balance of the magnetic steel and steel support structure is based on current market prices for cast and plate steel and generally accepted fabrication practices. The engineering supervision provided by LLNL for this task is included in 5.1.3.1, the EDIA for fabrication by a vendor.

Russian steel fabrication costs are based on one half the domestic cost of the same items, minus additional PHENIX expenses associated with Russian procurement..

Most recent vendor estimates are about four months old, and represent a different design than is currently being contemplated. However, the size and scope of the the total job has not changed enough to discount the validity of these estimates. Not included are the outriggers, transport system, and track system. The estimates were given in different levels of detail, but can be summarized as follows:

Vendor A	$1500k
Vendor B	$1522k
Vendor C	$2400k
Vendor D	$3800k

If we discount highest and lowest estimates,
average of the two middle estimates: $(1522+2400)/2 = $1961k

Several items are not included in the above estimates and are enumerated below.

transport system = $86k

track system = $175k

Total domestic steel fabrication cost:
$1961k+ $86k+ $175k= ***$2222k***

Part of domestic steel fabrication done in Russia
= ***$1961k***

Part of domestic steel fabrication done in US
= ***$2222k- $1961k= $261k***

Total estimated payment to Russian supplier:
Total payment to the Russian supplier is calculated by taking 50% of the US based cost estimate and subtracting additional costs which are unique to the Russian procurement. These additional costs include extra shipping and extra EDIA due to the logistics of working with a Russian supplier. Current Russian estimate for trans Atlantic shipping is $175k, which is subtracted from the US based cost estimate below. We divide this shipping cost equally between the muon magnet and the central magnet.

$1961k/2 - $175/2k (shipping) - $81.95k (Russian fab EDIA) = $811k
(this number used in agreement between BNL and PNPI)

Total cost to fabricate in Russia (with some items in US), including overland shipping:
The total cost to fabricate in Russia includes the estimated payment to the Russian supplier plus US purchased items and an additional $75k required to move the steel overland to BNL, divided between the muon magnet and the central magnet.

$811k (Russian cost) + $261k (US items)+ $75k/2 (overland shipping) = **$1110k**

Assy/Installation (mm): 23.0 **Cost** ($k): 201.1k **Dur:** 1/95-10/95

5.1.3.4

This includes assembly and installation of the two pole pieces, all magnetic flux return steel and the entire steel support structure (including the Central Magnet transport system) in the detector hall. It includes all structural alignment and fit-up of the magnet and doing all subsystem integration checkouts. Assembly and installation of the outer and inner coils is included in WBS 5.1.1.4 and 5.1.2.4 and is not costed here. Once magnet assembly is complete, the magnet will be rolled into place and installed in its operating position on the RHIC beamline. The engineering supervision for this task is included in 5.1.3.1, the EDIA for this portion of assy/installation.

Magnet assembly will require 10 technicians 2 months to construct and assemble the magnet support structure, completely assemble the two pole pieces onto the support structure and align and mate all hardware. This work includes welders, riggers and general technicians as well as their own supervisory staff. This time includes the moving of the subassembly from the high bay area (where assembly is taking place) into the beamline itself. In addition, 2 alignment surveyors will be needed for 3 months. Their effort will be shared equally between the Muon Piston Magnet so the amount charged will be a total of 3 man-months. Total manpower required for the central magnet is 23 man-months. Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 10.35 man-months per man year to account for items such as vacation, sick leave, holidays, etc.

Assumptions:
outside rigging specialists cost $119k/year, 25% of total
local assembly labor cost $70k/year, 75% of total

Combined cost of rigging team = $82.25k/year

Cost = 23.0 man-months/10.35 man-months * $82.25k/yr = **$182.8k**

Misc. hardware and supply costs is estimated at 10% of labor costs or **$18.3k**.

Total cost is: $182.8k + $18.3k = **$201.1k**

Testing (mm): 0.0 **Cost** ($k): 0.0k **Dur:** n/a

5.1.3.5

No activity or task is associated with this task.

Unit type: ea **Number of units:** 1

Estimate Type: Bottoms Up (BU)

Risk Factors:

Technical: 6 Basis: Fabrication of large pole pieces is at industry limit.
Cost: 3 Basis: Cost based on several vendor budgetary estimates.
Schedule: 8 Basis: Fabrication delay affects overall Detector completion.

Definitions for use of the Risk Factors are as follows:

Risk Factor Table

Risk Factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
10	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
15	New design way beyond the current state-of-the-art	Engineering judgment	not used

Contingency is calculated using the above Risk Factors and the Risk Percentage Table. The following is the Risk Percentage Table:

Risk Percentage Table

	Condition	Risk Percentage
Technical	Design OR manufacturing concerns	2%
	Design AND manufacturing concerns	4%
Cost	Material cost OR labor rate concern	1%
	Material cost AND labor rate concern	2%
Schedule		1%

Contingency is calculated by multiplying the Risk Factor by the appropriate Risk Percentage using the table above.

Contingency (%) = [Technical Risk Factor X Risk Percentage] + [Cost Risk Factor X Risk Percentage] + [Schedule Risk Factor X Risk Percentage]

As an example, the maximum contingency allowed by this process is:
Maximum contingency = [15 X 4%] + [15 X 2%] = [8 X 1%] = 98%

Values greater than 98% contingency can be used at the discretion of the estimator. Additional justification must be included to warrant these higher contingency values.

Contingency: [6 X 4%] + [3 X 1%] + [8 X 1%] = **35%**

Misc Comments:

Trans Atlantic shipping requires a 100% contingency.

Basis of Estimate

WBS: **5.1.4** Item: **PHENIX - Muon Piston Mag Coils**

Date: October 4, 1993 Rev: 0K By: R. Yamamoto

Element Scope:

This element covers the entire cost of the engineering, design, fabrication, assembly, installation and testing of the two cylindrical coils for the Muon Piston Magnet (MM).

Technical design description:

Muon Piston Coil:

The muon piston coil (1 required) is a bifilar wound solenoidal coil (having two layers) which will be vacuum epoxy impregnated onto its epoxy-fiberglass winding form. It is made up of two identical coils with the only difference being that one is slightly smaller in diameter than the other. Each coil is 676.4 mm (26.63 in) in overall length. The small coil (coil #1) is nominally 1623.8 mm (63.93 in) in ID and 1740.4 mm (68.52 in) in OD. The large coil (coil #2) is 1880.6 mm (74.04 in) in ID and 1997.2 mm (78.63 in) in OD.

The muon piston coil has a design value of 300,000 amp-turns. It utilizes a square, hollow, copper magnet conductor which is nominally 24.13 mm (0.95 in) square with a 15.49 mm (0.6098 in) hole. The coil configuration is a 102 turn conductor package comprised of two layers of solenoidal type windings. Each coil has 51 turns each. Total conductor length required is 581meters (1906 ft) for the entire two coil assembly; the small coil requires 270 meters of conductor and the large coil requires 311 meters. Overall coil assembly weight is 2047 kg (4514 lbs); the small coil weighs 951 kg (2097 lbs) and the large coil weighs 1096 kg (2417 lbs). Each bifilar wound conductor segment has its own individual water circuit in addition to each coil layer having its own parallel water supply giving rise to a total of 8 individual water circuits. The LCW system provides cooling water to achieve a pressure drop of 60 psig with a maximum water temperature rise of 35°C (inlet water temperature is 20°C) which corresponds to an average conductor temperature of 25.6°C for the smaller coil and 27.1°C for the larger coil. The copper conductor will be insulated with a "half-lap" of mylar tape enclosed in a continuous dacron sheath, wound on a coil winding form, ground wrapped with wide dacron cloth tape and epoxy impregnated under vacuum in a potting mold. Both before and after vacuum impregnation, the coils will be electrically checked for shorts and hydrostatically pressure checked and flow checked through each of the 8 water circuits. Required water flow rate is approx. 67.9 gallons/minute for the entire coil assembly; 35.3 gpm for the small coil and 32.6 gpm for the large coil.

The muon coil requires 2941 amps @ 76.6 volts (35.5 volts for the small coil and 41.1 volts for the large coil) for a power supply requirement of 225 kwatts (300,000 amp-turns). The coil can theoretically achieve 587,739 amp-turns by allowing the outlet water temperature to rise to 80°C (vs. approx. 34°C) and using a power supply of 944 kwatts (5762 amps @164 volts).

Eng/Dsgn/Ins/Adm (mm): 12.25[1] Cost ($k):148.57k Dur: 4/93-10/95

5.1.4.1 MM Coils:
This estimate for EDIA is based upon recent design experience resulting from the design of several conventional coil magnet subsystems (including the CM Outer Coils) and from the experience gained in the design and specification of the GEM magnet subsystem The manpower for this effort is divided into two categories: effort required for the engineering/design/analysis (Dsgn Phase) of the coil (4/93 through 8/93; 5 months) and effort required for the purchase/fabrication/assembly/installation/test (Fab Phase) of the coil (the present plan is that the MM coils will be fabricated somewhere in the United States and will take approx. 12 months to procure and fabricate). As of the end of July, '93, approx. $46K has been spent on the final design and analysis of the MM coils. In addition to the estimate below, LLNL has contributed **$30k** to the preliminary engineering design of the MM coils during the early stages of the PHENIX program. This amount is included in the EDIA total shown above.
The estimate is based upon actual LLNL charge rates for each individual and averaged by category type and is estimated as follows:

WBS	Name	Type	Salary $av/mo	Design m-m's	Design total k$	Fab m-m's	Fab total k$	total K$
5.1.4.1.1	Bob Yamamoto	Eng	9,281	1.50	$13.92	2.00	$18.56	$32.48
5.1.4.1.2	Ross Schlueter	Eng	9,281	0.50	$4.64	0.00	$0.00	$4.64
5.1.4.1.3	Art Harvey	Eng	9,281	1.00	$9.28	0.00	$0.00	$9.28
5.1.4.1.7	Winston Wong	Des	6,506	3.00	$19.52	1.00	$6.51	$26.03
5.1.4.1.8	Brigitte Gim	Des	6,506	0.50	$3.25	1.00	$6.51	$9.76
5.1.4.1.11	Rudy Carpenter	Cord	6,506	0.75	$4.88	0.50	$3.25	$8.13
5.1.4.1.12	Checker	Des	6,506	0.50	$3.25	0.00	$0.00	$3.25
			totals:	**7.75**	**$58.74**	**4.50**	**$34.83**	**$93.57**

5.1.4.1.13 LLNL contribution: preliminary engineering design: **$30k**

5.1.4.1.14 Travel: Estimate travel to coil vendors and trips to BNL to be a total of 4 trips for the duration of the job. Total time required to complete this task is 5 mo for design (in which 4 months is already completed) + effort through the fall of '95 (for fabrication, assembly, installation and testing at BNL) which equals 24 months. This does not include any foreign travel as it is assumed that the fabrication of the coils will be done in the US. Assume 2 people per trip @ $2k average cost per trip.
Total travel cost is: (4 trips) X (2 people) X ($2k/trip) = **$16k**

Based upon the last 6 months, the following items incurred real costs on the PHENIX program at LLNL. These cost are estimated for the duration of the task:

5.1.4.1.15 TID (Technical Information Department) which includes photocopying, color reproduction, making design review booklets, etc. An average cost of $700/mo were incurred for the entire PHENIX program at LLNL. It is estimated that these costs will decrease over the life of the program. These costs are estimated at $200/mo. for the total PHENIX project or $50/mo per major task (CM coils + steel & MM coils + steel).
TID cost is: ($50/mo) X (24 months) = **$1.2K**

5.1.4.1.16 Computer support (includes upgrading AutoCad revisions, quickmail troubleshooting, etc) is:
$10/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$5.2k**

5.1.4.1.17 FED X and office supplies is:
$5/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$2.6k**

Total CM Inner Coil EDIA cost:
$93.57k + $30k + $16k + $1.2k + $5.2k + $2.6k = **$148.57k**

[1]plus travel and other related expenses

Prototype ($k): **10k** Dur: **8/92-10/92**

5.1.4.2 Prototype work was done during the conceptual design of the MM Coil. A 1/4 scale prototype of the tapered coil concept was fabricated by the LLNL coil shop to demonstrate the feasibility of making this type of coil. The conclusion is that this type of tapered coil can be made without a large degree of difficulty. LLNL provided the labor and materials to produce this prototype. Total prototype cost is **$10k**. Subsequently, the two coil cylindrical solenoid concept was adopted as the baseline. This configuration is costed in this BOE.

Fabrication ($k): **166.8 + 58.0 = 224.8k** Dur: **3/94-2/95**

5.1.4.3 MM Coils:

The fabrication of the MM Coils will be a build to print from LLNL provided drawings. The winding mandrel and the potting fixture will be specified by LLNL. The detail design of this support hardware will be the responsibility of the coil vendor with the design being approved by LLNL. Based on vendor estimates, it will take 4 months to procure the copper conductor and 8 months to fabricate the coils. The fabrication cost estimate is based on actual cost data from a similar type of epoxy impregnated coil built at LLNL (3/91). Some of the cost data has been modified (downward) due to recent vendor estimates on the cost of the conductor and economy of scale. The engineering supervision provided by LLNL for this task is included in 5.1.4.1, the EDIA for fabrication by a vendor. Historical single coil costs includes:

materials, fixtures, labor	$9.0k	
copper conductor	$1.8k	($4.00/lb for conductor + excess)
misc hardware, supplies	$1.2k	
water manifolds, supports	$3.0k	
Total:	$15.0k	per 450 lb complete coil assembly

5.1.4.3.1 Muon coil (1):
MM coil cost estimate on a per lb basis:
MM Coil total weight: 4514 lbs
Coil Fabrication cost: 4514 lbs times $15k/450 lbs = $150.5k

In addition, 3 budgetary estimates from vendors were received:

Estimate #1: (from KEK/Japanese company): $150+K (@¥125=$1) which includes the copper conductor + coils only.
Cost for misc. hardware + manifolds, etc: [$1.2k + $3.0k] X 4514/450 lbs = $42.1k
Total cost: $150+k + $42.1k = $192.1+k

Estimate #2: (from US company): $77k which includes the coils only.
Cost for copper conductor + misc. hardware + manifolds, etc: [$1.8k + $1.2k + $3.0k] X 4514/450 lbs = $60.2k
Total cost: $77k + $60.2k = $137.2k

Estimate #3 (from US company): $67.3k which includes the coils only.
Cost for copper conductor + misc. hardware + manifolds, etc: [$1.8k + $1.2k + $3.0k] X 4514/450 lbs = $60.2k
Total cost: $67.3k + $60.2k = $127.5k

Average MM Coil costs: [150.5k + $192.1k + $137.2k + 127.5k]/4 units = **$151.8k.**

A special handling fixture has been identified to safely transport and install the MM coils onto the muon piston core. Estimated cost of this fixture is **$15k** (120 hours fab time X $100/hr. shop rate + $3k for raw materials).

Total cost is: $151.8k + $15k = **$166.8k**

<u>5.1.4.3.2</u> Power Supplies: Muon Coil (1):

The power supply specified is the nominal amount required to achieve the baseline operating field of the magnet system. It includes extra capacity to account for voltage drop through the electrical bus system and some safety margin. The muon coils will be run in series by a single power supply to eliminate any power fluctuations between coils that might occur if two separate power supplies were used. This effect would create a non uniform magnetic field which is very undesirable. Provided is the following table which reflects both baseline and maximum operating coil conditions (maximum coil operating set by limiting the exit cooling water temperature to 80°C):

Coil type	amp-turns baseline	reqd power supply baseline	amp-turns maximum	reqd power supply maximum
muon	300,000	225 kwatts	587,739	944 kwatts

The power supplied specified for the MM Coil is:
3600 amps @125 volts which equals 450 kwatts
(Baseline coil requirement is 2941 amps @76.6volts)

Nominal power supply requirements include:
Input Voltage 13.8 kv (or 480 volt) - 3 phase

Rectifier Configuration	12 phase
Output Voltage Ripple	5 volts (use output filter)
Long Term Reproducibility	0.1% (one year)
One Hour Stability	0.01%
One Minute Stability	0.001%
Control and Status Interface	Digital (Optional)
Trim Input Analog Range	1%
Input Tap Switch Settings	100%, 50% and 25%, (Optional)
Reversing Switch	Mechanical (Optional)

Two budgetary estimates were received from US Companies:

Estimate #1: $46k
Estimate #2: $70k

Average MM Coil Power Supply cost: **$58k**

Total fabrication costs: $166.8k + $58k = **$224.8k**

Assy/Installation (mm): 3.0 **Cost** ($k): 20.3k **Dur:** 3/95-6/95

5.1.4.4 MM Coils:

This includes installing the MM coils onto the Muon piston steel in the detector hall. It includes all of the electrical and LCW (low conductivity water) hook-ups and doing all system integration checkouts. Once completed, the MM is ready for test operation. The engineering supervision for this task is included in 5.1.4.1, the EDIA for this portion of assy/installation.

The MM coils will require special handling and installation fixturing to prevent possible damage of the coils. The cost of this fixture is included in the fabrication section above. I estimate it will take approx. 3 technicians 1 month to completely assemble and install the coils onto the piston. This would include all of the additional fixturing and preparation required for this installation. The coil subassemblies will come from the vendor ready for coil installation. Little work will need to be done to the coils on site in preparation of this task. Total manpower required for the MM coils is: 3 technicians X 1 month = 3 man-months. Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 0.29 man-years and accounts for items such as vacation, sick leave, holidays, etc. The dollar rate used assumes that BNL staff will be used to support this task.

Cost = 0.29 man-years * $70k/yr = **$20.3k**

Testing (mm): 3.0 **Cost ($k):** 70.29k[2] **Dur:** 7/95-10/95

5.1.4.5 MM Coils:

This includes running the MM coils at full rated current, magnetically mapping the magnetic field produced in the cone volume between the piston and the lampshades and other key locations around the magnet as required and checking all instrumentation and system performance. The engineering supervision for this task is included in 5.1.4.1, the EDIA for this testing.

It is estimated that it will take 3 technicians 1 month to test and map the coil.

Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 10.35 mm per man year to account for items such as vacation, sick leave, holidays, etc. The dollar rate used assumes that BNL staff will be used to support this task.

Cost = 3 man-months/10.35 man-months * $70/yr = **$20.29k**

[2]Estimated cost for the magnetic mapper, data acquisition system and misc hardware is $100.0k but cost is shared equally between the Central Magnet Outer Coils and the Muon Piston Coils so that the cost to the MM Coil is **$50.0k**

Total cost is $20.29k + $50.0k = **$70.29k**

Unit type: ea **Number of units:** 1

Estimate Type: Bottoms Up (BU)

Risk Factors:

Technical:	4	Basis: New design based on established, well-proven technology
Cost:	3	Basis: Cost based on vendor estimates .
Schedule:	4	Basis: Fabrication delay does not affect overall Magnet completion.

Definitions for use of the Risk Factors are as follows:

Risk Factor Table

Risk Factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
10	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
15	New design way beyond the current state-of-the-art	Engineering judgment	not used

Contingency is calculated using the above Risk Factors and the Risk Percentage Table. The following is the Risk Percentage Table:

Risk Percentage Table

	Condition	Risk Percentage
Technical	Design OR manufacturing concerns	2%
	Design AND manufacturing concerns	4%
Cost	Material cost OR labor rate concern	1%
	Material cost AND labor rate concern	2%
Schedule		1%

Contingency is calculated by multiplying the Risk Factor by the appropriate Risk Percentage using the table above.

Contingency (%) = [Technical Risk Factor X Risk Percentage] + [Cost Risk Factor X Risk Percentage] + [Schedule Risk Factor X Risk Percentage]

As an example, the maximum contingency allowed by this process is:
Maximum contingency = [15 X 4%] + [15 X 2%] = [8 X 1%] = 98%

Values greater than 98% contingency can be used at the discretion of the estimator. Additional justification must be included to warrant these higher contingency values.

Contingency: [4 X 2%] + [3 X 2%] + [4 X 1%] = 18%

Misc Comments:

Basis of Estimate

WBS: **5.1.5** Item: **PHENIX - Muon Magnet Steel**

Date: Oct 5, 1993 Rev: 0K By: J. Bowers

Element Scope:

This element covers the entire cost of the engineering, design, fabrication, assembly, installation and testing of the magnet steel and its associated support structure for the Muon Piston Magnet.

Technical design description:

The basic magnet steel structure (LLNL assembly drawing #AAA93-101858-0C)will consist of a large tapered iron core (LLNL drawing #AAA93-101860-0C) bolted to a flux return end plate which is 30 cm (11.81 in) in thickness (LLNL drawing #AAA93-101885-00). Eight trapazoidal steel plates, 8 cm in thickness, are arranged in an octogon pattern ("lampshade") around the iron core. These plates provide the return flux path for the muon piston magnet. The bottom three plates bolt together to form a permanant element of the overall structure. The top five plates are split across the global Z axis into a permanent teacup section and five independently removable lamshade pieces. The tapered iron core will be forged as a single piece and weigh approximately 60 tons. The end plate will be constructed from three plate sections bolted together and the "lampshade" flux return will be fabricated from rolled plate. All magnetic material will be ASTM 1006, or equivalent. The iron core, back plate, and "lampshade" plate assemblies will form a rigid steel structure. This structure will be designed to allow for access of the three sets of muon chambers that mount inside the open volume between the iron core and the "lampshade". The muon piston magnet assembly is a stationary structure which rests on metal shims during detector operation. Steel plates are embedded into the experimental hall floor to provide load spreading of the muon magnet into the concrete foundation.

Primary loadings on the magnet assembly include seismic excitation, magnetic forces, and thermal expansion. Each of these is addressed in the design details.

Entire magnet assembly will be fabricated and prefit in Russia. Design will accomodate shipping constraints, and allow 100% bolt up assembly at BNL. A strict quality assurance program will be implemented in Russia to minimize risk to the program. An installation study will be performed by an experienced rigging company to determine equipment, manpower, space, time and logistics requirements. A contract will be negotiated with Long Island Lighting Company (LILCO) for use of their docking facility at Shoreham Nuclear Power Station, which is in close proximity to BNL. This facility will be used to off load major steel components from barges to be transported over local roads using multiaxis, self jacking trailers.

Eng/Dsgn/Ins/Adm (mm): 37.8[1] Cost ($k): 359.62 Dur: 4/92-10/95

5.1.5.1 Muon Piston Magnet Steel:

This estimate for EDIA is based upon recent LLNL design experience resulting from the design and specification of a magnet subsystem for another large particle detector(SSCL/GEM). The manpower for this effort is divided into two categories: effort required for the engineering/design/analysis (Dsgn Phase) of the steel (11/92 through 10/93; 12 months) and effort required for the purchase/fabrication/assembly/installation/test (Fab Phase) of the steel (11/93 through 10/95; 24 months). As of the end of July, '93, approx. **$109K** has been spent on the final design and analysis of the muon magnet steel. In addition to the estimate below, LLNL has contributed **$24k** to the preliminary engineering design of the muon magnet steel design during the early stages of the PHENIX program. This amount is included in the EDIA total shown above.

A rigging study will cost approximately $30k, and will be subcontracted at a fixed price to an outside vendor. This cost will be shared by the muon steel and the central magnet steel, at **$15k** each.

EDIA costs for Russia are calculated in the charts below, and are in addition to the cost estimated if all work was done in the US. These additional costs are due to estimates of project management and quality assurance associated with construction in Russia, as well as lost time inherent in the inefficient nature of both travel to Russia and communication delays of critical information. These activities are also included in the Central Magnet steel EDIA (5.1.3), but costs are not double counted. Purchasing expenses are for smaller items, such as nuts and bolts. The estimate is based upon actual LLNL charge rates for each individual and averaged by category type as follows.

Design phase labor costs:

WBS	Name	Type	Salary $av/mo	Design m-m's	Design total k$	Russia des m-m's	Russia des total k$	total K$
5.1.5.1.1	Bob Yamamoto	Eng	9,281	0.8	$7.42	0.5	$4.64	$12.07
5.1.5.1.4	Joel Bowers	Eng	9,281	2	$18.56	1	$9.28	$27.84
5.1.5.1.5	Palmer House	Eng	9,281	0.5	$4.64	0	$0.00	$4.64
5.1.5.1.6	Metallurgist	Eng	9,281	0.5	$4.64	1	$9.28	$13.92
5.1.5.1.9	Marcus Libkind	Eng	9,281	2	$18.56	0	$0.00	$18.56
5.1.5.1.12	Dwg Checker	Des	6,506	1	$6.51	0	$0.00	$6.51
5.1.5.1.16	Bob Holmes	Des	6,506	2	$13.01	1	$6.51	$19.52
5.1.5.1.10	Purchasing	Pur	6,506	0	$0.00	0	$0.00	$0.00
5.1.5.1.14	Technician	Tech	6,506	0	$0.00	0	$0.00	$0.00
5.1.5.1.15	Coord/QA	Cord	6,506	0.75	$4.88	0.75	$4.88	$9.76
			totals:	9.55	$78.23	4.25	$34.59	$112.82

Fabrication phase labor costs:

WBS	Name	Type	Salary $av/mo	US Fab m-m's	US Fab total k$	Russia Fab m-m's	Russia Fab total k$	total K$
5.1.5.1.1	Bob Yamamoto	Eng	9,281	1	$9.28	0.5	$4.64	$13.92
5.1.5.1.4	Joel Bowers	Eng	9,281	1.5	$13.92	1.5	$13.92	$27.84
5.1.5.1.5	Palmer House	Eng	9,281	1.5	$13.92	0	$0.00	$13.92
5.1.5.1.6	Metallurgist	Eng	9,281	0.5	$4.64	1.5	$13.92	$18.56
5.1.5.1.9	Marcus Libkind	Eng	9,281	0	$0.00	0	$0.00	$0.00
5.1.5.1.12	Dwg Checker	Des	6,506	0	$0.00	0	$0.00	$0.00
5.1.5.1.16	Bob Holmes	Des	6,506	1	$6.51	1	$6.51	$13.01
5.1.5.1.10	Purchasing	Pur	6,506	2	$13.01	0	$0.00	$13.01
5.1.5.1.14	Technician	Tech	6,506	0	$0.00	1	$6.51	$6.51
5.1.5.1.15	Coord/QA	Cord	6,506	2	$13.01	2	$13.01	$26.02
			totals:	9.5	$74.29	7.5	$58.51	$132.80

5.1.5.1.17 LLNL contribution: preliminary engineering design: **$24k**

5.1.5.1.18 Rigging study contract: **$15k**

total manpower for US estimate = $78.23k + $74.29k = $152.52k
additional cost if procured in Russia = $34.59k + $58.51k = $93.1k

total manpower cost if procured in Russia = $112.82k + $132.80k = **$245.62k**

5.1.5.1.19 Travel: During the design phase, estimated travel to domestic steel vendors and trips to BNL to be a total of 1 per 2 months, which equals 6 trips. Assume 2 people per trip @ $2k average cost per trip. An additional trip to Russia cost $6k, divided between the central magnet and the muon magnet. During the fabrication phase, estimated travel to BNL totals 6 trips. Approximately 6 additional trips to Russia at $6k per trip. All trips are divided between the central magnet and the muon magnet.

design phase domestic travel: (6 trips) X (2 people) X ($2k/trip)/2= $12k
design phase trip to Russia: (1 trip) X (2 people) X ($6k/trip) / 2 = $6k
(this trip not required if all fabrication is done in the US)

fabrication phase domestic travel:(6 trips) X (2 people) X ($2k/trip)/2 = $12k
fabrication phase trips to Russia: (6 trips) X (2 people) X ($6k/trip) / 2 = $36k

Total travel cost is: $12k + $6k + $12k + $36k = **$66k**

Based upon the last 6 months, the following items incurred real costs on the PHENIX program at LLNL. These cost are estimated for the duration of the task:

5.1.5.1.20 TID (Technical Information Department) which includes photocopying, color reproduction, making design review booklets, etc. An average cost of $700/mo were incurred for the entire PHENIX program at LLNL. It is estimated that these costs will decrease over the life of the program. These costs are estimated at $200/mo. for the total PHENIX project or $50/mo per major task (CM coils + steel & MM coils + steel).
TID cost is: ($50/mo) X (24 months) = **$1.2K**

5.1.5.1.21 Computer support (includes upgrading AutoCad revisions, quickmail troubleshooting, etc) is:
$10/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$5.2k**

5.1.5.1.22 FED X and office supplies is:
$5/day X 5 days/wk X 52 wk/yr x 24 mo/12 mo per year = **$2.6k**

Total MM steel EDIA cost:
$24.0k + $15k + $245.62k + $66k + $1.2k + $5.2k + $2.6k = **$359.62k**

[1]plus travel and other related expenses

Prototype (**$k**): **0 k** **Dur:** **n/a**

5.1.5.2 No prototype work is planned for the muon magnet steel.

Fabrication (**$k**): **$1116k** **Dur:** **1/94-1/95**

5.1.5.3 Muon Magnet Steel:

The fabrication of the Muon Magnet steel and structure will be a build to print from LLNL provided drawings. All components will be made from pieces as large as can be fabricated by shops in the St. Petersburg, Russia area. For example, the muon piston core (approx. 60 tons) will be forged from a single ingot. The back plate will be made from 3 major slab sections. Fabrication costs are based on vendor estimates made for budgetary purposes. The balance of the magnetic steel and steel support structure is based on current market prices for cast and plate steel and generally accepted fabrication practices. The engineering supervision provided by LLNL for this task is included in 5.1.5.1, the EDIA for fabrication by a vendor.

Russian steel fabrication costs are based on one half the domestic cost of the same items, minus additional PHENIX expenses associated with Russian procurement. Trans Atlantic shipping has been estimated at $500k for the CM and MM together, or roughly $250k each.

Most recent vendor estimates are about four months old, and represent a different design than is currently being contemplated. However, the size and scope of the the total job has not changed enough to discount the validity of these estimates. The estimates were given in different levels of detail, but can be summarized as follows:

Vendor A	$1000k
Vendor B	$2176k
Vendor C	$2485k

If we discount highest and lowest estimates, use $2176k for cost basis

Several items are not included in the above estimates and are enumerated below.

Mounting plates embedded in hall floor: $25k

Access doors/tracks/actuators for muon magnet lampshade: 8 x $12k = $96k

Jacking cylinders and wedge supports: $50k

Total domestic steel fabrication cost:
2176k + $25k + $96k + $50k = ***$2347k***

Part of domestic steel fabrication done in Russia
= ***$2176k***

Part of domestic steel fabrication done in US
= ***$2347k- $2176k= $171k***

Total estimated payment to Russian supplier:
Total payment to the Russian supplier is calculated by taking 50% of the US based cost estimate and subtracting additional costs which are unique to the Russian procurement. These additional costs include extra shipping and extra EDIA due to the logistics of working with a Russian supplier. Current Russian estimate for trans Atlantic shipping is $175k, which is subtracted from the US based cost estimate below. We divide this shipping cost equally between the muon magnet and the central magnet.

$2176k/2 - $175/2k (shipping) - $93.1k (Russian fab EDIA) = $907.4k
(this number used in agreement between BNL and PNPI)

Total cost to fabricate in Russia (with some items in US), including overland shipping:
The total cost to fabricate in Russia includes the estimated payment to the Russian supplier plus US purchased items and an additional $75k required to move the steel overland to BNL, divided between the muon magnet and the central magnet.

$907.4k (Russian Cost) + $171k (US items) + $75k/2 (overland shipping) = **$1116k**

Assy/Installation (mm): 21.0 Cost ($k): 183.6k Dur: 1/95-10/95

5.1.5.4

This includes assembly and installation of the piston core, the back plate, the muon ID plates, the "lampshade" flux return and the entire steel support structure required to support this assembly in the detector hall. It includes all structural alignment and fit-up of the magnet and doing all subsystem integration checkouts. Assembly and installation of the muon piston coil is included in WBS 5.1.4 and is not costed here. Once magnet assembly and installation is complete, the magnet will be in its operating position on the RHIC beamline and ready for final checkout and testing. The engineering supervision for this task is included in 5.1.5.1, the EDIA for this portion of assy/installation.

Magnet assembly and installation will require 6 technicians 3 months to construct and assemble the magnet support structure, completely assemble the iron core onto the back plate, assemble the "lampshade" plate elements and align and mate all hardware. This work includes welders, riggers and general technicians as well as their own supervisory staff. In addition, 2 alignment surveyors will be needed for 3 months. Their effort will be shared equally between the Central Magnet so the amount charged will be a total of 3 man-months. Total manpower required for the muon piston magnet is 21 man-months. Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 10.35 man-months per man year to account for items such as vacation, sick leave, holidays, etc.

Assumptions:
outside rigging specialists cost $119k/year, 25% of total
local assembly labor cost $70k/year, 75% of total

Combined cost of rigging team = $82.25k/year

Cost = 21.0 man-months/10.35 man-months * $82.25k/yr = **$166.9k**

Misc. hardware and supply costs is estimated at 10% of labor costs or **$16.7k.**

Total cost is: $166.9k + $16.7k = **$183.6k**

Testing (mm): 0.0 Cost ($k): 0.0k Dur: n/a

5.1.5.5

No activity or task is associated with this task.

Unit type: ea **Number of units:** 1

Estimate Type: Bottoms Up (BU)

Risk Factors:

Technical: 6 Basis: Fabrication of large iron core is at industry limit.
Cost: 3 Basis: Cost based on several vendor budgetary estimates.
Schedule: 8 Basis: Fabrication delay affects overall Detector completion.

Definitions for use of the Risk Factors are as follows:

Risk Factor Table

Risk Factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
10	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
15	New design way beyond the current state-of-the-art	Engineering judgment	not used

Contingency is calculated using the above Risk Factors and the Risk Percentage Table. The following is the Risk Percentage Table:

Risk Percentage Table

	Condition	Risk Percentage
Technical	Design OR manufacturing concerns	2 %
	Design AND manufacturing concerns	4 %
Cost	Material cost OR labor rate concern	1 %
	Material cost AND labor rate concern	2 %
Schedule		1 %

Contingency is calculated by multiplying the Risk Factor by the appropriate Risk Percentage using the table above.

Contingency (%) = [Technical Risk Factor X Risk Percentage] + [Cost Risk Factor X Risk Percentage] + [Schedule Risk Factor X Risk Percentage]

As an example, the maximum contingency allowed by this process is:
Maximum contingency = [15 X 4%] + [15 X 2%] = [8 X 1%] = 98%

Values greater than 98% contingency can be used at the discretion of the estimator. Additional justification must be included to warrant these higher contingency values.

Contingency: [6 X 4%] + [3 X 1%] + [8 X 1%] = **35%**

Misc Comments:

Trans Atlantic shipping requires a 100% contingency.

Basis of Estimate

WBS: **5.1.6** Item: **PHENIX - Muon ID Steel**

Date: Oct 4,1993 Rev: 0G By: J. Bowers

Element Scope:

This element covers the entire cost of the engineering, design, inspection and administration of the PHENIX Muon ID Steel. Conceptual design has not yet been performed, so estimates are based on incomplete design requirements.

Technical design description:

The Muon ID will consist of several layers of low carbon steel plate located behind the high Z end of the Muon Magnet assembly. The configuration of layer thicknesses, from the low z to the high Z direction, is 10 cm, 10cm, 20 cm, 20 cm, 20 cm, with a 20 cm air gap between each layer. In addition, bracing and anchoring structures must be designed to accommodate safety requirements. The assembly must also allow for the Muon ID panels to be installed, secured and aligned.

Eng/Dsgn/Ins/Adm (mm): 21[1] **Cost** ($k): 139.04 **Dur:** 8/93-3/95

5.1.6.1

This estimate for EDIA is based upon recent LLNL design experience resulting from the design and specification of the magnet subsytems for the PHENIX detector. The manpower for this effort is divided into two categories: effort required for the engineering/design/analysis and effort required for the purchase/fabrication/assembly/installation/test (Fab Phase) of the steel. The estimate is based upon actual LLNL charge rates for each individual and averaged by category type and is estimated as follows:

WBS	Name	Type	Salary $av/mo	Design m-m's	Design total k$	Fab m-m's	Fab total k$	total K$
5.1.6.1.1	Bob Yamamoto	Eng	9,281	0.5	$4.64	0.5	$4.64	$9.28
5.1.6.1.2	Joel Bowers	Eng	9,281	3	$27.84	2	$18.56	$46.41
5.1.6.1.3	Palmer House	Eng	9,281	1	$9.28	0	$0.00	$9.28
5.1.6.1.4	Marcus Libkind	Eng	9,281	1	$9.28	0	$0.00	$9.28
5.1.6.1.5	Bob Holmes	Des	6,506	4	$26.02	0.5	$3.25	$29.28
5.1.6.1.6	Coord/QA	Coord	6,506	1	$6.51	2	$13.01	$19.52
			totals:	10.5	$83.58	5	$39.47	$123.04

Travel: Estimate travel to steel vendors/rolling mills and trips to BNL to be a total of 4 trips for the duration of the job. This travel does not include potential foreign travel to Europe/Russia and Asia since it is assumed that we will use surplus steel that has been identified at several locations within the US. Assume 2 people per trip @ $2k average cost per trip.

Total travel cost is: (4 trips) X (2 people) X ($2k/trip) = **$16k**

Additional costs for TID (Technical Information Department) charges, video conferencing, computer support, Federal Express, and office supplies are included in steel estimates for the Central Magnet and Muon Magnet, and are not counted here.

Total EDIA cost: $123.04k + $16k = **$139.04k**

[1] not including travel

Prototype ($k): 0 k **Dur:** n/a

5.1.6.2 No prototype work is planned for the muon ID steel.

Fabrication **($k): $412** **Dur: 1/94-9/94**

5.1.6.3 Muon ID Steel:

The fabrication of the Muon ID steel and structure will be a build to print from LLNL provided drawings. The large slab pieces will be produced from rolled plate generally in the reject or seconds category because of its chemical composition. No specification on mechanical properties or chemical composition will be given in the purchase order other than minimum iron content, uniformity, and continuity. Domestic estimates have been obtained based on current stock availability at vendor's locations, with some projections on future availability. Since this is mill reject material, there is no guarantee on pricing or stock inventory until actual time of RFQ.

Quantities required for the Muon ID result in an approximate price of $0.21/lb, including cutting and shipping to BNL. Addition costs will be incurred to weld the parts together, and these are included in 5.1.6.4.

Overall dimensions of each muon ID plate = 976 cm wide x 993.5 cm high
Total volume of Muon ID steel (10+10+20+20+20) x 976 x 993.5 = 77,572,480 cm^3

Total weight = 77,572,480 cm^3 /$(2.54)^3$ x 0.28 lb/in^3= 1,325,453 lb = 662 tons

Total cost of steel = 1,325,453 lb x 1.15 (cutting waste) x $0.21/lb = $320k

Add 10% for lifting fixtures/ rigging attachment points = $32k

Blasting/painting = $20k

Foundation plates = $40k

total cost = $320 + $32 + $20 + $40 = $412k

Assy/Installation **(mm): 22.0** **Cost ($k): $442.3k** **Dur: 10/94-3/95**

5.1.6.4

This includes assembly and installation of the foundation plates, all muon ID steel plates, and muon ID panel attachments. It includes all structural alignment and fit-up of each of the precut slabs. Installation of the muon ID panels is not included.

Muon ID assembly will require 10 people 2 months for construction and assembly. This work includes welders, riggers and general technicians as well as their own supervisory staff. This time includes setting up special rigging and welding equipment. In addition, 2 alignment surveyors will be needed for 1 month. Total manpower required is 22 man-months. Use 1794 hours per man year (out of a total of 2080 hours in a year) which equates to 10.35 man-months per man year to account for items such as vacation, sick leave, holidays, etc.

Assumptions:
outside rigging specialists cost $119k/year, 25% of total
local assembly labor cost $70k/year, 75% of total

Combined cost of rigging team = $82.25k/year

Cost = 22.0 man-months/10.35 man-months * $82.25k/yr = $174.8k

Misc. hardware and supply costs is estimated at 10% of labor costs or $17.5k

Use of standard rigging equipment, such as heavy lift jacking frame estimated at $200k

Fabrication of special rigging equipment unique to this assembly $50k

Total cost is: $174.8k + $17.5k + $200k + $50k = **$442.3k**

Testing (mm): 0.0 **Cost ($k): 0.0k** **Dur: n/a**

5.1.3.5

No activity or task is associated with this task.

Unit type: ea **Number of units:** 1
Estimate Type: Bottoms Up (BU)

Risk Factors:
Technical: 6 Basis: Steel composition and quality will vary widely
Cost: 3 Basis: Cost based on several vendor budgetary estimates.
Schedule: 7 Basis: Fabrication delay affects overall Detector completion.

Definitions for use of the Risk Factors are as follows:

Risk Factor Table

Risk Factor	Technical	Cost	Schedule
1	Existing design and off-the-shelf hardware	Off the shelf or catalog item	not used
2	Minor modifications to an existing design	Vendor quote from established drawings	No schedule impact on any other item
3	Extensive modifications to an existing design	Vendor quote with some design sketches	not used
4	New design within established product line	In-house estimate for item within current product line	Delays completion of non-critical path subsystem item
6	New design different from established product line. Existing technology	In-house estimate for item with minimal company experience but related to existing capabilities	not used
8	New design. Requires some R&D development but does not advance the state-of-the-art	In-house estimate for item with minimal company experience and minimal in-house capability	Delays completion of critical path subsystem item
10	New design. Development of new technology which advances the state-of-the-art	Top down estimate from analogous programs	not used
15	New design way beyond the current state-of-the-art	Engineering judgment	not used

Contingency is calculated using the above Risk Factors and the Risk Percentage Table. The following is the Risk Percentage Table:

Risk Percentage Table

	Condition	Risk Percentage
Technical	Design OR manufacturing concerns	2 %
	Design AND manufacturing concerns	4 %
Cost	Material cost OR labor rate concern	1 %
	Material cost AND labor rate concern	2 %
Schedule		1 %

Contingency is calculated by multiplying the Risk Factor by the appropriate Risk Percentage using the table above.

Contingency (%) = [Technical Risk Factor X Risk Percentage] + [Cost Risk Factor X Risk Percentage] + [Schedule Risk Factor X Risk Percentage]

As an example, the maximum contingency allowed by this process is:
Maximum contingency = [15 X 4%] + [15 X 2%] = [8 X 1%] = 98%

Values greater than 98% contingency can be used at the discretion of the estimator. Additional justification must be included to warrant these higher contingency values.

Contingency: [6 X 4%] + [3 X 1%] + [7 X 1%] = **34%**

Misc Comments:

Attachment-2

LLNL-93-018
RHIC-xxxxxx

UNIVERSITY OF CALIFORNIA
LAWRENCE LIVERMORE NATIONAL LABORATORY

TITLE	LLNL Lead Engineer / DATE
RHIC/PHENIX Detector	Joel Bowers
Magnet Steel Fabrication	APPROVED: BNL Procurement M. F. Healey
	APPROVED: PHENIX Collaboration S. Nagamiya
Attachment to Inter laboratory Collaborative Agreement between	APPROVED: RHIC Project Office T. Ludlam
Brookhaven National Laboratory and Petersburg Nuclear Physics Institute	APPROVED: PNPI Director A. Vorobjev
	APPROVED: Efremov/CYCLONE/Director Y. P. Severgin
	APPROVED: Efremov/CYCLONE/Dept. Head V.S. Kashikhin

		CLASSIFICATION
REV. A BY	DATE	

1. SCOPE

1.1 Purpose This attachment defines minimum fabrication and quality assurance requirements for the PHENIX detector magnet steel at the Relativistic Heavy Ion Collider (RHIC) located at Brookhaven National Laboratory (BNL), Upton, NY. Additional requirements may be presented on the accompanying drawings.

1.2 Application This attachment applies to off-site fabrication, fitup, disassembly, and packaging of a large magnet subsystem for RHIC, but does not include on site inspection, assembly and installation. Included are the following operations:

a) Steel ingot production.
b) Fabrication by rolling, forging, forming and machining operations.
c) Cutting by shearing, plasma arc, carbon arc, oxyacetylene, or sawing.
d) Welding low carbon steel, using Gas Tungsten Arc Welding (GTAW), Shielded Metal Arc Welding (SMAW), Submerged Arc Welding (SAW), Gas Metal Arc Welding (GMAW), or Flux Cored Arc Welding (FCAW) processes.
e) Blasting, sanding, polishing, painting, and other finishing operations
f) Cleaning
g Inspection
h) Documentation

1.3. Definitions

LLNL Lawrence Livermore National Laboratory, Livermore, CA, responsible for production of all design drawings, structural calculations, and other informational items required for fabrication.

BNL Brookhaven National Laboratory, Upton, NY, is the site of final assembly, test, and operation of the PHENIX Detector.

Efremov D.V. Efremov Scientific Research Institute of Electrophysical Apparatus, St. Petersburg Russia, generally referred to herein as the Principal Supplier, whose responsibility is the manufacture of the Subsystem in accordance with the Drawing, this Attachment, as well as schedule and budget constraints specified in this Attachment.

PNPI Petersburg Nuclear Physics Institute, Gatchina, Russia, whose responsibility is to be principal scientific and financial liaison to BNL. PNPI shall delegate all manufacturing and engineering responsibility to the Principal Supplier. PNPI physicists will be responsible for mapping the magnet subsystem and for analysis of the mapping data after final installation at BNL.

Central Magnet (CM) A 450 ton assembly of steel forgings and weldments designed to provide a shaped magnetic field for performing high energy physics experiments.

Muon Magnet (MM) A 500 ton assembly of steel plate weldments, and a central conical forging, designed to provide a magnetic field for detection of muons.

The Subsystem The Subsystem is the assembly of steel structures and magnetic field shaping components which comprise the PHENIX Central Magnet and Muon Magnet.

The Drawing Any and all detail and assembly, fabrication and machining drawings or sketches which are supplied by LLNL and constitute the design package for the Subsystem. Not included are shop drawings, such as those for cutting rough shapes, or producing temporary fixtures. Shop drawings are produced as required at the discretion of the Principal Supplier.

Responsible Supplier Any subcontractor, supplier, or collaborating institution who provides goods or services which influence the end product in this Attachment. In some circumstances, Efremov is the Responsible Supplier. A Responsible Supplier is the originator of the goods or services.

Authorized Technical Representative: Individuals who are officially Authorized in this Attachment to represent their respective organizations in all official correspondence regarding technical issues relating to The Drawing or The Subsystem.

LLNL: Joel Bowers, Jim Thomas, Robert Yamamoto
BNL: Sam Aronson, Peter Kroon, Tom Shea
Efremov: V.S. Kashikhin, Y. P. Severgin
PNPI: A. Vorobjev, A. Abrosimov

Codes Documents that have the weight of law in the United States such as the American Welding Society Structural Welding Code D1.1 and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code.

PHENIX Detector Hall A high bay facility at the BNL RHIC site and installation location of the PHENIX Detector.

On Site Location of the PHENIX detector hall facility at BNL

<u>Off Site</u> Any facility besides on site at which some of the construction may take place. This can include steel mills, fabrication shops, and foundries.

2. REFERENCE DOCUMENTS

The following documents form a part of this Attachment to the extent specified herein. The issue date shall be the one in effect on the date of request for quotation. The Principal Supplier will be responsible for resolving any conflicts or contradictions found between this Attachment and the following specifications, or between the listed specifications.

American Society of Mechanical Engineers Boiler and Pressure Vessel Code

Section II	Material Specifications
Section IX	Welding and Brazing Qualification

American Iron and Steel Institute (AISI)

1006	Low carbon steel

American Welding Society (AWS)

A2.4	Symbols for Welding and Nondestructive Testing
D1.1	Structural Welding Code - Steel
QC-1-88	Certification of Welding Inspectors

American National Standards Institute (ANSI)

Z1.8	General Requirements for a Quality Program
Y14.5	Dimensioning and Tolerancing for Engineering Drawings
B46.1	Surface Texture

American Society for Testing and Materials (ASTM)

Bolts:	A307	Externally and Internally Threaded Standard Fasteners
	A325	High Strength Bolts for Structural Steel Joints, Including Suitable Nuts and Plain Hardened Washers,
	A449	Quenched and Tempered Steel Bolts and Studs
	A490	Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints
Plate:	A6	General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use
	A36	Structural Steel
	A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
Forgings:		
	A388	Ultrasonic Examination of Heavy Steel Forgings
	A688	Steel Forgings, Carbon and Alloy, for General Industrial Use
	A711	Steel Forging Stock
	A751	Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
	A788	Steel Forgings, General Requirements

American Institute of Steel Construction (AISC)

Steel Construction Manual, Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings

American Society for Nondestructive Testing, Specification 1A

Department of Energy Order: 5700.6C, Quality Assurance Requirements for the DOE

3. FABRICATION REQUIREMENTS

Any deviations in design or fabrication from any of the listed references in this Attachment shall be approved by LLNL. The Principal Supplier shall use the Deviation Request(DR) form (or LLNL approved equivalent) provided in Appendix C to request planned deviations.

3.1 Welds Weld joints shall blend into the adjacent base metal in gradual smooth curves, using acceptance criteria consistent with AWS D1.1. Specific quality assurance requirements will be shown on the Drawing or this Attachment. All welds shall be visually inspected by AWS or ASME Certified Weld Inspectors (CWI), or Certified Associate Weld Inspectors (CAWI) under the supervision of a CWI.

Additional inspection requirements may be specified in the Drawing.

3.1.1 Weld Design Welds will be specified on the Drawing, and conform to AWS D1.1.

3.1.2 Distortion Control Weld procedures and fixtures shall be selected to control distortion within dimensional limits defined by the Drawing, ASME Section VIII, and AISC Structural Code as applicable. All final weld inspection shall take place after any straightening, realignment, or stress relief of welded assemblies.

3.1.3 Weld Processes Due to the variety of types of welds in this project, several different weld process may be applicable. For partial penetration welds using inert gas shielding, root pass shall be carried out under the protection of an inert gas shield on both sides of the joint. The type and flow rate of inert gas will depend on the weld process determined by The Principal Supplier and approved by LLNL.

3.1.3.1 Oxyfuel Gas Welding Oxyfuel Gas Welding processes shall not be used.

3.1.3.2 Electroslag Welding Electroslag Welding processes shall not be used, unless specifically approved by BNL and LLNL. Approval will be contingent on Efremov performing magnetic and radiographic tests on welds for the same cross section and material, showing no degradation in mechanical or magnetic performance. Judgement on radiographic testing will be in accordance with AWS D1.1. The only allowable application for electroslag welding, if qualified, is on the back plate sections of the muon magnet, LLNL drawing numbers AAA93-101886 and AAA93-101885.

3.1.3.3 Back gouging For full penetration double welds, back gouging shall be employed to assure weld quality.

3.1.3.4 Backing bars Use of weld backing bars not specified on the Drawing require approval from LLNL.

3.1.4 Weld Procedure Specification (WPS) The Principal Supplier shall create a WPS for each type of production weld and submit it to LLNL for review and approval prior to construction. All welders shall follow the WPS to control welding parameters. Guidelines for a WPS are given in AWS D1.1. Items such as holding fixtures, welding equipment, weld time, number of passes, welding sequence, filler metal, shielding gas, and cleaning procedures shall be included in the WPS. Specific welding parameters, such as gas flow, current and voltage settings, preheat and post heat, wire stickout (if applicable), wire diameter, gun angle, preheat, wire feed rate, spray and pulsed spray settings shall also be included, if applicable. The WPS shall be available for reference and review by LLNL or BNL at the fabrication site.

3.1.5 Procedure Qualification Record (PQR) A PQR is required for each welding process used. Qualification of a WPS shall be recorded by a Certified Weld Inspector in a PQR, which is a record of the welding data used to qualify a welding process by welding a test coupon, and record results of the tested specimens. Refer to AWS D1.1 for more information on PQR's. The PQR's shall be available for reference and review by LLNL or BNL at the fabrication site.

3.1.6 Welder Performance Qualification (WPQ) All welding shall be done by qualified welders with certifications in accordance with the applicable standards in section 2 of this Attachment, and the WPS developed for each weld. Certifications shall indicate that the welder has demonstrated the ability to make sound welds of the same type and position, for the same process and materials, using the same equipment as specifically required for construction. During fabrication, questionable quality of workmanship in process may be challenged by LLNL or Certified Weld Inspector, who may request requalification of a particular welder. The Principal Supplier will be responsible requalifying a welder whose performance does not meet the applicable standards in this Attachment.

3.1.6.1 Welder Certification A WPQ is required for each welder or welding operator covering the required welding processes. A Certified Welding Inspector shall approve all WPQ 's. WPQ records shall be available at any time after commencement of construction for reference and review by LLNL or BNL at the fabrication site.

3.1.6.2 Weld Inspector Certification AWS or ASME Certified Weld Inspectors (CWI) shall maintain records which attest to the active status of certification. These records shall be available at any time after commencement of construction for reference and review by LLNL or BNL at the fabrication site. Non-Destructive Evaluation (NDE) personnel shall be qualified in accordance with ASNT-TC-1A.

3.1.6.2 Alternate Certifications Alternate certifications for weld inspectors and welders will be considered acceptable by LLNL if compatible with AWS or ASME. LLNL will have the right to reject alternate certifications as invalid if they do not meet these criteria.

3.1.7 Filler Metal Electrodes and filler wire for structural welds shall be selected per AWS D10.4, Table 7, and shall conform to AWS A5.9. A Certified Material Test Report (CMTR) on the chemical analysis from the filler metal supplier shall be delivered to LLNL. If more than one lot or heat number is involved in the filler metal order or shipment, a separate report shall be provided for each heat or lot supplied.

3.1.7.1 Filler Metal Storage All welding wire and flux (if applicable) shall be stored in accordance with AWS D1.1. Handling and use of welding wire and flux shall be done in such a way as to preclude contamination from grease, dirt or other contaminants. Some fluxes may require storage in local ovens in accordance with AWS 1.1 or manufacturer's instructions.

3.1.8 Base Metal The base metal shall conform to the Drawing and this Attachment, and shall be procured under a standard approved by LLNL.

3.1.8.1 Base Metal Inspection All magnet steel and support structure materials shall be 100% ultrasonically inspected in accordance with the following specifications:

Forgings: A388 Ultrasonic Examination of Heavy Steel Forgings
Rolled plate: AWS D1.1

3.1.9 Weld Symbols Weld symbols on the Drawing shall be interpreted in accordance with AWS A2.4. Any conflicts or questions related to application or interpretation of weld symbols should be directed to LLNL for disposition and clarification.

3.1.10 Joint Preparation Finish Acceptable joint preparation finishes include machining or plasma arc cutting and band grinding. Before welding, joints shall be cleaned of all foreign materials such as oil, grease, dust, and oxides or sulfides resulting from chemical reaction of the surface. Cleaning shall remove all visible evidence of contamination, including all mill scale, painting primer, stains and discoloration of the surfaces. The cleaning process shall be approved by LLNL.

3.1.10.1 Paint Removal Any shop paint on surfaces adjacent to joints shall be removed by wire brushing at least 25 mm from the weld heat affected zone.

3.1.11 Multilayer Welds For welds which require multiple passes, each layer shall be cleaned in accordance with paragraph 3.1.10 before the next layer is deposited. For GTAW process, the non consumable electrode shall be clean of contamination and properly ground before commencement of additional passes. For FCAW, SAW, or SMAW processes, all slag shall be removed between passes. SAW flux shall not be reused. Visual inspections shall be performed by a CWI and recorded between each pass, in addition to any inspection specified on the Drawing. Cracks, porosity, undercut, inclusions, and unfilled craters shall be repaired before commencement of additional passes.

3.1.12 Intermittent Welds If intermittent welds are specified in the Drawing, the minimum length of each weld segment shall be total actual length exclusive the possible weld crater at the end of the weld segment. Weld craters shall be crack free with no undercut.

3.1.12.1 Intermittent Weld Preparation Unless specified in the Drawing, intermittent weld prep is allowable but not required. Intermittent weld prep refers to machining, grinding, or burning the prep only in the actual weld zone. Prepped area shall be cleaned in accordance with paragraph 3.1.11 before welding.

3.1.13 Weld Identification The Principal Supplier will maintain records identifying the welder associated with each weld zone specified on the Drawing. Each welder shall be assigned a unique symbol or identification number that cannot be transferred.

3.1.14 Weld Specimens The Principal Supplier shall demonstrate one of each type of weld process, for each combination of wire filler and base metal type and size to be used in the construction of the support structure.

3.1.15 Weld Inspection The Drawing will specify the type of additional weld inspection required for each weld. If the type of inspection specified is determined to be impractical or inappropriate by The Principal Supplier, LLNL shall be notified and consulted for disposition, using the Deviation Request (Appendix C).

3.1.15.1 Visual Inspection The minimum inspection requirement for all welds in this Attachment is a visual inspection in accordance with AWS D1.1. Visual inspection includes a preweld check of joint preparation and fitup, as well as for straightness, alignment and perpendicularity, as specified in the Drawing. Warped, bent, improperly cut, or otherwise damaged parts are considered nonconformances and shall be rejected or written up in a Nonconformance Report (Appendix B).

Visual inspection shall always be employed in addition to any other inspection methods specified in the Drawing.

3.1.15.2 Dye Penetrant Inspection If required by the Drawing, dye penetrant examination shall be performed in accordance with AWS D1.1. Dye shall be thoroughly removed after test completion. Cleaning method and solvent shall be approved by LLNL.

3.1.15.3 Magnetic Particle Inspection Where called out on the Drawing, Magnetic Particle testing and documentation is required in accordance with AWS D1.1. Elongated defects parallel to the magnetic field may not give a sufficient indication. The field should be applied from two directions at or near right angles to each other.

3.1.15.4 Ultrasonic and Radiographic Inspection No radiographic inspection will be required on partial penetration welds. If required by the Drawing, raw material shall be 100% ultrasonic inspected for lamination defects and voids in accordance with ASME Section VIII before any fabrication begins. All forgings shall be ultrasonically examined in accordance with ASTM A388, Ultrasonic Examination of Heavy Steel Forgings. If specified, radiographic inspection shall conform to ASME section VIII acceptance criteria.

3.2 Dimensional Requirements The Subsystem shall meet all dimensional and other specified requirements of the Drawing. Any supplied materials that are non conforming shall be tagged and LLNL shall be notified in accordance with the Nonconformance Report (NR), Appendix B.

3.2.1 Drawing Interpretation The Drawing dimensions and tolerances shall be interpreted in accordance with ANSI Y14.5.

3.3 Dimensional Inspection The Principal Supplier shall be required to develop a dimensional inspection procedure to assure that the completed Central Magnet and Muon Magnet are within tolerance limits shown on the Drawing. A written inspection report recording actual dimensions shall be submitted prior to LLNL acceptance of the Subsystem.

3.4 Material Requirements The Subsystem shall be fabricated from materials specified in the Drawing. All materials used in the fabrication of the Subsystem shall have mill certification in accordance with ASME Boiler and Pressure Vessel Code Section II or Certified Material Test Report from the manufacturer. Chemical analysis of product material shall be done in accordance with ASTM A751. Any materials that do not meet these requirements shall be tagged and not used.

3.4.1 Material Storage All materials used in the Subsystem shall be marked and stored in such a way as to prevent accidental substitution and allow immediate identification in an Quality Assurance audit. Welding wire and flux shall be stored in accordance with AWS D1.1.

3.4.2 Material Sources Any recycled or scrap steel used in the production of billets for use in the Subsystem shall not contain any radioactive material. Radioactive material includes any steel which has become activated beyond ambient levels. All steel used in this subsystem shall be tested, with a maximum acceptable level of emissions of 25 microRads/hour, measured at the surface of the material. Testing may be postponed at The Principal Supplier's option until ultrasonic testing is performed.

3.4.3 Magnet Material The majority of the Subsystem magnet components shall be constructed from AISI 1006 or approved substitute, as specified in individual detail drawings. The following standards shall be used, depending on the type of fabrication:

Forged	ASTM A711, Steel Forging Stock ASTM A688, Steel Forgings, Carbon and Alloy, for Gen'l Industrial Use ASTM A788, Steel Forgings, Gen'l Requirements
Rolled	A6 General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use

plus the following chemical composition:

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V
0.11% max	0.25-0.65	0.04 max	0.05 max	0.07-0.15	0.35 max	0.30 max	0.30 max	0.10 max	0.03 max

3.4.4 Aluminum material The aluminum components shall be constructed according to the following standards:

ASTM B209-92a	Specification of Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B221-92a	Specification of Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes and Tubes
ASTM B308/B308M-92a	Specification of Aluminum Alloy 6061-T6 Standard Structural Shapes

3.4.5 Stainless Steel material The stainless steel components shall be constructed according to the following standards:

ASTM A167-92b	Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A276-92	Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A473-92a	Standard Specification for Stainless and Heat-Resisting Steel Forgings
ASTM A480/A480M-91a	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A484/A484M-92a	Standard Specification for General Requirements for Stainless and Heat-Resisting Steel Bars, Billets and Forgings
ASTM A666-92	Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

3.5 Surface Finishes

3.5.1 Painting low carbon steel The main purpose of painting is preservation of low carbon steel surfaces. Paint will be selected to resist effects of the environment, heat impact, abrasion, and corrosives. However, care must be taken by The Principal Supplier to strategically schedule painting to minimize damage to the finished surface. Because a secondary function of paint is aesthetic, application must be done in such a way as to be neat and consistent. Type of paint, primer, and paint colors will be specified on the Drawing.

3.5.1.1 Surface Preparation Preparation for painting primer shall remove mill scale, dirt, rust, grease, oil and foreign matter. Sand blasting is recommended for surface preparation. The Principal Supplier shall allow LLNL to review and approve surface preparation and painting procedures.

3.5.2 Mating surfaces of major components Mating surfaces of steel components shall not be painted, but shall be protected from environmental contamination and moisture using a non-permanent adhesive backed plastic sheeting.

3.6 Lifting Attachments Lifting attachment points shall be provided by LLNL on the Drawing. If alternative rigging is required for which there is no lifting attachment provided, The Principal Supplier shall use the enclosed Deviation Request (Appendix C) to request additional fixtures. LLNL shall be responsible for approving the new attachment or specifying an alternate.

3.6.1 Lifting Fixtures Lifting fixtures which are not permanently attached to the Subsystem are the design responsibility of The Principal Supplier. These include, but are not limited to straps, chains, hoists, gantries, cranes, booms, strong backs, spreader bars, shackles, turnbuckles, hooks, and wire rope.

3.6.2 Bolt Procurement Fasteners for final assembly at the PHENIX Detector Hall shall be supplied by BNL. These bolts will not be supplied to The Principal Supplier for Off Site assembly. The Principal Supplier will provide all fasteners necessary for safe off site erection of the Subsystem.

3.6.3 Threaded Inserts Threaded inserts for certain tapped holes are required. These threaded inserts shall be provided by BNL for installation.

3.7 Assembly The Subsystem shall be temporarily assembled to verify fit and form at an Off Site location before shipping to the PHENIX Detector Hall. Temporary assembly will be accomplished using bolted interfaces as defined in the Drawing. These fasteners shall be supplied by The Principal Supplier. Central Magnet and Muon Magnet will be assembled using a rigging procedure approved by LLNL. After dimensional inspection is performed in accordance with section 4.3, Central Magnet and Muon Magnet will be disassembled and prepared for shipping.

3.8 Continuity Each forged part shall be produced from a single heat of steel. Combining two ingots into one forging is not permitted.

3.9 Fit Unless otherwise specified on The Drawing, individual parts shall be machined on their mating surfaces so that the maximum gap size between parts is limited to 2 mm. Maximum step size at the interface of mating parts shall be limited to 1 mm.

3.10 Flaws Maximum acceptable subsurface flaw size, as determined by ultrasonic examination, will be 6 mm in any dimension. The maximum void fraction in any 1000 cc volume of steel shall not exceed 0.1%.

3.11 Muon Magnet Support Leg Construction: The muon magnet support leg has specific requirements in addition to other applicable requirements in this document.

3.11.1 Material Muon Magnet Support Leg shall be constructed from rolled plate, ASTM A36, or equivalent.

3.11.2 Fit During welding, structural subassemblies will be held in fixtures to minimize distortion. Mating flanges of support leg subassemblies shall be machined to their final dimensions after all welding and any required stress relief is completed.

3.11.3 Flaws Maximum acceptable flaw size, as determined by ultrasonic examination, will be 6 mm.

3.11.4 The maximum void fraction in any 1000 cc volume of steel shall not exceed 0.1%.

4. ACTIVITIES and MILESTONES

4.1 Milestone Inspection and Testing at The Principal Supplier's Facility The Principal Supplier shall perform inspections and tests assure conformance to this Attachment. Each of the milestones listed below will be made available for inspection by LLNL/BNL personnel. The inspections will be made at the appropriate facility. The Drawing may specify additional documentation requirements. All documentation submitted to LLNL or BNL shall be written in the English language. All units of measure shall be in SI (System Internationale) units.

The following schedule shall be used:

4.1.0 Purchase of material — complete 12/1/93
- 4.1.0.1 Signing of the attachment completed by all parties
- 4.1.0.2 Placing or steel order by Principle Supplier

4.1.1 Preliminary documentation — complete 2/1/94
- 4.1.1.1 Weld Procedure Specifications
- 4.1.1.2 Forging or casting procedures, as applicable
- 4.1.1.3 Manufacturing Plan (final version)
- 4.1.1.4 QA Program Plan
- 4.1.1.5 Complete set of shop drawings for Russian fabrication

4.1.2 Progress documentation — complete 3/1/94
- 4.1.2.1 Weld Inspector Certifications
- 4.1.2.2 Welder Certifications
- 4.1.2.3 Surveying Plan
- 4.1.2.4 Off site Assembly/Rigging Plan
- 4.1.2.5 Shipping and Handling Procedures

4.1.3 Ingot Production, ladle chemical analysis/magnetic analysis — complete 3/28/94
- 4.1.3.1 Pole ring ingots (2 heats)
- 4.1.3.2 Pole piece ingots (2 heats)
- 4.1.3.3 Pole key ingots (4 heats)
- 4.1.3.4 CM yoke ingots (2 heats)
- 4.1.3.5 MM piston ingots (1 heat)
- 4.1.3.6 MM back plate ingots (3 heats)
- 4.1.3.7 MM lampshade plate ingots
- 4.1.3.8 CM core piece ingots

4.1.4 Plate Rolling Production, coupon testing — complete 4/31/94
- 4.1.5.1 MM back plate rolled stock
- 4.1.5.2 MM lampshade rolled stock
- 4.1.5.3 CM core piece rolled stock
- 4.1.5.4 MM support leg rolled stock

4.1.5 Rolled plate cutting/premachining/ultrasonic testing — complete 6/1/94
- 4.1.4.1 MM back plate rolled stock
- 4.1.4.2 MM lampshade rolled stock
- 4.1.4.3 CM core piece rolled stock

4.1.6 Forging Production, heat treatment, coupon testing — complete 5/31/94
- 4.1.6.1 Pole ring forgings
- 4.1.6.2 Pole piece forgings
- 4.1.6.3 Pole key forgings
- 4.1.6.4 CM yoke forgings

4.1.6.5 MM piston forging

4.1.7 Weldment production, weld inspection — complete 7/13/94
- 4.1.7.1 MM back plates
- 4.1.7.2 MM support legs
- 4.1.7.3 CM outriggers
- 4.1.7.4 MM teacup

4.1.8 Forging premachining/ultrasonic testing — complete 6/27/94
- 4.1.8.1 Pole ring UT
- 4.1.8.2 Pole piece UT
- 4.1.8.3 Pole key UT
- 4.1.8.4 CM yoke UT
- 4.1.8.5 MM piston UT

4.1.9 Final machining, dimensional inspection — complete 10/5/94
- 4.1.9.1 Pole ring machining
- 4.1.9.2 Pole piece machining
- 4.1.9.3 Pole key machining
- 4.1.9.4 CM yoke machining
- 4.1.9.5 MM piston machining
- 4.1.9.6 MM back plate machining
- 4.1.9.7 MM lampshade machining
- 4.1.9.8 CM core piece machining
- 4.1.9.9 Support leg machining

4.1.10 Off site assembly, dimensional inspection — complete 12/28/94
- 4.1.10.1 CM assembly
- 4.1.10.2 MM assembly

4.1.11 Packaging/crating — complete 2/1/95
- 4.1.11.1 CM packaging/crating
- 4.1.11.2 MM packaging/crating

4.1.12 Shipping to US port of entry — complete 4/3/95
- 4.1.12.1 CM components
- 4.1.12.2 MM components
- 4.1.12.3 Dimensional inspection reports
- 4.1.12.4 Certified Material Test Reports
- 4.1.12.5 Nonconformance Reports
- 4.1.12.6 Deviation Requests
- 4.1.12.7 Weld inspection Reports
- 4.1.12.8 Fabrication (shop/field) Drawings
- 4.1.12.9 As Built Drawings

4.2 Manufacturing Plan The Principal Supplier shall submit for LLNL approval a complete, detailed manufacturing plan (4.1.1) which specifies how fabrication will proceed and how this fabrication sequence will interface with the test, inspection, and assembly activities. This plan will contain resource loading histograms, identification of all subcontractors, location of all fabrication sites, and detailed schedule.

4.3 Schedule Tracking The Principal Supplier shall provide a detailed production schedule to LLNL within one month of effective date of attachment. The schedule will be updated biweekly for LLNL review and approval. If the schedule is modeled on a computer software program, an electronic media copy of the updated schedule shall be submitted along with a hard (paper) copy.

5. COMPENSATION

Compensation in the amount of $1,600,000 will be made to PNPI ($50,000) and the Principle Supplier ($1,550,000) for the following tasks:

5.1 Fabrication and assembly of the following components:

Description (quantity)	LLNL Drawing Number
CM Assembly (1)	AAA93-104183-00
CM Yoke Assy Upper (1)	AAA93-104204-00
CM Pole Key Upper (1)	AAA93-104185-00
CM Yoke Upper (1)	AAA93-104187-00
CM Yoke Assy Lower (1)	AAA93-104190-00
CM Pole Key Lower (1)	AAA93-104184-00
CM Yoke Lower (1)	AAA93-104186-00
CM Eyebrow Ring (2)	AAA93-101850-0B
CM Pole Piece Center (2)	AAA93-104188-00
CM Pole Piece Plug (2)	AAA93-104189-00
CM Outrigger Support (4)	AAA93-101882-00
CM Coil Retaining Ring (8)	AAA93-104167-00
CM Coil Retainer (2)	AAA93-104205-00
MM Assembly (1)	AAA93-101858-0C
MM Piston Core (1)	AAA93-101860-0D
MM Backplate Disk (1)	AAA93-101864-0A
MM Backplate, Side (1) Tab 01	AAA93-101886-0B
MM Backplate, Side (1) Tab 02	AAA93-101886-0B
MM Backplate, Center (1)	AAA93-101885-0B
MM Teacup (1)	AAA93-104173-00
MM Support Leg (1) Tab 01	AAA93-101887-0A
MM Support Leg (1) Tab 02	AAA93-101887-0A
MM Fin (1) Tab 01	AAA93-104157-00
MM Fin (1) Tab 02	AAA93-104157-00
MM Splice Bar (5)	AAA93-104175-00
MM Lampshade Panel #1 (1)	AAA93-101888-0B
MM Lampshade Panel #2 (2)	AAA93-101890-0B
MM Lampshade Panel #3 (1) Tab 01	AAA93-101891-0A
MM Lampshade Panel #3 (1) Tab 02	AAA93-101891-0A
MM Lampshade Panel #4 (1)	AAA93-101893-0A
MM Lampshade Panel #5 (2)	AAA93-104174-00
MM Door, Fixed (1) Tab 01	AAA93-104178-00
MM Door, Fixed (1) Tab 02	AAA93-104178-00
MM Door, Hinged (2)	AAA93-104179-00
MM Door, Teacup Side (2)	AAA93-104180-00
MM Wedgeplate, Lower (17)	AAA93-104164-00
MM Wedgeplate, Upper (17)	AAA93-104163-00
MM Spacer Bar (5)	AAA93-104176-00
MM Stiffener, Hinge, Inside (4)	AAA93-104206-00
MM Stiffener, Hinge, Outside (4)	AAA93-104208-00
MM Hinge, Pillow Block (4)	AAA93-104207-00
MM Shaft, Door Hinge (4)	AAA93-104203-00
MM Bracket, Door Restraining (4)	AAA93-104201-00
MM Base, Bearing (8)	AAA93-104202-00
MM Locator Pin (3)	AAA93-104177-00

MM Retainer, Coil No. 1 (8)	AAA93-104209-00
MM Retainer, Coil No. 2 (8)	AAA93-104210-00
MM Spacer, Coil No. 2 (8)	AAA93-104211-00
MM Shim (17) Tab 01	AAA93-104165-00
MM Shim (34) Tab 02	AAA93-104165-00
MM Shim (17) Tab 03	AAA93-104165-00
MM Piston Nose Cone (1)	AAA93-104212-00
MM Spacer, Floorplate (4) Tab 01	AAA93-104172-00
MM Spacer, Floorplate (12) Tab 02	AAA93-104172-00
MM Spacer, Floorplate (4) Tab 03	AAA93-104172-00
MM Washer (65)	AAA93-104213-00

5.2 Shipping of these components to a US Port of entry to be determined later.

5.3 Project management by PNPI and the Principle Supplier for items 5.1 and 5.2

The PHENIX Project will be assigned a contingency fund based on a task-by-task calculation. Included in this fund will be a contingency for the tasks described above as follows:

5.4 Fabrication and management contingency, estimated at 25% of the cost.

5.5 Shipping contingency, estimated at 100% of the cost, based on the current uncertainty in the future cost of Russian shipping relative to world market prices.

