AVLIS

Documentation Overview and Tables of Contents

Document E-001
November 15, 1984

Reviewed by:

A.L. Lotts, AVLIS Division
Director
Martin Marietta Energy Systems, Inc.

Reviewed by:

M.L. Spaeth, Laser Isotope Separation
Deputy Program Leader
Lawrence Livermore National Laboratory

Approved by:

J.I. Davis, Laser Isotope Separation
Program Leader
Lawrence Livermore National Laboratory

LAWRENCE LIVERMORE NATIONAL LABORATORY

University of California · Livermore, California · 94550

MARTIN MARIETTA ENERGY SYSTEMS, INC.

Oak Ridge, Tennessee, 37831

MARTIN MARIETTA

NOTICE
SECTIONS OF THIS REPORT ARE ILLEGIBLE.
has been reproduced from the best
stable copy to permit the broadest
possible availability.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MITCHELL

RECEIVED
FEDERAL BUREAU OF INVESTIGATION
U. S. DEPARTMENT OF JUSTICE
WASHINGTON, D. C.
JAN 10 1964

TABLE OF CONTENTS

1. Introduction.....	1
1.1. Data Package III Objectives.....	1
1.2. Data Package Organization and General Content.....	2
1.2.1. Program Planning.....	2
1.2.2. Risk Analysis.....	5
1.2.3. Project Management.....	5
1.2.4. Engineering and Production Basis.....	6
1.2.5. Capital Cost.....	6
1.2.6. Operating Cost.....	7
1.3 Information Requirement for Data Package III.....	7
2. Tables of Contents for Data Package III Documents.....	20
2.1 <u>EXECUTIVE SUMMARY (E-Series)</u>	
E010 AVLIS Production Plant Executive Summary.....	22
E020 AVLIS Production Plant Overall Design Report.....	24
2.2 <u>PROGRAM PLANNING (PP-Series)</u>	
PP010 AVLIS Program Plan.....	32
PP020 AVLIS Industrial Access Program.....	36
PP030 DOE/AVLIS Long Term Competitiveness in the World Enrichment Market.....	39
2.3 <u>PRODUCTION AND ENGINEERING BASIS (EB-Series)</u>	
EB030 AVLIS Production Plant Laser System Design Report.....	43
EB040 AVLIS Production Plant Separator System Design Report Volume I.....	48
Volume II.....	52
EB050 AVLIS Production Plant Uranium Processing Design Report.....	56
EB060 AVLIS Production Plant Conventional Facilities and Process Support Design Report.....	61

2.4 AVLIS PRODUCTION PLANT (APP-Series)

Project Management

APP010	AVLIS Production Plant Project Management Plan.....	68
APP020	AVLIS Production Plant Work Breakdown Structure and Dictionary.....	76
APP030	AVLIS Production Plant Project Schedule and Milestones.....	78
APP041	AVLIS Production Plant Preliminary Environmental Assessment.....	80
APP042	AVLIS Production Plant Preliminary Safety Analysis Report.....	84
APP043	AVLIS Production Plant Safeguards Assessments.....	87
APP044	AVLIS Production Plant Reliability, Availability, and Maintainability.....	91
APP045	AVLIS Production Plant Preliminary Quality Assurance Plan and Assessment.....	93
APP046	AVLIS Production Plant Waste Management Plan.....	96
APP047	AVLIS Impact on Nuclear Proliferation.....	101

2.5 AVLIS PRODUCTION PLANT (APP-Series)

Capital Cost

APP050	AVLIS Production Plant Capital Cost Summary.....	105
APP060	AVLIS Production Plant Capital Cost Bill of Materials Volume I.....	108
	Volume II.....	110
APP080	AVLIS Production Plant Capital Cost Vendor Estimates.....	112

2.6 AVLIS PRODUCTION PLANT (APP-Series)

Operating Cost

APP090	AVLIS Production Plant Operations and Maintenance Plan.....	115
APP100	AVLIS Production Plant Reliability Engineering Assessment.....	120
APP110	AVLIS Production Plant Operating Cost Summary.....	124
APP120	AVLIS Production Plant Operating Cost Labor Analysis.....	126
APP130	AVLIS Production Plant Operating Cost Material Analysis.....	129
APP140	AVLIS Production Plant Operating Material Cost Basis.....	132

AVLIS DOCUMENTATION OVERVIEW AND TABLES OF CONTENTS

1. INTRODUCTION

Three documents constitute the executive summary series in Data Package III: this document (Documentation Overview and Tables of Contents (E001)) plus the AVLIS Production Plant Executive Summary (E010) and the AVLIS Production Plant Overall Design Report (E020). They provide progressively greater detail on the key information and conclusions contained within the data package.

The Executive Summary and Overall Design Report present summaries of each Data Package III document. They are intended to provide a global overview of AVLIS Production Plant deployment including program planning, project management, schedules, engineering design, production, operations, capital cost, and operating cost.

The purpose of Overview and Tables of Contents is threefold: to briefly review AVLIS goals for Data Package III documentation, to present an overview of the contents of the data package, and to provide a useful guide to information contained in the numerous documents comprising the package.

1.1. DATA PACKAGE III OBJECTIVES

The goals of this AVLIS Data Package are to provide information in a manner useful for process selection and to provide for the AVLIS Program a complete, current, integrated basis for continuing our efforts toward production plant deployment.

We have sought to comply completely and thoroughly with the guidance for the content of Data Package III that was provided by the Process Evaluation Board and the Department of Energy.^{1,2} In addressing the requested

¹Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies, July 31, 1984, USDOE.

²Memorandum: Guidance on Data Package III, Nort Haberman, Director Advanced Technology Projects, UE/DNE, September 21, 1984.

information, we have sought to assure a level of detail sufficient to permit an organized, complete review and assessment by all parties involved in the selection process including the AGC Program, Mitre Corporation, the Economic Assessment Team, the Special Assessment Study teams, the Process Evaluation Board, and the Department of Energy.

The information presented in the data package should permit a review and evaluation of the AVLIS potential to supply reliable enrichment services at predictable, competitive prices, and of the AVLIS capability to remain competitive in the world enrichment market beyond the turn of the century.

1.2. DATA PACKAGE ORGANIZATION AND GENERAL CONTENT

Documents included in Data Package III are intended to form a complete basis for the Technology Assessment phase of process selection. The logical framework for the AVLIS package is illustrated in Figure 1-1; a complete title listing is presented in Table 1-1. Individual documents cited in Fig. 1-1 are listed by the key programmatic area which they support: program planning, risk assessments, project management, engineering and production basis, capital cost, and operating cost. Documents and resources supporting these six key areas provide the Technology Assessment basis for evaluating the AVLIS Production Plant, deployment strategies, and financial performance.

An overview of the content of Data Package III follows. Supporting documents are summarized according to the principal programmatic area which they support and in the order defined by the documentation logic tree (Fig. 1-1).

1.2.1. Program Planning

Documents in this area provide a broad view of AVLIS deployment in the context of U.S. and world enrichment markets, and they suggest strategies for maintaining a DOE/AVLIS production cost advantage well beyond the turn of the century.

The AVLIS Program Plan provides the organizational structure and planning to implement the AVLIS Production Plant design basis, equipment development, systems demonstrations, and operations support.

The AVLIS Industrial Access Program presents data on commercial readiness including topics on procurement plans, technology transfer, producibility, materials qualification, supplier networks, and commercial availability.

Fig. 1-1. AVLIS Data Package III documentation logic tree

Table 1-1. Data Package III documents

o EXECUTIVE SUMMARY (E-Series)

E001 AVLIS Documentation Overview and Tables of Contents
E010 AVLIS Production Plant Executive Summary
E020 AVLIS Production Plant Overall Design Report

o PROGRAM PLANNING (PP-Series)

PP010 AVLIS Program Plan
PP020 AVLIS Industrial Access Program
PP030 DOE/AVLIS Long-Term Competitiveness in the World Enrichment Market

o PRODUCTION AND ENGINEERING BASIS (EB-Series)

EB010 AVLIS Reference Design Definition (Data Package I)
EB020 AVLIS Technology and Engineering Design Basis (Data Package II)
EB030 AVLIS Production Plant Laser System Design Report
EB040 AVLIS Production Plant Separator System Design Report
EB050 AVLIS Production Plant Uranium Processing Design Report
EB060 AVLIS Production Plant Conventional Facilities and Process Support Design Report

o AVLIS PRODUCTION PLANT (APP-Series)

Project Management

APP010 AVLIS Production Plant Project Management Plan
APP020 AVLIS Production Plant Work Breakdown Structure and Dictionary
APP030 AVLIS Production Plant Project Schedule and Milestones
APP041 AVLIS Production Plant Preliminary Environmental Assessment
APP042 AVLIS Production Plant Preliminary Safety Analysis Report
APP043 AVLIS Production Plant Safeguards Assessments
APP044 AVLIS Production Plant Reliability, Availability, and Maintainability
APP045 AVLIS Production Plant Preliminary Quality Assurance Plan and Assessment
APP046 AVLIS Production Plant Waste Management Plan
APP047 AVLIS Impact on Nuclear Proliferation

Capital Cost

APP050 AVLIS Production Plant Capital Cost Summary
APP060 AVLIS Production Plant Capital Cost Bill of Materials
APP080 AVLIS Production Plant Capital Cost Vendor Estimates

Operating Cost

APP090 AVLIS Production Plant Operations and Maintenance Plan
APP100 AVLIS Production Plant Reliability Engineering Assessment
APP110 AVLIS Production Plant Operating Cost Summary
APP120 AVLIS Production Plant Operating Cost Labor Analysis
APP130 AVLIS Production Plant Operating Cost Material Analysis
APP140 AVLIS Production Plant Operating Material Cost Basis

DOE/AVLIS Long-Term Competitiveness in the World Enrichment Market

provides a compelling assessment of foreign competition and an analysis of the U.S. and foreign enrichment market through the turn of the century. The capability of AVLIS to compete in this marketplace over the long term is evaluated.

1.2.2. Risk Analysis

During the 1982 Process Selection, multivariable sensitivity analyses (MVSS) were found to be an invaluable tool for assessing cost and performance risk. We have recently expanded our capability in this area to include schedule risk, as described in Project Schedule and Milestones (APP030). Although we currently do not have a definite plan for issuing specific risk assessment documents, these assessments are regularly utilized in developing plant designs and deployment strategies, and are part of a significant effort in this area that supports the Economic Assessment Team at Martin Marietta Energy Systems, Inc.

1.2.3. Project Management

The Project Management Plan details the project execution, including planning approach, organization, responsibilities, interfaces, and project control systems.

The Project Schedule and Milestones presents three deployment option schedules for engineering, procurement, and construction of the initial increment and fully activated AVLIS Production Plant. Multifaceted constraints and objectives are considered in developing these schedules, including degree of conservatism, enrichment enterprise cash flow, development program status, contractual arrangements, and historical schedule experience.

A Work Breakdown Structure (WBS) is presented as part of the program planning effort. The key role of the WBS is to ensure completeness and logical organization in plant development, design, procurement, construction, and capital cost estimates.

All key project assessments have been documented in detail to assure complete accounting for planning and cost impacts. Project assessments include those on environment, safety, safeguards, proliferation, RAM, quality assurance, and waste management.

1.2.4. Engineering and Production Basis

Documentation in this key area was initiated with Data Package I and II submittals (AVLIS Reference Design Definition and AVLIS Technology and Engineering Design Basis, respectively), which presented the technology and engineering design basis for the AVLIS Production Plant.

The Production Plant Design Reports are the principal Data Package III engineering documents in this programmatic area. They detail the complete AVLIS Production Plant design and include reports on:

- o Laser systems.
- o Separator systems.
- o Uranium processing.
- o Conventional facilities and process support.

This Design Report set presents a level of engineering detail for the AVLIS Production Plant sufficient to accurately project capital cost, operating cost, production rate, schedule, plant reliability, operations and maintenance scenarios, and commercial readiness.

Two documents in this Design Report series, the Executive Summary and Overall Design Report, respectively provide global and more detailed overviews of the principal conclusions and information for the Data Package III submittal.

1.2.5. Capital Cost

Documents supporting capital cost include summaries and detailed backup for the first-increment, fully activated, and Greenfield (stand-alone) AVLIS Production Plants. The Capital Cost Summary details cost by WBS, presents the estimate methodology, and provides the cost basis for the estimate.

The Capital Cost Bill of Materials itemizes all capital costs by WBS to as low as Level 7, depending upon the detail required for an accurate estimate. The Capital Cost Vendor Estimates for laser and separator special process equipment represent approximately half the production plant capital cost and provide more detailed cost breakout for these systems.

1.2.6. Operating Cost

Documents supporting the operating cost also present estimates for the first-increment, fully activated and Greenfield (stand-alone) AVLIS Production Plants. The Operating Cost Summary, Operating Cost Labor Analysis, and Operating Cost Materiel Analysis documents together present startup as well as mature operating cost; they include details on labor, materials, services, electrical power, and utilities. Operating cost estimates are developed consistent with the Operations and Maintenance Plan, the Reliability Engineering Assessment and Materiel Cost Basis documents. The first of these documents defines requisite operations and maintenance activities. Staffing levels, work descriptions, training requirements, staffing utilization, and work schedules are defined. The Reliability Engineering Assessment (REA) identifies failure modes and effects and quantifies subsystem and component reliability and life. The RAM Assessment (APP044) and plant capacity factors derive from this information. Replacement rates from the REA provide the data base necessary to project materiel operating cost; this information is contained in Operating Materiel Cost Basis.

1.3 INFORMATION REQUIREMENT FOR DATA PACKAGE III

In preparing the Data Package III documents discussed above, our goal was to provide a complete, consistent, integrated set of information that is responsive to the needs of the AGC Program, the Process Evaluation Board, and the Department of Energy. The topics addressed in these documents derive from DOE and PEB information guidance in Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies³ and the September 21 memorandum from Nort Haberman.⁴ Data requested by these guides have been assembled in Tables 1-2 through 1-5 together with the corresponding documents which provide the requested information. These tables defining data needs

³USDOE, op. cit.

⁴Haberman, op. cit.

are essentially identical to those in the Methodology and Criteria guidance, but include the additional information requested by the Haberman memorandum.

Our objective is to meet as closely as possible this data package guidance to assure that the upcoming Data Package III reviews and assessments can be approached with a complete and current AVLIS information base. As the logic of our data package suggests (Fig. 1-1), we also include a thorough and consistent data base for the upcoming financial and economic assessment phase of process selection.

The information provided in this data package serves as a current and complete record of the status of the AVLIS Production Plant plans, engineering, cost, management, and deployment. We are confident that all parties to the selection process will find these documents valuable and responsive.

TABLE 1-2. REPRESENTATIVE DATA NEEDS FOR DEFINING REFERENCE
PLANT DESIGN, OPERATIONAL CHARACTERISTICS,
AND COST ESTIMATES

Feature	Data Needed (Typical)	Documents addressing feature/data required
PLANT DESIGN COMPLETENESS	<ul style="list-style-type: none"> o Plant layout on site o Work Breakdown Structure o Major components and facilities o Balance of plant including instrumentation and control equipment o Material and energy flows * Alternatives to UF₆ feed and product * Stand-alone facilities for subsequent production plants 	<ul style="list-style-type: none"> o AVLIS Production Plant Design Reports: <ul style="list-style-type: none"> - Executive Summary (E010) - Overall Design Report (E020) - Laser System (E030) - Separator System (E040) - Uranium Processing (E050) - Conventional Facilities and Process Support (E060) o Project Assessments (APP041-APP047) o Work Breakdown Structure and Dictionary (APP020)

o Documentation requested in Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, UE/ONE, September 21, 1984.

TABLE 1-2, Cont'd. REPRESENTATIVE DATA NEEDS FOR DEFINING REFERENCE
PLANT DESIGN, OPERATIONAL CHARACTERISTICS,
AND COST ESTIMATES

Feature	Data Needed (Typical)	Documents Addressing feature/data required
OPERATIONAL CHARACTERISTICS	o Reliability/Availability/Maintainability	o Reliability, Availability, and Maintainability (APP044)
	<ul style="list-style-type: none"> - Failure/shut-down: modes and effects - Mean time between failures - Mean time to restore - Operating levels relative to ultimate or maximum safe levels - Modular shutdown (part-load operation) capability - Scheduled maintenance and downtime - Number of replacement units/spares required - Onsite refurbishing facilities and personnel required - Reliance on special outside personnel - Consequences of, and provisions for, power outages 	<ul style="list-style-type: none"> o Reliability Engineering Assessment (APP100) o Production Plant Design Reports: <ul style="list-style-type: none"> - Executive Summary (EO10) - Overall Design Report (EO20) - Laser System (EO30) - Separator System (EO40) - Uranium Processing (EO50) - Conventional Facilities and Process Support (EO60) o Operations and Maintenance Plan (APP090) o Operating Cost Summary (APP110) o Operating Cost Labor Analysis (APP120) o Operating Material Analysis (APP130) o Operating Material Cost Basis (APP140)

o Documentation requested in Criteria and Methodology for the Assessment of the AGE and AVIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, OE/OAE, September 21, 1984.

