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7. Abstract

Functions and requirements for the Waste Dislodging & Conveyance System to be deployed in Gunite and Associated Tanks (GAAT) and tested and evaluated as a candidate tank waste retrieval technology by the GAAT Treatability Study (GAAT TS).

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FUNCTIONS AND REQUIREMENTS

for a

WASTE DISLODGING AND CONVEYANCE SYSTEM

for the

GUNITE AND ASSOCIATED TANKS TREATABILITY STUDY

AT OAK RIDGE NATIONAL LABORATORY

September 26, 1995

by

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O.D. Mullen

Remote System and Sensor Applications

Westinghouse Hanford Company
Richland, Washington

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Functions and Requirements for a
Waste Dislodging and Conveyance System
for the Gunite and Associated Tanks Treatability Study
at Oak Ridge National Laboratory

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1.0 INTRODUCTION

1.1. BACKGROUND:

Since the mid 1940's, the Department of Defense (DOD) and the Department of Energy (DOE) have conducted research and development activities at the Oak Ridge National Laboratory (ORNL) in support of urgent national interests in the fields of nuclear weaponry and nuclear energy. Some of these activities resulted in radiologically hazardous waste being temporarily deposited at ORNL, Waste Area Grouping 1. At this location, waste is stored in several underground storage tanks, awaiting ultimate final disposal. There are tanks of two basic categories, one category is referred to as the "gunite" tanks, the other category is "associated" tanks.

The ORNL Gunite and Associated Tanks Treatability Study (GAAT TS) project was initiated in FY 1994 to support a record of decision in selecting from seven different options of technologies for retrieval and remediation of these tanks. This decision process is part of a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Remedial Investigation and Feasibility Study (RI/FS) presented to DOE and the Tennessee Department of Environment and Conservation (TDEC). As part of this decision process, new waste retrieval technologies will be evaluated at the 25 foot diameter gunite tanks in the North tank farm.

Of the seven technology GAAT TS options, three require the waste to be retrieved from gunite tanks. Final retrieval of this waste from the tanks involves dislodging it from the tanks, conveying it above ground, and transporting it to a waste treatment facility, a waste retention system, or another tank. For the GAAT TS decision making process, the waste will be initially transferred from source tank W-3 to another nearby tank, instead of to a retention tank or waste treatment facility. Regardless of the final destination, the scope of the system subject of these F&Rs ends at the interface between the conveyance line and the site-furnished system for transfer of the waste to the eventual destination, and does not include functions beyond that interface .

Work is currently being conducted at Hanford and the University of Missouri-Rolla to evaluate and develop some technologies having high probability of being most practical and effective for the dislodging and conveying of waste from underground storage tanks. The findings of these efforts indicate that a system comprised of a dislodging end effector employing jets of high pressure fluids, coupled to a water-jet conveyance system, all carried above the waste by a mechanical arm or other mechanism, is a viable retrieval technology for the GAAT TS tasks. References 3-10 constitute a partial bibliography for further information on this subject. The technological approach to waste retrieval for the GAATS options is based upon this Hanford research and development, and forms the basis for the design criteria set forth by this document.

1.2. SCOPE:

The system used to dislodge the waste and convey it to an above ground location, from which it may be transferred to either the waste treatment facility or another tank, is collectively identified as the ORNL Waste Dislodging and Conveyance (WD&C) system. The purpose of this document is to establish the functions and requirements for the design of the ORNL Waste Dislodging and Conveyance (WD&C) system

All waste treatment facilities or other tanks, and systems for transport of waste to these facilities after it has been retrieved by the WD&C, are part of the balance of plant (BOP) and are therefore beyond the scope of this document. Therefore, all systems beyond the interface at the conveyance line outlet are part of the balance of plant. The crawler vehicle or the Modified Light Duty Utility Arm (MLDUA) and gripper end effector (GEE) planned to support WD&C operations are also considered separate systems from and not part of the WD&C system and are beyond the scope of this document for other than reference purposes. The BOP, crawler vehicle, MLDUA (Ref 27), and GEE (Ref 27) are defined by other documentation.