6. COMPENSATION SCHEDULE

Compensation will be made by BNL for successful completion of milestones described in section 4.1 of this Attachment. Amount of each payment will be made on a percentage basis with respect to the total compensation given in section 5 above. LLNL will be responsible for determining the completion status of each milestone, and The Principal Supplier will be responsible for providing LLNL with access to all necessary documentation, facilities, components or other items needed to make a complete evaluation.

milestone	description	payment
4.1.0	Purchase of steel	25%
4.1.1	Preliminary documentation	2%
4.1.2	Progress documentation	2%
4.1.3	Ingot Production, ladle chemical analysis/magnetic analysis	2%
4.1.4	Plate Rolling Production, coupon testing	2%
4.1.5	Rolled plate cutting/premachining/ultrasonic testing	2%
4.1.6	Forging Production, heat treatment, coupon testing	2%
4.1.7	Weldment production, weld inspection	2%
4.1.8	Forging premachining/ultrasonic testing	2%
4.1.9	Final machining, dimensional inspection	15%
4.1.10	Off site assembly, dimensional inspection	20%
4.1.11	Packaging/crating	4%
4.1.12	Shipping to US port of entry	20%

QUALITY ASSURANCE PROGRAM REQUIREMENTS

1. General Requirements The Principal Supplier shall prepare and implement a Quality Assurance (QA) program covering the procurement, inspection, testing, and fabrication of the Subsystem. The Principal Supplier's existing QA program may suffice if it adequately implements the quality requirements in this Attachment. LLNL will review and approve the QA program, monitor QA activities, and perform audits and /or surveillance to assure compliance. The QA program shall address, but not be limited to elements described in the following sections.

The Principal Supplier's QA program shall follow guidelines established in Department of Energy Order 5700.6C, or ANSI Z1.8, General Requirements for a Quality Program.

2. Organization All organizations responsible for procurement and manufacture of the Subsystem shall be identified. The duties, responsibilities, and authority of each functional group shall be established and the interfaces between them defined. This information shall be submitted to LLNL within one month of effective date of attachment.

3. QA Program Plan The scope of activities covered by the QA program shall be defined. Documents detailing QA requirements and procedures shall be prepared. The scope, extent, and thoroughness of the requirements, policies, and procedures shall be established taking into consideration the impact of quality deficiencies on performance, cost schedule, and safety. A preliminary QA program plan outline shall be submitted with the Principal Supplier's quotation. If any of the plans or procedures required by the QA program plan are covered in other documents, the Principal Supplier may reference them.

4. Procurement Control The QA program plan shall establish procedures to assure that the Principal Supplier's procurement activities provide for compliance with the plan by the Principal Supplier's Responsible Suppliers.

5. Material Identification and Control The QA program plan shall include provisions for adequate identification and control of raw material and components. Provisions shall be established to dispose of materials and components identified as being deficient in quality. The Principal Supplier shall be able to demonstrate by a written procedure and by actual practice that a method of material application and identification be used through the fit up operation. The identification method shall be capable of verifying proper material application as it relates to

a) Material Specification Designation
b) Heat Number
c) Certified Material Test Reports

6. Process Control, Inspection, and Testing Quality requirements for manufacturing functions and the associated material handling and control, inspection and testing activities, and process equipment identification shall be planned, performed to written procedures, and documented.

7. Deviations and Nonconformances The QA program plan shall provide for disposition and resolution of departures from approved drawings, specifications, data, procedures, and standards.

7.1 Deviations (Planned Departures Before The Fact) Any planned deviation in material, workmanship, dimensional tolerances, procedures, records, or qualifications shall require written LLNL approval before proceeding. Any missing data on the Drawing or this Attachment shall be provided via the Deviation Request. The Principal Supplier shall submit a Deviation Request and obtain approval from LLNL prior to initiation of subject activity. The following procedure shall be followed to insure proper description, documentation, and response in requesting a deviation.

1) In all reports of a planned deviation, the Principal Supplier or Responsible Supplier shall complete the information of the type of deviation, the quantity of items involved, and other identification information.
2) The Responsible Supplier or Principal Supplier technical management shall identify the technical requirements of this Attachment which would be violated by the deviation, such as a violation of engineering drawing dimensions, specifications, codes, and standards, process procedures, QA verification, etc.
3) The Responsible Supplier or Principal Supplier technical management shall describe the deviation by identifying the condition that would cause the item to depart from the requirements of this Attachment.
4) The Responsible Supplier or Principal Supplier technical management shall propose a disposition of the item, and detail justifications or facts to validate why subject planned deviation is an acceptable alternative.
5) Additional documents related to or explaining in more detail the subject matter required by any heading on the Deviation Report forms shall be attached to the form and listed under attachments.
6) Indicated estimated cost or schedule impact based on the recommended decision.
7) The Principal Supplier shall determine the urgency of problem, its impact on cost and schedule, and use the following terms to initiate response to the Deviation Report:

   Routine: Seven days response required
   Urgent: Three day response required
   Emergency: 24 Hour response required
8) All Deviation Requests shall be submitted to LLNL through the Principal Supplier, even if originated by a Responsible Supplier.
9) No work shall proceed on the proposed deviation until approved in writing from LLNL

7.2 Nonconformances (Unplanned Departures) A nonconformance is defined as any violation of the Drawing or this Attachment which has already occurred. Any nonconformance in material, workmanship, dimensional tolerances, procedures, records, or qualifications shall require written LLNL approval. The Principal Supplier shall submit a Nonconformance Report and obtain approval from LLNL prior to initiation of corrective action. The following procedure shall be followed to insure proper description, documentation, and response in resolving a nonconformance.

1) In all reports of a Product nonconformance, the Principal Supplier or Responsible Supplier shall complete the information of the type of nonconformance, the quantity of items involved, and other identification information.
2) The Responsible Supplier technical management shall identify the technical requirements of this Attachment violated by the nonconformance, such as a violation of engineering drawing dimensions, specifications, codes, and standards, process procedures, QA verification, etc.
3) The Responsible Supplier technical management shall describe the nonconformance by identifying the condition that causes the item to depart from the requirements of this Attachment.
4) A site inspector representing the Principal Supplier shall initial the Nonconformance Report at the appropriate space, indicating acknowledgement of the nonconformance description and proposed resolution.
5) The Responsible Supplier technical management shall propose a disposition of the item, and detail remedial actions or facts to validate such disposition.
6) The Responsible Supplier shall report the cause of the nonconformance and the corrective action to be applied to prevent the reoccurrence of this event.
7) Additional documents related to or explaining in more detail the subject matter required by any heading on the Nonconformance Report forms shall be attached to the form and listed under attachments.
8) Indicated estimated cost or schedule impact based on the recommended decision.
9) The Principal Supplier shall determine the urgency of problem, its impact on cost and schedule, and use the following terms to initiate response to the Nonconformance Report:

Routine:	Seven days response required
Urgent:	Three day response required
Emergency:	24 Hour response required

10) All Nonconformance Reports shall be submitted to LLNL through the Principal Supplier, even if originated by a Responsible Supplier.

8. QA Records

9. QA Audits (Internal) A plan for the Principal Supplier's auditing the implementation of the QA program plan shall be included in the plan. Copies of internal audits shall be furnished to LLNL.

10. QA Audits (External) LLNL and BNL shall have the right to conduct an unannounced audit of the Principal Supplier's QA program at any time during the project. Such an audit might include, but not be limited to the following:

Welder Qualification Records
Weld Inspector Qualifications
Material Certifications
State and Local Permits where Required
Drawing Files
Equipment Maintenance Records

Attachment -2

APPENDIX B

Nonconformance Report

Routine (7 day) Urgent (3 day) Emergency (24 hour) Date:

To:	From:

Type : material part subassy final assy procedure design conflict spec conflict

Item Name and serial number	Dwg # or Spec#	Agreement item
Project name	QTY nonconforming items	Related Nonconformance Reports

Description of nonconformance see attached		Requirements violated see attached	
Inspector or originator	date	Principal Supplier inspector	date
Recommended Disposition Accept rework reject repair		Cost / schedule impact	
Remedial Action/ justification see attached		Cause and corrective action see attached	

Responsible Supplier Approvals

Engineering	date	Quality Assurance	date

Principal Supplier Approvals

Engineering	date	Quality Assurance	date
LLNL Disposition accept nonconformance deny see attached			

LLNL Approvals

Engineering	date	Quality Assurance	date

Attachment -2

APPENDIX C

Deviation Request

Routine (7 day)	Urgent (3 day)	Emergency (24 hour)	Date:

To:	From:

Type : material part subassy final assy procedure design conflict spec conflict

Item Name and serial number	Dwg # or Spec#	Agreement item
Project name	QTY nonconforming items	Related Deviation Requests

Description of deviation see attached	Requirements violated see attached

Planner or originator	date	Principal Supplier Planner	date

Recommended Disposition Accept redesign reject repair	Cost / schedule impact
Remedial Action/ justification see attached	Cause and corrective action see attached

Responsible Supplier Approvals

Engineering	date	Quality Assurance	date

Principal Supplier Approvals

Engineering	date	Quality Assurance	date

LLNL Disposition accept request deny request see attached

LLNL Approvals

Engineering	date	Quality Assurance	date

PHENIX

UNIVERSITY OF CALIFORNIA
LAWRENCE LIVERMORE NATIONAL LABORATORY

TITLE	LLNL Lead Engineer / DATE
Relativistic Heavy Ion Collider **Brookhaven National Laboratory** **Statement of Work** **for the** **PHENIX Magnet Installation** **Concept Plan**	Joel Bowers
	APPROVED: BNL Procurement M. F. Healey
	APPROVED: PHENIX Project Manager S. Aronson
	APPROVED: PHENIX Collaboration S. Nagamiya
	APPROVED: RHIC Project Office T. Ludlam

1. SCOPE

1.1 Purpose This Statement of Work outlines services for providing an installation concept plan to Lawrence Livermore National Laboratory (LLNL) for the installation of the PHENIX Central Magnet, Muon Magnet, and Muon Identifier. PHENIX is a high energy particle detector to be installed at the Relativistic Heavy Ion Collider (RHIC) located at Brookhaven National Laboratory (BNL), Upton, NY.

1.2 Application This Statement of Work applies to an engineering study of transportation, handling, assembly, and installation of a large assembly of steel forgings and weldments shipped from Russia, as well as heavy steel plate shipped from domestic sources.

1.3. Definitions

LLNL Lawrence Livermore National Laboratory, Livermore, CA, responsible for production of all design drawings, structural calculations, and oversight of fabrication and installation.

BNL Brookhaven National Laboratory, Upton, NY, is the site of final assembly, test, and operation of the PHENIX Detector. BNL is also the the location of the PHENIX project office.

Central Magnet (CM) A 500 ton assembly of steel forgings and weldments designed to provide a shaped magnetic field for performing high energy physics experiments.

Muon Magnet (MM) A 500 ton assembly of steel plate weldments and a central conical forging, designed to provide a magnetic field for the detection of muons.

Muon Identifier (MI) A 1000 ton assembly of steel plates used to identify and characterize muons.

The Subsystem The Subsystem is the assembly of steel structures and magnetic field shaping components which comprise the PHENIX Central Magnet steel, Central Magnet coils, Muon Magnet steel, Muon Magnet coils, and Muon Identifier.

The Drawing Any and all detail and assembly, fabrication and machining drawings or sketches which are supplied by LLNL and constitute the design package for the Subsystem. Not included are shop drawings, such as those for cutting rough shapes, or for producing temporary fixtures.

Efremov D.V. Efremov Scientific Research Institute of Electrophysical Apparatus, St. Petersburg Russia, whose responsibility is the manufacture of the Central Magnet and Muon Magnet steel in accordance with the Drawing. The Muon Identifier will be procured from an unnamed domestic source.

Installation Plan The governing document which describes the installation of the Subsystem. The Installation Concept Plan, which is the scope of this Statement of Work, will provide the basis of the Installation Plan.

Planning Contractor The contractor who is awarded this scope of work, and subsequently produces the Installation Concept Plan.

Rigging Contractor US company which will be contracted to perform all work described in the Installation Plan for the Subsystem.

Major Facility Hall A high bay facility at the BNL RHIC site and installation location of the PHENIX Detector.

On Site Location of the PHENIX detector hall facility at BNL

Shoreham Nuclear Power Station A former nuclear power plant at Shoreham, NY (Long Island), with a heavy dock facility on Long Island Sound. Shoreham is located roughly 15 miles to BNL using local roads.

2. REFERENCE DOCUMENT

The following document forms a part of this Statement of Work:

PHENIX Central Magnet and Muon Subsystem Steel Final Design Review

3. BACKGROUND

The PHENIX detector is a major experiment at the Relativistic Heavy Ion Collider (RHIC). It is located at the Major Facility Hall in the RHIC accelerator ring. The Subsystem, consisting of a Central Magnet (CM), Muon Magnet (MM), and Muon Identifier(MI) will consist of individual components weighing up to 110 tons.

Fabrication of the CM and MM steel will be accomplished in St. Petersburg, Russia. These subassemblies will be final machined, preassembled, and dimensionally inspected in Russia. All activities covered by this scope of work for the CM and MM begin when the components arrive to the US port of entry from St. Petersburg. This port has not been identified yet, but can be assumed to be located between Norfolk, Virginia and Boston, MA.

Fabrication of the MI will be performed at a domestic source, and shipped by rail to BNL. Some final fabrication work will be required on the MI in the Major Facility Hall. All activities covered by this scope of work for the MI begin when the MI components arrive by rail to BNL. The following chart sumarizes the sources of major components to the locations at which the activities in this Statement of Work begin.

Item	Built at	Shipped to
Central magnet steel	St. Petersburg, Russia	US east coast port
Central magnet outer coil	Tokin, Japan	BNL, NY
Central magnet inner coil	Unnamed domestic source	BNL, NY
Muon magnet steel	St. Petersburg, Russia	US east coast port
Muon magnet coil #1	Unnamed domestic source	BNL, NY
Muon magnet coil #2	Unnamed domestic source	BNL, NY
Transport track system	Unnamed domestic source	BNL, NY
Muon Identifier steel	Unnamed domestic source	BNL, NY
Steel foundation plates	Unnamed domestic source	BNL, NY
Permanent rigging hardware	Unnamed domestic source	BNL, NY
Muon Identifier steel	Unnamed domestic source	BNL, NY

4. PROJECT OBJECTIVES

The Planning Contractor is expected to accomplish the following major objectives:

Develop a transportation plan to barge the Muon Magnet and Central Magnet steel components from the US east coast port of entry to the Shoreham Nuclear Power Station, Shoreham, NY, and truck them to the Major Facility Hall at Brookhaven National Laboratory, Upton, NY.

Develop an integrated assembly installation plan for the entire Subsystem.

5 PROJECT TASKS

5.1 Develop a detailed transportation plan, including cost, schedule and manpower required, for Muon Magnet and Central Magnet components after they are shipped to the US port of entry.

5.1.1 Identify dockside lifting equipment needed at US port of entry.

5.1.2 Identify waterborne equipment needed to move components from the US port of entry to Shoreham.

5.1.3 Identify dockside lifting equipment needed at Shoreham.

5.1.4 Identify transportation equipment needed to move components from Shoreham to BNL.

5.1.5 Identify special permits required (including lead time and cost) and suitability of local roads for transport between Shoreham and BNL. Verify that the local route between Shoreham and BNL requires no structural modifications to bear the required loads. Verify overhead clearances of power lines, overpasses, trees, etc.

5.1.6 Identify storage space required, at US port of entry, Shoreham Nuclear Power Station and BNL.

5.1.7 Identify concerns or high risk areas with transportation, and proposed solutions.

5.2 Develop a detailed installation concept plan for the Subsystem, including cost, schedule and manpower required.

5.2.1 Identify lifting points on Subsystem components.

5.2.2 Identify each major lift required, including up ending (horizontal to vertical orientation) of components, within the constraints of the Major Facility Hall.

5.2.3 Prepare a Major Facility Hall usage plan, showing space usage logistics at each step in the installation.

5.2.4 Develop an installation alignment plan.

5.2.5 Assess the use of BNL rigging personnel to assist in the installation. Determine requirements for use of local union personnel.

5.2.6 Identify and develop lifting/alignment fixture concepts for steel components and magnet coils.

5.2.7 Identify primary lifting equipment to be used in the Major Facility Hall.

5.2.8 Identify concerns or problem areas with installation

5.3 Assess the availability of equipment for this project.

5.4 If the recommended equipment in any of the preceding tasks is unique to a particular rigging or transportation contractor, alternate equipment common in the industry shall be identified which would adequately perform the work, along with the cost, personnel, and time resources associated with the alternative.

5.5 Develop an integrated manpower and cost histograms for the duration of the project, and the basis for such estimates.

6 PROJECT DELIVERABLES

6.1 The Planning Contractor shall deliver a completed written report which covers and includes all of the Section 5 Project Tasks to LLNL at project's end. This work shall be presented in the form of a bound document containing descriptive text and clarifying illustrations or sketches, as well as any related printed material.

6.2 The Planning Contractor shall perform an oral presentation on the written report to BNL.

6.3 The Planning Contractor shall deliver a monthly progress report to LLNL on the 15th day of every month during the contract.

7 SUBSYSTEM DESCRIPTION

7.1 Central Magnet

The Central Magnet is comprised of two pairs of concentric circular coils (inner and outer) which are recessed in the faces of two large magnetic poles. The coils are resistive in type and use conventional square, hollow copper conductor. The large steel poles as well as the upper and lower flux return are all made up from 1006 steel. The Central Magnet is mobile, and sits on a track system on the floor of the Major Facility Hall.

7.1.1 Inner and Outer Coils

The inner coils (2 required) are made up of 6 bifilar wound double pancake coils which are vacuum epoxy impregnated in three sets of two double pancake assemblies each. All three pancake assemblies are identical in size and configuration. The nominal inside diameter (ID) of the coil is 1084.7 mm (42.7 in) which leaves a 6 mm clearance between the ID of the coil and the inside surface of the counterbore (to allow for coil installation onto the steel poles). The nominal outside diameter (OD) of the coil is 1553.5 mm (61.2 in). Nominal coil assy width is 300 mm (11.81 in). When installed, the three sets of two double pancake assemblies are nested together side by side and rest on the circular counterbore machined into the iron pole pieces of the Central Magnet.

The outer coils (2 required) are conceptually identical in design to the inner coils. They are made up of 6 identical (except for the electrical flag connections) bifilar wound double pancake coils with each double pancake assembly being individually vacuum epoxy impregnated. They have an inside diameter of 3200 mm (125.98 in) and a nominal outside diameter of 3729 mm (146.8 in). Nominal coil assembly width is 300 mm (11.81 in). There is a 6 mm clearance between the ID of the coil and the inside surface of the counterbore (to allow for coil installation onto the steel poles). LLNL drawing AAA93-101878-0A shows the North Pole coil stack. As in the inner coil, the six double pancake assemblies that make up the outer coil are nested together side by side and rest on the circular counterbore machined into the steel pole pieces of the Central Magnet.

Special handling fixtures will be required to insure that the coils are not damaged.

	Central Magnet		Muon Piston
	Inner Coils (2)	Outer Coils (2)	Coil (1)
Configuration	5 Dbl. Pancakes	6 Dbl. Pancakes	Solenoid
Cond Material	Copper	Copper	Copper
Inside Dia (m)	0.99/1.71	3.20	1.62/2.05
Outside Dia (m)	1.58/2.30	3.80	1.72/2.15
Weight (kg)	1532	3990	2131

7.1.2 Central Magnet steel

The 500 ton Central Magnet will consist of two poles, two large flux returns, and a set of outriggers. All magnetic material will be ASTM 1006, or equivalent. The large size of these poles exceeds world forging capacity, so each is split into three concentric parts. The outermost part, called the eyebrow ring (AAA93-101850), has a finished weight of 60 tons and interfaces the flux returns. The pole piece (AAA93-101853) fits into the pole ring and weighs 61 tons. The center element of the pole, which surrounds the RHIC beam pipe, is made from thick rolled plate and weighs seven tons. Machined circular grooves in the pole assemblies accept the inner and outer coils. The two poles, when assembled into the central magnet, will be separated by a nominal gap of 1.2 meters, and will resist an attractive magnetic force of approximately 170,000 lb. The two facing poles will be magnetically and structurally tied together with two large flux return yokes (approx. 3.2 M^2 cross section), attached to the top and bottom of the poles. The large size of these return yokes dictates that they be split into smaller pieces so that they can be fabricated. Each yoke subassembly consists of two pole keys and a yoke. Total weight of the each yoke subassembly is 90 tons.

The entire pole assembly will be supported on a set of four steel outriggers, which rest on Hilman rollers to allow the Central Magnet to move horizontally into the assembly area of the detector hall. A complete transporter system consisting of Hilman rollers, hydraulic jacks, and steel track is planned for this purpose.

A track network fabricated from W24 beams will allow the Central Magnet to be transported to various locations in the Experimental Hall. A pair of such beams running from the experimental area toward the high bay roll up door would be shimmed and stabilized by cross beams. This track system will be shop fabricated domestically and shipped to BNL. This Statement of Work includes the installation and alignment of the track sections, but not their fabrication.

A finite element analysis has been developed to characterize the mode shapes, static deflection, magnet loaded deflection, and principal stress of the central magnet structural components.

Each pole assembly consists of three parts which nest concentrically about a common horizontal axis. These parts will most likely be nested with their common axis vertical, followed by an up ending lift to bring the pole to a horizontal axis position. It must then be lifted onto the lower return yoke. After both pole assemblies are lifted onto the lower return yoke, the upper return yoke must be lifted and bolted into place. As part of this Statement of Work, consistent with section 5.2.2, the Planning Contractor shall show how these steps will be performed.

Design will accommodate shipping constraints, and allow 100% bolt up assembly at BNL. A contract is being negotiated with Long Island Lighting Company (LILCO) by BNL for use of their docking facility at Shoreham Nuclear Power Station, which is in close proximity to BNL. This facility will be used to off load major steel components from barges to be transported over local roads using large capacity trailers.

The Central Magnet assembly, excluding the transport system, will be fabricated and prefit in Russia from build-to-print drawings provided by LLNL. A strict quality assurance program will be implemented to minimize risk to the program. All heavy cross section elements will be forged at the Izhora Steel Plant, St. Petersburg, Russia. All machining, welding, and preassembly, and inspection will occur in St. Petersburg shops. The Efremov Institute in St. Petersburg has been assigned lead responsibility for fabrication, preassembly, and shipment to the US port of entry.

7.2 Muon Magnet

The Muon Magnet is comprised of two cylindrical coils installed onto a conical steel forging, and surrounded by a flux return structure consisting in the shape of a lamp shade. The coils are resistive in type and use conventional square, hollow copper conductor. The large conical piston, as well as the lamp shade flux return are all made up from 1006 steel. The Muon Magnet is stationary, and is bolted to foundation plates embedded in the floor of the Major Facility Hall.

7.2.1 Coil

The muon piston coil (1 required) is a bifilar wound solenoidal coil (having two layers) which will be vacuum epoxy impregnated onto its epoxy-fiberglass winding form. It is made up of two identical coils with the only difference being that one is slightly smaller in diameter than the other. Each coil is 676.4 mm (26.63 in) in overall length. The small coil (coil #1) is nominally 1623.8 mm (63.93 in) in ID and 1740.4 mm (68.52 in) in OD. The large coil (coil #2) is 1880.6 mm (74.04 in) in ID and 1997.2 mm (78.63 in) in OD.

7.2.2 Muon Magnet Steel

The 400 ton Muon Magnet (LLNL assembly drawing #AAA93-101858-0C) will consist of a large tapered iron core (LLNL drawing #AAA93-101860-0C) bolted to a flux return back plate which is 30 cm thick (LLNL drawing #AAA93-101885-00). Eight trapazoidal steel plates, 8 cm in thickness, are arranged in an octagon pattern ("lampshade") around the iron core. The tapered iron core will be forged as a single piece and weigh approximately 60 tons. The end plate will be constructed from three plate sections bolted together with a maximum unit weight of 120 tons. All magnetic material will be ASTM 1006, or equivalent. The iron core, back plate, and lampshade plate assemblies will form a rigid steel structure. The muon piston magnet assembly is stationary. Steel plates are embedded into the experimental hall floor to provide load spreading of the muon magnet into the concrete foundation.

A finite element analysis has been developed to characterize the mode shapes, static deflection, magnet loaded deflection, and principal stress of the muon piston magnet structural components. Rasna's Applied Structures software is being used as the modeling platform.

Assembly and installation of the iron core, the back plates, and the lampshade plates are non trivial. The back plates require tilt up or rotation capable jacking frames which can accomodate 120 tons of lift. As part of this Statement of Work, the Planning Contractor shall specifically show how this assembly will be performed.

Steel foundation plates will be embedded in the floor beneath the Muon Magnet, to provide adequate load distribution into the concrete. The floor will be chipped out to a sufficient depth to allow flush mounting of the 3" thick plate, which will be leveled using epoxy anchor studs. Additional grout will be pressure injected into holes in the plate to completely fill the gap between the plate and the floor. Hydraulic jacks and wedge shims will be used to level the Muon Magnet on top of the foundation plates.

7.3 Muon Identifier Steel

The Muon Identifier (MI) consists of six heavy cross section slabs of steel which stand on end, behind the Muon Magnet. A clear bore of about two meters is cut through all the slabs to allow penetration of the RHIC beam pipe. Each slab, varying in thickness from 4 inches (2 each) to 8 inches (4 each), is approximately 30 feet high by 30 feet wide. Shipping constraints require that these sections be built up from separate pieces shipped to the Major Facility Hall, and erected on site. The specific sizes of these pieces which comprise each slab will depend on the recommendations for handing and erection provided by the Planning Contractor.

The fabrication of the MI steel and structure will be a build to print from LLNL provided drawings. The large slab pieces will be produced from low carbon steel rolled plate, generally in the reject or seconds category because of its chemical composition. No specification on mechanical properties or chemical composition will be given in the purchase order other than minimum iron content, uniformity, and continuity. Flatness and surface finish will be specified, along with the dimensions and tolerances of cut edges. Domestic estimates have been obtained based on current stock availability at vendor's locations, with some projections on future availability.

PHENIX-LLNL-93-021

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TITLE	LLNL Project Engineer DATE
RHIC/PHENIX Detector	Robert M. Yamamoto
Magnet Subsystem	
Central Magnet	APPROVED: PHENIX Project Manager Sam Aronson
Outer Coil	APPROVED: PHENIX Collaboration Shoji Nagamiya
	APPROVED: KEK Engineer Kazuhiro Tanaka
Fabrication Specification	APPROVED: TOKIN Management Kenichi Kuroki
September 1993	APPROVED: TOKIN Engineer Kazuo Katoh

		CLASSIFICATION
REV. A BY	DATE	

Specification for the Fabrication of the Central Magnet Outer Coils for the PHENIX Detector

I. General:

This specification describes the fabrication of the PHENIX Detector's Central Magnet (CM) Outer Coils. Two coil assemblies are required. Each coil assembly consists of 6 double pancake bifilar wound subassemblies as shown on the referenced drawings. The two coil assemblies are electrically connected in series and energized by a single DC power supply. The coils are however hydraulically cooled in parallel with each double pancake assembly having two independent water circuits. This is required to minimize the average operating coil temperature. A total of 24 parallel water circuits are required for the CM Outer Coils.

There are two slightly different coil configurations used to make a 6 double pancake coil assembly. They are designated by Tab 01 (open lead) and Tab 02 (crossed lead). The difference is in the electrical connection (flag) area and conductor end locations. The location and orientation of the through hole flags and tapped hole flags are interchanged which allows each coil configuration to be joined in alternating sequence via machine screws. Aside from this, both coil types are identical in all other aspects and features.

The coils have an inside diameter of 3200 mm finished "potted" dimension. They are nominally 3729 mm in outside diameter and 300 mm in width.

The following drawings are part of this specification:

AAA93-101878-0A	1 sheet	Coil Stack (North Pole)	Reference
AAA93-101879-0A	1 sheet	Coil Stack (South Pole)	Reference
AAA92-101099-0D	5 sheets	Winding - Double Pancake	
Tab-01 Open Lead Configuration			6 required
Tab-02 Crossed Lead Configuration			6 required
AAA93-101873-0B	4 sheets	Assembly - Double Pancake	
Tab-01 Open Lead Configuration			6 required
Tab-02 Crossed Lead Configuration			6 required
AAA93-101874-0B	1 sheet	Bus Flag - Thru	12 required
AAA93-101875-0B	1 sheet	Bus Flag - Tapped	12 required
AAA93-101876-0A	1 sheet	Thermostat Mount	24 required
AAA93-101855-0A	1 sheet	Flag Contact Pad	Reference (14 reqd total)

II. Coil Characteristics:

Conductor:
CDA 101/102 Copper
20.32 mm square with a 12.83 mm diameter hole and 1.5 mm corner radius

Conductor Arrangement:
Two pancakes of 12 turns each wound two in hand (bifilar). Each pancake has two water circuits and all turns are connected in series electrically. The two pancakes are assembled together to form a double pancake assembly. There are four water circuits (4 inlet and 4 outlet water fittings) per double pancake subassembly.

Number of Turns:
12 turns per pancake
24 turns per double pancake
144 turns per coil assembly

Current and Voltage:
1719 amps @ 174 volts per coil assembly (6 double pancakes)

Resistance:
0.102 ohms at room temperature

Power Dissipation:
300 Kwatts per coil assembly (6 double pancakes)

Cooling Water Temperature:
20°C inlet and 45.6°C outlet (average coil temperature: 32.8°C)
60 PSIG pressure drop through water circuit

Cooling Water Requirement:
3.66 GPM per circuit (12 parallel paths per coil)
43.9 GPM per coil assembly (6 double pancakes)

Conductor Length:
Approx. 263 meters per double pancake
Approx. 3156 meters total for two coil assemblies

Coil Weight:
Approx. 4003 kg per coil assembly (6 double pancakes)

III. Fabrication:

A. Overview

The square hollow copper conductor is insulated with a layer of 25-45% overlapped mylar tape, covered with a woven dacron sleeve. Epoxy-fiberglass sheet is inserted between each pancake layer, the outer faces of each double pancake and on the inside diameter. All epoxy-fiberglass sheet is perforated with holes to allow for epoxy to flow through the entire assembly during vacuum impregnation of the coil. In addition, the epoxy-fiberglass sheet is sandblasted to ensure good adhesion to the epoxy during impregnation. The entire package is ground wrapped with dacron cloth tape.

Brazed joints with ferrules are used to join conductor lengths and at the pre-assembled transition sections of the coil. The electrical connections between pancakes are accomplished with flags brazed onto the conductor ends. The flags are aligned and bolted together between double pancake assemblies. Six double pancake assemblies fastened together are required for one coil assembly. Silver plating is brushed onto the flags and a copper mesh is inserted between flags to promote good electrical contact between flag faces. Thread inserts are used on the tapped flags.

Water connections are accomplished by brazing fittings onto the conductor ends. Two different sizes of fittings are used to minimize the chance of mixing up inlet and outlet water circuits. The inlet water circuit uses the smaller water fitting (3/4" size) and the outlet water circuit uses the larger water fitting (1" size). Thermostats are attached to each outlet water circuit to monitor coil temperature.

B. Conductor

Procurement of the conductor as shown and specified on the Winding - Double Pancake drawing (AAA92-101099-0D sheet 1) is the responsibility of the fabricator. Once received, the conductor must be inspected and approved by LLNL. No coil fabrication can commence until this requirement has been successfully completed.

C. Brazing

The braze joint filler material shall be Sil-Fos (Handy and Harmon) used with no external flux (or LLNL approved equivalent). The chemical composition of this braze material is 15% Ag, 5% Phosphorus and 80% Cu; solidus is 1190°F (645°C) and liquidus is 1475°F (800°C). The conductor joint designs are indicated on the Coil Winding drawing (AAA92-101099-0D sheet 4 of 5) and the water fitting design is shown on the Assembly drawing (AAA93-101873-0B sheet 4 of 4). Refer to LRL Engineering Note 7939-22-M7C for specific brazing procedures. It is highly recommended that a fixture be used to perform these brazing operations. In addition, a temperature measurement device should be used to ensure that the proper braze flow temperature has been reached and not exceeded during the brazing operation.

The braze joint shall develop in tension at least 80% of the strength of the conductor cross sectional area. The fabricator shall submit to LLNL a minimum of three brazed sample joints between two conductors. The conductor used shall be identical to that of the production coil. Each conductor shall be a minimum of 6 inches long and shall use the same brazing technique as used in the production coils. These braze samples will be used for tensile testing, pressure testing and sectioning by LLNL prior to the start of coil production. Additional test samples may be requested by LLNL if required.

D. Testing

All coils shall be tested per the notes described on the Assembly - Double Pancake, drawing AAA93-101873-0B sheet 1. A "Coil Test Report" form has been provided to facilitate recording of all test data. Each double pancake assembly shall have its own "Coil Test Report" form. A total of 12 report forms are required; 6 for the open lead configuration (Tab 01) and 6 for the crossed lead configuration (Tab 02).

E. Tooling

All tooling and fixturing used to fabricate the CM Outer Coils must be approved by LLNL prior to its usage. In particular, three areas are of critical importance:

1) The coil forming tooling: A properly fabricated coil winding form is required to hold the critical dimensions of the coil. It is recommended that this form be fabricated of metal to ensure that the finish potted coil dimensions are achieved.
2) The tooling required to locate the flags onto the coil: This is the most critical part of the fabrication process. The flags must be located properly so that the double pancake assemblies will line-up and be able to fastened to one another without inducing any stress onto the lead area of the coil. Flag location must be repeatable between each double pancake assembly. It is therefore recommended that only one tooling fixture be used for this operation to ensure uniform and repeatable placement of the flags relative to themselves and the center of the coil assembly.
3) The vacuum impregnation potting mold: The double pancake assemblies may be vacuum epoxy impregnated in either an open or closed mold. It is recommended that this mold be fabricated from metal. Correct orientation and location of the flags is critical to the success of these coils. Filler material as described in the notes on the Assembly - Double Pancake drawing AAA93-101873-0B sheet 1 is acceptable to minimize areas of unreinforced epoxy in which cracking may occur. Vacuum impregnation procedures and acceptable epoxy formulations are described in UC/LLNL Mechanical Engineering Note M20E. Any exceptions must be approved by LLNL prior to coil fabrication.

F. Pre-assembly

Fit-up and assembly of a 6 double pancake coil package as shown on the drawings Coil Stack (South Pole) AAA93-101879-0A and on Coil Stack (North Pole) AAA93-101878-0A is required prior to shipment of the coils. This will ensure that the double pancake coil assemblies properly fit together. After successful assembly, the coil will be disassembled into its 6 double pancake subassemblies and prepared for individual shipment. The coils shall not be shipped as a completed unit. Each double pancake assembly will be shipped in an individual transportation container. 12 separate shipping containers are required total.

IV. Inspection Report

All double pancake assemblies (12 total) shall have their own individual inspection report. Provided is a form "Coil Test Report" to facilitate this documentation requirement. In addition, the date of all tests and the person performing the test shall be recorded and supplied to LLNL.

V. LLNL Notification and Inspection

LLNL shall be notified when inspection and testing of the coils is to occur so that if desired, LLNL personnel can be present to witness the inspection and acceptance of the coils.

Three critical inspection points/milestones have been identified. LLNL representatives shall be present to conduct these inspections. A minimum of 2 weeks notice is required to be given to LLNL personnel prior to the inspection to allow for the necessary travel and documentation arrangements to be made. The inspection points are:

1) Just prior to the start of coil winding, the conductor and the winding tooling must be inspected. This task includes not only visual inspection of the conductor but also dimensional verification of the conductor and the winding fixture. Conductor samples will have already been tensile and pressure tested prior to this time as stated in section III C above.

2) Prior to the start of the vacuum impregnation process, the potting mold must be inspected. Dimensional inspection and structural integrity of the potting mold as well as the tooling required to accurately place the bus flags will be checked at this time. It is assumed that these inspections can not take place until all 12 double pancake assemblies have been wound since a large fraction of the tooling and fixturing for the potting mold is used in the coil winding process.

3) After all double pancake assemblies have been vacuum impregnated and are in the final stages of performance testing, the assemblies shall be visually inspected and dimensionally checked. Witnessing of the final electrical verification tests are to be performed at this time as well. It is hoped that the shipping containers that will transport the coils from Japan to BNL will also be available for inspection.

The responsible LLNL project engineer for the Central Magnet Outer Coils representing the PHENIX collaboration is Mr. Robert M. Yamamoto. Mr. Yamamoto has sole authority and responsibiltiy to verify all coil tooling and performance testing. In addition, Mr. Yamamoto must approve any engineering/design change that is proposed; either because of ease of fabrication for the manufacturer or to solve a problem that has developed during fabrication. All questions, comments or concerns should be addressed to Mr. Yamamoto. In the event that Mr. Yamamoto is unable to perform his duties, Mr. Joel M. Bowers or Dr. James H. Thomas will act in his behalf. Mr. Bowers or Dr. Thomas will then have sole authority and responsibility for the Central Magnet Outer Coils until Mr. Yamamoto is able to resume his role as project engineer.

VI. Shipping

Before shipping, dry air or nitrogen gas shall be circulated through the water passages of the double pancake assembly to remove all water. Each water circuit shall be sealed with an air tight removable cap. The assembly shall be wrapped with a waterproof material and placed in a transportation container which will provide the proper protection to prevent mechanical damage of the coil. Shipment of the double pancake assembly shall not occur until all tests have been satisfactorily completed and LLNL has approved that these requirements have been fulfilled. A total of 12 individual shipping containers each containing a single double pancake coil assembly is required. Shipment of these assemblies to Brookhaven National Laboratory, Long Island, New York is to be determined by the vendor and approved by LLNL.

VII. Deviation Request

Deviations (Planned Departures Before The Fact) Any planned deviation in material, workmanship, dimensional tolerances, procedures, records, or qualifications shall require written LLNL approval before proceeding. Any missing data on the drawing or this specification shall be provided via the Deviation Request. Tokin/KEK shall submit a Deviation Request and obtain approval from LLNL prior to initiation of subject activity. No work shall proceed on the proposed deviation until approved in writing by LLNL. Use of the Deviation Request form for this is required. A copy of this form is attached to this specification.

VIII. Nonconformance Report

Nonconformances (Unplanned Departures) A nonconformance is defined as any violation of the drawing or this specification which has already occurred. Any nonconformance in material, workmanship, dimensional tolerances, procedures, records, or qualifications shall require written LLNL approval. Tokin/KEK shall submit a Nonconformance Report and obtain approval from LLNL prior to initiation of corrective action. Use of the Nonconformance Report for this is required. A copy of this form is attached to this specification.

PHENIX

Deviation Request

☐ Routine (7 day)	☐ Urgent (3 day)	☐ Emergency (24 hour)	Date:

To:	From:

Type : ☐ material ☐ part ☐ subassy ☐ final assy ☐ procedure ☐ design conflict ☐ spec conflict

Item name and serial number	Dwg # or Spec#	Agreement item
Project name	Quantity of deviated items	Related deviation requests

Description of deviation ☐ see attached	Requirements violated ☐ see attached

Planner or originator	date	TOKIN/KEK Planner	date

Recommended disposition ☐ accept ☐ redesign ☐ reject ☐ repair	Cost / schedule impact
Remedial action / justification ☐ see attached	Cause and corrective action ☐ see attached

Responsible Supplier Approvals

Engineering	date	Quality Assurance	date

TOKIN/KEK Approvals

Engineering	date	Quality Assurance	date

LLNL Disposition	☐ accept request	☐ deny request	☐ see attached

LLNL Approvals

Engineering	date	Quality Assurance	date

PHENIX Nonconformance Report

☐ Routine (7 day) ☐ Urgent (3 day) ☐ Emergency (24 hour) Date:

To:	From:

Type : ☐ material ☐ part ☐ subassy ☐ final assy ☐ procedure ☐ design conflict ☐ spec conflict

Item name and serial number	Dwg # or Spec#	Agreement item
Project name	Quantity of nonconforming items	Related nonconformance reports

Description of nonconformance ☐ see attached	Requirements violated ☐ see attached

Inspector or originator	date	TOKIN/KEK Inspector	date

Recommended disposition ☐ accept ☐ rework ☐ reject ☐ repair	Cost / schedule impact
Remedial action / justification ☐ see attached	Cause and corrective action ☐ see attached

Responsible Supplier Approvals

Engineering	date	Quality Assurance	date

TOKIN/KEK Approvals

Engineering	date	Quality Assurance	date

LLNL Disposition ☐ accept nonconformance ☐ deny ☐ see attached

LLNL Approvals

Engineering	date	Quality Assurance	date

PHENIX MAGNET SUBSYSTEM	# COIL TEST REPORT	Lawrence Livermore National Laboratory
dwg #AAA92-101873-0B Tab-01	Central Magnet Outer Coil **OPEN** Lead Configuration	Coil #: Sheet 1 of 2

During Coil Winding Operations - Prior to Brazing the Two Layers Together
Flow Circuit #1

Description	Record	Requirement	Witness
1) Hi-Pot to 1500 Volts	Leakage Current: micro amps	< 5 micro amps	
2) Resistance Check Coil Temperature	Resistance: ohms Temperature: ℃		
3) Vacuum Leak Check	☐ Pass ☐ Fail	$<1\times10^{-8}$ std. atm-cc/sec	
4) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
5) Flow Check	Flow Rate: GPM	> 3.5 GPM per circuit @ 80 PSIG inlet pressure	

During Coil Winding Operations - Prior to Brazing the Two Layers Together
Flow Circuit #2

Description	Record	Requirement	Witness
6) Hi-Pot to 1500 Volts	Leakage Current: micro amps	< 5 micro amps	
7) Resistance Check Coil Temperature	Resistance: ohms Temperature: ℃		
8) Vacuum Leak Check	☐ Pass ☐ Fail	$<1\times10^{-8}$ std. atm-cc/sec	
9) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
10) Flow Check	Flow Rate: GPM	> 3.5 GPM per circuit @ 80 PSIG inlet pressure	

Prior to Vacuum Epoxy Impregnation & After Brazing the Two Layers Together

Description	Record	Requirement	Witness
11) Hi-Pot to 1500 Volts	Leakage Current: micro amps	< 5 micro amps	
12) Resistance Check Coil Temperature	Resistance: ohms Temperature: ℃		

TOKIN/KEK Approvals

Engineering	date	Quality Assurance	date

LLNL Approvals

Engineering	date	Quality Assurance	date

PHENIX MAGNET SUBSYSTEM	# COIL TEST REPORT	Lawrence Livermore National Laboratory
dwg #AAA92-101873-0B Tab-01	Central Magnet Outer Coil **OPEN** Lead Configuration	Coil #: Sheet 2 of 2

After Vacuum Epoxy Impregnation - Total Double Pancake Assembly			
Description	**Record**	**Requirement**	**Witness**
13) Hi-Pot to 3000 Volts	Leakage Current: micro amps	< 2 micro amps	
14) Resistance Check	Resistance: ohms Temperature: °C		
15) Impulse Check	☐ Pass ☐ Fail	Test to 3000 volts peak	
16) Inductance Test	Inductance: mhenrys		

After Vacuum Epoxy Impregnation - Flow Circuit #1			
Description	**Record**	**Requirement**	**Witness**
17) Vacuum Leak Check	☐ Pass ☐ Fail	$<1x10^{-8}$ std. atm-cc/sec	
18) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
19) Flow Check	Flow Rate: GPM	>3.5 GPM per circuit @ 80 PSIG inlet pressure	

After Vacuum Epoxy Impregnation - Flow Circuit #2			
Description	**Record**	**Requirement**	**Witness**
20) Vacuum Leak Check	☐ Pass ☐ Fail	$<1x10^{-8}$ std. atm-cc/sec	
21) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
22) Flow Check	Flow Rate: GPM	>3.5 GPM per circuit @ 80 PSIG inlet pressure	

TOKIN/KEK Approvals

Engineering	date	Quality Assurance	date

LLNL Approvals

Engineering	date	Quality Assurance	date

PHENIX MAGNET SUBSYSTEM	COIL TEST REPORT	Lawrence Livermore National Laboratory
dwg #AAA92-101873-0B Tab-02	Central Magnet Outer Coil CROSSED Lead Configuration	Coil #: Sheet 1 of 2

During Coil Winding Operations - Prior to Brazing the Two Layers Together
Flow Circuit #1

Description	Record	Requirement	Witness
1) Hi-Pot to 1500 Volts	Leakage Current: micro amps	< 5 micro amps	
2) Resistance Check Coil Temperature	Resistance: ohms Temperature: °C		
3) Vacuum Leak Check	☐ Pass ☐ Fail	$<1x10^{-8}$ std. atm-cc/sec	
4) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
5) Flow Check	Flow Rate: GPM	> 3.5 GPM per circuit @ 80 PSIG inlet pressure	

During Coil Winding Operations - Prior to Brazing the Two Layers Together
Flow Circuit #2

Description	Record	Requirement	Witness
6) Hi-Pot to 1500 Volts	Leakage Current: micro amps	< 5 micro amps	
7) Resistance Check Coil Temperature	Resistance: ohms Temperature: °C		
8) Vacuum Leak Check	☐ Pass ☐ Fail	$<1x10^{-8}$ std. atm-cc/sec	
9) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
10) Flow Check	Flow Rate: GPM	> 3.5 GPM per circuit @ 80 PSIG inlet pressure	

Prior to Vacuum Epoxy Impregnation & After Brazing the Two Layers Together

Description	Record	Requirement	Witness
11) Hi-Pot to 1500 Volts	Leakage Current: micro amps	< 5 micro amps	
12) Resistance Check Coil Temperature	Resistance: ohms Temperature: °C		

TOKIN/KEK Approvals

Engineering	date	Quality Assurance	date

LLNL Approvals

Engineering	date	Quality Assurance	date

PHENIX MAGNET SUBSYSTEM	COIL TEST REPORT	Lawrence Livermore National Laboratory
dwg #AAA92-101873-0B Tab-02	Central Magnet Outer Coil **CROSSED** Lead Configuration	Coil #: Sheet 2 of 2

After Vacuum Epoxy Impregnation - Total Double Pancake Assembly

Description	Record	Requirement	Witness
13) Hi-Pot to 3000 Volts	Leakage Current: micro amps	< 2 micro amps	
14) Resistance Check	Resistance: ohms Temperature: °C		
15) Impulse Check	☐ Pass ☐ Fail	Test to 3000 volts peak	
16) Inductance Test	Inductance: mhenrys		

After Vacuum Epoxy Impregnation - Flow Circuit #1

Description	Record	Requirement	Witness
17) Vacuum Leak Check	☐ Pass ☐ Fail	$<1\times10^{-8}$ std. atm-cc/sec	
18) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
19) Flow Check	Flow Rate: GPM	>3.5 GPM per circuit @ 80 PSIG inlet pressure	

After Vacuum Epoxy Impregnation - Flow Circuit #2

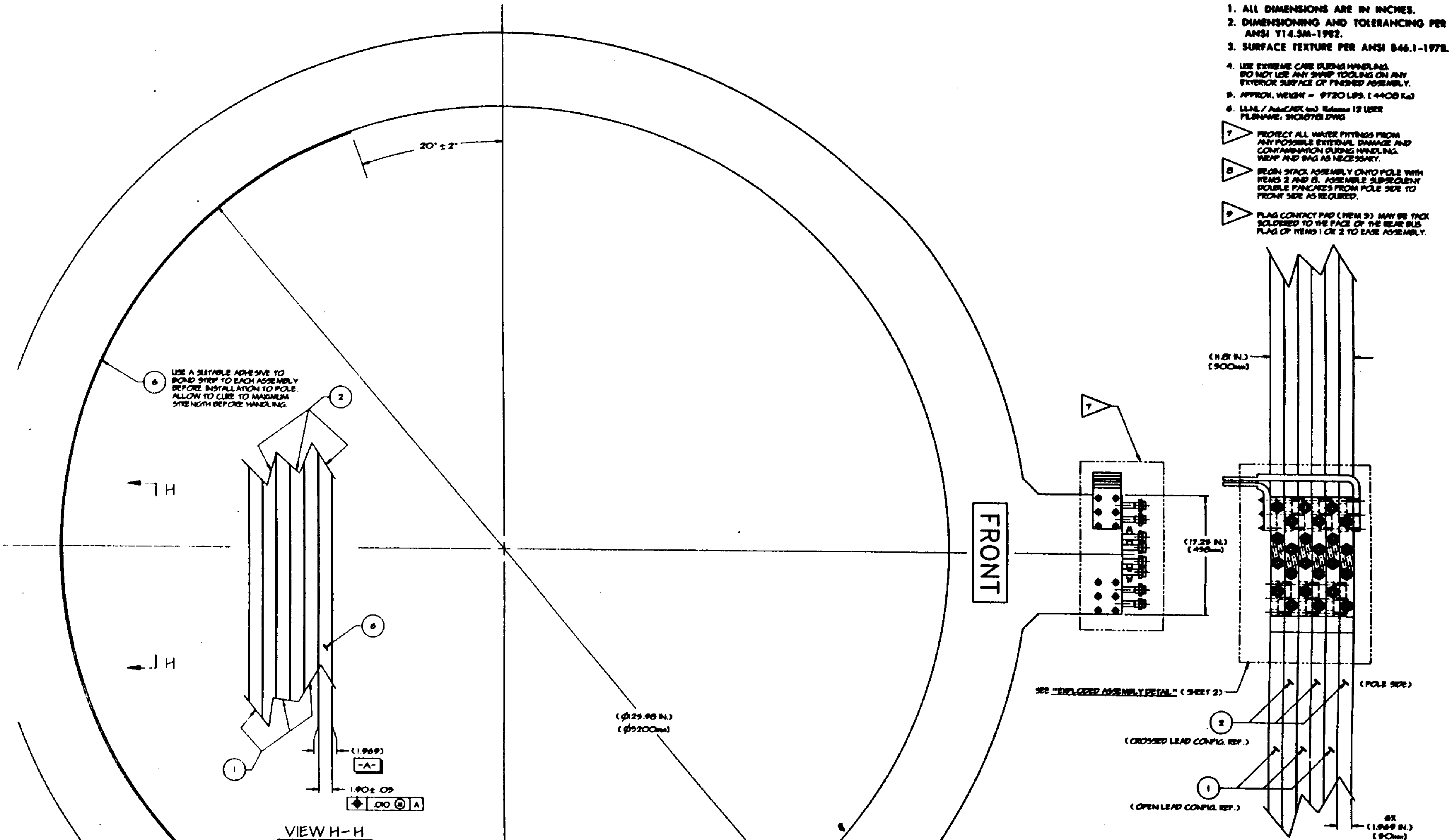
Description	Record	Requirement	Witness
20) Vacuum Leak Check	☐ Pass ☐ Fail	$<1\times10^{-8}$ std. atm-cc/sec	
21) Pressure Test	☐ Pass ☐ Fail	Test @ 150 PSIG	
22) Flow Check	Flow Rate: GPM	>3.5 GPM per circuit @ 80 PSIG inlet pressure	

TOKIN/KEK Approvals

Engineering	date	Quality Assurance	date

LLNL Approvals

Engineering	date	Quality Assurance	date



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. USE EXTREME CARE DURING HANDLING. DO NOT USE ANY SHARP TOOLING ON ANY EXTERIOR SURFACE OF FINISHED ASSEMBLY.
5. APPROX. WEIGHT = 9720 LBS. (4408 Kg)
6. LLNL / AutoCAD (m) Release 12 USER FILENAME: 3101878l.DWG
7. PROTECT ALL WATER FITTINGS FROM ANY POSSIBLE EXTERNAL DAMAGE AND CONTAMINATION DURING HANDLING. WRAP AND BAG AS NECESSARY.
8. BEGIN STACK ASSEMBLY ONTO POLE WITH ITEMS 2 AND 8. ASSEMBLE SUBSEQUENT DOUBLE PANCAKES FROM POLE SIDE TO FRONT SIDE AS REQUIRED.
9. FLAG CONTACT PAD (ITEM 3) MAY BE TACK SOLDERED TO THE FACE OF THE REAR BUS FLAG OF ITEMS 1 OR 2 TO EASE ASSEMBLY.

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM
12		O-RING, SERIES #2-239 (1/8"W X 1-1/16" I.D.)	(VITON)		11
12		O-RING, SERIES #2-116 (3/32"W X 3/4" I.D.)	(VITON)		10
1		INNER BUS CONNECTOR			9
1		OUTER BUS CONNECTOR			8
42		WASHER, BELLVILLE, ASMCO P/N 24291	(SSTL)		7
6		SHEET OR STRIP, .250" THK.	(TEFLON)		6
42		WASHER, FLAT, ASMCO P/N 549-.095-55-1	(SSTL)		5
42		SCREW, SOC HD CAP, .375-24UNF X 1.75" LG	(CRES)		4
7	93-101899	FLAG CONTACT PAD			3
3	93-101879 (TAB-01)	ASS'Y - DOUBLE PANCAKE (CROSSED LEAD CONFIG.)			2
3	93-101879 (TAB-02)	ASS'Y - DOUBLE PANCAKE (OPEN LEAD CONFIG.)			1

DWN W J WONG 9/95
CHK W J WONG 9/95
APVD R.M. YAMAMOTO 9/95

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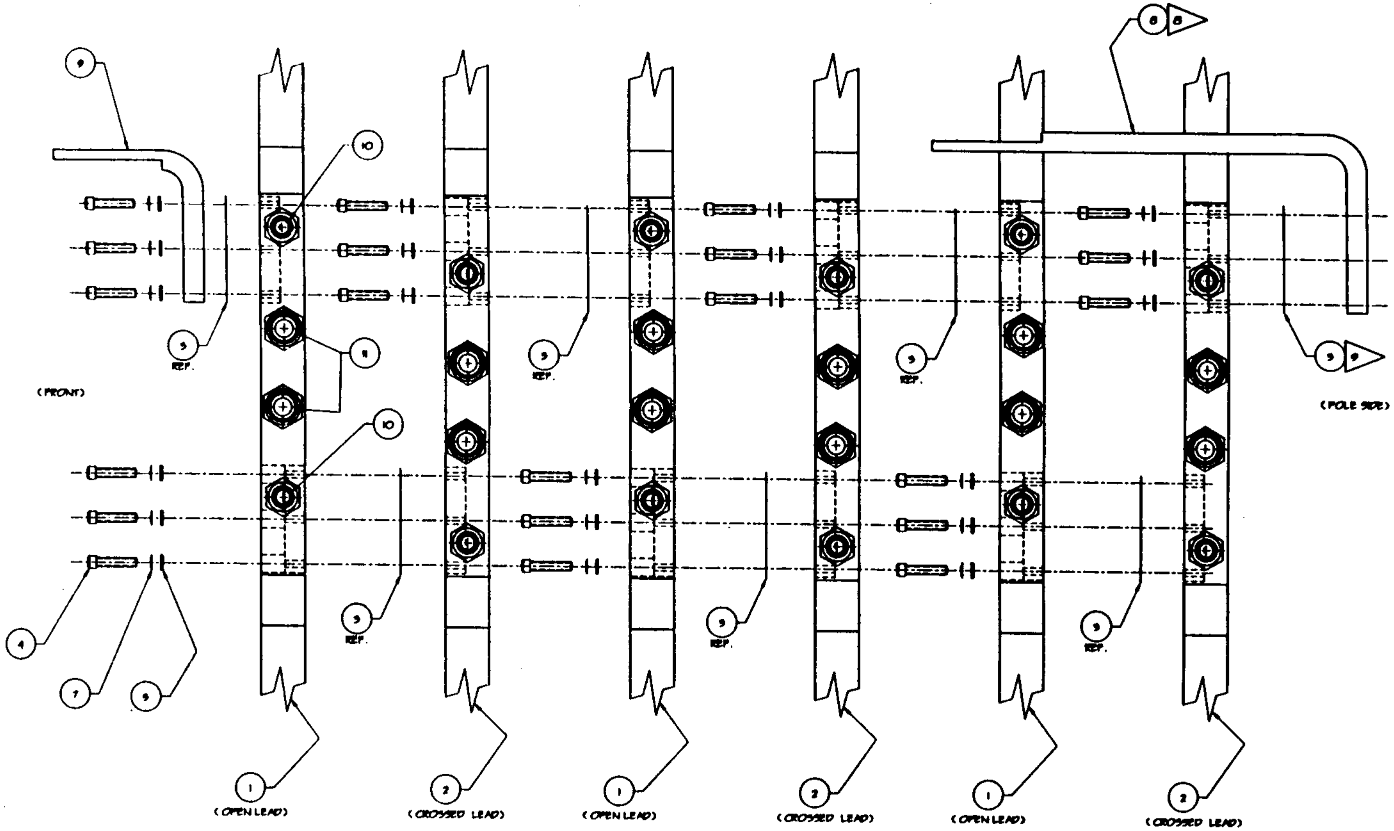
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT

FERMI-LISF

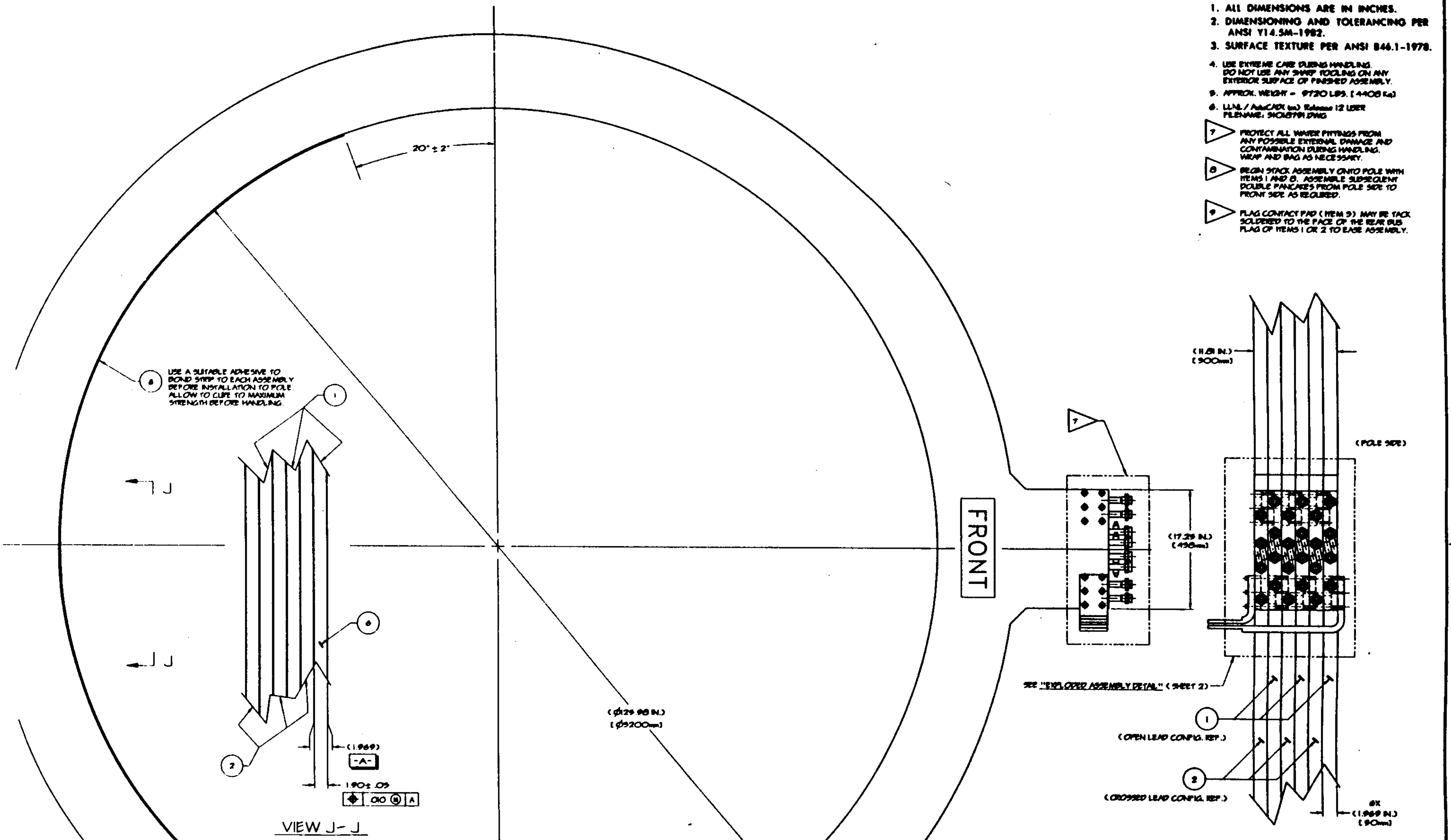
MAJOR UNIT: PHENIX
SUBASSY: CENTRAL COIL - OUTER
DETAIL: COIL STACK (NORTH POLE)
DRAWING NO: AAA 93-101878-0A
SHEET 1 OF 2



EXPLODED ASSEMBLY DETAIL
(SCALE: 1=2)

OFFICIAL USE

CLASSIFICATION	UNCLASSIFIED
DRAWING NO.	AAA93-101878-0A



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. USE EXTREME CARE DURING HANDLING. DO NOT USE ANY SHARP TOOLING ON ANY EXTERIOR SURFACE OF FINISHED ASSEMBLY.
5. APPROX. WEIGHT = 9720 LBS. [4408 Kg]
6. LLNL / AutoCAD (tm) Release 12 USER FILENAME: 910879R.DWG

7. PROTECT ALL WATER FITTINGS FROM ANY POSSIBLE EXTERNAL DAMAGE AND CONTAMINATION DURING HANDLING. WRAP AND BAG AS NECESSARY.

8. BEGIN STACK ASSEMBLY ONTO POLE WITH ITEMS 1 AND 8. ASSEMBLE SUBSEQUENT DOUBLE PANCAKES FROM POLE SIDE TO FRONT SIDE AS REQUIRED.

9. FLAG CONTACT PAD (ITEM 3) MAY BE TACK SOLDERED TO THE FACE OF THE REAR BUS FLAG OF ITEMS 1 OR 2 TO EASE ASSEMBLY.

NO REQD			PART / LLNL STK NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM
		12		O-RING, SERIES #2-219 (1/8"W X 1-1/16" I.D.)	(VITON)		11
		12		O-RING, SERIES #2-116 (3/32"W X 3/4" I.D.)	(VITON)		10
		1		INNER BUS CONNECTOR			9
		1		OUTER BUS CONNECTOR			8
		42		WASHER, BELLVILLE, ASMCO P/N 24291	(SSTL.)		7
		6		SHEET OR STRIP, .250" THK.	(TEFLON)		6
		42		WASHER, FLAT, ASMCO P/N 949-.095-55-1	(SSTL.)		5
		42		SCREW, SOC HD CAP, .375-24UNF X 1.75" LG	(CRES)		4
		7	93-101695	FLAG CONTACT PAD			3
		3	93-101879 (1AB-01)	ASS'Y - DOUBLE PANCAKE (CROSSED LEAD CONFIG.)			2
		3	93-101879 (1AB-02)	ASS'Y - DOUBLE PANCAKE (OPEN LEAD CONFIG.)			1

LTR	DATE	CHK	APVD	DATE	DESIGN	CHANGE
A						GEN. REV., ADD ITEMS 7-11, ADD SHT 2

DWN W J WONG 9/93

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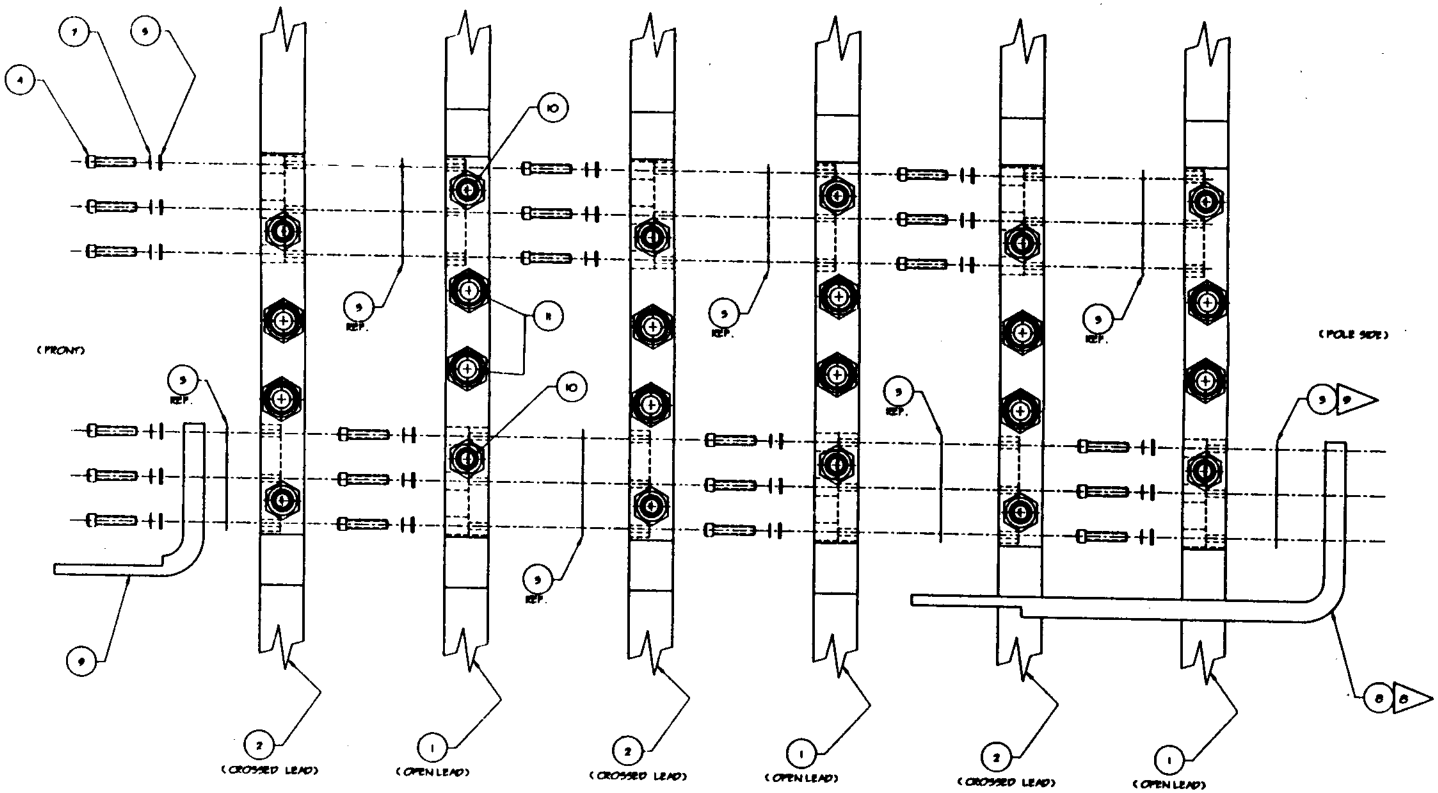
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

MAJOR UNIT: PHENIX
SUBASSY: CENTRAL COIL - OUTER
TITLE: COIL STACK (SOUTH POLE)

DRAWING NO: AAA93-101879-0A

SCALE: [illegible] SHEET 1 OF 2



EXPLODED ASSEMBLY DETAIL
(SCALE: 1-2)

OFFICIAL USE

CLASSIFICATION
UNCLASSIFIED
DRAWING NO
AAA93-101879-0A

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. AutoCAD/LLNL Release 12 USER FILENAME: 21010991.DWG
5. DIMENSION NOTATION: INCHES [mm]

FABRICATION NOTES FOR PHENIX OUTER CENTRAL COIL

IN SEQUENCE AS APPLICABLE

1. EACH COIL SHALL CONSIST OF TWO CONDUCTORS, BIFILAR WOUND, IN DOUBLE PANCAKE FASHION TO PROVIDE TWO 12 TURN PARALLEL WATER COOLANT PATHS CONNECTED ELECTRICALLY IN SERIES FOR A TOTAL OF 24 TURNS PER COIL ASSEMBLY.

2. SUBSTITUTION FOR MATERIALS SPECIFIED MAY BE MADE WITH THE APPROVAL OF LLNL. IN GENERAL THE PERFORMANCE SPECIFICATIONS OF SUBSTITUTE MATERIALS SHALL MEET OR EXCEED THOSE SPECIFIED BY LLNL.

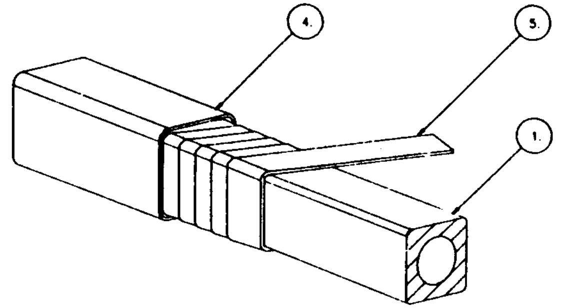
3. CLEAN ALL EXTERIOR CONDUCTOR SURFACES OF DIRT, GREASE, OIL, EXCESS OXIDES, ETC. PRIOR TO INSULATING.

4. THE CONDUCTOR SHALL BE INSULATED BY A LAYER OF 25-45% OVERLAPPED TAPE,(ITEM 5) FOLLOWED BY APPLICATION OF A SLEEVE(ITEM 4). SLEEVE ENDS MAY BE SECURED BY ADHESIVE TAPE OR OTHER MEANS TO PREVENT SLIPPING. SLEEVE JOINTS MAY BE SEWN OR OTHERWISE SECURED TO PREVENT JOINT PARTING. USE A SIMILAR METHOD TO INSULATE TRANSITIONS (ITEM 2). IN THE RAMP AREA CUSTOM INSULATE TO PROVIDE AN LLNL APPROVED EQUIVALENT PROTECTION.

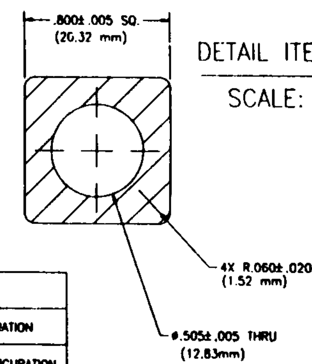
5. APPROXIMATE CONDUCTOR LENGTH PER COIL IS 880 FEET (268 METERS).

6. CONDUCTOR JOINTS SHALL BE MADE IN ACCORDANCE WITH LRL ENGINEERING NOTE 7939-22-M7C AND CONDUCTOR SPLICE DETAIL (SHEET 4) OR AN LLNL APPROVED EQUAL PROCEDURE.

7. PANCAKE SPACERS (ITEM 3) SHALL BE RANDOMLY PUNCHED WITH 0.5 IN. DIA. HOLES ON APPROXIMATELY 2 IN. CENTERS TO PERMIT RESIN FLOW THROUGH DURING IMPREGNATION. SURFACES SHALL BE LIGHTLY SANDBLASTED OR OTHERWISE ABRADED TO ENHANCE BONDING. SPACERS AND SHEETS MAY BE SEGMENTED, BUTTED, AND TAPED TOGETHER.



CONDUCTOR INSULATING PACKAGE



DETAIL ITEM-1

SCALE: 4X

TAB NO.	DESCRIPTION
TAB-01	OPEN LEAD CONFIGURATION
TAB-02	CROSSED LEAD CONFIGURATION

		NO REQD		PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
(SEE SHEET-4)	A/R	A/R			TUBE ø.625 X.062W CDA 101/102 HIGH PURITY(Cu)		7
(SEE SHEET-5)	4	4			RAMP,BAR OR PLATE CDA 101/102 HIGH PURITY(Cu)		6
(SEE SHEET-2&3)	A/R	A/R			MYLAR TAPE,.75"W X .0035" THK. ADHESIVE BACKED	SCOTCH 97(3M)	5
(SEE SHEET-2&3)	A/R	A/R			SLEEVE, DACRON, WOVEN TUBE, ø1.25" X .015"W		4
	A/R	A/R			EPOXY-FIBERGLASS SHEET.030" THICK SANDBLASTED	G-10 OR FR-4	3
(SEE SHEET-5)	2	2			TRANSITION		2
	A/R	A/R			CONDUCTOR .800 IN. X .800 IN. X ø.505 IN. BORE (20.32mm X 20.32mm X ø12.83mm) CDA 101/102	(HIGH PUR.Cu)	1
	TAB-02	TAB-01					

LTR	DWN	CHK	APVD	DATE		CHANGE
D	LM			5/93		GEN REV.
C	LM			4/93		GEN REV.
B	WW			3/93		GEN REV.
A	WW			2/93		GEN REV./ADD CROSSED LEAD CONF.