TABLE 1-2, Cont'd. REPRESENTATIVE DATA NEEDS FOR DEFINING REFERENCE
PLANT DESIGN, OPERATIONAL CHARACTERISTICS,
AND COST ESTIMATES

Feature	Data Needed (Typical)	Documents addressing feature/data required
OPERATIONAL CHARACTERISTICS, Cont'd	o Operational flexibility	o Production Plant Executive Summary (E010)
	- Potential range of product and tails assays per plant	o Production Plant Overall Design Report (E020)
	- Time and cost required to change plant output	o Production Plant Uranium Processing Design Report (E050)
	- Impact of demand change on process performance	o DOE/AVLIS Long Term Competitiveness in the World Enrichment Market (PP030)
		o Project Schedule and Milestones (APP030)
	o Energy and power requirements	o Production Plant Design Reports
	- Energy and power needed for	- Overall Design (E020)
	-- Startup/shutdown	- Laser System (E030)
	-- Normal operation	- Separator System (E040)
	-- Emergency procedures	- Uranium Processing (E050)
	- Average kWh/SWU	- Conventional Facilities and Process Support (E060)
		o Operating Cost Summary (APP110)
		o Operating Cost Material Analysis (APP130)
	* Current data and information	o AVLIS Technology and Engineering Basis (E020, Data Package II)
	- Process performance	o AVLIS Program Plan (PP010)
	- Equipment scale	

o Documentation requested in Criteria and Methodology for the Assessment of the AEC and AVLIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, UE/ONE, September 21, 1984.

TABLE 1-2, Concluded. REPRESENTATIVE DATA NEEDS FOR DEFINING REFERENCE
PLANT DESIGN, OPERATIONAL CHARACTERISTICS,
AND COST ESTIMATES

Feature	Data Needed (Typical)	Documents addressing feature/data required
BASIS FOR PLANT CAPITAL AND OPERATING COST ESTIMATES	<ul style="list-style-type: none"> * Capital cost estimates <ul style="list-style-type: none"> - First production plant - Stand-alone, subsequent production plant * Operating cost estimates <ul style="list-style-type: none"> - First production and stand-alone subsequent production - Material cost - Staffing levels and functional descriptions o Cost experience (process-specific) o Work Breakdown Structure and level of detail o Reliance on learning curves o Use of scaling laws o Commercial availability of hardware o Contingencies applied 	<ul style="list-style-type: none"> o Capital Cost: <ul style="list-style-type: none"> - Summary (APP050) - Bill of Materials (APP060) - Vendor Estimates (APP080) o Operating Cost: <ul style="list-style-type: none"> - Summary (APP110) - Manpower Analysis (APP120) - Material Analysis (APP130) - Material Cost Basis (APP140) o Operations and Maintenance Plan (APP090) o Work Breakdown Structure and Dictionary (APP020) o Industrial Access Program (PP020) o AVLIS Technology and Engineering Basis (EB020, Data Package II)

- o Documentation requested in Criteria and Methodology for the Assessment of the AEC and AVLIS Technologies, US Department of Energy; July 31, 1984.
- o Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, OE/ONE, September 21, 1984.

Table 1-3. REPRESENTATIVE DATA NEEDS FOR DEFINING
DEVELOPMENT/IMPLEMENTATION SCHEDULES AND PLANS

Feature	Data Needed (Typical)	Documents addressing feature/data required
DEVELOPMENT/ IMPLEMENTATION PLANS	<ul style="list-style-type: none"> * Program plan o R&D approaches o Alternative development paths o Resources required to reach design goal o Provision for delays and contingencies (including design alternatives and performance and cost implications if R&D fails) o Plans for integrating developments into a full-scale plant 	<ul style="list-style-type: none"> o Program Plan (PP010) o Project Management Plan (APP010) o AVLIS Technology and Engineering Basis (E0020, Data Package II) o Project Schedule and Milestones (APP030)
BASIS FOR SCHEDULE ESTIMATES	<ul style="list-style-type: none"> * Project schedule o Schedule experience o Critical path analysis o Optimistic/pessimistic schedules 	<ul style="list-style-type: none"> o Project Schedule and Milestones (APP030) o Program Plan (PP010) o Production Plant Executive Summary (E010) o Production Plant Overall Design Report (E020)

o Documentation requested in Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, IE/ONE, September 21, 1984.

**Table 1-3, Concluded. REPRESENTATIVE DATA NEEDS FOR DEFINING
DEVELOPMENT/IMPLEMENTATION SCHEDULES AND PLANS**

Feature	Data Needed (Typical)	Documents addressing feature/data required
BASIS FOR R&D	o R&D cost experience (process-specific)	o Program Plan (PP010)
COST ESTIMATES	o Cost components <ul style="list-style-type: none"> - Special equipment - Demonstration facilities - Provisions for contingencies 	o Capital Cost Vendor Estimates (APP080)

- o Documentation requested in Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies, US Department of Energy; July 31, 1984.
- * Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, UE/UNE, September 21, 1984.

TABLE 1-4. REPRESENTATIVE DATA NEEDS FOR DEFINING
DEPLOYMENT ASPECTS

Feature	Data Needed (Typical)	Documents addressing feature/data required
LONG-TERM COMPETITIVENESS	<ul style="list-style-type: none"> o Current status relative to foreign competition o Probable competitive advantage and lifetime o Fundamental process limitations: <ul style="list-style-type: none"> - Unit capital cost (\$/(SMU/yr)) - Energy intensiveness (kwh/SMU) - Product cost (\$/kgU) 	<ul style="list-style-type: none"> o DOE/AVLIS Long-Term Competitiveness in the World Enrichment Market (PP030) o Production Plant Executive Summary (E010) o Production Plant Overall Design Report (E020)
MANAGEMENT PLANS (INCLUDING BUDGETS)	<ul style="list-style-type: none"> * Project management plan o R&D plans o Implementation/procurement/training plans o Technology transfer and procurement plans * Quality assurance plan and assessment 	<ul style="list-style-type: none"> o Program Plan (PP010) o Project Management Plan (APP010) o Industrial Access Program (PP020) o Preliminary Quality Assurance Plan and Assessment (APP045) o Operations and Maintenance Plan (APP090)

- o Documentation requested in Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies, US Department of Energy; July 31, 1984.
- * Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, UE/ONE, September 21, 1984.

TABLE 1-4, Concluded. REPRESENTATIVE DATA NEEDS FOR DEFINING
DEPLOYMENT ASPECTS

Feature	Data Needed (Typical)	Documents addressing feature/data required
COMMERCIAL READINESS	<ul style="list-style-type: none"> o Producibility/fabricability of components o Status of design, procurement, and construction activities o Vendor qualification and network establishment o Materials qualification plan 	<ul style="list-style-type: none"> o Industrial Access Program (PP020) o Program Plan (PP010) o Production Plant Design Reports: <ul style="list-style-type: none"> - Executive Summary (EO10) - Overall Design Report (EO20) - Laser System (EB030) - Separator System (EB040) - Uranium Processing (EB050) - Conventional Facilities and Process Support (EB060) o AVLIS Technology and Engineering Design Basis (EB020, Data Package II)

o Documentation requested in Criteria and Methodology for the Assessment of the AEC and AVLIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, UE/DNE, September 21, 1984.

TABLE 1-5. REPRESENTATIVE DATA NEEDS FOR DEFINING
EXTERNAL/SOCIETAL CONSIDERATIONS

Feature	Data Needed (Typical)	Documents addressing feature/data required
SAFETY	<ul style="list-style-type: none"> o Failure modes o Consequences <ul style="list-style-type: none"> - Personnel hazards - Property damage o Criticality considerations o Health physics; nuclear material handling procedures o Mitigating measures o Vulnerability to natural disasters (tornadoes, earthquakes, hurricanes, etc.) o Ability to meet applicable standards 	<ul style="list-style-type: none"> o Preliminary Safety Analysis Report (APP042) o Production Plant Design Reports: <ul style="list-style-type: none"> - Laser System (EB030) - Separator System (EB040) - Uranium Processing (EB050) - Conventional Facilities and Process Support (EB060) o Preliminary Environmental Assessment (APP041)

o Documentation requested in Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, OE/ONE, September 21, 1984.

TABLE 1-5, Cont'd. REPRESENTATIVE DATA NEEDS FOR DEFINING
EXTERNAL/SOCIETAL CONSIDERATIONS

Feature	Data Needed (Typical)	Documents addressing feature/data required
SAFEGUARDS	o Mass/material integrity of system	o Safeguards Assessment (APP043)
	o In-process (resident) inventory <ul style="list-style-type: none"> - Quantity - Uncertainty - Accountability 	o Production Plant Design Reports: <ul style="list-style-type: none"> - Executive Summary (E010) - Overall Design Report (E020) - Separator System (E040) - Uranium Processing (E050) - Conventional Facilities and Process Support (E060)
	o Process-unique security measures required <ul style="list-style-type: none"> - Plant size (e.g., perimeter) - Security force size 	o Operating Cost Labor Analysis (APP120)
	o IAEA safeguards/inspection provisions	
PROLIFERATION POTENTIAL	o Ease of manufacture of critical components and operating system	o AVIIS Impact on Nuclear Proliferation (APP047)
	o Sophistication of technology	
	o Potential for producing weapons-grade material	

o Documentation requested in Criteria and Methodology for the Assessment of the AGC and AVIIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, OE/DNE, September 21, 1984.

TABLE 1-5, Concluded. REPRESENTATIVE DATA NEEDS FOR DEFINING
EXTERNAL/SOCIETAL CONSIDERATIONS

Feature	Data Needed (Typical)	Documents addressing feature/data required
ENVIRONMENTAL IMPACT	<ul style="list-style-type: none"> o Land used <ul style="list-style-type: none"> - Total vs disturbed acreage - Site plan o Employment schedule <ul style="list-style-type: none"> - Construction - Operation o Pollutant emissions <ul style="list-style-type: none"> - Air-borne - Water-borne o Water use requirement o Hazardous waste disposal needs o Noise levels at fence o Reliance on strategic materials 	<ul style="list-style-type: none"> o Preliminary Environmental Assessment (APP041) o Waste Management Plan (APP046) o Preliminary Safety Analysis Report (APP042) o Production Plant Design Reports: <ul style="list-style-type: none"> - Laser System (EB030) - Separator System (EB040) - Uranium Processing (EB050) - Conventional Facilities and Process Support (EB060) o Project Management Plan (APP010) o Capital Cost Summary (APP050) o Operating Cost Summary (APP110)

o Documentation requested in Criteria and Methodology for the Assessment of the AGC and AVLIS Technologies, US Department of Energy; July 31, 1984.

* Supplementary documentation requested in memorandum: Guidance on Data Package III, Norton Haberman, Director Advanced Technology Projects, OE/CNE, September 21, 1984.

2. TABLES OF CONTENTS FOR DATA PACKAGE III DOCUMENTS

To provide a guide to specific information contained in Data Package III, we have assembled in Sec. 2 the table of contents for each document in the data package. Document titles and the location of their contents are listed in the Contents of this document. The table of contents listing which immediately follows provides a more specific definition of information and its location within each data package document. To find the title of the document containing desired information, consult the document logic tree (Fig. 1-1), the tables (1-1 to 1-4) which cross-reference PEB/DOE data needs to AVLIS Data Package III document titles, or the brief document descriptions in the previous section. This section provides an information index and a guide to the AVLIS Data Package III documents.

2.1 EXECUTIVE SUMMARY

DOCUMENTS

Lawrence Livermore
National Laboratory

Energy Systems

AVLIS

Production Plant

Executive Summary (U)

**Atomic Vapor
Laser Isotope Separation**

**Document E-010
November 15, 1984**

TABLE OF CONTENTS

1. Introduction and Summary	1
1.1. Purpose of Design Report	3
2. AVLIS Production Plant Design Description	5
2.1. Overall Plant Design	9
2.2. Laser System Design	16
2.3. Separator System Design	24
2.4. Uranium Conversion System Design	31
2.5. Balance of Plant and Support Systems Design	38
2.6. "Greenfield" Site Plant Design	55
3. Cost Estimates	58
3.1. Capital Costs	60
3.2. Operating Costs	68
3.3. Separative Work Cost	73
4. Project Activities	78
4.1. Project Schedule	78
4.2. Project Assessments	86
4.3. Operations & Maintenance	97
4.4. Management Plan	99
4.5. Program Plan	105

**Lawrence Livermore
National Laboratory**

Energy Systems

AVLIS Production Plant Overall Design Report (U)

**Atomic Vapor
Laser Isotope Separation**

**Document E-020
November 15, 1984**

TABLE OF CONTENTS

1. Executive Summary	1
1.1 Design Description	2
1.1.1 Overall Plant Design	5
1.1.2 Laser System Design	10
1.1.3 Separator System Design	13
1.1.4 Uranium Conversion System Design	16
1.1.5 Balance of Plant and Support System Design	19
1.1.6 "Greenfield" Site Design	20
1.2 Cost Estimates	20
1.2.1 AVLIS Production Plant Capital Cost Estimates.	22
1.2.2 AVLIS Production Plant Operating Cost Estimates	26
1.2.3 Separative Work Cost	28
1.3 Project Activities	31
1.3.1 Project Schedule	31
1.3.2 Project Assessments	38
1.3.3 Operations and Maintenance	42
1.3.4 Project Management Plan	43
1.3.5. Program Plan	47
2. Plant Description	52
2.1 Purpose	52
2.2 General Design Criteria	53
2.2.1 Enrichment Demand	53
2.2.2 Initial Increment Plant	56
2.2.3 Fully Activated Plant	58
2.3 Plant Performance	60
2.4 Material Flow	65
2.4.1 Flow Streams	69
2.4.2 Material Handling	72
2.5 The Modular Concept	79
2.5.1 Separator Module	79
2.5.2 Laser Module	81

2.6	AVLIS Production Plant Site Layout	85
2.6.1	Site Location	85
2.6.2	Process Facility	88
2.6.3	Greenfield Site	91
2.7	Technology Overview	95
3.	Design Descriptions	103
3.1	Laser Systems	103
3.1.1	Copper and Dye Laser Systems	105
3.1.2	Optics	116
3.1.3	Instrumentation and Control System	118
3.1.4	Refurbishment and Test	121
3.1.5	Process Support Systems	125
3.1.6	Buildings and Facilities	127
3.2	Separator and Facilities	128
3.2.1	Plant and Facilities	132
3.2.2	Separator System	134
3.2.3	Separator Support Systems	148
3.3	Uranium Processing Facilities	154
3.3.1	Design Overview	155
3.3.2	Feed Preparation from UF ₆	165
3.3.3	Product Conversion to UF ₆	174
3.3.4	Process Support	178
3.3.5	Waste Management	181
3.3.6	Alternatives to Onsite Uranium Processing	184
3.4	Conventional Facilities/Process Support	186
3.4.1	Data Acquisition and Control Summary	187
3.4.2	Electrical Distribution Summary	190
3.4.3	Process Support Summary	194
3.4.4	AVLIS Site Selection, Location Improvements Summary	199
3.4.5	Outside Utilities Summary	200
3.4.6	Process Building Summary	202
3.4.7	Other Structures Summary	208
3.4.8	Plant Support Facilities Summary	211
3.5	Greenfield Site Design	213

4.	Cost Estimate Summary.	221
4.1	Capital Cost	221
4.1.1	Summary and Conclusions	221
4.1.2	Estimates Bases and Methodology	229
4.2	Operating Cost	234
4.2.1	Basis of the Operating Costs	236
4.2.2	Summary Cost Tables	240
4.2.3	Plant Startup and Initial Operating Costs	241
4.3	Separative Work	255
5.	Program Plan.	261
5.1	Introduction	261
5.2	Program Direction	262
5.3	Program Evaluation Criteria	263
5.4	Deployment Strategy	264
5.5	Schedule and Funding	267
5.6	Financial Performance	268
5.7	Privatization	268
5.8	Long Term Competition	269
6.	Preliminary Assessments	271
6.1	Safeguards Plan	271
6.1.1	Purpose and Objectives	271
6.1.2	Conclusions	271
6.1.3	Methodology and Criteria	272
6.1.4	Results	272
6.1.5	Summary	273
6.2	Safety Assessment	280
6.2.1	Purpose and Objectives	280
6.2.2	Conclusions	280
6.2.3	Methodology and Criteria Summary	280
6.2.4	Assessment Impact	281
6.2.5	Hazards and Abnormal Operations	281
6.2.6	Accidents	295
6.3	Waste Management Plan	300
6.3.1	Purpose and Objectives	300

6.3.2	Conclusions	301
6.3.3	Methodology	301
6.3.4	Assessment Results Implementation	302
6.3.5	Document Summary	303
6.4	Quality Assurance Plan	320
6.4.1	Purpose and Objectives	320
6.4.2	Methodology and Criteria.	321
6.4.3	Scope	322
6.4.4	Quality Assurance Program	322
6.4.5	Organization	323
6.4.6	Quality Assurance Action Elements	323
6.4.7	Risk Assessments	324
6.4.8	Program Implementation and Control	325
6.5	Reliability, Availability, and Maintainability Assessment	328
6.5.1	Plant RAM Objectives	328
6.5.2	Conclusions	329
6.5.3	Organization of Assessment Activity	329
6.5.4	Basis for Assessment	330
6.5.5	Plant RAM Assessment	332
6.5.6	Summary	338
6.6	Preliminary Environmental Assessment	339
6.6.1	Purpose and Objectives	339
6.6.2	Conclusions	339
6.6.3	Methodology	339
6.6.4	Assessment Impact	340
6.6.5	Environmental Impacts of Site Preparation and Plant Facilities Construction.	341
6.6.6	Environmental and Occupational Impacts of Facility Operation	342
6.6.7	Environmental Impacts of Accidents	350
6.7	Nuclear Proliferation	354
7.	Operations and Maintenance Plan	356
7.1	Purpose, Objectives, and Scope of Plan	356
7.2	Operating Organization and Planning Basis	357
7.3	Production Operations	359