Unless otherwise specified, the scope of this document is limited to only that equipment in the five basic WD&C sub-systems listed below, including the internal utilities required to support their operation.

The Sub-Systems Comprising the WD&C System are:

1) Waste Dislodging End Effector (WDEE)
   - Dislodging end effector
   - End effector utilities & supply conduits

2) Waste Conveyance System (WCS)
   - Waste conveyance pump
   - Waste conveyance conduits
   - Supporting utilities

3) WD&C Deployment System (DS)
   - Deployment Boom
   - Hose and Cable Management

4) Confinement and Contamination Control (CCC)
   - Containment housing
   - Decontamination system

5) Instrumentation and Controls (I&C)
   - I&C controls and monitors
   - Actuators & sensors
   - Data storage

1.3. ASSUMPTIONS AND UNKNOWNS:

Some requirements and parameters specified in this document are not fully defined at this time, but remain to be determined (TBD) before the WD&C design can be finalized. Such incompletely defined terms are identified in the text of this document by the symbol (TBDXXX), where the XXX represents a three digit number for that particular unknown or family of unknowns. A complete listing of all TBD's are found in section 7.0 of this document and identify the organization responsible for their respective resolutions.

The requirements defined in this document are based on maneuvering the waste dislodging end effector within the tank using the MLDUA (performance capabilities as referenced in Appendix A and

References 26, 27, 28) or a crawler vehicle. Should an alternative method of maneuvering the WDEE be used, portions of this document may no longer be valid. Any alternative deployment system shall have dexterity and payload capacity at least equal to that of the MLDUA. The crawler vehicle will be required to accomplish the same maneuvers as the MLDUA, but will not be able to reach as high on the tank walls.

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1.4. ACRONYMS AND ABBREVIATIONS:

The acronyms and abbreviations used in this document are defined as follows:

BOP	Balance of Plant (BOP). The BOP is a term used to refer inclusively to all other portions of the waste retrieval process not included in the WD&C system defined in this document.
CCC	Confinement and Contamination Control (CCC). That part of the WD&C system which acts as a barrier to protect personnel and the environment from contamination.
CCS	Collision Control System (CCS). A portion of the WD&C I&C system which deals with in-tank collision avoidance.
CMS	Cable Management System (CMS). That portion of the WD&C deployment system which handles and manipulates the conduit, hoses, cables, etc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).
DOD	Department of Defense (DOD).
DOE	Department of Energy (DOE).
DS	Deployment System (DS). Referring to the WD&C deployment system.
EE	End Effector (EE). A general term used to identify those special tools and instruments attached to the end of the MLDUA arm by means of the TIP. Not part of the WD&C.
GAAT	Gunite and Associated Tanks (GAAT). Refers to the underground waste storage tanks in the North and South tank farms at ORNL.
GAAT TS	Gunite and Associated Tanks Treatability Study (GAAT TS). A project started in FY 1994 to support a record of decision on remediation of waste at ORNL.
GEE	Gripper End Effector (GEE). A special end effector which enables the MLDUA to engage with the WDEE inside the tank. The GEE is within the LDUA workscope and is not part of the WD&C system.
HLCS	High Level Control System (HLCS).
ICS	Instrumentation and Control System (ICS).
ITH	In-Tank Hardware (ITH). The tank being processed may contain various items of scrap metal, tools, or other articles that have been tossed into it as radioactive "scrap". All such scrap and structures are considered to be ITH.
LATA	Los Alamos Technical Associates, Inc.
MLDUA	Modified Light Duty Utility Arm (MLDUA). A Light Duty Utility Arm in production with special modifications to comply with ORNL applications (e.g. increased load capacity, etc.).