DWN	W. J. WONG	2/93
CHK	W. J. WONG	2/93
APVD	R. M. YAMAMOTO	2/93

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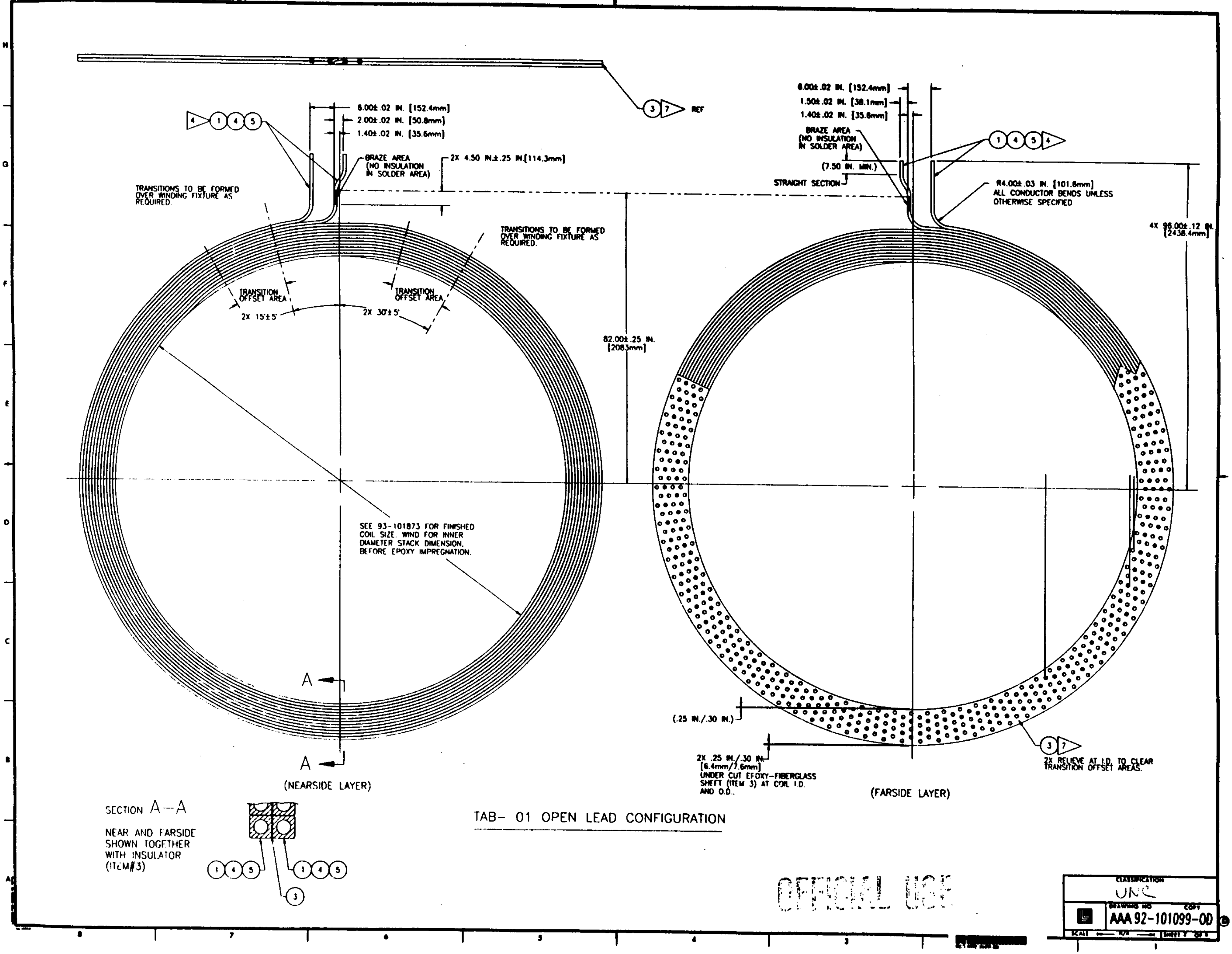
PHENIX

CENTRAL COIL - OUTER

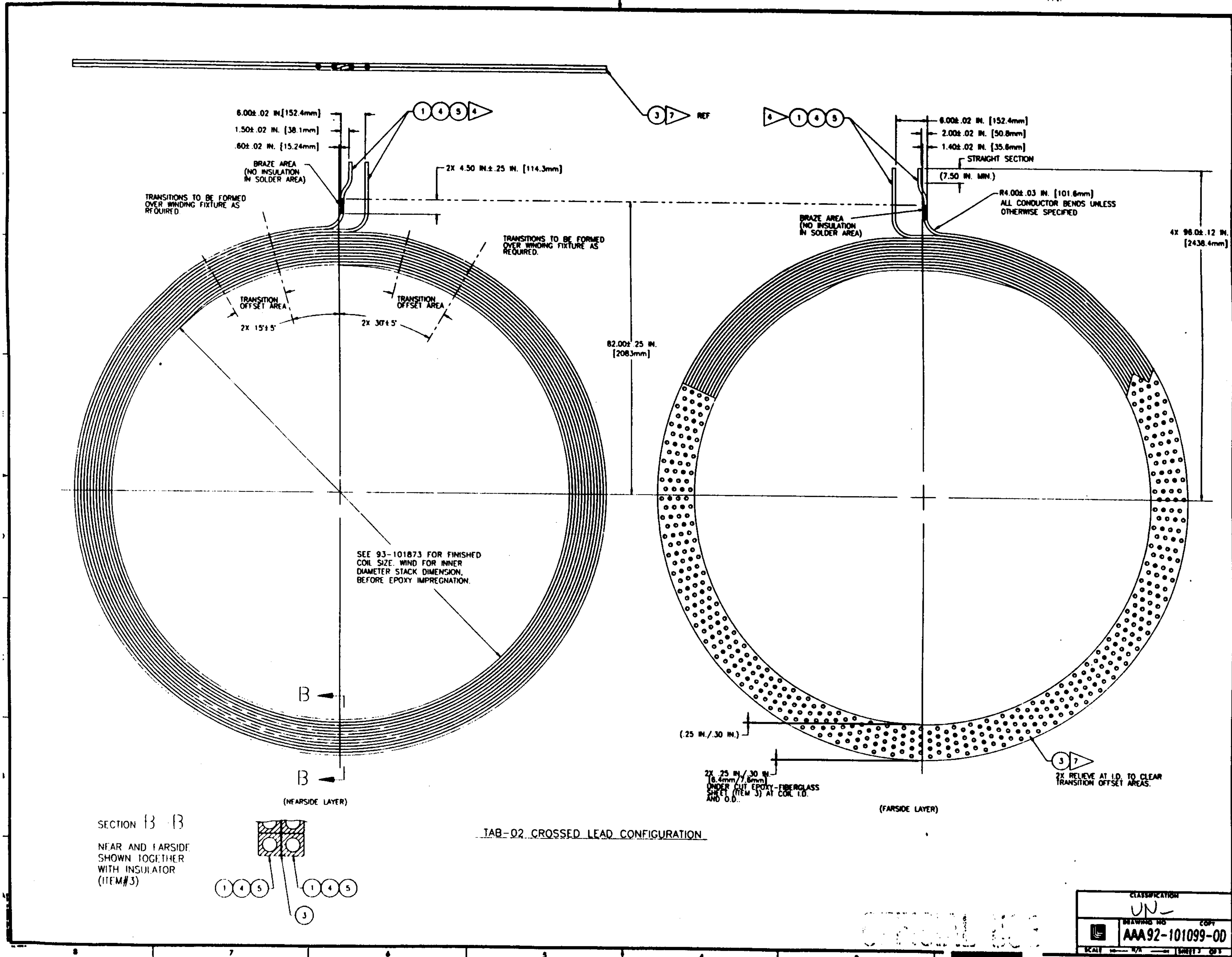
WINDING - DOUBLE PANCAKE

DRAWING NO AAA 92-101099-OD D

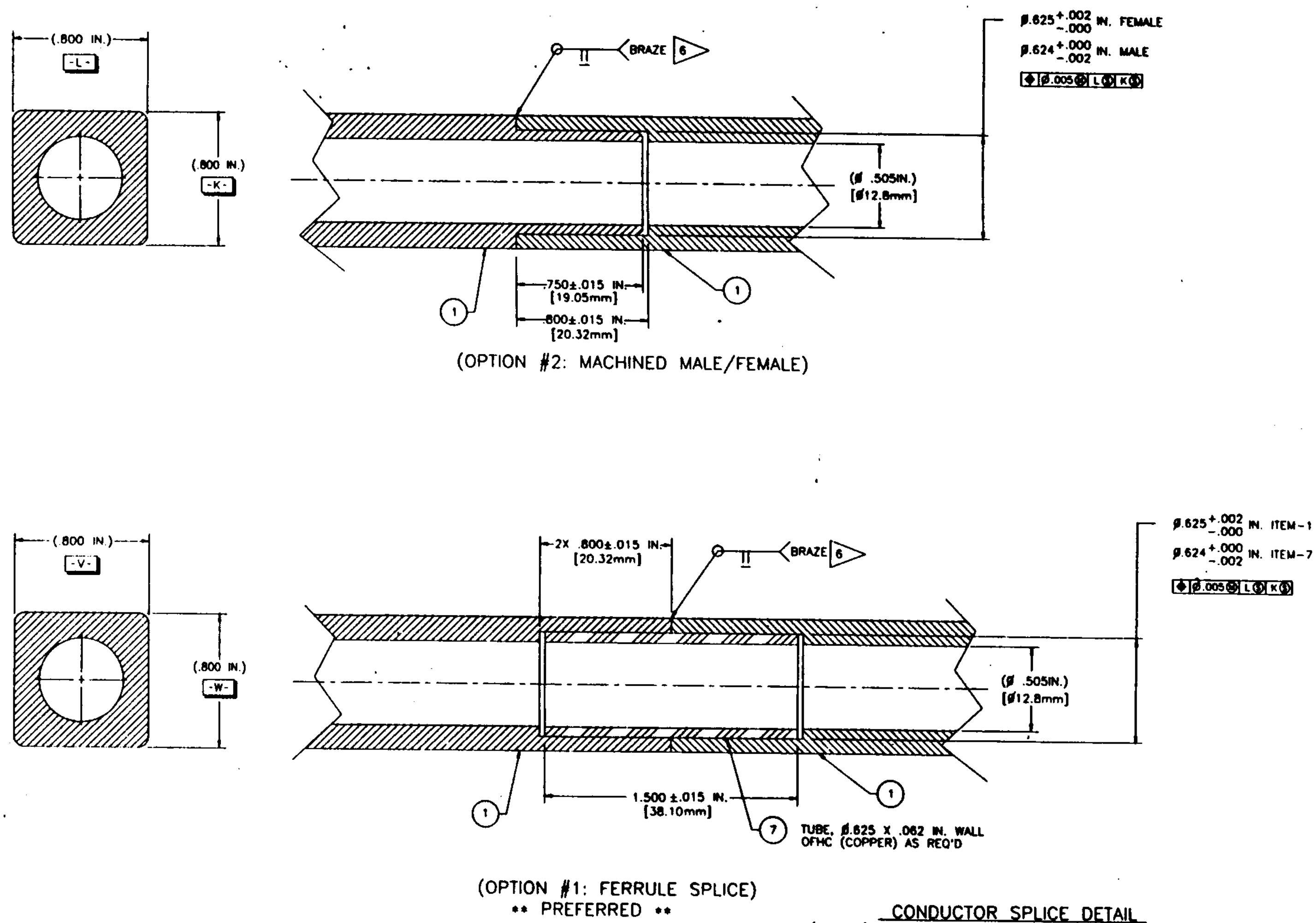
SCALE N/A SHEET 1 OF 7



REF
6.00± .02 IN. [152.4mm]
2.00± .02 IN. [50.8mm]
1.40± .02 IN. [35.6mm]
BRAZE AREA (NO INSULATION IN SOLDER AREA)
2X 4.50 IN.± .25 IN.[114.3mm]
TRANSITIONS TO BE FORMED OVER WINDING FIXTURE AS REQUIRED.
TRANSITION OFFSET AREA
2X 15°± 5°
2X 30°± 5°
82.00± .25 IN. [2083mm]
SEE 93-101873 FOR FINISHED COIL SIZE. WIND FOR INNER DIAMETER STACK DIMENSION, BEFORE EPOXY IMPREGNATION.
A
A
(NEARSIDE LAYER)
6.00± .02 IN. [152.4mm]
1.50± .02 IN. [38.1mm]
1.40± .02 IN. [35.6mm]
BRAZE AREA (NO INSULATION IN SOLDER AREA)
(7.50 IN. MIN.)
STRAIGHT SECTION
R4.00± .03 IN. [101.6mm] ALL CONDUCTOR BENDS UNLESS OTHERWISE SPECIFIED
4X 96.00± .12 IN. [2438.4mm]
(.25 IN./.30 IN.)
2X .25 IN./.30 IN. [6.4mm/7.6mm] UNDER CUT EPOXY-FIBERGLASS SHEET (ITEM 3) AT COIL I.D. AND O.D..
2X RELIEVE AT I.D. TO CLEAR TRANSITION OFFSET AREAS.
(FARSIDE LAYER)
SECTION A—A
NEAR AND FARSIDE SHOWN TOGETHER WITH INSULATOR (ITEM#3)
TAB- 01 OPEN LEAD CONFIGURATION
OFFICIAL USE
CLASSIFICATION
UNC
DRAWING NO
AAA 92-101099-00

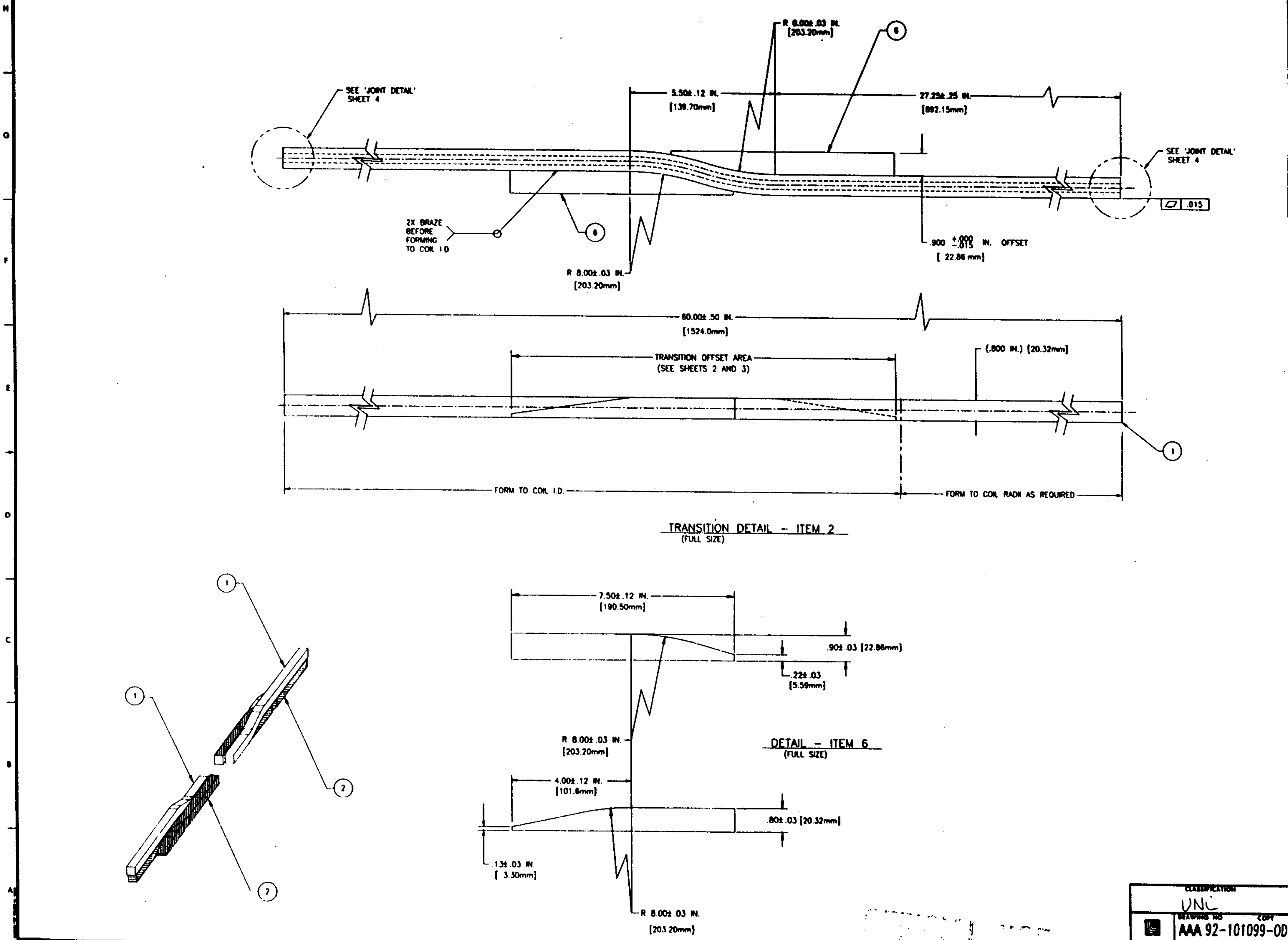


6.00± .02 IN.[152.4mm]
1.50± .02 IN. [38.1mm]
.60± .02 IN. [15.24mm]
BRAZE AREA (NO INSULATION IN SOLDER AREA)
TRANSITIONS TO BE FORMED OVER WINDING FIXTURE AS REQUIRED
2X 4.50 IN.± .25 IN. [114.3mm]
REF
TRANSITION OFFSET AREA
2X 15°± 5°
2X 30°± 5°
82.00± .25 IN. [2083mm]
SEE 93-101873 FOR FINISHED COIL SIZE. WIND FOR INNER DIAMETER STACK DIMENSION, BEFORE EPOXY IMPREGNATION.
B
(NEARSIDE LAYER)
6.00± .02 IN. [152.4mm]
2.00± .02 IN. [50.8mm]
1.40± .02 IN. [35.6mm]
STRAIGHT SECTION
(7.50 IN. MIN.)
R4.00± .03 IN. [101.6mm]
ALL CONDUCTOR BENDS UNLESS OTHERWISE SPECIFIED
4X 96.0± .12 IN. [2438.4mm]
(.25 IN./.30 IN.)
2X .25 IN./.30 IN. [6.4mm/7.6mm] UNDER CUT EPOXY-FIBERGLASS SHEET (ITEM 3) AT COIL I.D. AND O.D.
2X RELIEVE AT I.D. TO CLEAR TRANSITION OFFSET AREAS.
(FARSIDE LAYER)
SECTION B-B
NEAR AND FARSIDE SHOWN TOGETHER WITH INSULATOR (ITEM#3)
TAB-02 CROSSED LEAD CONFIGURATION
CLASSIFICATION
UN
DRAWING NO
AAA92-101099-00
SCALE N/A



CONDUCTOR SPLICE DETAIL
(4X SIZE) - BEFORE INSULATING WRAP AND FORMING.

CLASSIFICATION UNC
DRAWING NO AAA 92-101099-00



CLASSIFICATION
UNC
DRAWING NO
AAA 92-101099-0D

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. LLNL / AutoCADX (tm) Release 12 USER FILENAME: 3101873I.DWG
5. DIMENSION NOTATION: INCHES (mm)
6. WELD SYMBOLS ARE PER ANSI / AWS A2.4-76.

FABRICATION NOTES FOR PHENIX - OUTER CENTRAL COIL ASSEMBLY

(IN SEQUENCE AS APPLICABLE)

1. PROVIDE GROUND WRAP (ITEM 8) AS SHOWN ON SHEET 2 USING 25 - 49 % OVER LAP TO COMPLETELY COVER THE COIL WINDING. DURING THIS OPERATION, FILL ALL VOID AREAS LARGER THAN .125 INCH WITH FIBROUS GLASS MATERIAL (i.e. EPOXY-FIBERGLASS BLOCKS, CLOTH, MAT, ETC.).
2. PRIOR TO BRAZING (SEE SPECIFICATION # 7959-22-M7C) THE CONDUCTORS OF THE TWO HYDRAULIC CIRCUITS TOGETHER. ISOLATE THE TWO CIRCUITS AND HI-POT TO 1500 VOLTS. TOTAL LEAKAGE NOT TO EXCEED 5 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE OF EACH CIRCUIT.
3. PLACEMENT OF BUS FLAGS (ITEMS 5 AND 11) SHALL BE DONE WITH ADEQUATE FIXTURING TO COMPLY WITH PARALLELISM AND POSITIONING TOLERANCES SPECIFIED IN DRAWING. BUS FLAGS WILL SUBSEQUENTLY BE SECURED TO, BUT ELECTRICALLY ISOLATED FROM THE VACUUM IMPREGNATION MOLD TO INSURE THAT THESE TOLERANCES ARE MAINTAINED.
4. LLNL SHALL PROVIDE COIL TEST REPORT FORMS TO DOCUMENT TESTING PERFORMED IN NOTE 5.
5. EACH HYDRAULIC CIRCUIT (TWO PER DOUBLE PANCAKE ASSEMBLY) SHALL BE TESTED WITH ALL FITTINGS BOTH BEFORE AND AFTER POTTING. ONE 'COIL TEST REPORT' SHALL BE GENERATED FOR EACH SERIALIZED ASSEMBLY. THE FOLLOWING PROCEDURES SHALL CONSTITUTE ONE COMPLETE TEST ON EACH CIRCUIT:
   - A) A DRY NITROGEN PURGE MAY BE USED TO EVAPORATE ANY RESIDUAL MOISTURE WITHIN THE COIL. VACCUM TEST PER ASTM E490-75 WITH A MAXIMUM ALLOWABLE LEAK RATE OF 1 X 10e-8 ATM-CC/SECOND OF HELIUM AT 10e-5 TORR WITH ALL INTERIOR VOLUME CONNECTED TO A RESIDUAL GAS ANALYZER (RGA) OR A HELIUM MASS SPECTROMETER LEAK DETECTOR. COVER (BAG) THE ENTIRE COIL ASSEMBLY, INCLUDING LEAD FITTINGS IN A HELIUM FILLED ENCLOSURE PRIOR TO THE LEAK TEST. RECORD RESULTS INTO 'COIL TEST REPORT'.
   - B) PRESSURE TEST WITH WATER IN ACCORDANCE WITH ASME BOILER AND PRESSURE VESSEL CODE SECTION VIII USING THE TEST PRESSURE DEFINED IN NOTE 20. RECORD RESULTS IN 'COIL TEST REPORT'.
   - C) WATER FLOW TEST WITH AN INLET PRESSURE OF 80± 5 PSIG. EXIT FLOW RATE SHALL BE AT LEAST 5.5 US GALLONS PER MINUTE (GPM). RECORD THE RESULTS IN 'COIL TEST REPORT'.
6. FILL LARGE VOID VOLUMES IN LEAD AREA WITH CONTOURED EPOXY-FIBERGLASS BLOCKS (ITEM 13) FOLLOWED BY GROUND WRAP (ITEM 8) OVERWRAP. DO NOT COVER BUS FLAG(S) FACES.
7. VACUUM IMPREGNATION MOLD SHALL BE OF SUFFICIENT RIGIDITY AND MANUFACTURING TOLERANCES TO MAINTAIN THE COIL DIMENSIONS SPECIFIED. MOLD SHALL BE VACUUM TIGHT UNLESS THE ENTIRE MOLD WILL BE ENCLOSED IN A VACUUM CHAMBER, IN WHICH CASE THE MOLD SHALL BE LIQUID TIGHT.
8. SURFACE COAT ALL AREAS OF VACUUM IMPREGNATION MOLD AND EXPOSED BUS FLAG FACES WITH SUITABLE MOLD RELEASE. COAT THREADED HOLES AND BOLTS WITH SILICONE OR TEFLON GREASE AND PLUG BUS FLAG CLEARANCE HOLES.
9. ENCLOSE COIL IN THE MOLD. ENSURE THAT EXPOSED BUS FLAGS, BOLTS, AND LEADS ARE ELECTRICALLY ISOLATED FROM THE MOLD. FILL VOIDS AS DESCRIBED IN NOTE 1.
10. HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 1500 VOLTS. LEAKAGE NOT TO EXCEED 5 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE OF EACH CIRCUIT PRIOR TO POTTING.
11. AFTER SEALING, HEAT AND EVACUATE MOLD FOR 12 HOURS MINIMUM PRIOR TO VACUUM IMPREGNATION TO FULLY RID MOLD OF MOISTURE AND AIR FROM THE PORES OF THE FIBROUS MATERIAL (TAPE, SLEEVE, ETC.). INSURE THAT SUFFICIENT HEATING IS PRESENT TO FULLY CURE THE RESIN AFTER IMPREGNATION. IF HOT WATER IS USED THROUGH THE CONDUCTOR BORE, AUXILIARY HEATING MAY BE REQUIRED IN AREAS REMOTE FROM THE CONDUCTOR (SUCH AS IN THE TERMINAL AREA).
12. VACUUM IMPREGNATE COIL ASSEMBLY PER UC/LLNL MECHANICAL ENGINEERING SPECIFICATION M20E.
13. AFTER COOL DOWN AND PRIOR TO DEMOLDING, HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 5000 VOLTS. CURRENT LEAKAGE NOT TO EXCEED 2 MICRO AMPS.

(CON'TD)

14. AFTER DEMOLDING, REMOVE FLASHING AND SAND SHARP EDGES OF COIL ASSEMBLY. CLEAN BUS FLAG FACES OF MOLD RELEASE AND SILVER PLATE USING A BRUSH ON CHEMICAL SILVER PLATE, SUCH AS 'COOL-AMP' ® OR LLNL APPROVED EQUAL. REMOVE PLUGS AND GREASE FROM THREADED AND BOLT ACCESS HOLES. DO NOT FRAY OR BREACH WRAP ON ANY EXTERIOR SURFACE OR EDGE. CHASE AND CLEAN ALL EXCESS PLATING FROM THREADED HOLES.
15. PERFORM THE FOLLOWING ELECTRICAL TESTS:
   - A. IMPULSE TEST COIL TO 5000 VOLTS PEAK.
   - B. MEASURE COIL RESISTANCE AND TEMPERATURE.
   - C. MEASURE COIL INDUCTANCE.
16. INSTALL THERMOSTATS (ITEM 9) WHERE SHOWN, AFTER EPOXY IMPREGNATION HAS BEEN COMPLETED.
17. AFFIX A PERMANENT LABEL ON THE OUTER EDGE OF EACH FINISHED DOUBLE PANCAKE ASSEMBLY. USE ANY SUITABLE PERMANENT ADHESIVE TO BE APPROVED BY LLNL. IMPRINTED IN 5/16" HIGH CHARACTERS WITH THE FOLLOWING DATA AS SHOWN: (LABEL SIZE - 25"W X 1.75"H X .050"THK. MAX)

INDICATE APPROPRIATE TAB NO. AND "LEAD" DESCRIPTION. (i.e. '(TAB-01) OPEN' OR '(TAB-02) CROSS')

PRESSURE TEST FOR MANNED AREA	TEST PRESSURE : 150 PSIG
LLNL DWG. AAA93-101873 (TAB-01) OPEN	TEST DATE : (MO./DAY/YR)
COIL SERIAL NO. : (PER MANUFACTURER)	INSP'D BY : (INSPECTORS' NAME)

DO NOT BREACH FINISHED POTTED ASSEMBLY WITH ANY EXTERNAL FASTENER.

ALSO MARK ON THE SIDE OF THE LEAD AREA NEAR LABEL, "COIL WEIGHT - 1620 LBS. (736 KG)" IN 1.5" HIGH LETTERS USING A PERMANENT INDELIBLE INK. FINAL PROTECTIVE CLEAR COAT OVER INK IS ALLOWABLE.

18. FLUSH ALL COIL PASSAGES OF LOOSE DIRT AND FOREIGN PARTICLES WITH 130°F WATER. BLOW PASSAGES FOR APPROXIMATELY 5 MINUTES WITH LOW PRESSURE DRY NITROGEN. SUFFICIENTLY CAP COIL ENDS FOR TRANSPORTATION. HANDLE FINISHED COIL ASSEMBLY WITH EXTREME CARE. PACKAGE AND CRATE COIL TO PROTECT SURFACES AND LEADS FROM EXTERNAL DAMAGE DURING SHIPPING.
19. APPROXIMATE FINISHED ASSEMBLY WEIGHT - 1620 LBS (736 KG) EACH DOUBLE PANCAKE.
20. THE COIL ASSEMBLY 'MAXIMUM OPERATING PRESSURE' (MOP) SHALL BE 80 PSIG. RELIEF VALVE SETTING DURING NORMAL OPERATION, OR 'MAXIMUM ALLOWABLE WORKING PRESSURE' (MAWP) SHALL BE 100 PSIG. TEST PRESSURE SHALL BE 150 PSIG.
21. THE FOLLOWING DOCUMENTATION SHALL BE DELIVERED WITH THE FINISHED COIL ASSEMBLIES:
   - A) ALL 'COIL TEST REPORTS'
   - B) DIMENSIONAL INSPECTION REPORTS
   - C) MATERIAL CERTIFICATIONS FOR ALL COIL, FITTINGS, AND BRAZE FILLER METALS.
22. PANCAKE SPACERS AND OUTSIDE SURFACE PROTECTION SHEETS (ITEMS 6 AND 7) SHALL BE RANDOMLY PUNCHED WITH 0.5 IN. DIA. HOLES ON APPROXIMATELY 2 IN. CENTERS TO PERMIT RESIN FLOW THROUGH DURING IMPREGNATION.
23. SURFACES SHALL BE LIGHTLY SANDBLASTED, OR OTHERWISE ABRADED, TO ENHANCE BONDING. SPACERS AND SHEETS MAY BE SEGMENTED, BUTTED AND TAPED TOGETHER.
24. BEFORE POTTING, TWIST BRAZED "RETURN" (CENTRAL LEADS) CONDUCTORS APPROXIMATELY 15° AND BEND "SUPPLY" (OUTER LEADS) CONDUCTORS SO THAT ALL WATER FITTINGS ARE INLINE AND CENTERED AS SHOWN ON SHEET 3.
25. NO MACHINING ON ANY PORTION OF THE COIL IS PERMISSIBLE AFTER VACUUM IMPREGNATION.
26. INSTALL INSERTS (ITEM 10) INTO BUS FLAG - TAPPED (ITEM 11) AFTER BRAZING AND CLEANING OF FLAG ON CONDUCTOR AS SHOWN PRIOR TO VACUUM IMPREGNATION.

TAB NO.	DESCRIPTION **
TAB-01	OPEN LEAD CONFIGURATION
TAB-02	CROSSED LEAD CONFIGURATION

** SEE SHEETS 2 AND 3 FOR CLARITY.

	NO REQD TAB-02	NO REQD TAB-01	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
(SEE SHEET 3)	AR	AR		SLEEVE, DACRON, WOVEN TUBE, 01.25" X .015"W		15
(SEE SHEET 3)	AR	AR		MYLAR TAPE, .75"W X .0035"THK., ADH. BACKED, 3M®	SCOTCH TYPE 57	14
6 (SEE SHEET 4)	AR	AR		EPOXY-FIBERGLASS SHEET, VARIOUS SIZES, NEMA GRADE	(FR-4/G-10)	13
	2	2	93-101876	THERMOSTAT MOUNT		12
	1	1	93-101875	BUS FLAG - TAPPED		11
26, 14 (SEE SHEET 4)	6	6		INSERT, FLOATING, .375-24UNF-3B, EXT THD .750-16UN, P/N KNKX(L) 624J, TRIDAIR KEENSERTS (tm) (SSTL)		10
16 (SEE SHEET 3)	2	2		THERMOSTAT, NC, 150°F-165°F, 'KLIXON' (tm) P/N 4344-13 (TEXAS INTRUMENTS)		9
(SEE SHEET 2/3)	AR	AR		TAPE, DACRON CLOTH, 4" WIDE X .012" THK.		8
23 (SEE SHEET 2/3)	AR	AR		EPOXY-FIBERGLASS SHEET, .030" THICK, NEMA GRADE	(FR-4/G-10)	7
23 (SEE SHEET 2/3)	AR	AR		EPOXY-FIBERGLASS SHEET, .015" THICK, NEMA GRADE	(FR-4/G-10)	6
	1	1	93-101874	BUS FLAG - THRU		5
(SEE SHEET 2/4)	2	2		BLIND BODY, P/N #SS-16-VCO-1-BL (SSTL)	CAJON®	4
(SEE SHEET 2/4)	2	2		SOCKET WELD CONN., BODY, P/N #SS-12-VCO-1 (SSTL)	CAJON®	3
	1		92-101099 (TAB-02)	WINDING - DOUBLE PANCAKE (CROSSED LEAD)		2
		1	92-101099 (TAB-01)	WINDING - DOUBLE PANCAKE (OPEN LEAD)		1

LTR	DWN	CHK	APVD	DATE		CHANGE
B2	WW	CH	BW	3/99		NEW FORMAT SHEETS #2, #3 AND #4
B1	WW	CH	BW	3/99		ADD ITEMS 13-15, NOTES 22-26
A	WW	BW		3/99		GENERAL REVISION

DWN W. J. WONG 3/99
CHK W. J. WONG 3/99
APVD 3/99

CLASSIFICATION

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LAWRENCE LIVERMORE NATIONAL LABORATORY

OFFICIAL USE

MAJOR UNIT: PHENIX

ASSEMBLY: CENTRAL COIL - OUTER

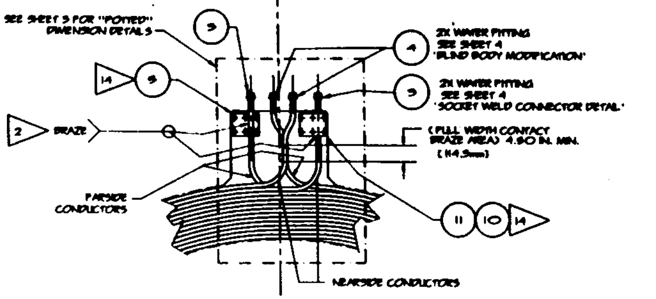
DETAIL: ASSEMBLY - DOUBLE PANCAKE

DRAWING NO: AAA93-101873-0B

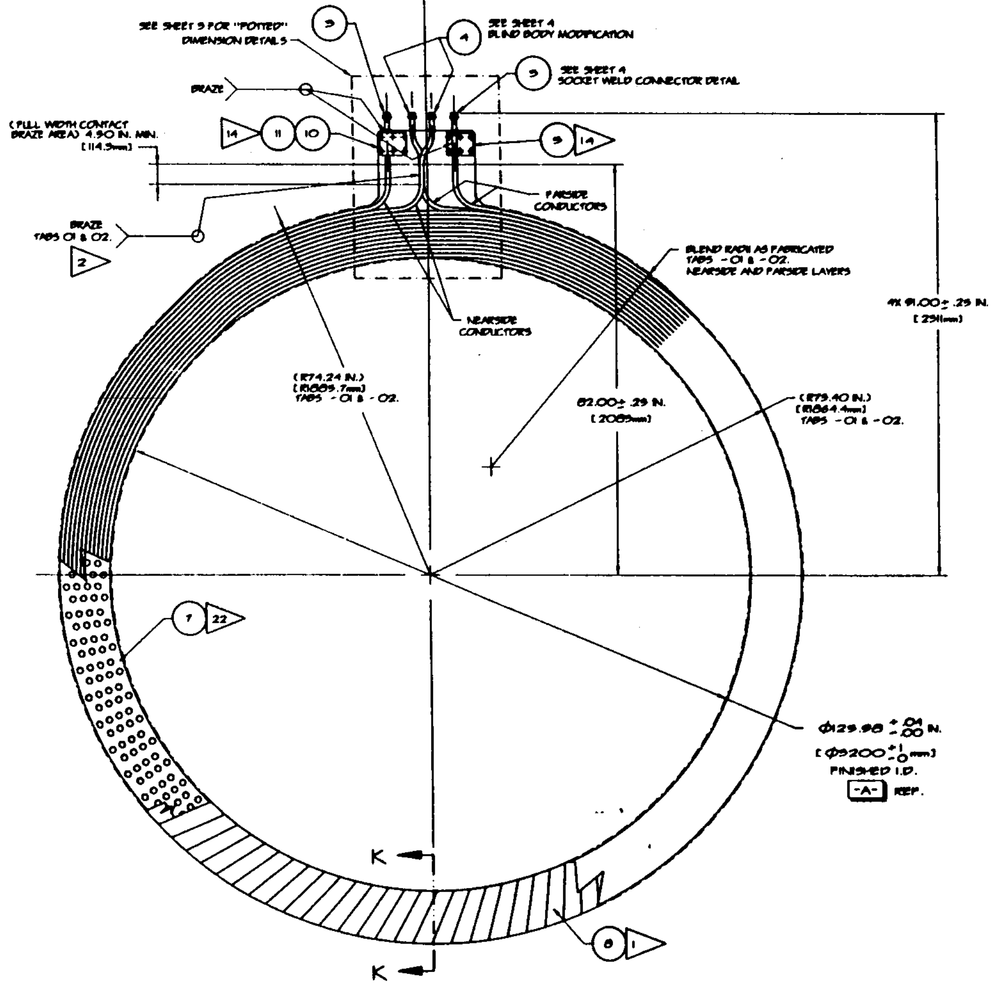
SCALE N/A SHEET 1 OF 4

GENERAL NOTES: (SEE SHEET 1.)

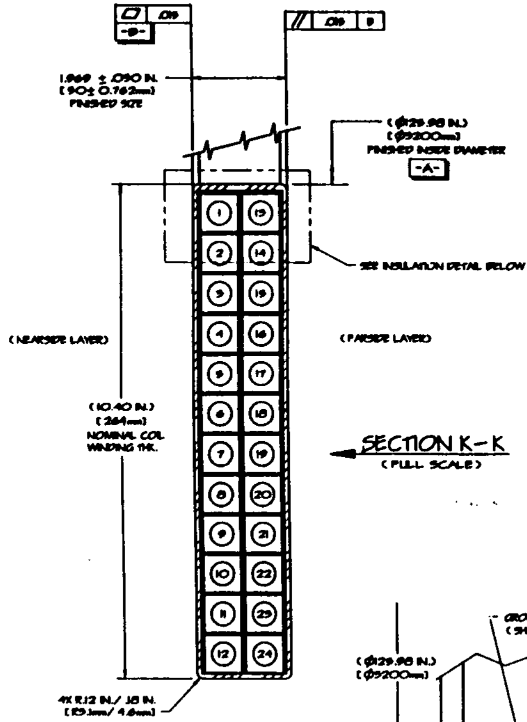
1. AutoCAD / LLNL Release 12
   FILENAME: 31018792.DWG
2. DIMENSION NOTATION: INCHES (mm)



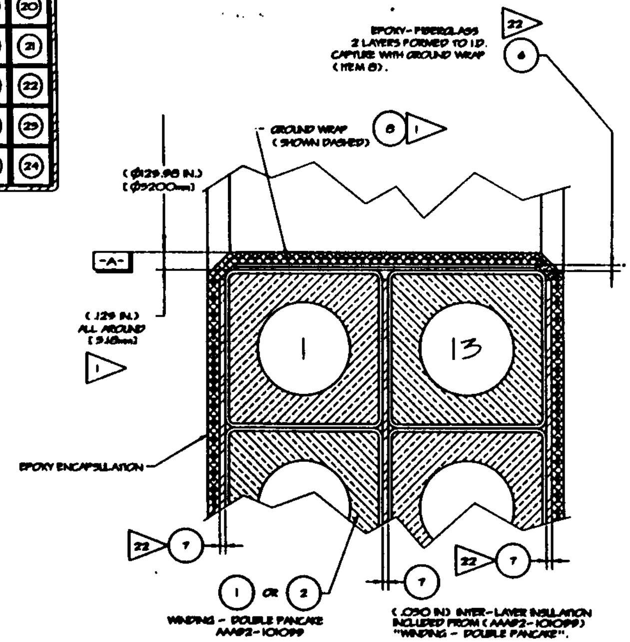
CROSSED LEAD CONFIGURATION (ITEM 2)



OPEN LEAD CONFIGURATION (ITEM 1)



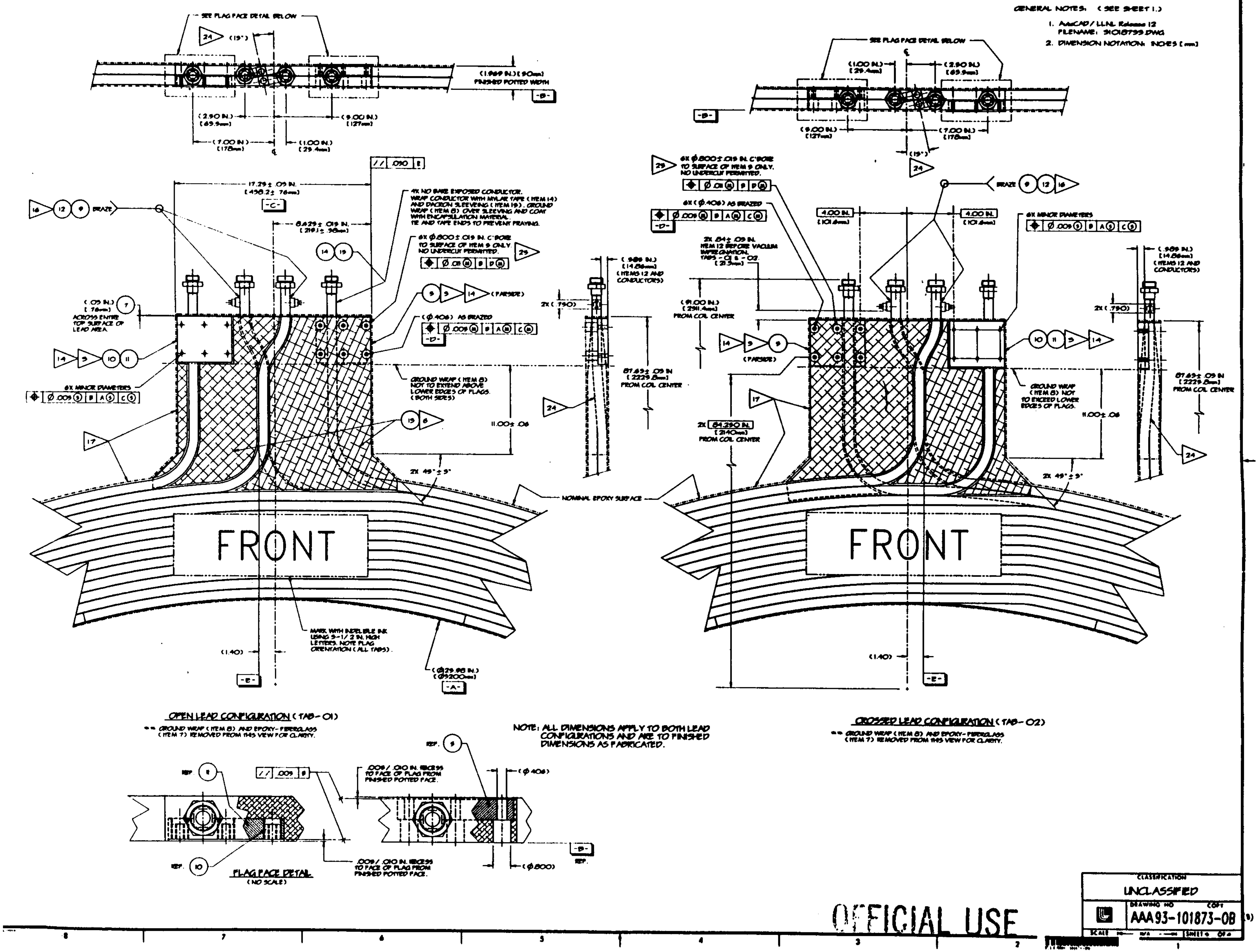
SECTION K-K
(FULL SCALE)



INSULATION DETAIL
(4X SCALE)

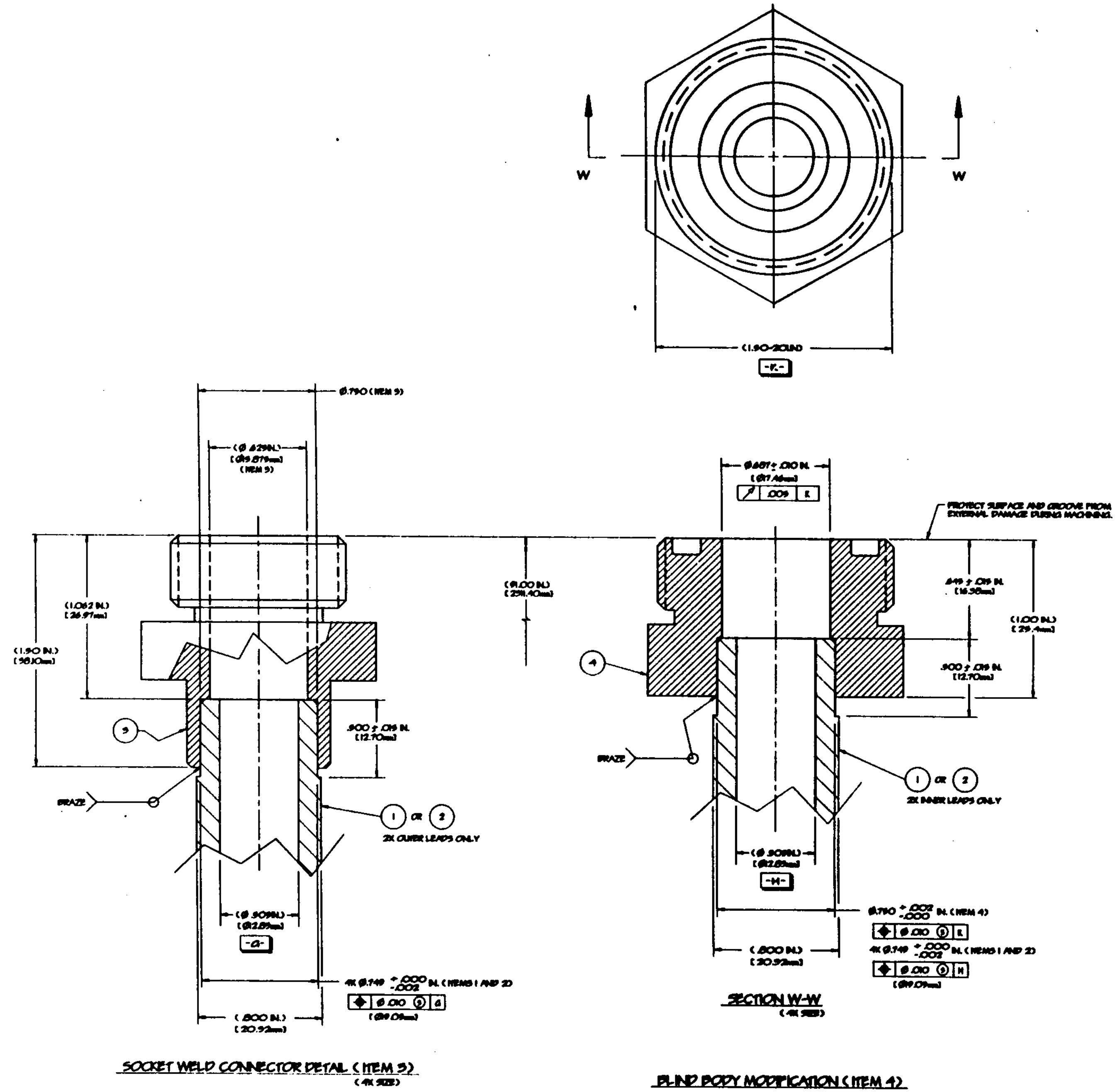
OFFICIAL USE

CLASSIFICATION	UNCLASSIFIED
DRAWING NO	AAA93-101873-08
SCALE	N/A
SHEET	8 OF 4


GENERAL NOTES: (SEE SHEET 1.)
1. AutoCAD / LLNL Release 12 FILENAME: 91018799.DWG
2. DIMENSION NOTATION: INCHES [mm]
SEE FLAG FACE DETAIL BELOW
FRONT
FRONT
NOMINAL EPOXY SURFACE
MARK WITH INDELIBLE INK USING 3-1/2 IN. HIGH LETTERS. NOTE FLAG ORIENTATION (ALL TABS).
GROUND WRAP (ITEM 8) NOT TO EXTEND ABOVE LOWER EDGES OF FLAGS. (BOTH SIDES)
OPEN LEAD CONFIGURATION (TAB-01)
CROSSED LEAD CONFIGURATION (TAB-02)
NOTE: ALL DIMENSIONS APPLY TO BOTH LEAD CONFIGURATIONS AND ARE TO FINISHED DIMENSIONS AS FABRICATED.
FLAG FACE DETAIL
(NO SCALE)
CLASSIFICATION
UNCLASSIFIED
DRAWING NO
AAA93-101873-0B
OFFICIAL USE

GENERAL NOTES: (SEE SHEET 1.)

1. AutoCAD / LLNL Release 12
   FILENAME: 910167S4.DWG
2. DIMENSION NOTATION: INCHES [mm]

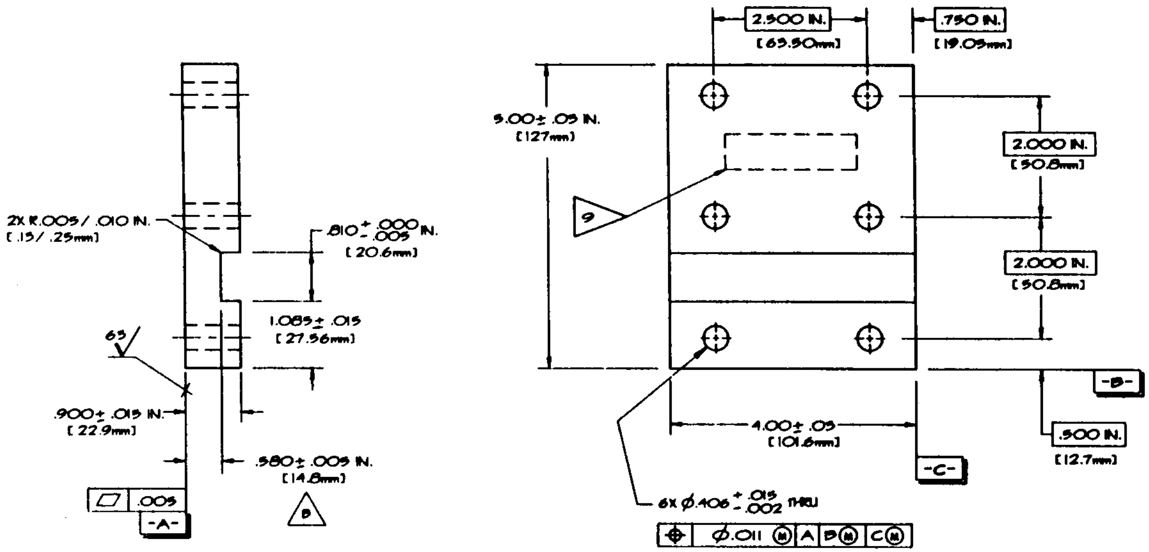


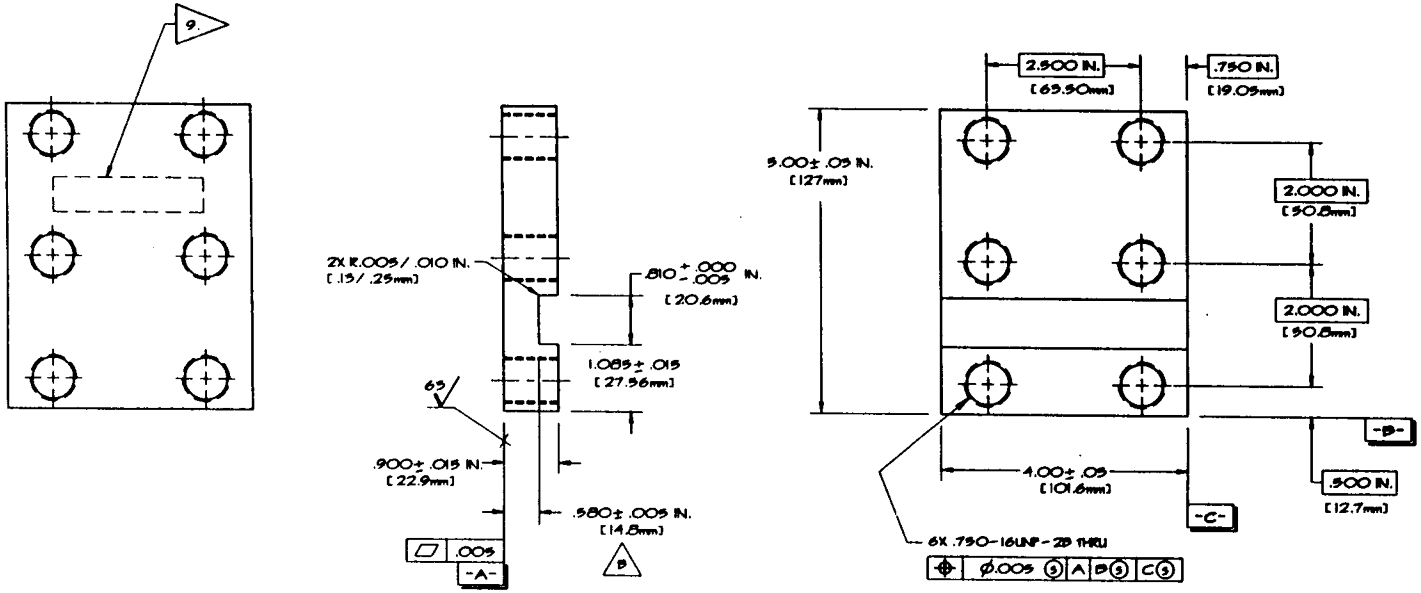
OFFICIAL USE [redacted]

CLASSIFICATION	UNCLASSIFIED
DRAWING NO	AAA93-101873-08
SCALE	N/A
SHEET	4 OF 4

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 63√ FINISH ALL MACHINED SURFACES.
5. DIMENSION NOTATION: INCHES [mm]
6. BAG AND TAG WITH LLNL DWG.
7. REMOVE BURRS AND BREAK SHARP EDGES .005/.010 IN. [.15/.25mm].
8. FINISHED PART TO BE CLEAN AND FREE OF ALL GREASE, OIL, DIRT, ETC.
9. STAMP THE WORD "FRONT" IN 1/8" HIGH LETTERS APPROXIMATELY WHERE INDICATED.
10. AutoCAD/LLNL REL. 12 USER FILENAME: 5101874I.DWG





NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 63√ FINISH ALL MACHINED SURFACES.
5. DIMENSION NOTATION: INCHES [mm]
6. BAG AND TAG WITH LLNL DWG.
7. REMOVE BURRS AND BREAK SHARP EDGES .005/ .010 IN. [.13/ .25mm].
8. FINISHED PART TO BE CLEAN AND FREE OF ALL GREASE, OIL, DIRT, ETC.
9. STAMP THE WORD "FRONT" IN 1/8" HIGH LETTERS APPROXIMATELY WHERE INDICATED.
10. AutoCAD/ LLNL REL. 12 USER FILENAME: 3101875I.DWG

LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE
B	WW	CW	SMY	5/95	5-B	.580 WAS .584
A	WW		SMY	5/95		GENERAL REVISION

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
		BAR OR PLATE, CDA 101/ 102 HIGH PURITY (Cu)		

DWN	W. J. WONG	2/95
CHK	W. J. WONG	2/95
APVD	R. M. YAMAMOTO	2/95
CLASSIFIED BY:		
TITLE		DATE

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

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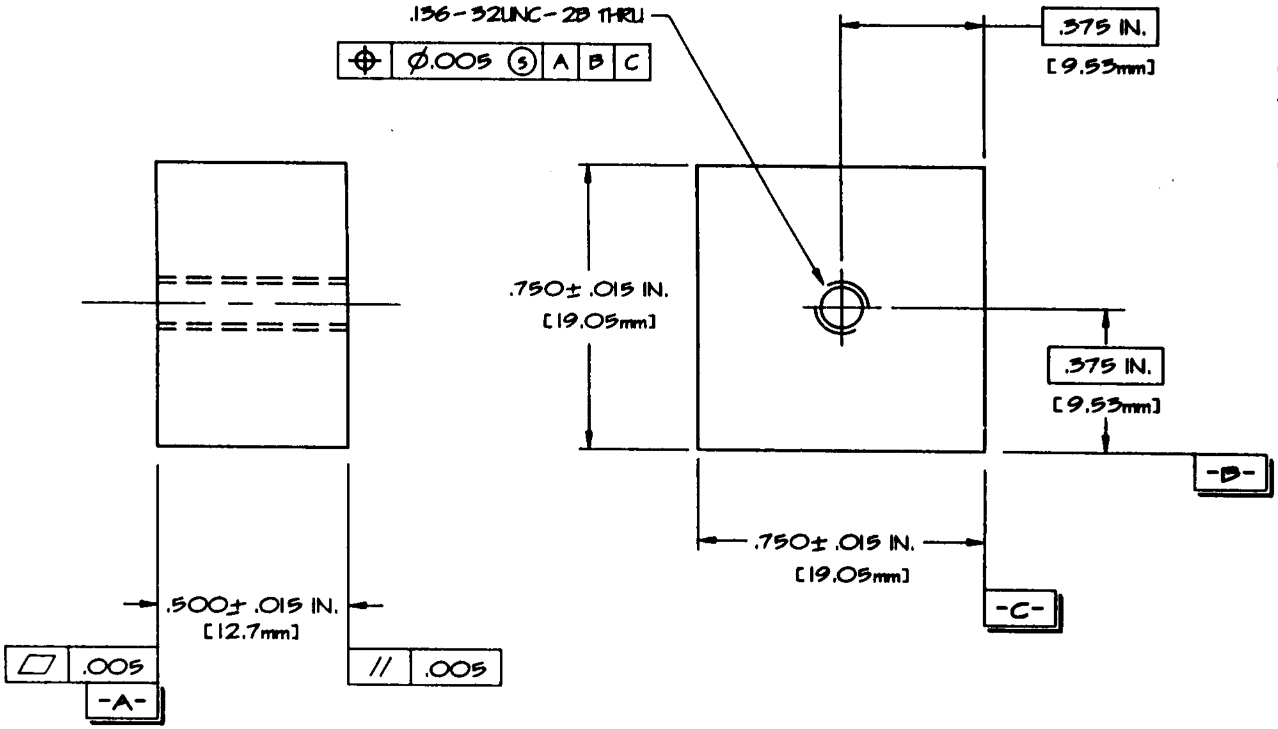
MAJOR UNIT: PHENIX
SUBASSY: ASSEMBLY - DOUBLE PANCAKE
DETAIL: BUS FLAG - TAPPED
SHOWN ON AAA: 93-101873
ACCT NO: 8865-25
DRAWING NO: AAA 93-101875-0B
SCALE: 2.00"
SHEET 1 OF 1

OFFICIAL USE

NOTES

UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. 63 FINISH ALL MACHINED SURFACES.
4. AutoCAD / LLNL Release 12
   FILENAME: 31018761.DWG
5. DIMENSION NOTATION: INCHES [mm]
6. BAG AND TAG WITH LLNL DWG.
7. REMOVE BURRS AND BREAK SHARP EDGES .005 / .010 IN. [.13 / .25mm].
8. FINISHED PART TO BE CLEAN AND FREE OF ALL GREASE, OIL, DIRT, ETC.



NO REQD	PART/LLNL STK NO	BAR OR PLATE, CDA 101/102 HIGH PURITY (Cu) — DESCRIPTION/MATERIAL	SPEC NO	ITEM

DWN	WJWONG	2/93
CHK	WJWONG	2/93
APVD	RMYAMAMOTO	2/93
CLASSIFIED BY:		
TITLE		DATE

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OFFICIAL USE

MAJOR UNIT: PHENIX

SUBASSY: ASSEMBLY - DOUBLE PANCAKE

DETAIL: THERMOSTAT MOUNT

SHOWN ON AAA	DRAWING NO	COPY
93-101873	AAA 93-101876-0A	
ACT 8869-25		

SCALE 1.00" — SHEET 1 OF 1

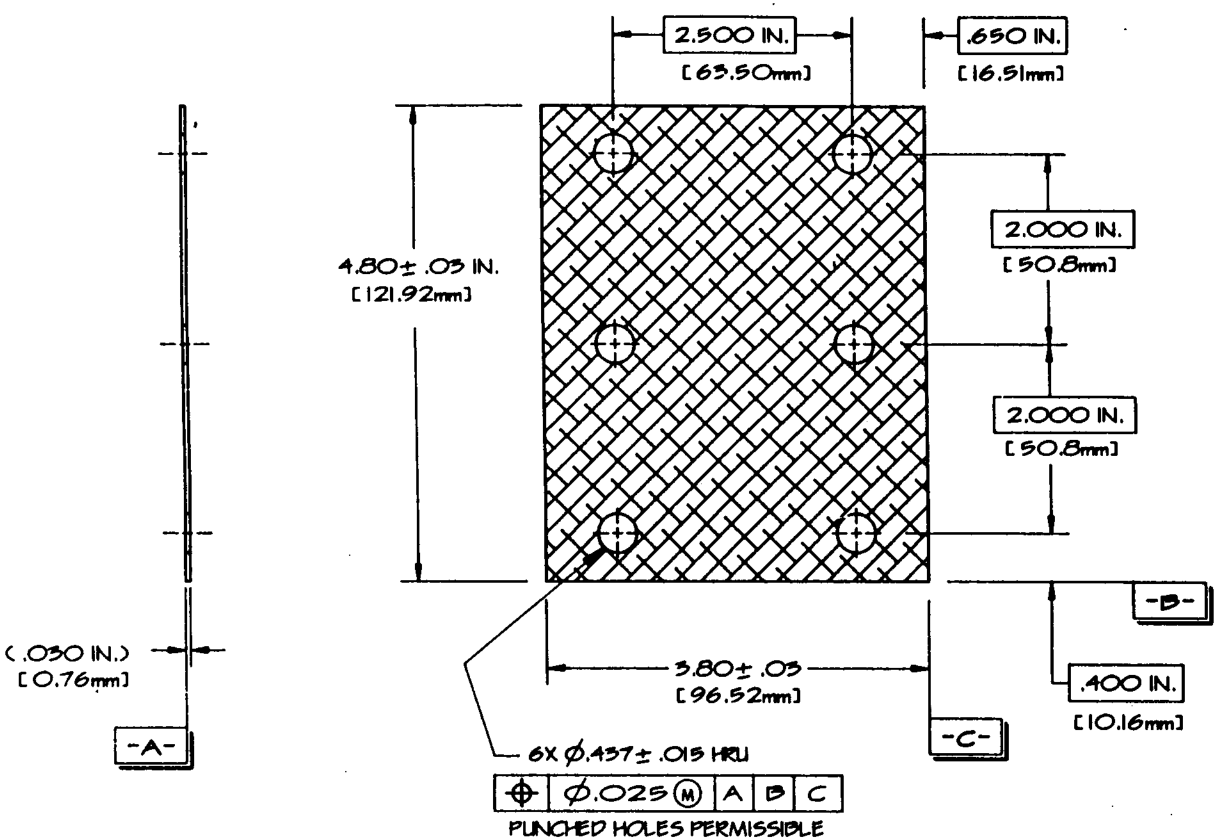
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

LTR	DWN	CHK	DATE	ZONE	CHANGE
A	WJW	RMY	5/4/93		GENERAL REVISION, FORMAT CHANGE

LL 1005-1 (Rev. 6/83)

4 3 1

AAA93-101876-0A



NOTES

UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. DIMENSION NOTATION - INCHES [MM]
4. STOCK FINISH ALL OVER.
5. ALL DIMENSIONS APPLY TO PART IN AN UNRESTRAINED CONDITION.
6. SUGGESTED VENDOR:
   HI TECHMETAL GROUP
   1101 EAST 55th STREET
   CLEVELAND, OHIO 44103
   PH: (216) 881-8100
7. FINISHED PART TO BE CLEAN AND FREE OF OIL, GREASE, DIRT, ETC..
8. BAG AND TAG WITH LLNL DWG. NO.
9. LLNL AutoCAD(tm) Release 12 USER FILENAME: 31018551.DWG
10. CAUTION: DO NOT CRUSH MATERIAL DURING FABRICATION OR HANDLING PROCESSES.

NO REQD	PART/LLNL STK NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
		6 FOAMETAL (tm), .030" THICK, .008"-.012" FILAMENT DIA., 37-42 CELLS/IN., .022"-.026" PORE DIA., PORE TYPE 30 (COPPER)		

DWN	WJWONG 黄錦星	4/93
CHK	WJWONG	4/93
APV.D	RMYAMAMOTO	4/93
CLASSIFIED BY		
TITLE		DATE

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

MAJOR UNIT: PHENIX
SUBASSY: CENTRAL COIL
DETAIL: FLAG CONTACT PAD

SHOWN ON AAA 93-101878 93-101879
ACT 8863-29
DRAWING NO: AAA 93-101855-0A
COPY
SCALE 2.00"
SHEET 1 OF 1

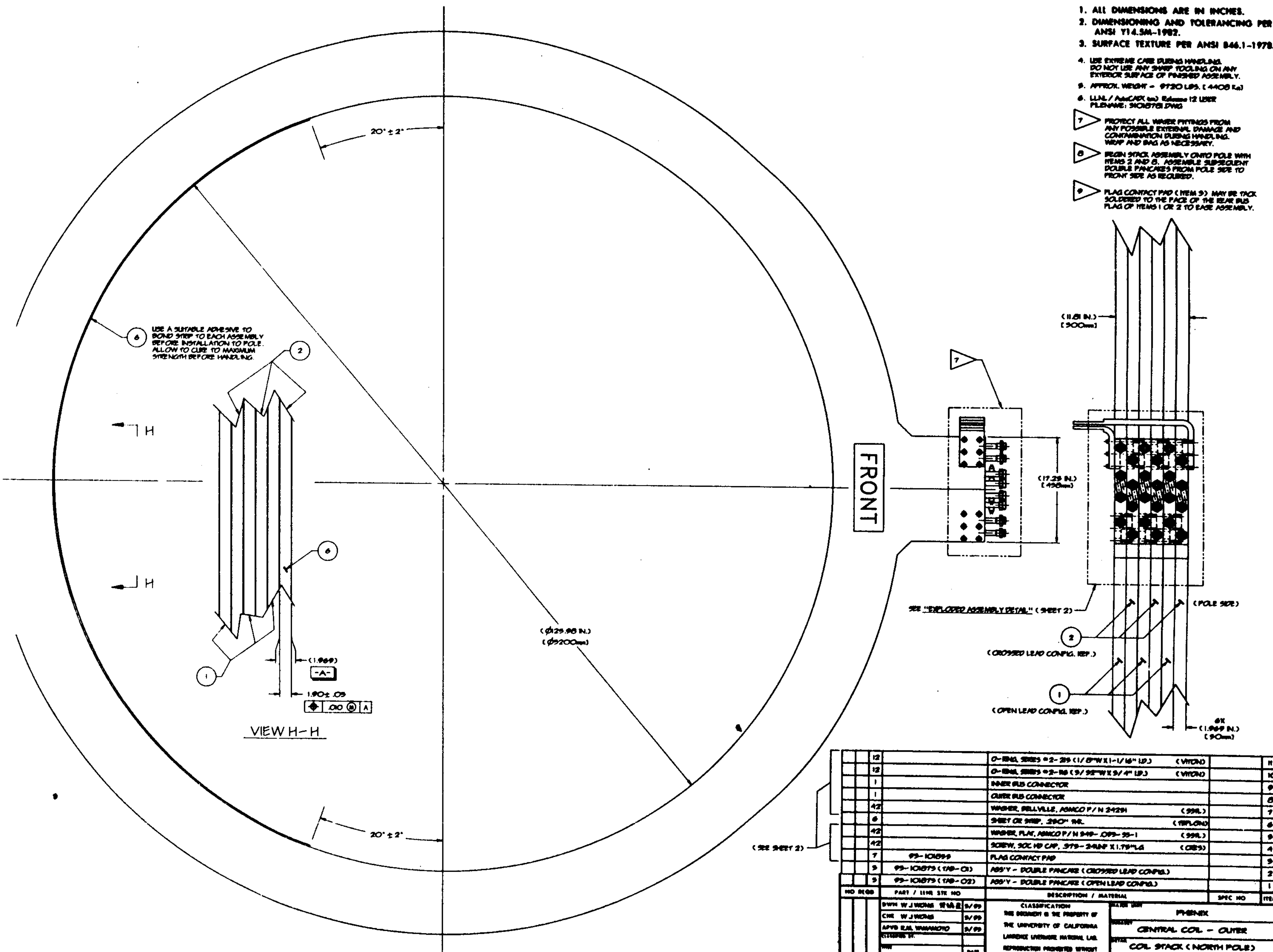
LTR	DWN	CHK	DATE	ZONE	CHANGE
A	WJW	RMY	9/4/93		GENERAL REVISION

4 3 1

AAA93-101855-0A0

PHENIX Central Magnet - Outer Coil Drawings

Coil Stack (North Pole)	AAA93-101878-0A
Coil Stack (South Pole)	AAA93-101879-0A
Winding - Double Pancake	AAA92-101099-0D
Assembly - Double Pancake	AAA93-101873-0B
Flag Contact Pad	AAA93-101855-0A
Bus Flag - Thru	AAA93-101874-0B
Bus Flag - Tapped	AAA93-101875-0B
Thermostat Mount	AAA93-101876-0A



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. USE EXTREME CARE DURING HANDLING. DO NOT USE ANY SHARP TOOLING ON ANY EXTERIOR SURFACE OF FINISHED ASSEMBLY.
5. APPROX. WEIGHT = 9720 LBS. (4408 Kg)
6. LLNL / AutoCAD(tm) Release 12 USER FILENAME: 3101878I.DWG

7. PROTECT ALL WATER FITTINGS FROM ANY POSSIBLE EXTERNAL DAMAGE AND CONTAMINATION DURING HANDLING. WRAP AND BAG AS NECESSARY.

8. BEGIN STACK ASSEMBLY ONTO POLE WITH ITEMS 2 AND 8. ASSEMBLE SUBSEQUENT DOUBLE PANCAKES FROM POLE SIDE TO FRONT SIDE AS REQUIRED.

