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|  <p style="text-align: center;">STANFORD LINEAR ACCELERATOR CENTER</p> <p style="text-align: center;">SPECIFICATION</p> <p style="text-align: center;">STANFORD SYNCHROTRON RADIATION LABORATORY</p> | | |
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| Author(s): Jack Tanabe, Nanyang Li | | Date: Aug. 29, 1999 |

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| First Line: SPEAR3 |
| Second Line: Magnet System |
| Title: Gradient Dipole Magnet Core Production |

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| <p>145D & 109D Dipole</p> <p>CORE</p> <p>Specification</p> <p>145和109D二极铁</p> <p>铁芯</p> <p>生产说明书</p> | Approved: SPEAR3 System Manager Richard Boyce |
| | Date: |
| | Approved: SLAC Magnet Group Leader Domenico Dell'Orco |
| | Date: |
| | Approved: IHEP Administrative Representative Yanling Jiang |
| | Date: |
| | Approved: IHEP Technical Representative Huamin Qu |
| | Date: |

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1. GENERAL / 概况

This document is presented in both English and Chinese text; in case of differences, the English version shall be used.

本说明一楹 杏00牧街治淖郑 纒街治淖钟肋环 一 杂00奈 肌一

1.1 Scope of the Specification / 说明书范围

This specification outlines the minimum requirements governing the acquisition of sheet steel, tooling, lamination punching and the assembly of the cores for the SPEAR3 prototype, 145D and 109D gradient dipole magnets. It defines the required inspection, and provides the general outline for the documentation required in order to maintain a quality assurance program during the fabrication.

本说明书概况了SPEAR3工程145D和109D梯度二极铁及其样机钢材，工装、芯片冲制和铁芯组装的基本技术要求。规定了检验项目和在生产中实施质量检验和监督的文件要求。

1.1.1 Applicable Documents / 使用文件

- Drawing PF 444-402-20 Gradient Dipole Core Lamination / 芯片图纸
- Drawing SA 444-402-55 Gradient Dipole Prototype Core End Stack Assembly / 样机铁芯叠片 端板安装
- Drawing SA 444-402-03 Gradient Dipole 145D Core Assembly / 145D铁芯组装
- Drawing SA 444-402-83 Gradient Dipole 109D Core Assembly / 109D铁芯组装

1.1.2 Reference Documents / 参考文件

- Drawing PF 444-402-56 Gradient Dipole Lamination Stamping Sheet Layout / 芯片冲制排样图
- Engineering Note M319 Gradient Dipole Magnet Engineering Design/ 梯度二极铁设计书
- Engineering Note M308 Gradient Dipole Magnet Core Assembly Procedure / 铁芯组装工艺
- Engineering Note M307 Gradient Dipole Magnet Chamfer Development Procedure/ 削斜工艺

1.2 Scope of Work / 工作范围

IHEP shall procure all required tooling including a die set. IHEP shall purchase all the steel sheet, plate and all fasteners and other commercial components required for core fabrication. IHEP shall stamp and sort all the laminations, fabricate all required parts and assemble the cores required for a prototype magnet, and production quantities of the 145D magnets and 109D magnets. IHEP shall provide all detail drawings required to fabricate the tooling and core parts, develop inspection documentation (travelers) for quality assurance and perform all Quality Assurance (QA) procedures.

高能所应负责包括一套冲模在内的所有工装的设计、制造。应一责铁芯制造所需钢材、板材和紧固件以及其他标准件的采购;负责所有样机和145D和109D批量二极铁所需芯片的冲制和掺和;还应负责所有零部件的设计和生 产。制订质量管理的文件(跟踪卡)和实施质量检测及监督。

1.2.1 Quantities / 数量

The number of cores required for the production quantities of the 145D and 109D dipoles, spares and prototype magnets are called out in Attachment 1 to the Inter laboratory Collaborative Agreement (ICA).

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样机和批量145D和109D二极铁铁芯所需数量以所间合作协议附件1为准。

2. TOOLING / 工装

2.1 Die Set / 冲模

The die set shall be designed, fabricated and assembled in such a manner that its life will be sufficient to stamp at least 150% of production required laminations. The die and punch parts will have sufficient material for the number of times it will need to be sharpened.