NTF	North Tank Farm - tanks W-1 through W-4 of the GAAT
OCC	Operator Control Console (OCC).
ORNL	Oak Ridge National Laboratory (ORNL). The Federal Government facility at Oak Ridge, Tennessee, at which the WD&C system will be employed.
OU	Operating Unit
STF	South Tank Farm - Tanks W-5 through W-10 of the GAAT
TBD	To Be Determined (TBD). Requirements and parameters specified in this document which are not fully defined at this time, but remain to be determined before the WD&C design can be finalized. See section 7.0.
TDEC	Tennessee Department of Environment and Conservation (TDEC)
TIP	Tool Interface Plate (TIP). The TIP is a two part component of the MLDUA used to allow the GEE to be manually attached to the end of the MLDUA arm in a standardized manner. The arm TIP half remains attached to the MLDUA arm. The end effector TIP half remains attached to the GEE. The TIP is not part of the WD&C.
Waste	In this document the term "waste" refers only to those chemical compounds stored in the tank, which were the result of past processing of various chemical and nuclear materials, and does not include various ITH found within the tank.
WCS	Waste Conveyance System (WCS). That portion of the WD&C system that receives waste from the WDEE and transfers it above ground to the BOP.
WD&C	Waste Dislodging and Conveyance (WD&C). The overall system of equipment (excluding the MLDUA or crawler and the GEE) directly used to dislodge and convey waste from inside the GAATs underground storage tanks to the interface with the BOP
WDEE	Waste Dislodging End Effector. That portion of the WD&C system used to dislodge waste from the tank and transfer it to the Waste Conveyance System.

2.0 FUNCTIONAL CHARACTERISTICS

Equipment functions described in this document are based upon the results of research and development activities recently completed at the Hanford nuclear reservation at Richland, WA, and the University of Missouri-Rolla (Ref. 5, 8, 9)

The overall function of the WD&C system is to dislodge the waste inside a tank and convey it above ground to a BOP interface point at the end of the WD&C conveyance system. This function must be accomplished in a manner protective of personnel and the environment. Although the BOP for the GAAT TS process may differ from the matured BOP, in that it involves transfer of waste to another tank instead of to a waste treatment facility, the interface between the WD&C and BOP will be at the end of the WD&C conveyance system for either case (see 1.3, 3.3.2.2)

In-tank operations will be performed remotely, by robotic or teleoperated equipment, with operator vision provided by TV cameras and lights provided on the MLDUA, as well as by overview cameras and lighting within the tank.

The following paragraphs provide a general description of the functions to be accomplished by each of the five basic subsystems of the WD&C system.

2.1. WASTE DISLODGING END EFFECTOR:

The primary function of the Waste Dislodging End Effector (WDEE) system is to dislodge waste from the mass in the tank and mobilize it for removal by the waste conveyance system. The WDEE System includes:

- the end effector device for the MLDUA (the WDEE) which acts directly upon the waste.
- the energy source(s) for the WDEE which provide power in the appropriate form(s), including prime mover (such as pumps and associated fueling, cooling and exhausting equipment) and/or utility connections to site systems.
- the cables and hoses which transmit energy and/or working fluids to/from the WDEE from the energy source(s).

The WDEE is deployed into the tank by the WD&C deployment system through a tank riser. The Modified Light Duty Utility Arm (MLDUA), with the Gripper End Effector (GEE) affixed, enters the tank through a different riser than the WDEE and CMS, engages with the WDEE, and maneuvers it over the waste for dislodging and retrieval operations. In the north tank farm, the MLDUA is deployed through center riser and WD&C deployed through peripheral riser. In the south tank farm the MLDUA is deployed through peripheral risers and WD&C deployed through the center riser. (see Figure 1 for a typical operation). During retrieval operation, the WDEE remains attached to the inlet of the waste conveyance system conduit. Movement of the WDEE during the dislodging process may be either non-automated (full operator control) tele-operation or semi-automated (operator real-time control with some automated sub-routines), as selected by the operator(s) at their discretion. Full automation may be implemented to the extent supported by the MLDUA controls and practical for the operators.