9. FLAG CONTACT PAD (ITEM 3) MAY BE TACK SOLDERED TO THE FACE OF THE REAR BUS FLAG OF ITEMS 1 OR 2 TO EASE ASSEMBLY.

NO REQD			PART / LINE STK NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM
		12		O-RING, SERIES #2-215 (1/8"W X 1-1/16" I.D.)	(VITON)		11
		12		O-RING, SERIES #2-118 (3/32"W X 3/4" I.D.)	(VITON)		10
		1		INNER BUS CONNECTOR			9
		1		OUTER BUS CONNECTOR			8
		42		WASHER, BELLVILLE, ASMCO P/N 24291	(SS/L)		7
		6		SHEET OR STRIP, .250" THK.	(TEFLON)		6
		42		WASHER, FLAT, ASMCO P/N 949-.095-35-1	(SS/L)		5
		42		SCREW, SOC HD CAP, .375-24UNF X 1.75"LG	(CRES)		4
		7	93-101699	FLAG CONTACT PAD			3
		3	93-101879 (1A9-01)	ASS'Y - DOUBLE PANCAKE (CROSSED LEAD CONFIG.)			2
		3	93-101879 (1A9-02)	ASS'Y - DOUBLE PANCAKE (OPEN LEAD CONFIG.)			1

DWN	W J WONG 9/99
CHK	W J WONG 9/99
APVD	R.M. YAMAMOTO 9/99

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LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT

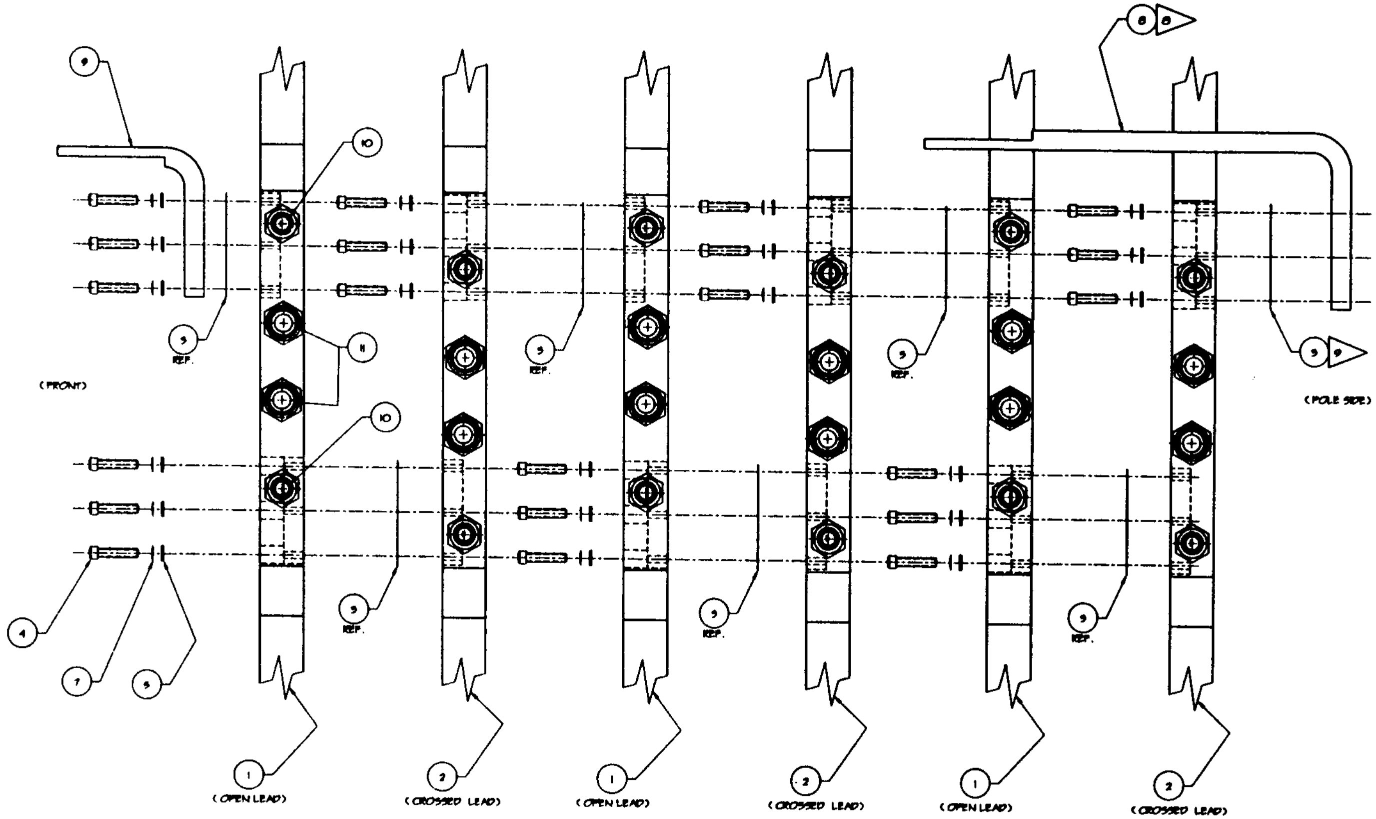
FINAL USE

PHENIX
CENTRAL COIL - OUTER
COIL STACK (NORTH POLE)

DRAWING NO AAA93-101878-0A

SCALE 1/10 SHEET 1 OF 2

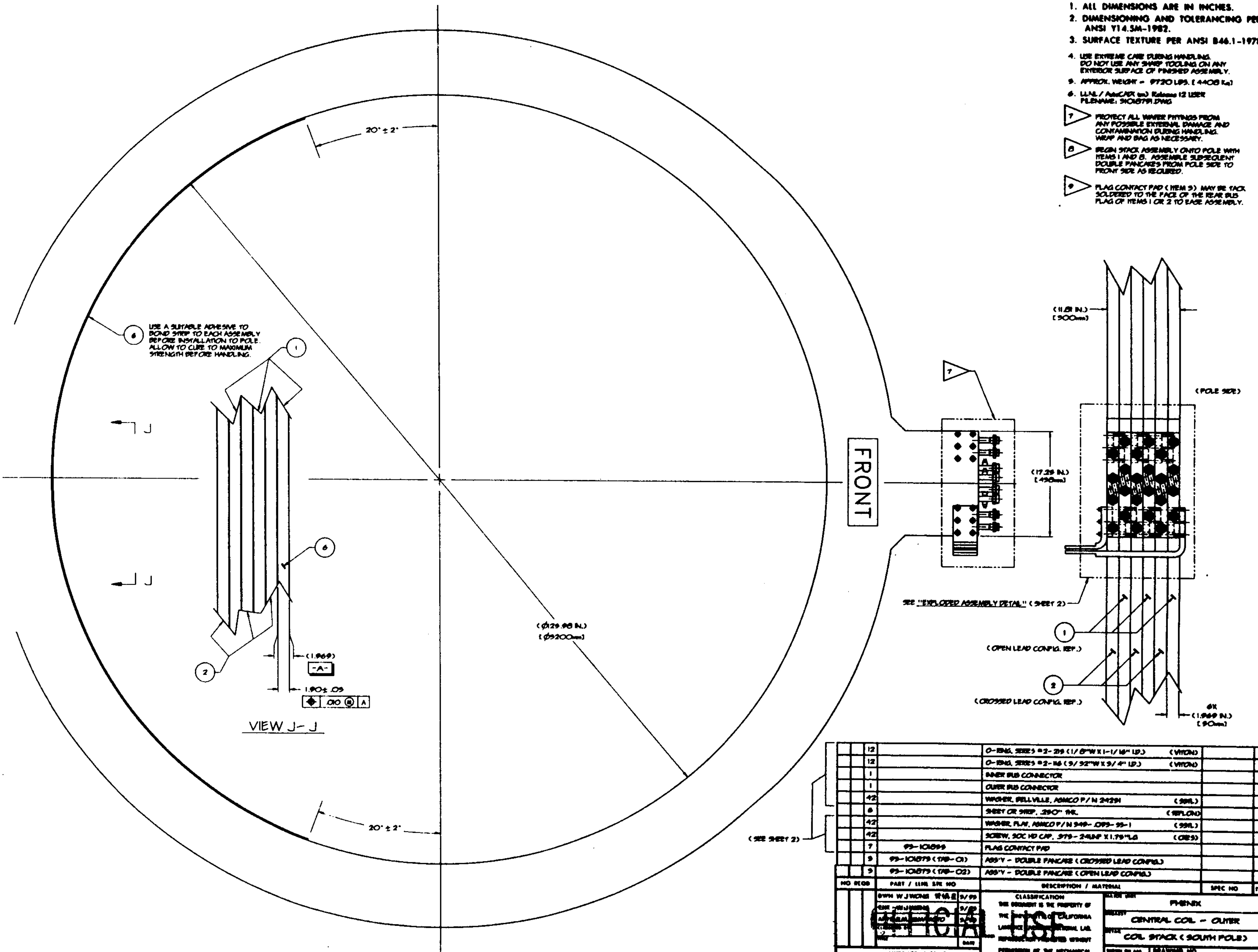
[redacted]



EXPLODED ASSEMBLY DETAIL
(SCALE: 1=2)

OFFICIAL USE

CLASSIFICATION
UNCLASSIFIED
DRAWING NO.
AAA 93-101878-0A



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. USE EXTREME CARE DURING HANDLING. DO NOT USE ANY SHARP TOOLING ON ANY EXTERIOR SURFACE OF FINISHED ASSEMBLY.
5. APPROX. WEIGHT = 9720 LBS. [4408 Kg]
6. LLNL / AutoCAD (tm) Release 12 USER FILENAME: 3101879I.DWG

7. PROTECT ALL WATER FITTINGS FROM ANY POSSIBLE EXTERNAL DAMAGE AND CONTAMINATION DURING HANDLING. WRAP AND BAG AS NECESSARY.

8. BEGIN STACK ASSEMBLY ONTO POLE WITH ITEMS 1 AND 8. ASSEMBLE SUBSEQUENT DOUBLE PANCAKES FROM POLE SIDE TO FRONT SIDE AS REQUIRED.

9. FLAG CONTACT PAD (ITEM 3) MAY BE TACK SOLDERED TO THE FACE OF THE REAR BUS FLAG OF ITEMS 1 OR 2 TO EASE ASSEMBLY.

		NO RECD	PART / LINE SPE NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM
		12		O-RING, SERIES #2-219 (1/8"W X 1-1/16" I.D.)	(VITON)		11
		12		O-RING, SERIES #2-116 (3/32"W X 3/4" I.D.)	(VITON)		10
		1		INNER BUS CONNECTOR			9
		1		OUTER BUS CONNECTOR			8
		42		WASHER, BELLVILLE, ASMCO P/N 24291	(SSTL.)		7
		6		SHEET OR STRIP, .250" THK.	(TEFLON)		6
		42		WASHER, FLAT, ASMCO P/N 349-.093-35-1	(SSTL.)		5
		42		SCREW, SOC HD CAP, .375-24UNF X 1.75"LG	(CRES)		4
		7	93-101899	FLAG CONTACT PAD			3
		3	93-101879 (TAB-01)	ASS'Y - DOUBLE PANCAKE (CROSSED LEAD CONFIG.)			2
		3	93-101879 (TAB-02)	ASS'Y - DOUBLE PANCAKE (OPEN LEAD CONFIG.)			1

DWN W J WONG 9/99

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OFFICIAL USE

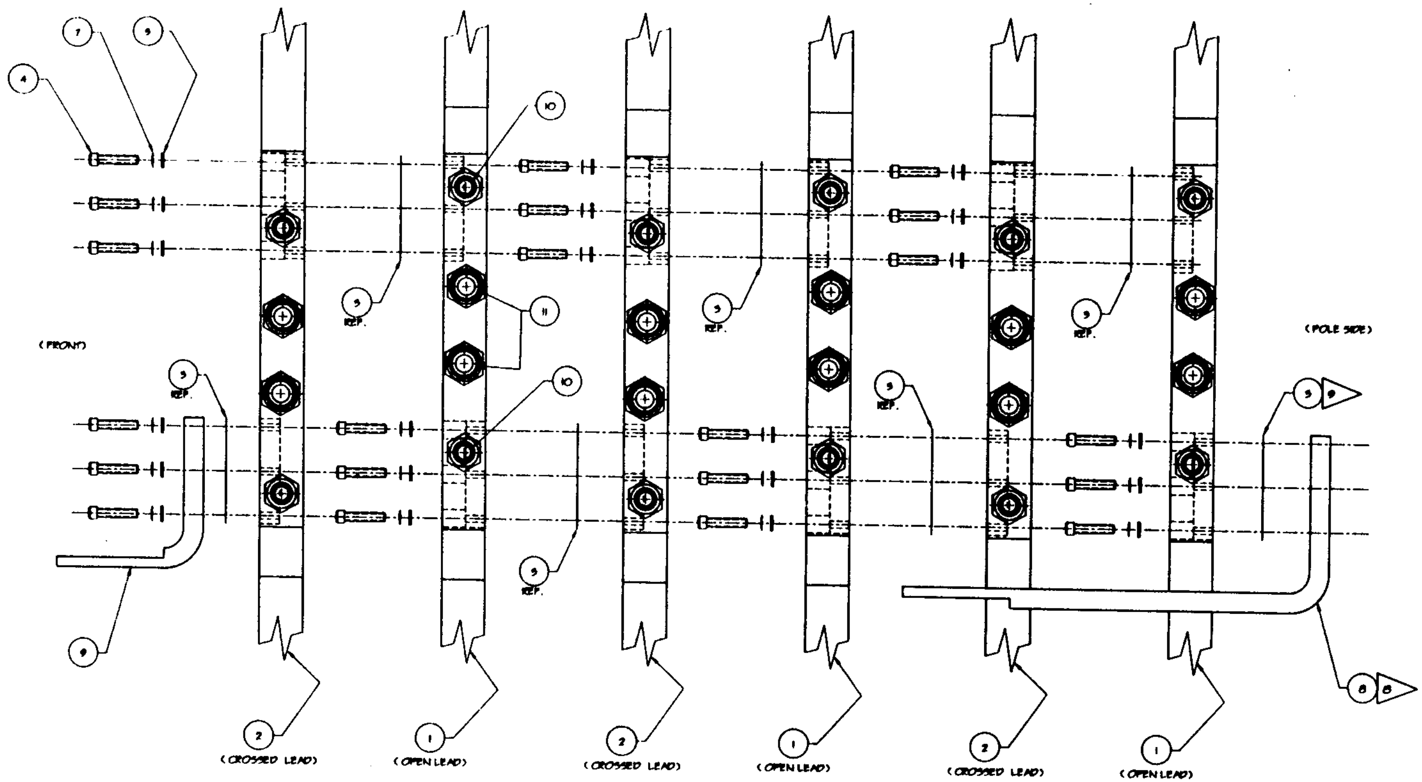
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

PHENIX
CENTRAL COIL - OUTER
COIL STACK (SOUTH POLE)

DRAWING NO
AAA93-101879-0A

SCALE
SHEET 1 OF 2

A | ADD REV., ADD ITEMS 9-11, ADD SHT 2



EXPLODED ASSEMBLY DETAIL
(SCALE: 1-2)

OFFICIAL USE

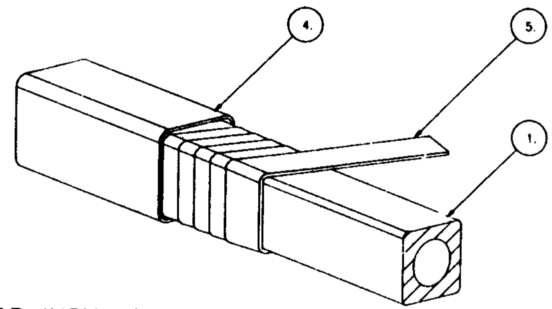
CLASSIFICATION
UNCLASSIFIED
DRAWING NO AAA93-101879-0A

NOTES
UNLESS OTHERWISE SPECIFIED:

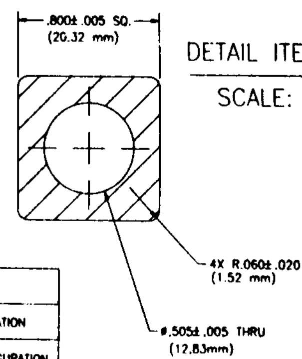
1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. AutoCAD/LLNL Release 12 USER FILENAME: 21010991.DWG
5. DIMENSION NOTATION: INCHES [mm]

FABRICATION NOTES FOR PHENIX OUTER CENTRAL COIL
IN SEQUENCE AS APPLICABLE

1. EACH COIL SHALL CONSIST OF TWO CONDUCTORS, BIFILAR WOUND, IN DOUBLE PANCAKE FASHION TO PROVIDE TWO 12 TURN PARALLEL WATER COOLANT PATHS CONNECTED ELECTRICALLY IN SERIES FOR A TOTAL OF 24 TURNS PER COIL ASSEMBLY.
2. SUBSTITUTION FOR MATERIALS SPECIFIED MAY BE MADE WITH THE APPROVAL OF LLNL. IN GENERAL THE PERFORMANCE SPECIFICATIONS OF SUBSTITUTE MATERIALS SHALL MEET OR EXCEED THOSE SPECIFIED BY LLNL.
3. CLEAN ALL EXTERIOR CONDUCTOR SURFACES OF DIRT, GREASE, OIL, EXCESS OXIDES, ETC. PRIOR TO INSULATING.
4. THE CONDUCTOR SHALL BE INSULATED BY A LAYER OF 25-45% OVERLAPPED TAPE,(ITEM 5) FOLLOWED BY APPLICATION OF A SLEEVE(ITEM 4). SLEEVE ENDS MAY BE SECURED BY ADHESIVE TAPE OR OTHER MEANS TO PREVENT SLIPPING. SLEEVE JOINTS MAY BE SEWN OR OTHERWISE SECURED TO PREVENT JOINT PARTING. USE A SIMILAR METHOD TO INSULATE TRANSITIONS (ITEM 2). IN THE RAMP AREA CUSTOM INSULATE TO PROVIDE AN LLNL APPROVED EQUIVALENT PROTECTION.
5. APPROXIMATE CONDUCTOR LENGTH PER COIL IS 880 FEET (268 METERS)
6. CONDUCTOR JOINTS SHALL BE MADE IN ACCORDANCE WITH LRL ENGINEERING NOTE 7939-22-M7C AND CONDUCTOR SPLICE DETAIL (SHEET 4) OR AN LLNL APPROVED EQUAL PROCEDURE.
7. PANCAKE SPACERS (ITEM 3) SHALL BE RANDOMLY PUNCHED WITH 0.5 IN. DIA. HOLES ON APPROXIMATELY 2 IN. CENTERS TO PERMIT RESIN FLOW THROUGH DURING IMPREGNATION. SURFACES SHALL BE LIGHTLY SANDBLASTED OR OTHERWISE ABRADED TO ENHANCE BONDING. SPACERS AND SHEETS MAY BE SEGMENTED, BUTTED, AND TAPED TOGETHER.



CONDUCTOR INSULATING PACKAGE



DETAIL ITEM-1
SCALE: 4X

TAB NO.	DESCRIPTION
TAB-01	OPEN LEAD CONFIGURATION
TAB-02	CROSSED LEAD CONFIGURATION

	TAB-02	TAB-01	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
(SEE SHEET-4)	A/R	A/R		TUBE ⌀.625 X.062W CDA 101/102 HIGH PURITY(Cu)		7
(SEE SHEET-5)	4	4		RAMP,BAR OR PLATE CDA 101/102 HIGH PURITY(Cu)		6
(SEE SHEET-2&3)	A/R	A/R		MYLAR TAPE,.75"W X .0035" THK. ADHESIVE BACKED	SCOTCH 57(3M)	5
(SEE SHEET-2&3)	A/R	A/R		SLEEVE, DACRON, WOVEN TUBE, ⌀1.25" X .015"W		4
	A/R	A/R		EPOXY-FIBERGLASS SHEET.030" THICK SANDBLASTED	G-10 OR FR-4	3
(SEE SHEET-5)	2	2		TRANSITION		2
	A/R	A/R		CONDUCTOR .800 IN. X .800 IN. X ⌀.505 IN. BORE (20.32mm X 20.32mm X ⌀12.83mm) CDA 101/102	(HIGH PUR.Cu)	1

LTR	DWN	CHK	APVD	DATE	CONC	CHANGE
D	LW		RW	6/93		GEN REV.
C	LW		RW	4/93		GEN REV.
B	WW		RW	2/93		GEN REV.
A	WW		RW	2/94		GEN REV./ADD CROSSED LEAD CONFIG.

DWN W. J. WONG 2/93
CHK W. J. WONG 2/93
APVD R. M. YAMAMOTO 2/93

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
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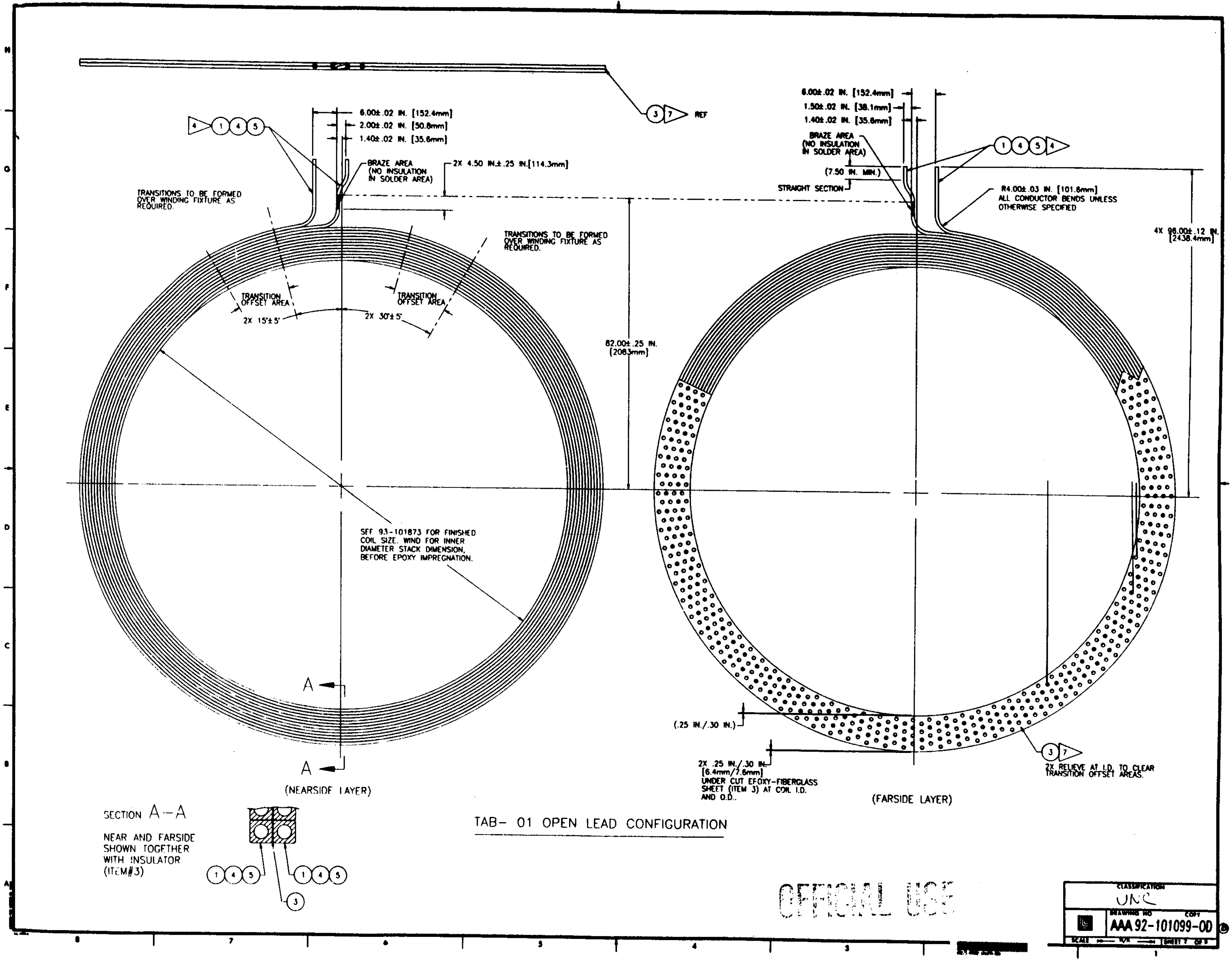
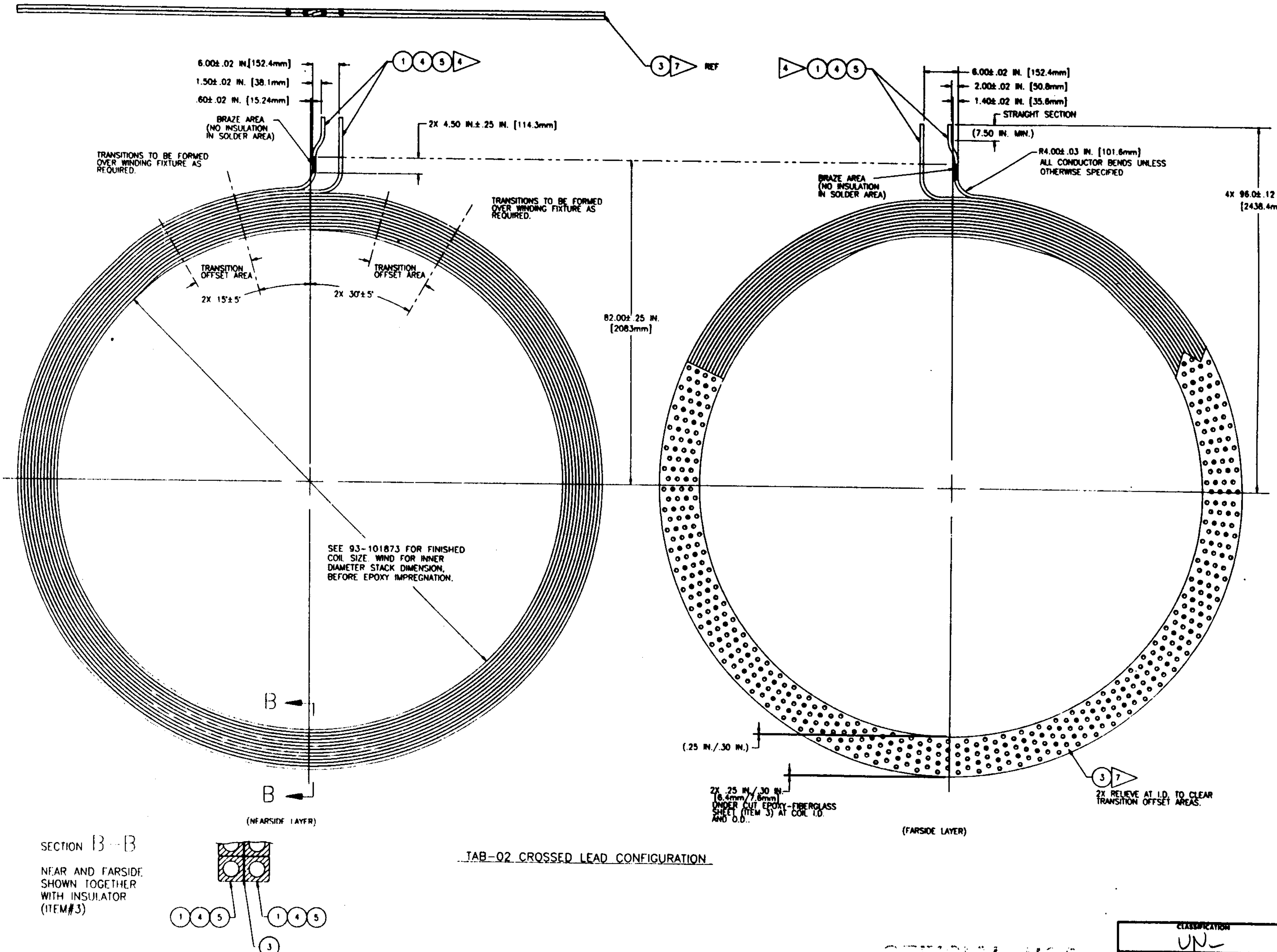
PHENIX
CENTRAL COIL - OUTER
WINDING - DOUBLE PANCAKE

DRAWING NO
AAA 92-101099-00 D

SCALE N/A SHEET 1 OF



3 7 REF
4 1 4 5
6.00± .02 IN. [152.4mm]
2.00± .02 IN. [50.8mm]
1.40± .02 IN. [35.6mm]
BRAZE AREA (NO INSULATION IN SOLDER AREA)
2X 4.50 IN.± .25 IN.[114.3mm]
TRANSITIONS TO BE FORMED OVER WINDING FIXTURE AS REQUIRED.
TRANSITION OFFSET AREA
2X 15'± 5'
2X 30'± 5'
82.00± .25 IN. [2083mm]
SEE 93-101873 FOR FINISHED COIL SIZE. WIND FOR INNER DIAMETER STACK DIMENSION, BEFORE EPOXY IMPREGNATION.
A
(NEARSIDE LAYER)
6.00± .02 IN. [152.4mm]
1.50± .02 IN. [38.1mm]
1.40± .02 IN. [35.6mm]
1 4 5 4
(7.50 IN. MIN.)
STRAIGHT SECTION
R4.00± .03 IN. [101.6mm] ALL CONDUCTOR BENDS UNLESS OTHERWISE SPECIFIED
4X 96.00± .12 IN. [2438.4mm]
(.25 IN./.30 IN.)
2X .25 IN./.30 IN. [6.4mm/7.6mm] UNDER CUT EPOXY-FIBERGLASS SHEET (ITEM 3) AT COIL I.D. AND O.D..
2X RELIEVE AT I.D. TO CLEAR TRANSITION OFFSET AREAS.
(FARSIDE LAYER)
SECTION A-A
NEAR AND FARSIDE SHOWN TOGETHER WITH INSULATOR (ITEM#3)
1 4 5
3
TAB- 01 OPEN LEAD CONFIGURATION
OFFICIAL USE
CLASSIFICATION
UNC
DRAWING NO
AAA 92-101099-00



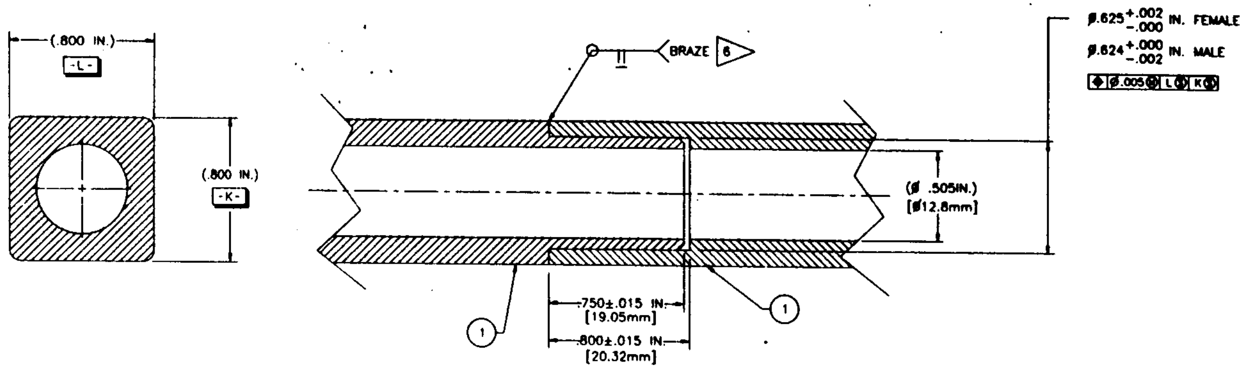
TAB-02 CROSSED LEAD CONFIGURATION

OFFICIAL USE

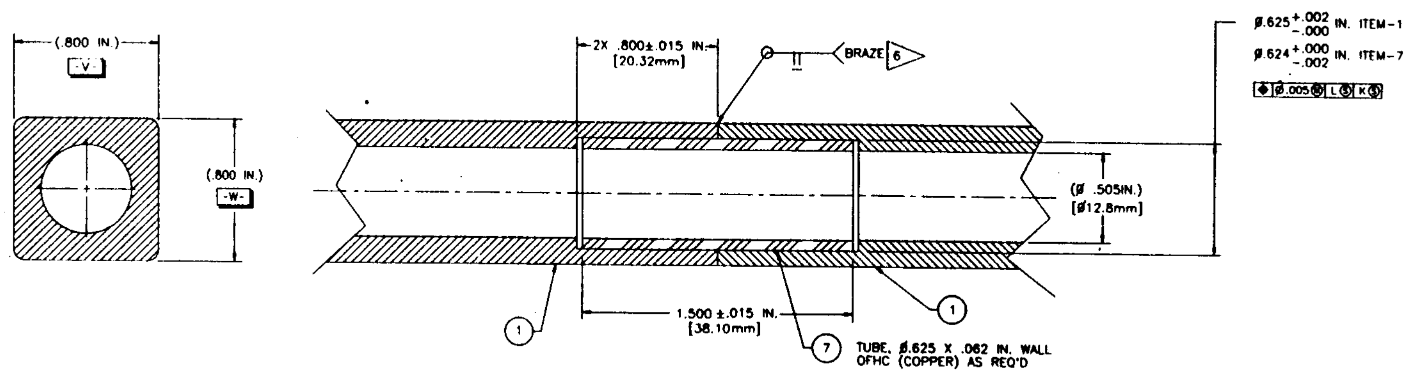
CLASSIFICATION: UN

DRAWING NO: AAA92-101099-00

SCALE N/A



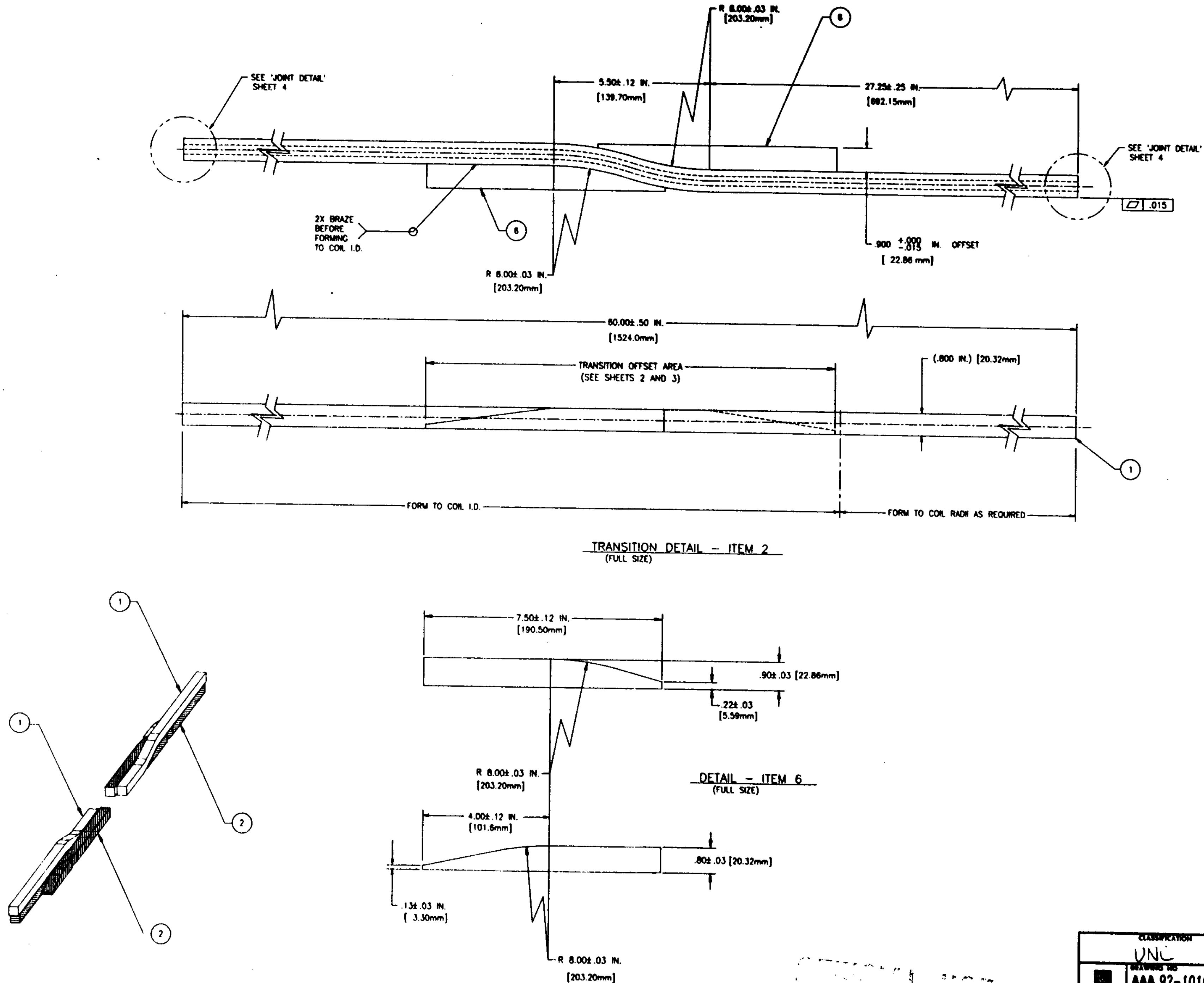
(OPTION #2: MACHINED MALE/FEMALE)



(OPTION #1: FERRULE SPLICE)
** PREFERRED **

CONDUCTOR SPLICE DETAIL
(4X SIZE) – BEFORE INSULATING WRAP AND FORMING.

CLASSIFICATION
UNC
DRAWING NO
AAA 92-101099-OD



CLASSIFICATION
UNC
DRAWING NO
AAA 92-101099-00

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. LLNL / AutoCADX (tm) Release 12 USER FILENAME: 3101873I.DWG
5. DIMENSION NOTATION: INCHES [mm]
6. WELD SYMBOLS ARE PER ANSI / AWS A2.4-76.

FABRICATION NOTES FOR PHENIX - OUTER CENTRAL COIL ASSEMBLY

(IN SEQUENCE AS APPLICABLE)

1. PROVIDE GROUND WRAP (ITEM 8) AS SHOWN ON SHEET 2 USING 25-45 % OVER LAP TO COMPLETELY COVER THE COIL WINDING. DURING THIS OPERATION, FILL ALL VOID AREAS LARGER THAN .125 INCH WITH FIBROUS GLASS MATERIAL (i.e. EPOXY-FIBERGLASS BLOCKS, CLOTH, MAT, ETC.).

2. PRIOR TO BRAZING (SEE SPECIFICATION #7954-22-MTC) THE CONDUCTORS OF THE TWO HYDRAULIC CIRCUITS TOGETHER. ISOLATE THE TWO CIRCUITS AND HI-POT TO 1500 VOLTS. TOTAL LEAKAGE NOT TO EXCEED 5 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE OF EACH CIRCUIT.

3. PLACEMENT OF BUS FLAGS (ITEMS 5 AND 11) SHALL BE DONE WITH ADEQUATE FIXTURING TO COMPLY WITH PARALLELISM AND POSITIONING TOLERANCES SPECIFIED IN DRAWING. BUS FLAGS WILL SUBSEQUENTLY BE SECURED TO, BUT ELECTRICALLY ISOLATED FROM THE VACUUM IMPREGNATION MOLD TO INSURE THAT THESE TOLERANCES ARE MAINTAINED.

4. LLNL SHALL PROVIDE COIL TEST REPORT FORMS TO DOCUMENT TESTING PERFORMED IN NOTE 5.

5. EACH HYDRAULIC CIRCUIT (TWO PER DOUBLE PANCAKE ASSEMBLY) SHALL BE TESTED WITH ALL FITTINGS BOTH BEFORE AND AFTER POTTING. ONE 'COIL TEST REPORT' SHALL BE GENERATED FOR EACH SERIALIZED ASSEMBLY. THE FOLLOWING PROCEDURES SHALL CONSTITUTE ONE COMPLETE TEST ON EACH CIRCUIT:

   A) A DRY NITROGEN PURGE MAY BE USED TO EVAPORATE ANY RESIDUAL MOISTURE WITHIN THE COIL. VACCUM TEST PER ASTM E499-73 WITH A MAXIMUM ALLOWABLE LEAK RATE OF 1 X 10e-8 ATM-CC/SECOND OF HELIUM AT 10e-5 TORR WITH ALL INTERIOR VOLUME CONNECTED TO A RESIDUAL GAS ANALYZER (RGA) OR A HELIUM MASS SPECTROMETER LEAK DETECTOR. COVER (BAG) THE ENTIRE COIL ASSEMBLY, INCLUDING LEAD FITTINGS IN A HELIUM FILLED ENCLOSURE PRIOR TO THE LEAK TEST. RECORD RESULTS INTO 'COIL TEST REPORT'.

   B) PRESSURE TEST WITH WATER IN ACCORDANCE WITH ASME BOILER AND PRESSURE VESSEL CODE SECTION VIII USING THE TEST PRESSURE DEFINED IN NOTE 20. RECORD RESULTS IN 'COIL TEST REPORT'.

   C) WATER FLOW TEST WITH AN INLET PRESSURE OF 80± 5 PSIG. EXIT FLOW RATE SHALL BE AT LEAST 3.5 US GALLONS PER MINUTE (GPM). RECORD THE RESULTS IN 'COIL TEST REPORT'.

6. FILL LARGE VOID VOLUMES IN LEAD AREA WITH CONTOURED EPOXY-FIBERGLASS BLOCKS (ITEM 13) FOLLOWED BY GROUND WRAP (ITEM 8) OVERWRAP. DO NOT COVER BUS FLAG(S) FACES.

7. VACUUM IMPREGNATION MOLD SHALL BE OF SUFFICIENT RIGIDITY AND MANUFACTURING TOLERANCES TO MAINTAIN THE COIL DIMENSIONS SPECIFIED. MOLD SHALL BE VACUUM TIGHT UNLESS THE ENTIRE MOLD WILL BE ENCLOSED IN A VACUUM CHAMBER, IN WHICH CASE THE MOLD SHALL BE LIQUID TIGHT.

8. SURFACE COAT ALL AREAS OF VACUUM IMPREGNATION MOLD AND EXPOSED BUS FLAG FACES WITH SUITABLE MOLD RELEASE. COAT THREADED HOLES AND BOLTS WITH SILICONE OR TEFLON GREASE AND PLUG BUS FLAG CLEARANCE HOLES.

9. ENCLOSE COIL IN THE MOLD. ENSURE THAT EXPOSED BUS FLAGS, BOLTS, AND LEADS ARE ELECTRICALLY ISOLATED FROM THE MOLD. FILL VOIDS AS DESCRIBED IN NOTE 1.

10. HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 1500 VOLTS. LEAKAGE NOT TO EXCEED 5 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE OF EACH CIRCUIT PRIOR TO POTTING.

11. AFTER SEALING, HEAT AND EVACUATE MOLD FOR 12 HOURS MINIMUM PRIOR TO VACUUM IMPREGNATION TO FULLY RID MOLD OF MOISTURE AND AIR FROM THE PORES OF THE FIBROUS MATERIAL (TAPE, SLEEVE, ETC.). INSURE THAT SUFFICIENT HEATING IS PRESENT TO FULLY CURE THE RESIN AFTER IMPREGNATION. IF HOT WATER IS USED THROUGH THE CONDUCTOR BORE, AUXILIARY HEATING MAY BE REQUIRED IN AREAS REMOTE FROM THE CONDUCTOR (SUCH AS IN THE TERMINAL AREA).

12. VACUUM IMPREGNATE COIL ASSEMBLY PER UC/LLNL MECHANICAL ENGINEERING SPECIFICATION M20E.

13. AFTER COOL DOWN AND PRIOR TO DEMOLDING, HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 5000 VOLTS. CURRENT LEAKAGE NOT TO EXCEED 2 MICRO AMPS.

(CON'TD)

14. AFTER DEMOLDING, REMOVE FLASHING AND SAND SHARP EDGES OF COIL ASSEMBLY. CLEAN BUS FLAG FACES OF MOLD RELEASE AND SILVER PLATE USING A BRUSH ON CHEMICAL SILVER PLATE, SUCH AS 'COOL-AMP' ® OR LLNL APPROVED EQUAL. REMOVE PLUGS AND GREASE FROM THREADED AND BOLT ACCESS HOLES. DO NOT FRAY OR BREACH WRAP ON ANY EXTERIOR SURFACE OR EDGE. CHASE AND CLEAN ALL EXCESS PLATING FROM THREADED HOLES.

15. PERFORM THE FOLLOWING ELECTRICAL TESTS:
   A. IMPULSE TEST COIL TO 5000 VOLTS PEAK.
   B. MEASURE COIL RESISTANCE AND TEMPERATURE.
   C. MEASURE COIL INDUCTANCE.

16. INSTALL THERMOSTATS (ITEM 9) WHERE SHOWN, AFTER EPOXY IMPREGNATION HAS BEEN COMPLETED.

17. AFFIX A PERMANENT LABEL ON THE OUTER EDGE OF EACH FINISHED DOUBLE PANCAKE ASSEMBLY. USE ANY SUITABLE PERMANENT ADHESIVE TO BE APPROVED BY LLNL. IMPRINTED IN 5/16" HIGH CHARACTERS WITH THE FOLLOWING DATA AS SHOWN: (LABEL SIZE - 25"W X 1.75"H X .030"THK. MAX)

INDICATE APPROPRIATE TAB NO. AND 'LEAD' DESCRIPTION. (i.e. '(TAB-01) OPEN' OR '(TAB-02) CROSS')

PRESSURE TEST FOR MANNED AREA	TEST PRESSURE : 150 PSIG
LLNL DWG. AAA93-101873 (TAB-01) OPEN	TEST DATE : (MO./DAY/YR)
COIL SERIAL NO. : (PER MANUFACTURER)	INSP'D BY : (INSPECTORS' NAME)

DO NOT BREACH FINISHED POTTED ASSEMBLY WITH ANY EXTERNAL FASTENER.

ALSO MARK ON THE SIDE OF THE LEAD AREA NEAR LABEL, "COIL WEIGHT - 1620 LBS. [735 KG]" IN 1.5" HIGH LETTERS USING A PERMANENT INDELIBLE INK. FINAL PROTECTIVE CLEAR COAT OVER INK IS ALLOWABLE.

18. FLUSH ALL COIL PASSAGES OF LOOSE DIRT AND FOREIGN PARTICLES WITH 150°F WATER. BLOW PASSAGES FOR APPROXIMATELY 5 MINUTES WITH LOW PRESSURE DRY NITROGEN. SUFFICENTLY CAP COIL ENDS FOR TRANSPORTATION. HANDLE FINISHED COIL ASSEMBLY WITH EXTREME CARE. PACKAGE AND CRATE COIL TO PROTECT SURFACES AND LEADS FROM EXTERNAL DAMAGE DURING SHIPPING.

19. APPROXIMATE FINISHED ASSEMBLY WEIGHT - 1620 LBS [735 KG] EACH DOUBLE PANCAKE.

20. THE COIL ASSEMBLY 'MAXIMUM OPERATING PRESSURE' (MOP) SHALL BE 80 PSIG. RELIEF VALVE SETTING DURING NORMAL OPERATION, OR 'MAXIMUM ALLOWABLE WORKING PRESSURE' (MAWP) SHALL BE 100 PSIG. TEST PRESSURE SHALL BE 150 PSIG.

21. THE FOLLOWING DOCUMENTATION SHALL BE DELIVERED WITH THE FINISHED COIL ASSEMBLIES:
   A) ALL 'COIL TEST REPORTS'
   B) DIMENSIONAL INSPECTION REPORTS
   C) MATERIAL CERTIFICATIONS FOR ALL COIL, FITTINGS, AND BRAZE FILLER METALS.

22. PANCAKE SPACERS AND OUTSIDE SURFACE PROTECTION SHEETS (ITEMS 6 AND 7) SHALL BE RANDOMLY PUNCHED WITH 0.5 IN. DIA. HOLES ON APPROXIMATELY 2 IN. CENTERS TO PERMIT RESIN FLOW THROUGH DURING IMPREGNATION.

23. SURFACES SHALL BE LIGHTLY SANDBLASTED, OR OTHERWISE ABRADED, TO ENHANCE BONDING. SPACERS AND SHEETS MAY BE SEGMENTED, BUTTED AND TAPED TOGETHER.

24. BEFORE POTTING, TWIST BRAZED "RETURN" (CENTRAL LEADS) CONDUCTORS APPROXIMATELY 15° AND BEND "SUPPLY" (OUTER LEADS) CONDUCTORS SO THAT ALL WATER FITTINGS ARE INLINE AND CENTERED AS SHOWN ON SHEET 3.

25. NO MACHINING ON ANY PORTION OF THE COIL IS PERMISSIBLE AFTER VACUUM IMPREGNATION.

26. INSTALL INSERTS (ITEM 10) INTO BUS FLAG - TAPPED (ITEM 11) AFTER BRAZING AND CLEANING OF FLAG ON CONDUCTOR AS SHOWN PRIOR TO VACUUM IMPREGNATION.

TAB NO.	DESCRIPTION **
TAB-01	OPEN LEAD CONFIGURATION
TAB-02	CROSSED LEAD CONFIGURATION

** SEE SHEETS 2 AND 3 FOR CLARITY.

REF	NO REQD (TAB-02)	NO REQD (TAB-01)	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
(SEE SHEET 3)	AR	AR		SLEEVE, DACRON, WOVEN TUBE, 01.25" X .015"W		15
(SEE SHEET 3)	AR	AR		MYLAR TAPE, .75"W X .0035"THK., ADH. BACKED, 3M®	SCOTCH TYPE 57	14
6 (SEE SHEET 4)	AR	AR		EPOXY-FIBERGLASS SHEET, VARIOUS SIZES, NEMA GRADE	(FR-4/G-10)	13
	2	2	93-101876	THERMOSTAT MOUNT		12
	1	1	93-101875	BUS FLAG - TAPPED		11
26, 14 (SEE SHEET 4)	6	6		INSERT, FLOATING, .375-24UNF-3B, EXT THD .750-16UN, P/N KNKFX(L)624J, "ROSAN KEENSERTS (tm) (SSTL)		10
16 (SEE SHEET 3)	2	2		THERMOSTAT, NC, 150°F-165°F, 'KLIXON' (tm) P/N 4344-15 (TEXAS INSTRUMENTS)		9
(SEE SHEET 2/3)	AR	AR		TAPE, DACRON CLOTH, 4" WIDE X .012" THK.		8
23 (SEE SHEET 2/3)	AR	AR		EPOXY-FIBERGLASS SHEET, .030" THICK, NEMA GRADE	(FR-4/G-10)	7
23 (SEE SHEET 2/3)	AR	AR		EPOXY-FIBERGLASS SHEET, .015" THICK, NEMA GRADE	(FR-4/G-10)	6
	1	1	93-101874	BUS FLAG - THRU		5
(SEE SHEET 2/4)	2	2		BLIND BODY, P/N #SS-16-VCO-1-BL (SSTL)	CAJON®	4
(SEE SHEET 2/4)	2	2		SOCKET WELD CONN. BODY, P/N #SS-12-VCO-1 (SSTL)	CAJON®	3
	1		92-101099 (TAB-02)	WINDING - DOUBLE PANCAKE [CROSSED LEAD]		2
		1	92-101099 (TAB-01)	WINDING - DOUBLE PANCAKE [OPEN LEAD]		1

LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE
B2	WW	CW		5/95		NEW FORMAT SHEETS #2, #3 AND #4
B1	WW	CW		5/95		ADD ITEMS 13-15, NOTES 22-26
A	WW			3/95		GENERAL REVISION

DWN W. J. WONG 9/93
CHK W. J. WONG 9/93
APVD R. M. YAMAMOTO 9/93

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LAWRENCE LIVERMORE NATIONAL LABORATORY

OFFICIAL USE

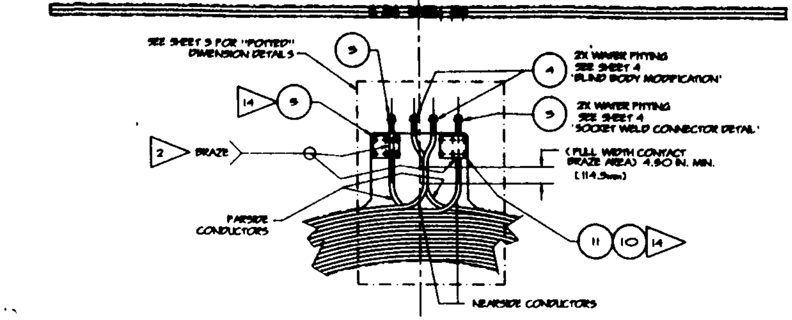
MAJOR UNIT: PHENIX
SUBASSY: CENTRAL COIL - OUTER
DETAIL: ASSEMBLY - DOUBLE PANCAKE

DRAWING NO AAA93-101873-0B

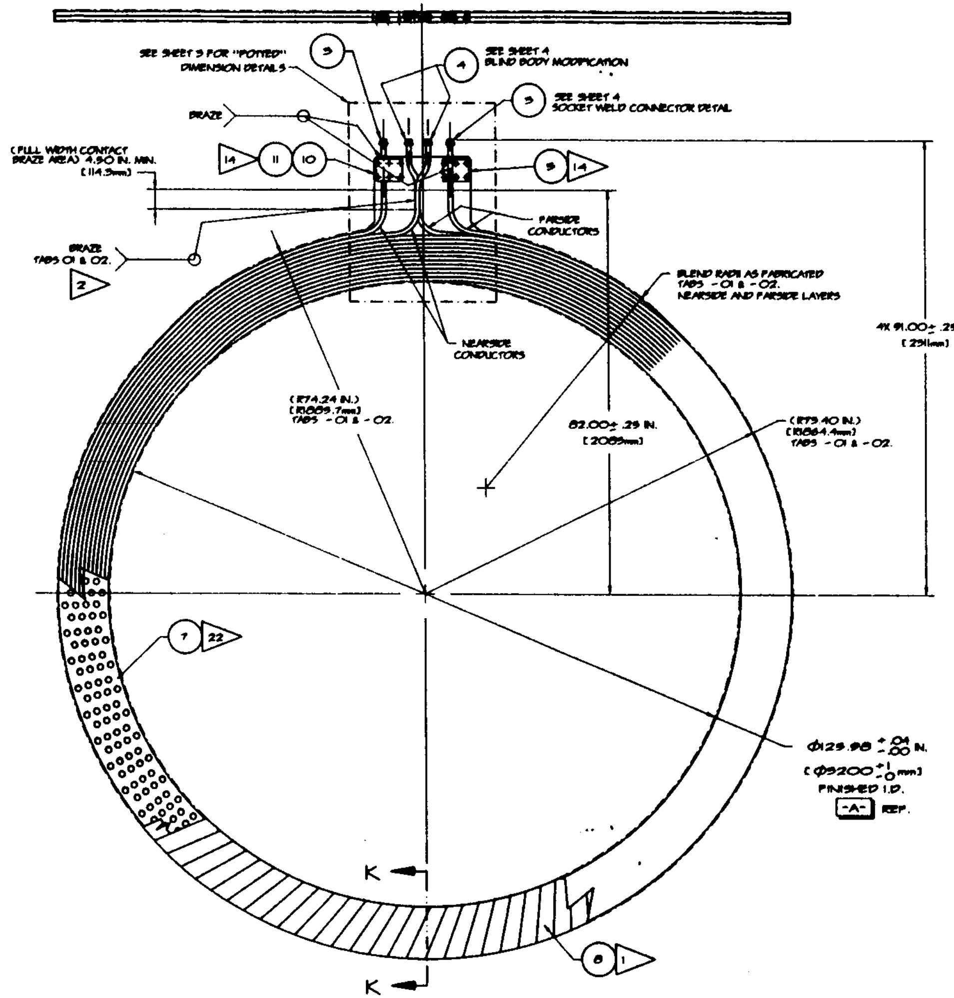
SCALE N/A — SHEET 1 OF 4

GENERAL NOTES: (SEE SHEET 1.)

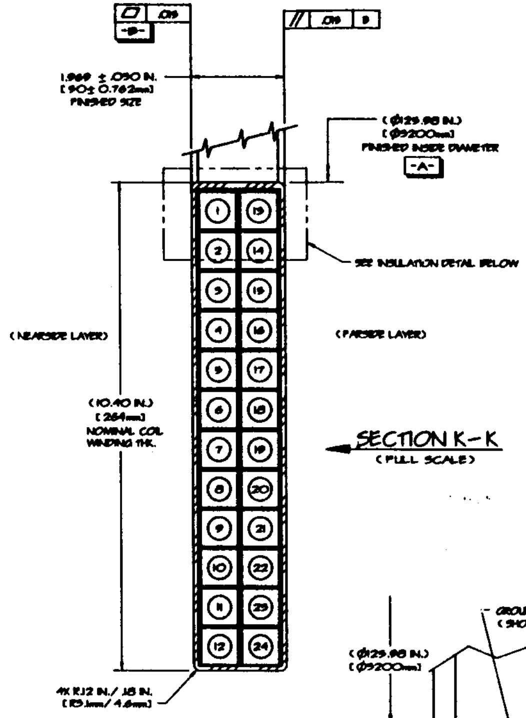
1. AutoCAD/LLNL Release 12
   FILENAME: 3101879 2.DWG
2. DIMENSION NOTATION: INCHES [mm]



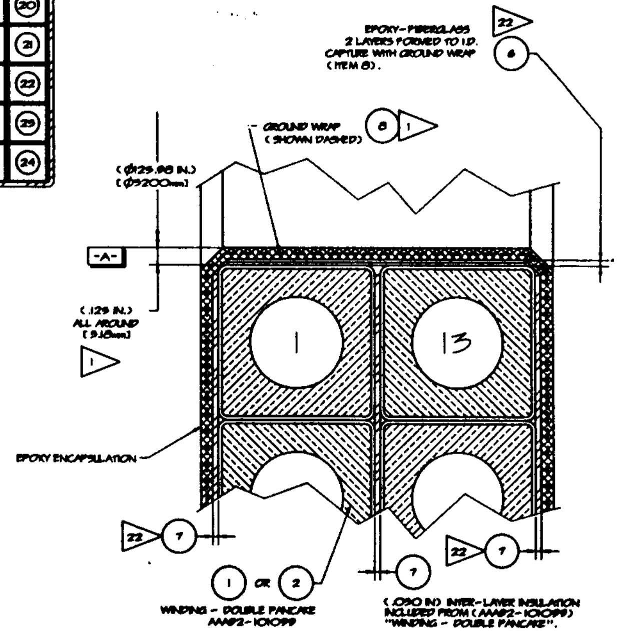
CROSSED LEAD CONFIGURATION (ITEM 2)



OPEN LEAD CONFIGURATION (ITEM 1)



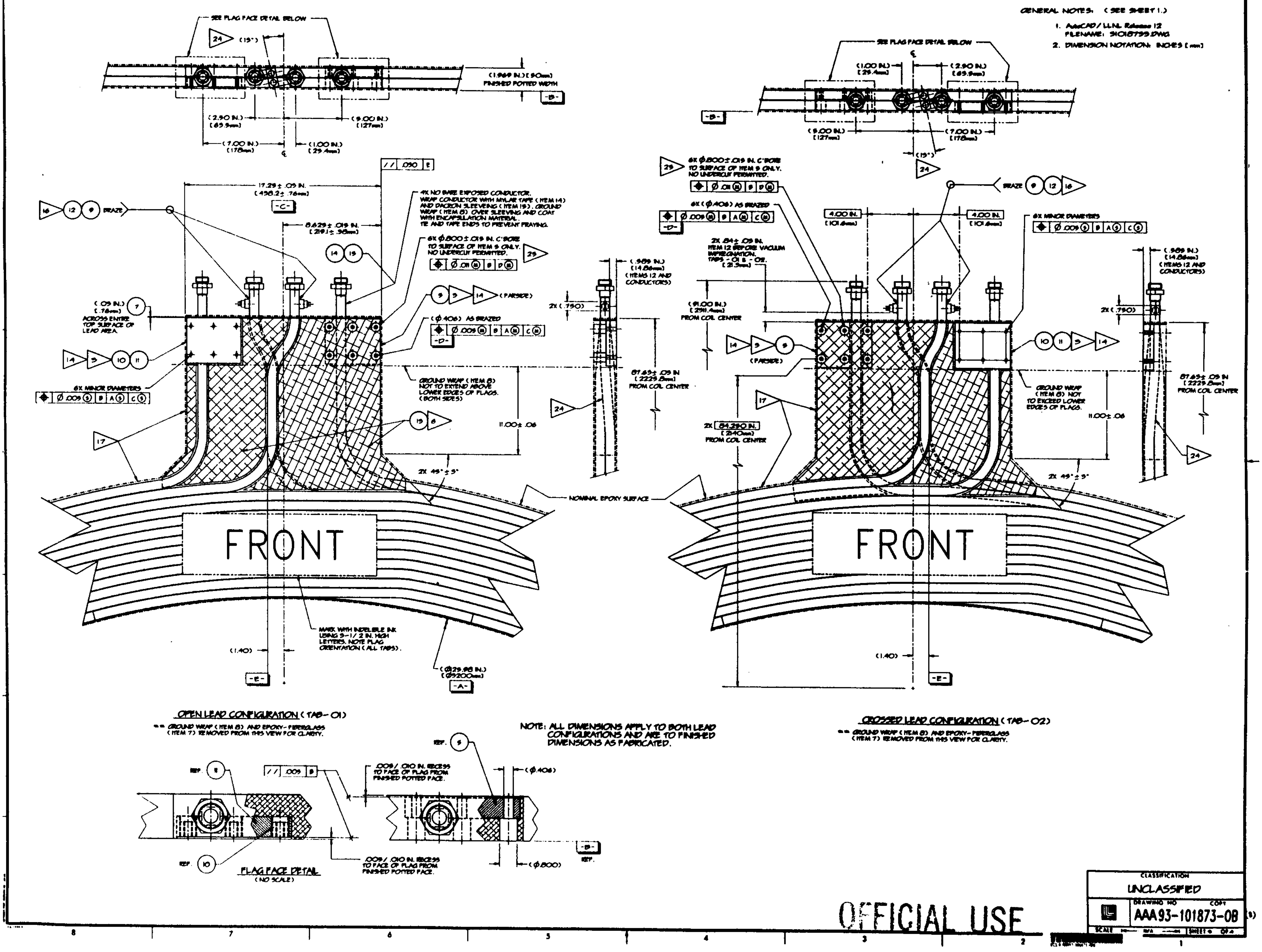
SECTION K-K
(FULL SCALE)



INSULATION DETAIL
(4X SCALE)

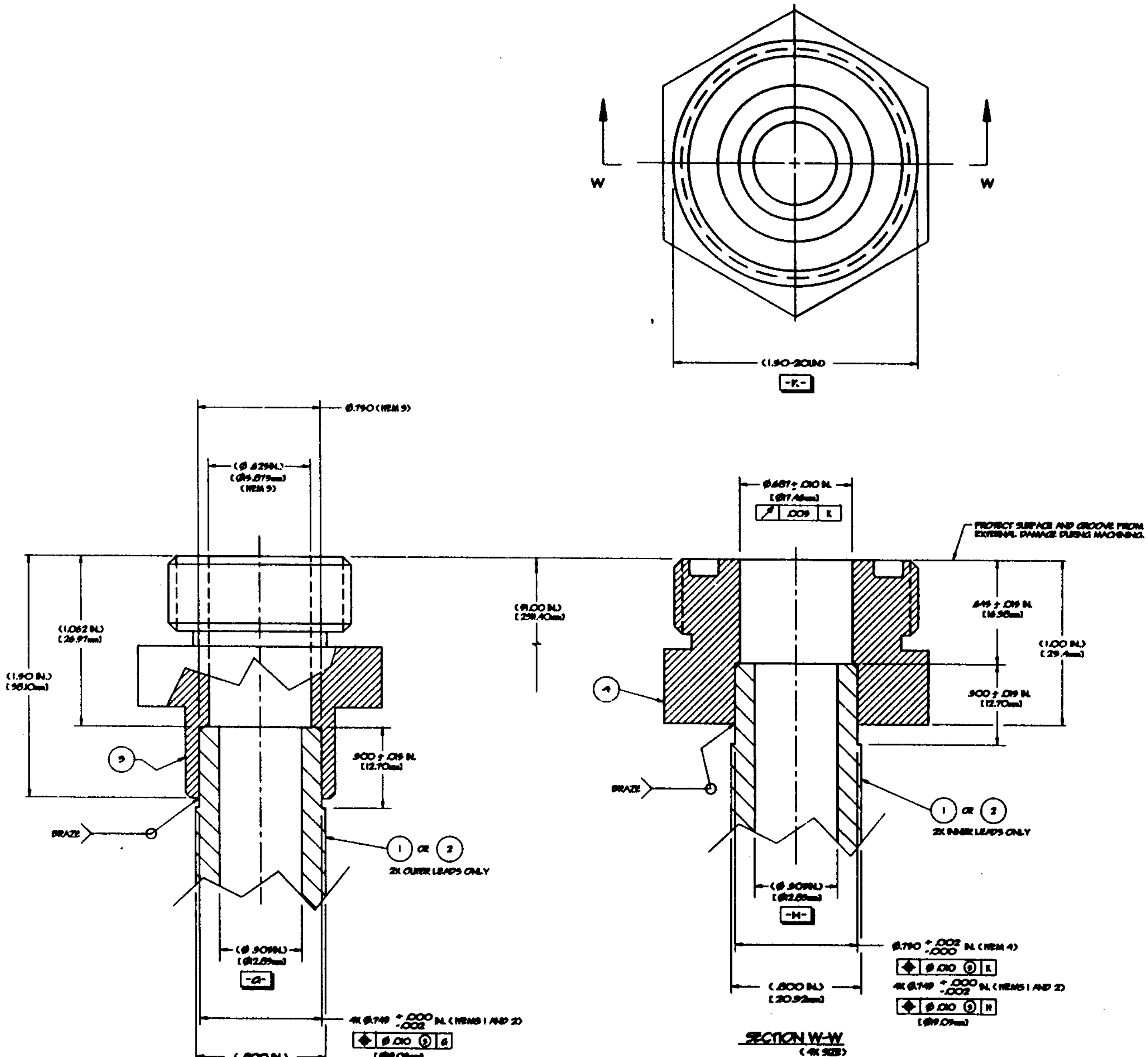
OFFICIAL USE

CLASSIFICATION
UNCLASSIFIED
DRAWING NO. AAA93-101873-0B
SCALE N/A SHEET 2 OF 4


GENERAL NOTES: (SEE SHEET 1.)
1. AutoCAD / LLNL Release 12 FILENAME: SIO18799.DWG
2. DIMENSION NOTATION: INCHES [mm]
SEE FLAG FACE DETAIL BELOW
(1.969 IN.) [50mm] FINISHED POTTED WIDTH
(2.50 IN.) [63.5mm]
(5.00 IN.) [127mm]
(7.00 IN.) [178mm]
(1.00 IN.) [25.4mm]
(2.90 IN.) [63.9mm]
17.29 ± .03 IN. [439.2 ± .76mm]
8.629 ± .015 IN. [219.1 ± .38mm]
4X NO BARE EXPOSED CONDUCTOR. WRAP CONDUCTOR WITH MYLAR TAPE (ITEM 14) AND DACRON SLEEVEING (ITEM 15). GROUND WRAP (ITEM 8) OVER SLEEVING AND COAT WITH ENCAPSULATION MATERIAL. TIE AND TAPE ENDS TO PREVENT FRAYING.
6X Ø.800 ± .015 IN. C'BORE TO SURFACE OF ITEM 9 ONLY. NO UNDERCUT PERMITTED.
(Ø.406) AS BRAZED
BRAZE
(FARSIDE)
ACROSS ENTIRE TOP SURFACE OF LEAD AREA.
6X MINOR DIAMETERS
GROUND WRAP (ITEM 8) NOT TO EXTEND ABOVE LOWER EDGES OF FLAGS. (BOTH SIDES)
87.63 ± .03 IN [2225.8mm] FROM COIL CENTER
11.00 ± .06
2X 45° ± 5°
NOMINAL EPOXY SURFACE
4.00 IN. [101.6mm]
2X .84 ± .03 IN. ITEM 12 BEFORE VACUUM IMPREGNATION. TABS - O1 & - O2. [21.3mm]
(91.00 IN.) [2311.4mm] FROM COIL CENTER
2X 84.290 IN. [2140mm] FROM COIL CENTER
GROUND WRAP (ITEM 8) NOT TO EXCEED LOWER EDGES OF FLAGS.
(.589 IN.) [14.86mm] (ITEMS 12 AND CONDUCTORS)
2X (.750)
FRONT
FRONT
MARK WITH INDELIBLE INK USING 3-1/2 IN. HIGH LETTERS. NOTE FLAG ORIENTATION (ALL TABS).
(1.40)
(Ø29.86 IN.) [Ø9200mm]
OPEN LEAD CONFIGURATION (TAB-O1)
GROUND WRAP (ITEM 8) AND EPOXY-FIBERGLASS (ITEM 7) REMOVED FROM THIS VIEW FOR CLARITY.
NOTE: ALL DIMENSIONS APPLY TO BOTH LEAD CONFIGURATIONS AND ARE TO FINISHED DIMENSIONS AS FABRICATED.
CROSSED LEAD CONFIGURATION (TAB-O2)
GROUND WRAP (ITEM 8) AND EPOXY-FIBERGLASS (ITEM 7) REMOVED FROM THIS VIEW FOR CLARITY.
REF.
.005/.010 IN. RECESS TO FACE OF FLAG FROM FINISHED POTTED FACE.
(Ø.406)
(Ø.800)
FLAG FACE DETAIL (NO SCALE)
OFFICIAL USE
CLASSIFICATION
UNCLASSIFIED
DRAWING NO
AAA93-101873-0B
SCALE
SHEET

GENERAL NOTES: (SEE SHEET 1.)

1. AutoCAD / LLNL Release 12
   FILENAME: 9101879-4.DWG
2. DIMENSION NOTATION: INCHES (mm)

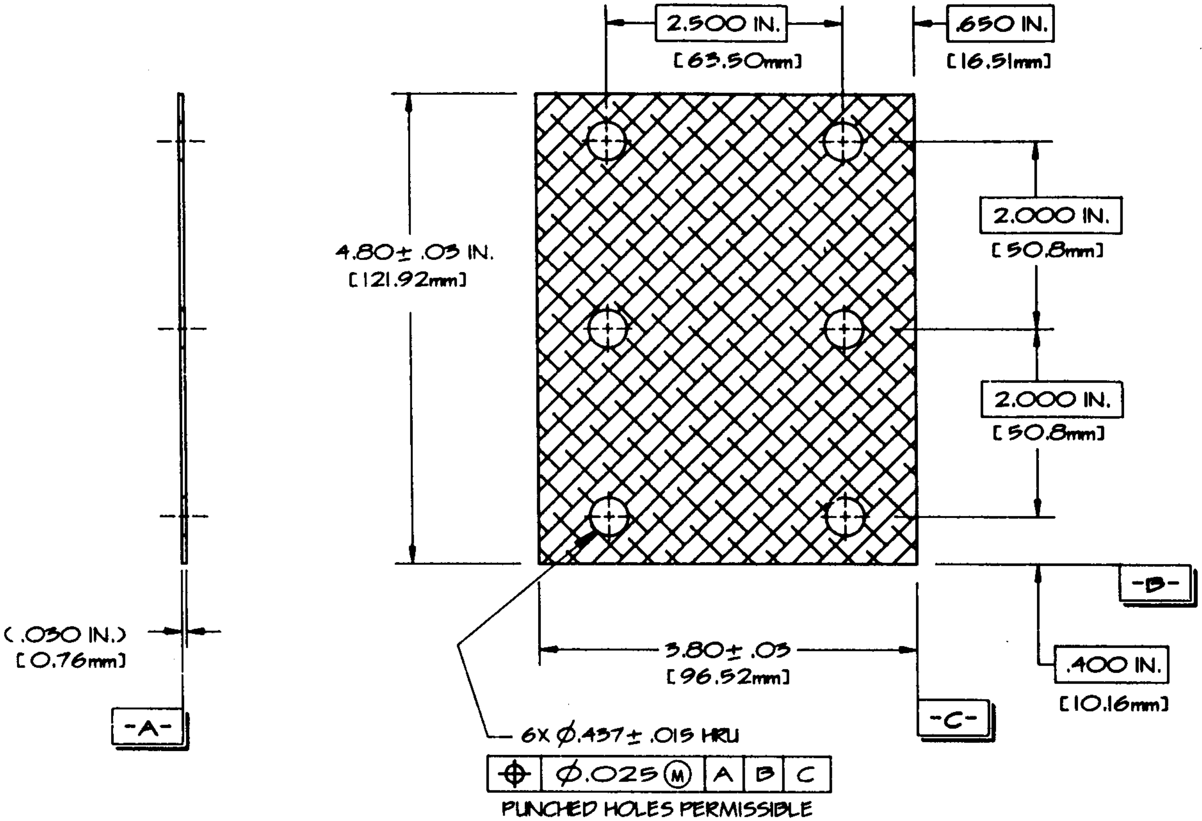


SOCKET WELD CONNECTOR DETAIL (ITEM 5)
(4X SIZE)

BLIND BODY MODIFICATION (ITEM 4)

OFFICIAL USE

CLASSIFICATION	UNCLASSIFIED
DRAWING NO	AAA93-101873-0B
SCALE	N/A
SHEET	4 OF 4



NOTES
UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. DIMENSION NOTATION - INCHES [MM]
4. STOCK FINISH ALL OVER.
5. ALL DIMENSIONS APPLY TO PART IN AN UNRESTRAINED CONDITION.
6. SUGGESTED VENDOR:
   HI TECHMETAL GROUP
   1101 EAST 55th STREET
   CLEVELAND, OHIO 44103
   PH: (216) 881-8100
7. FINISHED PART TO BE CLEAN AND FREE OF OIL, GREASE, DIRT, ETC..
8. BAG AND TAG WITH LLNL DWG. NO.
9. LLNL AutoCAD(tm) Release 12 USER FILENAME: 31018551.DWG
10. CAUTION: DO NOT CRUSH MATERIAL DURING FABRICATION OR HANDLING PROCESSES.