冲模的设计寿命应1.5倍于批量生产所需芯片总量。凸凹模刃口的高度应考虑到留有足够的修模余量。

2.1.1 Die Set Inspection and Sample Laminations / 冲模和样片的检验

The die set will be thoroughly inspected in order to assure that all dimensions and die and punch clearances are consistent with producing the required laminations to the dimensions, tolerances and burr specifications outlined in lamination drawing. After inspection of the die set and approval of sample laminations at IHEP, a IHEP measurement report for at least three sample laminations shall be sent to SLAC. Those three sample laminations shall be kept by IHEP. Another three laminations shall be delivered to SLAC for verification of dimensions. Punching of laminations for the prototype or for the production quantity of magnets using the die set shall not proceed until SLAC inspection is completed and approval has been obtained.

冲模应经详细检验，确保尺寸和凸凹模间隙使其能冲制出符合芯片图纸尺寸和毛刺公差要求的芯片。高能所验模和通过样片检验之后，至少应向SLAC递交3张芯片的检验报告。高能所应妥善保存该3张芯片，另寄三张样片给SLAC核检。在SLAC核-穀ù 聘隼粗 埃 团 刻-芯片的冲制不得开始。

2.2 Core Compression Tooling / 叠片工装

IHEP shall design and fabricate all the tooling required to assemble and compress the core to the required tolerances defined in the core assembly drawings. IHEP shall purchase all necessary components and devices required to compress the cores before assembly.

高能所应设计和制造叠片工装，工装应保证能加工出符合铁芯组装图所标明的技术要求的铁芯。高能所应采购工装所需的一切元件和仪表。

2.3 Core Assembly Tooling / 铁芯组装工装

A procedure has been developed and used at LBNL and SLAC for the fabrication of large cores for magnets which avoids welds and the distortions due to welding. SLAC recommends IHEP to adopt this procedure for SPEAR3 gradient dipole core assembly. The suggested procedure is described in the Engineering Note M308 "Gradient Dipole Magnet Core Assembly Procedure". This procedure requires tooling for applying a steel loaded epoxy (brand name Devcon) after the core is compressed, fastened and dowelled to fix the laminations to the assembled frame. IHEP shall purchase the tooling required for applying this material.

LBNL和SLAC开发了一种组装大型铁芯的新工艺，以避免采用焊接工艺造成的焊接变形。SLAC建议高能所在SPEAR3梯度二极铁铁芯组装时采用这一工艺。该一艺详述于工程设计说明书M308“梯度二极铁铁芯组装工艺”。此种工艺需使用一种工具，用以在铁芯叠压好，并紧固和锁定在外板框架后，向铁芯填充加铁环氧。高能所应购买这种工具。

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2.4 Handling Equipment / 起吊工一

The weight and size of the core makes it difficult to handle, lift and turn. During the core assembly procedure, it will be necessary to lift and turn the core several times. IHEP shall design lifting devices and procedures so that the core can be lifted in a manner to safeguard both the core in various stages of manufacture and personnel working on the core assembly.

铁芯在安装过程中，需多次起吊和翻转。但是铁芯的重量和尺寸使操作十分困难。高能所应设计—
惶灼鸬豕ぶ昂凸ひ眨 固 驹溢圃旄鸬锥蔚钠鸬嵯头 —都能保证其本身和操作人员的安全。

3. MATERIAL / 材料

IHEP shall procure all material required for the fabrication of the quantity of cores specified in 1.2.1. 高能所应采购生产1. 2. 1款所规定铁芯数量需要的所有材料。

3.1 Steel Sheet for Laminations / 芯片钢板

3.1.1 Material Radioactivity Measurement/ 材料放射性测量

There is no radioactivity above background level shall be present in steel sheet used for dipole lamination punching, i.e. the measurement should be within background + 2 standard deviations. Measurements of all material heats shall be recorded.

所有用于二极铁芯片冲制的钢板都应做放射剂量 测量，任何一组钢板都不应测出高于本底 剂量的放射物含量，也就是测得的剂量应为本底（环境）剂量+2个标准误差。测量结果应作记录。

3.1.2 Material Specification / 材料检验

The following section describing the requirements for the sheet steel had previously been negotiated with IHEP for the purchase of standard magnetic sheet steel for the PEPII Low Energy Ring (LER) quadrupole and dipole core fabrication. It is understood that this same material is available from Chinese steel manufacturers. It is the intention of this specification to ensure that material with magnetic performance and ease of stamping and fabrication be used which is at least equal to the sheet steel used for the PEPII LER magnet core fabrication. The sheet steel shall be standard IHEP coated magnet lamination steel, DW540G-50. IHEP shall purchase the sheet steel and define and carry out the acceptance tests for the sheet steel described in sections 3.1.2.1, 3.1.2.2, 3.1.2.3, 3.1.2.4 and 3.1.2.5 of this specification. IHEP will submit the final technical specification for the steel purchase to SLAC for approval prior to placing the order.

