Argonne National Laboratory

9700 Cass Avenue

Argonne, Illinois 60439

DOCUMENT NO. L143-00030

SLAC NO. SP-381-001-00

STATEMENT OF WORK

FOR

LCLS UNDULATOR STRONGBACK

WBS L.1.04.03

Prepared by Glen S. Lawrence Date 10 Sept 2004
Originator

Approved by Patric Den Hartog Date 13 Sept 2004
XFE Group Leader

Approved by Thomas Barsz Date 13 Sept 2004
QC Coordinator

Approved by Marion White Date 14 Sept 2004
LCLS Undulator CA Manager

Approved by Stephen Milton Date 15 Sept 2004
LCLS Project Manager

***The document number as it appears on this page only shall be used to identify this document. The last two digits denote the revision number of this document (see Revision Authorization block below).**

This document is fully representative of the Document No. only when the revision number on its pages correspond with those in the index below.

INDEX OF PAGE REVISIONS

(INDEX)

PAGE NO.	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
REV. NO.	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01

PAGE NO.	16	17	01	02	03	04	05	06	07	08	09	10	11	12	13
REV. NO.	01	01	02	02	02	02	02	02	02	02	02	02	02	02	02

PAGE NO.	14	15	16	17	01	02	03	04	05	06	07	08	09	10	11
REV. NO.	02	02	02	02	03	03	03	03	03	03	03	03	03	03	03

PAGE NO.	12	13	14	15	16	17	01	02	03	04	05	06	07	08	09
REV. NO.	03	03	03	03	03	03	04	04	04	04	04	04	04	04	04

PAGE NO.	10	11	12	13	14	15	16	17	18	01	02	03	04	05	06
REV. NO.	04	04	04	04	04	04	04	04	04	05	05	05	05	05	05

PAGE NO.	07	08	09	10	11	12	13	14	15	16	17	18			
REV. NO.	05	05	05	05	05	05	05	05	05	05	05	05			

REVISION AUTHORIZATION

REVISION NUMBER	00	01	02	03	04	5	06	07	08
DCN NUMBER	040908-03	041201-06	050107-03	050203-02	050714-02	050825-07			
DATE	09/03/04	12/01/04	01/07-05	02/03/05	07-14-05	08-25-05			
APPROVED BY	LP	GSL	GSL	GSL	GSL	GSL			

TABLE OF CONTENTS

1.0 INTRODUCTION:

The Linac Coherent Light Source (LCLS) will be the world's first x-ray free electron laser when it becomes operational in 2009. The LCLS is a US-DOE-funded project that is currently in the detailed project engineering and design phase. Design and construction are accomplished by a partnership of three US national laboratories including the Stanford Linear Accelerator Center (SLAC) as home laboratory, together with the Lawrence Livermore National Laboratory (LLNL) and Argonne National Laboratory (ANL). The start of construction is planned in FY2005. Pulses of x-ray laser light from the LCLS will be many orders of magnitude brighter and several orders of magnitude shorter than presently-available x-rays from other sources. These characteristics will enable frontier new science in areas that include discovering and probing new states of matter, understanding and following chemical reactions and biological processes in real time, imaging chemical and structural properties of materials on the nanoscale, and imaging non-crystalline biological materials at atomic resolution.

In a FEL, the actual lasing occurs as a result of the electron beam passing through a precision magnetic device called an undulator. Undulator construction is the responsibility of ANL.

2.0 SCOPE:

2.1 Scope of Work for the LCLS Undulator Strongback.

A total of 40 undulators are required for the LCLS project. The present procurement is for the strongback for each of the undulators. An experimental prototype undulator was constructed and tested at the Advanced Photon Source (APS) at ANL. Some design and value engineering changes were made as a result, and are incorporated into the production unit design.

The production contract may be awarded to two Contractors with each delivering a First Article Strongback. After evaluation of contractor performance on the First Article, one contractor would be given approval to proceed with the manufacture of either 0, 9, 19, 29 or 38 additional Strongbacks, and the other contractor given approval to proceed with the other required Strongbacks.

Each undulator is comprised of a precision-tuned array of very strong permanent magnets and magnetic poles that result in a precisely-set magnetic field down the axis along which the electron beam eventually travels. There are extremely stringent requirements on the magnetic field uniformity and quality in the final device. Careful attention must be paid at each step in the construction to ensure that the final-assembled, magnetically-tuned undulator meets all requirements. Similar devices were constructed and tuned for the Advanced Photon Source and other light-source facilities; however, some of the precision and stability requirements for the LCLS devices far exceed those for existing undulators.

If these requirements are not met, or if the devices are not stable enough over time, then the desired interaction between the radiation produced in the undulator and the electron beam will not take place, and the free-electron laser will not function.