By itself, the MLDUA does not have the capability to reach or remotely engage with the WDEE inside some tanks due to riser spacing. The WDEE will be deployed into such tanks and maneuvered

into position for engagement by means of the Deployment System (see Section 2.3) The engagement function shall be provided by means of a Gripper End Effector (GEE) supplied with and attached to the MLDUA. Before the MLDUA is deployed into the tank the GEE, and its Tool Interface Plate (TIP) half, will be installed to the end of the MLDUA (see Appendix A, Figure A-2). After entering the tank, the MLDUA will position the GEE adjacent to the WDEE to enable it to grip the WDEE (see Figure 2, Figure 3). The MLDUA and GEE functions as the sole support and means of mobility for the WDEE during dislodging and retrieval operations and will move the WDEE relative to the tank waste in a manner determined by the MLDUA operator. The MLDUA, TIP, and the GEE are not part of the WD&C System.

The withdrawal of the WD&C from the tank is similar in principle to insertion, the system being placed in the same configuration as for the mating of GEE to the WDEE, the GEE releasing the WDEE, and the WD&C system and MLDUA being retracted through their respective risers. The WDEE need not be rigidly attached to the DS for retraction; it may be tethered by means independent of the utility and conveyance hoses. The tethered WDEE must hang in an orientation which allows retraction and does not stress the utility and conveyance hoses excessively.

2.2. WASTE CONVEYANCE SYSTEM:

The primary function of the Waste Conveyance System (WCS) is to receive waste from the WDEE, convey it above ground, and deliver it to the BOP interface. The WCS includes:

- waste conveyance conduit which is attached to, and receives waste from, the WDEE.
- the energy source(s) for the WCS which provide power in the form(s) appropriate for the WCS, including prime mover and/or utility connections, fueling, cooling and exhausting equipment.
- the cables and hoses which transmit energy and/or working fluids to/from the WCS from the energy source(s).

2.3. WD&C DEPLOYMENT SYSTEM:

The primary function of the WD&C Deployment System (DS) is to provide means of deploying and retracting the WDEE, WCS conduit, and their utility hoses and cables into and out of a tank, providing limited management of the WCS conduit, utility hoses and cables with respect to the WDEE, and handling them in a controlled manner during the dislodging and retrieval process. The WD&C DS includes:

- a deployment mechanism for deploying and retracting the WDEE (attached to the WCS conduit) into and out of the tank through a riser, presenting the WDEE to the GEE, and positioning conduit, hoses and cables inside the tank for optimum waste dislodging and retrieval.
- a cable management system outside the tank to handle any lengths of conduit, hose and cable required outside the tank (above the riser) to accommodate the WDEE range of travel

The WD&C Deployment System (DS) will bring the WDEE in/out of the tank through a tank riser and hold it in a position where it can be engaged/disengaged by the GEE on the end of the MLDUA (see Figure 2, Figure 3). The WCS conduit, and hoses and cables supplying utilities to the WDEE are supported by the WD&C deployment mechanism during insertion, waste retrieval and equipment

retraction. As the MLDUA moves the WDEE about the waste, the Deployment System will support and position the conduit, hoses and cables to the WDEE in such manner as to avoid exceeding the load capacity of the MLDUA, and to avoid entanglement with the MLDUA or obstacles (see Figure 4). The above-ground cable management system provides means for paying-out and retrieving conduit, hose and cable to accommodate the WDEE full range of travel. The degree of active control of the DS is to be the minimum neccessary to perform the above functions.

2.4. CONFINEMENT AND CONTAMINATION CONTROL:

The primary function of the Confinement and Contamination Control (CCC) system is to shield and protect personnel and the environment from the in-tank atmosphere and the radioactive and toxic hazards associated with the handling of contaminated WD&C equipment (i.e. the WDEE and portions of the WCS) and to provide means for decontamination of the WD&C equipment. The CCC interfaces with the tank riser by means of a compliant joint to form an isolation barrier that will protect the geophysical environment from the in-tank environment during retrieval operations. The CCC is to enable personnel to safely perform maintenance on that WCS equipment contained within, either while connected to a riser or in transit, storage or deployment positions.