NO REQD	PART/LLNL STK NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
6		FOAMETAL (tm), .030" THICK, .008"-.012" FILAMENT DIA., 37-42 CELLS/IN., .022"-.026" PORE DIA., PORE TYPE 30 (COPPER)		

DWN	WJWONG 黄伟星	4/93
CHK	WJWONG	4/93
APVD	RMYAMAMOTO	4/93
CLASSIFIED BY:		
TITLE		DATE

LTR	DWN	CHK	DATE	ZONE	CHANGE
A	WJW	RMY	5/4/93		GENERAL REVISION

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

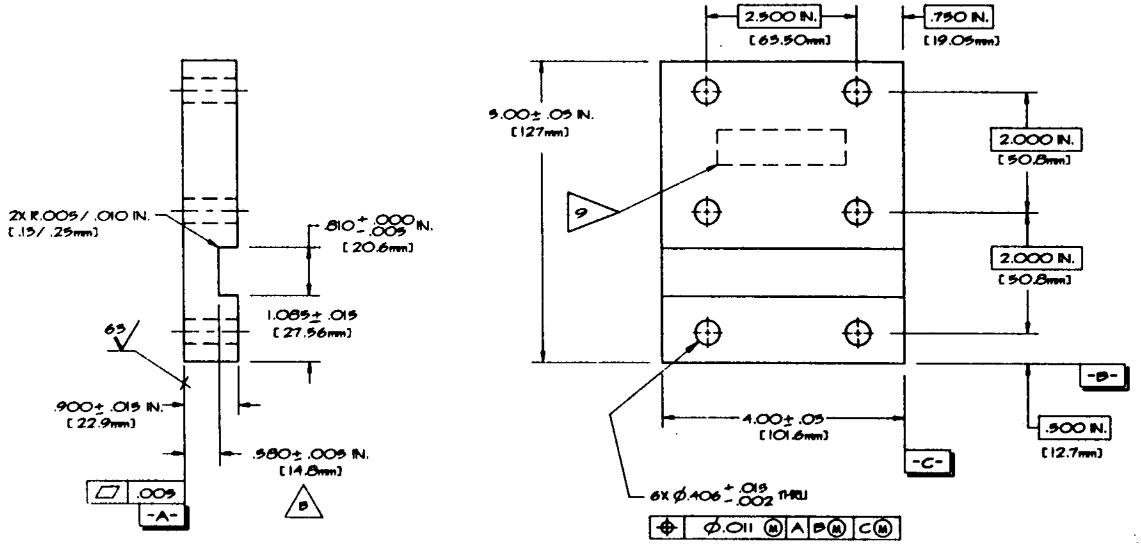
MAJOR UNIT: PHENIX
SUBASSY: CENTRAL COIL
DETAIL: FLAG CONTACT PAD
SHOWN ON AAA 93-101878, 93-101879
ACT 8863-23
DRAWING NO: AAA 93-101855-0A
COPY
SCALE: 2.00"
SHEET 1 OF 1

AAA93-101855-0A0

LL 1005-1 (Rev. 6/83)

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 63√ FINISH ALL MACHINED SURFACES.
5. DIMENSION NOTATION: INCHES [mm]
6. BAG AND TAG WITH LLNL DWG.
7. REMOVE BURRS AND BREAK SHARP EDGES .005/.010 IN. [.13/.25mm].
8. FINISHED PART TO BE CLEAN AND FREE OF ALL GREASE, OIL, DIRT, ETC.
9. STAMP THE WORD "FRONT" IN 1/8" HIGH LETTERS APPROXIMATELY WHERE INDICATED.
10. AutoCAD/LLNL REL. 12 USER FILENAME: 31018741.DWG



B	WW	CW	RMY	5/99	6-9	.580 WAS .584
A	WW		RMY	5/99		GENERAL REVISION
LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE

		BAR OR PLATE, CDA 101/102 HIGH PURITY (Cu)	
NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO / ITEM

DWN W. J. WONG 黄瑞昌	2/99
CHK W. J. WONG	2/99
APVD R. M. YAMAMOTO	2/99
CLASSIFIED BY:	
TITLE	DATE

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MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION
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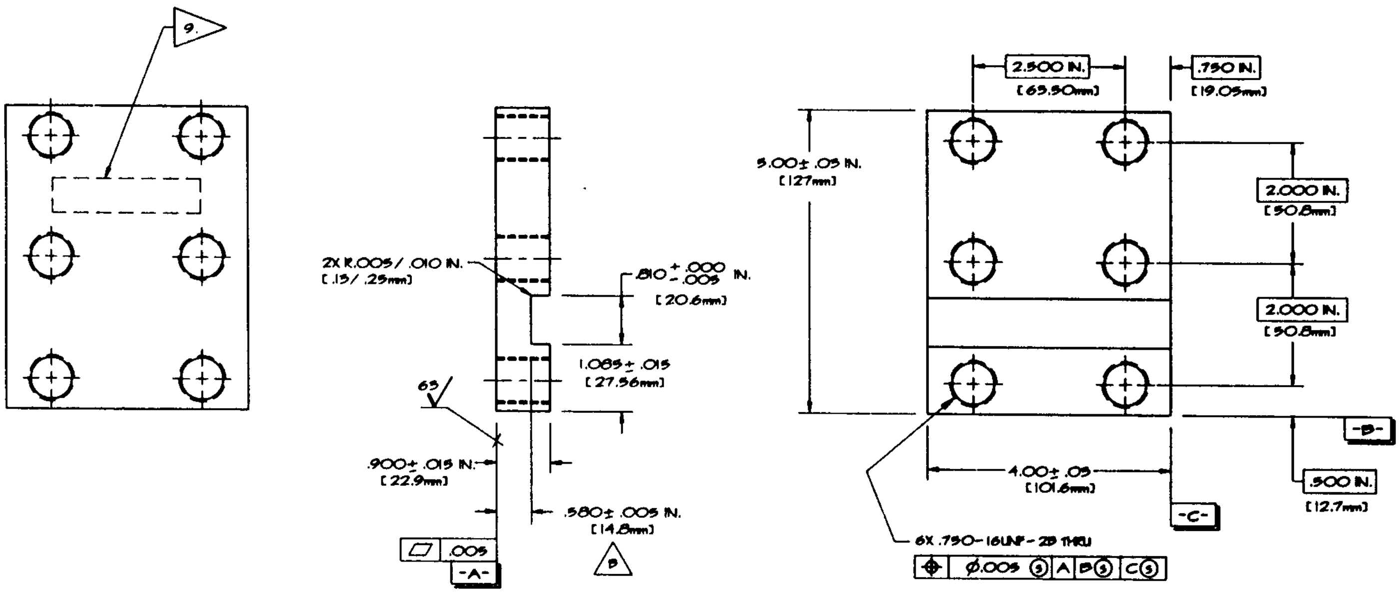
MAJOR UNIT: PHENIX
SUBASSY: ASSEMBLY - DOUBLE PANCAKE
DETAIL: BUS FLAG - THRU
SHOWN ON AAA: 93-101875
ACCT NO: 6865-29
DRAWING NO: AAA 93-101874-0B
SCALE: 2.00"
SHEET 1 OF 1

OFFICIAL USE



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 63 √ FINISH ALL MACHINED SURFACES.
5. DIMENSION NOTATION: INCHES [mm]
6. BAG AND TAG WITH LLNL DWG.
7. REMOVE BURRS AND BREAK SHARP EDGES .005/.010 IN. [.13/.25mm].
8. FINISHED PART TO BE CLEAN AND FREE OF ALL GREASE, OIL, DIRT, ETC.
9. STAMP THE WORD "FRONT" IN 1/8" HIGH LETTERS APPROXIMATELY WHERE INDICATED.
10. AutoCAD/LLNL REL. 12 USER FILENAME: 3101875I.DWG

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
		BAR OR PLATE, CDA 101/102 HIGH PURITY (Cu)		

DWN	W. J. WONG	2/95
CHK	W. J. WONG	2/95
APVD	E. M. YAMAMOTO	2/95
CLASSIFIED BY:		
TITLE		DATE

CLASSIFICATION
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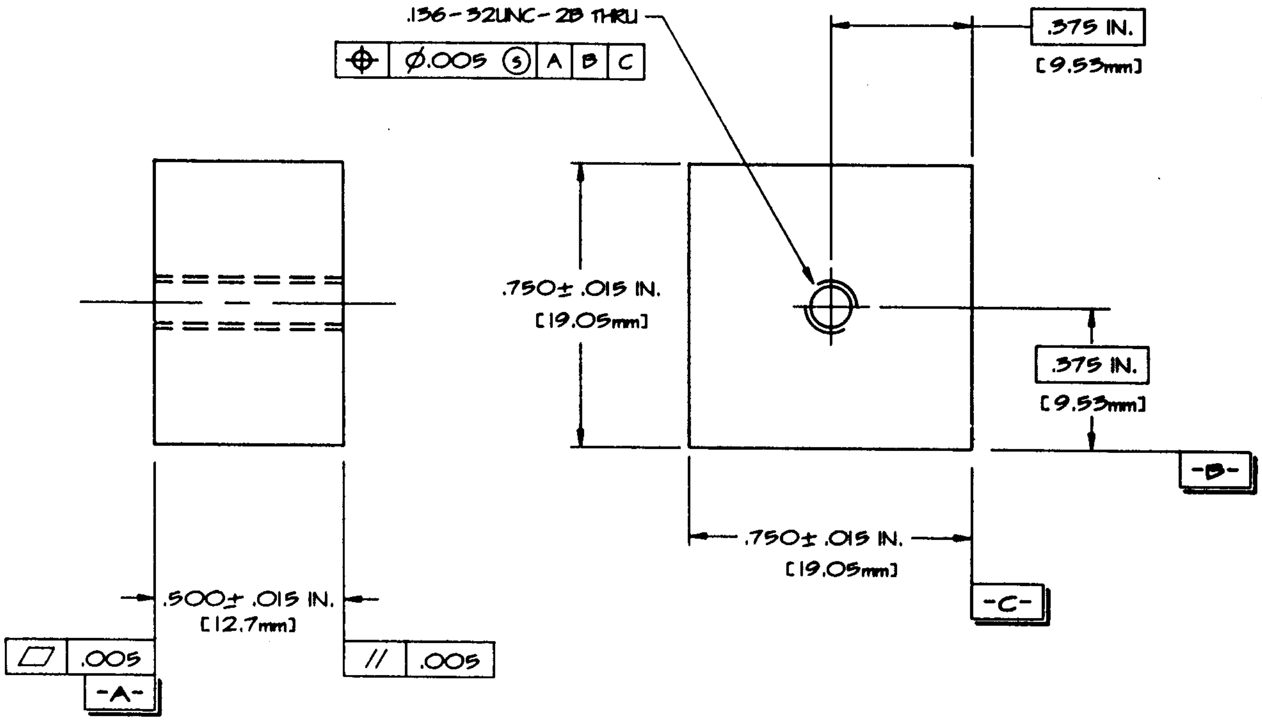
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

MAJOR UNIT: PHENIX
SUBASSY: ASSEMBLY - DOUBLE PANCAKE
DETAIL: BUS FLAG - TAPPED
SHOWN ON AAA 93-101873
ACCT NO 8869-25
DRAWING NO AAA 93-101875-0B
SCALE 2.00"
SHEET 1 OF 1

LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE
B	WW	CW	EMY	5/95	5-9	.980 WAS .984
A	WW		EMY	5/95		GENERAL REVISION

OFFICIAL USE



NOTES

UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. 63√ FINISH ALL MACHINED SURFACES.
4. AutoCAD / LLNL Release 12
   FILENAME: 31018761.DWG
5. DIMENSION NOTATION: INCHES [mm]
6. BAG AND TAG WITH LLNL DWG.
7. REMOVE BURRS AND BREAK SHARP EDGES .005/ .010 IN. [.13/ .25mm].
8. FINISHED PART TO BE CLEAN AND FREE OF ALL GREASE, OIL, DIRT, ETC.

NO REQD	PART/LLNL STK NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
		BAR OR PLATE, CDA 101/ 102 HIGH PURITY (Cu)		

DWN	WJWONG	2/93
CHK	WJWONG	2/93
APVD	RMYAMAMOTO	2/93
CLASSIFIED BY:		
TITLE		DATE

LTR	DWN	CHK	DATE	ZONE	CHANGE
A	WJW	RMY	5/4/93		GENERAL REVISION, FORMAT CHANGE

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MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

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OFFICIAL USE

MAJOR UNIT: PHENIX

SUBASSY: ASSEMBLY - DOUBLE PANCAKE

DETAIL: THERMOSTAT MOUNT

SHOWN ON AAA 93-101873

ACT 8869-23

DRAWING NO: AAA 93-101876-0A

COPY

SCALE 1.00"

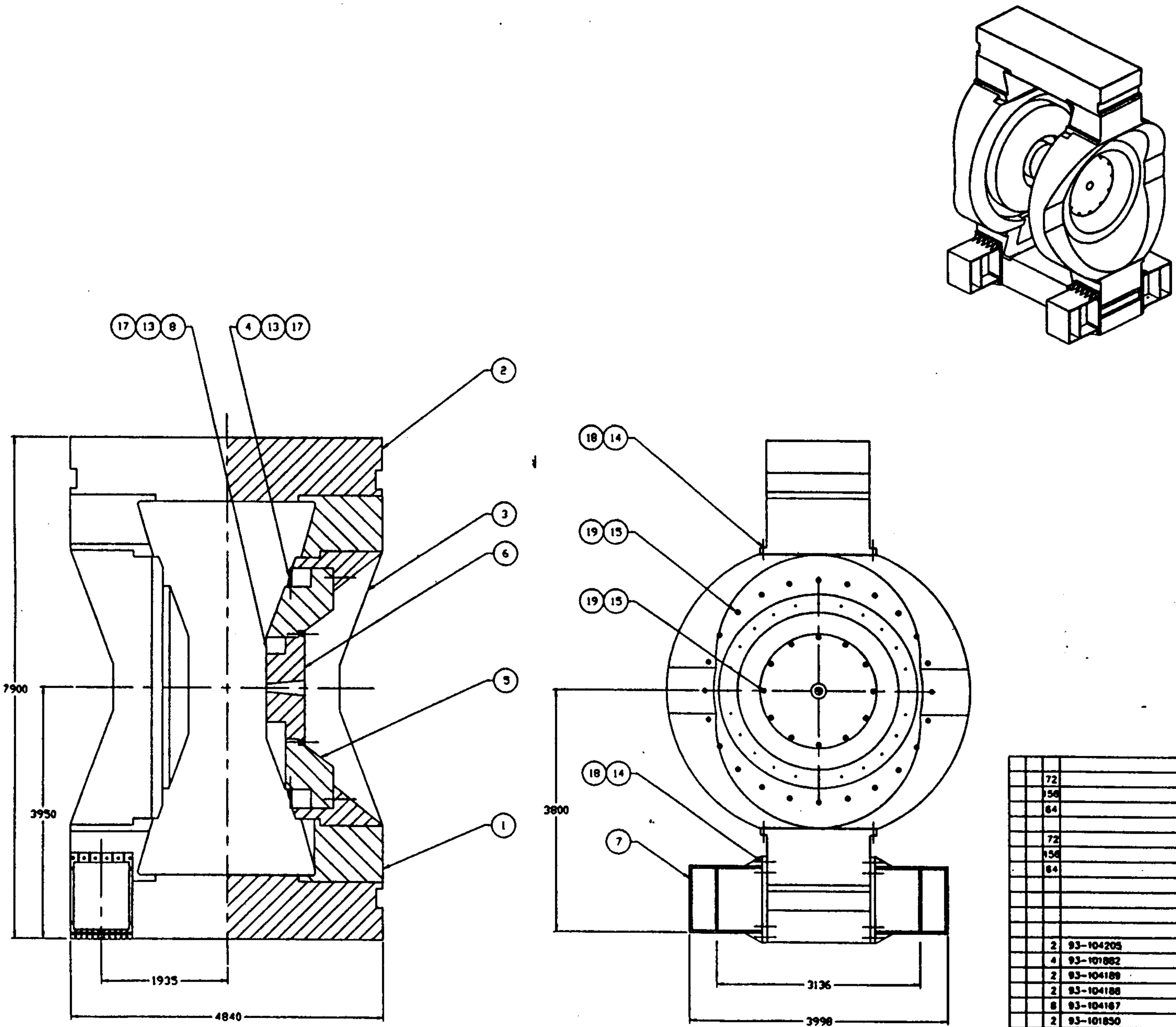
SHEET 1 OF 1

LL 1005-1 (Rev. 6/83)

AAA93-101876-0A

PHENIX Central Magnet - Steel Drawings

Central Magnet Assembly	AAA93-104183-00
Eyebrow Ring	AAA93-101850-0B
Pole Piece Center	AAA93-104188-00
Pole Piece Plug	AAA93-104189-00
Yoke Assembly Upper	AAA93-104204-00
Yoke Upper	AAA93-104187-00
Pole Key Upper	AAA93-104185-00
Yoke Assembly Lower	AAA93-104190-00
Yoke Lower	AAA93-104186-00
Pole Key Lower	AAA93-104184-00
Outrigger Support	AAA93-101882-00
Coil Retaining Ring	AAA93-104167-00



PRELIMINARY
10/11/93

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
72		F.WASHER 75 O.D.X 49 I.D.X 6 THK. STL.ZINC PLT.		19
156		F.WASHER 58 O.D.X 37 I.D.X 6 THK. STL.ZINC PLT.		18
64		F.WASHER 34 O.D.X 21 I.D.X 4 THK. STL.ZINC PLT.		17
				16
72		SOC.HD.CAP SCREW BLACK,M48X5 180	DIN 912 8.8	15
156		SOC.HD.CAP SCREW BLACK,M36X4 160	DIN 912 8.8	14
64		SOC.HD.CAP SCREW BLACK,M20X2.5 160	DIN 912 8.8	13
				12
				11
				10
				9
2	93-104205	COIL RETAINER		8
4	93-101882	OUTRIGGER SUPPORT		7
2	93-104189	POLE PIECE PLUG		6
2	93-104188	POLE PIECE CENTER		5
8	93-104187	COIL RETAINING RING		4
2	93-101850	EYEBROW RING		3
1	93-104204	YOKE ASSEMBLY UPPER		2
1	93-104190	YOKE ASSEMBLY LOWER		1

DRN L.MULLINS 9-93

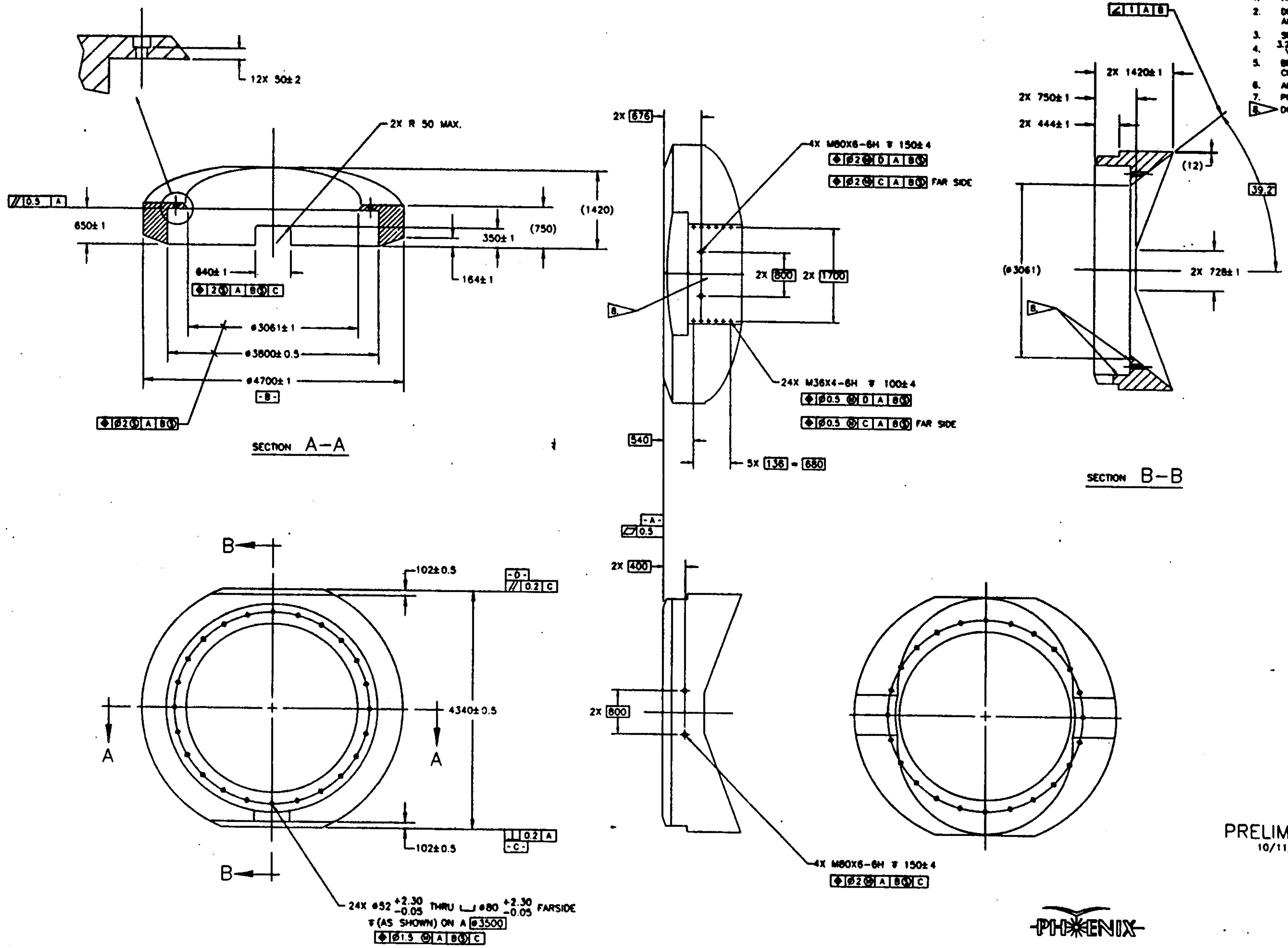
CLASSIFICATION
FILE NAME: 31041330

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER
SUBASSY: CENTRAL MAGNET
DETAIL: CENTRAL MAGNET ASSEMBLY

DRAWING NO
AAA 93-104183-00

SCALE 300 SHEET 1 OF 1



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5
7. PRIME AND PAINT PER LLNL SPECIFICATIONS.
8. DO NOT PRIME OR PAINT THIS SURFACE.

PHENIX

STEEL, AISI 1006 OR EQUIV.

DESCRIPTION / MATERIAL

NO REQD — PART / LLNL STK NO — SPEC NO — ITEM

DWN L. MULLINS 6-93

CHK

APVD

CLASSIFICATION
FILE NAME: 31018508.DWG
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RELATIVISTIC HEAVY ION COLLIDER (RHIC)
CENTRAL MAGNET
EYEBROW RING

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

DRAWING NO
AAA 93-101850-0B

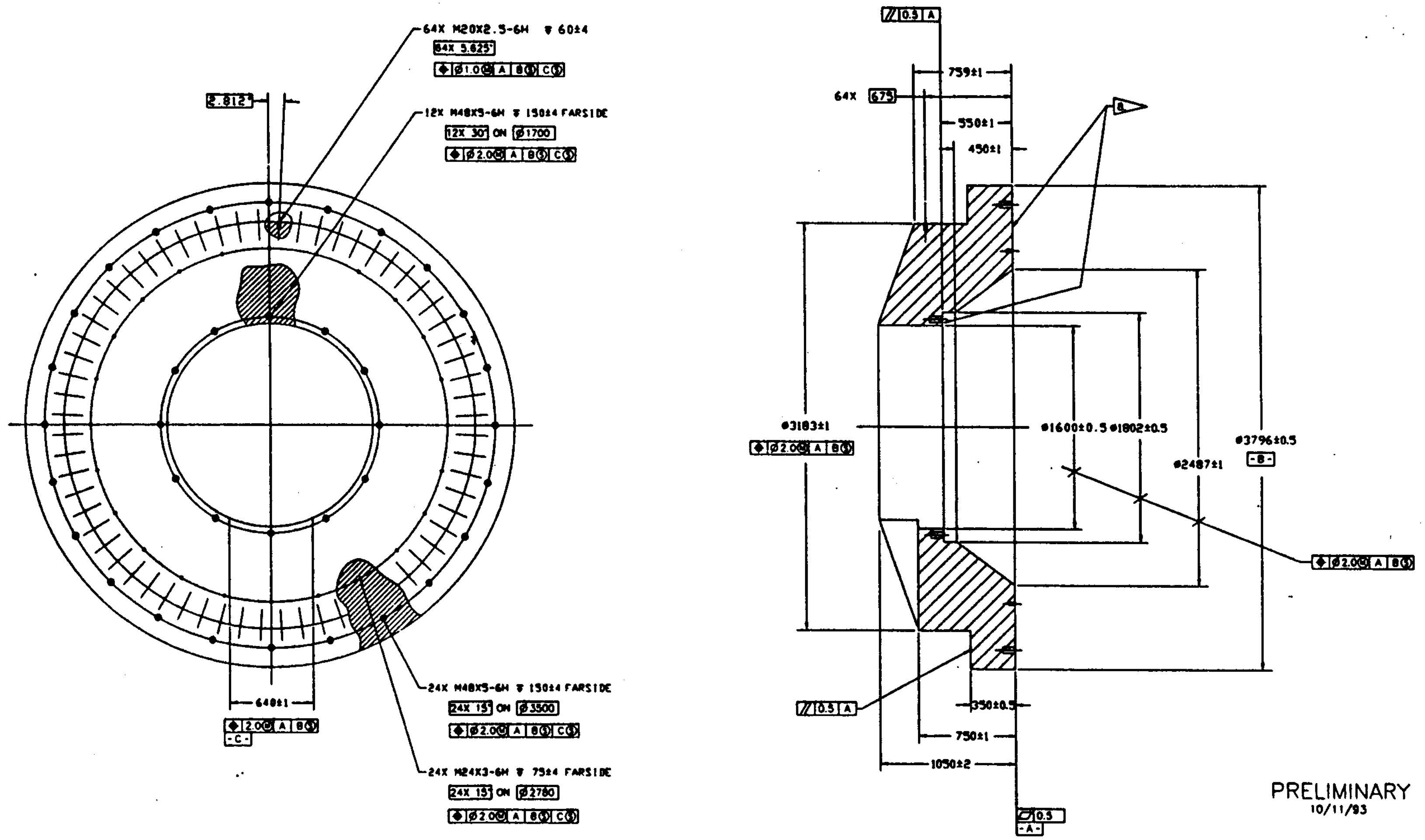
SCALE 1:200 SHEET 1 OF 1

LTR				DATE	DESCRIPTION
B	LM			4/93	REVISED AND REDRAWN
A	DH			2/93	GEN REV

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2√ ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5
7. PRIME AND PAINT PER LLNL SPECIFICATIONS.
8. DO NOT PRIME OR PAINT THIS SURFACE.



PRELIMINARY
10/11/93

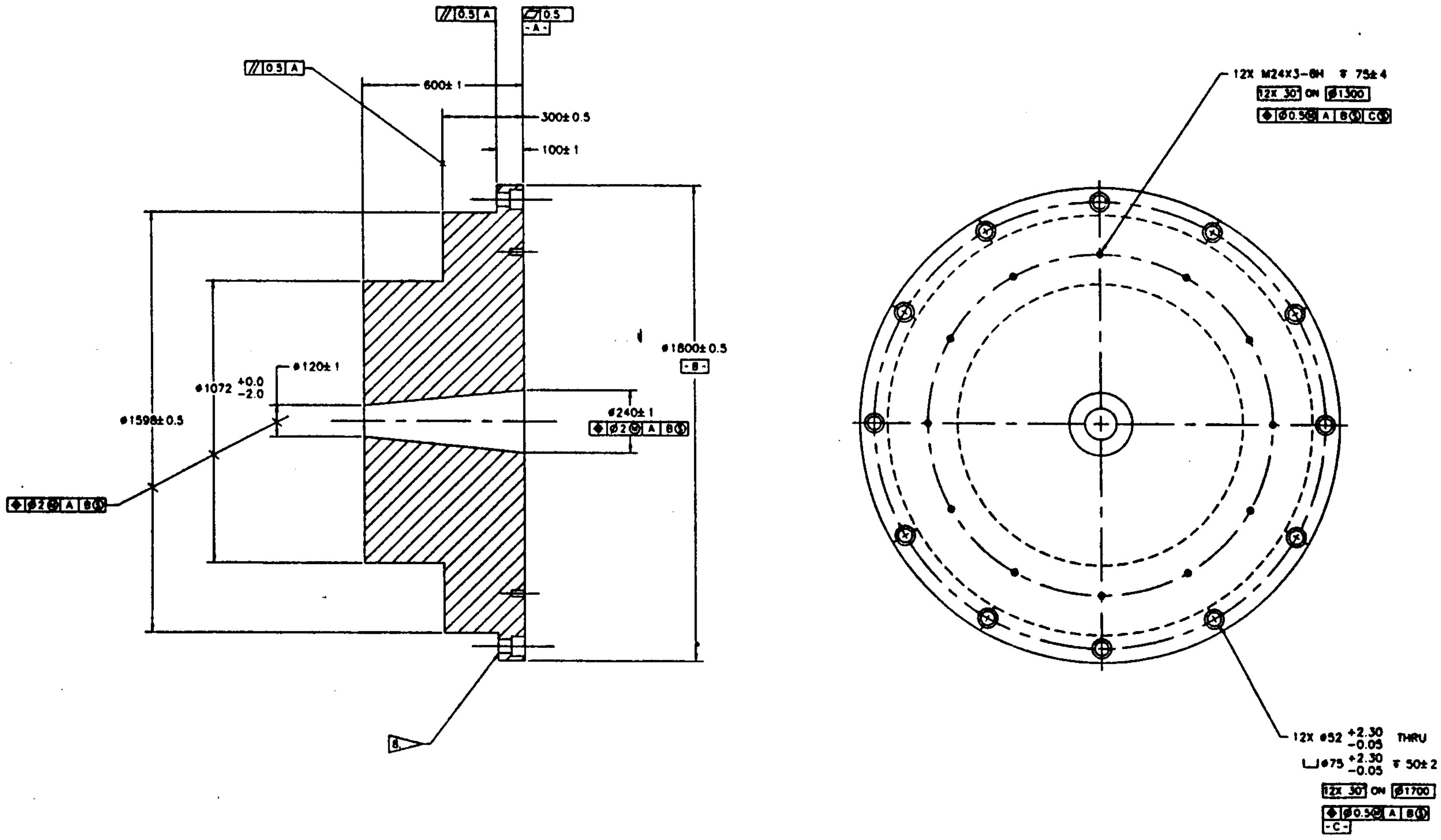
PHENIX

NO RECD	PART / LLNL STK NO	STEEL, AISI 1006 OR EQUIV. — DESCRIPTION / MATERIAL
DWN L. MULLINS 8-93	CLASSIFICATION: FILE NAME 31041880.DWG	MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER RHIC
CHK		CENTRAL MAGNET
APVD		DETAIL: POLE PIECE CENTER
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA		DRAWING NO AAA 93-104188-00
		SCALE 640 — SHEET 1 OF 1

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2√ ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5
7. PRIME AND PAINT PER LLNL SPECIFICATIONS.
8. DO NOT PRIME OR PAINT THIS SURFACE.



PRELIMINARY
10/11/93

PHENIX

NO REQD	PART / LLNL STK NO	STEEL, AISI 1006 OR EQUIV. — DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN L MULLINS 8-93

CHK

APVD

CLASSIFIED BY

TITLE DATE

LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA

CLASSIFICATION

FILE NAME: 31041890.DWG

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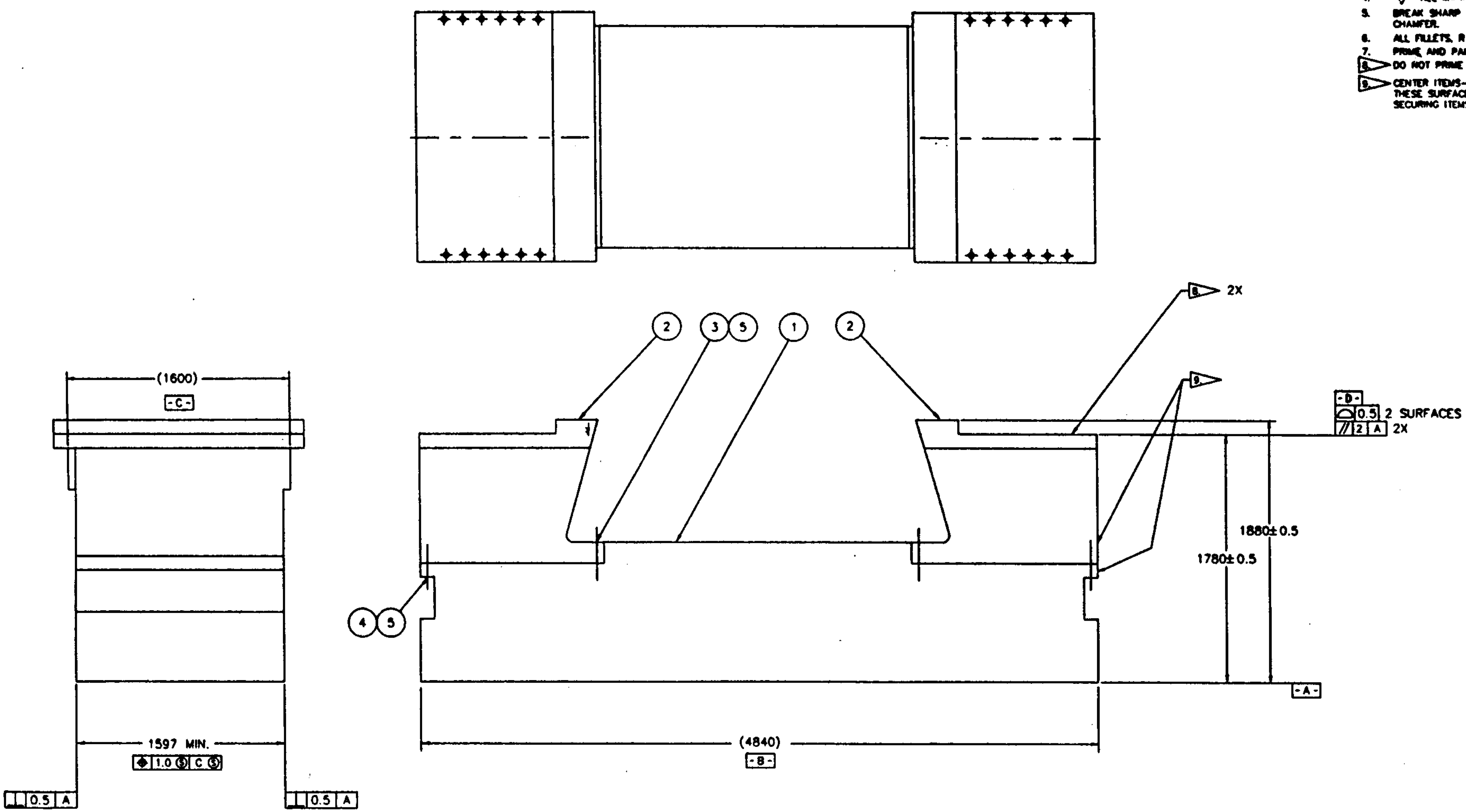
RELATIVISTIC HEAVY ION COLLIDER (RHIC)

CENTRAL MAGNET

POLE PIECE PLUG

DRAWING NO AAA 93-104189-00

SCALE 1:20 SHEET 1 OF 1



NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2√ ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5
7. PRIME AND PAINT PER LLNL SPECIFICATIONS.
8. DO NOT PRIME OR PAINT THIS SURFACE.
9. CENTER ITEMS-2 ON ITEM-1 AND MAKE THESE SURFACES FLUSH BEFORE SECURING ITEMS-2 TO ITEM-1

PRELIMINARY
10/11/93

PHENIX

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
32		F.WASHER 58 O.D. X 37 I.D. X 6 THK. STL.ZINC PLT		5
16		SOCKET HEAD CAP SCREW BLACK,M36X4 140	DIN 912 8.8	4
16		SOCKET HEAD CAP SCREW BLACK,M36X4 180	DIN 912 8.8	3
2	93-104185	POLE KEY UPPER		2
1	93-104187	YOKE UPPER		1

DWN L. MULLINS 10-93
CHK
APVD

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

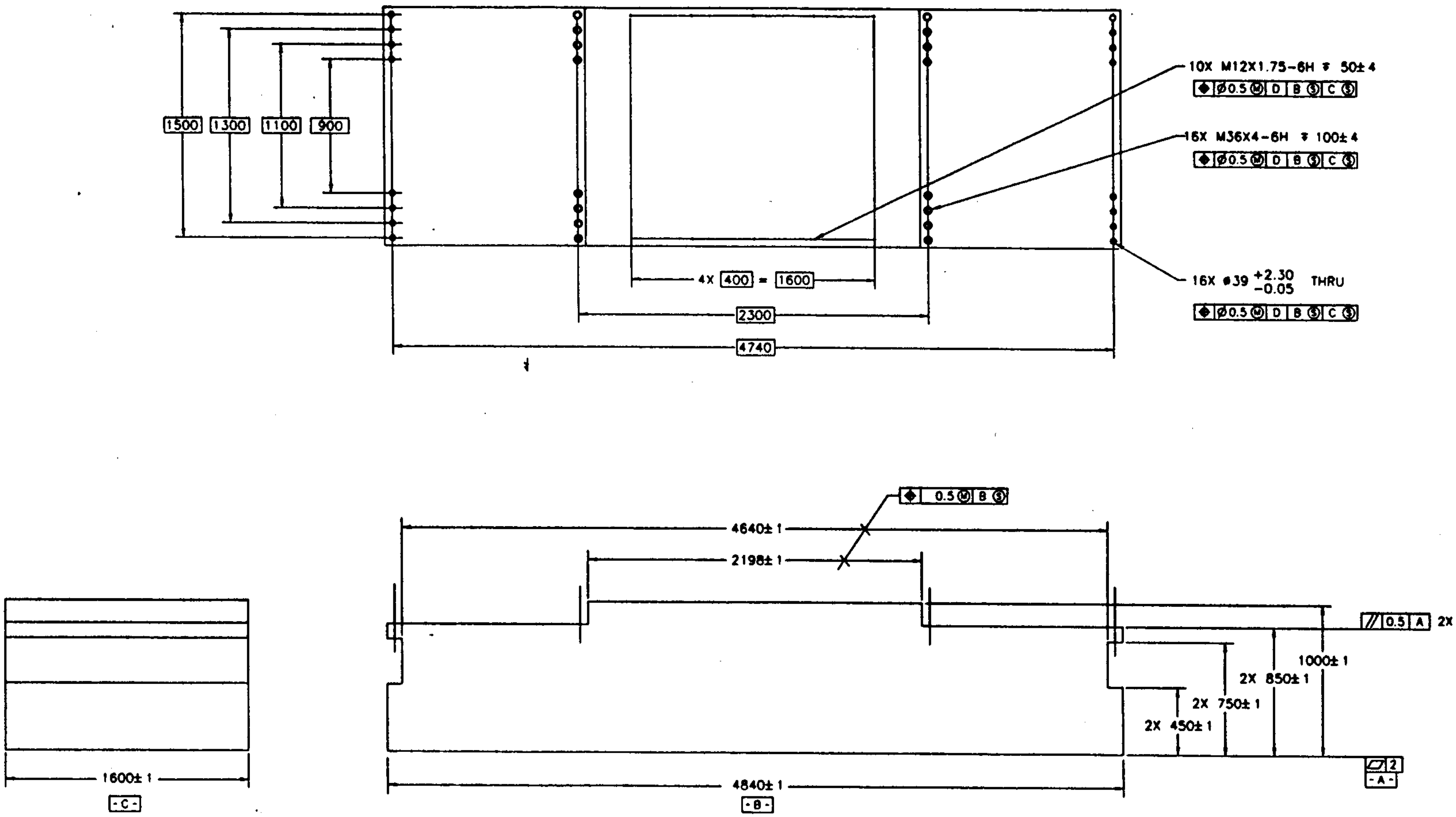
FILE NAME: 31042040.DWG

RELATIVISTIC HEAVY ION COLLIDER (RHIC
CENTRAL MAGNET
YOKE ASSEMBLY UPPER
DRAWING NO AAA 93-104204-00
SCALE 500 SHEET 1 OF 1

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2√ ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5



PRELIMINARY
10/11/93

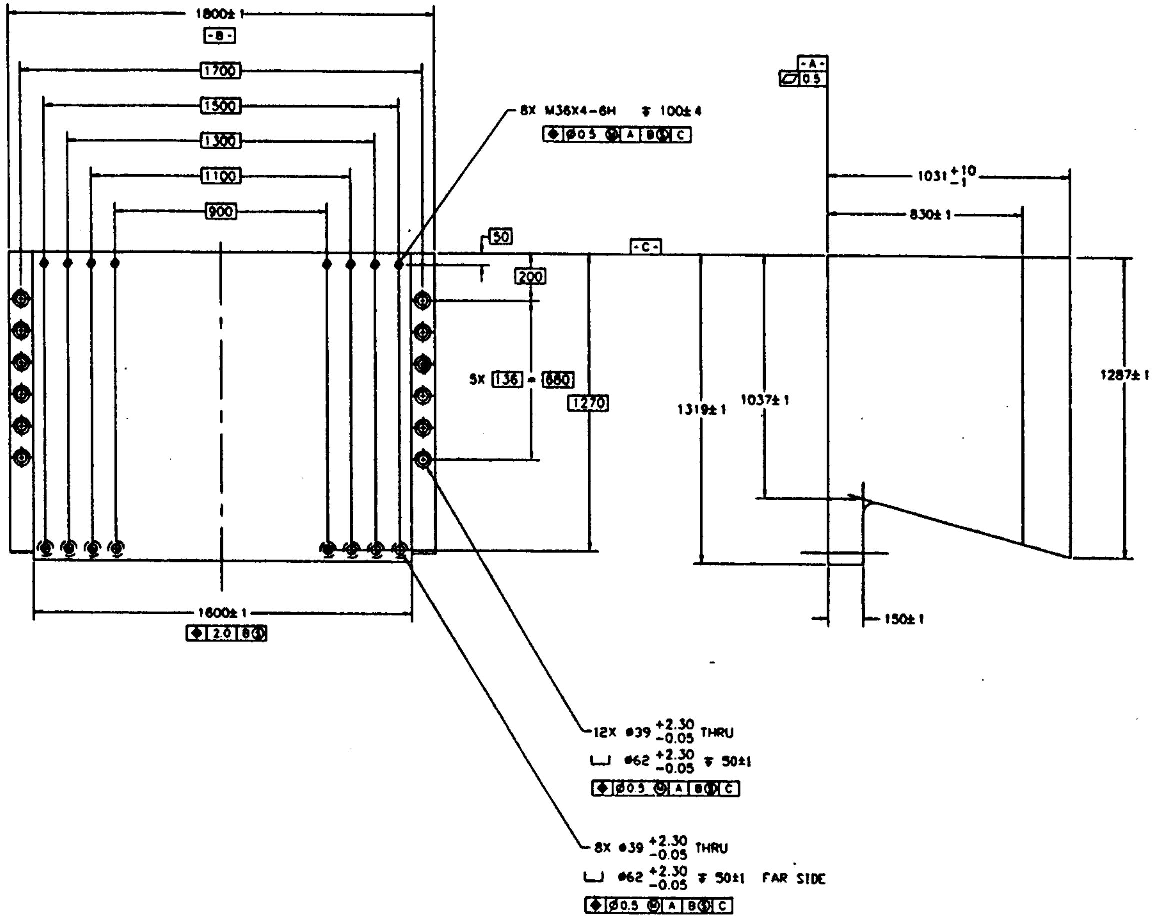
-PHOENIX-

NO REQD	PART / LLNL STK NO	STEEL, AISI 1006 OR EQUIV. DESCRIPTION / MATERIAL	SPEC NO
	DWN L.MULLINS 8-93	CLASSIFICATION FILE NAME: 31041870.DWG	RELATIVISTIC HEAVY ION COLLIDER (RH
	CHK	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT	CENTRAL MAGNET
	APVD		YOKE UPPER
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA			DRAWING NO AAA 93-104187-0
			SCALE 500 SHEET 1 OF

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2√ ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5



PRELIMINARY
10/11/93

PHENIX

NO REQD	PART / LLNL STK NO	STEEL, AISI 1006 OR EQUIV. — DESCRIPTION / MATERIAL	SPEC NO	ITEM

DRN L MALLINS 8-93

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION
FILE NAME: 3104'850.DWG

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RELATIVISTIC HEAVY ION COLLIDER (PHIC)

CENTRAL MAGNET

POLE KEY UPPER

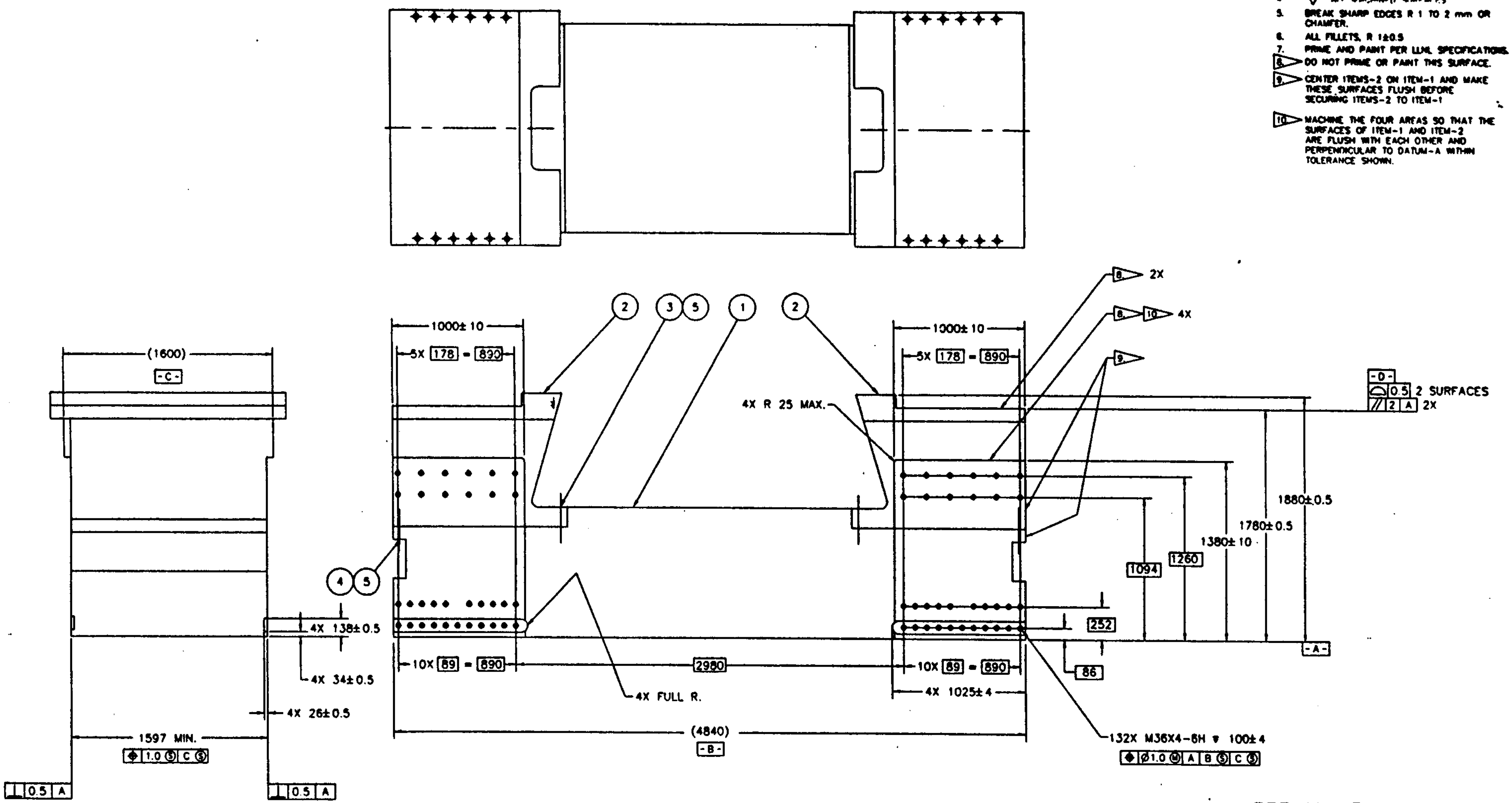
DRAWING NO AAA 93-104185-00

SCALE 1:40 SHEET 1 OF 1

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 √ ALL MACHINED SURFACES
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5
7. PRIME AND PAINT PER LLNL SPECIFICATIONS.
8. DO NOT PRIME OR PAINT THIS SURFACE.
9. CENTER ITEMS-2 ON ITEM-1 AND MAKE THESE SURFACES FLUSH BEFORE SECURING ITEMS-2 TO ITEM-1
10. MACHINE THE FOUR AREAS SO THAT THE SURFACES OF ITEM-1 AND ITEM-2 ARE FLUSH WITH EACH OTHER AND PERPENDICULAR TO DATUM-A WITHIN TOLERANCE SHOWN.



PRELIMINARY
10/11/93

		32		F.WASHER 58 O.D. X 37 I.D.X 6 THK. STL.ZINC PLT	.	5
		16		SOCKET HEAD CAP SCREW BLACK,M36X4 140	DIN 912 8.8	4
		16		SOCKET HEAD CAP SCREW BLACK,M36X4 180	DIN 912 8.8	3
		2	93-104184	POLE KEY LOWER		2
		1	93-104186	YOKE LOWER		1
NO REQD			PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN L MULLINS 8-93

LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA

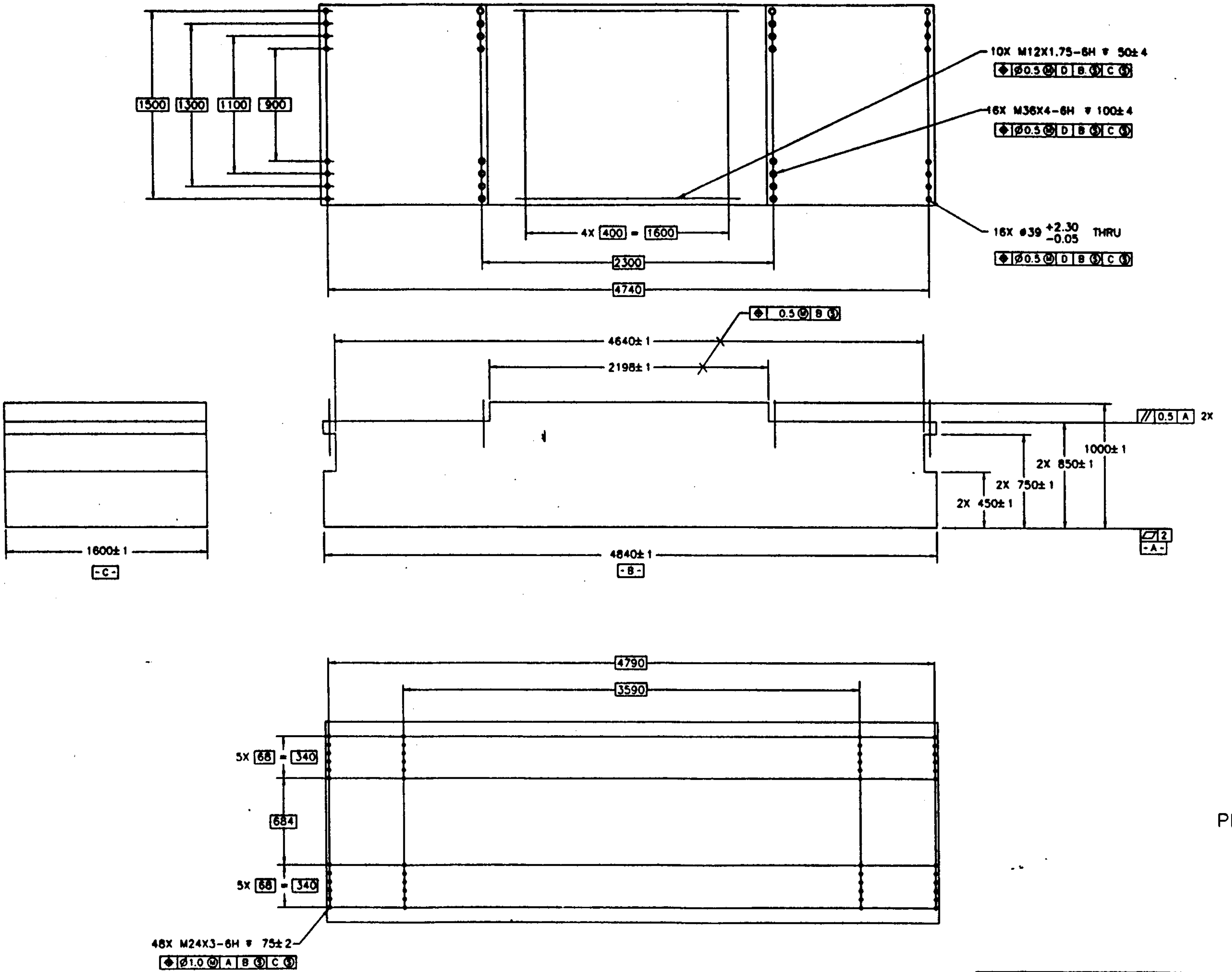
CLASSIFICATION
FILE NAME: 31041900.DWG

RELATIVISTIC HEAVY ION COLLIDER (RHIC)
CENTRAL MAGNET
YOKE ASSEMBLY LOWER

DRAWING NO
AAA 93-104190-00

SCALE 300 SHEET 1 OF 1

PHENIX



NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2√ ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5

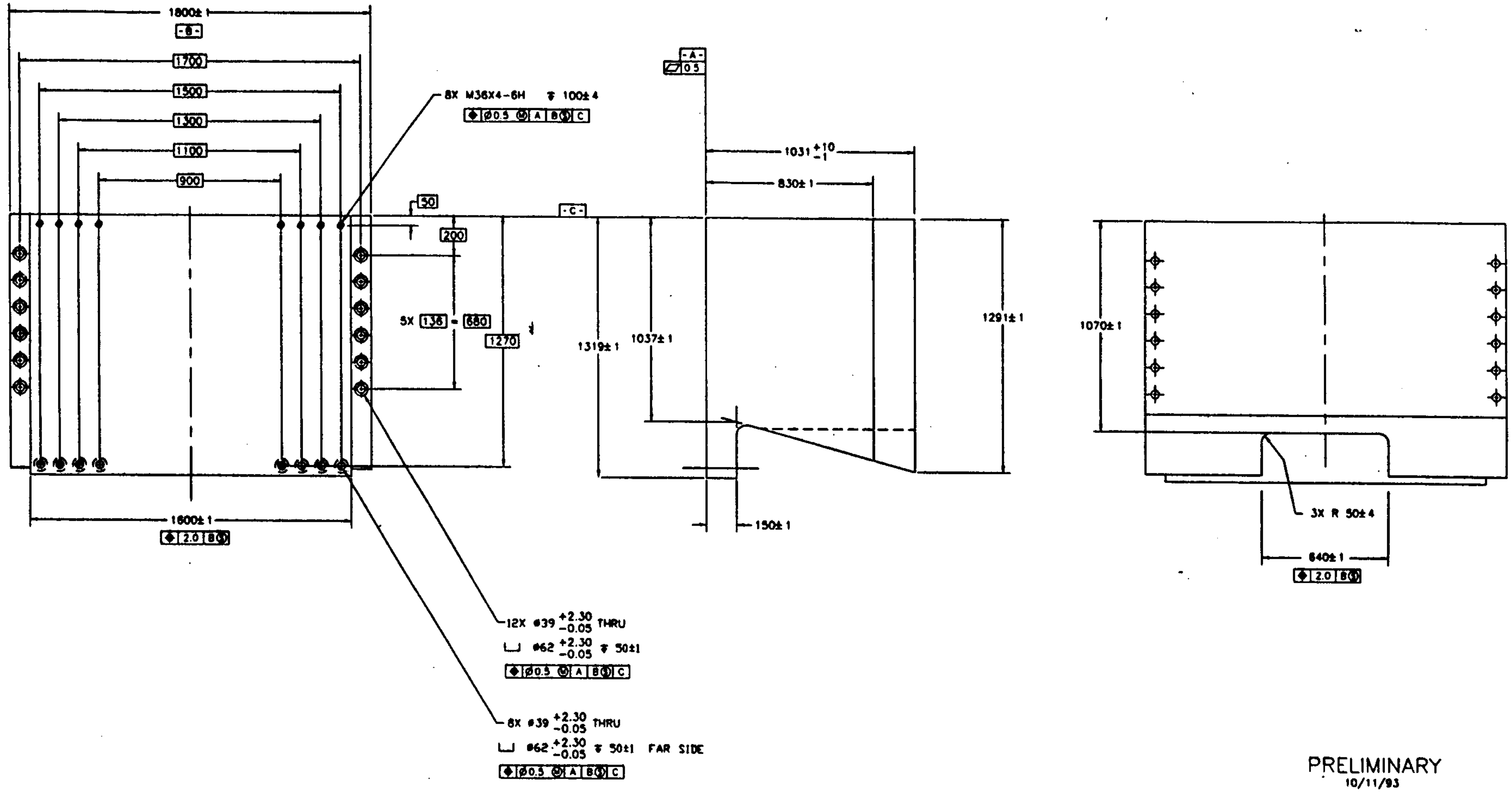
PRELIMINARY
10/11/93

PHENIX

NO REQD	PART / LLNL STK NO	STEEL, AISI 1008 OR EQUIV. — DESCRIPTION / MATERIAL
DWN L MULLINS 7-93	CLASSIFICATION	RELATIVISTIC HEAVY ION COLLIDER (RHIC)
CHK	FILE NAME: 31041860.DWG	CENTRAL MAGNET
APVD		YOKE LOWER
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB. REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT	DRAWING NO AAA 93-104186-00
		SCALE 500 SHEET 1 OF 1

NOTES
UNLESS OTHERWISE SPECIFIED:

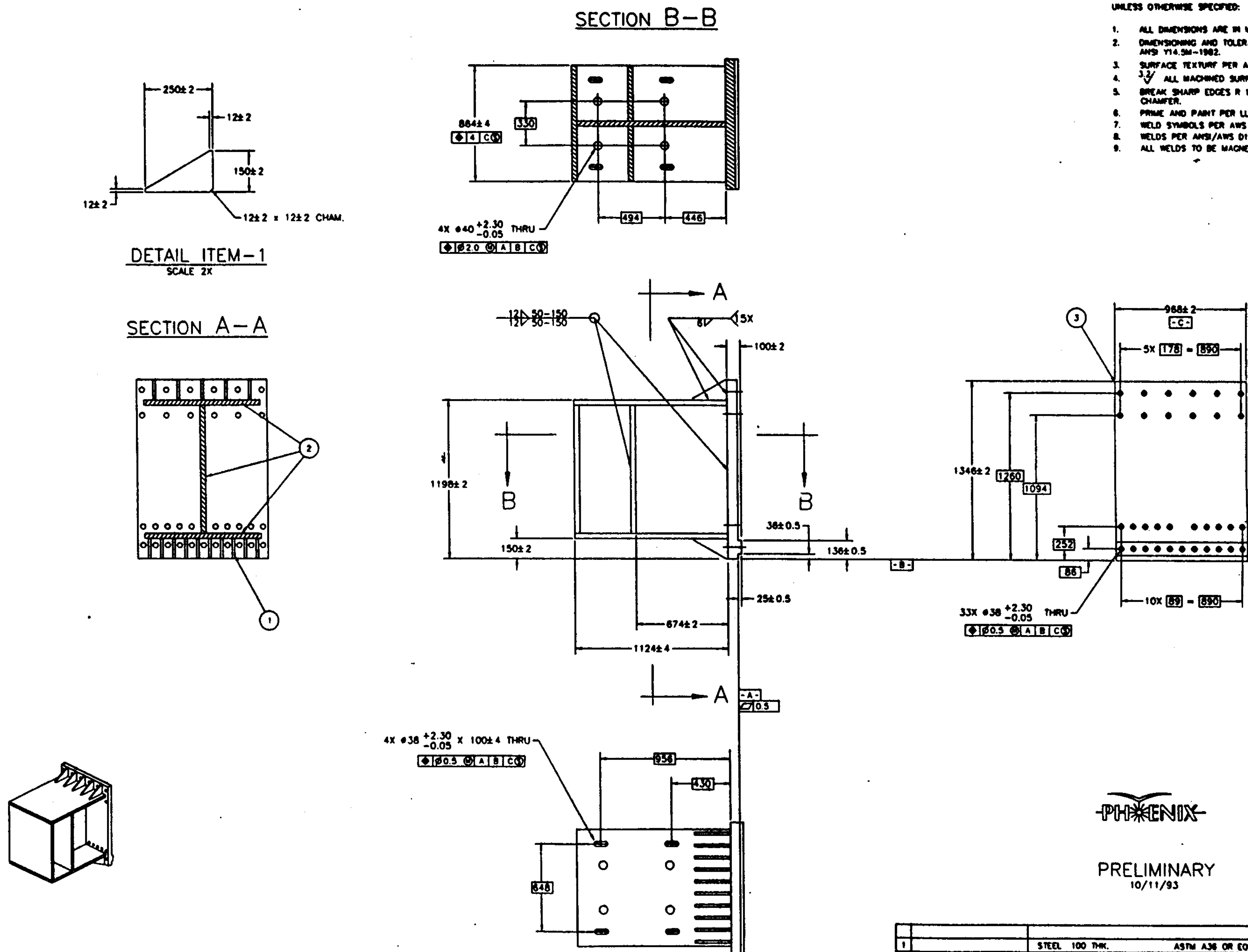
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5



PRELIMINARY
10/11/93

PHENIX

NO REQD	PART / LLNL STK NO	STEEL, AISI 1006 OR EQUIV. DESCRIPTION / MATERIAL	SPEC NO
	DWN L MULLINS 7-93	CLASSIFICATION FILE NAME: 31041840.DWG	MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
	CHK	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB	CENTRAL MAGNET
	APVD	REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	DETAIL: POLE KEY LOWER
	LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA		DRAWING NO AAA 93-104184-00
			SCALE 400 SHEET 1 OF 1



PHENIX

PRELIMINARY
10/11/93

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. PRIME AND PAINT PER LLNL SPECIFICATIONS.
7. WELD SYMBOLS PER AWS 2.4, 1979
8. WELDS PER ANSI/AWS D1.1
9. ALL WELDS TO BE MAGNETIC PARTICLE TESTED

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM
1		STEEL 100 THK.	ASTM A36 OR EQUIV.		3
10		STEEL 38 THK.	ASTM A36 OR EQUIV.		2
15		STEEL 19 THK.	ASTM A36 OR EQUIV.		1

DRN L MULLINS 3-93
CHK
APVD
SUPERSEDED BY

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

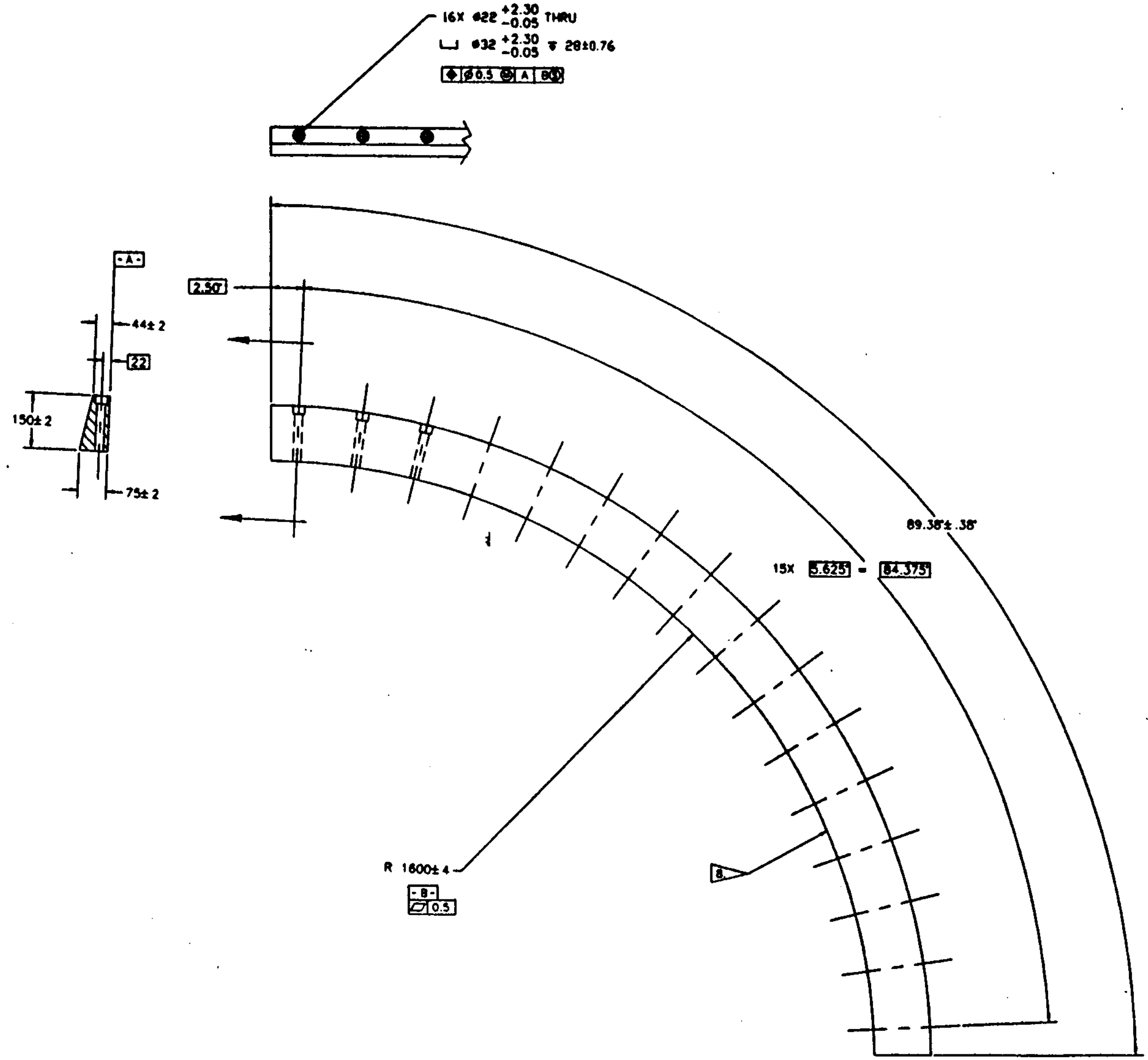
CLASSIFICATION
FILE NAME: 31018820.DWG

MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUB-ASSY: CENTRAL MAGNET
DETAIL: OUTRIGGER SUPPORT
DRAWING NO: AAA 93-101882-00
SCALE 1200
SHEET 1 OF 1

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2√ ALL MACHINED SURFACES.
5. BREAK SHARP EDGES R 1 TO 2 mm OR CHAMFER.
6. ALL FILLETS, R 1±0.5
7. PRIME AND PAINT PER LLNL SPECIFICATIONS.
8. DO NOT PRIME OR PAINT THIS SURFACE.



PRELIMINARY
10/11/93

-PHENIX-

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL: STEEL, AISI 1006 OR EQUIV.
DWN L MULLINS 7-93	CLASSIFICATION	RELATIVISTIC HEAVY ION COLLIDER (RHIC)
CHK	FILE NAME: 3104167.DWG	CENTRAL MAGNET
APVD		COIL RETAINING RING
CLASSIFIED BY		DRAWING NO AAA 93-104167-00
TITLE DATE		SCALE ~240
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT	SHEET 1 OF 1

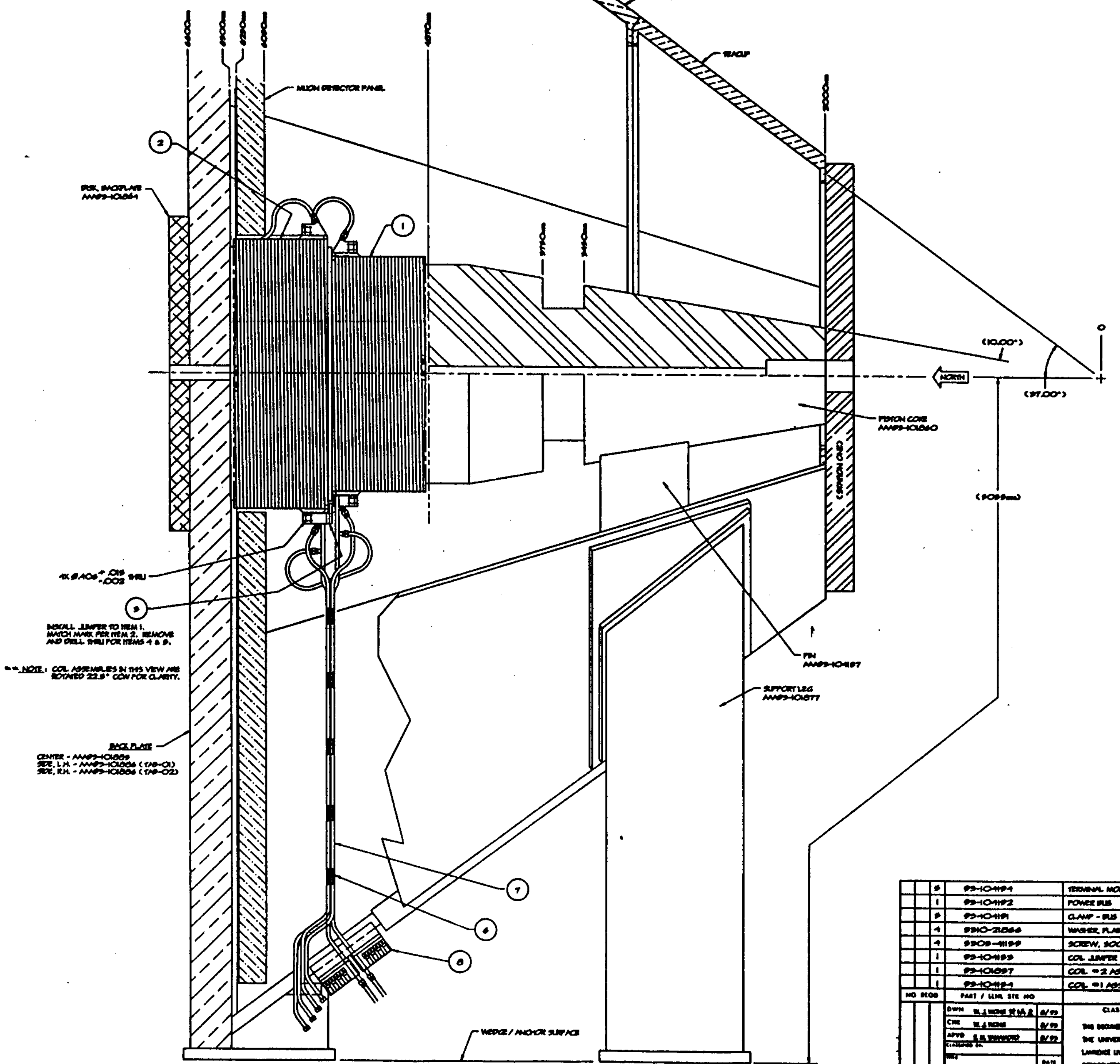
SPEC NO | ITEM | [illegible] 8093-23

PHENIX Muon Magnet - Coil Drawings

Muon Coil Installation	AAA93-104155-00
Coil #1 Assembly	AAA93-104154-00
Coil #2 Assembly	AAA93-101857-00
Coil Transition	AAA93-101856-00
Bus Flag - Inner Lead	AAA93-101899-00
Bus Flag - Outer Lead	AAA93-104152-00
Coil Jumper	AAA93-104153-00
Shorting Pad	AAA93-104150-00
Shorting Block	AAA93-104151-00
Outlet Conductor Fitting	AAA93-101897-00
Inlet Conductor Fitting	AAA93-101898-00

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. LLNL / AutoCAD Release 12 USER FILENAME: 310-1155.DWG



		5	93-104194	TERMINAL MOUNT - BUS		8
		1	93-104192	POWER BUS		7
		5	93-104191	CLAMP - BUS		6
		4	9310-21066	WASHER, PLAIN, FLAT, 3/8 SIZE (CRES)		5
		4	9309-41159	SCREW, SOC. HD CAP, .375-24UNF X1.50"L (CRES)		4
		1	93-104193	COIL JUMPER		3
		1	93-101897	COIL #2 ASSEMBLY		2
		1	93-104194	COIL #1 ASSEMBLY		1
NO	REQD		PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN W. J. NONE 8/93
CHK W. J. NONE 8/93
APVD 8/93

CLASSIFICATION

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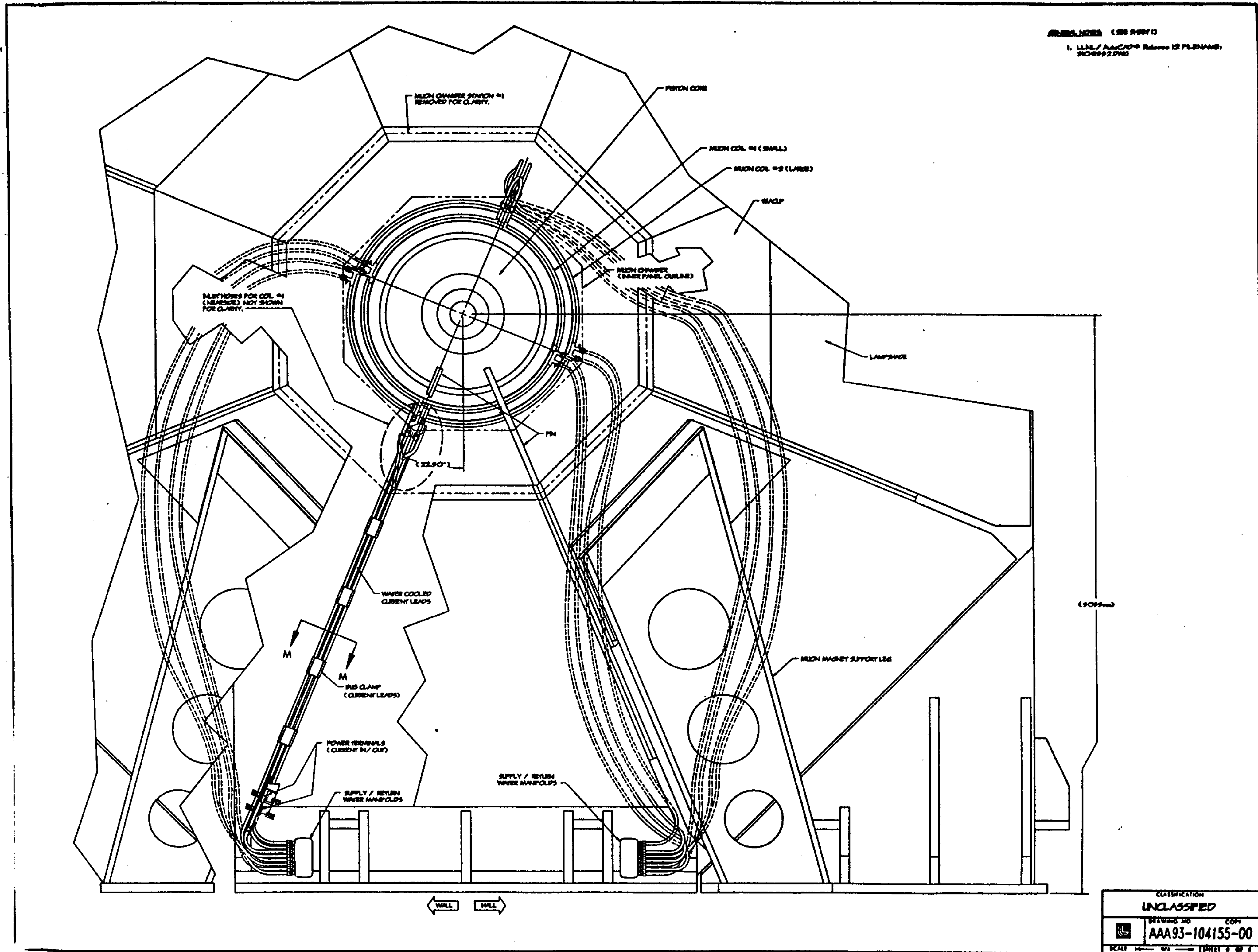
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

PHENIX
MUON MAGNET
MUON COIL INSTALLATION

DRAWING NO AAA93-104155-00

SCALE — SHEET 1 OF 2



MUON CHAMBER STATION #1 REMOVED FOR CLARITY.
PISTON CORE
MUON COIL #1 (SMALL)
MUON COIL #2 (LARGE)
MUON CHAMBER (INNER PANEL OUTLINE)
INLET HOSES FOR COIL #1 (NEARSIDE) NOT SHOWN FOR CLARITY.
LAMPSHADE
PIN
(22.90°)
WATER COOLED CURRENT LEADS
M
M
BUS CLAMP (CURRENT LEADS)
POWER TERMINALS (CURRENT IN/OUT)
SUPPLY / RETURN WATER MANIFOLDS
SUPPLY / RETURN WATER MANIFOLDS
MUON MAGNET SUPPORT LEG
(9099mm)
WALL
HALL
CLASSIFICATION
UNCLASSIFIED
DRAWING NO
COPY
AAA93-104155-00
SCALE
SHEET

FABRICATION NOTES - (#1) SMALL PISTON COIL ASSEMBLY

(IN SEQUENCE AS APPLICABLE)

7. EACH COIL SHALL CONSIST OF TWO CONDUCTORS, BIFILAR WOUND, IN A CYLINDRICAL, DOUBLE LEAD, TWO-LAYER FASHION TO PROVIDE FOUR 12.8 TURN PARALLEL WATER COOLANT PATHS CONNECTED ELECTRICALLY IN SERIES FOR A TOTAL OF 51 TURNS PER COIL ASSEMBLY.