The strongback is the housing that holds all of the magnet and pole assemblies and, therefore, is the critical component in determining the mechanical and thermal stability of the undulator. The part shall be forged out of Grade 2 commercially pure Titanium, and machined to final size per ANL drawing L143-110700, Strongback.

2.2 Delivery.

The LCLS Undulator Strongbacks described in Section 2.1 of this Statement of Work are needed at the rate of one unit every 2 weeks. The required delivery is one unit every two weeks starting 6 weeks after the receipt of the first article which should be 25 weeks after the award of contract. Due to the possible division of work between two contractors, the delivery dates for a contractor shall be finalized when the delivery quantity is finalized.

Each Strongback shall be identified in such a way that it can be correlated to the proper purchase order, ANL drawing number, and descriptive title as listed above in Section 2.1. Each Strongback shall be marked with a unique serial number and that serial number shall be used on all records of test and measurement data and certifications relating to that strongback. If more than one contractor is involved, a range of serial numbers will be issued to each Contractor.

2.3 First Article.

Each contractor shall deliver one first-article of the Strongback per L143-110700 for On-Site acceptance no later than 18 weeks after the contract has been awarded. The contractor shall not proceed with the remainder of the contract unless and until the First Article is accepted.

3.0 APPLICABLE DOCUMENTS AND /OR SPECIFICATIONS:

The contractor effort shall be in conformance with the following referenced documents, drawings, and specifications.

1) Undulator Strongback drawing L143-110700"Undulator Magnet Assembly Strongback Machining"
2) ASTM B381 "Standard Specification for Titanium and Titanium Alloy Forgings"
3) AMS H-82200 "Heat Treatment of Titanium and Titanium Alloys"
4) Vibratory Stress Relief Treatment Procedure, Titanium Strongback Project Prepared by Bruce B. Klauba, Product Group Manager, VSR Technology Group, Airmatic Inc.

4.0 TECHNICAL TASKS AND QUALITY ASSURANCE:

4.1 Fabrication.

The contractor shall furnish all materials, personnel, facilities, tools, equipment, and services, except as noted in Section 4.1.1 of this Statement of Work, to fabricate, test, document and deliver the Undulator Strongback, part no. L143-110700 listed in Section 2.1 of this Statement of Work.

4.1.1. Forging.

The Strongback shall be forged from Grade 2 Commercially Pure Titanium per ASTM Specification B 381-03, Grade F2. The contractor shall certify that the forgings supplied have been inspected and tested in accordance with the requirements of ASTM B 381, and that the results of the chemical analysis meet the requirements for Grade F2.

4.1.2 Annealing and Vibration Stress Relief.

It is important for the long-term mechanical stability of the strongback that all residual stresses be removed. The Strongback forging shall be annealed and a vibration stress relief shall be done before and after rough machining.

4.1.2.1 The Strongback forging shall be annealed according to AMS-H-81200A. The annealing schedule is shown on Table V of AMS-H-81200A under "Commercially Pure" and "Bars and Forgings," and includes the requirements of note 8 to Table V.

4.1.2.2 The contractor shall certify for each Strongback that the forging was successfully annealed according to AMS-H-81200A. Copies of the part temperature profiles during the annealing processes shall be included with the Certifications. The data should be complete enough to demonstrate compliance with both the time-temperature profile and the temperature uniformity requirements of the specification.

4.1.2.3 The machined Strongback shall be vibration stress relieved prior to machining and also after rough machining, but prior to final machining (should be ~1.5 mm left to machine on critical surfaces). The vibration stress relief equipment to be used shall use resonant vibration. The vibration stress relief shall be done according to the "Vibratory Stress Relief Treatment Procedure, Titanium Strongback Project" prepared by Bruce B. Klauba. The procedure is attached as Appendix A to this Statement of Work. The application of the process prior to machining should help reduce the risk of major movement during the final application of vibration stress relief after rough machining.

4.1.2.4 The contractor shall certify for each Strongback was successfully vibration stress relieved per the procedure in Appendix A. Copies of the VSR treatment charts showing the pre- and post –treatment scans of the resonant peaks shall be included with the certification. Successful treatment scans should show an increase in resonant peak height and/or a shift to lower frequency in the peak.

4.1.3 Marking.

Each Strongback shall be marked for identification with its ANL Part Number (L143-110700) and Revision Number, its SLAC number (SA-381-000-86). These numbers are all on the part drawing. In addition, the Strongback shall be marked with a unique serial number to distinguish it from the other Strongbacks so that accompanying documents and data can be correctly correlated to each individual Strongback.