以下重复了PEPII低能环磁铁工程时高能所使用钢材的技术要求，据悉这种材料目前仍能购得—
—固以PEPII低能环磁铁工程钢板各项技术指标为本说明依据。SLAC所用钢板的磁性能和机械性能至少要等同于这些指标。钢板为DW540G50加涂高能所标准涂料。高能所应采购钢材和制
订符合本说明3.1.2.1.1,3.1.2.2,3.1.2.3, 3.1.2.4和3.1.2.5各款的验收指标，并实施检验。

3.1.2.1 Chemical Analysis / 化学成分

The chemical analysis after all processing shall be (maximum):

经各处理过程后，钢板的化学成分应为：（表中指标为最大值）

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|--------|------|------|-------|--------|------|
| C | Si | Mn | P | S | Al |
| 0.007% | 0.8% | 0.3% | 0.08% | 0.007% | 0.4% |

A certified chemical analysis shall be furnished.

需附正式检验报告。

3.1.2.2 Magnetic Test Samples / 磁测样片

Total about 27 Epstein samples (50% parallel and 50% perpendicular to the rolling direction) shall be assembled from strips collected from every 20 packages from different heat of the material used for the dipole production. Magnetic permeability and coercive force measurements shall be made using these samples as outlined in sections 3.1.2.3. After testing, the samples shall be kept at IHEP for SLAC possible later re-testing to verify the measured properties.

二极铁生产所用钢板，每20包出自不一炉的钢板应从其中一包剪取三张Epstein样片（50%平行，50%垂直于轧制方向）。二极铁大约共取27张样片。用这些样片按3.1.2.3款要求测试磁通量和矫顽力。测量后，样片要保留在高能所，以备SLAC日后复检。

3.1.2.3 Magnetic Properties Test / 磁性能测试

The Epstein samples described in 3.1.2.2 shall be measured at an excitation of $H_m = 100$ oersted, the magnetic induction B shall be at least 17,900 gauss. After excitation to $H_m = 100$ oersted, the excitation shall be reduced to zero and the coercive force H_c shall be measured and shall not exceed 2.0 oersted. The variation of coercivity through the whole delivery of steel sheet must stay within ± 0.1 oersted.

在激磁 $H_m=100$ 时测试3.1.2.2款所述Epstein样片的磁感应强度 B ，其值不应小于17,900高斯。在激磁强度达到100奥耳斯特后，回零，测量此时的矫顽力。其值不应超过2.0奥耳斯特。所有样片矫顽力的偏差不应大于正负0.1奥耳斯特。

3.1.2.4 Crown and Thickness / 同板度和厚度公差

Three 1 meter long x 20 mm wide strip will be cut from both ends and the center of a sheet from each steel sheet package used for the dipole production. The strips shall be cut so that the 1 meter dimension is cut from the 1 meter face of the 1 x 2 meter sheet. Measurements of the crown and thickness variation across the sheet width will be made for each of the nine samples. The thickness variation across the sheet shall not exceed 0.05 mm. The crown shall not exceed 0.03 mm.

二极铁生产所用的每包钢板都应取一张钢板裁样。样片应在沿钢板长度方向的两端和中间裁取，其宽度为20毫米。每张板三条(1mx0.2m)样条，测同板差和厚度差。同板差不应大于0.03毫米，厚度差不应大于0.05毫米。

3.1.2.5 Hardness / 硬度

Material from the head, center and tail of each heat shall be tested for hardness. All material shall have hardness on the Rockwell scale of B 56 to 90 (HV 90 to 180).

每炉钢头、尾，中所轧材料都应测量硬度，所有材料的硬度值都应在洛氏B56-90(HV90-180)的范围内。

3.1.2.6 Coating / 涂层

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The sheet steel shall be supplied with 0.005 mm thick inorganic or semi- inorganic insulation. This coating is offered by IHEP as a component of standard Chinese magnet steel.

钢板的表面应有0.005毫米无机或半无机涂料。该涂层是为高能所提供的中国标准磁性板材成分。

3.1.3 Quantity of Lamination Steel Required / 芯片钢板数量

IHEP shall purchase sufficient material to provide for loss, waste and other contingencies beyond the amount required for the specified number of required magnet cores. This amount should exceed the minimum amount required for the specified number of required magnet cores by no less than 10%.