The CCC functions as a structural member to support the WD&C Deployment System, thereby preventing excessive loads from being imposed on the tank or riser by the WCS, the WD&C Deployment System, or by the CCC itself. A platform (Reference 14, 23) may be provided by the site and used to support the above ground portions of the WD&C system, including the CCC, over the tank and riser. This platform, if used, will transmit loads from the CCC safely to the ground (see Figure 1). The platform structure is not part of the WD&C system. The CCC must be designed to incorporate legs and footings to enable free-standing deployment, without the platform.

The WD&C equipment must be capable of complying with on-site transportation requirements. To meet this need, the CCC shall incorporate an automated decontamination function for gross decontamination of the in-tank portions of the WD&C as they are removed from the riser. Provision is to be made for manual gross decontamination of other contaminated WD&C components prior to their dismantling from the riser. Unacceptable contamination levels shall be detected and alarmed by radiation monitors provided by site Health Physics technicians and installed temporarily inside the CCC confinement.

The CCC shall include a functional means to prevent overspray from its decontamination system from spreading contamination to other zones within confinement.

The CCC will serve as storage and transportation container for the WD&C equipment. Therefore, it must be designed to properly support the contents and protect them from vibration and shock during road transport.

2.5. INSTRUMENTATION AND CONTROLS:

The WD&C Instrumentation and Control System (ICS) shall control and monitor the operation of the WD&C system and provide an operator interface. The WD&C ICS will not require direct control interface with either the MLDUA or the GEE except for common E-stops. The WD&C ICS shall not be slave to, or master over, the MLDUA or the GEE. The WD&C ICS shall provide joint position information defining the configuration of the DS to the World Model for position analysis and display, supporting motion planning and collision avoidance during position change modeling and physical

position changes of the MLDUA. Coordination between the MLDUA and any active joints on the DS shall be required when the two systems are connected. This coordination may be accomplished manually by the operators of the two systems: the MLDUA (including the GEE), and the WD&C.The WD&C ICS must provide for an interface to a future High Level Control System (HLCS) that would provide one operator with control of both systems: the MLDUA (including the GEE), and the WD&C system.

The WD&C ICS shall provide the following:

a) Operator interface for the WD&C system.

b) A graphical real-time display of process variable information including control settings and system behavior.

c) A permanent record of selected system information sufficient to reconstruct and analyze events, system dynamics and waste properties.

d) Automatic, event triggered response to deviations from the normal operating envelope, designed to mitigate consequences of unsafe conditions and restore safe conditions. If such response requires stopping motion, the response shall include E-stop of the MLDUA motion. The ICS shall require operator action to return the system to a normal operating status after any such automatic intervention. This function shall be coordinated with MLDUA controls. E-stop of the MLDUA shall initiate E-stop of the WD&C system.

e) Monitoring and alarming of WD&C conditions which may be hazardous to personnel and facilities.

f) A position information model to the MLDUA World Model .

g) May provide a High Level Control System interface in the event that a HLCS is adopted.

h) Closed-loop control of WD&C subsystems subject to external perturbation

3..0 DESIGN REQUIREMENTS

This section of the document defines the requirements applicable to the design of the WD&C system:

3.1. GENERAL DESIGN REQUIREMENTS:

3.1.1. Environment Internal to the Waste Tank:

Those portions of the WD&C equipment which are exposed to the interior of the waste tank must be designed to remain fully operational and achieve full design life when subjected to the following normal in-tank environment:

3.1.1.1. Tank Contents - Tank waste, covered by an aqueous supernate, with a vaporous air space above the supernate.

3.1.1.2. Tank Waste Properties: (see Ref. 11) (Note: Tank waste sampling and characterization data is very limited. Information following is "best estimate" and should be used conservatively.)

- Chemical - Non-heat generating, not sensitive to impact, rubbing or abrasion. The pH may vary from 7 to 11. Organic compounds (not identified) are present, as are nitrates, phosphates and sulfates.
- Physical - Silty, clay, pasty particles; some crystallized solids which may have formed during storage; contains lumps of gunite which may have eroded from the tank walls and miscellaneous debris such as plastic bags, coveralls, metal cans (sources: anecdotal and Ref. 11.) Some waste forms may be highly abrasive . Density may range from 1.07 g/ml to 1.37 g/ml.
- Quantity - Depth of sludge/solid waste on tank floor may range from 0 m to 0.7 m. Tank sludge/solid waste volumes are estimated to be as much as 34 m^3. Tank W-3 is estimated to contain about 5 m^3.
- Thermal - Temperature may range from 4 to 27 °C (40 °F to 80 °F)
- Radiological - 100mR/hr to 25 R/hr, point sources of up to 50 R/hr.
- Topography of the waste surface is irregular, including waste adhered to tank sides.

3.1.1.3. Supernate Properties:

- Chemical - Water, containing some soluble material from the tank waste. May be a thicker transition phase close to waste surface. The pH may vary from 7 to 11. Conductivity 10 - 20 µmho/cm. Organic compounds (TOC) are present in concentrations of 200 - 8500µg/g. Note that tank W-10 contains PCBs >2ppm but <10ppm
- Physical - Density may range from 0.99 g/ml to 1.06 g/ml. Viscosity approximately equal to that of water.

- Quantities - Supernate depth may be from 0.06 m to 2.8 m deep.
- Thermal - Temperature may range from 4 to 27 °C (40 °F to 80 °F)
- Radiological - 100mR/hr to 25 R/hr

3.1.1.4. Vapor Space:

- Chemical - Air, containing vapors emitted from the supernate. Non-flammable, non-explosive.
- Physical - Pressure may vary from -124 Pa to 0 Pa (-0.5 to 0 inches H_20)(gage pressure). Relative humidity ranges from 4% to 100%.
- Thermal - Temperature may range from 4 to 27 °C (40 °F to 80 °F)

3.1.1.5. Tank Structure - Gunite concrete, 3 parts sand : 1 part cement. Wall thickness 150 - 200 mm (6 - 8 inches), floor thickness 75 mm (3 inches). Some gunite may be spalled or damaged.

3.1.2. *Environment External to the Waste Tank:*

Those portions of the WD&C equipment which are located external of the waste tank must be designed to remain fully operational and achieve full design life when operating in the following normal geophysical environment:

The following describes the out-of-tank environment.

3.1.2.1. Ambient Temperature - System components shall be designed and constructed to function in external temperatures ranging from -13 °C to +37 °C (+9 °F to +98°F) and shall be designed to tolerate additional heat loads resulting from operation in direct sunlight.

3.1.2.2. Storage Temperature - System components shall be designed to be stored in outdoor containers with an internal temperature range of -15°C to +49°C (-5°F to 120°F). Note: Components are not required to operate at these temperatures, but all WD&C components (whether for use in-tank or out-tank) must be capable of operating after long term storage at these temperatures.

3.1.2.3. Relative Humidity - System components shall be designed and constructed to function in external-humidity environments ranging from 4% to 100%.

3.1.2.4. Wind Speed - System components shall be designed and constructed to operate in external wind up to 64 km/h (40 mph) and be able to withstand winds up to 129 km/h (80 mph).

3.1.2.5. Moisture - System components shall be designed and constructed to function in external-rain environments with rainfall up to 50mm/h (2 in./h).

3.1.2.6. Snow - System components must be able to withstand periodic-snow environments with snowfall accumulations of 300mm (1 ft), although operation at this condition is not required.

3.1.2.7. Obstacles - Maneuverability is required to bring WD&C equipment within the tank farm area; the design must consider access through gates, above-ground ducts, and other above-ground equipment. Equipment shall be craned into position on the platforms or tanks.

3.1.3. Codes and Standards:

3.1.3.1. The WD&C system is an assemblage of temporary outdoor equipment and shall not be classified as, nor have to meet the requirements of, a permanent facility.

3.1.3.2. Electrical wiring and components shall be in accordance with the National Fire Protection Association codes and National Electrical Manufacturers Association standards, as applicable.