   THE COIL WINDING MANDREL SHALL BE AN INTEGRAL PART OF THE POTTING MOLD UNLESS OTHERWISE APPROVED BY LLNL.

   THE MANUFACTURER SHALL ENSURE THAT THE WINDING MANDREL IS SUITABLE FOR THE WINDING OPERATION AND CAPABLE OF BEING VACUUM SEALED PRIOR TO POTTING. IT SHALL BE CONSTRUCTED TO FACILITATE EASY REMOVAL AFTER THE POTTING OF THE COIL TO ITS FINISHED SIZE.

   A POSITIVE TOLERANCE HAS BEEN PROVIDED (DIMENSIONALLY) TO ALLOW FOR CONDUCTOR AND INSULATION TOLERANCES, CONDUCTOR TWISTS AND MISALIGNMENTS DURING THE WINDING OPERATION. ADDITIONAL SPACE HAS ALSO BEEN ALLOTTED TO RELOCATE TRANSITIONS (ITEMS 5 & 6) AND LEADS TO PASS SUBSEQUENT INTERFERING WINDINGS IN THE OUTER LAYER. THE WINDINGS ARE TO BE DISTRIBUTED ALONG THE ALLOTTED SPACE.

8. INTERLAYER SPACERS AND END SURFACE PROTECTION SHEETS (ITEMS 9 AND 10) SHALL BE RANDOMLY PUNCHED WITH 0.5 IN. DIA. HOLES ON APPROXIMATELY 2 IN. CENTERS TO PERMIT RESIN FLOW THROUGH DURING IMPREGNATION. SURFACES SHALL BE LIGHTLY SANDBLASTED OR OTHERWISE ABRADED TO ENHANCE BONDING. SPACERS AND SHEETS MAY BE SEGMENTED, BUTTED AND TAPED TOGETHER.

9. CLEAN ALL EXTERIOR CONDUCTOR SURFACES AND BRAZE JOINTS OF DIRT, GREASE, OIL, OXIDES, EXCESS BRAZE, ETC. PRIOR TO TAPING AND SLEEVING.

10. THE CONDUCTOR SHALL BE INSULATED BY A LAYER OF 25-45% OVERLAPPED MYLAR TAPE (ITEM 2), FOLLOWED BY THE APPLICATION OF A SLEEVE (ITEM 3). SLEEVE ENDS MAY BE SECURED BY ADHESIVE TAPE OR OTHER MEANS TO PREVENT SLIPPING. SLEEVE JOINTS MAY BE SEWN OR OTHERWISE SECURED TO PREVENT SLEEVE JOINT PARTING. USE A SIMILAR METHOD TO INSULATE COIL TRANSITIONS (ITEMS 5 & 6). IN THE TRANSITION AREA CUSTOM INSULATE TO PROVIDE AN LLNL APPROVED EQUIVALENT PROTECTION. FILL ALL VOID AREAS LARGER THAN .125 INCH WITH SHAPED FIBROUS GLASS MATERIALS (ITEM 11) AS NEEDED.

11. FILL LARGE VOID VOLUMES IN LEAD AREA WITH CONTOURED EPOXY-FIBERGLASS BLOCKS (ITEM 11) FOLLOWED BY GROUND WRAP (ITEM 4) OVERWRAP.

12. CONDUCTOR JOINTS SHALL BE MADE IN ACCORDANCE WITH LBL ENGINEERING NOTE 7959-22-M7C AND CONDUCTOR SPLICE DETAIL (SHEET 4) OR AN LLNL APPROVED EQUAL PROCEDURE.

13. PLACEMENT OF BUS FLAGS (ITEMS 14, 15, 16, 17) SHALL BE DONE WITH ADEQUATE FIXTURING TO COMPLY WITH POSITIONING TOLERANCES SPECIFIED IN DRAWING. BUS FLAGS WILL SUBSEQUENTLY BE SECURED TO, BUT ELECTRICALLY ISOLATED FROM THE VACUUM IMPREGNATION MOLD TO ENSURE THAT THESE TOLERANCES ARE MAINTAINED.

14. APPROXIMATE COIL CONDUCTOR LENGTH IS 880 FEET (269 METERS).

15. LLNL SHALL PROVIDE COIL TEST REPORT FORMS TO DOCUMENT TESTING PERFORMED IN NOTE 16. SEE 'MUON MAGNET COIL SPECIFICATION' (PHENIX-LLNL-95-017).

16. EACH HYDRAULIC CIRCUIT (FOUR PER SMALL END COIL ASSEMBLY) SHALL BE TESTED WITH ALL FITTINGS BOTH BEFORE AND AFTER POTTING. ONE 'COIL TEST REPORT' SHALL BE GENERATED FOR EACH SERIALIZED ASSEMBLY. THE FOLLOWING PROCEDURES SHALL CONSTITUTE ONE COMPLETE TEST ON EACH CIRCUIT:

    A) A DRY NITROGEN PURGE MAY BE USED TO EVAPORATE ANY RESIDUAL MOISTURE WITHIN THE COIL. VACCUM TEST PER ASTM E490-75 WITH A MAXIMUM ALLOWABLE LEAK RATE OF 1 X 10-8 ATM-CC/SECOND OF HELIUM AT 10-5 TORR WITH ALL INTERIOR VOLUME CONNECTED TO A RESIDUAL GAS ANALYZER (RGA) OR A HELIUM MASS SPECTROMETER LEAK DETECTOR. COVER (BAG) THE ENTIRE COIL ASSEMBLY, INCLUDING LEAD FITTINGS IN A HELIUM FILLED ENCLOSURE PRIOR TO THE LEAK TEST. RECORD RESULTS IN 'COIL TEST REPORT'.

    B) PRESSURE TEST WITH WATER IN ACCORDANCE WITH ASME BOILER AND PRESSURE VESSEL CODE SECTION VIII USING THE TEST PRESSURE DEFINED IN NOTE 31. RECORD RESULTS IN 'COIL TEST REPORT'.

    C) WATER FLOW TEST WITH AN INLET PRESSURE OF 80±5 PSIG. EXIT FLOW RATE SHALL BE AT LEAST 8.5 US GALLONS PER MINUTE (GPM). RECORD THE RESULTS IN 'COIL TEST REPORT'.

17. PRIOR TO "ELECTRICALLY" CONNECTING BOTH CONDUCTOR CIRCUITS CONDUCTORS 'A' AND 'B', PERFORM THE FOLLOWING TEST:

    - MEASURE THE COIL RESISTANCE FOR BOTH SEPARATE CIRCUITS AT ROOM TEMPERATURE. RECORD DATA IN 'COIL TEST REPORT'.

18. "ELECTRICALLY" CONNECT BOTH CONDUCTOR CIRCUITS TOGETHER USING THE 'SHORTING BLOCK AND PADS' (ITEMS 20 AND 21). ENCLOSE COIL IN THE MOLD. ENSURE THAT EXPOSED BUS FLAGS, SCREWS AND LEADS ARE "ELECTRICALLY" ISOLATED FROM THE MOLD. PERFORM THE FOLLOWING TEST:

    - MEASURE THE COIL RESISTANCE OF THE CONNECTED COIL AT ROOM TEMPERATURE. RECORD DATA IN 'COIL TEST REPORT'.

(CONT'D)

19. PRIOR TO IMPREGNATION, HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 1500 VOLTS. LEAKAGE NOT TO EXCEED 5 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE AND INDUCTANCE OF THE COIL (AT ROOM TEMPERATURE) IN 'COIL TEST REPORT'.

20. VACUUM IMPREGNATION MOLD SHALL BE OF SUFFICIENT RIGIDITY AND MANUFACTURING TOLERANCES TO MAINTAIN THE COIL DIMENSIONS SPECIFIED. MOLD SHALL BE VACUUM TIGHT UNLESS THE ENTIRE MOLD WILL BE ENCLOSED IN A VACUUM CHAMBER, IN WHICH CASE THE MOLD SHALL BE LIQUID TIGHT.

21. SURFACE COAT ALL AREAS OF VACUUM IMPREGNATION MOLD AND EXPOSED BUS FLAG FACES WITH SUITABLE MOLD RELEASE. COAT THREADED HOLES AND BOLTS WITH SILICONE OR TEFLON GREASE AND PLUG BUS FLAG CLEARANCE AND THREADED HOLES.

22. AFTER SEALING, HEAT AND EVACUATE MOLD FOR 12 HOURS MINIMUM PRIOR TO VACUUM IMPREGNATION TO FULLY RID MOLD OF MOISTURE AND AIR FROM THE PORES OF THE FIBROUS MATERIAL (TAPE, SLEEVE, ETC.). ENSURE THAT SUFFICIENT HEATING IS PRESENT TO FULLY CURE THE RESIN AFTER IMPREGNATION. IF HOT WATER IS USED THROUGH THE CONDUCTOR BORE, AUXILIARY HEATING MAY BE REQUIRED IN AREAS REMOTE FROM THE CONDUCTOR (SUCH AS IN THE TERMINAL AREA).

23. VACUUM IMPREGNATE COIL ASSEMBLY PER UC/LLNL MECHANICAL ENGINEERING SPECIFICATION M20E.

24. AFTER COOL DOWN AND PRIOR TO DEMOLDING, HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 5000 VOLTS. CURRENT LEAKAGE NOT TO EXCEED 2 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE AND INDUCTANCE OF THE COIL AT ROOM TEMPERATURE IN 'COIL TEST REPORT'.

25. AFTER DEMOLDING, REMOVE FLASHING AND SAND SHARP EDGES OF COIL ASSEMBLY. CLEAN BUS FLAG FACES OF MOLD RELEASE AND SILVER PLATE USING A "BRUSH-ON" CHEMICAL SILVER PLATE, SUCH AS 'COOL-AMP'® OR LLNL APPROVED EQUAL. REMOVE PLUGS AND GREASE FROM THREADED AND BOLT ACCESS HOLES. DO NOT FRAY OR BREACH WRAP ON ANY EXTERIOR SURFACE OR EDGE. CHASE AND CLEAN ALL EXCESS PLATING FROM THREADED HOLES.

26. AFTER DEMOLDING, PERFORM THE FOLLOWING ELECTRICAL TESTS:
    A. IMPULSE TEST COIL TO 5000 VOLTS PEAK.
    B. MEASURE COIL RESISTANCE AND TEMPERATURE.
    C. MEASURE COIL INDUCTANCE.
    RECORD DATA IN 'COIL TEST REPORT'.

27. INSTALL THERMOSTATS (ITEM 12) WHERE SHOWN AFTER EPOXY IMPREGNATION HAS BEEN COMPLETED.

28. AFFIX A PERMANENT LABEL ON THE OUTER EDGE OF THE FINISHED SMALL END MUON COIL ASSEMBLY. USE ANY SUITABLE PERMANENT ADHESIVE TO BE APPROVED BY LLNL. IMPRINTED IN 3/8" HIGH CHARACTERS WITH THE FOLLOWING DATA AS SHOWN: (LABEL SIZE - 24"LG X 2"H X .030"THK. MAX)

PRESSURE TEST FOR MANNED AREA	TEST PRESSURE : 150 PSIG
LLNL DWG. AAA93-104154 SMALL MUON #1	TEST DATE : (MO./DAY/YR)
COIL SERIAL NO. : (PER MANUFACTURER)	INSP'D BY : (INSPECTORS' NAME)

DO NOT BREACH FINISHED POTTED ASSEMBLY WITH ANY EXTERNAL FASTENER.

ALSO MARK ON THE SIDE OF THE LEAD AREA NEAR LABEL, "COIL WEIGHT - 2100 LBS. (952 KG)" IN 1.5" HIGH LETTERS USING A PERMANENT INDELIBLE INK. FINAL PROTECTIVE CLEAR COAT OVER INK IS ALLOWABLE.

29. FLUSH ALL COIL PASSAGES OF LOOSE DIRT AND FOREIGN PARTICLES WITH 150°F WATER. BLOW PASSAGES FOR APPROXIMATELY 5 MINUTES WITH LOW PRESSURE DRY NITROGEN. SUFFICIENTLY CAP COIL ENDS FOR TRANSPORTATION. HANDLE FINISHED COIL ASSEMBLY WITH EXTREME CARE. PACKAGE AND CRATE COIL TO PROTECT SURFACES AND LEADS FROM EXTERNAL DAMAGE DURING SHIPPING. SEE 'MUON MAGNET COIL SPECIFICATION' (PHENIX-LLNL-95-017).

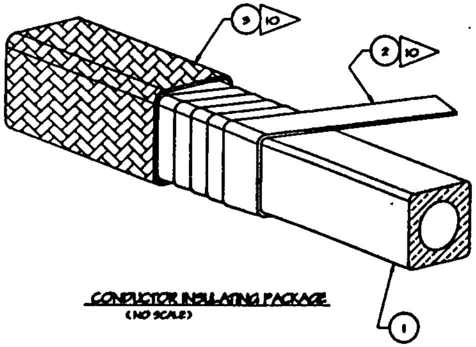
30. APPROXIMATE FINISHED ASSEMBLY WEIGHT - 2100 LBS. (952 KG)

31. THE COIL ASSEMBLY 'MAXIMUM OPERATING PRESSURE' (MOP) SHALL BE 80 PSIG. RELIEF VALVE SETTING DURING NORMAL OPERATION, OR 'MAXIMUM ALLOWABLE WORKING PRESSURE' (MAWP) SHALL BE 100 PSIG. TEST PRESSURE SHALL BE 150 PSIG.

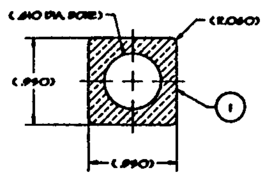
32. THE FOLLOWING DOCUMENTATION SHALL BE DELIVERED WITH THE FINISHED COIL ASSEMBLY.

    A) ALL 'COIL TEST REPORTS'
    B) DIMENSIONAL INSPECTION REPORTS
    C) MATERIAL CERTIFICATIONS FOR ALL COIL, FITTINGS, AND BRAZE FILLER METALS.

33. NO MACHINING ON ANY PORTION OF THE COIL IS PERMISSIBLE AFTER VACUUM IMPREGNATION.



CONDUCTOR INSULATING PACKAGE
(NO SCALE)



CONDUCTOR CROSS-SECTION
(2X SIZE)

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. LLNL/AutoCAD® Release 12 USER FILENAME: 3104154-1.DWG
5. WELD SYMBOLS ARE PER ANSI/AWS A2.4-79.
6. USE EXTREME CARE DURING HANDLING OF FINISHED COIL. CRATE FOR SHIPPING. SEE 'MUON MAGNET COIL SPECIFICATION' (PHENIX-LLNL-95-017).

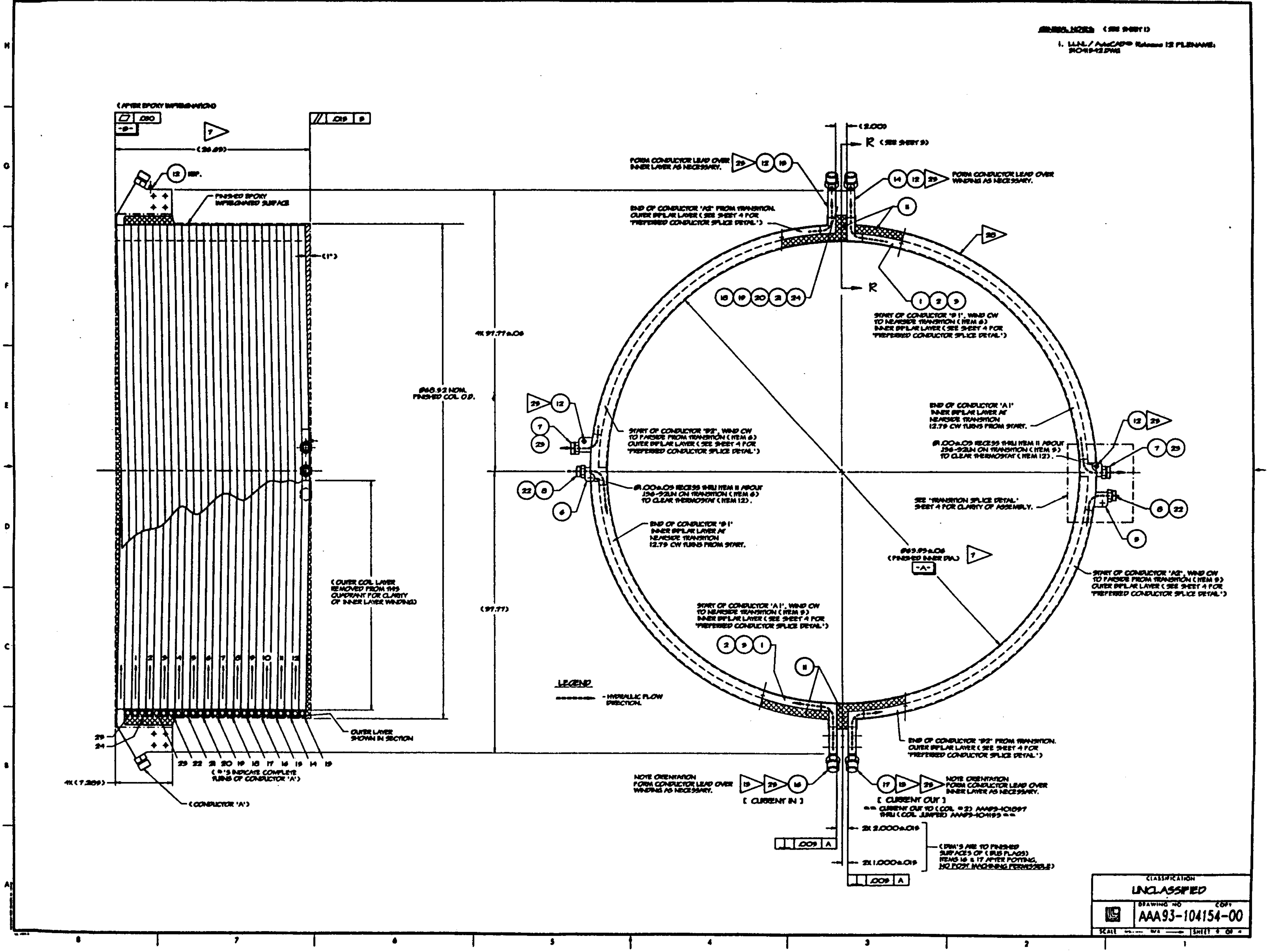
NO REQD	PART / LIST STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
4	9310-21797	NUT, HEX. PLAIN, .375-24UNF (CRES)		24
4		O-RING, PARKER SERIES #2-215, 1-1/16" ID X 1/8"W (VITON)		23
4		O-RING, PARKER SERIES #2-116, 3/4" ID X 3/32"W (VITON)		22
1	93-104191	SHORTING BLOCK		21
2	93-104190	SHORTING PAD		20
8	9310-21866	WASHER, PLAIN, 3/8" SIZE (CRES)		19
4		SCREW, SOC. HD. CAP, .375-24UNF X 4.50"L (CRES)		18
1	93-104192	BUS FLAG - OUTER LEAD (INLET/THREADED) TAB-03		17
1	93-101699	BUS FLAG - INNER LEAD (INLET/THREADED) TAB-02		16
1	93-104192	BUS FLAG - OUTER LEAD (OUTLET/THRU) TAB-01		15
1	93-101699	BUS FLAG - INNER LEAD (OUTLET/THRU) TAB-01		14
AR		TUBE, .750 O.D. X .062"W (OFHC)		13
4		THERMOSTAT, NC, 150°F-165°F, 'ELMON' (tm)		
		P/N 4344-15 (TEXAS INSTRUMENTS)		12
AR		EPOXY-FIBERGLASS SHEET, VARIOUS SIZES, NEMA GRADE	(FR-4/G-10)	11
AR		EPOXY-FIBERGLASS SHEET, .125" THICK, NEMA GRADE	(FR-4/G-10)	10
AR		EPOXY-FIBERGLASS SHEET, .015" THICK, NEMA GRADE	(FR-4/G-10)	9
2	93-101698	INLET CONDUCTOR FITTING		8
2	93-101697	OUTLET CONDUCTOR FITTING		7
1	93-101696	COIL TRANSITION TAB-02		6
1	93-101696	COIL TRANSITION TAB-01		5
AR		TAPE, DACRON CLOTH, 4" WIDE X .012" THK.		4
AR		SLEEVE, DACRON, WOVEN TUBE, 1.25" O.D. X .015"W		3
AR		MYLAR TAPE, .75"W X .0035"THK., ADH. BACKED, 3M®	SCOTCH TYPE 97	2
AR		CONDUCTOR, .990" X .990" X .610" BORE, APPROX.		
		WEIGHT = .3208 LBS/CU. IN. (CDA 101/102 COPPER)		1

DWN W.J.WONG		8/95
CHK W.J.WONG		8/95
APVD R.M.YAMAMOTO		8/95
CLASSIFIED BY		
		DATE

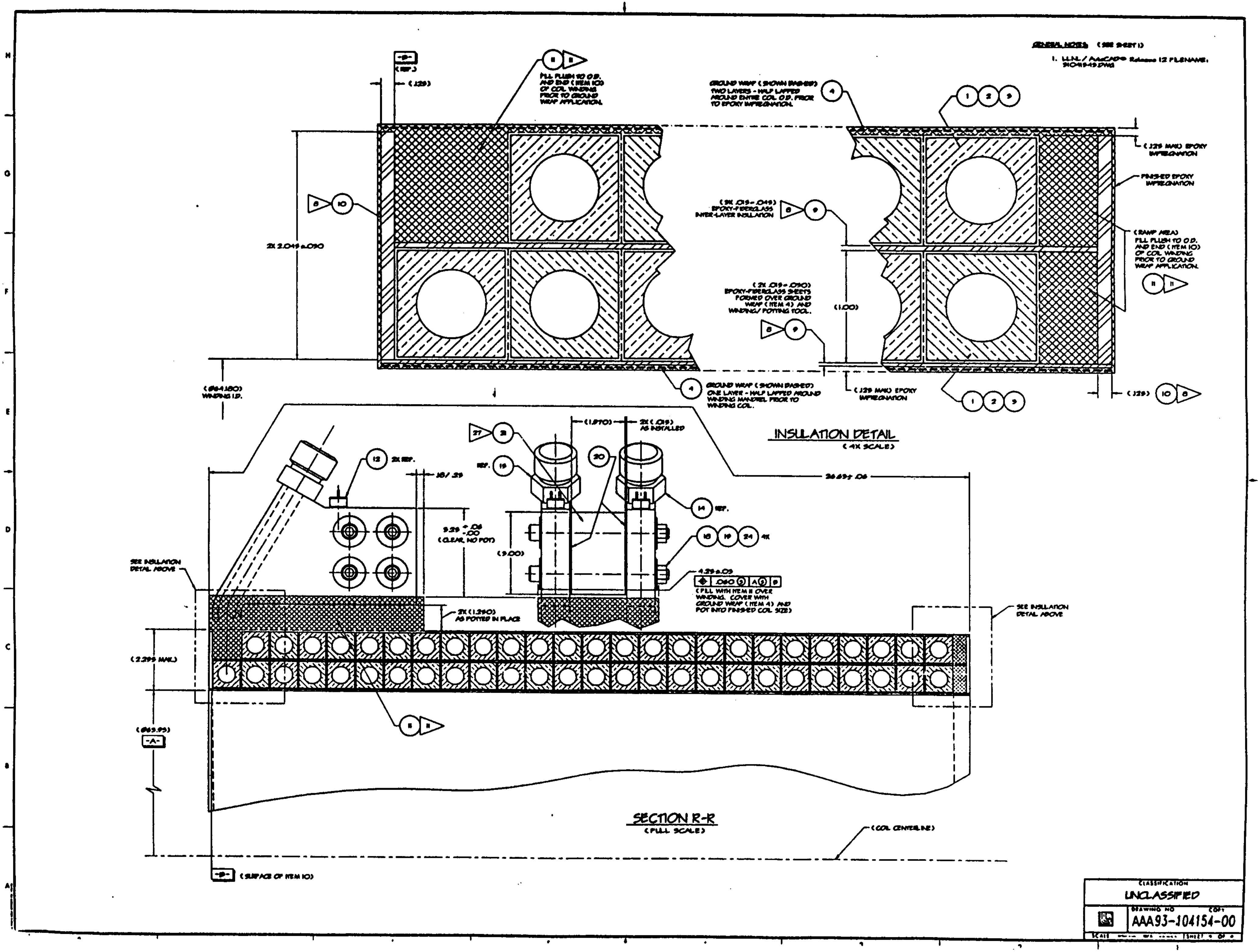
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

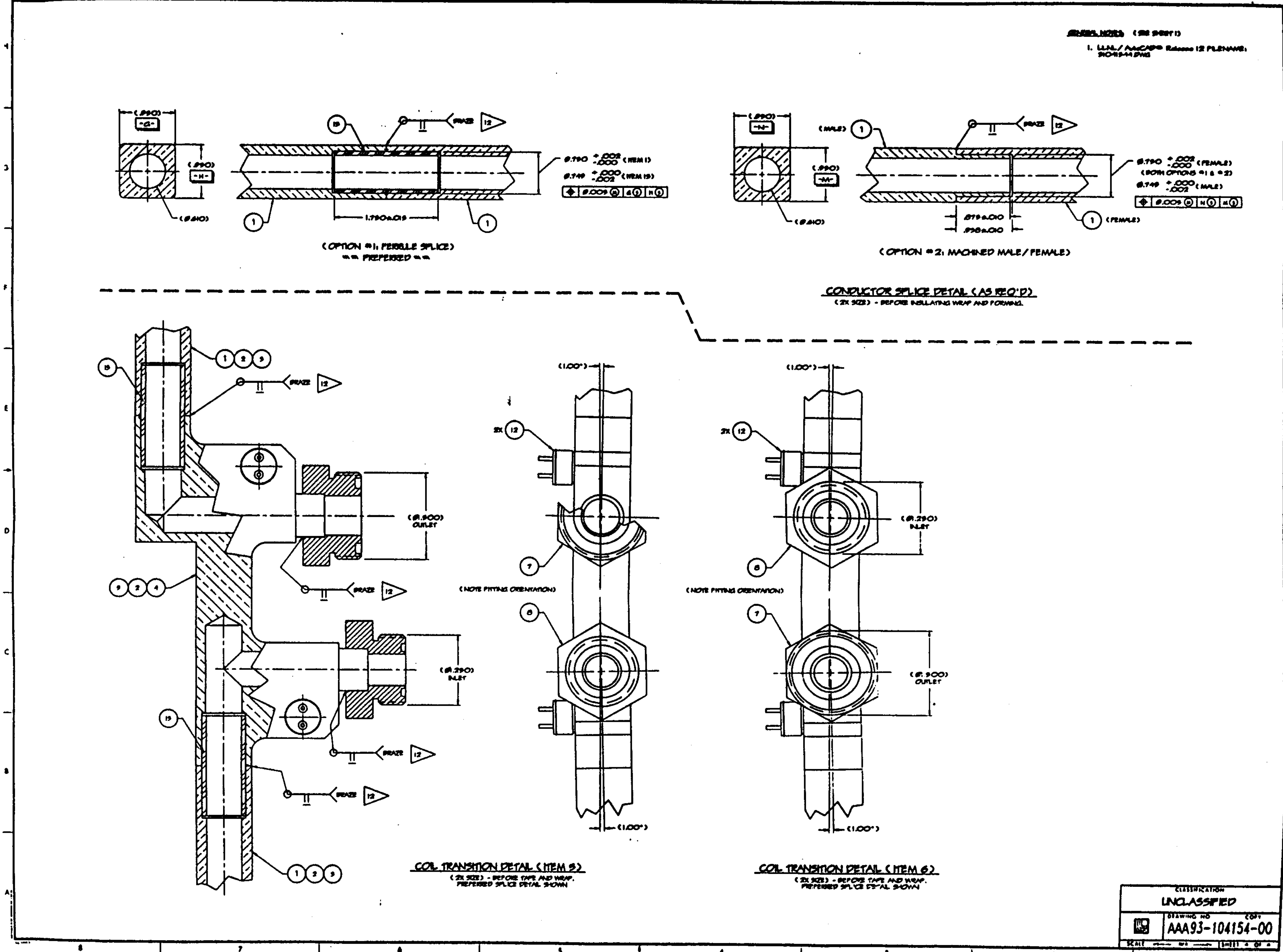
CLASSIFICATION

MAJOR UNIT: PHENIX
SUBASSY: SMALL MUON PISTON COIL
DETAIL: COIL #1 ASSEMBLY
DRAWING NO: AAA93-104154-00
SCALE N/A
SHEET 1 OF 4



LEGEND
- HYDRAULIC FLOW DIRECTION.
(CURRENT IN)
(CURRENT OUT)
(CONDUCTOR 'A')
OUTER LAYER SHOWN IN SECTION
FINISHED EPOXY IMPREGNATED SURFACE
CLASSIFICATION
UNCLASSIFIED
DRAWING NO
COPY
AAA93-104154-00
SCALE
SHEET


GENERAL NOTES: (SEE SHEET 1)
FILL FLUSH TO O.D. AND END (ITEM 10) OF COIL WINDING PRIOR TO GROUND WRAP APPLICATION.
GROUND WRAP (SHOWN DASHED) TWO LAYERS - HALF LAPPED AROUND ENTIRE COIL O.D. PRIOR TO EPOXY IMPREGNATION.
(.129 MAX) EPOXY IMPREGNATION
FINISHED EPOXY IMPREGNATION
2X 2.049 ±.030
(9X .019-.049) EPOXY-FIBERGLASS INTER-LAYER INSULATION
(RAMP AREA) FILL FLUSH TO O.D. AND END (ITEM 10) OF COIL WINDING PRIOR TO GROUND WRAP APPLICATION.
(2X .019-.030) EPOXY-FIBERGLASS SHEETS FORMED OVER GROUND WRAP (ITEM 4) AND WINDING/POTTING TOOL.
(1.00)
(Ø64.180) WINDING I.D.
GROUND WRAP (SHOWN DASHED) ONE LAYER - HALF LAPPED AROUND WINDING MANDREL PRIOR TO WINDING COIL.
(.129 MAX) EPOXY IMPREGNATION
INSULATION DETAIL
(4X SCALE)
AS INSTALLED
(9.00)
(CLEAR, NO POT)
SEE INSULATION DETAIL ABOVE
2X (1.290) AS POTTED IN PLACE
(FILL WITH ITEM 11 OVER WINDING. COVER WITH GROUND WRAP (ITEM 4) AND POT INTO FINISHED COIL SIZE)
(2.295 MAX)
-A-
SECTION R-R
(FULL SCALE)
(COIL CENTERLINE)
(SURFACE OF ITEM 10)
CLASSIFICATION
UNCLASSIFIED
DRAWING NO
AAA93-104154-00



(OPTION #1: FERRULE SPLICE)
** PREFERRED **
(OPTION #2: MACHINED MALE/FEMALE)
CONDUCTOR SPLICE DETAIL (AS REQ'D)
(2X SIZE) - BEFORE INSULATING WRAP AND FORMING
BRAZE
(NOTE FITTING ORIENTATION)
COIL TRANSITION DETAIL (ITEM 5)
(2X SIZE) - BEFORE TAPE AND WRAP. PREFERRED SPLICE DETAIL SHOWN
COIL TRANSITION DETAIL (ITEM 6)
(2X SIZE) - BEFORE TAPE AND WRAP. PREFERRED SPLICE DETAIL SHOWN
CLASSIFICATION
UNCLASSIFIED
DRAWING NO
COPY
AAA93-104154-00
SCALE
SHEET

FABRICATION NOTES - (#2) LARGE PISTON COIL ASSEMBLY

(IN SEQUENCE AS APPLICABLE)

7. EACH COIL SHALL CONSIST OF TWO CONDUCTORS, BIFILAR WOUND, IN A CYLINDRICAL, DOUBLE LEAD, TWO-LAYER FASHION TO PROVIDE FOUR 12.5 TURN PARALLEL WATER COOLANT PATHS CONNECTED ELECTRICALLY IN SERIES FOR A TOTAL OF 50 TURNS PER COIL ASSEMBLY.

THE COIL WINDING MANDREL SHALL BE AN INTEGRAL PART OF THE POTTING MOLD UNLESS OTHERWISE APPROVED BY LLNL.

THE MANUFACTURER SHALL ENSURE THAT THE WINDING MANDREL IS SUITABLE FOR THE WINDING OPERATION AND CAPABLE OF BEING VACUUM SEALED PRIOR TO POTTING. IT SHALL BE CONSTRUCTED TO FACILITATE EASY REMOVAL AFTER THE POTTING OF THE COIL TO ITS FINISHED SIZE.

A POSITIVE TOLERANCE HAS BEEN PROVIDED (DIMENSIONALLY) TO ALLOW FOR CONDUCTOR AND INSULATION TOLERANCES, CONDUCTOR TWISTS AND MISALIGNMENTS DURING THE WINDING OPERATION. ADDITIONAL SPACE HAS ALSO BEEN ALLOTTED TO RELOCATE TRANSITIONS (ITEMS 5 & 6) AND LEADS TO PASS SUBSEQUENT INTERFERING WINDINGS IN THE OUTER LAYER. THE WINDINGS ARE TO BE DISTRIBUTED ALONG THE ALLOTTED SPACE.

8. INTERLAYER SPACERS AND END SURFACE PROTECTION SHEETS (ITEMS 9 AND 10) SHALL BE RANDOMLY PUNCHED WITH 0.5 IN. DIA. HOLES ON APPROXIMATELY 2 IN. CENTERS TO PERMIT RESIN FLOW THROUGH DURING IMPREGNATION. SURFACES SHALL BE LIGHTLY SANDBLASTED OR OTHERWISE ABRADED TO ENHANCE BONDING. SPACERS AND SHEETS MAY BE SEGMENTED, BUTTED AND TAPED TOGETHER.

9. CLEAN ALL EXTERIOR CONDUCTOR SURFACES AND BRAZE JOINTS OF DIRT, GREASE, OIL, OXIDES, EXCESS BRAZE, ETC. PRIOR TO TAPING AND SLEEVING.

10. THE CONDUCTOR SHALL BE INSULATED BY A LAYER OF 25-49 % OVERLAPPED MYLAR TAPE (ITEM 2), FOLLOWED BY THE APPLICATION OF A SLEEVE (ITEM 3). SLEEVE ENDS MAY BE SECURED BY ADHESIVE TAPE OR OTHER MEANS TO PREVENT SLIPPING. SLEEVE JOINTS MAY BE SEWN OR OTHERWISE SECURED TO PREVENT SLEEVE JOINT PARTING. USE A SIMILAR METHOD TO INSULATE COIL TRANSITIONS (ITEMS 5 & 6). IN THE TRANSITION AREA CUSTOM INSULATE TO PROVIDE AN LLNL APPROVED EQUIVALENT PROTECTION. FILL ALL VOID AREAS LARGER THAN .125 INCH WITH SHAPED FIBROUS GLASS MATERIALS (ITEM 11) AS NEEDED.

11. FILL LARGE VOID VOLUMES IN LEAD AREA WITH CONTOURED EPOXY-FIBERGLASS BLOCKS (ITEM 11) FOLLOWED BY GROUND WRAP (ITEM 4) OVERWRAP.

12. CONDUCTOR JOINTS SHALL BE MADE IN ACCORDANCE WITH LLNL ENGINEERING NOTE 7959-22-MTC AND CONDUCTOR SPLICE DETAIL (SHEET 4) OR AN LLNL APPROVED EQUAL PROCEDURE.

13. PLACEMENT OF BUS FLAGS (ITEMS 14, 15, 16, 17) SHALL BE DONE WITH ADEQUATE FIXTURING TO COMPLY WITH POSITIONING TOLERANCES SPECIFIED IN DRAWING. BUS FLAGS WILL SUBSEQUENTLY BE SECURED TO, BUT ELECTRICALLY ISOLATED FROM THE VACUUM IMPREGNATION MOLD TO ENSURE THAT THESE TOLERANCES ARE MAINTAINED.

14. APPROXIMATE COIL CONDUCTOR LENGTH IS 1019 FEET (309 METERS).

15. LLNL SHALL PROVIDE COIL TEST REPORT FORMS TO DOCUMENT TESTING PERFORMED IN NOTE 16. SEE 'MUON MAGNET COIL SPECIFICATION' (PHENIX-LLNL-93-017).

16. EACH HYDRAULIC CIRCUIT (FOUR PER LARGE END COIL ASSEMBLY) SHALL BE TESTED WITH ALL FITTINGS BOTH BEFORE AND AFTER POTTING. ONE 'COIL TEST REPORT' SHALL BE GENERATED FOR EACH SERIALIZED ASSEMBLY. THE FOLLOWING PROCEDURES SHALL CONSTITUTE ONE COMPLETE TEST ON EACH CIRCUIT:

   A) A DRY NITROGEN PURGE MAY BE USED TO EVAPORATE ANY RESIDUAL MOISTURE WITHIN THE COIL. VACUUM TEST PER ASTM E490-73 WITH A MAXIMUM ALLOWABLE LEAK RATE OF 1 X 10-8 ATM-CC/SECOND OF HELIUM AT 10-5 TORR WITH ALL INTERIOR VOLUME CONNECTED TO A RESIDUAL GAS ANALYZER (RGA) OR A HELIUM MASS SPECTROMETER LEAK DETECTOR. COVER (BAG) THE ENTIRE COIL ASSEMBLY, INCLUDING LEAD FITTINGS IN A HELIUM FILLED ENCLOSURE PRIOR TO THE LEAK TEST. RECORD RESULTS IN 'COIL TEST REPORT'.

   B) PRESSURE TEST WITH WATER IN ACCORDANCE WITH ASME BOILER AND PRESSURE VESSEL CODE SECTION VIII USING THE TEST PRESSURE DEFINED IN NOTE 31. RECORD RESULTS IN 'COIL TEST REPORT'.

   C) WATER FLOW TEST WITH AN INLET PRESSURE OF 80±5 PSIG. EXIT FLOW RATE SHALL BE AT LEAST 8.0 US GALLONS PER MINUTE (GPM). RECORD THE RESULTS IN 'COIL TEST REPORT'.

17. PRIOR TO "ELECTRICALLY" CONNECTING BOTH CONDUCTOR CIRCUITS CONDUCTORS 'A' AND 'B', PERFORM THE FOLLOWING TEST:

   - MEASURE THE COIL RESISTANCE FOR BOTH SEPARATE CIRCUITS AT ROOM TEMPERATURE. RECORD DATA IN 'COIL TEST REPORT'.

18. "ELECTRICALLY" CONNECT BOTH CONDUCTOR CIRCUITS TOGETHER USING THE 'SHORTING BLOCK AND PADS' (ITEMS 20 AND 21). ENCLOSE COIL IN THE MOLD. ENSURE THAT EXPOSED BUS FLAGS, SCREWS AND LEADS ARE "ELECTRICALLY" ISOLATED FROM THE MOLD. PERFORM THE FOLLOWING TEST:

   - MEASURE THE COIL RESISTANCE OF THE CONNECTED COIL AT ROOM TEMPERATURE. RECORD DATA IN 'COIL TEST REPORT'.

(CONT'D)

19. PRIOR TO IMPREGNATION, HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 1500 VOLTS. LEAKAGE NOT TO EXCEED 5 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE AND INDUCTANCE OF THE COIL (AT ROOM TEMPERATURE) IN 'COIL TEST REPORT'.

20. VACUUM IMPREGNATION MOLD SHALL BE OF SUFFICIENT RIGIDITY AND MANUFACTURING TOLERANCES TO MAINTAIN THE COIL DIMENSIONS SPECIFIED. MOLD SHALL BE VACUUM TIGHT UNLESS THE ENTIRE MOLD WILL BE ENCLOSED IN A VACUUM CHAMBER, IN WHICH CASE THE MOLD SHALL BE LIQUID TIGHT.

21. SURFACE COAT ALL AREAS OF VACUUM IMPREGNATION MOLD AND EXPOSED BUS FLAG FACES WITH SUITABLE MOLD RELEASE. COAT THREADED HOLES AND BOLTS WITH SILICONE OR TEFLON GREASE AND PLUG BUS FLAG CLEARANCE AND THREADED HOLES.

22. AFTER SEALING, HEAT AND EVACUATE MOLD FOR 12 HOURS MINIMUM PRIOR TO VACUUM IMPREGNATION TO FULLY RID MOLD OF MOISTURE AND AIR FROM THE PORES OF THE FIBROUS MATERIAL (TAPE, SLEEVE, ETC.). ENSURE THAT SUFFICIENT HEATING IS PRESENT TO FULLY CURE THE RESIN AFTER IMPREGNATION. IF HOT WATER IS USED THROUGH THE CONDUCTOR BORE, AUXILIARY HEATING MAY BE REQUIRED IN AREAS REMOTE FROM THE CONDUCTOR (SUCH AS IN THE TERMINAL AREA).

23. VACUUM IMPREGNATE COIL ASSEMBLY PER UC/LLNL MECHANICAL ENGINEERING SPECIFICATION M308.

24. AFTER COOL DOWN AND PRIOR TO DEMOLDING, HI-POT COIL ASSEMBLY TO GROUND (IMPREGNATION MOLD) AT 3000 VOLTS. CURRENT LEAKAGE NOT TO EXCEED 2 MICRO AMPS. MEASURE AND RECORD THE RESISTANCE AND INDUCTANCE OF THE COIL AT ROOM TEMPERATURE IN 'COIL TEST REPORT'.

25. AFTER DEMOLDING, REMOVE FLASHING AND SAND SHARP EDGES OF COIL ASSEMBLY. CLEAN BUS FLAG FACES OF MOLD RELEASE AND SILVER PLATE USING A "BRUSH-ON" CHEMICAL SILVER PLATE, SUCH AS 'COOL-AMP'® OR LLNL APPROVED EQUAL. REMOVE PLUGS AND GREASE FROM THREADED AND BOLT ACCESS HOLES. DO NOT FRAY OR BREACH WRAP ON ANY EXTERIOR SURFACE OR EDGE. CHASE AND CLEAN ALL EXCESS PLATING FROM THREADED HOLES.

26. AFTER DEMOLDING, PERFORM THE FOLLOWING ELECTRICAL TESTS:
   A. IMPULSE TEST COIL TO 5000 VOLTS PEAK.
   B. MEASURE COIL RESISTANCE AND TEMPERATURE.
   C. MEASURE COIL INDUCTANCE.
   RECORD DATA IN 'COIL TEST REPORT'.

27. INSTALL THERMOSTATS (ITEM 12) WHERE SHOWN AFTER EPOXY IMPREGNATION HAS BEEN COMPLETED.

28. AFFIX A PERMANENT LABEL ON THE OUTER EDGE OF THE FINISHED LARGE END MUON COIL ASSEMBLY. USE ANY SUITABLE PERMANENT ADHESIVE TO BE APPROVED BY LLNL. IMPRINTED IN 3/8" HIGH CHARACTERS WITH THE FOLLOWING DATA AS SHOWN: (LABEL SIZE - 24"LG X 2"H X .050"THK. MAX)

PRESSURE TEST FOR MANNED AREA	TEST PRESSURE : 150 PSIG
LLNL DWG. AAA93-101857 LARGE MUON #2	TEST DATE : (MO./DAY/YR)
COIL SERIAL NO. : (PER MANUFACTURER)	INSP'D BY : (INSPECTORS' NAME)

DO NOT BREACH FINISHED POTTED ASSEMBLY WITH ANY EXTERNAL FASTENER.

ALSO MARK ON THE SIDE OF THE LEAD AREA NEAR LABEL, "COIL WEIGHT = 2400 LBS. (1088 KG)" IN 1.5" HIGH LETTERS USING A PERMANENT INDELIBLE INK. FINAL PROTECTIVE CLEAR COAT OVER INK IS ALLOWABLE.

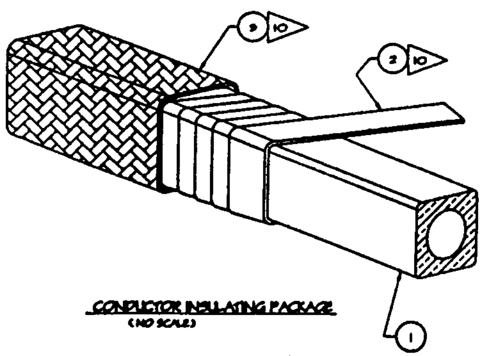
29. FLUSH ALL COIL PASSAGES OF LOOSE DIRT AND FOREIGN PARTICLES WITH 180°F WATER. BLOW PASSAGES FOR APPROXIMATELY 5 MINUTES WITH LOW PRESSURE DRY NITROGEN. SUFFICIENTLY CAP COIL ENDS FOR TRANSPORTATION. HANDLE FINISHED COIL ASSEMBLY WITH EXTREME CARE. PACKAGE AND CRATE COIL TO PROTECT SURFACES AND LEADS FROM EXTERNAL DAMAGE DURING SHIPPING. SEE 'MUON MAGNET COIL SPECIFICATION' (PHENIX-LLNL-93-017).

30. APPROXIMATE FINISHED ASSEMBLY WEIGHT = 2400 LBS. (1088 KG)

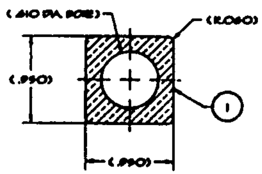
31. THE COIL ASSEMBLY 'MAXIMUM OPERATING PRESSURE' (MOP) SHALL BE 80 PSIG. RELIEF VALVE SETTING DURING NORMAL OPERATION, OR 'MAXIMUM ALLOWABLE WORKING PRESSURE' (MAWP) SHALL BE 100 PSIG. TEST PRESSURE SHALL BE 150 PSIG.

32. THE FOLLOWING DOCUMENTATION SHALL BE DELIVERED WITH THE FINISHED COIL ASSEMBLY.
   A) ALL 'COIL TEST REPORTS'
   B) DIMENSIONAL INSPECTION REPORTS
   C) MATERIAL CERTIFICATIONS FOR ALL COIL, FITTINGS, AND BRAZE FILLER METALS.

33. NO MACHINING ON ANY PORTION OF THE COIL IS PERMISSIBLE AFTER VACUUM IMPREGNATION.



CONDUCTOR INSULATING PACKAGE
(NO SCALE)



CONDUCTOR CROSS-SECTION
(2X SIZE)

NOTES
UNLESS OTHERWISE SPECIFIED:

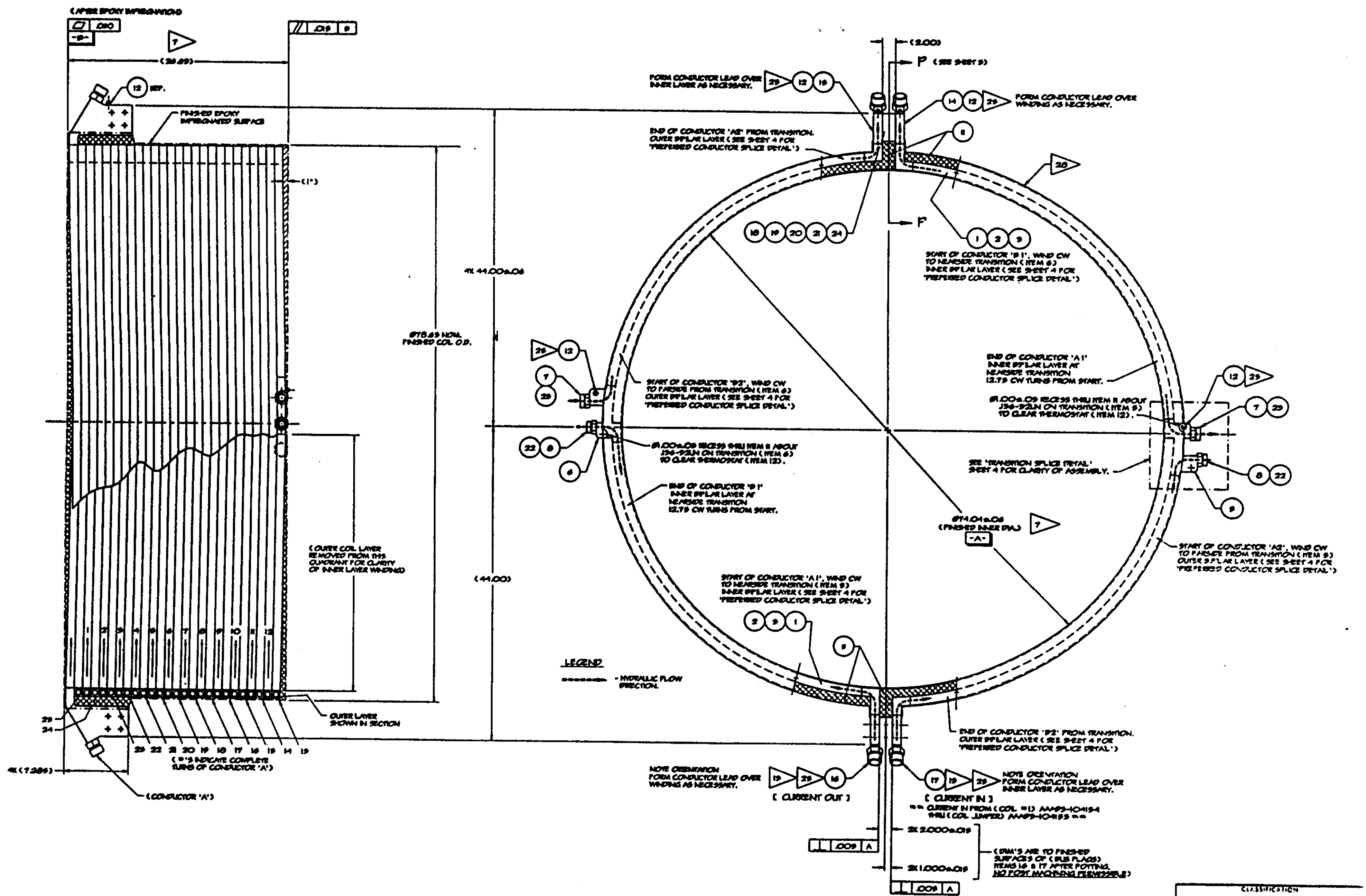
1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. LLNL / AutoCAD® Release 12 USER FILENAME: 3H0109 [illegible].DWG
5. WELD SYMBOLS ARE PER ANSI/ AWS A2.4-76.
6. USE EXTREME CARE DURING HANDLING OF FINISHED COIL. CRATE FOR SHIPPING. SEE 'MUON MAGNET COIL SPECIFICATION' (PHENIX-LLNL-93-017).

NO REQD	PART / LINE SIZE NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
4	9310-21797	NUT, HEX, PLAIN, .375-24UNF (CRES)		24
4		O-RING, PARKER SERIES #2-219, 1-1/16" ID X 1/8"W (VITON)		23
4		O-RING, PARKER SERIES #2-116, 3/4" ID X 3/32"W (VITON)		22
1	93-104191	SHORTING BLOCK		21
2	93-104190	SHORTING PAD		20
8	9310-21066	WASHER, PLAIN, 3/8" SIZE (CRES)		19
4		SCREW, SOC. HD. CAP, .375-24UNF X 4.50"L (CRES)		18
1	93-104192	BUS FLAG - OUTER LEAD (INLET/ THREADED) TAB-03		17
1	93-101099	BUS FLAG - INNER LEAD (INLET/ THREADED) TAB-02		16
1	93-104192	BUS FLAG - OUTER LEAD (OUTLET/ THRU) TAB-01		15
1	93-101099	BUS FLAG - INNER LEAD (OUTLET/ THRU) TAB-01		14
AR		TUBE, .750 O.D. X .062"W (OFHC)		13
4		THERMOSTAT, NC, 150°F-165°F, 'KLIXON' (tm)		
		P/N 4344-15 (TEXAS INSTRUMENTS)		12
AR		EPOXY-FIBERGLASS SHEET, VARIOUS SIZES, NEMA GRADE	(FR-4/ G10)	11
AR		EPOXY-FIBERGLASS SHEET, .125" THICK, NEMA GRADE	(FR-4/ G10)	10
AR		EPOXY-FIBERGLASS SHEET, .015" THICK, NEMA GRADE	(FR-4/ G10)	9
2	93-101098	INLET CONDUCTOR FITTING		8
2	93-101097	OUTLET CONDUCTOR FITTING		7
1	93-101096	COIL TRANSITION TAB-02		6
1	93-101096	COIL TRANSITION TAB-01		5
AR		TAPE, DACRON CLOTH, 4" WIDE X .012" THK.		4
AR		SLEEVE, DACRON, WOVEN TUBE, 1.25" O.D. X .015"W		3
AR		MYLAR TAPE, .75"W X .0035"THK., ADH. BACKED, 3M®	SCOTCH TYPE 57	2
AR		CONDUCTOR, .950" X .950" X .410" BORE, APPROX.		
		WEIGHT = .3908 LBS/ CU. IN. (CDA 101/ 102 COPPER)		1

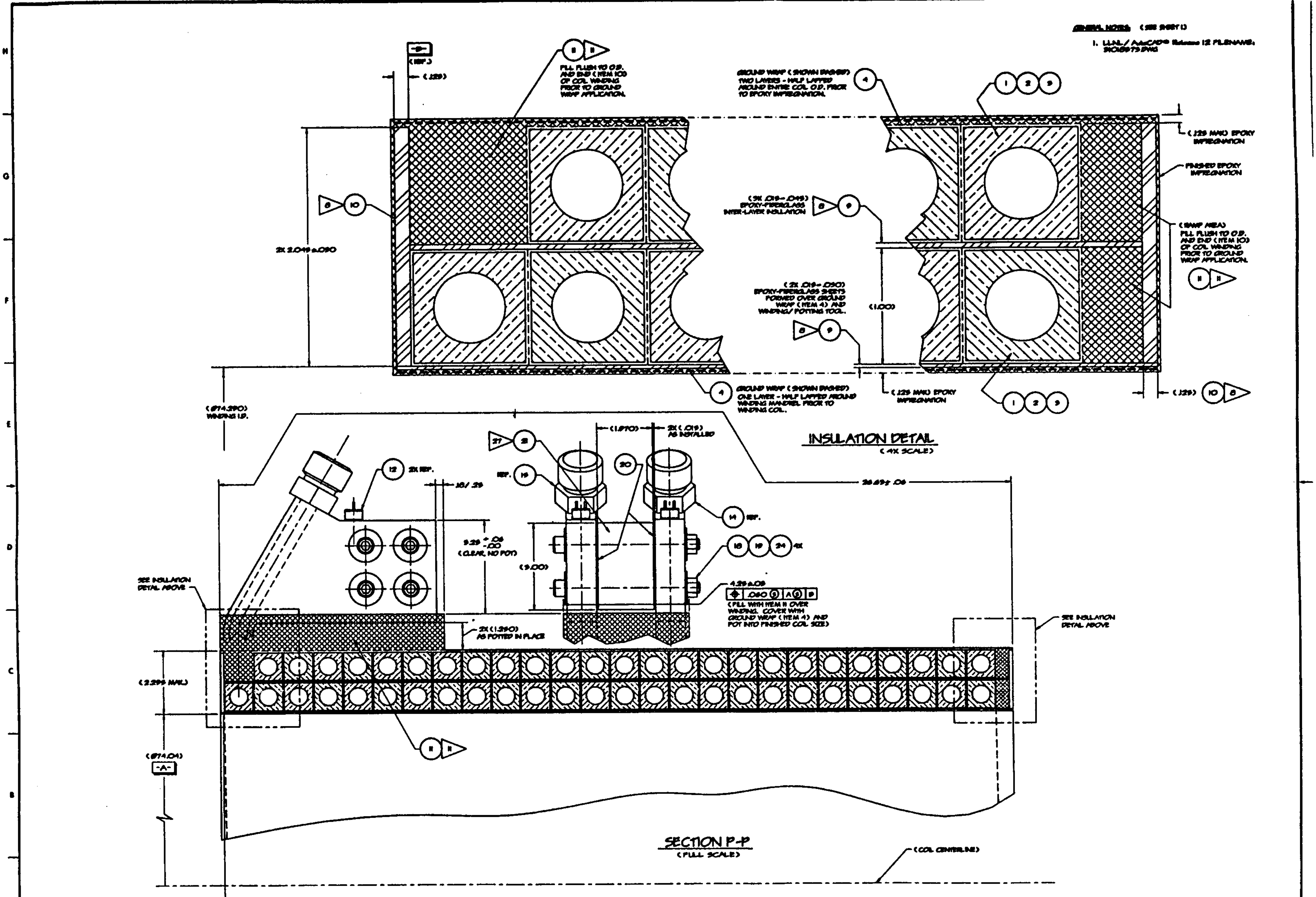
DWN W. J. WONG	7/93	CLASSIFICATION	MAJOR UNIT: PHENIX
CHK W. J. WONG	7/93	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE NATIONAL LAB. REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	ASSEMBLY: LARGE MUON PISTON COIL
APVD E. M. [illegible]	7/93		DETAIL: COIL #2 ASSEMBLY
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA			DRAWING NO AAA93-101857-00
			SCALE N/A SHEET 1 OF 6

GENERAL NOTES: (SEE SHEET 1)

1. LLNL / AutoCAD® Release 12 FILENAME:



CLASSIFICATION
UNCLASSIFIED
DRAWING NO AAA93-101857-00



CLASSIFICATION
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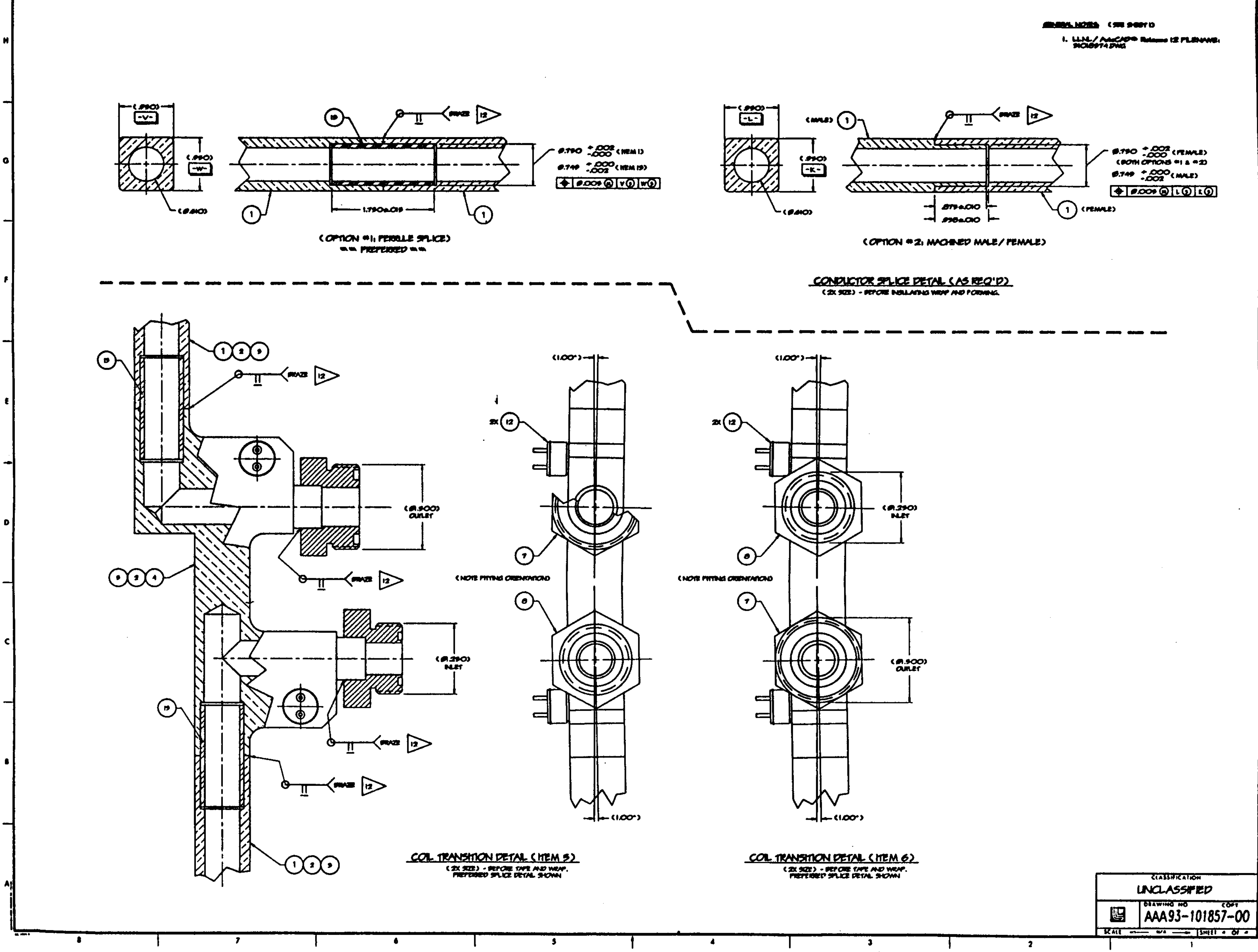
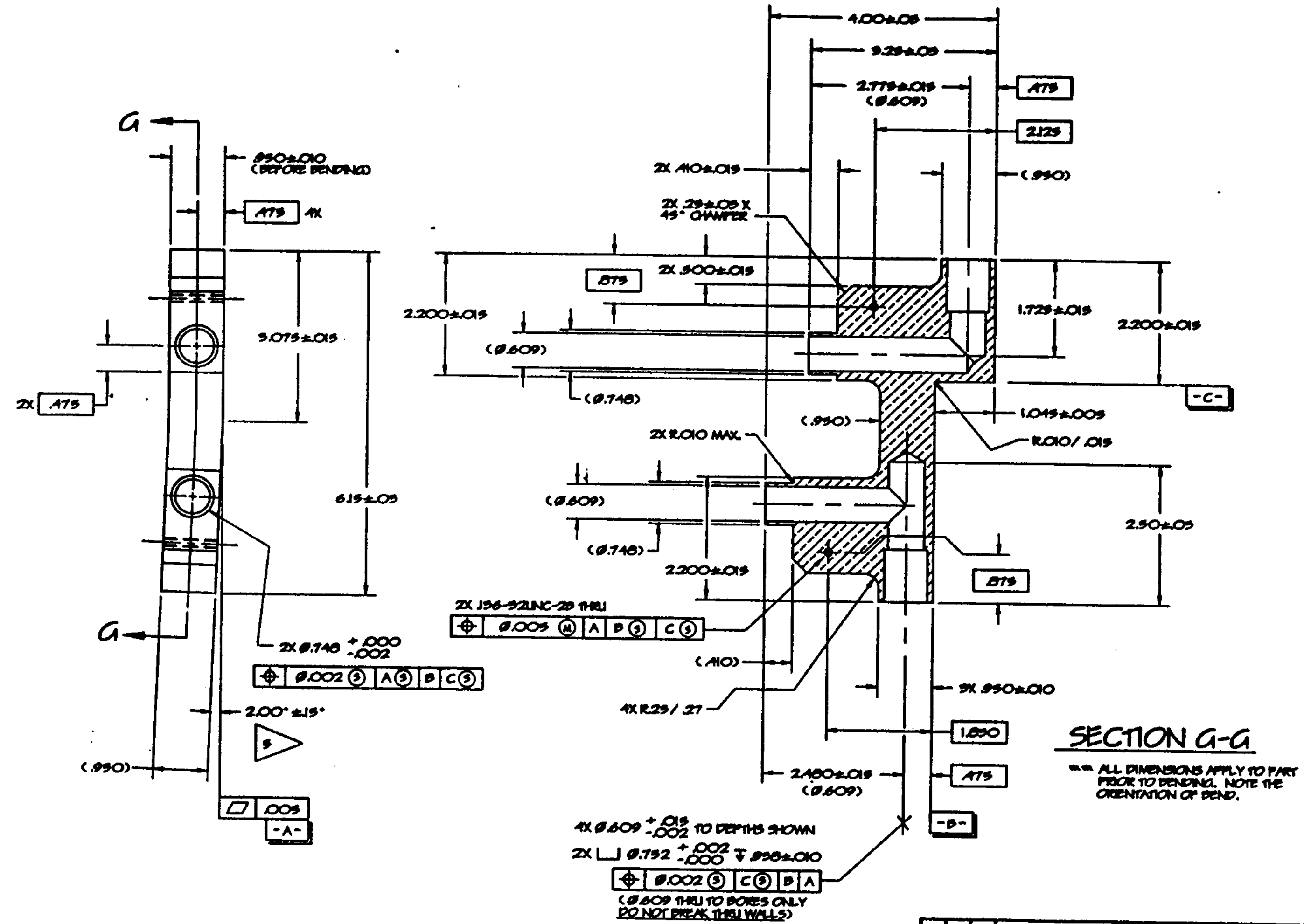
DRAWING NO
AAA93-101857-00


1. LLNL/AutoCAD® Release 12 FILENAME:
(OPTION #1: FERRULE SPLICE)
** PREFERRED **
(OPTION #2: MACHINED MALE/FEMALE)
CONDUCTOR SPLICE DETAIL (AS REQ'D)
(2X SIZE) - BEFORE INSULATING WRAP AND FORMING.
BRAZE
(MALE)
(FEMALE)
(BOTH OPTIONS #1 & #2)
OUTLET
INLET
(NOTE FITTING ORIENTATION)
(1.00")
COIL TRANSITION DETAIL (ITEM 5)
(2X SIZE) - BEFORE TAPE AND WRAP.
PREFERRED SPLICE DETAIL SHOWN
COIL TRANSITION DETAIL (ITEM 6)
(2X SIZE) - BEFORE TAPE AND WRAP.
PREFERRED SPLICE DETAIL SHOWN
CLASSIFICATION
UNCLASSIFIED
DRAWING NO
COPY
AAA93-101857-00
SCALE
SHEET



SECTION G-G

ALL DIMENSIONS APPLY TO PART PRIOR TO BENDING. NOTE THE ORIENTATION OF BEND.

4X Ø.609 +.015 -.002 TO DEPTHS SHOWN

2X ⌴ Ø.752 +.002 -.000 ↧ .938±.010

Ø.002 Ⓢ | C Ⓢ | B | A

(Ø.609 THRU TO BORES ONLY DO NOT BREAK THRU WALLS)

NOTES

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
3. √ FINISH ALL MACHINED SURFACES.
4. LLNL/AutoCAD® REL. 12 FILENAME: 3101856-1.DWG
5. ▷ PART SHALL BE BENT TO ANGLE SHOWN.
6. BAG AND TAG WITH LLNL DWG.
7. REMOVE BURRS AND BREAK SHARP EDGES .005/.010 IN. MAX.
8. FINISHED PART TO BE CLEAN AND FREE OF ALL GREASE, OIL, DIRT, ETC.