7.3.1	Separator Module Operations	359
7.3.2	Laser Operations	360
7.3.3	Support Utilities Operations	361
7.3.4	Materials Management	362
7.4	Uranium-Processing Facilities.	363
7.4.1	Feed Conversion Facility.	364
7.4.2	Feed Preparation Facility	364
7.4.3	Product Conversion Facility	364
7.4.4	Uranium Recovery Facility	365
7.4.5	Support Facilities	365
7.4.6	Materials Management	366
7.5	Waste Management	367
7.6	General AVLIS Production Plant Support Facilities	368
7.6.1	Materials Receiving/Storage.	368
7.6.2	Utilities	369
7.6.3	Electrical Distribution	369
7.7	Maintenance	370
7.7.1	Maintenance Services	370
7.7.2	AVLIS Process Facilities	371
7.7.3	Uranium Processing Facilities	371
7.7.4	Maintenance Support Services	372
7.7.5	Staff Services	372
8.	Project Schedule and Milestones	374
8.1	Summary and Conclusions.	375
8.2	Basis of the Authorization Limited Schedule	380
8.3	AVLIS Deployment Plan, Plants 1 and 2	384
9.	Project Management Plan	388
9.1	Project Objectives	388
9.2	Organization and Responsibilities	390
9.2.1	Memorandum of Understanding.	395
9.3	Work Plan	395
9.4	Work Breakdown Structure	399

9.5	Project Schedule and Milestones	399
9.6	Cost Manpower Estimates.	399
9.7	Performance Criteria	400
9.8	Project Management System	401
9.9	Information and Reporting	403
Appendix	AVLIS Production Plant Site Evaluation Study	405

2.2 PROGRAM PLANNING

DOCUMENTS

Lawrence Livermore
National Laboratory

Energy Systems

AVLIS Program Plan (U)

Atomic Vapor
Laser Isotope Separation

Document PP-010
November 15, 1984

CONTENTS

1. Executive Summary.....	1
1.1 Introduction.....	1
1.2 Program Direction.....	2
1.3 Program Evaluation Criteria.....	3
1.4 Deployment Strategy.....	4
1.5 Schedule and Funding.....	7
1.6 Financial Performance.....	8
1.7 Privatization.....	8
1.8 Long Term Competition.....	9
1.9 <u>AVLIS Program Plan Sections</u>	10
2. Program Objectives.....	11
2.1 DOE Objective.....	11
2.2 Objectives of the AVLIS Production Deployment.....	11
2.3 Objectives of the AVLIS Development Program.....	12
3. Program Description.....	13
3.1 Background.....	13
3.2 Current Status.....	16
3.2.1 Major Systems.....	16
3.2.2 Components.....	16
3.2.3 Full-Scale Demonstration Facility.....	21
3.2.4 Commercial Readiness.....	21
3.3 Development Program.....	23
3.3.1 Process Development.....	23
3.3.2 Plant Support.....	23
3.3.3 Process Improvements and New Applications.....	24
3.4 Production Plant Deployment.....	24
3.4.1 Initial Increment of the First Plant.....	24
3.4.2 Full Activation of the First Plant.....	26
3.4.3 Second Plant.....	26

3.5 Deployment Options.....	26
3.5.1 Engineering Limited Program.....	27
3.5.2 Authorization Limited Program.....	29
3.5.3 Funding Limited Program.....	29
3.6 Recommendation.....	29
4. Organization and Responsibilities.....	31
4.1 Roles of Program Participants.....	31
4.2 Program Organization.....	31
4.3 AVLIS Program Responsibilities.....	34
4.3.1 DOE Headquarters Responsibilities.....	34
4.3.2 DOE San Francisco Operations Responsibilities.....	34
4.3.3 DOE Oak Ridge Operations Responsibilities.....	35
4.3.4 DOE Oak Ridge Operations Field Project Office Responsibilities.....	35
4.3.5 General Responsibilities of the Technical Program Office	36
4.3.6 AVLIS Contractor Project Office Responsibilities.....	36
4.3.7 Project Review Board Responsibilities.....	37
4.3.8 Operating Contractor Responsibilities.....	37
5. Work Breakdown.....	39
5.1 Work Definition.....	39
5.2 Work Logic.....	39
5.2.1 Engineering Demonstrations.....	39
5.2.2 Production Plant.....	41
5.2.3 Design, Documentation, and Training.....	42
5.3 Work Breakdown Structure.....	42
5.3.1 AVLIS Production Plant.....	44
5.3.2 AVLIS Development Program.....	45
5.4 Milestones.....	48
5.4.1 AVLIS Production Plant Milestones.....	49
5.4.2 AVLIS Process Demonstration Milestones.....	49
5.4.3 Separator Demonstration Milestones.....	50
5.4.4 Laser Demonstration Milestones.....	51

6. Schedule.....	52
6.1 Long-Term Schedules.....	52
6.2 Milestone Schedules.....	52
6.3 Production Plant Master Schedule.....	58
7. Costs.....	60
7.1 Long-term Cost Projections.....	60
7.2 Near-term Cost Projections.....	60
8. Management Controls and Reporting.....	73
8.1 Management of the Development Program.....	73
8.2 Generation of the Program Plan.....	73
8.3 Technical Control.....	75
8.4 Schedule and Cost Control.....	75
8.5 Reports.....	76
8.5.1 Highlights.....	76
8.5.2 Monthly Budget and Milestone Status Reports.....	76
8.5.3 Milestone Briefs.....	76
8.5.4 Milestone Reports.....	76
8.5.5 Program Plans.....	76
8.5.6 Briefing Documents.....	77
8.5.7 Technical and Programmatic Documents.....	77
8.5.8 Production Plant Documents.....	77
8.6 Quarterly Meetings and Reviews.....	77
Appendix A. Memorandum of Understanding.....	78
Appendix B. List of Supporting Documents.....	82
Appendix C. AVLIS Program Milestone Definitions.....	84
Series 2000: Process demonstrations.....	85
Series 3000: Laser Technology and Operations.....	88
Series 3400: Separator Technology and Operations.....	91
Series 4000: Laser Demonstration Facility.....	95
Series 4400: Separator Demonstration Facility.....	96
Series 5400: AVLIS Production Plant.....	98
Appendix D. Financial Analysis of AVLIS Deployment Options.....	102

Lawrence Livermore
National Laboratory

MARTIN MARIETTA
Energy Systems

AVLIS

Industrial Access Program

Atomic Vapor
Laser Isotope Separation

Document PP-020
November 15, 1984

AVLIS INDUSTRIAL ACCESS PROGRAM

1. Executive Summary.....	1
1.1. Introduction.....	1
1.2. Purpose of the Industrial Access Program.....	2
1.3. Goals of the Industrial Access Program.....	3
1.3.1. Develop Reliable Supplier and Support Network.....	3
1.3.2. Promote Effective Use of Industrial Capability.....	3
1.3.3. Spin-Off AVLIS Technology.....	5
1.3.4. Utilize Small Business and Government Socio-Economic Guidelines.....	5
1.4. Project Description.....	5
1.4.1. Introduction.....	5
1.4.2. Physical Description.....	6
1.4.3. Schedule.....	7
1.4.4. Costs.....	7
1.5. General Procurement Discussion.....	10
1.5.1. Scope.....	10
1.5.2. Strategy.....	10
1.5.3. Data Base.....	11
1.5.4. Action Plan.....	11
2. Procurement Strategy.....	13
2.1. Background.....	13
2.1.1. Program Description.....	13
2.1.2. Process and Equipment Description.....	13
2.1.3. Nature of Procurements.....	19
2.1.4. Procurement Types.....	20
2.2. Discussion.....	23
2.2.1. Procurement Guidelines.....	23
2.2.2. Procurement Methods....	33
2.2.3. Quality Assurance.....	37

3. Procurement and Supplier Data Base.....	38
3.1. Introduction.....	38
3.2. Commercial Availability of AVLIS Equipment.....	38
3.3. Supplier List.....	42
3.4. AVLIS Production Plant Project Cost Breakdowns.....	46
3.4.1. Cost Breakdown by Work Breakdown Structure.....	46
3.4.2. Cost Breakdown by Procurement Category.....	47
3.5. Schedule.....	47
3.6. Developmental Materials/Equipment List.....	49
4. Action Plan.....	56
4.1. Potential Supplier Identification Activities.....	56
4.2. Action Items for Procurements Requiring Special Attention.....	57
4.2.1. Long Lead Items.....	57
4.2.2. Developmental Materials/Equipment.....	57
4.2.3. Vendor Access to Classified Technology.....	58
4.3. Technology Transfer Activities.....	58
4.3.1. Improvements in Existing Technology.....	58
4.3.2. Other Applications of Separator/Laser Technology.....	58
4.3.3. Industrial Photo-Chemical Processing.....	59
4.3.4. Application of Laser Isotope Separation in Other Areas...	59
4.3.5. Privatization.....	60
Appendix A: Industrial Access Program Supplier List	61
Appendix B: Developmental Materials/Equipment.....	97

**Lawrence Livermore
National Laboratory**

**MARTIN MARINETTA
Energy Systems**

DOE/AVLIS Long-Term Competitiveness in the World Enrichment Market

**Atomic Vapor
Laser Isotope Separation**

**Document PP-030
November 15, 1984**

CONTENTS

1. Executive Summary	
2. Introduction	
3. Description of Foreign Enrichment Capability	
3.1. France/Eurodif	
3.1.1. Gaseous Diffusion	
3.1.2. Centrifuge.	
3.1.3. Chemical Exchange	
3.1.4. Advanced Processes	
3.2. Urenco	
3.2.1. Gaseous Diffusion	
3.2.2. Centrifuge	
3.3. Japan	
3.3.1. Chemical Exchange	
3.3.2. Centrifuge	
3.3.3. AVLIS	
3.4. Russia/Techsnab	
3.5. Other Nations	
3.5.1. Argentina	
3.5.2. Australia	
3.5.3. Brazil	
3.5.4. China	
3.5.5. Pakistan	
3.5.6. South Africa	
4. Price Sensitivity of the Commercial Market.	
4.1. Calculation of Market Size	
4.1.1. Critique of this Analysis	
4.2. Maximum Credible Market for DOE	
5. The Secondary Market	
6. Projections for Cost and Price.	
6.1. Foreign Suppliers	

- 6.2. DOE/AVLIS
- 6.2.1. Production Cost Projections for
the First AVLIS Plant
- 6.2.2. Long Term AVLIS Cost Projections
- 6.3. Impact of Variable Product and Tails Assay
- 6.4. Comparison of Cost Projections for DOE Consolidated
(GDP:AVLIS) and Foreign Enrichers.
- 7. Reprocessing
- 7.1. Growth of ²³⁶Uranium and ²³⁴Uranium in Reprocessed Fuel
- 7.2. Technology Comparison for Re-Enrichment of
Uranium Spent Fuel
- 7.3. Reprocessing Projections
- 7.3.1. France
- 7.3.2. United Kingdom
- 7.3.3. Japan
- 7.3.4. Federal Republic of Germany
- 7.3.5. Belgium
- 7.4. Total Reprocessing Capacity
- 7.5. Impact of Reprocessing on Enrichment Planning
- 7.6. Cost Savings for AVLIS with Recycled Feed
- 8. Strength of the Dollar
- 9. Market Risk/Plant Deployment Analysis

2.3 PRODUCTION AND ENGINEERING BASIS

DOCUMENTS

UCID-20184

Lawrence Livermore
National Laboratory

MARTIN MARSHALL
Energy Systems

AVLIS

Production Plant

Laser System Design Report (U)

**Atomic Vapor
Laser Isotope Separation**

**Document EB-030
November 15, 1984**

CONTENTS

1. Executive Summary	1
1.1. Introduction	1
1.2. AVLIS Production Plant	2
1.3. Overall Laser System	5
1.4. Copper and Dye Laser Systems	9
1.4.1. Copper Lasers	12
1.4.2. Dye Laser System	13
1.5. Optical Systems	18
1.6. Instrumentation and Control System	20
1.7. Refurbishment and Test	23
1.8. Process Support Systems	26
1.8.1. Electrical Power	26
1.8.2. Laser Cooling Water Systems	27
1.9. Buildings and Facilities	28
2. Integrated System Requirements	30
2.1. Top-Level System Requirements	30
2.1.1. Laser System/Process Requirements	33
2.2. Laser System Architecture	37
2.2.1. Copper Laser System	40
2.2.2. Multiplexing of Copper Laser Chains	40
2.2.3. Dye Laser System	42
2.2.4. Laser System Floor Plan	44
2.3. Laser Component Requirements	44
2.3.1. Dye Laser System Components	46
2.3.2. Copper Laser System Components	50
2.3.3. Laser Refurbishment	53
2.3.4. Laser Utilities	55
3. Copper Laser Systems	59
3.1. Copper Laser Oscillator Package	59
3.1.1. Copper Laser Oscillator Tube, Mechanical	67
3.1.2. Oscillator Head Optics	68
3.1.3. Oscillator Enclosure, Mechanical	68
3.1.4. Copper Oscillator Enclosure, Electrical	68

3.1.5.	Copper Oscillator Pulsed Power Electronics, Mechanical	70
3.1.6.	Copper Laser Oscillator Pulsed Power Electronics, Electrical	71
3.1.7.	Copper Laser Oscillator Gas/Vacuum System, Mechanical	71
3.1.8.	Gas/Vacuum System Electrical	71
3.1.9.	Plant Mechanical Support System	72
3.2.	Copper Laser Amplifier	72
3.2.1.	Copper Laser Amplifier Head, Mechanical	74
3.2.2.	Amplifier Enclosure, Mechanical	75
3.2.3.	Amplifier Enclosure, Electrical	75
3.2.4.	Amplifier Pulsed Power System, Mechanical	75
3.2.5.	Amplifier Pulsed Power System, Electrical	78
3.2.6.	Amplifier Gas/Vacuum System	81
3.2.7.	Amplifier Electrical Distribution	81
3.2.8.	Plant Support System	81
3.3.	Herriott Cell	81
3.4.	Lifetime and Reliability	82
3.5.	Operating Modes and Energy Requirements for Startup, Normal Operation, Shutdown, and Emergency Operations of Laser System	83
3.5.1.	Copper Laser Operation	83
3.5.2.	Laser System Energy Requirements	84
3.5.3.	Emergency Laser System Operation	85
3.6.	Optical Support for Copper Laser	85
4.	Dye Laser System	91
4.1.	Waveform Generator	100
4.1.1.	Dye Master Oscillator	100
4.1.2.	Wavelength Acquisition and Stabilization Unit	105
4.1.3.	Electro-optical Devices--Electro-optic Modulator	107
4.2.	Dye Amplifiers	109
4.3.	Dye Characteristics and Handling Systems	121
4.3.1.	Dye Characteristics	121
4.3.2.	Dye Handling Systems	123
4.4.	Dye Laser System Support Facilities	134
4.5.	Facility Requirements	134

5. Optical Systems	138
5.1. Copper Laser Oscillator Package Beam Combination and Transport	139
5.2. Copper Laser Chain Beam Combination	140
5.3. Copper Laser Chain Beam Transport	144
5.4. Dye Laser Chain Beam Combination	147
5.5. Dye Laser Chain Beam Transport	147
5.6. Dye Laser Beam Wavefront Correction and Routing	149
5.7. Separator Module Chamber Optics	149
5.8. Separator Module Pod Alignment Optics	152
6. Instrumentation and Controls	154
6.1. Beam Diagnostics	162
6.2. Pointing and Centering Electronics	163
6.3. Master Timing System	167
6.4. Computer Main Frame and Peripherals	167
6.5. Communication Systems	168
6.6. Real-Time Control	169
6.7. Facility/Interlocks/Safety	172
7. Refurbishment and Test	178
7.1. Copper Laser Refurbishment	180
7.1.1. Subsystem Integration Area-Mechanical	180
7.1.2. Subsystem Integration Area-Electrical	187
7.1.3. Switching Power Supply Refurbishment	187
7.1.4. Pulsed Power Electronics Refurbishment	188
7.2. Laser Tube Refurbishment Area	189
7.2.1. Vacuum Ovens	189
7.2.2. Laser Tube Assembly Area	191
7.3. Dye Laser Refurbishment and Test	193
7.3.1. Dye Laser Workstation-Mechanical	200
7.3.2. Dye Laser Workstation-Hydraulic	203
7.3.3. Dye Laser Optical Alignment and Test	203
7.4. Laser Electronics and Electro-optics Refurbishment and Test	205
7.4.1. Optics Refurbishment	205
7.4.2. Electronics	206

7.5. Laser System Hazards	206
7.5.1. Laser System Hazards	206
8. Process Support Systems	211
8.1. Power Conditioning System	211
8.2. Cooling Water System	216
8.2.1. Low-Temperature, Low-Conductivity Cooling Water System	216
8.2.2. Process Chilled Water	221
9. Facilities	225
9.1. Area/Space Requirements	225
9.2. Laser Area	225
9.3. Laser Subassembly and Refurbishment Area	229
9.4. Foundation Requirements	232
9.5. Special Facility Requirements	232

**Lawrence Livermore
National Laboratory**

Energy Systems

AVLIS Production Plant Separator System Design Report Volume I (U)

**Atomic Vapor
Laser Isotope Separation**

**Document EB-040
November 15, 1984**

TABLE OF CONTENTS

1. Executive Summary	1
1.1 Plant and Facilities	5
1.1.1 Plant Input and Output.	5
1.1.2 Uranium Material Handling.	7
1.1.3 Plant Assessments	7
1.2 Separator System	7
1.2.1 Module	9
1.2.2 Pod	13
1.2.3 Controls	17
1.2.4 Refurbishment	19
1.3 Separator Support Systems	21
1.3.1 Electrical.	21
1.3.2 Cooling.	23
1.3.3 Vacuum	24
1.3.4 Ventilation	25
1.3.5 Building	26
2. Integrated Plant Design	28
2.1 Facility.	28
2.2 Plant Input and Output	32
2.3 Separator Area Material Flow	37
2.4 Uranium Material Handling	37
2.4.1 Design Considerations	37
2.4.2 Uranium	41
2.4.3 National Uranium Feed	42
2.4.4 Product Material.	50
2.4.5 Depleted Tails	59
2.4.6 Refurbishing Materials.	63
2.4.7 Scrap and Waste Material	64
2.5 Plant Assessment	65
2.6 Fully Activated Plant	65
3. Separator Module System	68
3.1 Vacuum Vessel	72
3.1.1 Process Chamber	72
3.1.2 Gas Scattering Chambers	74
3.1.3 Optics Chambers	74
3.1.4 Vacuum Isolation Valves	77
3.1.5 Partition Panels	77
3.1.6 Rail System	78
3.1.7 Field Coils	78
3.1.8 Process Vessel Liner	79
3.1.9 Module Mounting	79
3.1.10 Module Operations and Pod Change	79
3.1.11 Personnel Transporter.	86
3.2 Cooling Water Systems	86
3.2.1 Recirculated Treated Water System	86
3.2.2 Demineralized Water System	87

3.3	Vacuum Pumping System	87
3.3.1	Design	87
3.3.2	Overall System Description	87
3.3.3	Backing/Roughing System	88
3.4	Negative Air System	88
3.4.1	System Design and Performance	89
3.4.2	Instrumentation and Controls	91
3.4.3	Construction	91
3.4.4	Design Codes and Standards	91
3.5	Inert Gas System	92
3.5.1	Argon Gas System	92
3.5.2	Nitrogen Gas System	93
4.	Separator Pod Assembly	96
4.1	Vaporizer System	102
4.1.1	Crucible and Beam Dump	107
4.1.2	Electron Beam Gun Subsystem	111
4.1.3	Feed and Reflux Subsystem	122
4.1.4	Vaporizer Instrumentation and Control	128
4.2	Pod Carriage	131
4.2.1	Frame Assembly and Wheels	132
4.2.2	Umbilical Panels	134
4.2.3	Utility Distribution	137
4.2.4	Cooling Shroud	138
4.3	Extractor/Collector Assembly	139
4.3.1	Collector Enclosure	144
4.3.2	Ion Extractor	149
4.3.3	Withdrawal System	166
4.3.4	Extractor Alignment	168
4.3.5	Thermal Control	170
4.3.6	Extractor Instrumentation and Control	175
5.	Separator Process Control Systems	177
5.1	Operations Level	182
5.1.1	Hierarchy	182
5.1.2	Man/Machine Interface	184
5.2	Process Control Layer	189
5.2.1	Process Control Modules	189
5.2.2	Modes of Operation	191
5.2.3	Input/Output Point Count	200
5.2.4	Cooling System Controls	200
5.2.5	Other Process Controls	210
6.	Refurbishment and Test Facility	211
6.1	Refurbishment Equipment	211
6.1.1	Pod Transporter	214
6.1.2	Pod Disassembly Area	217
6.1.3	Oxidation Ovens	217
6.1.4	Coating Application	219
6.1.5	Component Decontamination	221

6.1.6	Electrical Component Refurbishment Equipment	221
6.1.7	Mechanical Component Refurbishment Equipment	222
6.1.8	Assembly Fixtures and Handling	222
6.1.9	Final Assembly and Storage	222
6.1.10	Transporter Refurbishment	225
6.1.11	Product and Tails Accumulator Refurbishment	225
6.1.12	Module Refurbishment	227
6.2	Test and Quality Assurance Equipment	227
6.2.1	Mechanical Tolerance Test Tooling	229
6.2.2	Electrical Test Equipment	229
6.3	Refurbishment Facility Requirements	229
6.3.1	Floor Layout	229
6.3.2	Transport and Handling Equipment	230
6.3.3	Personnel Hazards	230
6.3.4	Plant Services Required	231
6.4	Refurbishment Times and Staffing	232
6.5	Pod Spares Analysis	235
7.	Separator Process Support Systems	243
7.1	Separator Electrical Distribution	243
7.2	Separator Cooling Water Systems	249
7.2.1	Recirculated Treated Water System	249
7.2.2	Low Conductivity Water System	252
7.2.3	Low Temperature Water System	255
7.3	Separator Vacuum Pumping Systems	257
7.3.1	Design	258
7.3.2	Construction and Codes	261
7.4	Liquid Nitrogen System	263
7.5	Argon Gas System	263
7.6	Separator Area Ventilation	266
8.	Separator Facilities	269
8.1	Facility Area/Space Requirements	269
8.1.1	Separator	269
8.1.2	Pod Refurbishment	272
8.1.3	Uranium Materials Handling and Processing	272
8.1.4	Central Control	272
8.1.5	Shop and Facility Support	273
8.2	Separator Facility Layout	273
8.2.1	Separator Area	273
8.2.2	Separator Pod Refurbishment Area	275
8.2.3	Uranium Material Handling and Processing Area	278
8.2.4	Central Control Area	278
8.2.5	Shop and Facility Support Area	281
8.3	Building and Foundation Requirements	281
8.3.1	Separator Facility	281
8.3.2	Pod Refurbishment Area	285
8.3.3	Uranium Materials Handling and Processing Area	285
8.3.4	Central Control Area	285
8.3.5	Shop and Facility Support Area	286
8.3.6	Special Facility Requirements	286

Lawrence Livermore
National Laboratory

Energy Systems

AVLIS

Production Plant

Separator System Design Report

Volume II (U)

Atomic Vapor
Laser Isotope Separation

Document EB-040
November 15, 1984

TABLE OF CONTENTS

	Page
APPENDIX 1 - SUMMARY	
A1-1 Separator system work breakdown structure.	2
A1-2 Separator system work breakdown structure.	3
A1-3 Separator system work breakdown structure.	4
A1-4 Work breakdown index.	5
A1-5 Work breakdown index.	6
A1-6 Work breakdown index.	7
A1-7 Bibliography.	8
A1-8 Bibliography.	9
 APPENDIX 2 - PLANT DESIGN	
A2-1 Tails handling area.	11
A2-2 Tails pallet.	12
A2-3 Product handling area.	13
A2-4 Product pallet.	14
A2-5 Tails/product rotator (sections).	15
A2-6 Tails/product rotator (plan view).	16
 APPENDIX 3 - SEPARATOR MODULE DESIGN	
A3-1 Process vessel.	18
A3-2 Process vessel.	19
A3-3 Process vessel door.	20
A3-4 Magnet coils and vessel mounts.	21
A3-5 Gas scattering cell positioner.	22
A3-6 Pod drive system.	23
A3-7 Pod drive system.	24
A3-8 Pod transporter.	25
A3-9 Personnel access transport.	26
A3-10 Accumulator transporter.	27
A3-11 Transfer mechanism transporter.	28
A3-12 Pod removal logic.	29
A3-13 Pod removal time line.	30
A3-14 Flow diverter changeout time line.	31
A3-15 Pod installation logic.	32
A3-16 Pod installation time line.	33
 APPENDIX 4 - SEPARATOR POD DESIGN	
A4-1 Pod in module - cross section.	35
A4-2 Pod in module - longitudinal section.	36
A4-3 Bellows seal detail.	37
A4-4 Vaporizer cross section.	38
A4-5 Crucible assembly.	39
A4-6 Flow troughs.	40
A4-7 Feeder support.	41
A4-8 Billet feeder mechanism.	42
A4-9 Feed canister/magazine.	43

		Page
A4-10	Feed canister pallet.	44
A4-11	Collector sections & details.	45
A4-12	Collector sections & details.	46
A4-13	Collector sections & details.	47
A4-14	Extractor array control drawing.	48
A4-15	Product arch.	49
A4-16	Tab arch.	50
A4-17	Baffle arch.	51
A4-18	Product plate.	52
A4-19	Tab plate.	53
A4-20A	Baffle plates.	54
A4-20B	Baffle plates.	55
A4-20C	Baffle plates.	56
A4-20D	Baffle plates.	57
A4-21	Accumulator support.	58
A4-22	Accumulator transfer mechanism.	59
A4-23	Accumulator transfer mechanism.	60
A4-24	Accumulator vessel.	61
A4-25	Extractor alignment assembly.	62
A4-26	Pod frame and wheels.	63
APPENDIX 5 - SEPARATOR CONTROL SYSTEM		
A5-1	Vacuum system first level display.	65
A5-2	Vessel second level display.	66
A5-3	Vessel control state transition diagram.	67
A5-4	Roughing pumps second level display.	68
A5-5	Roughing pump third level display	69
A5-6	Diffusion pumps third level display.	70
A5-7	Process chamber diffusion pump state transition diagram.	71
A5-8	Backing pump third level display.	72
A5-9	Backing pump state transition diagram.	73
A5-10	Gun vacuum third level display.	74
A5-11	Gun vacuum cryopump state transition diagram	75
A5-12	Optic chamber second level console display.	76
A5-13	Optics chamber third level display.	77
A5-14	Optics chamber cryopump state transition diagram.	78
APPENDIX 6 - POD REFURBISHMENT		
A6-1	Disassembly line.	80
A6-2	Disassembly line.	81
A6-3	Vaporizer cart.	82
A6-4	Oxidation oven.	83
A6-5	Oxidation oven cart.	84
A6-6	Oxidation oven cart.	85
A6-7	Graphite refurbishment area.	86
A6-8	Pod trays.	87
A6-9	Assembly line.	88
A6-10	Vacuum oven.	89

	Page
A6-11 Separator pod refurbishment logic diagrams.	90
A6-12 Separator pod refurbishment logic diagrams.	91
A6-13 Separator pod refurbishment logic diagrams.	92
A6-14 Separator pod refurbishment logic diagrams.	93
A6-15 Separator pod refurbishment logic diagrams.	94
A6-16 Separator pod refurbishment logic diagrams.	95
A6-17 Separator pod refurbishment logic diagrams.	96
A6-18 Separator pod refurbishment logic diagrams.	97
A6-19 Separator pod refurbishment logic diagrams.	98
A6-20 Pod refurbishment time lines.	99
A6-21 Pod refurbishment time lines.	100
A6-22 Pod refurbishment time lines.	101
A6-23 Pod refurbishment time lines.	102
A6-24 Pod refurbishment time lines.	103
A6-25 Pod refurbishment time lines.	104
A6-26 Pod refurbishment time lines.	105
A6-27 Pod refurbishment time lines.	106
A6-28 Pod refurbishment time lines.	107
A6-29 Pod refurbishment time lines.	108
A6-30 Roof arch in fixture (photo).	109
A6-31 Collector parts being removed from pre-heat oven (photo).	110
A6-32 Roof arches in carrier (photo).	111
A6-33 MHDM manual spray coating (photo).	112
A6-34 MHDM roof lifting fixture (photo).	113
A6-35 MHDM pod lifting fixture (photo).	114
 APPENDIX 7 - PROCESS SUPPORT DESIGN	
A7-1 Mechanical equipment and utility building.	116
A7-2 Electrical utility pad.	117
A7-3 Separator building piping, lower level.	118
A7-4 Separator piping in trench.	119
A7-5 HVAC arrangement, module main floor.	120
A7-6 HVAC arrangement, module lower level.	121
A7-7 HVAC penthouse, floor layout.	122
A7-8 HVAC penthouse, equipment arrangement.	123
 APPENDIX 8 - BUILDING & FACILITY DESIGN	
A8-1 Site plan, electrical duct lines.	125
A8-2 Process building arrangement.	126
A8-3 Separator module bay operating floor.	127
A8-4 Separator module bay lower level.	128
A8-5 Separator bay, elevation section.	129
A8-6 Central control room.	130
A8-7 Refurbishment facility.	131
A8-8 Refurbishment building penthouse.	132
A8-9 Process building fire walls.	133

**Lawrence Livermore
National Laboratory**

Energy Systems

AVLIS Production Plant Uranium Processing Design Report (U)

**Atomic Vapor
Laser Isotope Separation**

**Document EB-050
November 15, 1984**

THE URANIUM PROCESSING FACILITIES

CONTENTS

1. Executive Summary	1-1
1.1. Design Overview	1-2
1.1.1. The Need for Uranium Processing	1-2
1.1.2. Process Facilities Review	1-3
1.1.3. Site Plot Plan	1-8
1.1.4. Conclusions	1-8
1.2. Feed Preparation from UF ₆ (WBS 1.3.1, 1.3.2, and 1.3.4)	1-11
1.2.1. Feed Conversion (WBS 1.3.1)	1-11
1.2.2. Feed Preparation (WBS 1.3.2)	1-15
1.2.3. Uranium Recovery (WBS 1.3.4)	1-17
1.3. Product Conversion to UF ₆ (WBS 1.3.3)	1-20
1.4. Process Support (WBS 1.3.5)	1-24
1.4.1. Toll Facility	1-24
1.4.2. UF ₆ Feed Facility	1-25
1.4.3. Fluorine Generation Facility	1-25
1.4.4. Tails Management	1-26
1.4.5. KF Conversion Facility	1-26
1.4.6. Interfacility Services	1-27
1.4.7. Office Building	1-27
1.5. Waste Management (WBS 1.3.4)	1-27
1.6. Potential Cost Improvements to the Enrichment Enterprise	1-30
1.6.1. Summary	1-30
1.6.2. Interfaces with the Feed Supplier	1-31
1.6.3. Interfaces with Fuel Fabricators	1-33
1.7. Introduction to Detailed Discussions	1-34
2. Feed Conversion (WBS 1.3.1)	2-1
2.1. General Overview	2-1
2.2. UF ₄ Production	2-6
2.2.1. System Design Basis	2-6
2.2.2. System Description	2-8
2.2.3. Fully Activated Plant	2-12
2.3. HF Recovery	2-13
2.3.1. System Design Basis	2-13
2.3.2. System Description	2-14
2.3.3. Fully Activated Plant	2-15
2.4. H ₂ Generation	2-15
2.4.1. System Design Basis	2-15
2.4.2. System Description	2-16
2.4.3. Fully Activated Plant	2-18
2.5. Derby Production	2-18
2.5.1. System Design Basis	2-18
2.5.2. System Description	2-23
2.5.3. Fully Activated Plant	2-34
2.6. Derby Roasting	2-35
2.6.1. System Design Basis	2-35

2.6.2.	System Description	2-36
2.6.3.	Fully Activated Plant	2-39
2.7.	Mg ₂ Slag Processing	2-39
2.7.1.	System Design Basis	2-39
2.7.2.	System Description	2-40
2.7.3.	Fully Activated Plant	2-45
2.8.	Instrumentation and Control	2-45
2.8.1.	Point of Control	2-45
2.8.2.	Control	2-46
2.8.3.	Monitoring	2-47
2.8.4.	Annunciation	2-48
2.8.5.	Fully Activated Plant	2-49
2.9.	Building/Services	2-49
2.9.1.	Feed Conversion Building	2-49
2.9.2.	Magnesium Storage Building	2-52
2.9.3.	Services	2-53
2.10.	Outside Services	2-53
3.	Feed Preparation (WBS 1.3.2)	3-1
3.1.	General Overview	3-1
3.2.	Charge Preparation	3-3
3.2.1.	System Design Basis	3-3
3.2.2.	System Description	3-6
3.2.3.	Fully Activated Plant	3-6
3.3.	Crucible Refurbishment	3-7
3.3.1.	System Design Basis	3-7
3.3.2.	System Description	3-7
3.3.3.	Fully Activated Plant	3-10
3.4.	Melting-Casting Operation	3-10
3.4.1.	System Design Basis	3-10
3.4.2.	System Description	3-12
3.4.3.	Fully Activated Plant	3-19
3.5.	Instrumentation and Control	3-19
3.5.1.	Point of Control	3-19
3.5.2.	Control	3-21
3.5.3.	Monitoring	3-21
3.5.4.	Annunciation	3-22
3.5.5.	Fully Activated Plant	3-23
3.6.	Building/Services	3-23
3.6.1.	Building	3-23
3.6.2.	Services	3-24
3.7.	Outside Services	3-32
4.	Product Conversion (WBS 1.3.3)	4-1
4.1.	General Overview	4-1
4.2.	Size Reduction	4-7
4.2.1.	System Design Basis	4-7
4.2.2.	System Description	4-9
4.2.3.	Fully Activated Plant	4-12
4.3.	Oxidation	4-13
4.3.1.	System Design Basis	4-13
4.3.2.	System Description	4-13
4.3.3.	Fully Activated Plant	4-15

4.4.	Flourination System	4-15
4.4.1.	System Design Basis	4-15
4.4.2.	System Description	4-16
4.4.3.	Fully Activated Plant	4-21
4.5.	Product Collection	4-21
4.5.1.	System Design Basis	4-21
4.5.2.	System Description	4-23
4.5.3.	Fully Activated Plant	4-25
4.6.	Purification and Blending	4-26
4.6.1.	System Design Basis	4-26
4.6.2.	System Description	4-26
4.6.3.	Fully Activated Plant	4-28
4.7.	Instrumentation and Control	4-29
4.7.1.	Point of Control	4-29
4.7.2.	Control	4-29
4.7.3.	Monitoring	4-31
4.7.4.	Annunciation	4-32
4.7.5.	Fully Activated Plant	4-33
4.8.	Building/Services	4-33
4.8.1.	Building	4-33
4.8.2.	Services	4-35
4.9.	Outside Services	4-44
5.	Uranium Recovery (WBS 1.3.4)	5-1
5.1.	General Overview	5-1
5.2.	Milling and Oxidation	5-4
5.2.1.	System Design Basis	5-4
5.2.2.	System Description	5-6
5.2.3.	Fully Activated Plant	5-11
5.3.	Fluorination	5-11
5.3.1.	System Design Basis	5-11
5.3.2.	System Description	5-13
5.3.3.	Fully Activated Plant	5-18
5.4.	UF ₆ Collection	5-18
5.4.1.	System Design Basis	5-18
5.4.2.	System Description	5-21
5.4.3.	Fully Activated Plant	5-25
5.5.	Instrumentation and Control	5-26
5.5.1.	Point of Control	5-26
5.5.2.	Control	5-26
5.5.3.	Monitoring	5-27
5.5.4.	Annunciation	5-29
5.5.5.	Fully Activated Plant	5-29
5.6.	Building/Services	5-29
5.6.1.	Building	5-29
5.6.2.	Services	5-31
5.7.	Outside Services	5-38
6.	Process Support	6-1
6.1.	General Overview	6-1
6.2.	Toll Facility	6-2
6.3.	UF ₆ Feed Facility	6-4
6.3.1.	System Design Basis	6-6

6.3.2.	System Description	6-6
6.3.3.	Control	6-17
6.3.4.	Building/Services	6-19
6.3.5.	Outside Services	6-25
6.3.6.	Fully Activated Plant	6-25
6.4.	Fluorine Generation Facility	6-28
6.4.1.	System Design Basis	6-28
6.4.2.	System Description	6-28
6.4.3.	Control	6-39
6.4.4.	Building/Services	6-41
6.4.5.	Outside Services	6-48
6.4.6.	Fully Activated Plant	6-49
6.5.	KF Conversion Facility	6-49
6.5.1.	System Design Basis	6-52
6.5.2.	System Description	6-52
6.5.3.	Control	6-55
6.5.4.	Building/Services	6-58
6.5.5.	Outside Services	6-58
6.5.6.	Fully Activated Plant	6-58
6.6.	Interfacility Services	6-60
6.6.1.	Introduction	6-60
6.6.2.	System Description	6-60
6.7.	Office Building	6-63
6.7.1.	Facility Description	6-67
6.7.2.	Control	6-67
6.7.3.	Building/Services	6-68
6.7.4.	Outside Services	6-74
6.7.5.	Fully Activated Plant	6-74
7.	Waste Management (WBS 1.3.6)	7-1
7.1.	General Overview	7-1
7.1.1.	Waste Management Objectives	7-1
7.1.2.	Design Objectives	7-2
7.1.3.	Waste Management Facilities	7-4
7.1.4.	Gaseous Waste Management	7-7
7.1.5.	Miscellaneous Wastes Management	7-18
7.2.	AVLIS Production Plant Waste Management Facilities	7-18
7.2.1.	Decontamination Facility, Building K-1420	7-18
7.2.2.	Neutralization Facility	7-20
7.2.3.	Incineration Facility	7-22
7.2.4.	Concrete Fixation Facility	7-27
7.2.5.	Shallow Land Burial Site	7-34
7.2.6.	Classified Burial Ground	7-37
7.2.7.	Transportation	7-38
8.	Site Plot Plan and Electrical Power System	8-1
8.1.	Plot Plan Development	8-1
8.2.	Overall Electrical Power Systems	8-7
Appendix A:	Engineering Guidelines	A-1
Appendix B:	Applicable Codes and Standards for Uranium Processing Facilities	B-1
Appendix C:	Guide to Reading the Process Flow Diagrams for the Uranium Processing Facilities	C-1
Appendix D:	Distribution	D-1

UCID-20187

**Lawrence Livermore
National Laboratory**

Energy Systems

AVLIS Production Plant Conventional Facilities and Process Support Design Report (U)

**Atomic Vapor
Laser Isotope Separation**

**Document EB-060
November 15, 1984**

TABLE OF CONTENTS

	Page
1. Executive Summary	1
1.1 Data Acquisition and Control System Summary	8
1.2 Electrical Distribution Summary	10
1.3 Process Support Summary	13
1.4 AVLIS Site Selection, Location and Improvement Summary	18
1.5 Outside Utilities Summary	20
1.6 Process Building Summary	22
1.7 Other Structures Summary	28
1.8 Plant Support Facilities Summary	31
2. Integrated Requirements and Interfaces	33
2.1 Functional Requirements and Interfaces	33
2.2 Design Bases	36
3. AVLIS Production Plant Control System	55
3.1 Plant Layer Control	60
3.1.1 Functions	60
3.1.2 Hardware	62
3.2 Operations Layer Control	66
3.2.1 Functions	66
3.2.2 Hardware	73
3.3 Process Layer Control	73
3.3.1 Function	74
3.3.2 Hardware	76
3.4 System Hardware Architecture	77
3.5 Control System Development Issues	82
4. Process Electrical Power Systems	88
4.1 Primary and Secondary Electrical Distribution	88
4.1.1 Applicable Codes and Standards	121
4.1.2 Grounding/Lightning Protection	121
4.1.3 Structure Lightning Protection	123
4.1.4 Cable and Raceway	123

4.1.5	Shielding	124
4.1.6	Cathodic Protection.	125
4.1.7	Protective Relaying.	126
4.1.8	System Reliability	127
4.1.9	Separator Power Supply System	127
4.1.10	Laser Power Supply System	129
4.1.11	Production Plant Power Growth	129
4.2	Standby AC Power System	130
4.2.1	System Requirements	131
4.2.2	Design Basis and Criteria	137
4.3	DC Systems	139
4.3.1	Area Requirements	141
4.3.2	Functional Requirements	142
4.3.3	Design Basis and Criteria	144
4.4	Uninterruptible Power Supply	146
4.4.1	Area Requirements	146
4.4.2	Functional Requirements	147
4.4.3	Design Basis and Criteria	148
4.5	120 Volt AC Supply	149
5.	Process Support	151
5.1	Cooling Water Systems	151
5.1.1	Recirculated Treated Water System	152
5.1.2	Demineralized Cooling Water System	165
5.1.3	Low Temperature Cooling Water System	170
5.1.4	Low Temperature Demineralized Cooling Water System	175
5.1.5	Process Chilled Water System	184
5.1.6	Cooling Water Systems Development Issues	188
5.2	Waste Systems	189
5.2.1	Central Neutralization Facility	192
5.2.2	Decontamination and Wet Uranium Recovery Facility (Building K-1420)	195
5.2.3	Central Waste Incinerator Facility	196
5.2.4	Central Concrete Fixation Facility	200
5.2.5	Central Waste Disposal Facility	200

5.2.6	Waste Collection, On-Site Transfer And Handling	202
5.3	Plant Air and Inert Gas Systems	203
5.3.1	Plant Air System	203
5.3.2	Argon Gas System	207
5.3.3	Nitrogen Gas System	210
5.4	Cooling Tower Water System	214
5.5	Demineralized Water Makeup System	222
5.6	Hot Water Heat Recovery System	225
6.	AVLIS Site Selection, Location and Improvements	227
6.1	Site Location	227
6.1.1	Oak Ridge Gaseous Diffusion Site	227
6.1.2	Greenfield Site Design	229
6.2	Site Selection	240
6.3	Oak Ridge Gaseous Diffusion Plant Site Advantages	241
6.4	Site Environment	242
6.4.1	Topography	243
6.4.2	Hydrology	243
6.4.3	Geology/Soils	244
6.4.4	Weather	245
6.4.5	Seismic Considerations	250
6.4.6	Wind/Tornado Considerations	254
6.5	Demolition	255
6.6	Clearing, Grading and Excavation	255
6.7	Relocating Structures and Utilities	257
6.8	Roads, Parking, Rail and Security	258
6.9	Landscaping	260
6.10	Plant Access	260
7.	Other Utilities	262
7.1	Steam and Condensate	262
7.2	Fire Protection Water	264
7.3	Sanitary Water	266
7.4	Storm Drains	266
7.5	Sanitary Drains	269

8. Process Area Structures and Facilities	271
8.1 Structure (Process Building)	272
8.1.1 Separator Area	279
8.1.2 Laser Area	280
8.1.3 Laser Subassembly and Refurbishment Area	286
8.1.4 Separator Pod Refurbishment Area	289
8.1.5 Central Control Area	291
8.1.6 Uranium Material Handling and Processing Area	291
8.1.7 Shop and Facility Support Area	295
8.1.8 Structural Development Issues	295
8.2 Process Building HVAC	297
8.2.1 Area Requirements	301
8.2.2 Functional Requirements	302
8.2.3 Design Basis and Criteria	302
8.2.4 Applicable Codes and Standards	305
8.2.5 Dye Laser Area HVAC System	306
8.2.6 Copper Laser Area HVAC System	308
8.2.7 Separator Bay HVAC System	308
8.2.8 Power Conditioning Area HVAC System	311
8.2.9 Laser Refurbishment HVAC System	311
8.2.10 Separator Refurbishment Area	319
8.2.11 Laser Control Area HVAC System	323
8.2.12 Central Control Area HVAC System	323
8.2.13 Separator Personnel Area HVAC System	326
8.2.14 Materials Handling and Processing Area HVAC System	326
8.2.15 Dye Pumphouse HVAC System	329
8.2.16 DYE Piping Tunnel Ventilation	331
8.2.17 HVAC Chilled Water System	331
8.2.18 HVAC Hot Water System	334
8.2.19 Utility Areas HVAC System	337
8.3 Fire Protection for the Process Building	337
8.3.1 Area Requirements	343
8.3.2 Functional Requirements	343
8.3.3 Design Basis and Criteria	344

8.3.4	Applicable Codes and Standards	344
8.3.5	Foam Water Sprinkler System	345
8.3.6	Halon Systems	345
8.3.7	Water Spray Systems	348
8.3.8	Closed Head Sprinkler System	348
8.3.9	Detection and Control Requirements	351
8.3.10	Local Fire Control Panels	351
8.4	Process Building Plumbing System	352
8.5	Process Building Drains	353
8.6	Plant Communications	356
8.7	Plant Security	356
8.8	Material Handling	359
8.9	Lighting	363
8.9.1	Area Requirements	364
8.9.2	Functional Requirements	364
8.9.3	Design Basis Criteria	366
9.	Other Structures	369
9.1	Dye Pump Building	373
9.2	Diesel Generator Building	377
9.3	Cooling Tower	377
9.4	Cooling Tower Pumphouse	377
9.5	Holding Pond	379
9.6	Separator Mechanical Equipment Building	379
9.7	Laser Mechanical Equipment Building	380
9.8	Separator Utility Building	380
9.9	Dye Piping Tunnel	384
9.10	Ethanol Storage and Dike	384
9.11	Transformer Pads	384
10.	Plant Support Facilities	385
10.1	Graphite Shop	386
10.2	Administration Building	391
10.3	Portals/Security	392

2.4 AVLIS PRODUCTION PLANT

PROJECT MANAGEMENT

DOCUMENTS

Lawrence Livermore
National Laboratory

MARTIN MARSHALL
Energy Systems

AVLIS Production Plant Project Management Plan

Atomic Vapor
Laser Isotope Separation

Document APP-010
November 15, 1984

TABLE OF CONTENTS

List of Figures	x
List of Tables	xii
Abstract	xiii
1. Executive Summary	1
1.1. Introduction and Description of AVLIS Production Plant Project.	1
1.2. Project Objectives.	3
1.3. Organization and Responsibilities	4
1.3.1 Memorandum of Understanding	10
1.4. Work Plan	13
1.5. Work Breakdown Structure	14
1.6. Project Schedule and Milestones	14
1.7. Cost and Manpower Estimates	14
1.8. Performance Criteria	15
1.9. Project Management System	16
1.10. Information and Reporting	18
1.11. Summary of Sections	19
2. Introduction and Description of AVLIS Production Plant Project	22
2.1. Overview	22
2.2. Project Description	23
2.2.1. Summary Description	23
2.2.2. AVLIS Production Plant Design Criteria	25
2.2.3. AVLIS Production Plant Enrichment Performance	26
2.2.4. AVLIS Production Plant Uranium Streams	26
2.2.5. Separator/Laser Architecture	30
2.2.6. AVLIS Production Plant - Functional Layout	33
2.3. Support Facilities	36

2.4.	AVLIS Base Technology	37
2.4.1.	Separator Development Status	39
2.4.2.	Laser Development Status	40
2.4.3.	Integrated Process Demonstration Status	41
2.4.4.	Uranium Processing Technology Status	42
2.4.5.	Waste Management Technology	42
2.5.	Project Assumptions/Clarifications	42
2.5.1.	Project Functional Support	42
2.5.2.	AVLIS Process Deployment	43
2.5.3.	Final Environmental Impact Statement	43
2.5.4.	DOE Requirements for Natural Phenomena	43
2.5.5.	Operational Safeguards and Security System	43
2.5.6.	Feed and Product	43
2.6.	Key Project Documents	44
3.	Project Objectives	45
3.1.	Purpose of the AVLIS Production Plant Project	45
3.2.	Project Requirements	45
3.2.1.	Technical Requirements	45
3.2.2.	Quality/Reliability Requirements	46
3.3.	Systems Objectives.	46
3.4.	Economic Objectives	47
3.5.	Schedule Objectives	47
3.6.	Cost Objectives	48
4.	Organization and Responsibilities	50
4.1.	Project Organizational Structure	54
4.2.	Responsibilities of Participating Organizations	54
4.2.1.	DOE Headquarters Responsibilities	58
4.2.2.	DOE Oak Ridge Operations/Field Project Office Responsibilities	58
4.2.3.	DOE San Francisco Operations Office Responsibilities	59
4.2.4.	AVLIS--Technical Program Office Responsibilities	59

4.2.5.	AVLIS Production Plant Project Organizational Responsibilities	60
4.2.6.	Project Review Board Responsibilities	60
4.2.7.	Operating Contractor Responsibilities	61
4.3.	Responsibilities of Key Positions in the AVLIS Production Plant Project Organization	61
4.3.1.	AVLIS Production Plant Project Manager	61
4.3.2.	AVLIS Production Plant Deputy Project Manager (LLNL)	61
4.3.3.	AVLIS Production Plant Project Design Manager	62
4.3.4.	AVLIS Production Plant Project Operations Manager	62
5.	Work Plan	64
5.1.	Introduction	64
5.2.	Delivery of Operating Hardware and Facilities	64
5.2.1.	Preconceptual Design Phase	64
5.2.2.	Conceptual Design	66
5.2.3.	Titles I, II, and III Activities	66
5.2.4.	Construction	67
5.2.5.	Procurement	68
5.2.6.	Installation of Equipment	69
5.2.7.	Training and Start up	69
5.2.8.	Work Assignments for Delivery of Operating Hardware and Facilities	72
5.3.	Project Assessment Activities	81
5.3.1.	National Environmental Policy Act	81
5.3.2.	Site Selection	81
5.3.3.	Systems Engineering	81
5.3.4.	Quality Assurance	82
5.3.5.	Safety Analysis and Planning	83
5.3.6.	Safeguards and Security	84
5.3.7.	Work Assignments for Project Assessments	85
5.4.	Activities Supporting Project Integration and Management.	85
5.4.1.	Integrating Components	86
5.4.2.	Schedule Control	86
5.4.3.	Cost Control	86
5.4.4.	Technical Integration and Configuration Control	86
5.4.5.	Project Review, Documentation, and Reporting	87

5.4.6 Work Assignments for Activities Supporting Project Integration and Management 87

6.	Work Breakdown Structure	88
6.1.	General	88
6.2	Project Summary Work Breakdown Structure and Dictionary	88
6.3	Contractor Work Breakdown Structures and Dictionaries	88
7.	Project Schedules and Milestones	92
7.1	Introduction	92
7.2	Basis of Authorization Limit Schedule	98
7.3	Major Project Milestone Descriptions	105
7.4	Schedule Uncertainty	107
7.5	AVLIS Deployment Plan, Plant 1 and 2	109
8.	Cost and Manpower Estimates	113
8.1.	General Funding Guidelines	113
8.1.1.	Total Estimated Cost	113
8.1.2.	Total Project Cost	114
8.2.	Project Cost Estimates	115
8.3.	Manpower Estimates	119
9.	Performance Criteria	125
9.1.	AVLIS Production Plant	125
9.2.	AVLIS Production Plant Performance Criteria	125
9.3.	Training and Activation	126
9.4.	Systems Integration Performance Criteria	126
10.	Project Management System	128
10.1.	Objectives of the Project Management System	128
10.2.	Project Management Approach	128
10.3.	Supporting Management Systems	131
10.4.	Cost and Schedule Control	131
10.4.1	General	131
10.4.2.	Organization	132
10.4.3.	Planning and Budgeting	132
10.4.4.	Accounting	133

10.4.5.	Analysis	133
10.4.6.	Revisions and Access to Data	135
10.5.	Funds Management System	135
10.6.	Project Change Control	136
10.6.1.	Change Identification	137
10.6.2.	Change Evaluation	137
10.6.3.	Change Approval	137
10.6.4.	Change Implementation	139
10.7.	Contingency Control	139
10.8.	Technical Control	140
10.8.1.	Criteria and Requirements	141
10.8.2.	Design Documentation and Control	141
10.8.3.	Design Review	142
10.8.4.	Configuration Control	143
10.8.5.	Interface Control	143
10.9.	Test and Evaluation Control	144
11.	Information and Reporting	145
11.1.	Project Documentation	145
11.1.1.	Administrative Documentation	145
11.1.2.	Programmatic Documentation	148
11.1.3.	Technical Documentation	148
11.1.4.	Document Preparation, Review, and Approval	148
11.2.	Project Reporting	148
11.3.	Project Review Meetings	160
11.3.1.	Monthly Progress Reviews	161
11.3.2.	Quarterly Project Reviews	161
11.3.3.	Other Meetings	162
11.4.	Project Correspondence	162
11.4.1.	Formal Correspondence	162
11.4.2.	Informal Correspondence	163
Appendix A.	Advanced Acquisition or Assistance Plan	164
A.1.	Description of Project Work	164

A.2.	Funding Plan	165
A.3.	Award Schedule	165
A.4.	Discussion of Project Risks	166
A.5.	Source Selection	167
A.6.	Anticipated Contractors and Participants	167
A.7.	Socioeconomic Programs	168
A.8.	Acquisition of Equipment, Supplies, and Contracted Services	169
A.9.	Anticipated Organization Conflict-of-Interest Concerns	170
A.10.	Patents and Data	170
A.11.	Report Requirements	170
A.12.	Receipts	171
A.13.	Nongovernmental Participation	171
A.14.	Site Selection and Acquisition of Real Property	171
A.15.	Use of Other Procedures	172
A.16.	Other Information	172
Appendix B.	Test and Evaluation Plan	173
B.1.	Process Demonstration	173
B.2.	Vendor Testing	173
B.3.	Acceptance Testing	175
B.4.	Operability Testing	175
Appendix C.	Environmental, Safety, and Health Protection	176
C.1.	Policy	176
C.2.	Safety Responsibilities	176
C.3.	Safety Assessments	177
C.4.	Maintaining Radiation and Toxic Exposures as Low As Practicable	178
C.5.	Lasers	179
C.6.	Waste Management	179
C.7.	Environmental Protection	179
C.8.	National Environmental Policy Act	179
C.9.	Health and Safety Training	180

C.10.	Emergency Planning	180
C.11.	Appraisals and Inspection	181
Appendix D.	Cost and Schedule Performance Measurement System	182
D.1.	Baseline Budget	182
D.2.	Data Collection	182
D.3.	Performance Measurement/Variance Analysis	183

**Lawrence Livermore
National Laboratory**

Energy Systems

AVLIS Production Plant Work Breakdown Structure and Dictionary

**Atomic Vapor
Laser Isotope Separation**

**Document APP-020
November 15, 1984**

CONTENTS

	Page
1. Executive Summary	1
1.1 Purpose of Work Breakdown Structure	1
1.2 AVLIS Deployment Strategy Impact to the Work Breakdown Structure	4
1.2.1 Fully Activated AVLIS Production Plant	4
1.2.2 Greenfield Site AVLIS Production Plant	6
1.3 Integration of Work Breakdown Structure and Cost Estimates	6
1.4 Defining the Work	10
1.5 Development of Contract Work Breakdown Structure	12
1.5.1 Contract Work Breakdown Structure Development of Levels	12
1.6 Work Breakdown Structure Dictionary	14
2. Work Breakdown Structure Extension to Lower Level Details	15
2.1 Details for Initial Increment of Production Plant	15
2.2 Fully Activated Plant Supplement	23
2.3 Work Breakdown Structure--Greenfield Site	27
3. Work Breakdown Structure Dictionary--Part I Index	29
4. Work Breakdown Structure Dictionary--Part II Element Definition	30
5. Work Breakdown Structure Dictionary-- Functional Requirements	31
Addendum A--Index	32
Addendum B--Element Definition	52

**Lawrence Livermore
National Laboratory**

Energy Systems

AVLIS

Production Plant

Project Schedule and Milestones

**Atomic Vapor
Laser Isotope Separation**

**Document APP-030
November 15, 1984**

TABLE OF CONTENTS

1. Executive Summary	1
1.1. Introduction	1
1.1.1. Summary and Conclusions	3
1.2. Basis of the Authorization Limited Schedule	7
1.3. AVLIS Deployment Plan, Plant 1 and 2	11
2. Authorization Limited Schedule	15
2.1. Schedule and Figures Description	15
2.1.1. Technology/Milestone Interrelations Schedule	17
2.1.2. Project Milestones	17
2.2. Schedule Validation	37
2.2.1. Schedule Validation Checklist	38
2.3. Schedule Considerations/Detail Backup	65
3. Fully Activated Schedule	68
3.1. Fully Activated Plant Deployment Schedule	68
4. Schedule Uncertainty	73
5. Major Project Milestones	75
6. Engineering Limited Schedule	87
6.1. Schedule and Figures	88
7. Funding Limited Schedule	99
7.1. Schedule and Figures	100
8. Schedule Comparisons	104
8.1. Construction Project Comparisons	104
8.2. Schedule Comparisons of Laser Construction Projects and AVLIS Production Plant	104
8.3. Schedule Comparisons of the AVLIS Separator Construction Projects and the AVLIS Production Plant	110
9. Schedule Analysis	113
9.1. Schedule Analysis Objectives	113
9.2. Venture Evaluation and Review Technique	113
9.3. Monte Carlo Schedule Analysis	115

**Lawrence Livermore
National Laboratory**

Energy Systems

AVLIS Production Plant Preliminary Environmental Assessment (U)

**Atomic Vapor
Laser Isotope Separation**

**Document APP-041
November 15, 1984**

TABLE OF CONTENTS

1	Executive Summary	1
1.1	Purpose and Objectives	1
1.2	Conclusions	1
1.3	Methodology and Criteria	2
1.4	Assessment Impact	2
1.5	Environmental Consequences	3
1.5.1	Environmental Impacts of Site Preparation and Plant Construction	3
1.5.2	Environmental and Occupational Impacts of Plant Operation	5
1.5.3	Environmental Impacts of Accidents	14
2	AVLIS Plant and Process Description	19
2.1	Location and External Appearance	19
2.1.1	Site Characteristics	19
2.1.2	AVLIS Production Plant	21
2.2	Process Descriptions	28
2.2.1	AVLIS Process	28
2.2.2	Uranium Processing	37
2.3	Identification of Agents and Contractors	46
3	Alternatives	48
3.1	Potential Fuel Cycle Changes	48
3.1.1	UF ₄ Feed Material	48
3.1.2	Derby Feed Material	49
3.2	Potential Separator Refurbishment Change	49
4	Characterization of the Affected Environment	51
4.1	Regional Demography	51
4.2	Land Use	55
4.3	Geology	57
4.4	Hydrology	58
4.5	Meteorology	60
4.6	Ecology	62

5	Environmental Impacts of Site Preparation and Plant Construction.	66
5.1	Project Activities	66
5.1.1	Land Use	66
5.1.2	Excavation	68
5.1.3	Construction Support Facilities	68
5.1.4	Construction Materials Usage	68
5.1.5	Chemical Waste	69
5.1.6	Sanitary and Other Wastes	69
5.1.7	Water Use	69
5.1.8	Noise	69
5.2	Transmission Construction	70
5.3	Radiation Dose Assessment of Construction Force	70
5.3.1	Direct Radiation	70
5.3.2	Gaseous Effluent Radiation	70
5.4	Social Impacts of Site Preparation and Plant Construction.	71
6	Environmental and Occupational Impacts of Plant Operation	73
6.1	Heat Dissipation System and Effects of Waste Heat	73
6.2	Radiological Impact from Routine Operation	73
6.2.1	Exposure Pathways	74
6.2.2	Radioactivity in the Environment	74
6.2.3	Radioactivity in the Work Areas	77
6.3	Occupational Exposure to Magnetic Fields	79
6.4	Occupational Exposure to Laser Beams	80
6.5	Effects of Chemical Discharges	82
6.5.1	Liquid Effluents	82
6.5.2	Solid Wastes	82
6.5.3	Gaseous Emissions	83
6.5.4	Chemicals Released to the Work Areas	84
6.6	Effects of Sanitary Waste Discharges.	84
6.7	Effects of Operation and Maintenance of the Electrical Transmission System	84
6.8	Effects of Transportation of Essential Materials, Feed, Product, and Wastes	84

6.9	Social Impacts of Plant Operation	85
6.9.1	Work Force	85
6.9.2	Public Service	85
6.9.3	Land Use	86
6.10	Mitigation of Adverse Environmental Impacts	86
6.11	Relationship Between Short-term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity	86
6.12	Relationship of Land-Use Plans	87
6.13	Reliance on Strategic Materials	87
7	Environmental Impacts of Accidents	89
7.1	Molten Metal/Water Reaction	89
7.2	Fire Involving Flammable Liquids	90
7.3	Natural Phenomena	92
7.4	Hydrogen Fluoride Release	93
7.5	Uranium Metal Fire	94
7.5.1	Product Conversion Facility Fire	94
7.5.2	Tails Storage Facility Fire	94
7.6	UF ₆ Release	95
7.7	Criticality	96

**Lawrence Livermore
National Laboratory**

**MARTIN MANIETTA
Energy Systems**

AVLIS Production Plant Preliminary Safety Assessment (U)

**Atomic Vapor
Laser Isotope Separation**

**Document APP-042
November 15, 1984**

TABLE OF CONTENTS

1. Executive Summary.....	1
1.1. Purpose and Objectives.....	1
1.2. Conclusions.....	1
1.3. Methodology and Criteria Summary.....	2
1.4. Assessment Impact.....	2
1.5. Hazards and Abnormal Operations.....	2
1.5.1. Laser Beam Exposure.....	3
1.5.2. Ionizing Radiation.....	3
1.5.3. Toxic Materials.....	15
1.5.4. Overpressurization.....	16
1.5.5. Fire.....	16
1.6. Accidents.....	17
1.6.1. Molten Metal/Water Reaction.....	18
1.6.2. Fire Involving Flammables.....	19
1.6.3. Natural Phenomena.....	19
1.6.4. HF Release.....	20
1.6.5. Uranium Metal Fire.....	20
1.6.6. UF ₆ Releases.....	21
1.6.7. Criticality.....	21
2. AVLIS Plant and Process Description.....	23
2.1. Location and External Appearance.....	23
2.1.1. Site Characteristics.....	23
2.1.2. AVLIS Production Plant.....	25
2.2. Process Descriptions.....	32
2.2.1. AVLIS Process.....	32
2.2.2. Uranium Processing.....	41
3. Characterization of the Affected Environment.....	51
3.1. Regional Demography.....	51
3.2. Land Use.....	55
3.3. Geology.....	57
3.4. Hydrology.....	58
3.5. Meteorology.....	60
3.6. Ecology.....	62
References.....	65
4. Principal Design Criteria.....	66
4.1. Purpose of Facilities.....	66
4.2.1. Wind/Tornado Loadings.....	66
4.2.2. Seismic Loadings.....	67
4.2.3. Flooding.....	68
4.2.4. Snow Loading.....	68
4.2.5. Process and Equipment Derived Loadings.....	68
4.2.6. Combined Loading.....	69
4.3. Facilities Design Criteria.....	69
4.4. Protection Systems.....	70
4.4.1. Ventilation.....	70
4.4.2. Fire Protection.....	71
4.4.3. Electrical.....	73
4.4.4. Waste Management.....	73
4.5. Nuclear Criticality Safety.....	74

4.6. Summary of Structures, Components, and Systems Criteria.....	78
4.7. Decommissioning.....	78
4.7.1. Design Goals.....	78
4.7.2. Design Features.....	79
References.....	80
5. Waste Confinement and Management.....	81
5.1. Safety Objectives.....	81
5.2. Waste Streams Characterization.....	81
5.3. Waste Management Plan Implementation.....	83
6. Radiation Protection.....	86
6.1. Radiation Protection Objectives.....	86
6.1.1. Design Considerations.....	86
6.1.2. Operational Considerations.....	89
6.2. Onsite Contamination Control.....	91
6.2.1. Zoning.....	91
6.3. Effluent Radioactivity Control.....	94
6.3.1. Ventilation/Off-Gas Treatment.....	94
6.3.2. Liquid Waste Management.....	95
6.4. Estimated Off-Site Exposure.....	95
6.4.1. Estimated Atmospheric Releases.....	96
6.4.2. Off-Site Exposures.....	96
References.....	98
7. Accident Analysis.....	99
7.1. Hazards and Abnormal Operations.....	99
7.1.1. Laser Beam Exposure.....	99
7.1.2. Ionizing Radiation.....	110
7.1.3. Magnetic Fields.....	115
7.1.4. Hazardous and Toxic Materials.....	116
7.1.5. Overpressurization.....	118
7.1.6. Fire.....	120
7.1.7. High-Voltage Shock.....	123
7.1.8. Pod Refurbishment Hazards.....	124
7.1.9. Graphite Machining.....	128
7.1.11. Noise Exposure.....	128
7.1.12. Heat Stress.....	130
7.1.13. Vacuum Systems.....	130
7.2. Accidents.....	131
7.2.1. Molten Metal/Water Reaction.....	131
7.2.2. Fire Involving Flammable Liquids.....	132
7.2.3. Natural Phenomena.....	134
7.2.4. Hydrogen Fluoride Release.....	135
7.2.5. Uranium Metal Fire.....	136
7.2.6. UF ₆ Releases.....	138
7.2.7. Criticality.....	139
References.....	142
8. Management Organization for Implementing Safety Programs.....	143
8.1. Organizational Structure and Responsibility.....	143
8.2. Facility Operations.....	143
8.3. Quality Assurance Program.....	143
8.4. Emergency Plan.....	144
8.5. Decommissioning.....	145

**Lawrence Livermore
National Laboratory**

**MARTIN MARSHALL
Energy Systems**

AVLIS Production Plant Safeguards Assessment (U)

**Atomic Vapor
Laser Isotope Separation**

**Document APP-043
November 15, 1984**

CONTENTS

Acknowledgments	iii
List of Figures	vii
List of Tables	viii
Glossary	ix
1. Executive Summary	1
1.1. Purpose and Objectives	1
1.2. Conclusions	1
1.3. Methodology and Criteria	2
1.4. Results	2
1.5. Summary	2
1.5.1. Introduction	2
1.5.2. Nuclear Material Accountability	4
1.5.3. Physical Security	7
2. Introduction	10
2.1. Process Description	10
2.1.1. Incoming Cylinders	10
2.1.2. Feed Conversion	12
2.1.3. Feed Preparation	13
2.1.4. Dry Recovery	14
2.1.5. Separator Modules	14
2.1.6. Refurbishment	16
2.1.7. Product Conversion	17
2.1.8. UF_6 Product Storage and Shipment	20
2.1.9. Depleted Tails Alloy Storage	20
2.1.10. Laboratory	20
2.2. Facility Description	21
2.2.1. Process Building	21
2.2.2. Dye Pump Building	25
2.2.3. Mechanical and Utility Buildings	25
2.2.4. Cooling Tower and Pump House	25
2.2.5. Graphite Shop	25
2.2.6. Administration Building	26
2.2.7. UF_6 Feed Facility	26
2.2.8. Feed Conversion Facility	26

2.2.9.	Ammonia Facility	28
2.2.10.	Feed Preparation Facility	28
2.2.11.	Argon Facility	28
2.2.12.	Product Conversion Facility	28
2.2.13.	Fluorine Generation Facility	30
2.2.14.	Uranium Recovery Facility	30
2.2.15.	Uranium Processing Office Building	33
2.2.16.	Magnesium Storage Building	33
2.2.17.	Toll Facility	33
2.2.18.	Waste Management Facilities	33
3.	Safeguards Systems Design Philosophy	35
3.1.	Philosophy	35
3.1.1.	Nuclear Material Accountability	35
3.1.2.	Physical Security	36
3.2.	Design Criteria	37
3.2.1.	Nuclear Material Accountability	37
3.2.2.	Physical Security	46
4.	Safeguards System Design Description	60
4.1.	Nuclear Material Accountability	60
4.1.1.	Material Balance Area Definition	60
4.1.2.	Key Measurement Point Definition	67
4.1.3.	Accountability Computer System	81
4.1.4.	Inventory Procedure	85
4.1.5.	Inventory Controls	96
4.1.6.	Inventory Difference	97
4.1.7.	Measurement and Statistical Control	99
4.1.8.	Internal Controls	101
4.1.9.	Instrumentation Plan-- Process Control Interface	106
4.1.10.	Sampling Plan	114
4.1.11.	Book Inventory	122
4.1.12.	Near Real Time Accounting	123
4.1.13.	Records and Reporting System	129
4.1.14.	Uranium Storage	132
4.1.15.	Sensitivity Analysis	138
4.1.16.	Scrap and Waste	139

4.1.17. International Safeguards	146
4.1.18. Tamper-Indicating Devices	152
4.1.19. External Transfers	154
4.2. Physical Security	156
4.2.1. Security Zones	156
4.2.2. Physical Barriers	158
4.2.3. Personnel Access Control	159
4.2.4. Vehicle Access Control	164
4.2.5. Central Alarm Station	165
4.2.6. Intrusion Detection System	167
4.2.7. Alarm Assessment and Response	168
4.2.8. Surveillance	169
4.2.9. Communication	170
4.2.10. Computer System	170
4.2.11. Test and Maintenance	171
4.2.12. Intrusion Analysis	171
4.2.13. Construction Separation	172
4.2.14. Control of Classified Data	176
4.2.15. Emergency Exit Control	180
4.3. System Integration	181
4.3.1. Accountability -- Physical Security Alarm Reporting	181
4.3.2. Safeguards Operations Requirements	183
4.3.3. Integrated Action Plan	187
4.4. Fully Activated Plant	188
4.4.1. Nuclear Material Accountability	188
4.4.2. Physical Security	189
5. References	190
Appendix A. Accountability Directives	192
Appendix B. Sensitivity Analysis	193
Appendix C. Intrusion Analysis	194

UCID-20175

Lawrence Livermore
National Laboratory

MARTIN MARINETTA
Energy Systems

AVLIS

Production Plant

Reliability, Availability, and Maintainability (U)