高能所采购的板材数量应考虑丢失、损耗和其他意外情况。额外材料的数量应至少为铁芯生产最低总需量的10%。

3.1.4 Sheet Size / 钢板规格

Each sheet will be 1 m x 2 meters will be flat have a nominal thickness of 0.5 mm.

钢板规格为1米x2米x0.5毫米平板。

3.1.5 Packaging and Labeling / 包装和标记

All steel shall be packaged to protect the sheets against moisture during shipment and storage. The packages shall be properly labeled to indicate the heat number. The label shall be placed so that identification is possible when the packages are stacked. The packages shall be suitably stacked and braced to prevent bending or damage during handling, shipment and storage.

钢板的包装应能在运输和储存的过程中防潮。每包钢板应标明炉号、标号应位于码放储存时的易见位置。钢包的打包和码放应防止其在运输、储存和起吊过程中被压弯或损伤。

3.1.6 Documentation / 文件

IHEP shall keep original acceptance reports covering all tests required in 3.1.2.1 through 3.1.2.5, but will forward their copies to SLAC along with the steel sheet payment invoice.

高能所应保存条款3.1.2.1至3.1.2.5中所规定的各项检测的原始报告，将其复印件随钢材付款收据一并交SLAC。

3.2 Steel Plate for End Plates, Top, Bottom and Back Plates / 框架外板材料

Steel Plate for the Fabrication of the two end plates, the top, bottom, back and front plates shall have equivalent chemical and mechanical properties specified for AISI 1020 Carbon steel.

制造铁芯框架外板的钢板的化学成分和机械性能应等同于美国1020碳钢。

3.3 Steel Loaded Epoxy (brand name Devcon) / 加铁环氧

The US made Devcon,

- Tradename: Plastic Steel Liquid (B) Resin;
- Retailer: E. V. Roberts & Associates, Inc.

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General offices:

8500 Steller Dr., P.O.Box 868, Culver City, CA 90232

Telephone: (310) 204-3159 or 1-800-374-3872

Fax (310) 839-9427

shall be used for core assembly.

铁芯组装应使用美- 募犹 -氧。

- 商品名称: Plastic Steel Liquid (B) Resin;
- 销售商: E. V. Roberts & Associates, Inc.

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4. LAMINATIONS / 芯一

4.1 Prototype Magnet Laminations / 样机芯片

The prototype magnet laminations shall be punched from material DW540G-50 that is left over from SLAC PEP II magnet project and already available at IHEP.

样机芯片应用高能所现存SLAC PEP II 磁铁工程剩余 DW540G-50 钢板冲制。

4.2 145D and 109D Core Laminations Punching / 145D和109D铁芯芯片

Sufficient number of laminations shall be stamped for 145D and 109D dipole magnets to provide for damage, loss or other contingency.

冲制芯片的数量除保证145D和109D二极铁的生产需要外, 还应有足够的余量以补偿损坏、丢失和其他意外的额外需要。

4.3 Lamination Stamping and Inspection / 芯片冲制和检验

Prior to core fabrication, laminations for the entire required quantities of the 145D and 109D dipole cores must be completed. The laminations must be periodically inspected in order to ensure adherence to both dimensional and burr tolerances.

145D和109D二极铁铁芯叠装之前, 两种铁需要的所-行酒 家 逮仆瓿稀P酒 逮乒 -中要定期检验, 确保尺寸和毛刺达到公差要求。

4.3.1 Burr Inspection / 毛刺检验

Stamped laminations shall adhere to the burr requirements outlined in drawing PF444-402-20. Burr inspections shall occur at frequencies determined by IHEP but not less than one lamination per steel package of 320 sheets. Should the burr exceed the drawing requirement, all laminations punched after last inspection shall either be rejected or deburred and the die and punch shall be re-sharpened.

芯片的毛刺要符合图纸PF444-402-20的要求。毛刺检验周期由高能所决定, 但不得短于每320张-话-的钢板抽检一张芯片。如果毛刺超过标准, 自前次检验以后所冲的芯片应予报废或去毛刺处理。模具刃口要修磨。

4.3.2 Inspection after Die Re-Sharpening / 修模后检验

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Three (3) sample laminations shall be inspected after each die or punch re-sharpening. If IHEP determines that the sample laminations satisfy dimensional and burr tolerances, stamping may proceed without SLAC approval. All sample laminations and inspection records shall be forwarded to SLAC.

每次修模或修磨刃口后，高能所应全面检测三张芯片。如检-久细癩 心琴 勺孕芯韶q -冲而不需获SLAC批准。所有样片和检测报告需送SLAC。

4.3.3 Lamination Gap Inspection / 芯片契隙检测

The gap in the “C” shape gradient magnet lamination is critical to the field quality and the reproducibility of the excitation from magnet to magnet. The gap size of the lamination may be affected by the release of rolling stress locked into the steel sheet material. This stress may vary between various batches of material used for stamping.

梯度二极铁的“C”型契隙对场的质量和铁间励磁强度的一致性至关重要。芯片契隙尺寸可能会受到钢板内应力的影响。该内应力会因所用钢板的批量不同而各异。

4.3.3.1 Gap Inspection / 契隙检测

The first lamination stamped from the first sheet of a package shall be inspected to determine the gap size prior to stamping the laminations from that package. A package is chosen as the means for determining the inspection frequency since all the material in a package will share the same chemistry and mechanical properties. The minimum gap at the throat of the lamination must satisfy the tolerance given in drawing PF 444-402-20. The measured data shall be recorded in the traveler.

每包钢板的第一张芯片都应检测契隙尺寸，检测结果合格之前，该包钢板不可开冲。以包为单位检验契隙是因为同包钢板的化学成分和机械性能应-襟且恢碌摹P酒 -契隙处尺寸应符合图纸PF 444-402-20要求。测量尺寸记入跟踪卡。

4.3.3.2 Pre-punching / 释放应力预冲

If the inspection described in 4.3.3.1 indicates that the gap tolerance is not met in the first lamination from a steel sheet package, the material in the package shall be set aside and pre-punched to remove some of the material from the throat region and release the stress prior to stamping the laminations from the material in the package.

如4.3.3.1款检测显示一包钢板的头一张芯片的契隙尺寸- -，此包钢板应搁置一旁，将该包内每一张板材芯片契隙部分的材料预冲开口，以释放材料的内应力。

4.3.4 Periodic Dimension Inspection / 尺寸定期检测

The total number of laminations required for the prototype and full production quantities of the 145D and 109D dipoles will exceed 100,000 laminations. After punching **10,000** and **80,000** laminations, three laminations shall be fully inspected for burrs and measured by IHEP for adherence to the lamination drawing tolerance.

145D和109D样机和生产铁所需芯片数量将超-整 蚱 T 诀速-一万片和八万片芯片之后，高能所要各全面检测三张芯片。

4.3.4.1 Approval / 核准

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If IHEP determines that sample lamination dimensional and burr tolerances are met, stamping may proceed without SLAC verification and approval. All sample laminations and inspection reports shall be delivered to SLAC for verification of dimensions.

如高能所认为检验结果证明芯片尺寸和毛刺均达到要求，可继续冲片，不必得到SLAC的批准。所有样片和检测报告送SLAC复审。

4.3.4.2 Adjustments/Repairs / 调模或修模

If IHEP determines that the dimensional and/or burr tolerances of the sample laminations are not met, SLAC shall be informed and the stamping will be stopped until appropriate repairs or adjustments are made to the die set and a new set of sample laminations are inspected and approved.

如果检测结果表明尺寸和/或毛刺超标，应立即通知SLAC，并停冲进行调模或修模，直至新的一组样片检测获合格为止。

4.3.5 Inspection Record / 检验记录

All items described in section 4.3 shall be inspected and recorded. Inspection sheets (travelers) shall be devised by IHEP and approved by SLAC. The information in these travelers shall include at minimum the following data:

- Steel sheet package number.
- Lamination Punching Serial Number.
- Burr size(s) if exceed the tolerance, its (their) location on the lamination.
- Gap dimension.
- Names of inspector.
- Date of inspection.
- CMM report.

款4.3所列各项内容均应检验并作记录。芯片检验跟踪卡应由高能所提供，交SLAC批准。芯片的跟踪卡至少应含以下内容：

- 钢包号
- 芯片冲制序号
- 毛刺尺寸，如— 睿 际驹谛酒 系奈恢—
- 契隙尺寸
- 检验员姓名
- 检验日期
- 三坐标检验报告

4.3.6 Handling and Storage / 操作和存放

Adequate care should be taken in order to avoid bending or otherwise damaging laminations during handling, sorting or storing. Laminations should not be stored on an uneven or soft surface. Bent, rusted or otherwise damaged laminations shall be discarded.

芯片的冲制、惨和及存放过程应十分小心。芯片绝不应堆放在不平或松软的表面。弯折、锈蚀或有其他损伤的芯片应报废。

5. CORE FABRICATION / 铁芯组装

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5.1 Prototype / 样机

5.1.1 Prototype Core Lamination Sorting / 样机铁芯芯片掺和

The lamination for prototype need not be sorted.

样机芯片不需掺和。

5.1.2 Prototype End Pack / 样机端板

The prototype core design is different from the design of the production cores. Its length will be the same as the 145D magnet core. However, the glued end packs will be machined, drilled and tapped in such a manner so that pole end inserts can be installed on the top and bottom pole (four insert locations on the prototype). At least sixteen (16) pole end inserts shall be cut from solid AISI 1010 low carbon steel plate or equivalent. A chamfer shape for the first four inserts shall be determined using preliminary magnetic measurement results on the assembled prototype using unchamfered inserts. This shape shall be machined on the four original inserts. These machined inserts shall be installed on the prototype magnet. The measurement, chamfer definition, and chamfer machining cycle will be repeated until a chamfer is determined which satisfies the field integral uniformity requirement for the SPEAR3 lattice. It is anticipated that this should take two iterations. However, this specification calls for enough inserts to perform four iterations. Details for this process are described in the Engineering Note M307 "Gradient Dipole Magnet Chamfer Development Procedure".

样机的铁芯设计不同于批量铁的设计。样机长度与145D铁相同，但是粘接端板上加工有螺孔和凹台，活极头可镶在粘接端板的上下极面上（样机共四个活极头）。至少要预先用1010低碳钢或同等材料加工出16个备用活极头。样机首先安装未经加工的活极头，磁测后，用该组测量数据决定第一套削斜活极头的几何尺寸。将这第一组削斜活极头装入端板，如此反复循环：测量、确定下轮削斜形状、加工活极头，直至达到SPEAR3拉梯斯设计要求的二极铁积分场均匀性指标。预计两个循环后，应能得到削斜最佳方案。本说明要求的活极头数量可供四个试验循环之用。详细步骤参见工程设计书“梯度二极铁端部削斜实验工艺”M307。

5.2 Production Dipole / 批量二极铁

5.2.1 Core Lamination Sorting / 铁芯芯片掺和

IHEP shall design a lamination shuffling plan and supply to SLAC for approval before lamination punching production.

The laminations for all required 145D and 109D dipole magnet cores including end packs must be sorted prior to start of assembly of the first dipole core. Prior to sorting, the pallets onto which the laminations are sorted shall be clearly marked with a sequential dipole core serial number (145D 01-30, 109D 31-40). Additional laminations shall be sorted in case of the possible rejection of end pack(s) or core(s). The package numbers of all steel sheet packages used to punch the laminations has to be recorded.

高能所应制订芯片掺合方案，在芯片冲制开始前交SLAC审核。

145D和109D二极铁开始叠装—谝蒙檣 埃 糜溢圃炯 —145D和109D铁铁芯包括叠片端板的芯片都应掺和完毕。在掺和开始之前，所有用于码放掺和后芯片的架子（箱子）应逐一—二极铁铁芯生产序号标明（145D01至30，109D31至40）。高能所还应掺和一定数量

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的额外芯片，以防可能出现的叠片端板或铁芯的报废。所有冲制磁铁、酒、钢板包号应有记录。

5.2.2 End Packs / 端板

5.2.2.1 Stacking and Gluing / 叠压和粘接

The laminations for the two end packs required for each dipole shall be carefully cleaned to remove any oil or grease, coated using thermal setting epoxy and compressed from the stack of sorted laminations for each magnet core. The laminations for the end packs shall be flipped about their centerline called out in end pack drawing in order to ensure symmetry. The glued end packs shall be cured using IHEP suggested curing cycle for an IHEP selected epoxy formulation. IHEP shall supply the epoxy formula to SLAC for approval before the prototype fabrication.

每个铁芯两块端板的芯片应取自该铁芯的掺和芯片，粘接前应经彻底去油污，热固化环氧涂膜处理，然后叠压。所用芯片应按叠片端板图纸要求以中心线为轴翻转，以保证叠装的对称性。粘接好的端板应按高能所为其所选环氧制订的固化工艺进行固化处理。高能所应提供所选环氧配方，在样机制造前交SLAC核准。

5.2.2.2 Identification / 标号

The cured end packs shall be marked with permanent ink with a production serial number at a location, which will be clearly visible after machining.

固化后的端板应在不加工位置用永久颜料清楚标明该端板的生产序号。

5.2.2.3 End Chamfer Machining / 端板加工

The end chamfer shape determined from the prototype studies shall be carefully machined on both poles of the end packs. The end pack should be carefully mounted on the machine tool in order to maintain top to bottom symmetry of the chamfer cut. The tool cutting depth and feed speed during the machining process shall be carefully determined to avoid excessive heating which can delaminate the glued end packs. IHEP shall develop a procedure to measure the chamfer dimensions. Should the chamfer dimensions exceed the tolerance, the end pack shall be re-machined or rejected. The measured data shall be recorded in the traveler.

端板上下极头应根据样机确定的端部削斜形状进行机加工。端板在加工机床上的定位和固定十分重要，应确保上下削斜的对称性。要小心确定加工过程中的进刀深度和速度，以避免过热而造成粘接端板芯片剥离。高能所应设计测量削斜尺寸的方法。如削斜尺寸超差，端板应重新加工或报废。检验数据应记入跟踪卡。

5.2.2.4 Inspection Record / 检验记录

Inspection sheets (travelers) shall be devised by IHEP and approved by SLAC. The information in these travelers shall include at minimum the following data:

- End pack serial number.
- Numbers and weight of laminations.
- End chamfer measurement data.
- End pack thickness.
- Names of inspector.

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- Date of inspection.

检验报告应由高能所一杓平簠LAC批准。端板跟踪卡应至少包括以下内容：

- 端板序号
- 芯片数量和重量
- 削斜尺寸
- 端板厚度
- 检验员姓名
- 检验日期

5.2.3 Core Stacking, Compression and Assembly / 铁芯叠压和组装

5.2.3.1 Lamination Flipping / 芯片翻转

The core shall use the laminations presorted for that core. To achieve core symmetry, laminations shall be flipped about their centerline at an interval called out in the core assembly drawing. The laminations at the interfaces between flipped laminations shall be deburred to assure good compression at the interface where burrs face each other and cannot nest.

铁芯应使用为该铁芯预掺和好的芯片。为保证对称性，芯片应按铁芯组装图纸要求沿中心线按叠翻转。为保证叠压精度，翻转擦之间，面面相对的芯片应去毛刺，以避免毛刺相对难以压紧。

5.2.3.2 Stacking Procedure/ 压紧

A specific instruction of gradient dipole core stacking procedure is described in the Engineering Note M308 “Gradient Dipole Magnet Core Assembly Procedure”.

工程说明书M308“梯度二极铁铁芯组装工艺”中详细说明了铁芯叠装工艺。

5.2.3.3 Stacking Core Quality/ 叠装质量

5.2.3.3.1 Packing Fraction / 叠装系数

Weigh only the laminations and partial laminations finally used in the core assembly and compare this weight to the weight of the lamination length of a core made from solid iron. The ratio of these weights shall be the packing fraction. The desired packing fraction for the cores shall be $> 97.5\%$. Because the coating thickness will effect the accuracy of the laminated core weight, this measurement will be considered as a secondary method for monitoring the packing fraction. Primary method for monitoring packing fraction will be Compression Young’s Modulus at the final compression stage as state in Engineering Note M308.

叠装所用的所有芯片和半芯片都应称重，将其总重量，且只限于这些芯片的总量与同样长一
 鹊氛敌奶 局示肯啾冉希 秸咧 戎导次 跋凳 F 涓 ∑ 恍 † $>97.5\%$ 。由于涂层积
 累厚度的重量，这一方式确定的叠装系数只可作为参考数据。第一位检验叠装系数的
 方式是参照工程技术说明书M308所述监测最终压力时的杨氏弹性模量。

5.2.3.3.2 Notification / 情况通报

If the packing fraction goal is not met for a core, IHEP should notify SLAC immediately and core assembly should be suspended until agreement can be reached as to whether to

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accept a lower packing fraction or means of increasing the packing fraction can be mutually agreed upon.

如果叠装系数达不到要求，高能所应立即通知SLAC- (9) V 股 敞了 骄腿缩胃慕-叠装方式提高叠装系数或接受低叠装系数达成协议。

5.2.3.3.3 Length and Squareness / 长-群途匪味-

The tolerances shown in core assembly drawing for length between the end pack faces, squareness and parallelness of the end plate faces shall be satisfied. If the crown or other variations in lamination thickness makes meeting these tolerances difficult, it is permissible to insert partial laminations. These partial laminations should be carefully aligned in order to avoid any discontinuities at the core pole surfaces.