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
		BAR OR PLATE, CDA 101/102 (COPPER)		

DWN	W. J. WONG	4/93
CHK	W. J. WONG	4/93
APVD	R. M. YAMAMOTO	4/93
CLASSIFIED BY.		
TITLE		DATE

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

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MAJOR UNIT: PHENIX

SUBASSY: MUON PISTON COIL

DETAIL: COIL TRANSITION

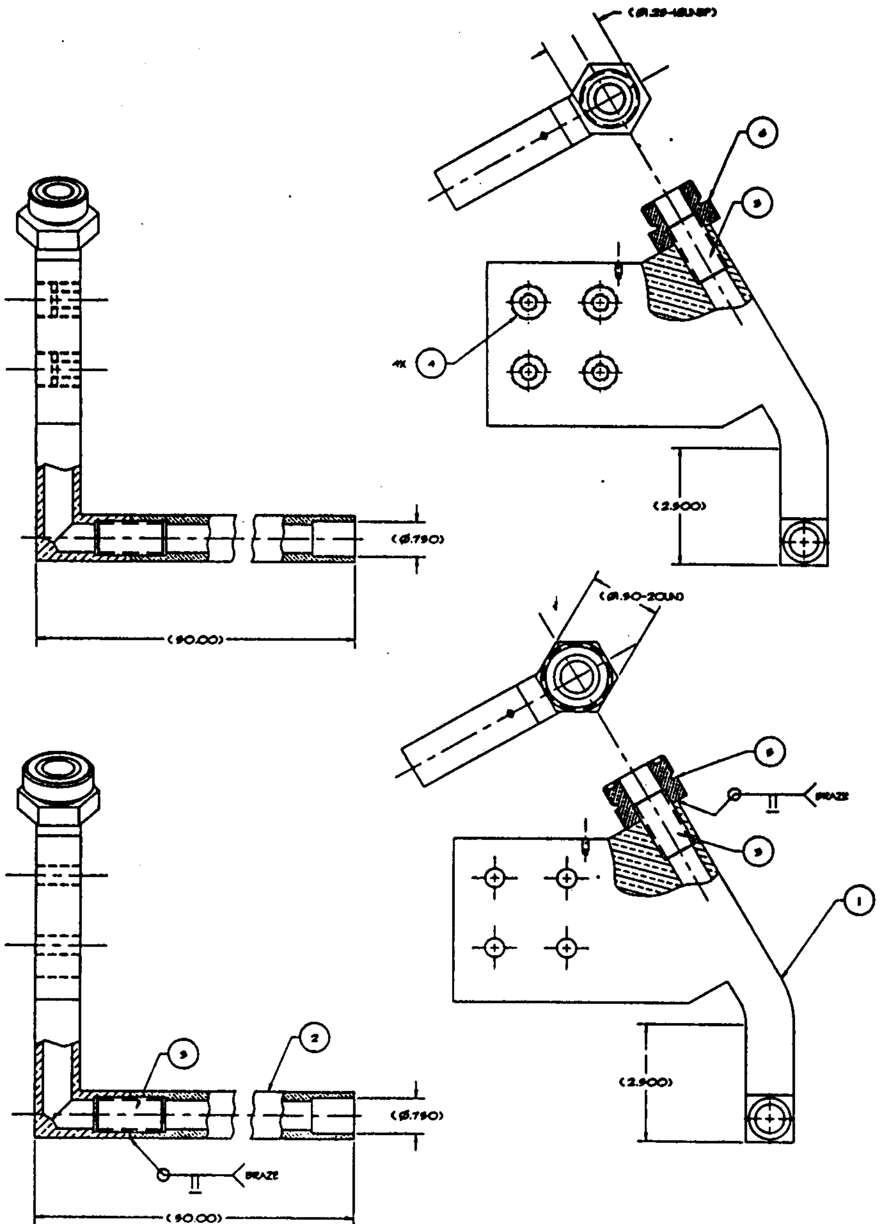
DRAWING NO: AAA 93-101856-00

SCALE 2.00" | SHEET 1 OF 1

LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. LLNL/ AutoCAD® Release 12 USER FILENAME: [illegible].DWG
5. WELD SYMBOLS ARE PER ANSI/ AWS A2.4-76.
6. USE CARE DURING HANDLING OF FINISHED PARTS DURING MACHINING AND BRAZING.
7. SEE SHEET 2 FOR PART DETAILS.
8. FINISHED PART SHOWN ON:
AAA93-101897
AAA93-101194



TAB-02 - INNER FLAG (INLET/ THREADED)

TAB-01 - INNER FLAG (OUTLET/ THRU)

TAB NO.	DESCRIPTION
TAB-01	INNER FLAG (OUTLET/ THRU)
TAB-02	INNER FLAG (INLET/ THREADED)

NO REQD			PART / IDENT STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
	1		93-101898	INLET CONDUCTOR FITTING		6
		1	93-101897	OUTLET CONDUCTOR FITTING		5
	4			INSERT, FLOATING, .375-24UNF-3B, EXT THD .750-16UN		
				P/N KNKP(L)624J, TRIDAIR KEENSERTS (tm) (SST.)		4
	2	2		TUBE, Ø.750 OD X .062"W X 136"L (CDA 101/102 COPPER)		3
	1	1		CONDUCTOR, .950" X .950" X .410" BORE, APPROX.		
				WEIGHT - .3906 LBS/ CU. IN. (CDA 101/102 COPPER)		2
	1	1		BAR OR PLATE, (CDA 101/102 COPPER)		1
	TAB-02	TAB-01				

DWN W. J. WONG 7/93
CHK W. J. WONG 7/93
APVD E. M. WAMMOTO 7/93

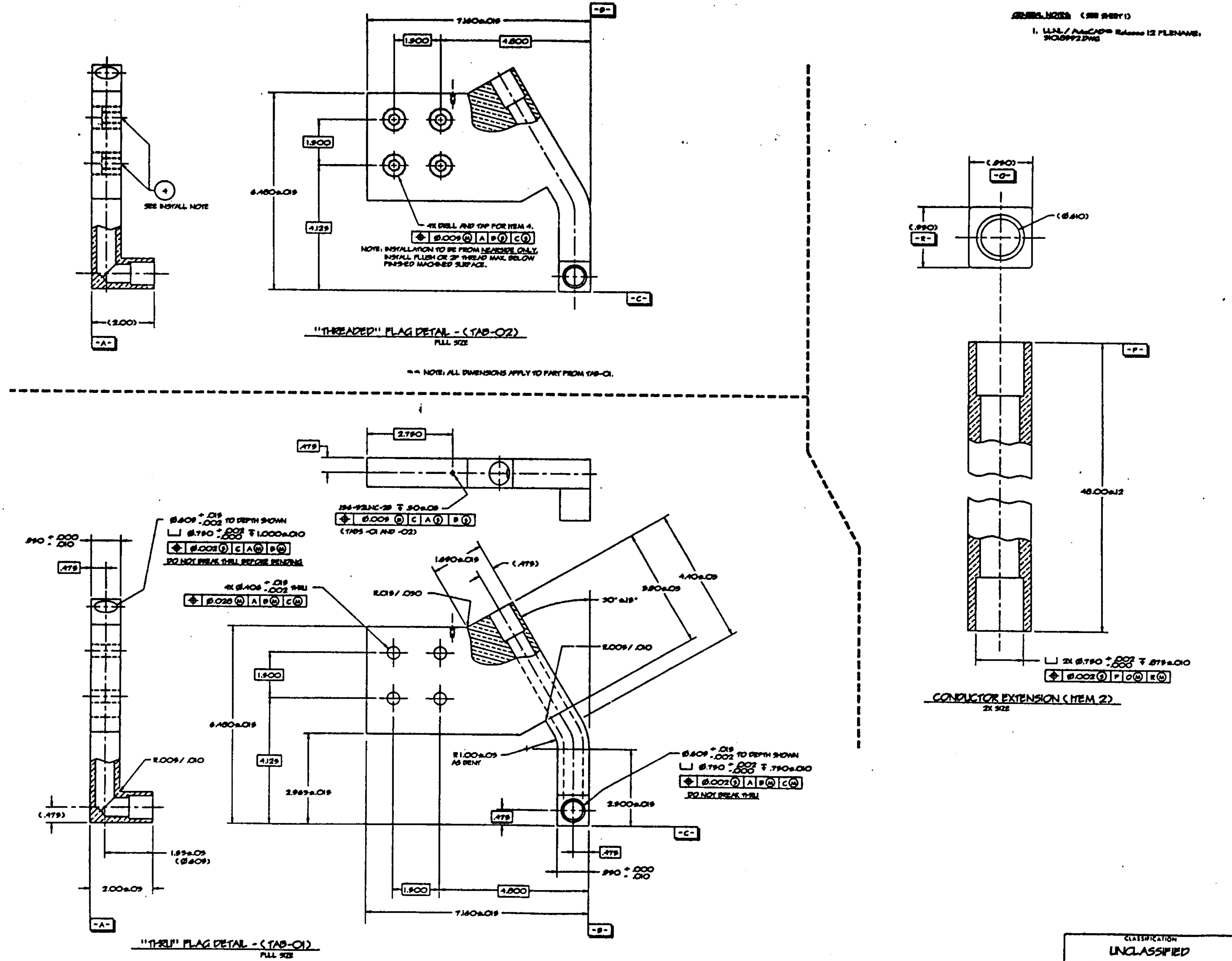
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

MAJOR UNIT: PHENIX
SUBASSY: LARGE MUON PISTON COIL
DETAIL: BUS FLAG - INNER LEAD

DRAWING NO: AAA93-101899-00

SCALE [illegible] SHEET 1 OF 2



CLASSIFICATION

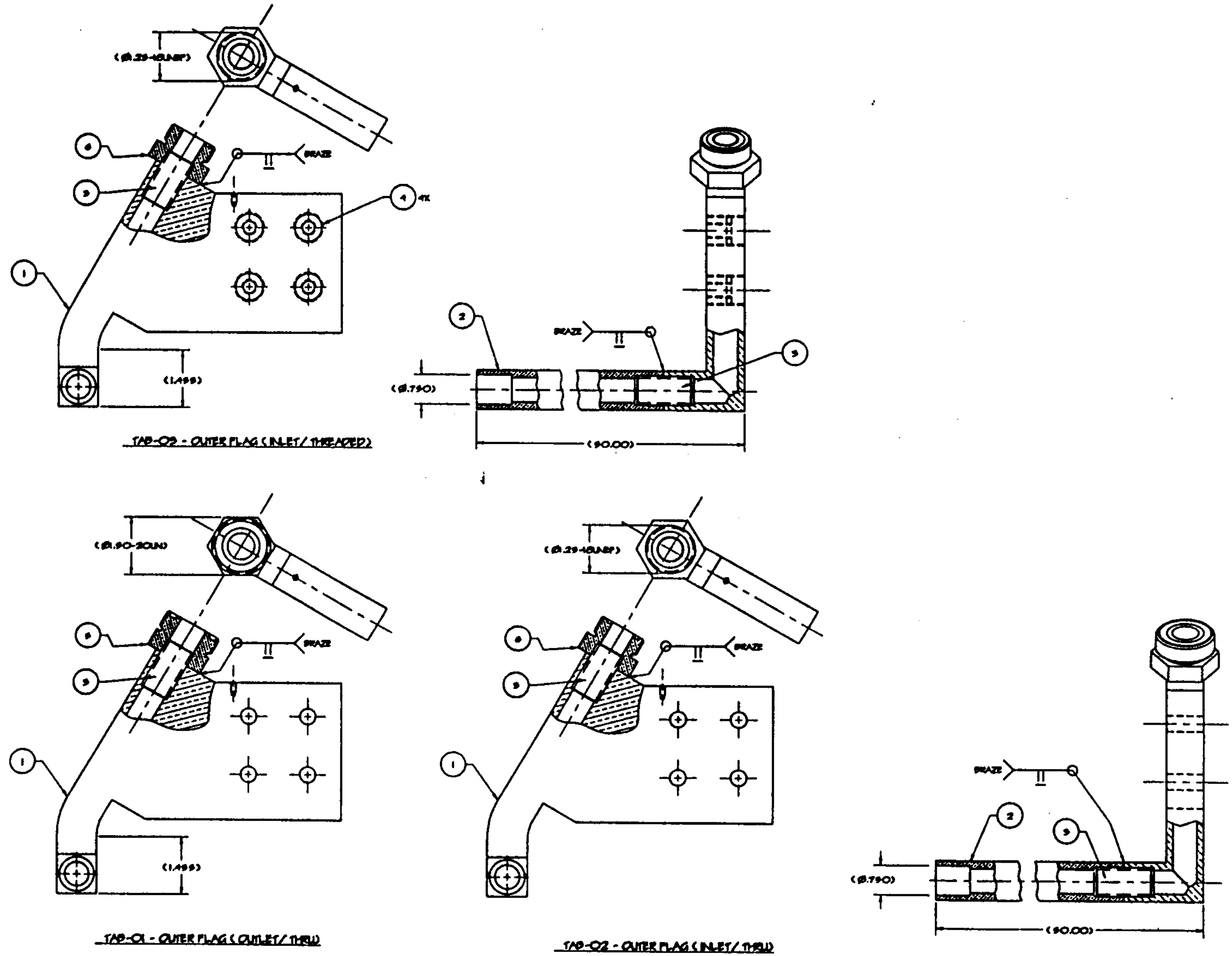
UNCLASSIFIED

DRAWING NO | COPY

AAA93-101899-00

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. LLNL/AutoCAD® Release 12 USER FILENAME: 3104152I.DWG
5. WELD SYMBOLS ARE PER ANSI/AWS A2.4-76.
6. USE CARE DURING HANDLING OF FINISHED PARTS DURING MACHINING AND BRAZING.
7. SEE SHEET 2 FOR PART DETAILS.
8. FINISHED PART SHOWN ON:
   AAA93-101097
   AAA93-104154



TAB NO.	DESCRIPTION
TAB-01	OUTER FLAG (OUTLET/THRU)
TAB-02	OUTER FLAG (INLET/THRU)
TAB-03	OUTER FLAG (INLET/THREADED)

NO REQD			PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
1	1		93-101098	INLET CONDUCTOR FITTING		6
		1	93-101097	OUTLET CONDUCTOR FITTING		5
4				INSERT, FLOATING, .375-24UNF-3B, EXT THD .750-16UN		
				P/N KNK(L)624J, TRIDAIR KEENSERTS (vm) (55L)		4
2	2	2		TUBE, Ø.750 OD X .062"W X 1.50"L (CDA 101/102 COPPER)		3
1	1	1		CONDUCTOR, .950" X .950" X .410" BORE, APPROX.		
				WEIGHT = .3208 LBS/CU. IN. (CDA 101/102 COPPER)		2
1	1	1		BAR OR PLATE. (CDA 101/102 COPPER)		1
TAB-03	TAB-02	TAB-01				

DWN	W. J. HONG 7/93
CHK	W. J. HONG 7/93
APVD	R. M. YAMAMOTO 7/93
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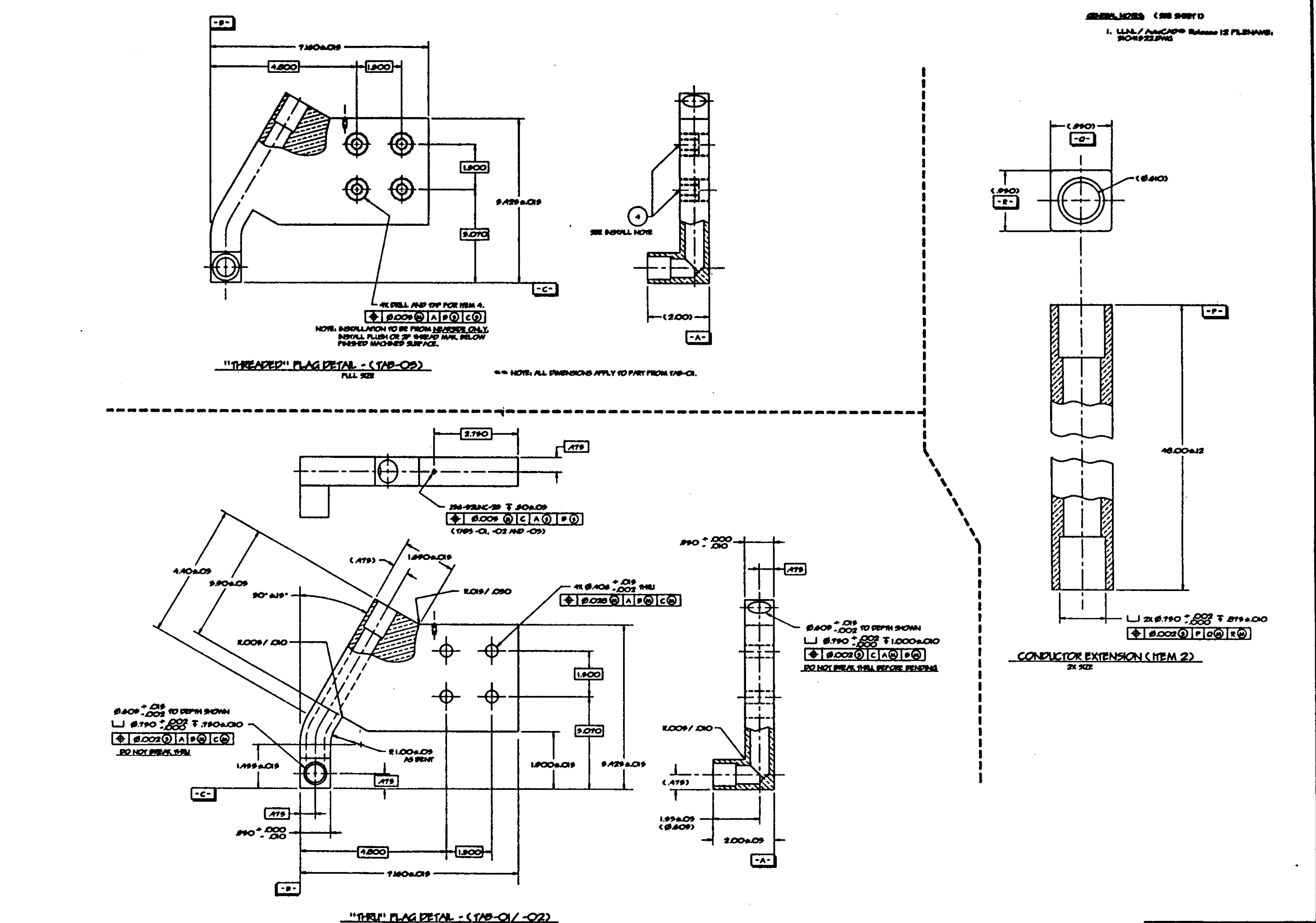
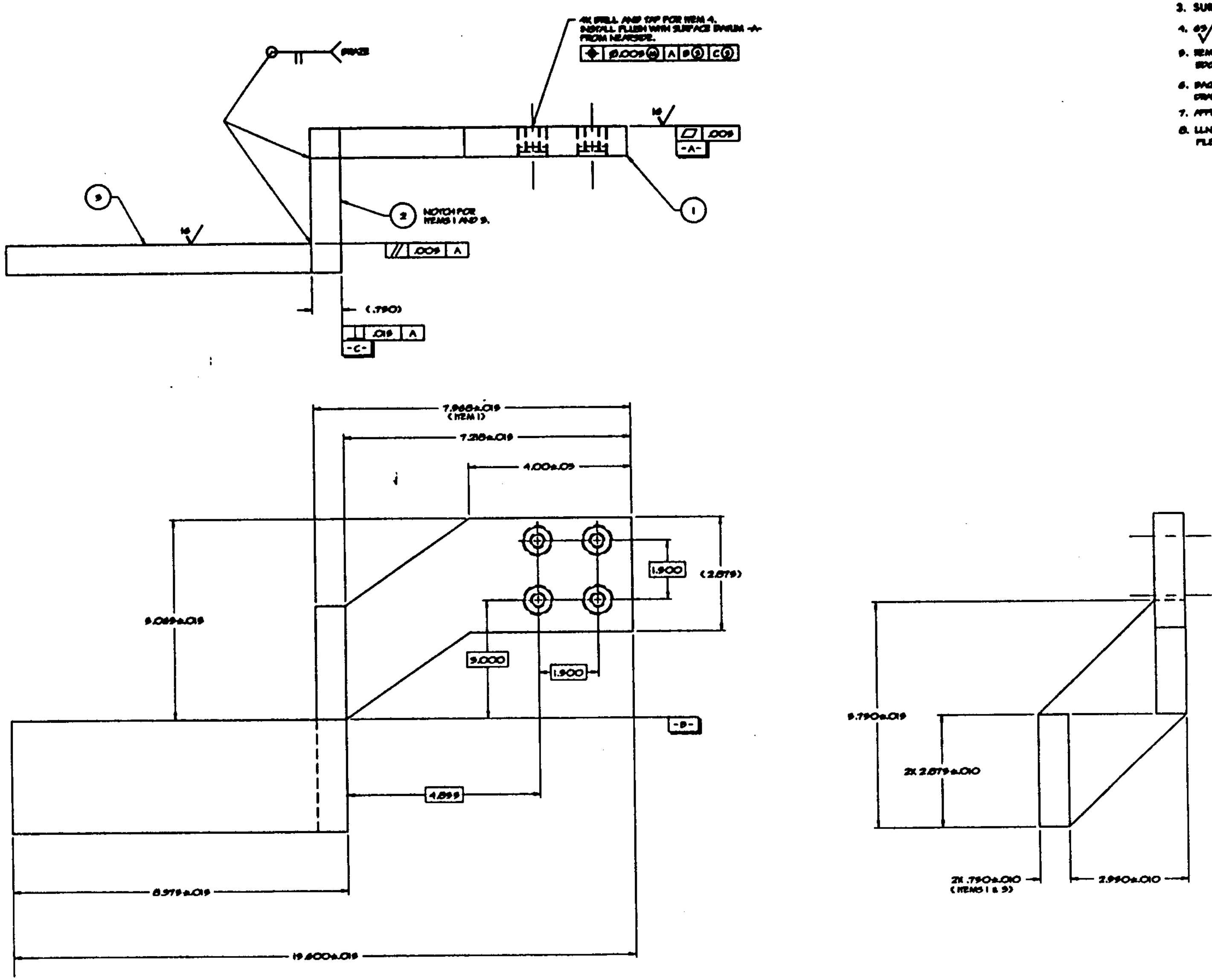
MAJOR UNIT	PHENIX
SUBASSY	LARGE MUON PISTON COIL
DETAIL	BUS FLAG - OUTER LEAD
DRAWING NO	AAA93-104152-00
SCALE	2.00
SHEET	1 OF 2

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA



CLASSIFICATION
UNCLASSIFIED

DRAWING NO AAA93-104152-00 COPY



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 63/ FINISH ALL MACHINED SURFACES.
5. REMOVE BURRS AND BREAK SHARP EDGES .005/.010.
6. BAG AND TAG FINISHED PART WITH LLNL DRAWING NUMBER.
7. APPROX. WEIGHT = 13.22 LBS.
8. LLNL / AutoCAD (tm) Release 12 USER FILENAME: 9104153.DWG

NO REQD			PART / IDENT NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM
		4		INSERT, FLOATING, .375-24UNF-3B, EXT THD .750-16UN			
				P/N KNCK(L) 624J, TRIDAIR KEENSERTS (tm)	(99TL)		4
		1		BAR OR PLATE	CDA 101 / 102 (COPPER)		3
		1		BAR OR PLATE, .750" THICK	CDA 101 / 102 (COPPER)		2
		1		BAR OR PLATE	CDA 101 / 102 (COPPER)		1

DWN W. J. WONG 7/99
CHK W. J. WONG 7/99
APVD E. M. WAKAMOTO 7/99
CLASSIFIED BY
TITLE DATE

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UNIVERSITY OF CALIFORNIA

CLASSIFICATION
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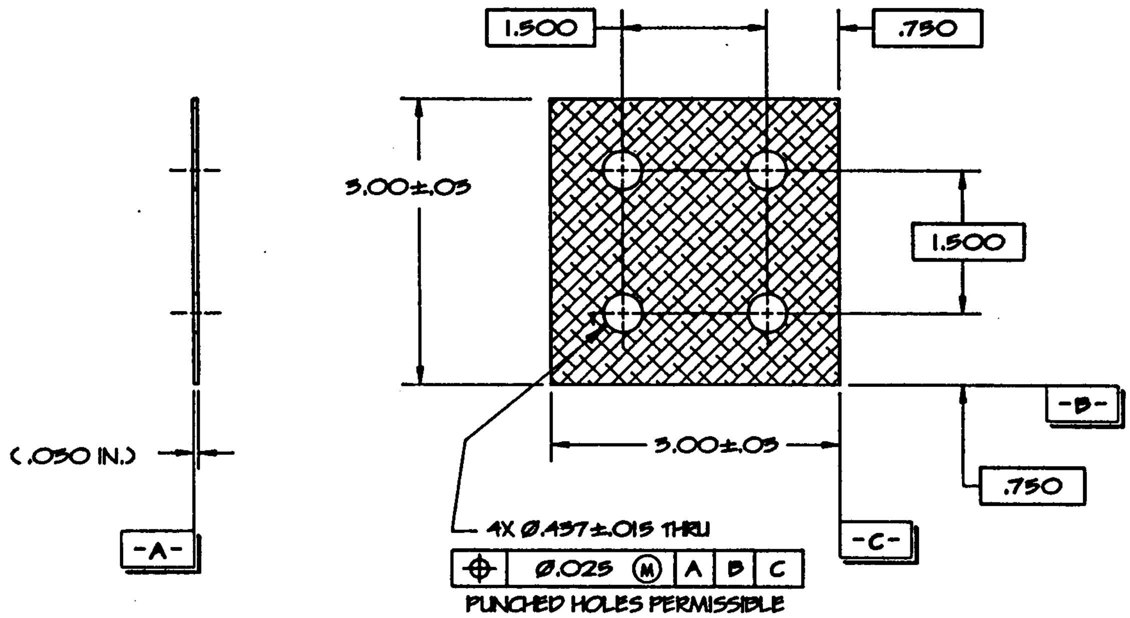
MAJOR UNIT: PHENIX
SUBASSY: MUON PISTON COIL
DETAIL: COIL JUMPER
DRAWING NO: AAA93-104153-00
SCALE .500 SHEET 1 OF 1

NOTES
UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. DIMENSIONS ARE IN INCHES.
4. STOCK FINISH ALL OVER.
5. ALL DIMENSIONS APPLY TO PART IN AN UNRESTRAINED CONDITION.
6. SUGGESTED VENDOR:
   HI TECHMETAL GROUP
   1101 EAST 55th STREET
   CLEVELAND, OHIO 44105
   PH: (216) 881-8100
7. FINISHED PART TO BE CLEAN AND FREE OF OIL, GREASE, DIRT, ETC..
8. BAG AND TAG WITH LLNL DWG. NO.
9. LLNL AutoCAD(tm) Release 12 USER FILENAME: 31041501.DWG
10. CAUTION: DO NOT CRUSH MATERIAL DURING FABRICATION OR HANDLING PROCESSES.



NO REQD		PART/LLNL STK NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
			6 FOAMETAL (tm), .030" THICK, .008"-.012" FILAMENT DIA., 37-42 CELLS/IN., .022"-.026" PORE DIA., PORE TYPE 30 (COPPER)		

DWN	WJWONG 黄偉星	7/95
CHK	WJWONG	7/95
APVD	RMYAMAMOTO	7/95
CLASSIFIED BY:		
TITLE		DATE

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CLASSIFICATION

MAJOR UNIT: PHENIX
SUBASSY: MUON PISTON COIL
DETAIL: SHORTING PAD

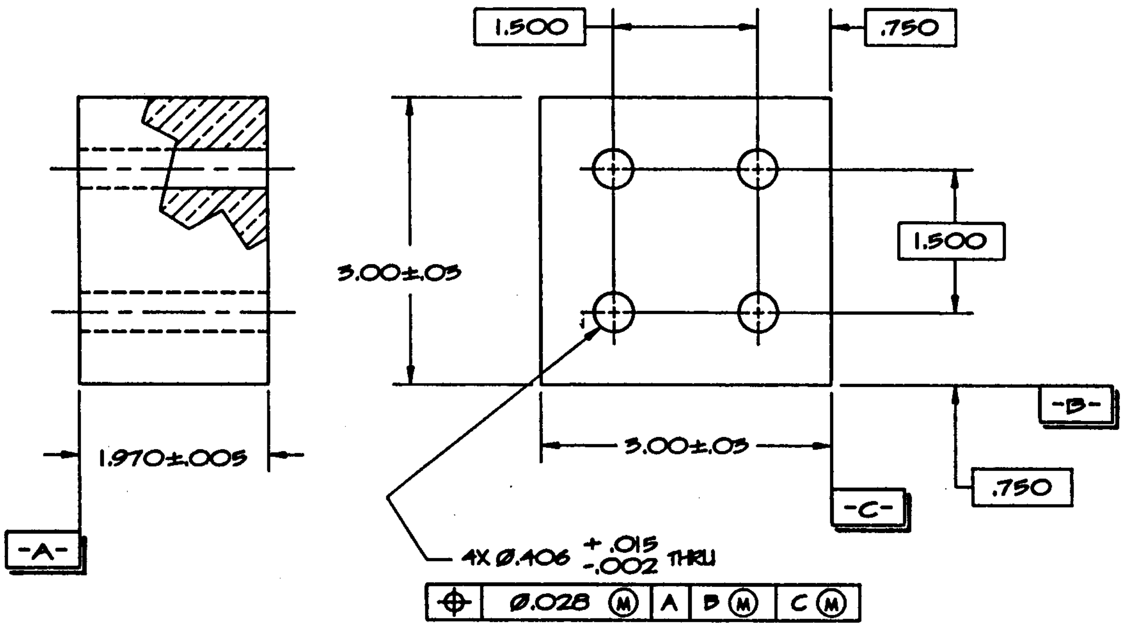
SHOWN ON AAA 93-104154 93-101697
ACT 8865-28
DRAWING NO: AAA93-104150-00
COPY
SCALE 2.00
SHEET 1 OF 1

LTR	DWN	CHK	DATE	ZONE	CHANGE

NOTES

UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. DIMENSIONS ARE IN INCHES.
4. STOCK FINISH ALL OVER (EXCEPT AS NOTED).
5. FINISHED PART TO BE CLEAN AND FREE OF OIL, GREASE, DIRT, ETC..
6. BAG AND TAG WITH LLNL DWG. NO.
8. LLNL AutoCAD(tm) Release 12 USER FILENAME: 31041511.DWG



NO REQD	PART/LLNL STK NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
		BAR OR PLATE, CDA 101/102 HIGH PURITY (COPPER)		

DWN	WJWONG 黄锦星	7/93
CHK	WJWONG	7/93
APVD	RMYAMAMOTO	7/93
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TITLE		DATE

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LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

MAJOR UNIT: PHENIX
SUBASSY: MUON PISTON COIL
DETAIL: SHORTING BLOCK

SHOWN ON AAA 93-101997 93-104154

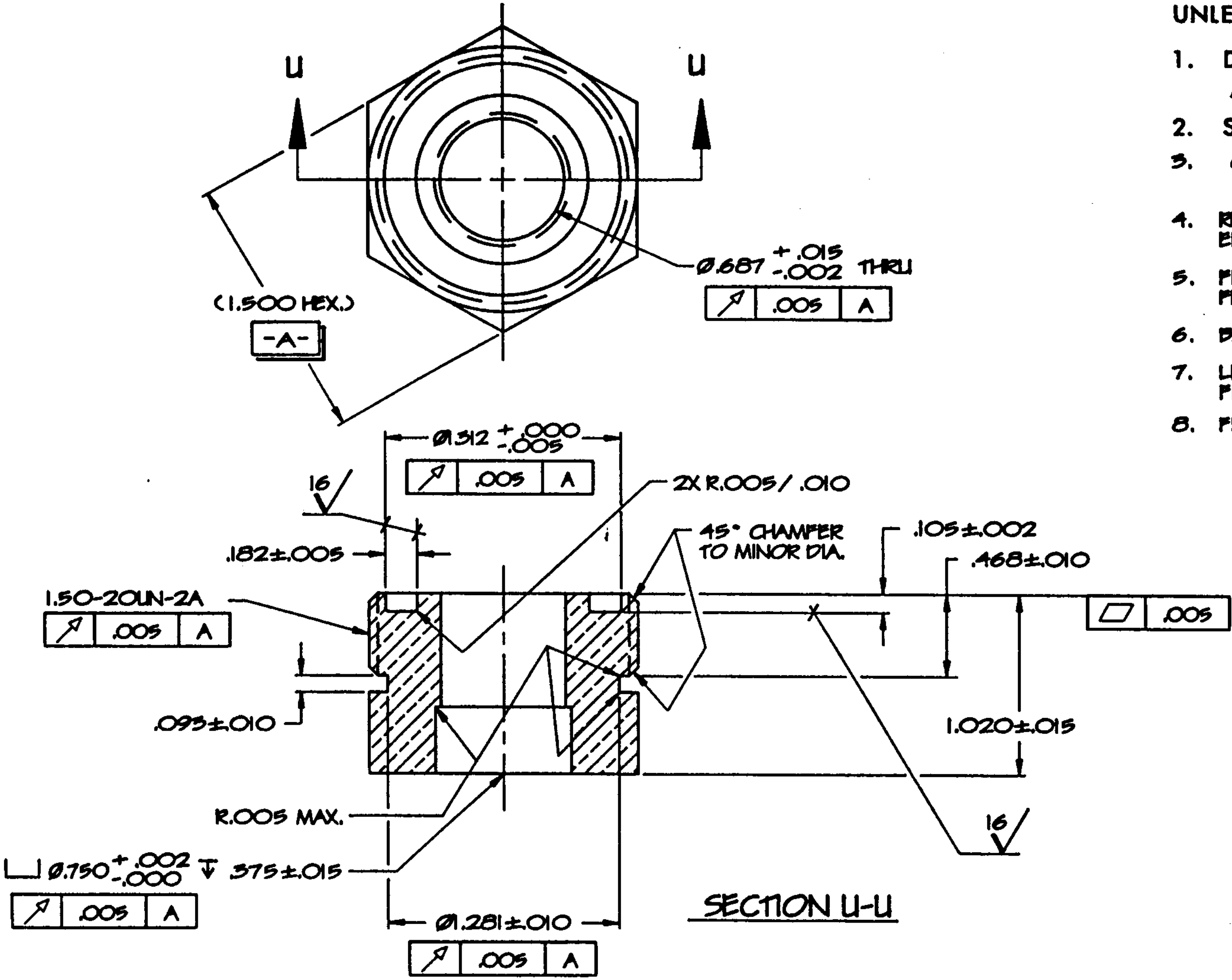
ACT 8863-23

DRAWING NO AAA93-104151-00 COPY

SCALE 2.00" SHEET 1 OF 1

LTR	DWN	CHK	DATE	ZONE	CHANGE

LL 1005-1



NOTES

UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. 63 √ FINISH ALL OVER (EXCEPT AS NOTED).
4. REMOVE BURRS AND BREAK SHARP EDGES .005/.010.
5. FINISHED PART TO BE CLEAN AND FREE OF OIL, GREASE, DIRT, ETC..
6. BAG AND TAG WITH LLNL DWG. NO.
7. LLNL/AutoCAD® RELEASE 12 USER FILENAME: 31018971.DWG
8. FINISHED PART SHOWN ON:
   AAA93-101857
   AAA93-101899
   AAA93-104152
   AAA93-104154

NO REQD	PART/LLNL STK NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
		BAR, 1.500" HEX. (CRES 304)		

DWN	WJWONG 黃偉昌	6/95
CHK	WJWONG	6/95
APVD	RMYAMAMOTO	6/95
CLASSIFIED BY:		
TITLE		DATE

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MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

MAJOR UNIT: PHENIX

SUBASSY: HYDRAULIC CONDUCTOR INTERFACE

DETAIL: OUTLET CONDUCTOR FITTING

SHOWN ON AAA (SEE NOTE 8)

ACT 8865-25

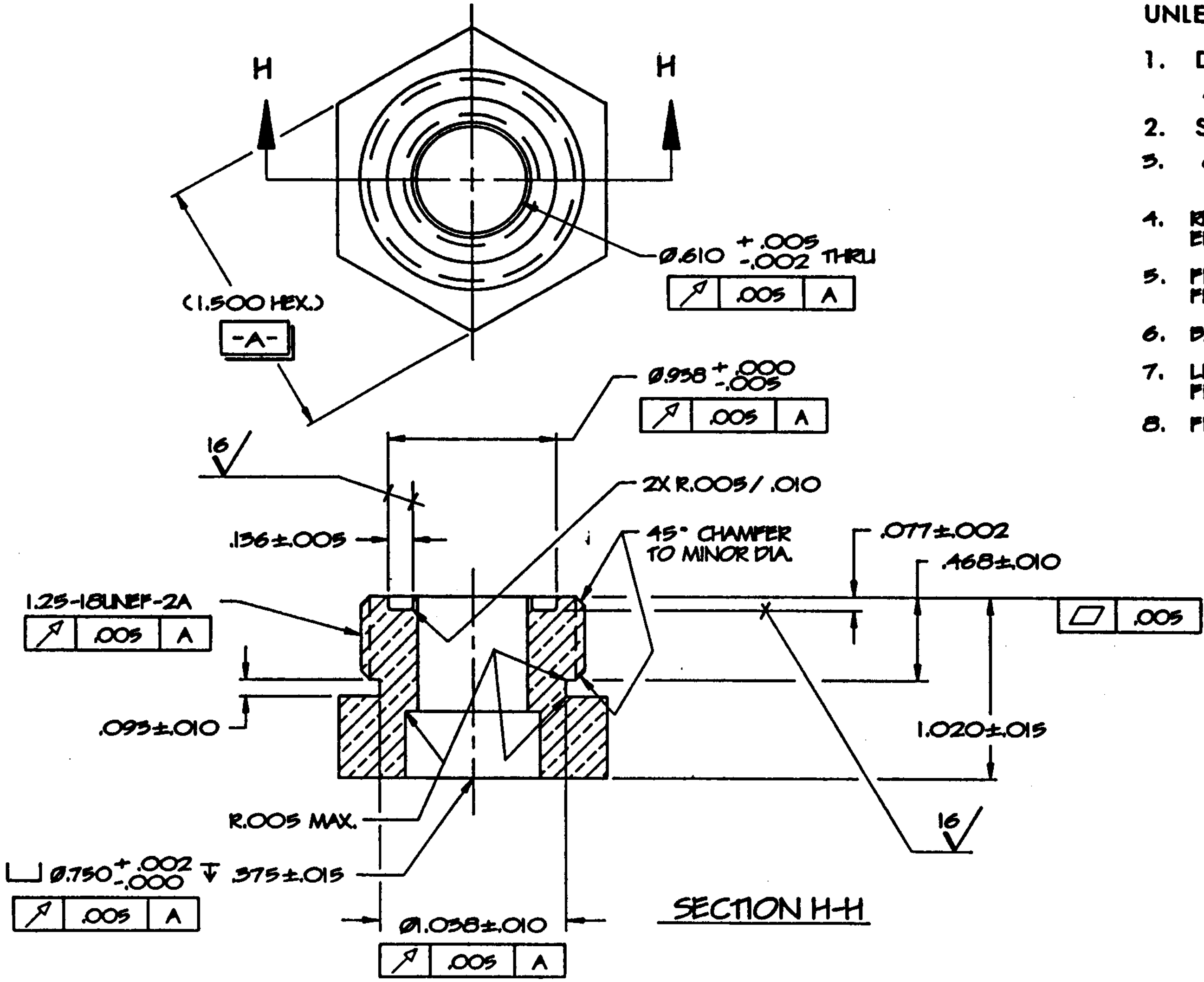
DRAWING NO: AAA 93-101897-00

COPY

SCALE 1.00"

SHEET 1 OF 1

LTR	DWN	CHK	DATE	ZONE	CHANGE



NOTES

UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. 63 √ FINISH ALL OVER (EXCEPT AS NOTED).
4. REMOVE BURRS AND BREAK SHARP EDGES .005/.010.
5. FINISHED PART TO BE CLEAN AND FREE OF OIL, GREASE, DIRT, ETC..
6. BAG AND TAG WITH LLNL DWG. NO.
7. LLNL/AutoCAD® RELEASE 12 USER FILENAME: 31018981.DWG
8. FINISHED PART SHOWN ON:
   AAA93-101857
   AAA93-101899
   AAA93-104152
   AAA93-104154

NO REQD	PART/LLNL STK NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
		BAR, 1.500" HEX. (CRES 304)		

DWN	WJWONG 黄錦星	6/95
CHK	WJWONG	6/95
APVD	RMYAMAMOTO	6/95
CLASSIFIED BY:		
TITLE		DATE

CLASSIFICATION

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

MAJOR UNIT: PHENIX

SUBASSY: HYDRAULIC CONDUCTOR INTERFACE

DETAIL: INLET CONDUCTOR FITTING

SHOWN ON AAA (SEE NOTE 8)

ACT 8863-25

DRAWING NO AAA93-101898-00 COPY

SCALE ⟵ 1.00" ⟶ SHEET 1 OF 1

LTR	DWN	CHK	DATE	ZONE	CHANGE

PHENIX Muon Magnet - Steel Drawings

Muon Piston Magnet Installation	AAA93-104171-00
Muon Piston Magnet Assembly	AAA93-101858-0C
Piston Core	AAA93-101860-0D
Teacup	AAA93-104173-00
Lampshade Panel Assembly	AAA93-101892-0A
Lampshade Panel No. 1	AAA93-101888-0B
Lampshade Panel No. 2	AAA93-101890-0B
Lampshade Panel No. 3	AAA93-101891-0A
Lampshade Panel No. 4	AAA93-101893-0A
Lampshade Panel No. 5	AAA93-104174-00
Fin	AAA93-104157-00
Support Leg	AAA93-101887-0A
Door, Fixed	AAA93-104178-00
Door, Hinged	AAA93-104179-00
Door, Teacup Side	AAA93-104180-00
Backplate, Side	AAA93-101886-0B
Backplate, Center	AAA93-101885-0B

PHENIX Muon Magnet - Steel Drawings

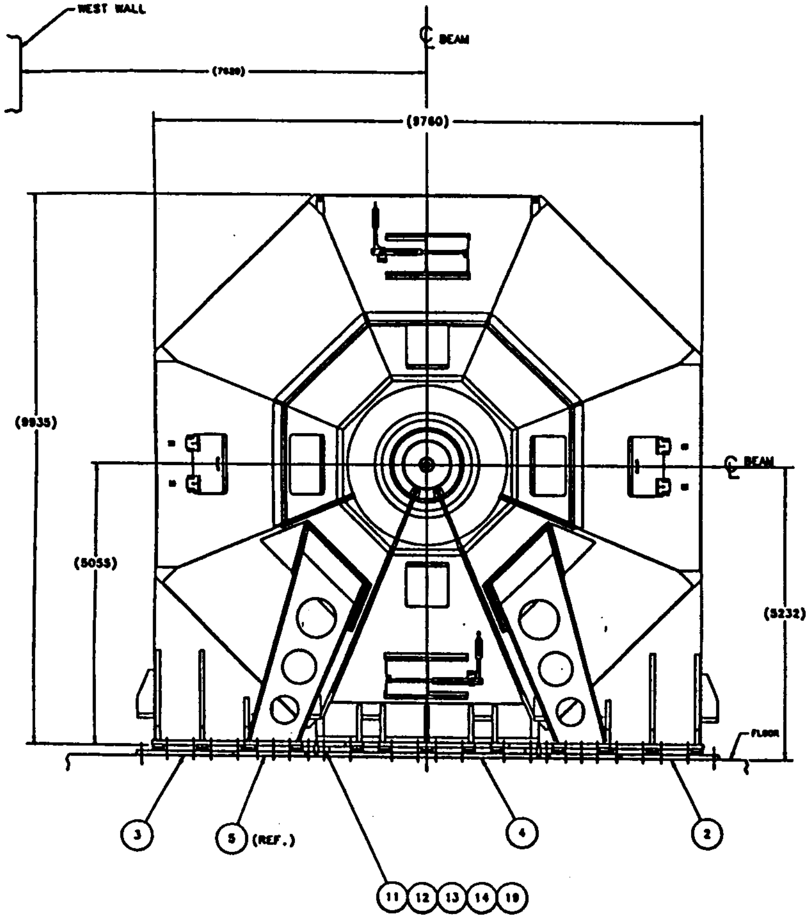
Stiffener, Hinge, Outside	AAA93-104208-00
Stiffener, Hinge, Inside	AAA93-104206-00
Hinge, Pillow Block	AAA93-104207-00
Shaft, Door Hinge	AAA93-104203-00
Base, Bearing	AAA93-104202-00
Spacer, Coil No. 2	AAA93-104211-00
Retainer, Coil No. 1	AAA93-104209-00
Retainer, Coil No. 2	AAA93-104210-00
Washer	AAA93-104213-00
Disk, Backplate	AAA93-101864-0B
Bracket, Door Restraining	AAA93-104201-00
Spacer Bar	AAA93-104176-00
Locator Pin	AAA93-104177-00
Splice Bar	AAA93-104175-00
Spacer, Floorplate	AAA93-104172-00
Wedgeplate, Lower	AAA93-104164-00
Wedgeplate, Upper	AAA93-104163-00

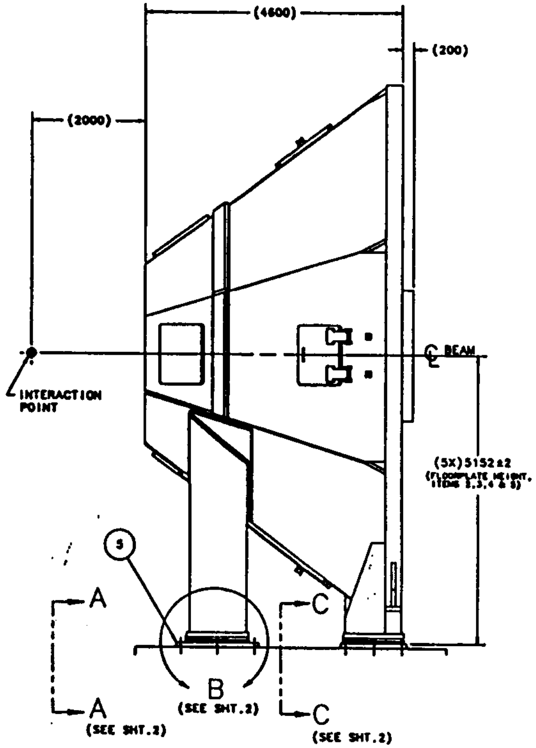
PHENIX Muon Magnet - Steel Drawings

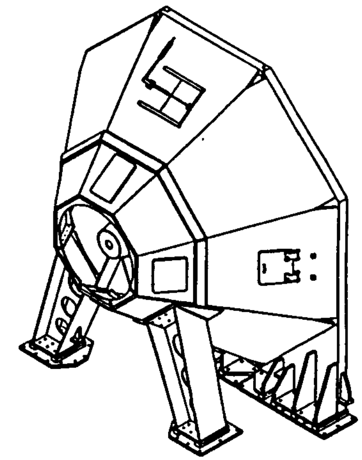
Shim	AAA93-104165-00
Bracket, Door Stop	AAA93-101867-00
Bracket No. 1, Cyl. Mtg.	AAA93-101865-00
Bracket No. 2, Cyl. Mtg.	AAA93-101866-00
Rail	AAA93-101894-00
Plunger	AAA93-101860-00
Cover Plate	AAA93-104162-00
Cup	AAA93-104161-00
Pump, Hydraulic, Rework	AAA93-104160-00
Floorplate, Front	AAA93-104158-00
Floor Plate, Rear, Center	AAA93-104166-00
Floor Plate, Rear, Side	AAA93-104159-00
Door	AAA93-101889-0A

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. CHIP OUT EXISTING FLOOR TO PROVIDE SPAC[E] FOR GROUT AND WRENCH CLEARANCE FOR HEIG[HT] ADJUSTMENT OF FLOORPLATE.
5. DRILL HOLES, INJECT EPOXY, INSERT STUDS AND CURE PER MANUFACTURERS INSTRUCTIONS.
6. FILL WITH GROUT AND CURE PER MANUFACTURER[S] INSTRUCTIONS. FULL CONTACT BETWEEN GROU[T] AND PLATE/FLOOR IS ESSENTIAL TO INSURE LOAD DISTRIBUTION. 1 1/4" NPTF HOLES PROVIDED IN FLOORPLATES FOR GROUT INJECTION.







ISOMETRIC VIEW

NO REQD			PART / IDEN STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
						29
						28
						27
						26
						25
						24
A/R			UNISORB V-100, OR EQUIV.	EPOXY		23
A/R			UNISORB V-1, OR EQUIV.	GROUT		22
2				NUT, STEEL, ZINC PLATE, 1.25(INCH)-7		21
58				STUD, 4140 STL, ZINC/CAD PLT, 1.25(INCH)-7 X 24(INCH) LONG		20
60				HEX. CAP SCREW, BLACK, M36 X 300	DIN931 8.8	19
						18
						17
						16
						15
A/R			93-104172 TAB 03	SPACER, FLOORPLATE		14
A/R			93-104172 TAB 02	SPACER, FLOORPLATE		13
4			93-104172 TAB 01	SPACER, FLOORPLATE		12
176			93-104213	WASHER, 110 O.D. X 38 I.D. X 30 THICK		11
A/R			93-104165 TAB 03	SHIM (10MM THICK)		10
A/R			93-104165 TAB 02	SHIM (4MM THICK)		9
A/R			93-104165 TAB 01	SHIM (2MM THICK)		8
17			93-104164	WEDGEPLATE, LOWER		7
17			93-104163	WEDGEPLATE, UPPER		6
2			93-104158	FLOORPLATE, FRONT		5
1			93-104166	FLOORPLATE, REAR, CENTER		4
1			93-104159 TAB 02	FLOORPLATE, REAR, SIDE		3
1			93-104159 TAB 01	FLOORPLATE, REAR, SIDE		2
1			93-101858	MUON PISTON MAGNET ASSEMBLY		1

DWN R.HOLMES
CHK
APVD

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

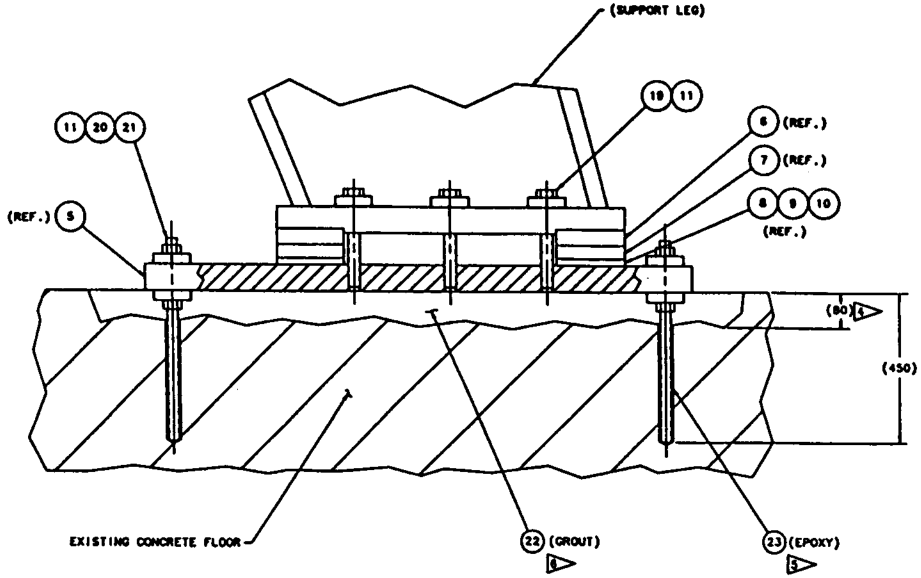
MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUBASSY: PHENIX MUON PISTON MAGNET
DETAIL: MUON PISTON MAGNET INSTALLATION

DRAWING NO: AAA93-104171-00

SCALE: NONE SHEET 1 OF 2

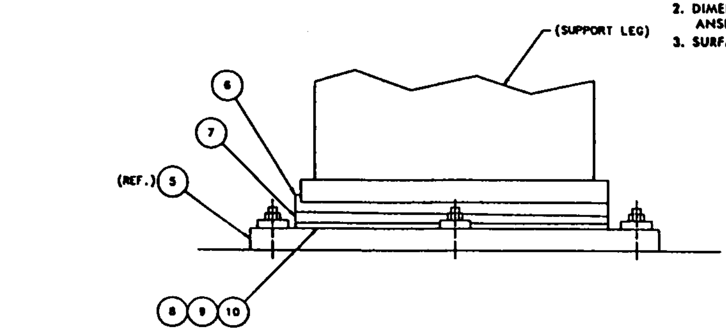
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



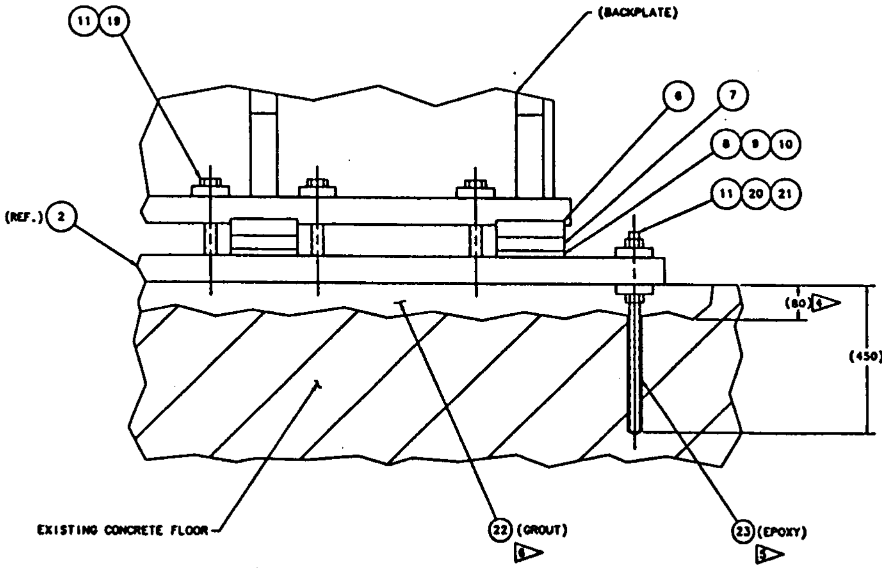
VIEW A-A

(FROM SHEET 1)



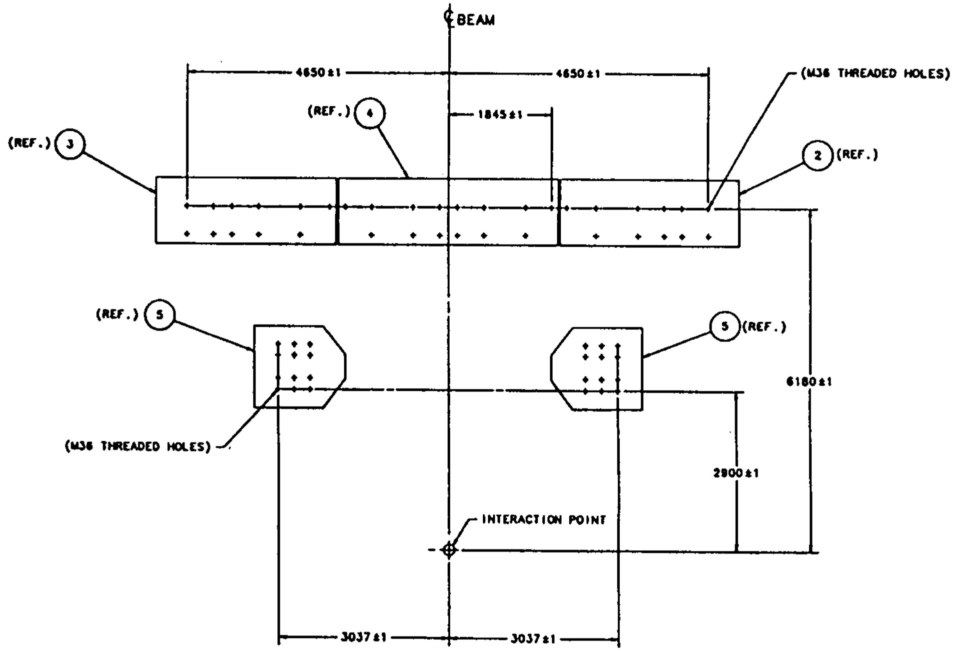
DETAIL B

(FROM SHEET 1)



VIEW C-C

(FROM SHEET 1)



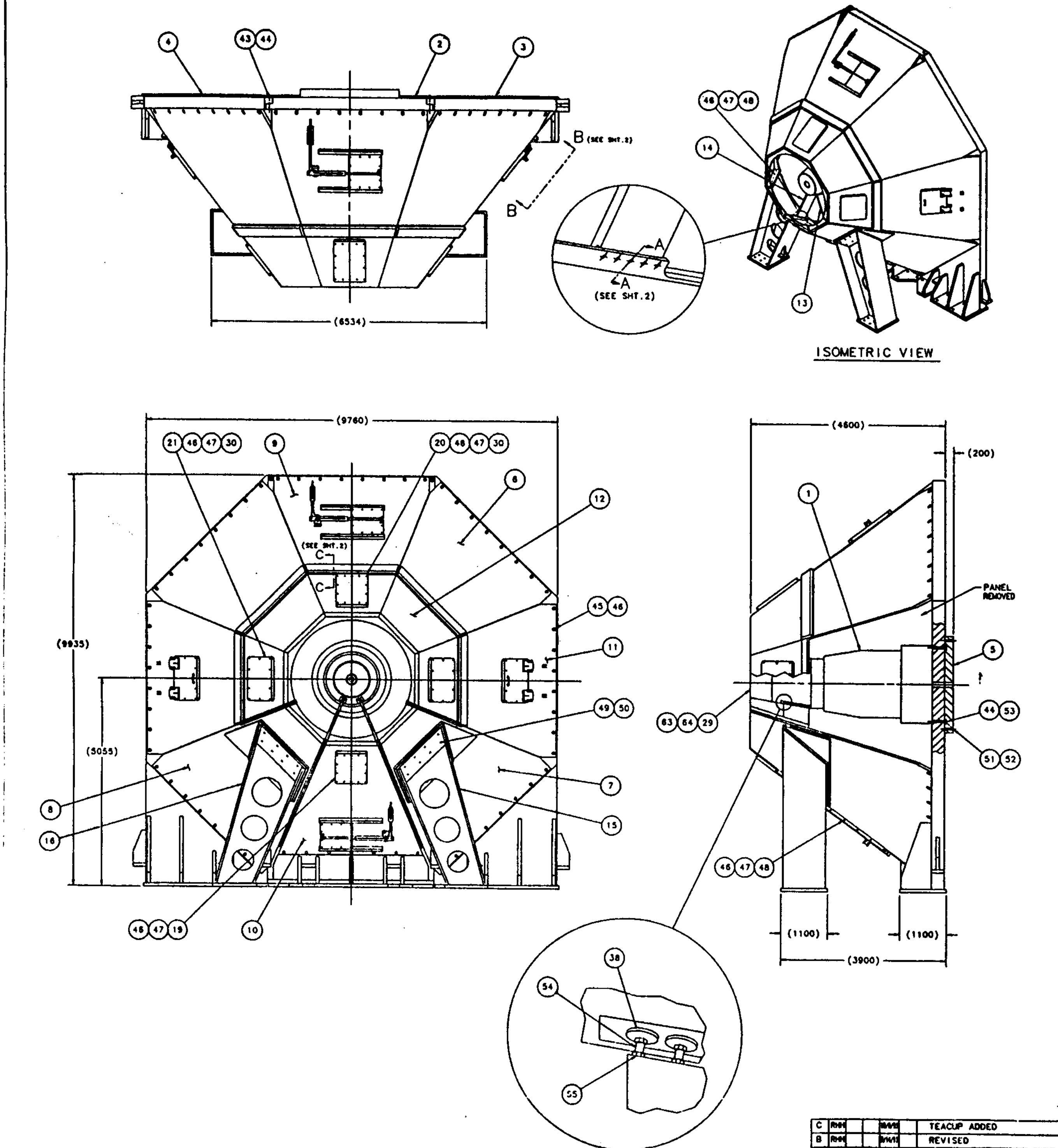
FLOORPLATE LOCATIONS

(PLAN VIEW)

NO REQD	PART / LINE SIZE NO	DESCRIPTION / MATERIAL	SPEC NO
	DWN R. HOLMES	CLASSIFICATION	RELATIVISTIC HEAVY ION COLLIDER (RHIC)
	CHK	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. PRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	PHENIX MUON PISTON MAGNET
	APVD		MUON PISTON MAGNET INSTALLATION
	LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT		DRAWING NO AAA93-104171-0
			SCALE NONE SHEET 2 OF

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
8		FLAT WASHER,STL.,ZINC PLATE,M20	DIN 125A	64
8		HEX.CAP SCREW,STL.,BLACK,M20X70	DIN 931 8.8	63
12		FLAT WASHER,STL.,ZINC PLATE,M12	DIN 125A	62
12		PAN HD.MACH.SCREW,PHILLIPS,ZINC PLATE,M5X16		61
8		HEX. CAP SCREW,STL.,BLACK,M12X50	DIN 931 8.8	60
40		HEX.FLAT WASHER,STL.,ZINC PLATE,M12	DIN 125A	59
32		HEX. CAP SCREW,STL.,BLACK,M12X90	DIN 931 8.8	58
30		SOC.HD. CAP SCREW,BLACK,M20X70	DIN 912 8.8	57
14	S310-21801	HEX. NUT,STNLS STL.,.750(INCH)-10		56
14		STUD,STNLS STL.,.750(INCH)-10 X 3" LG.		55
10		HEX. CAP SCREW,STL.,BLACK,M24X110	DIN 931 8.8	54
20		HEX. CAP SCREW,STL.,BLACK,M48X400	DIN 931 8.8	53
12		FLAT WASHER,STL.,ZINC PLATE,M36	DIN 7989 A	52
12		HEX. CAP SCREW,STL.,BLACK,M36X300	DIN 931 8.8	51
32		FLAT WASHER,STL.,ZINC PLATE,M30	DIN 7989 A	50
32		HEX. CAP SCREW,STL.,BLACK,M30X140	DIN 931 8.8	49
38		HEX. NUT,STL.,BLACK,M24	DIN 934 8	48
148		HEX. CAP SCREW,STL.,BLACK,M24X120	DIN 931 8.8	47
241		FLAT WASHER,STL.,ZINC PLATE,M24	DIN 7989 A	46
63		HEX. CAP SCREW,STL.,BLACK,M24X100	DIN 931 8.8	45
54		FLAT WASHER,STL.,ZINC PLATE,M48	DIN 125 B	44
34		HEX. CAP SCREW,STL.,BLACK,M48X200	DIN 931 8.8	43
				42
				41
				40
10	McMASTER CARR 91121A118	SPHERICAL WA. 1.06" I.D. X 2" O.D. X .5" THK.		39
14	CARR LANE CL-12-LF-S	LEVELING FEET,STNLS STL.,.750(INCH)-10		38
4	CARR LANE CL-16-T6	T-PIN, ø.75 INCH X 6 INCH LONG		37
8	SEAL MASTER NP-20R	PILLOW BLOCK, ø 1.25 INCH		36
2	McMASTER CARR 1402A46	DOOR PULL		35
				34
				33
				32
				31
3	93-104177	LOCATOR PIN		30
1	93-104212	PISTON NOSE CONE		29
8	93-104202	BASE, BEARING		28
4	93-104201	BRACKET, DOOR RESTRAINING		27
4	93-104203	SHAFT, DOOR HINGE		26
4	93-104208	STIFFENER, HINGE, OUTSIDE		25
4	93-104207	HINGE, PILLOW BLOCK		24
4	93-104206	STIFFENER, HINGE, INSIDE		23
2	93-104179	DOOR, HINGED		22
2	93-104180	DOOR, TEACUP SIDE		21
1	93-104178 TAB 02	DOOR, FIXED		20
1	93-104178 TAB 01	DOOR, FIXED		19
1	93-104176	SPACER BAR		18
5	93-104175	SPLICE BAR		17
1	93-101887 TAB 02	SUPPORT LEG,R.H.		16
1	93-101887 TAB 01	SUPPORT LEG,L.H.		15
1	93-104157 TAB 02	SUPPORT FIN,R.H.		14
1	93-104157 TAB 01	SUPPORT FIN,L.H.		13
1	93-104173	TEACUP		12
2	93-104174	LAMPSHADE PANEL NO.5		11
1	93-101892 TAB 02	LAMPSHADE PANEL ASSY.,LOWER		10
1	93-101892 TAB 01	LAMPSHADE PANEL ASSY.,UPPER		9
1	93-101891 TAB 02	LAMPSHADE PANEL NO.3,R.H.		8
1	93-101891 TAB 01	LAMPSHADE PANEL NO.3,L.H.		7
2	93-101890	LAMPSHADE PANEL NO.2		6
1	93-101864	DISK,BACKPLATE		5
1	93-101886 TAB 02	BACKPLATE,SIDE,R.H.		4
1	93-101886 TAB 01	BACKPLATE,SIDE,L.H.		3
1	93-101885	BACKPLATE,CENTER		2
1	93-101860	PISTON CORE		1

DWN R.HOLMES 2/11/93
CHK
APVD

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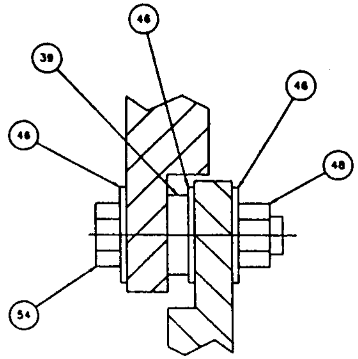
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

RELATIVISTIC HEAVY ION COLLIDER (RHIC)
PHENIX MUON PISTON MAGNET
MUON PISTON MAGNET ASSEMBLY

93-104171
DRAWING NO AAA93-101858-0C
SCALE NONE
SHEET 1 OF 2

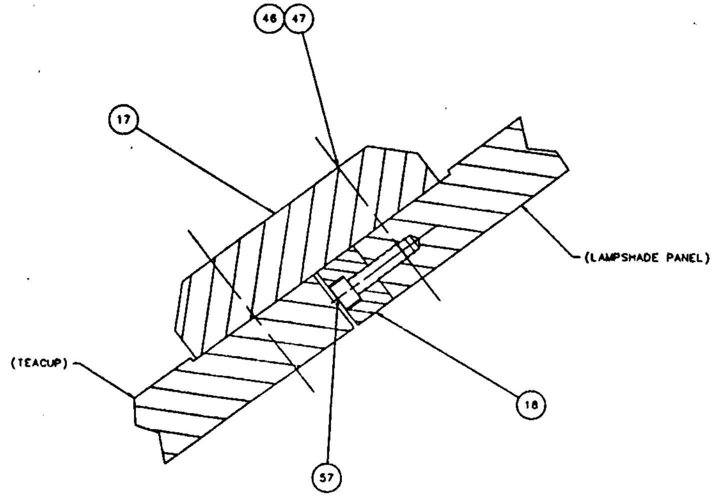
LTR	DWN	CHK	APVD	DATE	ECN	CHANGE
C	RHH					TEACUP ADDED
B	RHH					REVISED
A	RHH					REVISED

1. ALL DIMENSIONS ARE IN INCHES[MM]
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



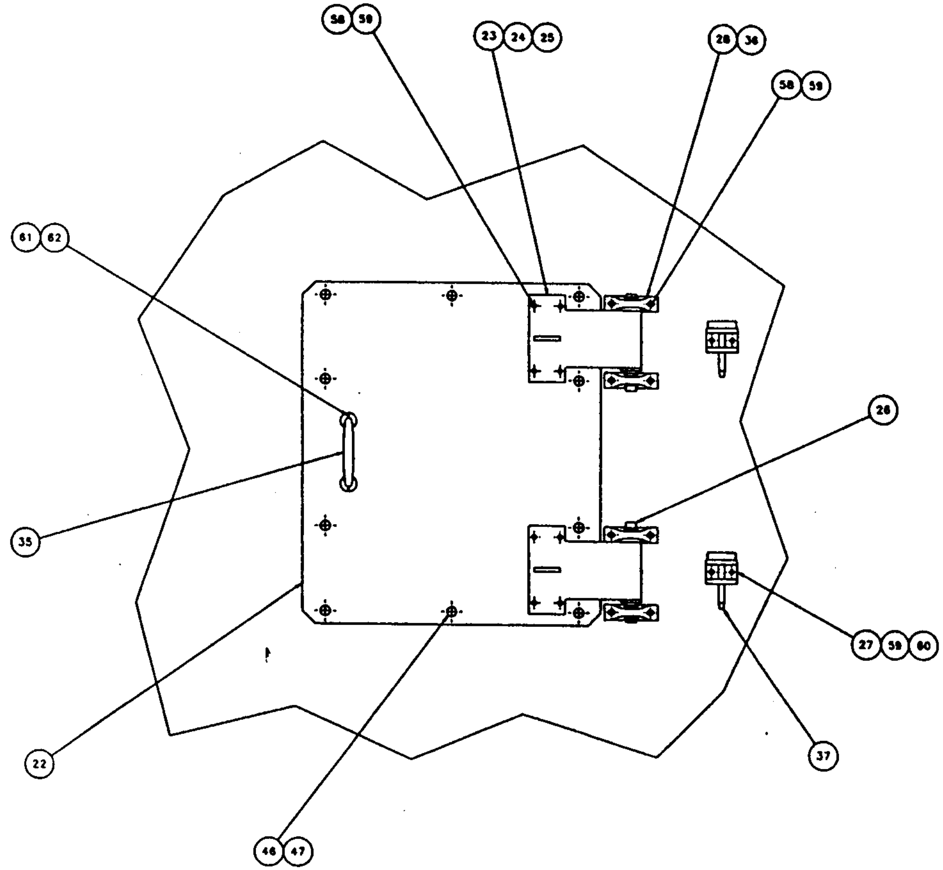
SECTION A-A

(FROM SHEET 1, ROTATED FOR CLARITY)



SECTION C-C

(FROM SHEET 1)



VIEW B-B

(FROM SHEET 1)

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN R.HOLMES 2/11/93

CHK

APVD

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LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA

RELATIVISTIC HEAVY ION COLLIDER (RHIC)

PHENIX MUON PISTON MAGNET

MUON PISTON MAGNET ASSEMBLY

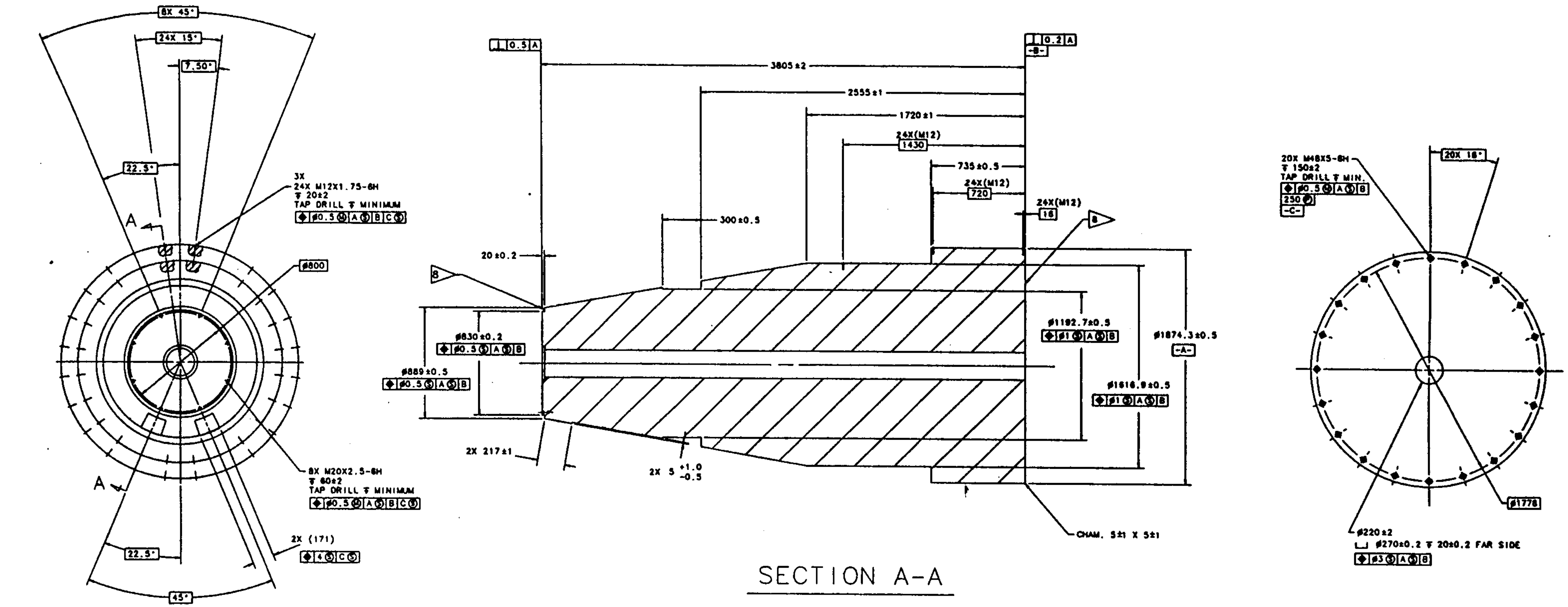
93-104171

DRAWING NO AAA93-101858-0C

SCALE NONE

SHEET 1 OF 2

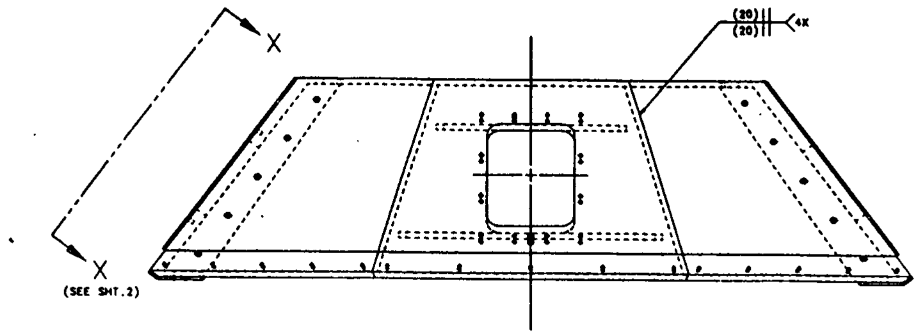
1. ALL DIMENSIONS ARE IN ~~INCHES~~(MM)
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2/ ALL MACHINED SURFACES.
5. ALL FILLETS, R 1±0.5
6. BREAK SHARP EDGES, CHAM. OR R 1 TO 2 MM
7. PRIME AND PAINT PER LLNL SPECIFICATIONS.
8. DO NOT PRIME OR PAINT THESE SURFACES.