All these identifying marks are to be etched or stamped on the center of the backside of the Strongback (opposite Datum -B-) in three lines.

a) The first line shall be the ANL Part Number-Revision Number (ANL Part No. L143-110700-00).
b) The second line shall be the SLAC Part Number (SA-381-000-86).
c) The third line shall be the unique serial number for the particular Strongback (Serial No. 01).

The information in brackets are examples of the information to be stamped on the strongback the actual revision and serial numbers shall be whatever is applicable to the part being marked.

4.1.4 Packaging and Shipping.

The Strongbacks shall be appropriately packaged to protect them from shipping damage. Particular care should be given to protecting the magnet assembly mounting surfaces (Datum-A- on drawing L143-110700 and the opposing surface), alignment reference surfaces (4 locations across the top shown in Detail D and 4 corresponding locations on the back side related to the Detail D locations as shown in Section C-C, the two flats on top at each end of the Strongback designated as 2 x 129.00 from the centerline and 2 x 40.0 wide, and the vertical surface on the front side of the Strong back denoted as Datum –B- on drawing L143-110700), and the Strongback mounting surfaces (shown in Section B-B and in bottom view on drawing L143-110700).

Shipment of the Strongbacks shall be FOB the docks of the designated Undulator Assembly Contractor (see Section 5.3). If the Undulator assembly contracts are not in place at the scheduled delivery time for a Strongback, the contractor shall store the finished Strongbacks until Argonne National Laboratory confirms the shipping

destination. A monthly storage rate shall be included in the bid for this task that would be effective only if storage is required.

4.2 Program Plan.

The contractor shall prepare and maintain a Program Plan describing and scheduling all phases of this program. The Laboratory shall review and approve the Program Plan and all changes thereto prior to implementation by the contractor.

4.2.1 Program Plan General Description.

The program management plan describes the contractor's concept, plan, practice, and approach for accomplishing (managing and controlling) project tasks, management interfaces, time-phased relationships of tasks and program elements, and the criteria against which performance may be judged. The plan is to be used as the basis for organizing, administering, and measuring work. The plan, with its interrelated and referenced documents, shall include sufficient data to demonstrate the capability to accurately report schedule, and technical performance indicators. The plan shall also be used to explain variances, to describe corrective actions and decisions, and to indicate required recovery or expeditious efforts.

4.2.2 Program Plan Content.

The plan shall describe the programmatic and management structure along with the management tools, which shall be used by the contractor in performance of the contractual effort. The following shall be included:

4.2.2.1 A brief description of the program objectives, with a summary of requirements and specifications as well as a concise description of the hardware and associated components.

4.2.2.2 Summary schedules, which reflect a direct condensation of the master schedules, and which are suitable for management review.

4.2.2.3 A description of the organization for the management of the program, indicating the internal interfaces between management and other elements of the contractor's organization.

4.2.2.4 A key personnel list, portraying the contractor's key personnel, beginning with the highest level program manager (or equivalent position) descending to the lowest echelon of key staff positions necessary for effective program management.

4.2.2.5 A description of the contractor's plan for interfacing with the Laboratory and with associated contractors, as well as technical management

4.2.2.6 A description of the contractor's management information system as applied to the data management, configuration management, and schedule management function of this contract.

4.2.2.7 Copies of the Work Breakdown Structure (if applicable).

4.2.2.8 A subcontractor plan which includes the method of procurement, procurement schedules, and procedures by which control shall be exercised for planned subcontract effort (if applicable).

4.2.2.9 A description of the contractor's resources being used in performance of the program, including plant capacity, facilities, machine tools, and manpower for all contract phases including fabrication.

4.2.2.10 A description of program tasks to be accomplished and a general outline of the methods and systems, which the contractor shall utilize to accomplish each major task.

4.2.3 Program Plan Format.

The contractor's own format shall be satisfactory. Contents should be displayed in sections for ease of separate consideration.

4.2.4 Program Plan Maintenance.

The plan shall be maintained current by page revision or complete reissue to reflect all approved program changes. Change to the key personnel list, consistent with the standard Terms and Conditions Clause, shall be forwarded to the Laboratory as soon as practical after the decision to make a change, and not later than the next scheduled progress report.

4.3 Program Meetings.

The contractor shall provide for program meetings with Laboratory representatives for purposes of reviewing and resolving progress, fabrication, testing, and managerial issues. Meetings will be held at the discretion of either the Laboratory or the contractor. Current information on all aspects of the program shall be made available by the contractor to the Laboratory one week in advance. Meetings shall be held at the contractor's facility, unless the Laboratory chooses otherwise. A mandatory notice and meeting agenda will be provided by the Laboratory one week before a program meeting can be held. The contractor shall have the responsibility to provide minutes of the meeting within two (2) weeks following the session.

4.4 Program Schedule.

The contractor shall prepare and maintain a Program Schedule. This schedule shall include the major program milestones. The Laboratory shall review and approve the Program Schedule and all changes thereto prior to implementation by the contractor.

4.4.1 Program Schedule General Description.

The program schedules depict the period of performance for work specified by the contract. They portray significant program/project milestones necessary to measure, analyze, and perform corrective action as well as indicate progress and performance.

4.4.2 Program Schedule Content.

In addition to major milestones required by the Laboratory and stipulated by the Statement of Work, the schedules shall also include where applicable:

4.4.2.1 Major milestones which depict program baselines, phase start and completion, go/no-go decision points, design and inspection reviews, delivery dates, etc.

4.4.2.2 Second level milestones which include long-lead procurement, intermediate design, manufacturing, and procurement points, development milestones and interfacing points, intermediate test and analysis points, etc.

4.4.2.3 Third level milestones which include all detail control milestones that govern the preparation of work package schedules.

4.4.3 Program Schedule Format.

The schedules shall be compatible with the Program Plans. They shall be susceptible to conversion and delineation at the detailed level to critical path schedules or other detailed scheduling techniques, which may be used for fabrication and test sequences.

4.4.4 Program Schedule Maintenance.

The schedules shall denote the most recent actual results compared with the forecasted progress. When major deviations between actual results and the baseline persist to the extent that the baseline becomes of little or no value for measuring and forecasting, the contractor shall change the appropriate parts of the baseline, subject to the following:

4.4.4.1 Changes shall be announced and described in the progress report for the period in which the change is made. Reasons for the change shall be described as well as the related effects on the work packages, and/or manufacturing schedules.

4.4.4.2 Schedule changes to (or affecting) Laboratory milestones shall be approved by Argonne prior to implementation.

4.5 Testing.

The contractor shall conduct testing of the Strongbacks listed in Section 2.1 of this Statement of Work prior to delivery and acceptance by the Laboratory. Acceptance tests

shall be in accordance with Section **4.5.1** of this Statement of Work. Test results shall be submitted by the contractor to the Laboratory within two weeks after conclusion of the test. Each shipment shall be accompanied or preceded by reports of actual test results identifiable to the acceptance criteria of items submitted and shall meet the requirements of the contract document and applicable drawings and specifications. These reports shall contain the signature and title of the authorized contract representative of the agency performing the tests and shall be subject to review and acceptance by Supplier Quality Control. The data submitted shall also be transmitted in electronic PDF format directly to the responsible ANL Engineer. If requested, the contractor shall furnish additional electronic or paper copies to the Undulator Assembly Contractor (see Section 5.3).

4.5.1 Measurements.

The Strongbacks shall be measured or otherwise tested by the contractor to verify all dimensions and other drawing requirements. While most dimensions may be reported as in conformance with the drawing, critical features shall be reported with the actual measured values and with the drawing required value or tolerance. Any non-conforming dimension or feature must be reported with the measured value and the required value or tolerance. All dimensions apply at a temperature of 20°C. The part must be in thermal equilibrium during measurements and at the same temperature at the beginning and conclusion of the measurements within ±0.3°C. The part temperature before, during, and after dimensional measurement shall be recorded and reported.

4.5.2 Critical Features.

The following items are critical features needing actual measured values to be reported.

1) Separation of Datum -A- and the opposite face (167.00 +0.05 -0.00). These are the two Magnet Assembly mounting surfaces.
2) Offset of Datum -A- from the part Centerline (83.50).
3) Flatness of Datum -A- (0.05).
4) Flatness of surface of face opposite to Datum -A- (0.05).
5) Surface finish of Datum -A- (1.6).
6) Surface finish of surface of face opposite to Datum -A- (1.6).
7) Parallelism of surface in Section B-B to Datum -A- (0.05). This is the Strongback mounting surface and applies to two locations on the bottom of the

Strongback with the left hand surface 960 mm left of the centerline and the right hand surface an equal distance to the right.

8) Flatness of Datum -B- (0.05). This is the front face of the Strongback and extends above and below the slot formed by Datum -A- and its opposite face.
9) Perpendicularity of Datum -B- to Datum -A- (0.1).

4.6 Special Tooling.

The contractor shall design and fabricate any special tooling required for fabrication of the Strongbacks listed in Section 2.1 of this Statement of Work, which is not provided by the Laboratory. All special tooling fabricated by the contractor is the property of the Laboratory and shall be accounted for by the contractor. Disposition of the special tooling at the conclusion of contract shall be at the option of the Laboratory in accord with FAR clause 52.245-17.

4.7 Quality Control.

The contractor shall adhere to all quality control requirements as specified in this Statement of Work. The contractor shall adhere to the ANL policy that prohibits the use of any suspect or counterfeit parts.

4.7.1 First-Article Inspection.

A first-article inspection shall be performed in the presence of a designated representative of ANL. The first-article inspection shall be accomplished using the first deliverable item of several of the same design or same type. The processes used and standards of workmanship shall as a minimum be representative of all items to be produced. The supplier shall notify the Laboratory Procurement Official at least seven (7) days prior to the time that the first-article is available for inspection. Unless otherwise designated by the Laboratory Procurement Official, first-article inspection will be conducted at the supplier's facility. The First Article Inspection shall consist, as a minimum, witnessing the verification of critical dimensions, reviewing Q/A documentation and material certification. Continued fabrication of additional items prior to notification of first-article acceptance shall be entirely at supplier's risk, and may result in non-reimbursement of related costs by the Laboratory.

4.7.2 Changes Proposed by Contractor.

Prior to effecting any change in ANL approved (1) design, (2) workmanship standards, or (3) manufacturing process for use in this procurement, supplier shall obtain the Laboratory's written approval. Such changes must be documented by the contractor as "marked drawing" changes to the engineering drawings for the affected item prior to the Laboratory's approval. If approved by the Laboratory, revised drawings shall be issued by the contractor.

4.7.3 Proprietary Designs and Processes.

The contractor shall notify ANL prior to effecting any change in proprietary processing or design. A meeting between the supplier, the Laboratory Procurement Official and LCLS Quality Assurance shall be called to determine the method by which contract requirements will be met while accommodating the contractor's proposed change.

4.8 Inspection and Test Plan.

The contractor shall prepare and maintain an Inspection and Test Plan. The contractor shall submit to the Laboratory Procurement Official for written approval by LCLS Quality Assurance prior to its required use, a plan, in the contractor's format, listing components, subassemblies and assemblies; and identifying those inspections and tests planned for verification of quality and identifying documentation/planning to be used for such accomplishment.

4.9 Quality Assurance.

The contractor shall prepare and maintain a Quality Verification Program for control of quality of articles furnished in accordance with this contract. A plan shall be prepared and submitted to the Laboratory Procurement Official for written approval by LCLS Quality Assurance prior to its required use by the contractor. The contractor's quality assurance manual may suffice providing it adequately implements the quality requirements specified.

4.10 Source Inspection.

The Laboratory reserves the right to perform source inspection of any and all materials, parts, subassemblies and assemblies required for performance of this contract.

4.11 Testing Surveillance.

The Laboratory reserves the right to witness any testing accomplished by the contractor. This surveillance will be informal except for final acceptance tests. The contractor shall notify the Laboratory two (2) weeks prior to the conduct of any test.

4.12 Test Failures.

The Laboratory shall be notified by the contractor within 48 hours after the failure of any material to meet the requirements of acceptance or qualification testing. The Laboratory shall be notified immediately of any failure occurring during assembly or acceptance testing of the Strongbacks listed in Section 2.1 of this Statement of Work.

4.13 Red Flag Notice.

The contractor shall immediately notify the Laboratory of any occurrence, which will impact contract schedule. The notification shall be either written or oral with written confirmation within 48 hours on a Red Flag Report, and shall include remedial action taken to offset the problem. The contractor shall provide his own format compatible with the following requirements:

4.13.1 Date and Number.

Each Red Flag Notice is to be dated and consecutively numbered.

4.13.2 Contract Required Delivery Date.

Contract delivery date for the subject of the report. It does not normally change from one report to the next.

4.13.3 Estimated Shipping Dates.

Include the prior Report estimate and this Report estimate.

4.13.4 Statement of Problem.

All problems shall be presented as separate items in clear concise text describing the reason why the end item is late, the reason for any slippage since the last report and the current status of the work.

4.13.5 Consequence.

The consequence of the problem or delay shall be concisely stated in terms of impact on delivery, the meeting of key milestones, the progress of other work, or on meeting specification requirements, etc.

4.13.6 Action Taken.

The action being taken to resolve the problem and recover schedule delays shall be described and the estimated effect of this action shall be highlighted. The name of the key individual in the contractor's organization who must act to resolve the problem shall be shown.

4.13.7 Action Required.

Future action to recover schedule shall be identified. The action shall be described, the action party identified by name, title and organization, and the date when completion of the action is required shall be set forth.

4.13.8 Assistance Required.

Any assistance required from the Laboratory to further the progress of the recovery program shall be set forth. The exact nature of any required assistance shall be stated and the date by which such action must be taken shall be provided.

4.13.9 Number of Times Reported.

The number of previous critical items reports which have identified the same problem as critical to the progress of the work or to satisfaction of the technical requirements shall be set forth.

4.13.10 Acknowledgement of Responsibility.

Each report shall acknowledge that the reporting of the critical items therein does not relieve the writer of responsibility for seeing that the necessary corrective action is taken on each item.

4.14 Nonconformance Reporting.

The contractor shall report any non-conformances to specifications, drawings, or other contract requirements on ANL Form 311.

4.15 Approvals.

All Laboratory approvals required by this contract shall be acted upon within two (2) weeks of receipt by ANL of submission by the contractor. Action will consist of a notice of approval, clarification request or rejection in writing from the Laboratory Subcontract Administrator. Approvals shall not relieve the contractor of any responsibility for reliability, quality, delivery, cost, performance or other requirements of this contract.

5.0 REPORTS, DATA, AND DELIVERABLES:

5.1 Progress Report.

The contractor shall submit monthly progress reports during the execution of this program. The progress report shall include narrative and tabular summary of performance during the report period. It shall include work performed, work forecast, and problem description and resolution. The contractor shall emphasize any deviations from plan or schedule, the reasons and impacts of such deviations, and the effects of management efforts undertaken for corrective or expeditious actions.

5.2 Technical Data.

The contractor shall deliver all technical data as specified below.

5.2.1 For each of the following items, one (1) electronic copy in PDF format followed by two (2) paper copies are required once 30 days after award of contract. Any changes to these documents must also be submitted.

a) Program Plan (Section 4.2)
b) Program Schedule (Section 4.4)
c) Inspection and Test Plan (Section 4.8)
d) Quality Verification Plan (Section 4.9)

5.2.2 For Progress Reports (Section 5.1), one (1) electronic copy in PDF format followed by two (2) paper copies are required Monthly 10 days after the end of the month. The first report shall be due 40 days after award of contract.

5.2.3 For Test results, measured values and Certifications (Sections 4.1.1, 4.1.2.2, 4.1.2.4 and 4.5), one (1) electronic copy in PDF format followed by two (2) paper copies are required for ANL and either one (1) set of electronic or paper copies for the Undulator Assembly Contractor is required within two (2) weeks of completion of testing of a given Strongback.

5.2.4 For each of the following items, one (1) electronic copy in PDF format followed by two (2) paper copies are required. These items are on an "as required" basis.

a) Red Flag Notice (Section 4.13), submit within 48 hours of an occurrence.
b) Nonconformance Report (Section 4.14), ANL approval required for disposition of a non-conformance.
c) Program Meeting Minutes (Section 4.3), submit within 2 weeks of a Program Meeting

5.3 Delivery.

The contractor shall deliver the Strongbacks listed in Section 2.1 of this Statement of Work per the schedule indicated in Section 2.2 of this Statement of Work. The Strongbacks are to be delivered to the Undulator Assembly Contractor and not directly to Argonne. It is likely that two (2) Undulator Assembly contractors will be selected and deliveries will alternate between the two contractors. It is possible that the assembly contracts will not be in place at the scheduled delivery time, in which case the finished Strongbacks are to be stored until Argonne National Laboratory confirms the shipping destination.

6.0 OTHER SPECIAL CONSIDERATIONS:

6.1 Subcontractors.

Should the contractor intend to subcontract any portion of this work, such intentions, possible subcontractors, and the scope of their involvement shall be included in the proposal. ANL is to be informed of any change in subcontractors prior to any such change taking effect. ANL reserves the right to reject the use of any particular sub-contractor.

6.2 Disclosure and Publication.

Dissemination of data and key results of the contracted effort is encouraged through the use of technical meetings, literature, and the like. The contractor shall obtain Laboratory approval prior to disclosure or publication of any information.

APPENDIX A

Vibratory Stress Relief Treatment Procedure

Titanium Strongback Project

Vibratory Stress Relief Treatment Procedure

Prepared by Bruce B. Klauba
Product Group Manager

Titanium Strongback Project

This report describes a preliminary approach to set-up and perform a VSR-8000 System Vibratory Stress Relief Treatment on the 12" diameter, ≈ 133" titanium bars to be used on a project for ARGONNE NATIONAL LABORATORY.

Because the Workpieces are cylindrical shaped, fixturing is required to enable suitable energy transfer between the Workpiece and the VSR-8000 System's flat-footed vibrator. Further, because we anticipate that the Workpiece will undergo significant flexure, in addition to high levels of acceleration, the best approach for consistent Treatments that can be clearly documented, is to use a heavy steel or cast iron base or fixture to which the Vibrator can be mounted. The Workpiece will be secured to the fixture with a custom, but simple, clamping that eliminates any slippage or impact noise generated during Treatment. Arrangement slippage or impact noise result in either a reduction in Treatment effectiveness, ambiguous or unclear Treatment Data, or both.

Shown in Photo-1, attached, is an example of a fixture that would be suitable for this project. The overall dimensions of this cast iron machining base are: 48" L, 36" W, 15" H. The T-slots that are cut into both the sides and top are useful in mounting both the VSR Vibrator and the Workpieces. The System's model BL-8 Vibrator is shown clamped to the top of the fixture, and its Axis-of-Rotation is correctly oriented relative to the Workpiece clamped to the fixture. We recommend a similar arrangement for the Treatments planned for this project.

The correct Vibrator orientation is one that aligns (parallels) the Vibrator's Axis-of-Rotation with the length of the Workpiece. This is the alignment used in the set-up depicted in the Photo, and, again, this is the recommended orientation for the proposed project.

To achieve effective clamping of the cylindrical shaped parts, steel support blocks, machined to mate with the OD of the Workpiece, are used for both of the two (2) set-ups, *ie*, both before and after rough machining. Referring to Sketch-1, attached, of the VSR System Set-up: #1 support block is used in both set-ups. Both #1 and #2 support blocks are machined from 14"W X 4"H X 2"L blocks. The 14" width and 4" height are depicted in the sketch. Support block #1 also has two (2) counterbored holes, which permit the thru-bolting of 3/4" Allen head cap screws, which would thread into the T-nuts engaged in the t-slots.

Support block #2 has the same shape as support block #1, but is without the holes.

The cross bar (#3) has a milled slot cut in its underside, in which the top of #2 support block rests.

A T-shaped cross bar (#4) is used for the *after* rough machining set-up. Note that the width of this cross bar's lower section fills the majority of the slot cut during the rough machining. The lengths of #1, #2, #3 and #4 are 2-inches; these lengths are all parallel with the length of the Workpiece in this set-up. The illustration is to scale.

The exact method of terminating and clamping the cross bars is not shown. While this detail can be left to the discretion of the machine shop involved, we do recommend that heavy duty milling clamps be employed, and that 3/4" diameter fasteners be the minimum size used.

Two (2) sets of support blocks will be needed to mount the Workpiece upon the fixture. Initially these should be spaced 24" apart, but this spacing could change, based upon the response of the Workpiece to treatment. This is because the VSR Process employs the resonance of the Workpiece to achieve stress relieving. Variations in Workpiece geometry, VSR Set-up, and intensity and distribution of residual stresses in the Workpiece affect the Workpiece's resonance pattern. These variables make the VSR Process an interactive process, so the exact details of Treatment will vary, based upon these parameters.

The response of the Workpiece will also determine:

A. The unbalance setting of the Vibrator (initially a minimal setting is used).

B. The orientation of the Accelerometer, relative to the Workpiece.

C. The Vibrator speeds and durations used to perform the VSR Treatment.

The VSR Vibrator's cast aluminum body has hardened steel inserts in its mounting feet. The 5/8" thru-holes in the feet/inserts are the preferred means of clamping in this application. (The photo shows the top of the stud engaged in a T-nut, and the heavy duty milling clamp nut required to secure it.)

An Accelerometer in used during the Treatment to monitor the Workpiece's response to vibration. This vibration sensor should be placed at the end of the Workpiece. The standard Accelerometer Clamp supplied with the equipment only has a 3" jaw opening, so the Accelerometer can be affixed to the Workpiece by making a clamping collar, consisting of a steel ring, 12" ID, with a 1" X 1" cross-section.

One location of the ring's OD surface has a mounting location for the Accelerometer: A flat milled surface, 1" wide, in which a 1/4 - 28 drilled and tapped hole is cut.

The Accelerometer has a similar 1/4 - 28 mounting hole in its base, which can then be used (using a 1/4 - 28 set-screw) for mounting. The ring's ID is sized to be a mild slip-fit onto the Workpiece, and two set screws, set 90° apart, should be used to secure it to the Workpiece.

The fixture itself will rest upon 3 or 4 Isolation Load Cushions, which provide isolation form the floor. These Load Cushions are provided with the VSR System. One cushion is visible in the photo.

The procedure used to perform the VSR Treatment is outlined in detail in both the VSR-8000 and VSR-790A Owner/Operator Manuals. The fixture set-up described above will then allow the procedure detailed in these manuals to be followed.

Bruce Klauba has a degree in Physics and a Level II Vibration Analysis Certification from the American Society for Non-Destructive Testing (ASNDT). As a pioneer in the cause and effect of Vibratory Stress Relief, Mr.Klauba was named chief inventor (*Klauba et al.)* in U.S. Patent 4,381,673, which is both an equipment and process patent describing advances in the technology. He has authored numerous articles and original research papers on the subject which have been published in leading magazines and periodicals. In 1983, the American Society of Mechanical Engineers (ASME) published *Productive Applications of Mechanical Vibration*, a breakthrough paper on the use and understanding of Vibratory Stress Relief, which was co-authored with C. Mel Adams, PhD, one of the Nation's leading authorities on metallurgy, and co-founder of MIT's Welding Research Institute. In addition, Mr. Klauba has extensive experience in designing, building, and troubleshooting Industrial and Commercial Electrical Controls with a focus on extending the performance and reliability of Electric Motors and the systems they power.

Photo 1: Fixture Example

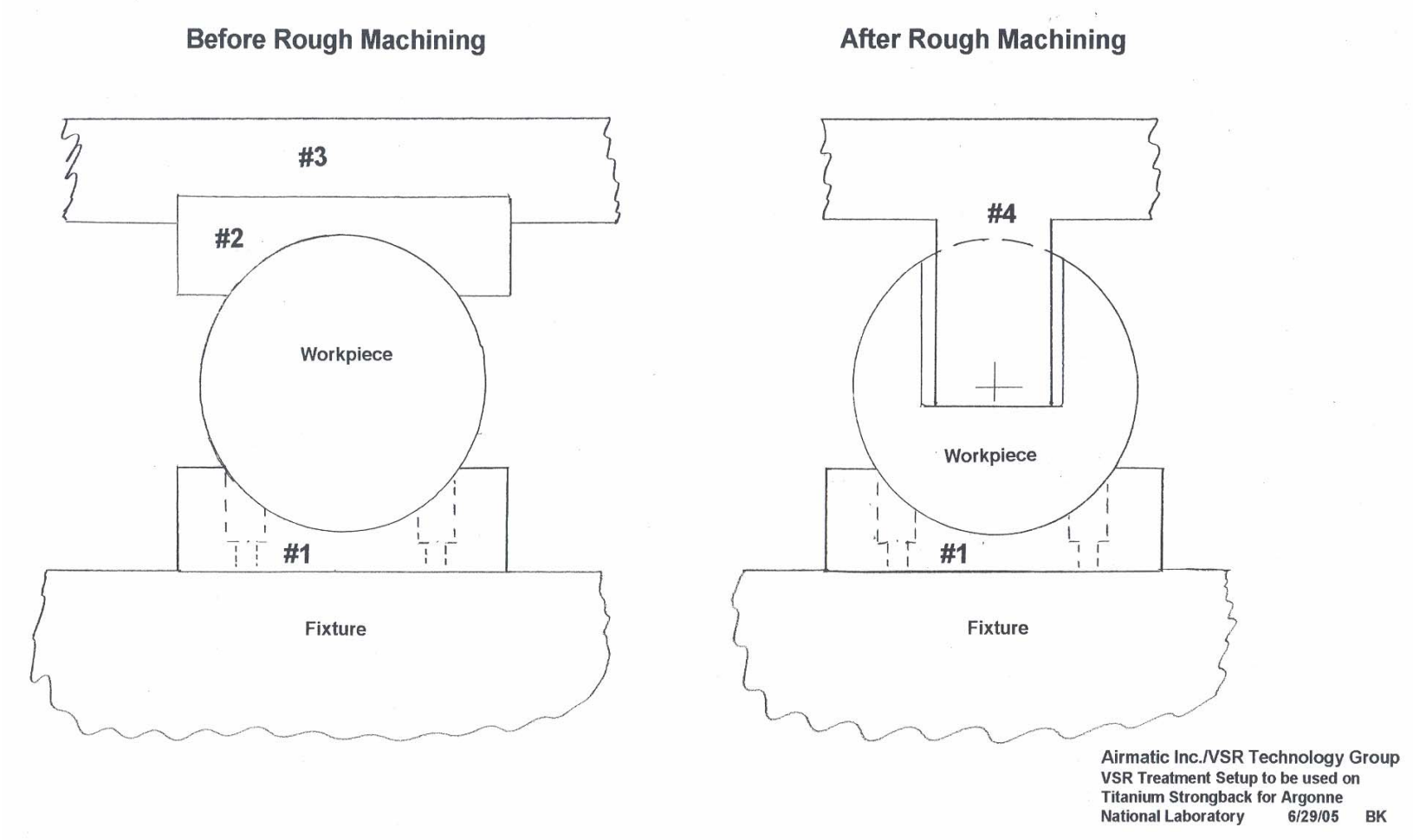
VSR Technology Group

The cost effective alternative to heat treatment

The cost effective alternative to heat treatment

VSR Technology Group

Sketch 1: Workpiece Set-up



Airmatic Inc./VSR Technology Group
VSR Treatment Setup to be used on
Titanium Strongback for Argonne
National Laboratory 6/29/05 BK