Atomic Vapor
Laser Isotope Separation

Document APP-044
November 15, 1984

CONTENTS

1.	Executive Summary	1
1.1.	Role of Assessment	1
1.2.	Plant RAM Objectives	1
1.3.	Major Conclusions	2
1.4.	Organization of Assessment Activity	2
1.5.	Basis for Assessment	3
1.6.	Plant RAM Assessment	5
1.6.1.	Separator Mean Runtime and Effective Availability	5
1.6.2.	Laser System Effective Availability	7
1.6.3.	Plant Capacity Factor	10
1.6.4.	Sensitivity Analyses	10
1.7.	Summary	10
2.	Overview of Plant Design and Operation	12
2.1.	Laser System	12
2.2.	Separator System	14
2.3.	Plant Support Services and Uranium Processing	14
3.	Plant RAM Assessment	18
3.1.	Separator System Effective Availability and Mean Runtime	18
3.1.1.	Methodology	18
3.1.2.	Results of Assessment	31
3.2.	Laser System Availability	53
3.2.1.	Methodology	53
3.2.2.	Results of Assessment	62
3.3.	Plant Capacity Factor	63
	References	65

**Lawrence Livermore
National Laboratory**

**MARTIN MARINETTA
Energy Systems**

AVLIS Production Plant Preliminary Quality Assurance Plan and Assessment

**Atomic Vapor
Laser Isotope Separation**

**Document APP-045
November 15, 1984**

CONTENTS

List of Figures	v
List of Tables	vi
 1. Executive Summary	 1
1.1. Introduction	1
1.2. Scope	2
1.3. Objective	2
1.4. Quality Assurance Program	3
1.5. Organization	4
1.6. Quality Assurance Action Elements	4
1.7. Risk Assessments	5
1.8. Program Implementation and Control	6
 2. Organization and Responsibilities	 10
 3. Quality Assurance Action Elements	 15
3.1. Design Control	15
3.2. Procurement Control	15
3.2.1. Procurement Document Control	15
3.2.2. Subcontractor Control	16
3.3. Instructions, Procedures, and Drawings	16
3.4. Document Control	16
3.5. Control of Purchased Materials, Equipment and Services	17
3.6. Identification and Control of Materials, Parts, and Components	17
3.7. Control of Special Processes	18
3.8. Inspection	18
3.9. Test Control	18

3.10. Control of Measuring and Test Equipment	19
3.11. Handling, Storage, and Shipping	19
3.12. Inspection, Test, and Operating Status	20
3.13. Control of Nonconforming Items	20
3.14. Software Control	20
3.15. Quality Assurance Records	21
3.16. Safety Control	21
4. Preliminary Risk Assessment	22
4.1. Introduction	22
4.2. Scope	22
4.3. Methodology	23
4.3.1. Consequence Level	25
4.3.2. Probability Factor	25
4.3.3. Risk Evaluation	28
4.4. Results	30
5. Program Implementation and Control	48
5.1. Level of Quality Assurance	48
5.2. Application of Quality Assurance Action Elements to Design	50
5.3. Application of Quality Assurance Action Elements to Procurement	52
5.4. Application of Quality Assurance Action Elements to Construction	53
5.5. Quality Assurance Program Schedule and Milestones	54
5.6. Quality Audits	54
5.7. Quality Failure Reports	54
5.8. Quality Management Reports	54
Appendix A: Terms and Definitions	58

**Lawrence Livermore
National Laboratory**

**MARTIN MARIETTA
Energy Systems**

AVLIS Production Plant Waste Management Plan

**Atomic Vapor
Laser Isotope Separation**

**Document APP-046
November 15, 1984**

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
<u>DOCUMENT OUTLINE DESCRIPTION</u>	vii
<u>GLOSSARY</u>	xi
1. Executive Summary	1
1.1. Background	1
1.1.1. AVLIS Project Assessment Objectives	1
1.1.2. Assessment Conclusions	1
1.1.3. Assessment Methodology	2
1.1.4. Assessment Results Implementation	3
1.2. Document Summary	3
1.2.1. Introduction	3
1.2.2. Waste Management Facilities Design Objectives	4
1.2.3. Waste Streams Characterization	5
1.2.4. Design Criteria	7
1.2.5. Waste Management Plan	8
1.2.6. Waste Management Plan Implementation	9

TABLE OF CONTENTS
(CONT'D)

<u>Section</u>	<u>Page</u>
2. Waste Management Facilities Design Objectives	21
2.1. Performance Objectives	21
2.1.1. General	21
2.1.2. Liquid Waste Management	21
2.1.3. Gaseous Waste Management	22
2.1.4. Solid Waste Management	23
2.2. Safety Objectives	23
3. AVLIS Production Plant Wastes	25
3.1. Waste Characterization	25
3.1.1. Introduction	25
3.1.2. Waste Generation Operations	25
3.1.3. Waste Stream Descriptions	27
3.1.3.1. Outside Utilities Wastes	27
3.1.3.2. Laser and Separator Wastes	28
3.1.3.3. Uranium Processing Facilities Wastes	29
3.1.4. Plant Support Facilities Waste	42
3.2. Waste Classification	43
3.2.1. Waste Categories	43
3.2.2. Waste Streams Classification	45
3.2.3. Classification of AVLIS Production Plant Waste Streams	46
4. Waste Management Design Criteria	51
4.1. General Overview	51

TABLE OF CONTENTS
(CONT'D)

<u>Section</u>	<u>Page</u>
4.2. Gaseous Waste Management Design Criteria	51
4.2.1. Applicable Federal and State Regulations	51
4.2.2. Plant Discharge Limits	52
4.2.3. Process Offgas Treatment Systems Design Criteria	57
4.2.4. Controls and Instrumentation	58
4.2.5. Gaseous Effluent Monitoring	59
4.2.6. Gaseous Waste Treatment Secondary Wastes	59
4.3. Liquid Waste Management Design Criteria	59
4.3.1. Applicable Federal and State Regulations	59
4.3.2. Plant Discharge Limits	60
4.3.3. Process and Disposal Systems Design Criteria	60
4.3.4. Liquid Effluent Monitoring	64
4.4. Solid Wastes Management Design Criteria	64
4.4.1. Radiological Solid Wastes	64
4.4.1.1. Applicable Federal and State Regulations	64
4.4.1.2. Radiological Wastes Treatment and Disposal	64
4.4.1.3. Solid Radiological Wastes Accountability	66
4.4.2. Non-radiological Solid Wastes	66
4.4.2.1. Applicable Federal and State Regulations	66
4.4.2.2. Non-radiological Solid Waste Treatment and Disposal	66
5. Waste Management Plan Description	68
5.1. Introduction	68
5.2. Waste Management Processes	68

TABLE OF CONTENTS
(CONT'D)

<u>Section</u>	<u>Page</u>
5.2.1. Gaseous Waste Streams	68
5.2.1.1. Treatment Processes	68
5.2.1.2. Disposal Processes	72
5.2.2. Liquid Waste Streams	72
5.2.2.1. Treatment Processes	72
5.2.2.2. Disposal Processes	75
5.2.3. Solid Waste Streams	77
5.2.3.1. Treatment Processes	77
5.2.3.2. Disposal Processes	85
5.3. AVLIS Production Plant Waste Management Plan	85
6. Waste Management Plan Implementation	91
6.1. Plan Implementation	91
6.2. Green-Field Plant	93

UCID-24752

Lawrence Livermore
National Laboratory

MENTOR GRAPHICS
Energy Systems

AVLIS Impact on Nuclear Proliferation (U)

Atomic Vapor
Laser Isotope Separation

Document APP-047
November 15, 1984

CONTENTS

Executive Summary	1
1. Issues Associated with AVLIS and Nuclear Nonproliferation	3
1.1. Nuclear Proliferation: Historical Perspective and Status	4
1.1.1. Proliferant Nations	5
1.1.2. Communist Nations	11
1.1.3. Allied Nations	12
1.2. Motivations for the Development of AVLIS	13
2. Technical Obstacles to AVLIS	17
2.1. Lasers	17
2.2. Electro-optics	19
2.3. Uranium Handling	20
2.3.1. Uranium Vaporization	21
2.3.2. Ion Extraction	22
2.3.3. Product and Waste Collection	23
2.4. System Integration	25
2.5. Resources	25
3. Production of HEU	28
3.1. Process Parameters	28
3.2. Single-Stage Enrichment	32
3.3. Multistage Approach	32
3.4. Conversion of an LEU Facility	33
4. Scenarios for Proliferation	35
4.1. Country-Specific Factors are Important	35
4.2. Nuclear Weapons States	35
4.3. Nonnuclear Weapons States	37
4.3.1. Covert Military Program	38
4.3.2. Overt Military Program	41
4.3.3. Overt Peaceful Program	41
4.4. Subnational Groups	44
4.5. Assessment of Proliferation Impact	44

CONTENTS

5. Comparison with Alternative Technologies	42
5.1. Characteristics for Comparison	48
5.2. Technologies to Be Compared	50
5.3. The Reference Technology	52
5.4. The Comparison Matrices	53
5.4.1. Covert Military Program, Advanced State	53
5.4.2. Covert Military Program, Developing State	53
5.4.3. Overt Military Program, Imported Plant	54
5.4.4. Overt Peaceful Program, Indigenous Plant	54
5.5. Summary	55
6. The Protection of AVLIS Technology	60
6.1. Classification	60
6.2. Export Control	62
6.3. International Agreements	68
6.4. Self-Denial	72

2.5 AVLIS PRODUCTION PLANT

CAPITAL COST

DOCUMENTS

Lawrence Livermore
National Laboratory

MARTIN MARINETTA
Energy Systems

AVLIS Production Plant Capital Cost Summary (U)

Atomic Vapor
Laser Isotope Separation

Document APP-050
November 15, 1984

6. Project Integration Cost.	113
6.1. Introduction	113
6.2. Bases and Methodology.	113
6.3. Assumptions, Inclusions, and Exclusions.	122
6.3.1. Assumptions.	122
6.3.2. Inclusions	123
6.3.3. Exclusions	124
6.4. Project Integration Cost Estimate Summary.	126
7. Contingency Analysis	131
8. Estimate Validation Considerations.	137
8.1. Introduction	137
8.2. Factors for Valid Cost Estimates	137
8.2.1. Process Science and Technology, Engineering Design Basis	137
8.2.2. Degree or Project Scope Definition (Status of Design).	138
8.2.3. Definition of Project Site Related Characteristics	142
8.2.4. Degree of Vendor Participation	142
8.2.5. Project Management Planning and Assessment	143
8.2.6. Experience and Knowledge of the Project Team	144

TABLE OF CONTENTS

1. Executive Summary	1
1.1. Introduction	1
1.2. Summary and Conclusions.	2
1.3. Estimating Bases, Methodology.	9
1.4. Summary of Report Content.	15
2. Initial Increment Plant Estimate.	17
2.1. Introduction	17
2.2. Capital Cost Summaries for Initial Increment of Production.	18
2.3. AVLIS Production Plant Major Cost Drivers.	28
2.3.1. Laser Systems.	29
2.3.2. Separator System Architecture.	30
2.4. Uranium Processing Plant	33
3. Fully Activated Plant Estimate.	42
3.1. Introduction	42
3.1.1. Buildings.	42
3.1.2. Process Equipment.	43
3.1.3. Refurbishment Areas and Equipment.	43
3.1.4. Support Systems.	43
3.2. Total Capital Cost Summaries for Fully Activated Plant	43
3.3. Changes for Fully Activated Plant.	55
4. Greenfield Site Estimate.	60
5. Scope and Basis for Estimate.	67
5.1. Overall Basis for Construction Estimate.	67
5.2. Exclusions	69
5.3. Methodology.	69
5.4. Summary of Scope and Basis for the Capital Cost Estimate.	74
5.4.1. Process Building Conventional Facilities (WBS 1.1). . .	74
5.4.2. Process Building Special Equipment (WBS 1.2)	83
5.4.3. Uranium Processing Facilities (WBS 1.3).	101
5.4.4. Plant Support Facilities (WBS 1.4)	109
5.4.5. Project Integration (WBS 1.5).	112

**Lawrence Livermore
National Laboratory**

**MARTIN MARINETTA
Energy Systems**

**AVLIS
Production Plant
Initial Increment
Capital Cost Bill of Materials
Volume I (U)**

**Atomic Vapor
Laser Isotope Separation**

**Document APP-060
November 15, 1984**

CONTENTS

1. Introduction.	1
2. Initial Increment Plant Estimate.	2
2.1. Introduction	2
2.2. Capital Cost Summaries for Initial Increment of Production.	3
3. Estimate Format	13
3.1. Computerized Estimating System	13
3.2. Code of Accounts	13
3.3. Major Components of the Estimate	15
4. Report Organization	17
4.1. Bill of Materials--Management Summaries.	17
4.2. Bill of Materials--Detailed Report Description.	17
4.3. Bill of Materials--Project Control Summaries	21

Lawrence Livermore
National Laboratory

MARTIN MANIETTA
Energy Systems

AVLIS
Production Plant
Fully Activated
Capital Cost Bill of Materials
Volume II (U)

Atomic Vapor
Laser Isotope Separation

Document APP-060
November 15, 1984

CONTENTS

1. Introduction	1
2. Fully Activated Plant Estimate.	2
2.1. Introduction	2
2.2. Total Capital Cost Summaries for Fully Activated Plant	3
3. Estimate Format	15
3.1. Computerized Estimating System.	15
3.2. Code of Account	15
3.3. Major Components of the Estimate.	17
4. Report Organization	19
4.1. Bill of Materials--Management Summaries	19
4.2. Bill of Materials--Detailed Report Description.	19
4.3. Bill of Materials--Project Control Summaries.	22

**Lawrence Livermore
National Laboratory**

**Research Triangle Park
Energy Systems**

AVLIS Production Plant Capital Cost Vendor Estimates (U)

**Atomic Vapor
Laser Isotope Separation**

**Document APP-080
November 15, 1984**

TABLE OF CONTENTS

1. Executive Summary	1
2. Background	2
3. Approach	3
3.1. Candidate Items	3
3.2. Data Packages	5
3.3. Vendor Contacts	8
4. Vendor Quotes	9
4.1. Laser System	9
4.1.1. Copper Laser Package Components	9
4.1.2. Laser Optics	11
4.1.3. Switching Power Supplies	11
4.2. Separator System	12
4.2.1. Electron Beam High-Voltage Power Supplies	12
4.2.2. Negative Air System	13
4.2.3. Recirculating Cooling Water	13
4.2.4. Vacuum Vessel	13
4.2.5. Vacuum Pumping System	13
4.3. Plant Instrumentation and Control	14
4.4. Refurbishment Equipment	14
5. Summary of Quotes	15
Appendix A. AVLIS Production Plant Vendor Quotes	
Received for Laser, Separator, Plant	
I&C, and Refurbishment Equipment	23

2.6 AVLIS PRODUCTION PLANT

OPERATING COST

DOCUMENTS

UCID-20202

**Lawrence Livermore
National Laboratory**

MARTIN MARIETTA
Energy Systems

AVLIS

Production Plant

Operations and Maintenance Plan

**Atomic Vapor
Laser Isotope Separation**

CAUTION DO NOT PUBLICLY RELEASE THIS DOCUMENT
This technical report is being transmitted prior to DOE patent clearance. No further dissemination or publication shall be made without prior approval of DOE Patent Counsel or LLNL Patent Group.
This document will be returned upon request or when no longer needed, unless notification has been received that this document has been cleared for release or publication.

Document APP-090
November 15, 1984

This is an informal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the authors and may or may not be those of the Laboratory.

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7403-Eng-48.