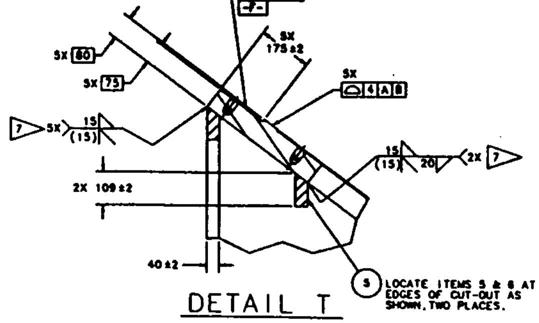


LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE
D						LENGTH SHORTENED 45MM
C						REVISED
B						REVISED
A						REVISED

DESCRIPTION / MATERIAL	STEEL, AISI 1006 OR EQUIV.
DWN	R. HOLMES 1/21/93
MAJOR UNIT	RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUBASSY	PHENIX MUON PISTON MAGNET
DETAIL	PISTON CORE
DRAWING NO	AAA93-101860-0D
SCALE	NONE
SHEET	1 OF 1

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

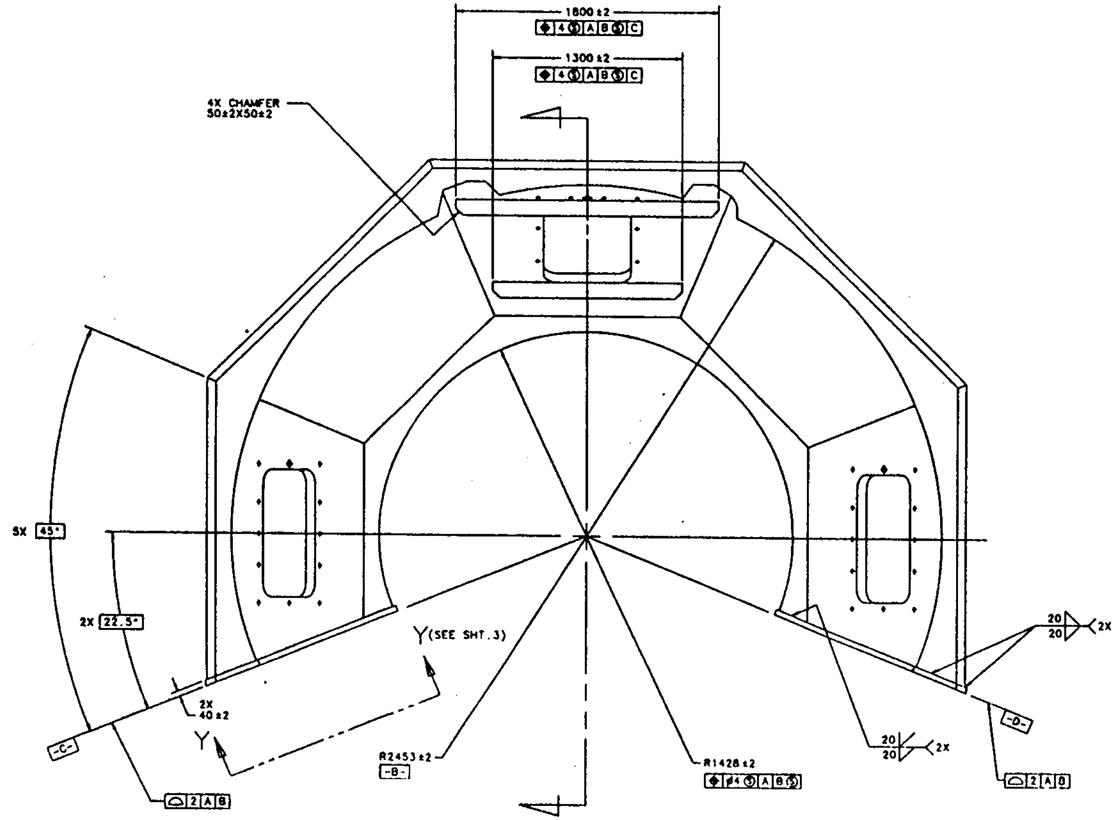


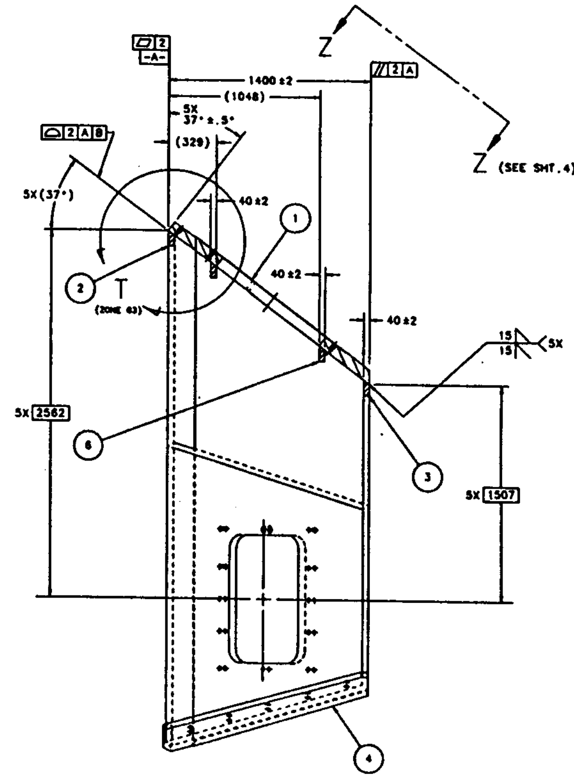


DETAIL T

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2/ALL MACHINED SURFACES.
5. BREAK SHARP EDGES, CHAM. OR R 1 TO 2MM
6. WELD SYMBOLS PER AWS 2.4, 1979.
7. WELDS PER ANSI/AWS D1.1, USE STNLS. STL. TYPE 308L ROD AT JOINTS NOTED.
8. ALL WELDS TO BE MAGNETIC PARTICLE TESTED.
9. PRIME AND PAINT PER LLNL SPECIFICATIONS.
10. DO NOT PRIME OR PAINT THIS SURFACE. (SEE VIEW X-X, SHT.2, AND SECTION R-R, SHT.4)





NO REQD			PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
63			BOSSARD NO. BN 902 M24 OR EQUIV.	THREAD INSERT, STL., SELF TAPPING, M24 (ENSAT TYPE 302)		8
						7
1				STNLS. STEEL, TYPE 304L OR EQUIV.		6
1				STNLS. STEEL, TYPE 304L OR EQUIV.		5
2				STEEL, AISI 1006 OR EQUIV.		4
1				STNLS. STEEL, TYPE 304L OR EQUIV.		3
1				STNLS. STEEL, TYPE 304L OR EQUIV.		2
5				STEEL, AISI 1006 OR EQUIV.		1

DWN R. HOLMES
CHK
APVD

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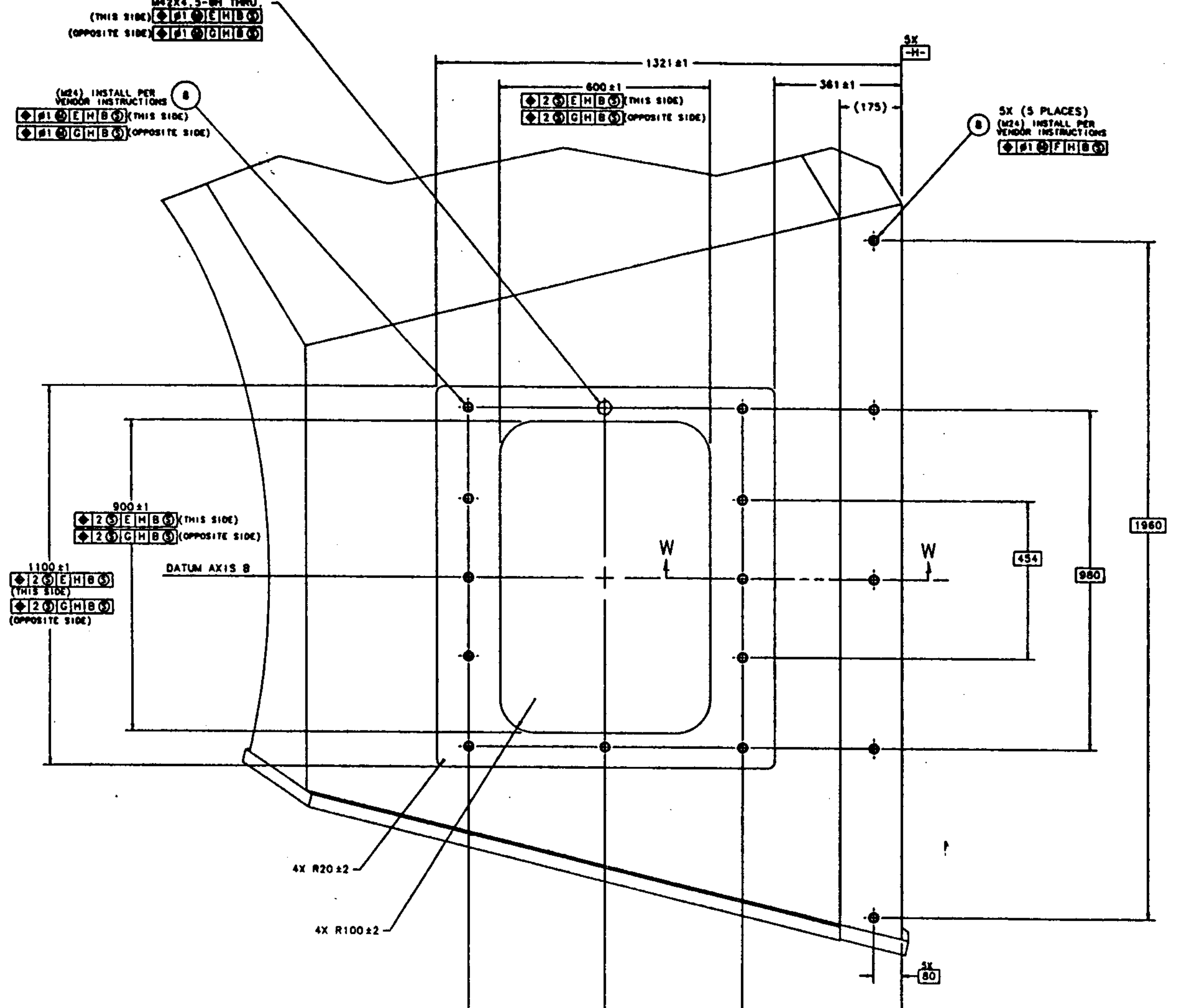
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

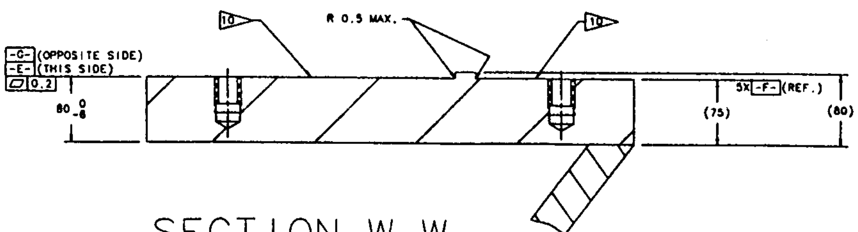
MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUBASSY: PHENIX MUON PISTON MAGNET
DETAIL: TEACUP
93-101850
DRAWING NO AAA93-104173-00
SCALE NONE
SHEET 1 OF 4

1. ALL DIMENSIONS ARE ~~IN INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



VIEW X-X (TRUE)

2X (FROM SHEET 1)
(ROTATED FOR CLARITY)



SECTION W-W

NO REQD	PART / LINE STE NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN	R. HOLMES
CHK	
APVD	
CLASSIFIED BY	
DATE	

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MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)

SUBASSY: PHENIX MUON PISTON MAGNET

DETAIL: TEACUP

93-101958

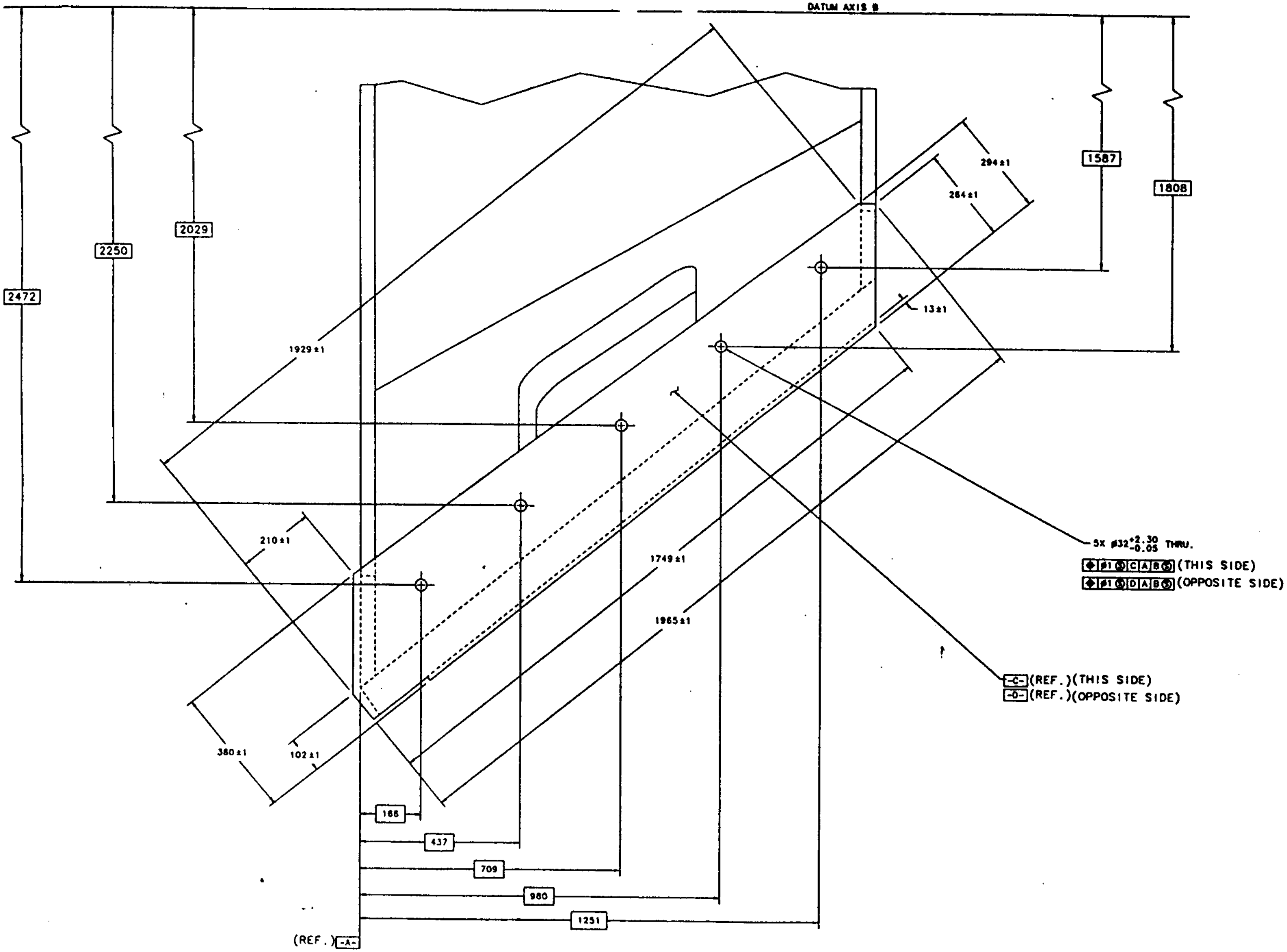
DRAWING NO: AAA93-104173-00

SCALE: NONE

SHEET 1 OF 1

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE ~~IN INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



VIEW Y-Y

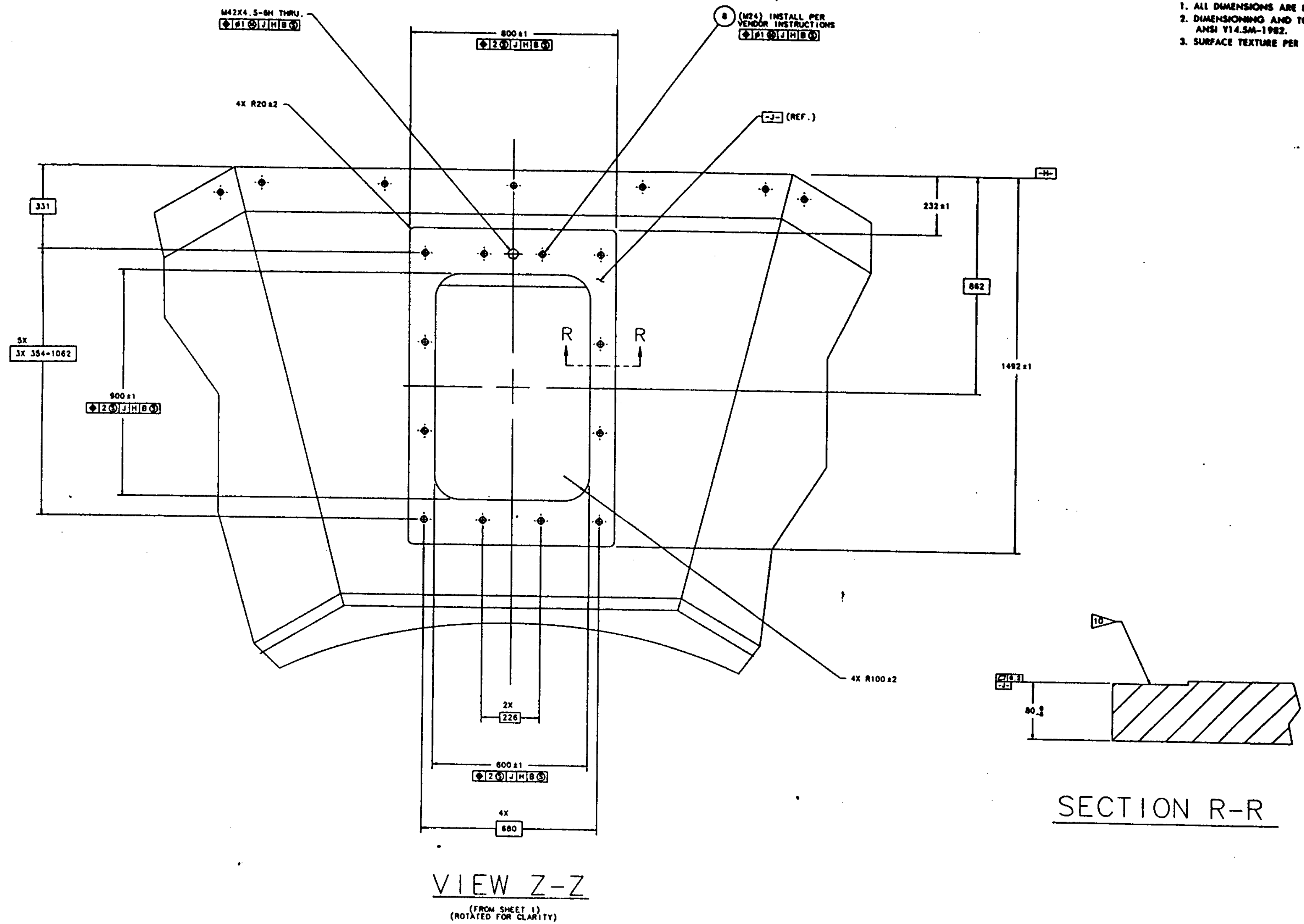
(FROM SHEET 1)

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN R. HOLMES		CLASSIFICATION	MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
CHK		THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. PRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	SUBASSY: PHENIX MUON PISTON MAGNET
APVD			DETAIL: TEACUP
CLASSIFIED BY			93-101858
	DATE		DRAWING NO AAA93-104173-00
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA			SCALE NONE — SHEET 3 OF 4

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN INCHES/MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN R.HOLMES

CHK

APVD

CLASSIFICATION

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LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

RELATIVISTIC HEAVY ION COLLIDER (RHIC)

PHENIX MUON PISTON MAGNET

TEACUP

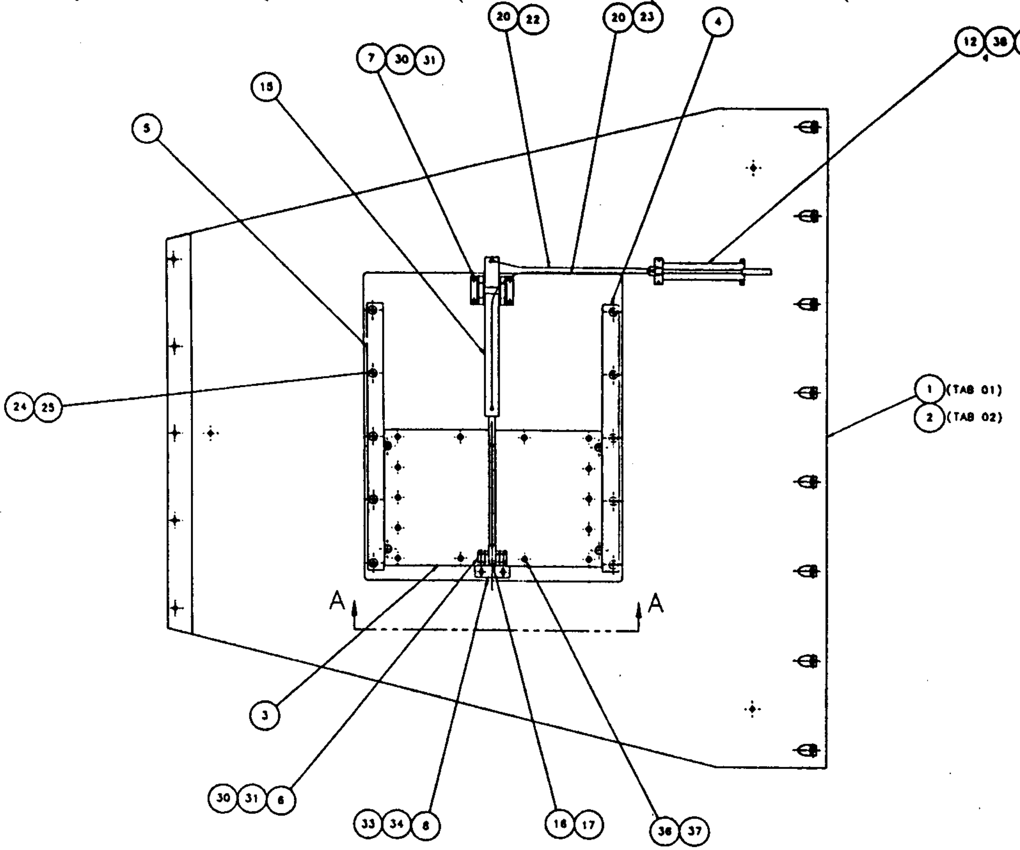
93-101558

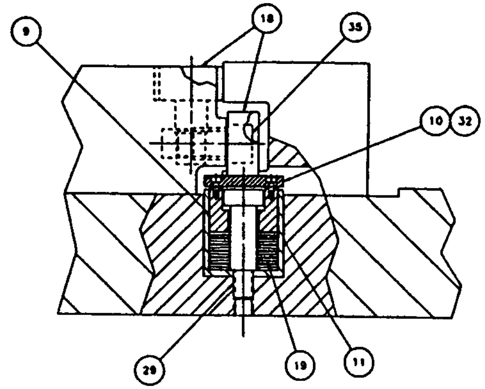
DRAWING NO AAA93-104173-00

SCALE NONE SHEET OF 4

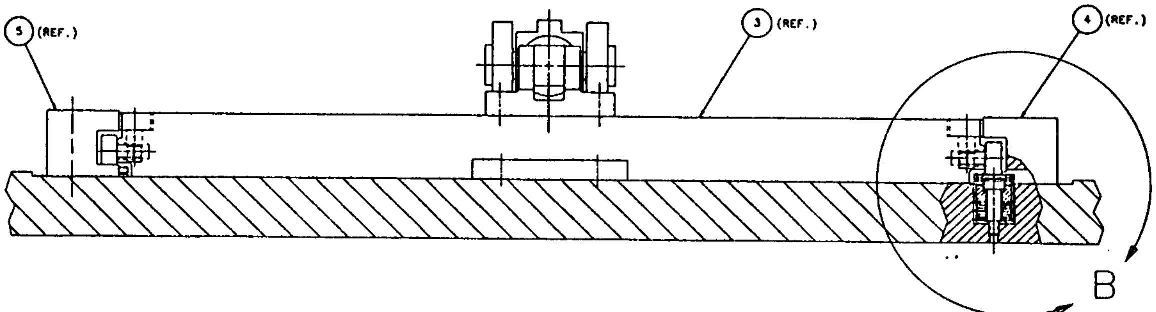
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.





DETAIL B



SECTION A-A

TAB NO.	REMARKS
01	LAMPSHADE ASSY., UPPER (SHOWN)
02	LAMPSHADE ASSY., LOWER

4	4			FLAT WASHER,STL.,ZINC PLATE,M8	DIN125A	39
4	4			HEX. CAP SCREW,STL.,BLACK,M8X30	DIN933 8.8	38
14	14			FLAT WASHER,STL.,ZINC PLATE,M24	DIN125A	37
14	14			HEX. CAP SCREW,STL.,BLACK,M24X120	DIN933 8.8	36
4	4			SOCKET HEAD CAP SCREW,STL,BLACK,M16X25	DIN912 8.8	35
2	2			FLAT WASHER,STL.,ZINC PLATE,M16	DIN125A	34
2	2			HEX. CAP SCREW,STL.,BLACK,M16X55	DIN933 8.8	33
8	8			SOCKET HEAD CAP SCREW,STL.,BLACK,M3X10	DIN912 8.8	32
14	14			FLAT WASHER,STL.,ZINC PLATE,M12	DIN125A	31
24	24			HEX. CAP SCREW,STL,BLACK,M12X80	DIN933 8.8	30
4	4			SOC. HD. SHLDR. SCREW,STL.,BLACK,ø16XM12X40LG.	ISO7379 12.9	29
						28
						27
						26
						25
						24
1	1		IMPERIAL EASTMAN [illegible]-58	HOSE ASSY.,3/8"I.D.X58"LG. (3/8"MNPT-3/8"TUBE)	SAE 100R2 TYPE AT	23
1	1		IMPERIAL EASTMAN [illegible]-32	HOSE ASSY.,3/8"I.D.X32"LG. (3/8"MNPT-3/8"TUBE)	SAE 100R2 TYPE AT	22
						21
2	2		IMPERIAL EASTMAN 849-FS-06X08	37°FLARED 90°ELBOW,STL,3/8"O.D.TUBEX1/2"MNPT		20
48	48		BOSSARD NO. BN808	DISC SPRING ø40 O.D.Xø18.3 I.D.X1.75 THK.		19
8	8		McGILL NO. MCF-40-SXB	CAMROL BEARING ø40 X 20 WIDE		18
1	1		WABCO NO. J800019	PIN, ROD EYE		17
1	1		WABCO NO. J800011	FEMALE ROD EYE		16
1	1		WABCO NO. MT4-HH-C	CYLINDER ASSY.,2"BOREX30"STROKE,13/8"øROD 1-14 MALE THRD.		15
						14
						13
1	1		93-104160	PUMP, HYDRAULIC, REWORK		12
4	4		93-104161	CUP		11
4	4		93-104162	COVER PLATE		10
4	4		93-101860	PLUNGER		9
1	1		93-101867	BRACKET, DOOR STOP		8
2	2		93-101866	BRACKET NO.2, CYL. MTG.		7
1	1		93-101865	BRACKET NO.1, CYL. MTG.		6
1	1		93-101864 TAB 02	RAIL, R.H.		5
1	1		93-101894 TAB 01	RAIL, L.H.		4
1	1		93-101889	DOOR		3
—	1		93-101893	LAMPSHADE PANEL NO.4		2
1	—		93-101888	LAMPSHADE PANEL NO.1		1
NO REQD			PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
TAB 01	TAB 02					

DWN R.HOLMES 6/17/93
CHK
APVD
CLASSIFIED BY
DATE

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MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

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MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)

SUBASSY: PHENIX MUON PISTON MAGNET

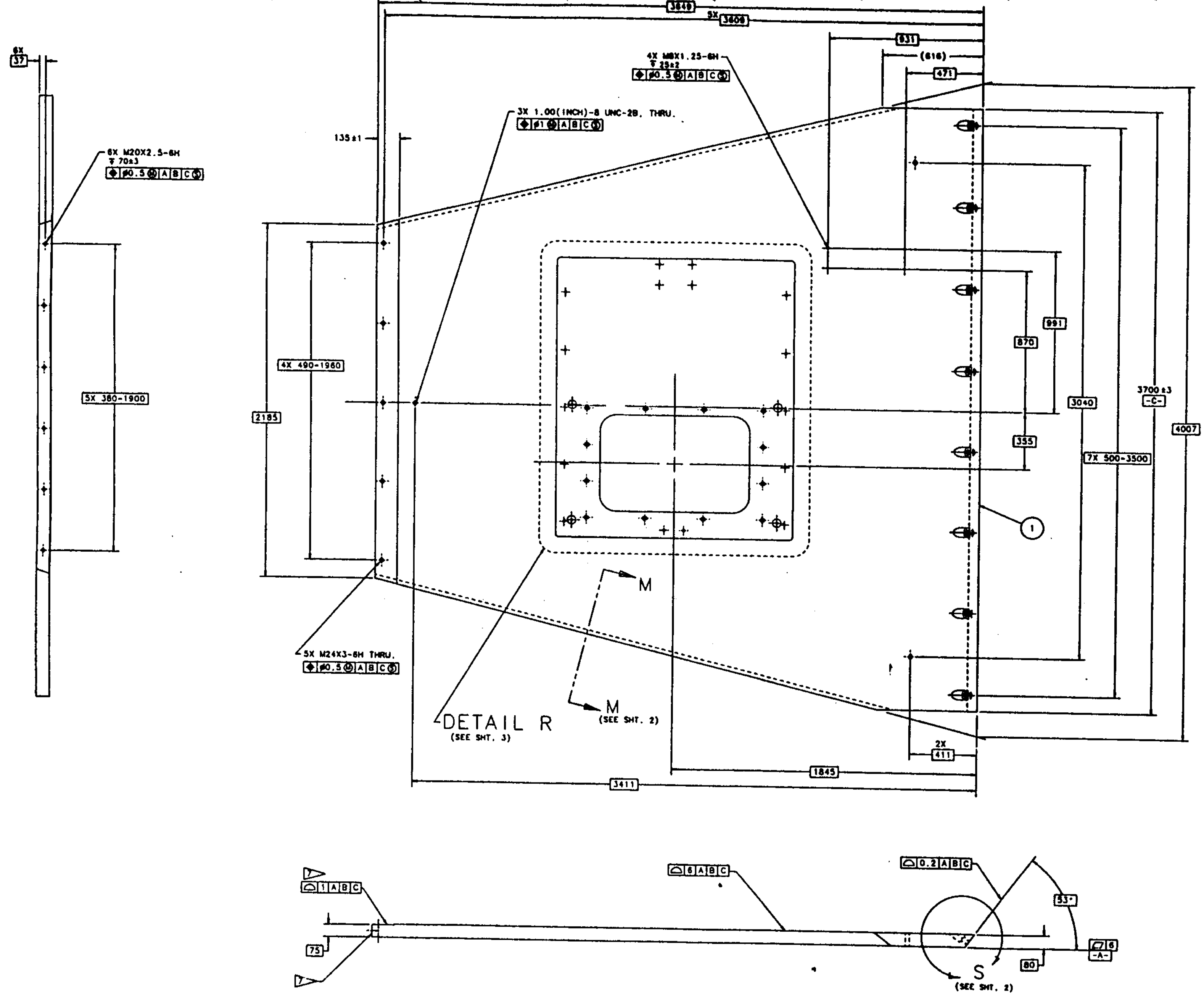
DETAIL: LAMPSHADE PANEL ASSY.

USED ON ASSY: 93-101850

DRAWING NO: AAA93-101892-0A

SCALE: NONE | SHEET 1 OF 1

A				8/17/93		ONE DOOR REMOVED
LTR		CHK	APVD	DATE	ZONE	CHANGE



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2/ALL MACHINED SURFACES.
5. BREAK SHARP EDGES, CHAM. OR R 1 TO 2 MM
6. PRIME AND PAINT PER LLNL SPECIFICATIONS.
7. DO NOT PRIME OR PAINT THIS SURFACE. (SEE ZONE B2, SHT.1, AND DETAIL S, SHT.2)

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
12		THREAD INSERT, STL., SELF TAPPING, M24(ENSAT TYPE 302)		2
1		STEEL, AISI 1006 OR EQUIV.		1

B	REVISED AND REDRAWN
A	REVISED

DWN R. HOLMES
CHK
APVD

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UNIVERSITY OF CALIFORNIA

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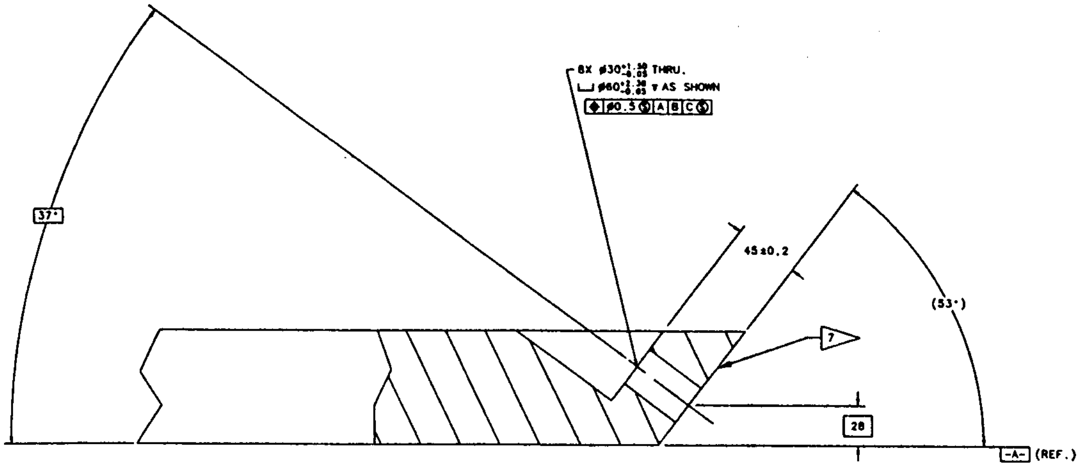
MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
ASSY: PHENIX MUON PISTON MAGNET
DETAIL: LAMPSHADE PANEL NO. 1

93-101892

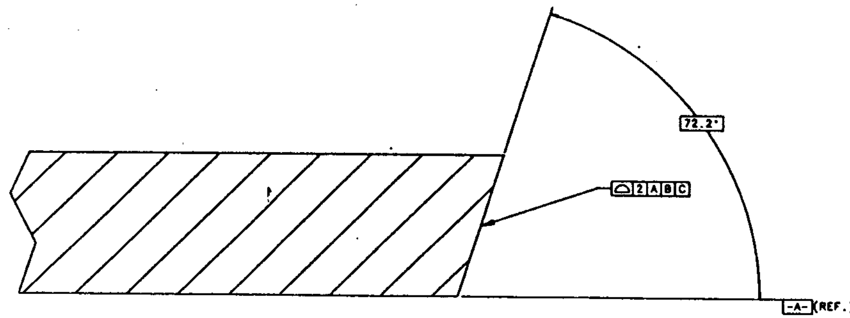
DRAWING NO AAA93-101888-0B

SCALE NONE — SHEET 1 OF 3

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



DETAIL S
(FROM SHEET 1)



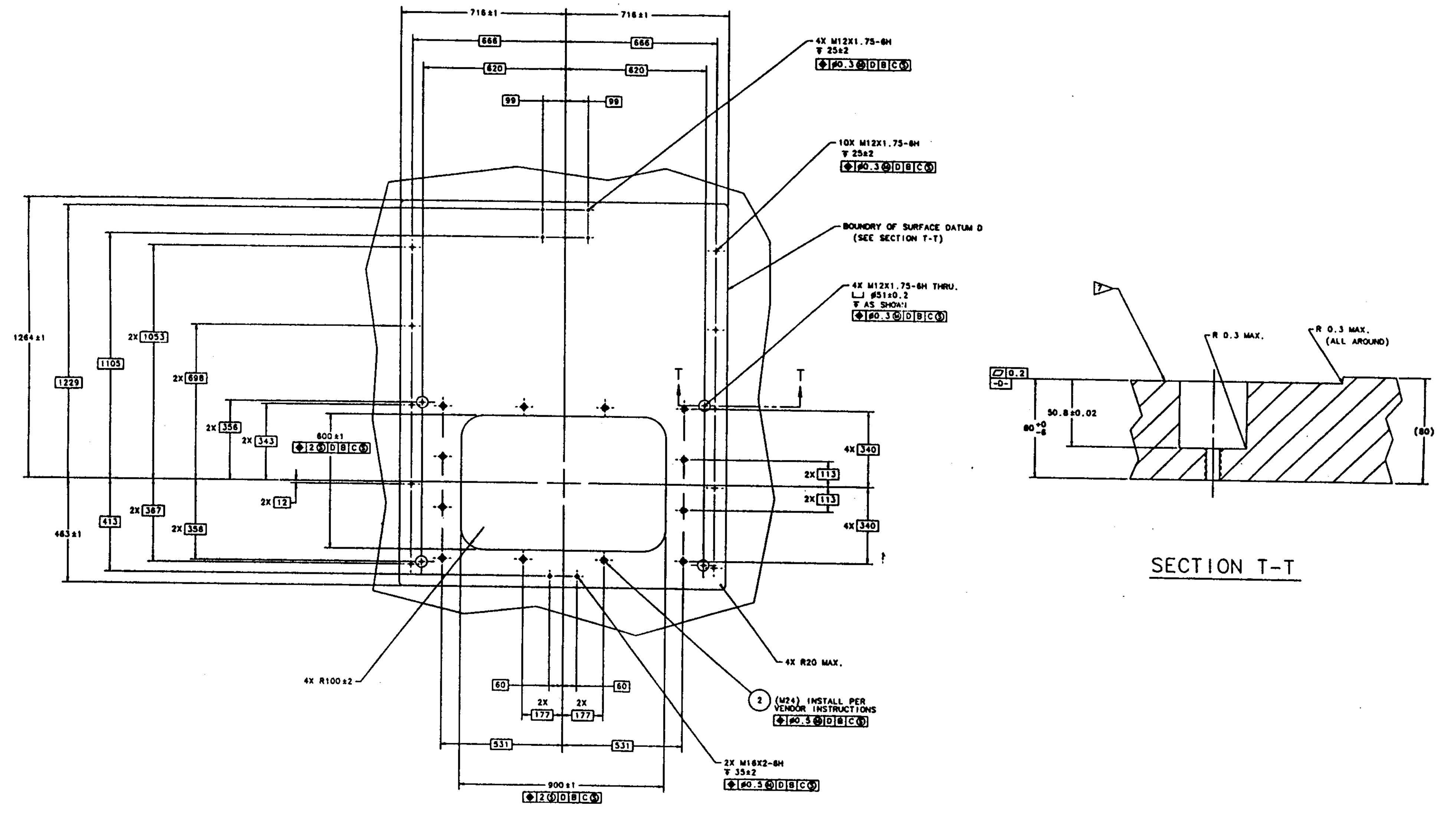
SECTION M-M (VIEW ROTATED FOR CLARITY)
(FROM SHEET 1)

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
	DWN R. HOLMES	CLASSIFICATION	MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)	
	CHK	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT	SUBASSY: PHENIX MUON PISTON MAGNET	
	APVD		DETAIL: LAMPSHADE PANEL NO. 1	
	CLASSIFIED BY		SHOWN ON ASSY 93-101892	DRAWING NO AAA93-101888-0B
			SCALE NONE	SHEET 2 OF 3

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



DETAIL R

(FROM SHEET 1)

SECTION T-T

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN R. HOLMES
CHK
APVD
CLASSIFIED BY

CLASSIFICATION

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LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)

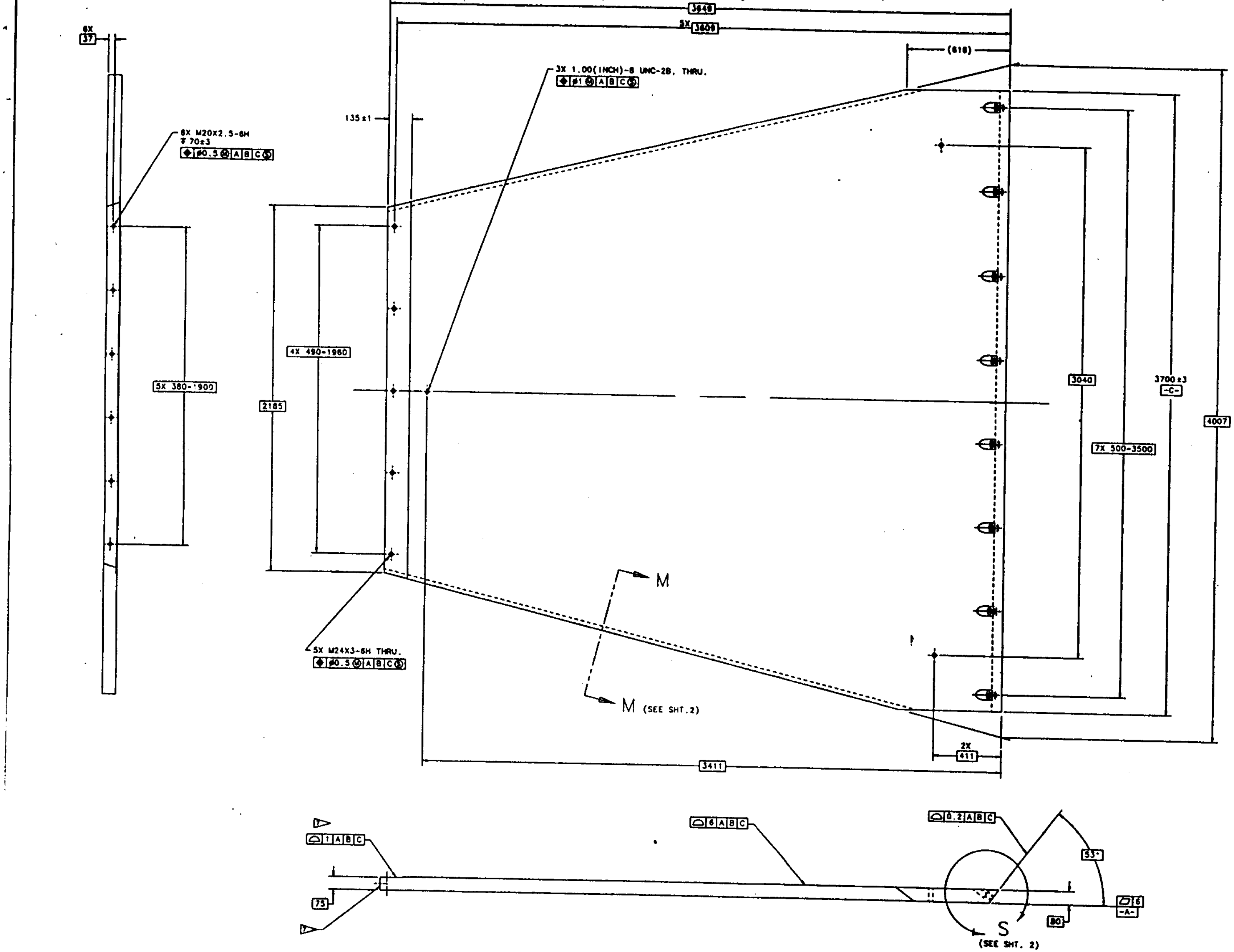
SUBASSY: PHENIX MUON PISTON MAGNET

DETAIL: LAMPSHADE PANEL NO. 1

DRAWING NO: AAA93-101888-0B

SCALE: NONE — SHEET 2 OF 3

LTR | DWN | CHK | APVD | DATE | ZONE | CHANGE



NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 ALL MACHINED SURFACES.
5. BREAK SHARP EDGES, CHAM. OR R 1 TO 2 MM
6. PRIME AND PAINT PER LLNL SPECIFICATIONS.
7. DO NOT PRIME OR PAINT THIS SURFACE. (SEE ZONE B2, SHT.1 AND DETAIL S, SHT.2)

B	RHH			REVISED AND REDRAWN	
A	RHH			REVISED	
LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE

STEEL, AISI 1006 OR EQUIV.

NO REQD | PART / LLNL STK NO | DESCRIPTION / MATERIAL | SPEC NO | ITEM

DWN R. HOLMES
CHK
APVD

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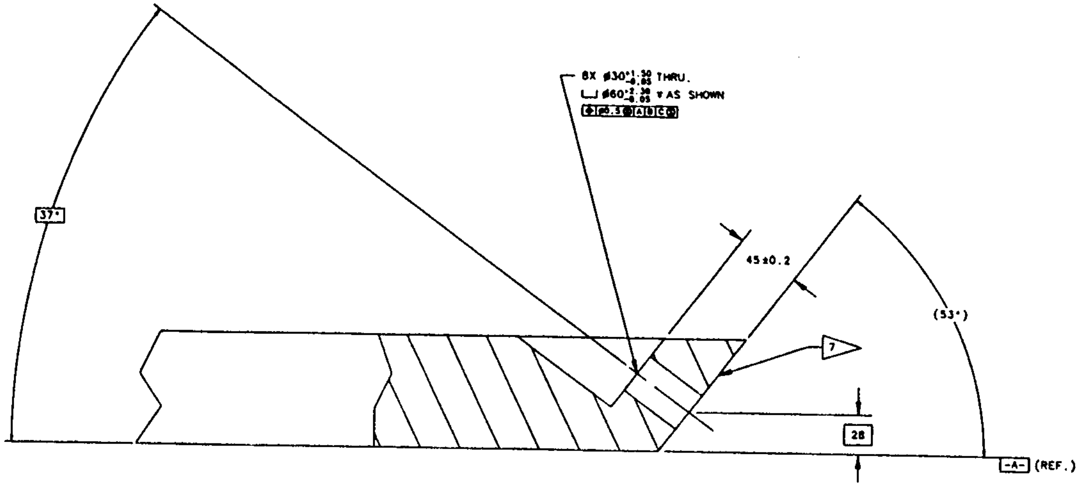
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

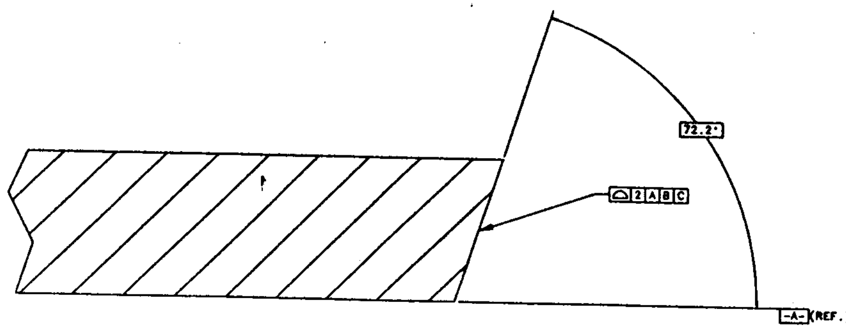
MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
SUBASSY: PHENIX MUON PISTON MAGNET
DETAIL: LAMPSHADE PANEL NO.2
93-101856
DRAWING NO: AAA93-101890-0B
SCALE: NONE
SHEET 1 OF 2

NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE ~~IN INCHES~~MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



DETAIL S
(FROM SHEET 1)



SECTION M-M (VIEW ROTATED FOR CLARITY)
(FROM SHEET 1)

STEEL, AISI 1006 OR EQUIV.	SPEC NO	ITEM
DESCRIPTION / MATERIAL		

NO REQD — PART / LINE SIZE NO

DWN R.HOLMES 6/30/93
CHK
APVD

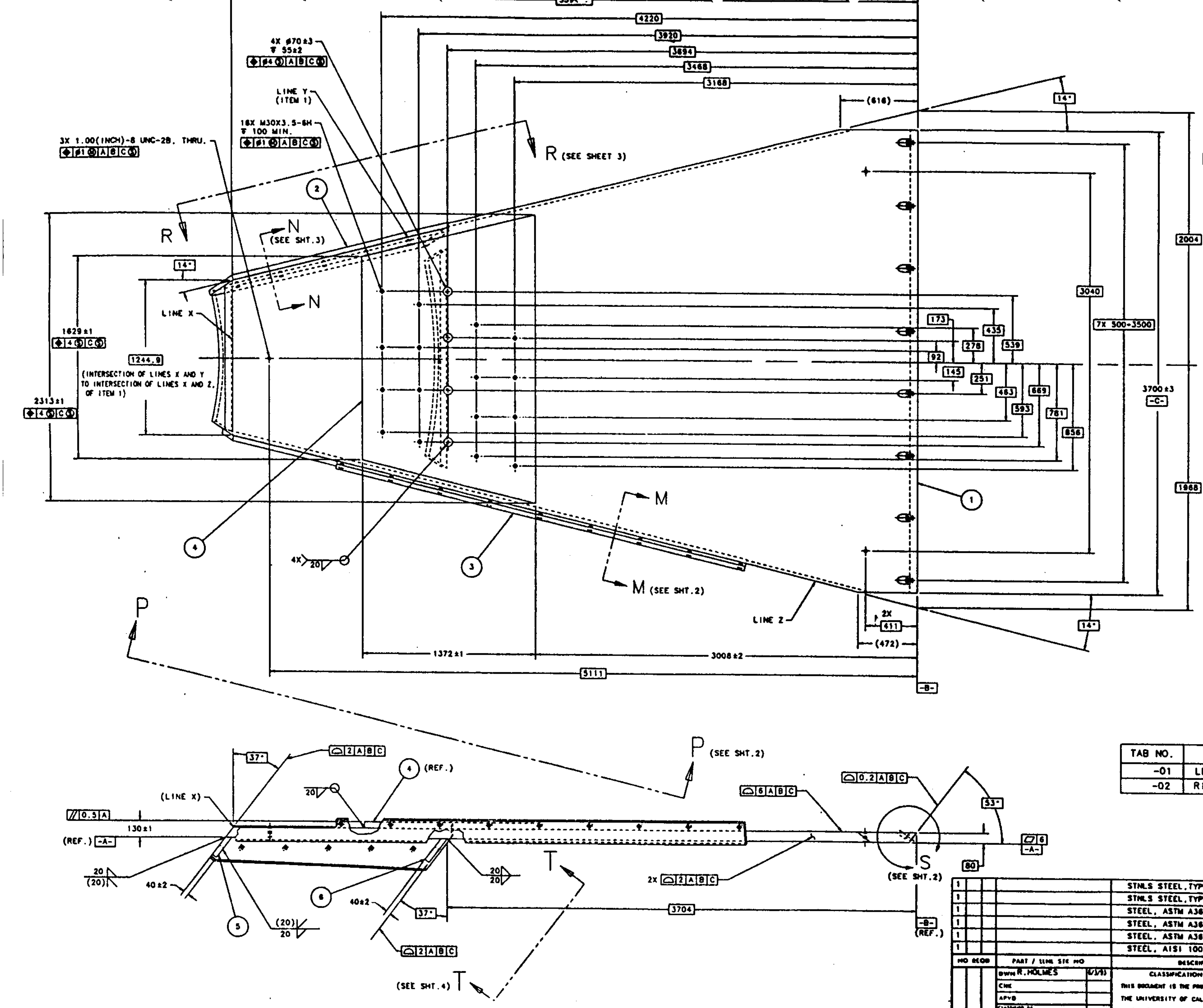
LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION
THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. PRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.

RELATIVISTIC HEAVY ION COLLIDER (RHIC)
PHENIX MUON PISTON MAGNET
LAMPSHADE PANEL NO.2
93-101850
DRAWING NO AAA93-101890-0B
SCALE NONE
SHEET 2 OF 2

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 ALL MACHINED SURFACES.
5. BREAK SHARP EDGES, CHAM. OR R 1 TO 2 MM
6. WELD SYMBOLS PER AWS 2.4, 1979.
7. WELDS PER ANSI/AWS D1.1
8. ALL WELDS TO BE MAGNETIC PARTICLE TESTED
9. PRIME AND PAINT PER LLNL SPECIFICATIONS.
10. DO NOT PRIME OR PAINT THIS SURFACE. (SEE DETAIL S, SHEET 2)



TAB NO.	REMARKS
-01	LEFT HAND (SHOWN), SEE SHEET 4
-02	RIGHT HAND (OPPOSITE), SEE SHEET 4

NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
1		STNLS STEEL, TYPE 304L OR EQUIV.		6
1		STNLS STEEL, TYPE 304L OR EQUIV.		5
1		STEEL, ASTM A36, OR AISI 1006, OR EQUIV.		4
1		STEEL, ASTM A36, OR AISI 1006, OR EQUIV.		3
1		STEEL, ASTM A36, OR AISI 1006, OR EQUIV.		2
1		STEEL, AISI 1006 OR EQUIV.		1

DWN R. HOLMES 6/1/93

CLASSIFICATION

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LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT

RELATIVISTIC HEAVY ION COLLIDER (RHIC)

PHENIX MUON PISTON MAGNET

LAMPSHADE PANEL NO.3

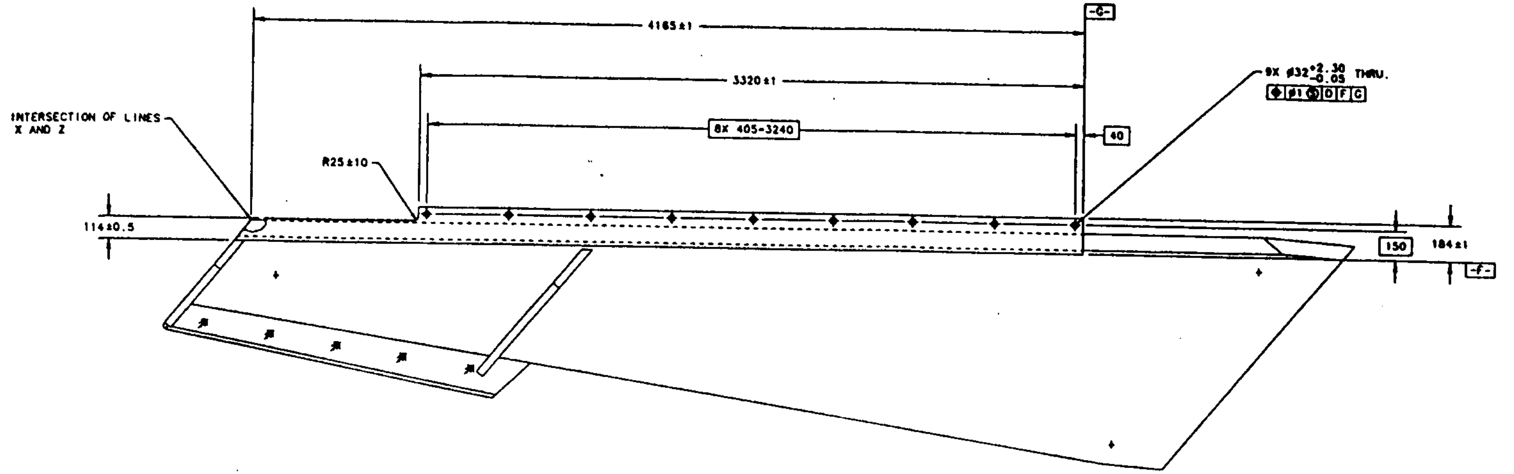
DRAWING NO AAA93-101891-0A

SHEET 1 OF 4

A — ITEM 2 REVISED AND ITEMS 5&6 ADDED

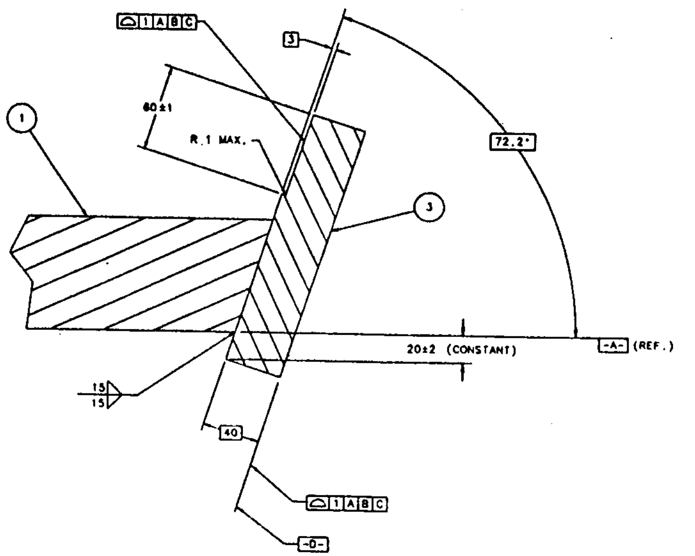
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



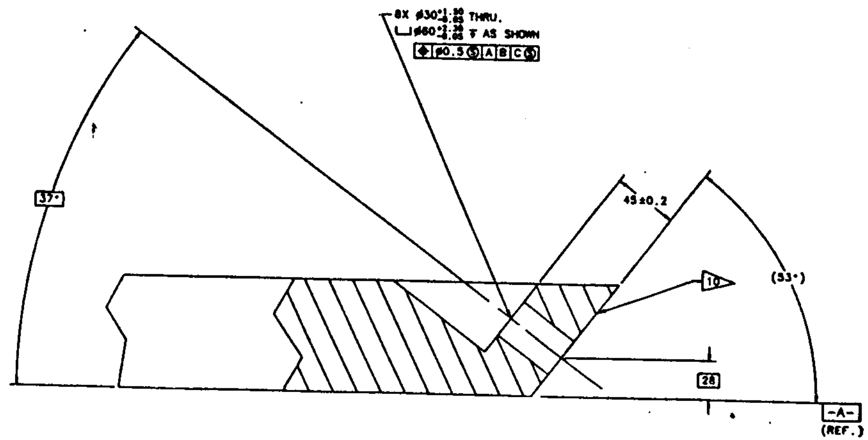
VIEW P-P (TRUE VIEW, DATUM SURFACE D)

(FROM SHEET 1) (VIEW ROTATED FOR CLARITY)



SECTION M-M (VIEW ROTATED FOR CLARITY)

(FROM SHEET 1)



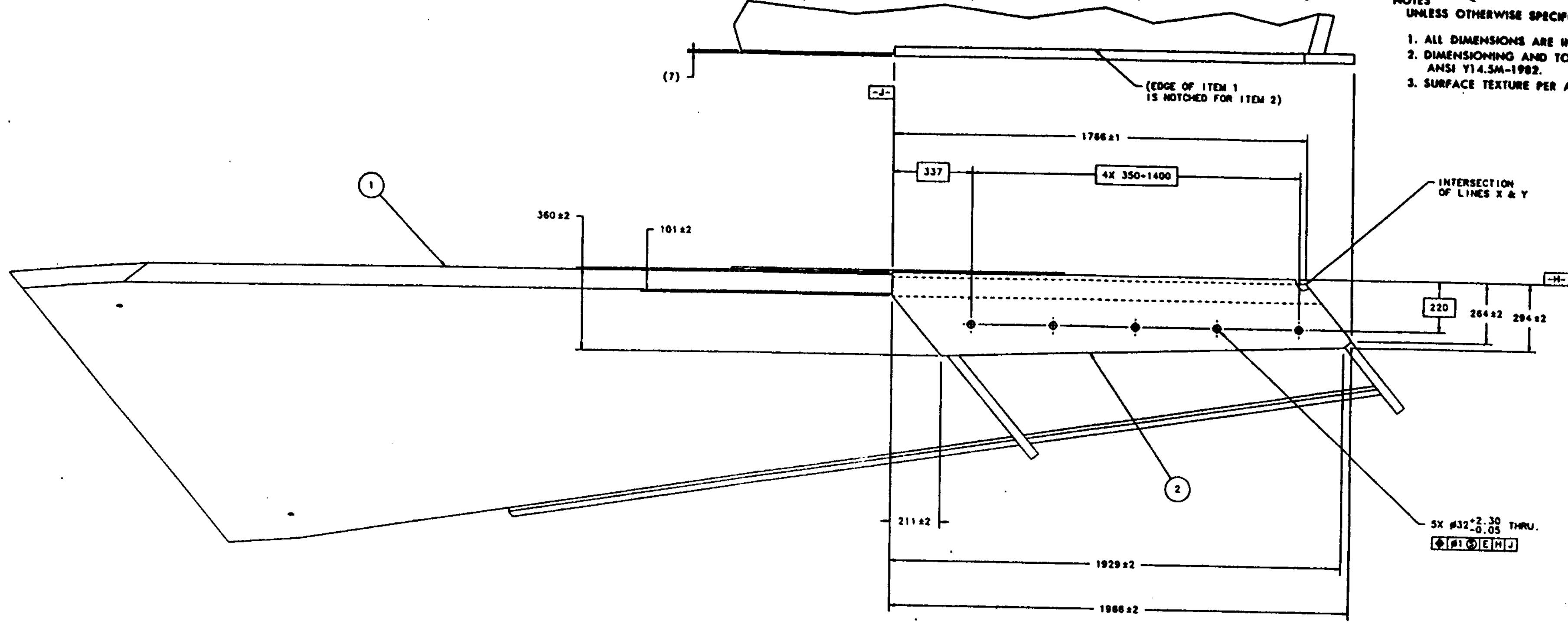
DETAIL S

(FROM SHEET 1)

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
DWN R. HOLMES	CLASSIFICATION	RELATIVISTIC HEAVY ION COLLIDER (RHIC)		
CHK	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. PRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	PHENIX MUON PISTON MAGNET		
APVD		LAMPSHADE PANEL NO. 3		
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA		DRAWING NO AAA93-101891-0A		
		SCALE	SHEET 2 OF 2	

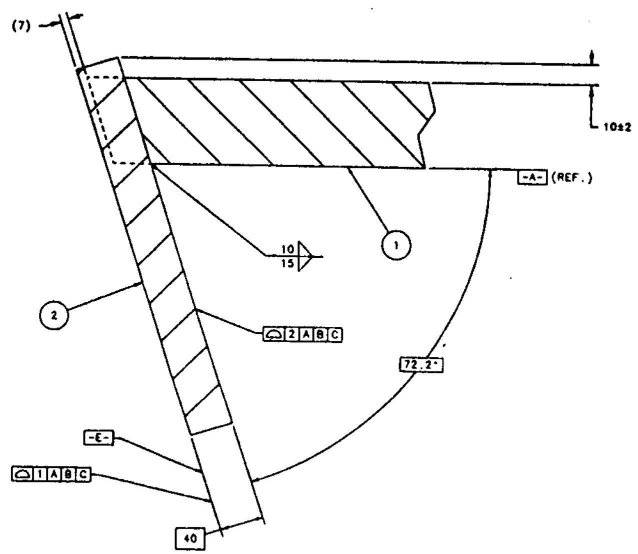
NOTES
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.



VIEW R-R (TRUE VIEW, DATUM SURFACE E)

(VIEW ROTATED FOR CLARITY)
(FROM SHEET 1)



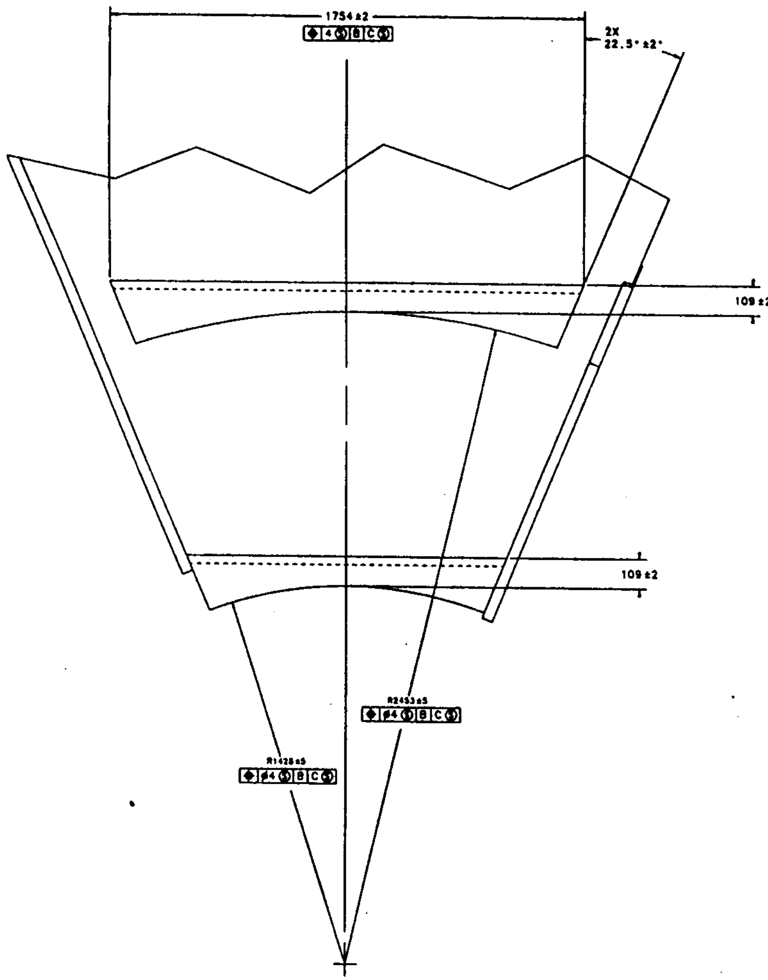
SECTION N-N (VIEW ROTATED FOR CLARITY)

(FROM SHEET 1)

NO REQD	PART / LINE STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
	DWN R. HOLMES 6/3/93	CLASSIFICATION	MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)	
	CHK	THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. PRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	SUBASSY: PHENIX MUON PISTON MAGNET	
	APVD		DETAIL: LAMPSHADE PANEL NO. 3	
	LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA		93-101858 DRAWING NO AAA93-101891-0A	
			SCALE — SHEET 3 OF 4	

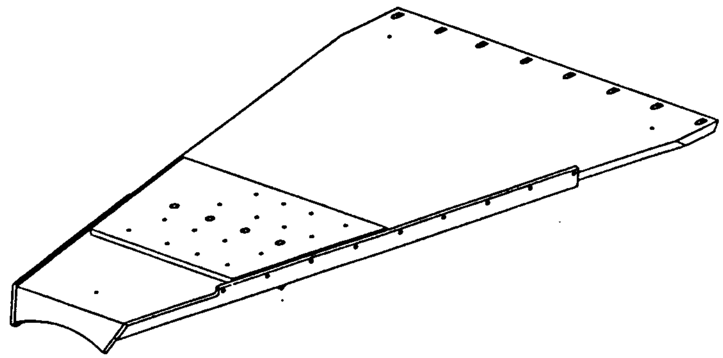
UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~ MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.

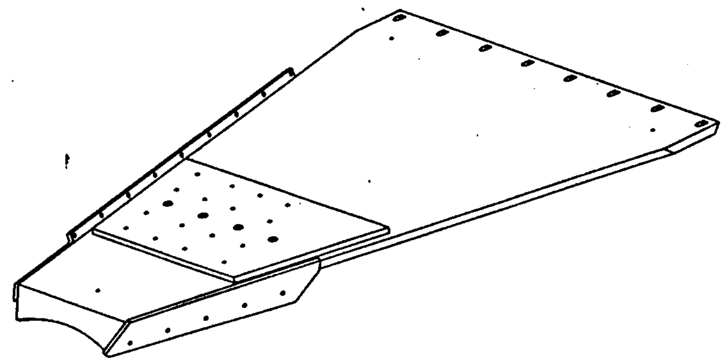


VIEW T-T (VIEW ROTATED FOR CLARITY)

(FROM SHEET 1, TRUE VIEW OR ITEMS 5 & 6)



VIEW OF LEFT HAND PART, TAB 01



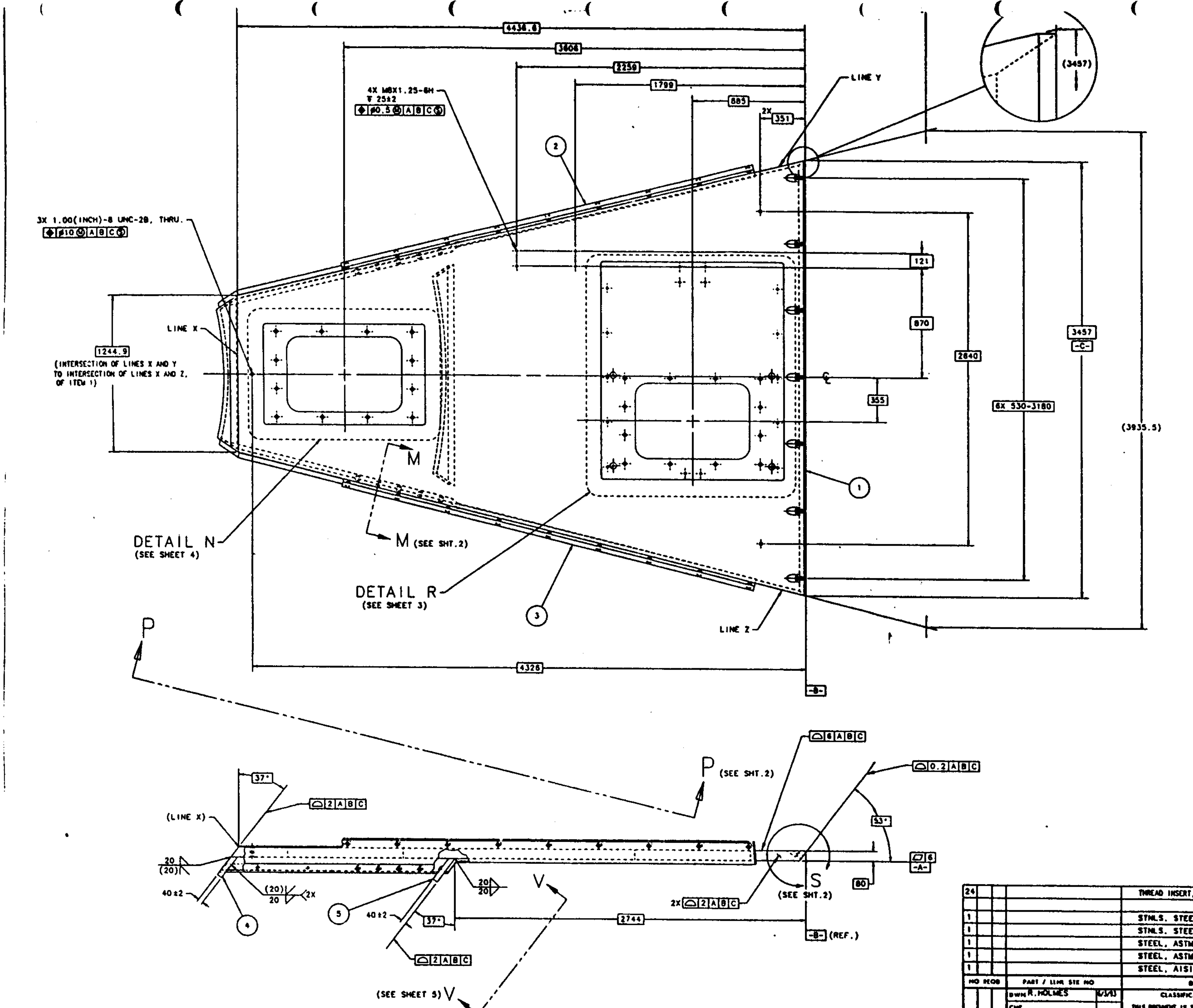
VIEW OF RIGHT HAND PART, TAB 02

NO REQD	PART / LINE SIZE NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM

DWN R. HOLMES	6/3/93	CLASSIFICATION	MAJOR UNIT: RELATIVISTIC HEAVY ION COLLIDER (RHIC)
CHK		THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. PRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	SUBASSY: PHENIX MUON PISTON MAGNET
APVD			DETAIL: LAMPSHADE PANEL NO.3
	DATE		SHOWN ON ASSY 93-101858
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA			DRAWING NO AAA93-101891-0A
			SCALE NONE — SHEET 4 OF 4

UNLESS OTHERWISE SPECIFIED:

1. ALL DIMENSIONS ARE IN ~~INCHES~~MM
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3. SURFACE TEXTURE PER ANSI B46.1-1978.
4. 3.2 ALL MACHINED SURFACES.
5. BREAK SHARP EDGES, CHAM. OR R 1 TO 2 MM
6. WELD SYMBOLS PER AWS 2.4, 1979.
7. WELDS PER ANSI/AWS D1.1
8. ALL WELDS TO BE MAGNETIC PARTICLE TESTED
9. PRIME AND PAINT PER LLNL SPECIFICATIONS.
10. DO NOT PRIME OR PAINT THIS SURFACE. (SEE DETAIL S, SHEET 2, AND SECTION T-T, SHEET 3, AND SECTION U-U, SHEET 4)



24		THREAD INSERT, STL., SELF TAPPING, M24 (ENSAT TYPE 302)			7
					6
1		STNLS. STEEL, TYPE 304L OR EQUIV.			5
1		STNLS. STEEL, TYPE 304L OR EQUIV.			4
1		STEEL, ASTM A36, OR AISI 1006, OR EQUIV.			3
1		STEEL, ASTM A36, OR AISI 1006, OR EQUIV.			2
1		STEEL, AISI 1006 OR EQUIV.			1
NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM

DWN R. HOLMES 6/3/93 CHK APVD CLASSIFIED BY REL	CLASSIFICATION THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. PRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT.	RELATIVISTIC HEAVY ION COLLIDER (RHIC) PHENIX MUON PISTON MAGNET LAMPSHADE PANEL NO. 4
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA		93-101892 DRAWING NO AAA93-101893-0A SCALE NONE SHEET 1 OF 5

A				8/7/93		REVISED DIMENSIONS, ITEMS ADDED
LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE