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Operation and Maintenance Manual for the Optical Alignment System (OAS) System 6250

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Abstract: The OAS is a camera and laser system that will be used as an end effector on the LDUA to properly align the arm with the entry riser. It is attached to the LDUA by means of a Tool Interface Plat (TIP) which provides a feed through for all electrical and pneumatic utilities needed by the end effector to operate.

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**OPERATION AND MAINTENANCE MANUAL
FOR THE OPTICAL ALIGNMENT SYSTEM (OAS)
SYSTEM 6250**

JUNE 28, 1996

BY

A. F. PARDINI

REMOTE SYSTEM AND SENSOR APPLICATIONS

**WESTINGHOUSE HANFORD COMPANY
RICHLAND, WASHINGTON**

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FOR THE OPTICAL ALIGNMENT SYSTEM (OAS)
SYSTEM 6250

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OPERATION AND MAINTENANCE MANUAL FOR THE OPTICAL ALIGNMENT SYSTEM (OAS)

This document defines the requirements for the operation, maintenance, and storage of the Optical Alignment System (OAS) used with the Light Duty Utility Arm (LDUA) system.

1.0 GENERAL INFORMATION

1.1 Introduction

The OAS is a camera and laser system that will be used as an end effector on the LDUA to properly align the arm with the entry riser (Figure 1). It is attached to the LDUA by means of a Tool Interface Plate (TIP) (Figure 2) which provides a feed through for all electrical and pneumatic utilities needed by the end effector to operate.

1.2 Equipment Description

The system consists of the OAS end effector and associated support electronics (located in the At Tank Instrument Inclosure (ATIE)). The end effector includes 4 point lasers which project outward and down through a prism located on the circumference of the end effector (Figure 3). The purpose of these lasers is to project a cylinder (when the LDUA wrist is rotated) of laser light, which maps out the volume that the LDUA outer mast would include when lowered through a riser, thereby allowing the lasers to provide any interference notification to the operator prior to tank entry. The end effector also includes 4 line lasers which project orthogonal laser lines from the end of the end effector (Figure 3). These lines form a tic-tac-toe pattern on a distant plane, and form parallel lines down the side of a riser prior to riser entry. A skewed or distorted pattern may indicate a bent or bowed riser. Each of these two laser systems are viewed using a single black and white camera located in the middle of the end effector (Figure 3). This camera will also be used for boresighting the top and bottom of the riser opening prior to riser entry. The final major components located within the end effector are 8 laser proximity sensors. These sensors are located around the periphery of the OAS at 90 degree placement with one set of 4 near the TIP side and 4 near the end of the end effector (camera view side) (Figure 3).

All laser and camera functions are controlled using the LDUA Supervisory Data Acquisition System (SDAS).

In the event of a low purge pressure, a signal from the LDUA control system will be provided to the end effector support electronics to instigate a shutdown of all power to the end effector.

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1.3 Reference Documents

The documents listed may be consulted as a source of information for the basic requirements of the LDUA Optical Alignment System.

WHC-SD-TD-CR-001, Rev. 1	Design Criteria for the Light Duty Utility Arm System End Effectors
WHC-SD-TD-FRD-003, Rev. 0	Functions and Requirements for the Light Duty Utility Arm Integrated System
WHC-SD-WM-TC-070, Rev. 0	Test Procedure for Calibration, Grooming, and Alignment of the LDUA Optical Alignment Scope

MECHANICAL DRAWINGS

H-6-14230 Rev. 0 (EES-22408-R1-021 Rev. B)	Alignment End Effector Assembly
H-6-14231 Rev. 0 (EES-22408-R3-022 Rev. B)	Alignment End Effector Front Housing Weldment
H-6-14232 Rev. 0 (EES-22408-R3-023 Rev. B)	Alignment End Effector Rear Housing Weldment
H-6-14233 Rev. 0 (EES-22408-R4-024 Rev. B)	Alignment End Effector Plate Details
H-6-14234 Rev. 0 (EES-22408-R4-025 Rev. B)	Alignment End Effector Bracket Details
H-6-14235 Rev. 0 (EES-22408-R4-026 Rev. A)	Alignment End Effector Misc. Details

ELECTRICAL DRAWINGS

H-6-14237 Rev. A (EES-22408-L7-047 Rev. B)	UST-ID Optical Alignment System Housing
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CVVE CHASSIS AND POWER SUPPLY CHASSIS DRAWINGS

CVVE CHASSIS

H-6-14270 Rev. A	Sheet 1 of 9	Common Video End Effector (CVVE) Support Electronics
H-6-14270 Rev. A	Sheet 2 of 9	CVVE and OAS end to end drawing
H-6-14270 Rev. A	Sheet 4 of 9	Common Video End Effector (CVVE) Chassis Layout
H-6-14270 Rev. A	Sheet 5 of 9	CVVE Chassis Preparation
H-6-14270 Rev. A	Sheet 6 of 9	CVVE Chassis Wiring Diagram (Part A)
H-6-14270 Rev. A	Sheet 7 of 9	CVVE Wiring Diagram (Part B)
H-6-14270 Rev. A	Sheet 8 of 9	CVVE/Kepco ¹ Interface
H-6-14270 Rev. A	Sheet 9 of 9	CVVE/PC Serial Connections

POWER SUPPLY DRAWINGS

H-6-14271 Rev. A	Sheet 1 of 3	WHC Power Chassis Layout (CVVE)
H-6-14271 Rev. A	Sheet 2 of 3	WHC Power Chassis Wiring Diagram (CVVE)
H-6-14271 Rev. A	Sheet 3 of 3	WHC Power Chassis Schematic (CVVE)

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2.0 SPECIAL REQUIREMENTS

2.1 Utilities Required

The OAS utilities are supplied to the end effector by the support electronics, more commonly known as the Common Video End Effector (CVEE) support electronics (H-6-14270 & H-6-14271). The CVEE is located within the ATIE and is connected to the actual OAS end effector utilizing the ATIE cabling and the umbilical located within the LDUA. The CVEE support electronics consist of the CVEE chassis containing the opto-22 modules and the power supply chassis containing power supplies for camera, motors, and lights. The power requirement for the CVEE and power supply chassis is one each, 120 Vac/60 Hz, single phase.

2.2 Special Tools and Equipment

Handling of the OAS is accomplished using the LDUA Manual End Effector Exchange System (MEEES). This system performs all the manual lifting and engaging of the OAS to the LDUA.

2.3 Calibration

Calibration of the OAS is not readily performed in field applications. A calibration and test assembly has been fabricated and installed in the FMEF test facility (Figure 4) and is the preferred calibration assembly for the OAS. Calibration will only be required when specific OAS components (i.e. camera or dot lasers) are replaced or if the OAS is damaged (i.e. camera or lasers are knocked out of position). Provisions for field calibration are being considered. Calibration of the OAS is performed using WHC-SD-WM-TC-070, Rev. 0, *Test Procedure for Calibration, Grooming, and Alignment of the LDUA Optical Alignment Scope*.

2.4 Safety

The following safety considerations shall be considered when operating and maintaining the OAS system.

2.4.1 Personnel Precautions

- All operation and maintenance shall be performed in accordance with applicable safety requirements as stipulated in WHC safety documents.
- Before beginning a task, the Person-In-Charge (PIC) is responsible to

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assure that all personnel taking part in the operation of the OAS have been briefed on its operation and that they understand the task being performed and any hazards associated with it.

- Wear appropriate laser eyewear when operating the laser systems. Follow the appropriate laser safety plan.

2.4.2 Equipment Precautions

- ****CAUTION**** The exterior of the OAS gets thermally hot when the lights are left on for a time. Use gloves when working with hot surfaces.
- Avoid contact with the 120Vac power connections on connection strips.

3.0 SETUP AND OPERATION

This section provides instructions for the normal handling and operation of the OAS in support of routine operations of the LDUA within a Hanford tank.

3.1 Equipment Setup

- 3.1.1 The OAS will be stored in a plastic bag within the hard plastic storage container. The top section of the storage container will be removed exposing the top of the end effector. Once the plastic bag is removed the end effector will be available for removal from the storage container using the MEEES.
- 3.1.2 The door of the TRIC will be opened and the MEEES will place the OAS in position for connection to the LDUA. This is accomplished using the TIP connecting mechanism.
- 3.1.3 Under normal operation the CVEE chassis and CVEE power supply chassis will be energized and all cable connections between the CVEE chassis and the LDUA interface will be made. Therefore once the OAS end effector is placed on the arm the system will be ready for operation. Actual operation of the OAS is performed utilizing SDAS. The SDAS Virtual Instrument (VI) (Figure 5) will be used to remotely operate the OAS.
- 3.1.4 Using the VI the operator can turn on pairs of lights for improved viewing. The four dot lasers may also be turned on in pairs which may be viewed on the monitor as laser dots projected on a distant orthogonal plane. Four line lasers may also be viewed on the monitor and resemble a tic-tac-toe pattern. The proximity sensors allow for a direct readout of distance to the riser wall.

3.2 Theory of Operation

- 3.2.1 Prior to tank entry the OAS will be used to align the LDUA with the tank entry riser so that the LDUA will enter without contacting the riser wall. The initial step will consist of boresighting the top of the riser flange with the end of the riser (approximately 16 feet into the tank). This will be performed using the camera image on the monitor and a reticule generator that provides a target pattern centered in the middle of the monitor screen. Alignment of the LDUA will be accomplished when the top and bottom circles (images of the top flange and end of the riser) are concentric with each other and centered along the axis of the OAS.

- 3.2.2 Once the boresighting process has been completed the four dot lasers will be turned on. These lasers will provide visual assurance that the OAS (and LDUA) are aligned with the entry riser. Normal alignment will be evident by seeing 4 laser dots on the distant waste surface, each dot touching a circle 10.5 inches in diameter. If any of the lasers are seen as streaks down the side of the riser then LDUA realignment may be necessary. The wrist mechanism on the LDUA may then be rotated. This action will sweep out a cylinder of laser light and any protruding object that intercepts the circle will be seen as an interruption of the laser cylinder (dot will become much brighter when it strikes the object much closer to the laser).
- 3.2.3 In the case of a bent or bowed riser it may be necessary to activate the 4 line lasers. These lasers provide symmetrical parallel lines of laser light streaking along the length of the riser. If the riser is bowed or bent a disruption of the symmetry will occur in the direction of the riser anomaly.
- 3.2.4 Once the operator is satisfied he will not contact the riser on entry he may begin the process of lowering the OAS into the riser. As the OAS enters the riser, the proximity sensors will begin providing a direct measurement of distance to the tank wall. This measurement will provide the operator with added assurance that the LDUA will not contact the riser during entry.
- 3.2.5 After the LDUA has entered the riser with no contact, the OAS will be raised out of the tank and removed from the LDUA, and other end effectors can now be used.

4.0 MAINTENANCE

4.1. Scheduled Maintenance

Scheduled maintenance is that preventive maintenance that is performed on the OAS at regular time intervals. The PIC shall be responsible for assuring that the designated maintenance activities are accomplished at the appropriate time interval as specified below.

Unless specifically directed otherwise, all maintenance shall be done with the OAS and support electronics disconnected from the power source.

4.1.1 Daily Maintenance (i.e. each additional 8 hours of operating time)

- Using a soft cloth and commercial window cleaner, gently clean all optical windows.
- Perform a general visual inspection.

4.1.2 Weekly Maintenance (i.e. each additional 40 hours of operating time)

- Perform a visual inspection to make sure all hex screws are fully backed out into the outer shell of the OAS.
- Visually inspect prisms for damage.

4.1.3 Six-Month Maintenance (i.e. each additional 172 hours of operating time)

- Replace all accessible o-rings (no need to replace o-rings that have been previously sealed using silicon sealants).
- Perform a general visual inspection of the interior of the OAS end effector.
- Perform a general visual inspection of the CREE chassis and power supply chassis.

4.1.4 Twelve-Month Maintenance (i.e. each additional 344 hours of operating time)

- Replace camera and lens assembly (will require recalibration).
- Replace all lamps.

4.1.5 Thirty-six Month Maintenance (i.e. each additional 516 hours operating time)

- Replace all laser systems.

4.2 Corrective Maintenance

Corrective maintenance addresses those situations where remedy is required to correct component failures which occur unexpectedly, and are therefore not performed in accordance with a schedule. Rigorous adherence to scheduled preventive maintenance should minimize the need to perform corrective maintenance. The components in the OAS are expected to have a reasonably long operating life, and corrective maintenance activities are minimal. The following items have been identified as potential corrective maintenance activities. A recommended spare parts list has been included in Appendix A. A complete parts list can be found on the OAS assembly drawing. Component original equipment manufacturer (OEM) documentation can be found in the OAS subsystem component specification file. The OEM documentation should provide sufficient information to assist in the adjustments or maintenance activities for the specific component.

Performance of unscheduled maintenance may require access to the LDUA SDAS and associated equipment for system checkout. Unscheduled maintenance may also require a recalibration of the OAS which may require sufficient decontamination to allow calibration in a non-radiation zone.

- 1) Lamp replacement (note: to replace the lamps care must be taken not to touch the halogen bulb with bare hands. Use rubber or cotton gloves to handle bulb and reflector assembly).
 - a. Unscrew the cover plate assembly (Figure 6) and remove.
 - b. Remove each bulb carefully and replace by inserting new bulb. Make sure new bulb is seated fully into its socket.
 - c. Reinstall the cover plate.
 - d. Power light to verify proper operation.
- 2) Prism replacement
 - a. Unscrew the prism assembly (Figure 7) and remove.
 - b. Reinstall with new prefabricated prism assembly.