CONTENTS

Foreword	11
List of Figures	vii
List of Tables	ix
1. Executive Summary	1
1.1. Purpose, Objectives, and Scope of Plan	1
1.1.1. Conclusions	1
1.1.2. Methodology	2
1.1.3. Results	2
1.2. AVLIS Production Plant (APP) and its Operating Organization.	3
1.3. Planning Basis and Philosophy	3
1.3.1. Personnel Training	5
1.3.2. First Module Startup Plan	5
1.3.3. Production Rampup Plan	6
1.4. Production Facilities.	6
1.4.1. Separator Module Operations.	7
1.4.2. Separator Module Changeout Operations	7
1.4.3. Separator Pod Refurbishment Operations	7
1.4.4. Laser Operations	8
1.4.5. Laser Changeout Operations	11
1.4.6. Laser Refurbishment Operations.	11
1.4.7. Support Utilities Operations	13
1.4.8. Materials Management.	14
1.5. Uranium Processing Facilities	15
1.5.1. Feed Conversion Facilities	15
1.5.2. Feed Preparation Facilities.	15
1.5.3. Product Conversion Facilities	16
1.5.4. Uranium Recovery	16
1.5.5. Support Facilities.	16
1.5.6. Materials Management	17
1.6. Waste Management	19

1.7. General AVLIS Production Plant Support Facilities	19
1.7.1. Materials Receiving/Storage.	20
1.7.2. Utilities.	20
1.7.3. Electrical Distribution	21
1.8. Maintenance	21
1.8.1. Maintenance Services	21
1.8.2. AVLIS Process Facilities.	22
1.8.3. Uranium Processing Facilities	23
1.8.4. Maintenance Support Services	23
1.8.5. Staff Services	23
2. Introduction and Organization	25
3. Planning Basis and Philosophy	34
3.1. Personnel Training.	36
3.2. Startup Plan - First Module	39
3.3. Production Rampup Plan	40
4. Production Facilities.	40
4.1. Separator Module Operations.	43
4.2. Separator Module Changeout Operations	45
4.3. Separator Pod Refurbishment Operations	55
4.3.1. Shroud Refurbishment	64
4.3.2. Oxidation and Disassembly of Graphite Components.	64
4.3.3. Vaporizer Refurbishment	67
4.3.4. Manual Refurbishment of Graphite Components	67
4.3.5. Automated Refurbishment of Graphite Components	67
4.3.6. Graphite Component Reassembly and Bake-Out	70
4.3.7. Pod Assembly	70
4.4. Laser Operations	70
4.4.1. Copper Laser Systems	77
4.4.2. Dye Laser Systems and Optics	79
4.4.3. Optics	79
4.5. Laser Changeout Operations	79
4.5.1. Copper Lasers	79
4.5.2. Dye Lasers	81
4.5.3. Optics	86
4.6. Laser Refurbishment Operations.	86
4.6.1. Copper Lasers	86

4.6.2. Dye Lasers	89
4.6.3. Optics	96
4.7. Support Utilities Operations	96
4.7.1. Personnel Staffing	96
4.7.2. Cooling Water	96
4.7.3. Electrical	100
4.7.4. Other Utilities.	101
4.8. Material Management	102
4.8.1. Uranium Materials	102
4.8.2. Designated Materials	102
5. Uranium Processing Facilities	103
5.1. Feed Conversion Facilities	105
5.1.1. System Description.	109
5.1.2. Preparation of the Reactor Vessel.	113
5.1.3. Preparation of Charge.	114
5.1.4. Capping Operation	114
5.1.5. Firing Operation	114
5.1.6. Reactor Vessel Cooling	114
5.1.7. Break-out and Cleanup	115
5.2. Feed Preparation Facilities	115
5.2.1. System Description	118
5.2.2. Crucible Refurbishment	120
5.2.3. Melting-Casting Operation	122
5.2.4. Instrumentation and Control.	123
5.2.5. Outside Services	127
5.3. Product Conversion Facilities	128
5.4. Uranium Recovery	130
5.4.1. Instrumentation and Control.	131
5.4.2. Maintenance	135
5.5. Support Facilities.	138
5.5.1. Toll	138
5.5.2. UF ₆ Feed	140
5.5.3. Fluorine Generation	141
5.5.4. Tails Management	145
5.5.5. KF Conversion	145

5.6. Materials Management	147
5.6.1. Uranium Materials	147
5.6.2. Designated Materials	148
6. Waste Management	149
7. General AVLIS Production Plant Support Facilities	155
7.1. Materials Receiving/Storage	157
7.2. Utilities	158
7.3. Electrical Distribution	161
8. Maintenance	163
8.1. Maintenance Service	163
8.1.1. Preventive Maintenance	163
8.1.2. Calibration/Certification	164
8.1.3. Troubleshooting/Repair	164
8.2. AVLIS Process Facilities	164
8.2.1. Separator Systems	164
8.2.2. Laser Systems	165
8.2.3. Refurbishment Areas	165
8.3. Uranium Processing Facilities	165
8.4. Maintenance Support Facilities.	166
8.5. Staff Services	166
8.5.1. Safety.	166
8.5.2. Quality Assurance	167
8.5.3. Training	167
8.5.4. Procedures	167
8.5.5. Engineering Support	168
8.5.6. Organization and Manning.	168
9. Acronyms	171
Appendix A. Staffing and Activities Summary	175
Appendix B. Outline of Existing ORGP Maintenance Organization.	182
Appendix C. Comprehensive Maintenance Service.	184

Lawrence Livermore
National Laboratory

Energy Systems

AVLIS Production Plant Reliability Engineering Assessment (U)

Atomic Vapor
Laser Isotope Separation

Document APP-100
November 15, 1984

CONTENTS

1.	Executive Summary	1
1.1.	Role and Objectives of Assessment	1
1.2.	Major Conclusions	2
1.3.	Basis for Assessment	2
1.4.	Organization of Assessment Activity	4
1.5.	Summary of Results	4
1.5.1.	Separator System Assessment Summary.	4
1.5.2.	Laser System Assessment Summary	5
1.5.3.	Uranium Processing Facilities Summary	8
1.5.4.	Plant Support Utilities Facilities Summary	8
1.6.	Organization of Document	10
2.	Definitions	11
3.	Separator Systems (WBS 1.2.2)	15
3.1.	Introduction and Overview	15
3.2.	Pod Reliability Engineering Assessment (WBS 1.2.2.1)	17
3.2.1.	Vaporizer Subsystem (WBS 1.2.2.1.1)	17
3.2.2.	Carriage Assembly (WBS 1.2.2.1.2)	75
3.2.3.	Extractor/Collector System (WBS 1.2.2.1.3)	80
3.3.	Controls Reliability Engineering Assessment (WBS 1.2.2.2)	149
3.4.	Module System Reliability Engineering Assessment (WBS 1.2.2.3)	149
3.4.1.	Vacuum Tankage System (WBS 1.2.2.3.1)	149
3.4.2.	Cooling Systems (WBS 1.2.2.3.2)	201
3.4.3.	Vacuum System (WBS 1.2.2.3.3)	215
3.4.4.	Air Handling System (WBS 1.2.2.3.4)	248
3.5.	Separator System Assessment Summary	252
4.	Laser Systems	264
4.1.	Introduction	264

4.2.	AVLIS Production Plant Laser System Functional Description	265
4.2.1.	General Description	265
4.2.2.	Functional Block Diagrams	267
4.3	Laser System Reliability Engineering Assessment	282
4.3.1.	Introduction	282
4.3.2.	Copper Laser System	283
4.3.3.	Dye Laser System	319
4.3.4.	Optical Systems	334
4.3.5.	Instrumentation and Control System	344
4.3.6.	Refurbishment/Test Areas	382
4.3.7.	Process Support Systems	382
4.4.	Laser System Availability Assessment	387
4.4.1.	Summary of Laser System Availability	387
4.4.2.	Copper Laser Module Availability	389
4.4.3.	Dye Laser and Optics System Availability	391
4.4.4.	Laser Utility Availability	391
4.4.5.	I&C and C&C System Availability	392
4.5.	Laser System Assessment Summary	393
5.	Uranium Processing	459
5.1.	General	459
5.2.	Feed Conversion	463
5.2.1.	UF ₄ Production	464
5.2.2.	HF Recovery	465
5.2.3.	H ₂ Generation	465
5.2.4.	Derby Production	465
5.2.5.	Derby Roasting and Cleaning	466
5.2.6.	MgF ₂ Slag Processing	467
5.3.	Feed Preparation	467
5.3.1.	Crucible Refurbishment	467
5.3.2.	Melting-Casting	468
5.4.	Product Conversion	468
5.4.1.	Product Size Reduction and Oxidation	468
5.4.2.	Refurbishment Size Reduction and Oxidation	469

5.4.3.	Product Fluorination	469
5.4.4.	Product Collection	470
5.4.5.	Product Purification and Blending	470
5.5.	Uranium Recovery	470
5.5.1.	Milling and Oxidation	471
5.5.2.	Fluorination	471
5.5.3.	UF ₆ Cold-Trapping	471
5.6.	Process Support	471
5.6.1.	UF ₆ Feed Facility	472
5.6.2.	Fluorine Generation Facility	472
5.6.3.	KF Conversion Facility	472
5.7.	Waste Management	473
5.8.	Fully Activated Plant	473
6.	Process Support and Utilities Facilities	474
6.1.	Overview	474
6.2.	Process Support and Utilities Functional Descriptions	480
6.2.1.	General Site and Services	480
6.2.2.	Electric Power for AVLIS Production Plant	481
6.2.3.	Cooling Water Systems	483
6.2.4.	Other Utility Systems	484
6.3.	Process Support and Utilities Reliability Engineering Assessment	485
6.3.1.	Electrical Power for AVLIS Production Plant	485
6.3.2.	Cooling Water Systems	504
6.4.	Summary	581
Appendix A		
	AVLIS Product Plant Work Breakdown Structure and Dictionary.	595

**Lawrence Livermore
National Laboratory**

**MARTIN MARIETTA
Energy Systems**

AVLIS

Production Plant

Operating Cost Summary (U)

**Atomic Vapor
Laser Isotope Separation**

**Document APP-110
November 15, 1984**

TABLE OF CONTENTS

1. Executive Summary	1
2. Introduction	4
3. Summary Cost Tables	5
4. Basis of the Operating Costs	13
5. Plant Startup and Initial Operating Costs	18
6. Operating Cost Labor Analysis Summary	27
6.1 Introduction	27
6.2 Production Facility Staffing	27
6.3 Uranium Processing Facilities Staffing	39
6.4 Support Facilities Staffing	39
6.5 Support Services Staffing	42
7. Operating Cost Materiel Analysis Summary	44
7.1 Introduction	44
7.2 Production Facility Materials	44
7.3 Uranium Processing Facilities Materials	50
7.4 Support Facilities Materials	53
7.5 Support Services Materials	54
7.6 Electrical Power	56
7.7 Utilities Materials	58
8. Operating Materiel Cost Basis Summary	60
8.1 Introduction	60
8.2 Data Collection Methods	62
9. Operations and Maintenance Plan Summary	66
9.1 Introduction	66
9.2 AVLIS Production Plant Operating Organization	67

Lawrence Livermore
National Laboratory

MARTIN MARITTA
Energy Systems

AVLIS Production Plant Operating Cost Labor Analysis (U)

Atomic Vapor
Laser Isotope Separation

CAUTION DO NOT PUBLICLY RELEASE THIS DOCUMENT
This technical report is being transmitted prior to DOE patent
clearance. No further dissemination or publication shall be made
without prior approval of DOE Patent Counsel or LLNL Patent

Document APP-120
November 15, 1984

TABLE OF CONTENTS

1. Executive Summary	1
2. Introduction	6
3. Basis of the Analysis	7
4. Production Facility Staffing	17
4.1 Laser Systems	19
4.1.1 Copper Laser Changeout	21
4.1.2 Laser Refurbishment	25
4.1.3 Laser Operations--Floor Support and Dye Pump Building	43
4.1.4 Laser Area--General Maintenance	43
4.1.5 Laser Mechanical Building	45
4.2 Separator Systems	48
4.2.1 Separator Pod Changeout	50
4.2.2 Separator Pod Refurbishment	67
4.2.3 Separator Operations--Floor Support	87
4.2.4 Separator Area--General Maintenance	89
4.2.5 Separator Mechanical and Utility Buildings	91
4.3 Uranium Materials Control and Handling	93
4.3.1 Feed Handling	96
4.3.2 Tails Handling	106
4.3.3 Product Handling	124
4.3.4 Waste Material Handling	143
4.4 Other Production Facility Support	144
4.4.1 Plant Control Rooms	146
4.4.2 Materials Supply and Control	149
4.4.3 Utilities and HVAC Operations	151
4.4.4 Shop Operations	153
4.5 Production Facility Administration	155

5. Uranium Processing Facilities Staffing	159
5.1 Feed Conversion Facility	159
5.2 Feed Preparation Facility	162
5.3 Product Conversion Facility	163
5.4 Uranium Recovery Facility	164
5.5 Process Support Facilities	164
5.6 Waste Management Services	166
5.7 Central Maintenance Services	168
6. Support Facilities Staffing	169
6.1 ORGDP Utilities Operations	170
6.2 ORGDP Power and Shift Operations	172
6.3 Material Receiving and Storage Facilities	174
6.4 Graphite Shop	176
7. Support Services Staffing	178
7.1 ORGDP Site Management	180
7.2 Employee Relations	182
7.3 Security and Plant Protection	184
7.4 Health, Safety, and Environmental Affairs	186
7.5 Finance, Materials, and Services	189
7.6 Maintenance Support Services	193
7.7 General Staff	195
7.8 Engineering	200
7.9 Operations, Analysis, and Planning	202
7.10 Computer Services	204
7.11 Process Support	206

UCID-20206

Lawrence Livermore
National Laboratory

MARTIN MANIETTA
Energy Systems

AVLIS

Production Plant

Operating Cost Materiel Analysis (U)

Atomic Vapor
Laser Isotope Separation

Document APP-130
November 15, 1984

CONTENTS

	Page
1. Executive Summary	1
2. Introduction	7
3. Basis of the Analysis	9
4. Production Facility Materials	13
4.1. Laser Refurbishment Materials	13
4.1.1. Copper Laser Oscillator Packages	15
4.1.2. Copper Laser Amplifier Packages	16
4.1.3. Waveform Generator and Dye Lasers	17
4.1.4. Optics	17
4.1.5. Other Materials and Consumables.	18
4.2. Separator Refurbishment Materials.	30
4.2.1. Vaporizer System	30
4.2.2. Ion Extractor	33
4.2.3. Withdrawal Hardware.	34
4.2.4. Separator Systems	34
4.3. Other Facility Work Materials	43
4.3.1. Separator Operations Areas	43
4.3.2. Laser Operations Areas	45
4.3.3. Building Service and Process Support Equipment	47
4.3.4. General Support Materials and Consumables.	47
5. Uranium Processing Facilities Materials.	49
5.1. Feed Conversion Facility	52
5.2. Feed Preparation Facility.	54
5.3. Product Conversion Facility.	55
5.4. Uranium Recovery Facility	56
5.5. Process Support Facilities	58
5.6. Waste Management Services	61
6. Support Facilities Materials	67
6.1. Materials Receiving and Storage Facilities	67
6.2. Graphite Shop	68

7.	Support Services Materials	70
8.	Electrical Power	72
8.1.	TVA Power Cost	72
8.2.	ORADP Power and Shift Operations Materials	73
9.	Utilities Materials	75

Lawrence Livermore
National Laboratory

MARTIN MARETTA
Energy Systems

AVLIS Production Plant Operating Materiel Cost Basis (U)

Atomic Vapor
Laser Isotope Separation

Document APP-140
November 15, 1984

CONTENTS

1. Executive Summary	1
1.1 Introduction	1
1.2 Purpose	2
1.3 General Discussion	4
1.4 Methodology	4
1.5 Summary of Results	5
2. Data Collection Methods	9
2.1 Materiel Usage Factors	9
2.1.1 Random Failure During Operation	9
2.1.2 Useful Life	9
2.1.3 Scheduled Maintenance	9
2.1.4 Random Failure During Maintenance	10
2.2 Data Sources	10
2.2.1 AVLIS Experience	10
2.2.2 Industrial Data	11
2.3 Organization by Work Breakdown Structure	11
3. Materiel Cost Analysis	12
3.1 Laser System Materiel	13
3.2 Separator System Materiel	53
3.3 Significant Cost Driver Assessments	54
3.3.1 Cost Driver Selection Criteria	55
3.3.2 Copper Laser Oscillator and Amplifier Assessments	55
3.3.3 Laser Optics Assessments	61
3.3.4 Separator Component Assessments	64

INTERNAL DISTRIBUTION.

R. E. Batzel	L-1
J. I. Davis	L-466
J. L. Emmett	L-488
A. C. Haussmann	L-28
R. D. Dewitt	L-372
J. Ackerman	L-441
E. R. Ault	L-463
A. B. Casamajor	L-440
M. H. Chew	L-399
J. W. Dubrin	L-467
M. Greer	L-438
L. A. Hackel	L-459
M. P. Hacker	L-470
R. S. Hargrove	L-467
J. G. Harri	L-470
G. M. Heestand	L-470
J. L. Held	L-470
R. E. Hendrickson	L-466
J. Z. Holtz	L-459
J. A. Horton	L-470
E. I. Moses	L-462
R. W. O'Neil	L-462
Y. Oster	L-440
R. W. Patterson	L-462
T. A. Shepp	L-470
M. L. Spaeth	L-467
J. Weed	L-440
R. J. Tosetti (5)	L-439
R. K. Robinson (5)	L-438
J. I. Davis	
CLYA Files (20)	L-466
TID (15)	L-658

EXTERNAL DISTRIBUTION

Dr. Lester Ettlinger
The MITRE Corporation
METREK Division
1820 Dolley Madison Blvd.
McLean, VA 22102

(3)

J. K. Hancock (2)
(Project File for Congressional
Archives)
U.S. Department of Energy
Advanced Technology Projects
Uranium Enrichment, NE-35
Office of Nuclear Energy
Washington, DC 20545

Dr. James Rushton
Program and Process Planning
Martin Marietta Energy Systems
P. O. Box P
Oak Ridge, TN 37831

(3)

J. R. Longenecker
U.S. Department of Energy
Office of Nuclear Energy
Washington, D.C. 20545

Mr. Kenneth Sommerfeld
Vice Pres., Enrichment
Martin Marietta Energy Systems
P. O. Box P
Oak Ridge, TN 37831

(10)

R. T. Ooten
U.S. Department of Energy
Oak Ridge Operations Office
P. O. Box E
Oak Ridge, TN 37830

Mr. Richard Dierlam
U.S. Department of Energy
Advanced Technology Projects
Uranium Enrichment, NE-35
Office of Nuclear Energy
Washington, DC 20545

J. Milloway
U.S. Department of Energy
Oak Ridge Operations Office
P. O. Box E
Oak Ridge, TN 37830

Mr. Don Erb
U.S. Department of Energy
Uranium Enrichment, NE-34
Office of Nuclear Energy
Washington, DC 20545

C. C. Hopkins
K. Jarmolow
Martin Marietta Energy Systems, Inc.
(Y-12), P.O. Box Y
Oak Ridge, TN 37831

Process Evaluation Board
c/o Dr. Kermit Laughon
PEB, Exec. Secretary
U.S. Department of Energy
Office of Nuclear Energy
Washington, D.C. 20545

(7)

D. F. Craig
M. O. Dixon
C. E. Frye
R. L. Hoglund
G. R. Jasny
A. L. Lotts (2)
J. R. Merriman
G. E. Michaels
J. S. Rayside
T. R. Smith
J. D. Stout
Martin Marietta Energy Systems
(K-25); P. O. Box P
Oak Ridge, TN 37830

Mr. Joseph W. Parks
U.S. Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, TN 37830

W. M. Polansky
U.S. Department of Energy
Advanced Technology Projects
Uranium Enrichment, NE-35
Office of Nuclear Energy
Washington, DC 20545

U.S. Department of Energy (27)
Technical Information Center
P. O. Box 62
Oak Ridge, TN 37830