应保证铁芯组装图纸要求的叠片端板间的长度、铁芯矩形度和端板平行度等公差。如果芯片的厚度或同板度误差使得这些要求难以达到，可以加半芯片。这些增加的半芯片的位置应很讲究，应绝对保证铁芯极面的连续性。

5.2.4 Final Core Assembly / 铁芯总装

A suggested core assembly procedure is described in Engineering Note M308. The final procedure shall be determined by IHEP in collaboration with SLAC staff.

工程设计说明书308中提供了一个铁芯总装建议方案。最后采用工艺由高能所人员经与SLAC有-盾嗽碧致鄂笕范a -

5.2.5 Painting / 喷漆

All dipole core assemblies shall be painted. All painted surfaces shall be primed with Rustoleum or Chinese equivalent metal primer before application of the final colored coat. SPEAR3 gradient dipole color is red. A sample shall be delivered to SLAC on a painted 6 x 6 (cm) piece of lamination steel for approval prior to painting of the production cores.

所有二极铁铁芯都需喷漆。所有喷漆表面在上色漆之前，应加涂Rustoleum或中国等同成分的防锈底漆。SPEAR3梯度二极铁漆色为红色。高能所应提供一块6X6喷漆样品，在批量铁芯正式喷漆开始之-敖霍LAC核准。

5.2.6 Unpainted Surfaces / 不喷漆表面

All specified non-painted surfaces shall be protected with rust preventative such as Lps-3 rust preventative oil or equivalent. For a Chinese equivalent rust preventative, IHEP shall submit a sample to SLAC for final approval.

所有不喷漆表面应喷涂Lps3防锈油或等同材料。如果选用中国产品，高能所应先提供样品交SLAC核准使用。

5.2.7 Identification / 身份号

Each dipole core shall be identified with a unique number. The number shall be marked on the solid plate in a location, which shall be visible after the magnet assembly. The identification number shall consist of two (2) components: Family of dipole and Production serial number. The 145D and 109D dipole core shall share the same production serial number.

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XXX
XX
 145 or 109 ———— Production Serial No £" 01-40£©

每块二极铁铁芯应指定一归其独有的身份号。该身份号应打在实心外板总装后可见的位置。身份号应由两部分组成：二极铁类别和生产序号。145D和109D两种二极铁应采用统一生产序号。

6 QUALITY ASSURANCE, INSPECTION AND DOCUMENTATION / 质量保证、检验和文件

An inspection sheet (traveler) shall be devised by IHEP and approved by SLAC. This traveler shall include pertinent fabrication parameters and inspection data. The information in the traveler shall include at minimum the following data.

- Core Serial Number.
- End Pack Serial Number.
- Laminated Core Length.
- Number and weight of Laminations.
- Computed packing fraction (laminations weight divided by solid core weight).
- Compression pressure.
- Compression Young's Modulus at the final compression stage.
- Surface flatness.
- Core squareness.
- Names of technicians assembling the core.
- Date of Core assembly.

高能所应设计铁芯总装质量检验跟踪卡，并交SLAC核准。跟踪卡应包括适当的生产数据和检验数据。其包括内容至少如下：

- 铁芯序号
- 端板序号
- 迭片铁芯长度
- 芯片数量和重量
- 计算叠装系数（芯片实际总重与假设为实心材料铁芯重量之比）
- 最终叠装压力
- 最终压力时杨氏弹性模量
- 一求面平直度
- 铁芯矩形度
- 操作人姓名
- 实施日期

6.1 Filling out the Traveler / 填写跟踪卡

The traveller shall be filled out, signed and dated by the technicians performing the assembly and/or inspection of the core and signed and dated by the technician supervisor signifying approval of the core for final magnet assembly.

跟踪卡应由生产和检验人员填写并签字，并经有关负责人签批转磁铁总装工序。

6.2 Traveler Original / 原始文件

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The original of the completed, signed and approved traveller shall accompany the core until final magnet assembly. After magnet assembly, the completed original traveler should be filed at IHEP.

填写和签批完毕的原始跟踪卡应随铁芯周转，直至最后的总装工序。在磁铁总装完后，原始文件-

6.3 Traveler Copies / 复印件

A copy of a traveler for each core shall be packaged with other completed travelers for each completed magnet and delivered to SLAC along with the magnet or mail to SLAC following the magnet being shipped out of IHEP.

每块铁芯的跟踪卡的复印件应与完工磁铁的其他跟踪卡的复印件一并汇总，随磁铁发往SLAC，或-