3) Camera and Lens replacement

- a. Screw inward on the hex screws located just below (away from TIP) the center ring where the prisms are located (Figure 8).
- b. Carefully pull apart the upper part of the OAS (TIP side) from the lower section (camera side). Note: the sections of the OAS have been marked so that they can be easily reassembled.
- c. Disconnect the camera and lens wiring.
- d. Remove screws holding the camera bracket and remove bracket, camera, and lens assembly.
- e. Replace the new bracket, camera, and lens assembly in the same position as the one removed.
- f. Reconnect camera and lens wiring.
- g. Carefully reassemble the OAS.
- h. Calibration of the OAS may now be necessary.

4) Base O-ring Replacement

All o-rings on the OAS can be worn or damaged during assembly and disassembly. To replace the o-ring which is at the interface between the OAS and the TIP it will be necessary to remove the TIP (Figure 2). All other o-rings can be replaced by disassembling the OAS as in step 3 above and using the same clean and grease technique as below.

- a. Position the OAS/TIP on its side.
- b. Remove the TIP from the OAS by removing the six bolts in the TIP. Reference SPAR documentation for the bolt location in the TIP. The bolts will require a 5/16" hex head driver. After the bolts are removed, carefully separate the TIP from the OAS, taking care not to strain the Hypertronic² connectors. These connectors will need to be unscrewed and pushed through their mounting holes.
- c. Remove the o-ring from the groove. Clean the o-ring groove and reapply Dow Corning³ High Vacuum grease or equivalent to the o-ring.
- d. Replace the o-ring in the groove.
- e. Reinstall the TIP to the OAS. There are two alignment dowels in the TIP which will align the TIP to the OAS. Carefully align the TIP with the OAS so that the two pieces mate properly and the o-ring is not pinched. Reinstall the six bolts in the TIP to secure the TIP to the OAS.

²Hypertronic is a trademark of Hypertronics Corporation

³Dow Corning is a trademark of Dow Corning Corporation

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- 5) Optical window replacement (note: all optical windows have been installed using an ultraviolet cured cement. To replace windows, the appropriate section of the OAS must be disassembled and the window knocked out using a blunt instrument and all remaining window material removed. A new cut-to-fit window may then be reinstalled and glued in place).

5.0 STORAGE

During normal operation the of the LDUA system, the OAS will reside in its storage container until it is needed for alignment purposes. This storage container is a large molded plastic container (Hardigg⁴, case molded plastic) with internal shock absorbing material (polyethylene (closed cell) foam). The OAS will be placed in a plastic bag after the decontamination process and sealed shut. It will then be placed into the storage container and the top of the container fastened. The storage container will be stored in the LDUA lay down area until needed.

⁴Hardigg is a trademark of Hardigg Inc.

APPENDIX A -- FIGURES

Figure 1 OAS Mounted on the end of the LDUA

Figure 2 Tool Interface Plate (TIP) Attached to the OAS

Figure 3 OAS Laser and Camera Systems

Figure 4 OAS in Calibration Fixture

Figure 5 OAS Virtual Instrument (VI)

Figure 6 Cover Plate Assembly

Figure 7 OAS Prism Assembly

Figure 8 OAS Disassembly

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APPENDIX B -- SPARE PARTS

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The following is a recommended OEM spare parts list for the OAS end effector.

- 1) Video Camera, Watec, Model #902
- 2) Lens, Fujinon, Model #D10X8A-HDM71M, 1:1, 4/8-80 mm.
- 3) Halogen Lamp, Osram, Model #35MR16/18/SP
- 4) Halogen Lamp, Osram, Model #35MR16/38/FL
- 5) O-Ring, 10.00 DIA X 1/8 THK, Ethylene Propylene, Parker #2-273 E540-80
- 6) O-Ring, 1.38 DIA X 3/32 THK, Ethylene Propylene, Parker #2-123 E540-80
- 7) O-Ring, 9.50 DIA X 1/8 THK, Ethylene Propylene, Parker #2-271 E540-80
- 8) Proximity Sensors, Adsens Technology Inc., Model #LAS-8010V
- 9) Single Dot Laser Projector, Lasirus, Model #DLS-500-635M-5
- 10) Laser Line Projector, Lasirus, Model #SNF-501L-635M-5-45