3.1.3.3. Piping shall be in accordance with ANSI-B31.3.

3.1.3.4. Structural elements shall be designed in accordance with the AISC ASD Steel Construction Manual (current edition)

3.1.4. Design/Analysis:

3.1.4.1. Design operating stresses in non-pressurized, load carrying members subject to dynamic as well as static loading, shall not exceed AISC allowables reduced by a factor of 2. Non-pressurized, load carrying members subject only to static loads, shall be designed to AISC allowables.

3.1.4.2. Although explosive concentrations of gases are not present, all equipment exposed to the in-tank atmosphere, directly or indirectly, shall be designed to minimize its potential as an ignition source, where practicable without significant cost or schedule impacts.

3.1.4.3. All portions of the WD&C equipment subject to gross decontamination operations shall be designed to withstand high pressure water spray of 3.4MPa (500 psig) maximum delivered through round jet nozzles at a rate of 6 l/m/nozzle (1.5 gpm/nozzle) from a distance not greater than 100mm (4 inches).

3.1.5. Operations:

3.1.5.1. Equipment shall be designed to operate for a minimum 1 month campaign without scheduled or planned maintenance, based upon 160 hrs/month during campaign. Service life of major structural components shall be adequate to support a minimum of 8 campaigns (up to 12 months). Service life of moving mechanisms, parts subject to wear

or degradation etc, shall be capable of supporting a minimum of 3 campaigns. Exceptions may be made, subject to prior engineering approval.

3.1.5.2. The entry riser through which the WD&C (i.e. WDEE, DS, and WCS) shall enter into the tank, shall be a 34 inch diameter riser, 6-feet long, with an effective internal diameter of 23.5-inches. In this document, this entry riser is also referred to as "the designated riser", or simply "the riser".

3.1.5.3. To assure free passage through the riser, the in-tank components of the WD&C shall not exceed a diameter of 20-inches, when configured for entry/retraction operations.

3.1.5.4. The WD&C equipment shall be used over the riser until waste retrieval is complete, and then dismantled and moved to another riser at the same tank or at another tank. Such moves may occur several times over the life of the equipment. This will require that the WD&C be designed to facilitate such moves, with attention given to contamination control, dismantling and re-assembly, lifting and placement, and transportation by flatbed truck

3.1.5.5. The WD&C equipment will be supported over the riser either
a) using a site supplied, load bearing platform with an available set-down space defined by Ref. 14, 23 or
b) independently, by means of a dedicated support structure, part of the WD&C system.

3.1.5.6. All equipment intended for hoisting and/or rigging for hoisting shall conform to DOE/ID-10500, DOE Hoisting and Rigging Manual (Reference 29). Lift attach points on the WD&C equipment shall be compatible with this hoisting equipment.

3.1.5.7. The addition of new water to a tank/tank waste by the WD&C system shall be minimized, and added water shall be retrieved to avoid any net addition to tank contents volume.

3.1.5.8. The WD&C shall not create a positive pressure within the tank, nor within its own confinement system, as measured relative to ambient.

3.1.5.9. The WD&C system shall be designed to remove waste from the floor and walls of each tank within the operating boundaries shown in Figure 6,Figure 7 for the STF and NTF tanks, respectively. Note: the MLDUA is dependent on additional reach provided by the WDEE and the GEE and EE TIP half (see Appendix A) to reach the full extent of the STF tanks.

3.1.5.10. The WD&C system shall be fully functional under the constraint of remote operation of its in-tank components and of those systems directly supporting dislodging and conveyance of waste. These remote operations shall be performed in fully automatic mode (an option for future campaigns), semi-automatic mode (automated subroutines invoked by an operator), or operator controlled mode, at the option of the operator. TV overview cameras, lights and monitors shall be provided by the MLDUA and by a separate overview camera, lighting and monitor system to assist the operator (see Appendix A, section 7.0). The video monitoring must provide sufficient resolution for the operator to evaluate tank surface conditions and control the dislodging process per 3.2.1.5.

3.1.6. Maintenance:

3.1.6.1. The WD&C equipment shall be designed for manual replacement of the WDEE while within the CCC system confinement, using common glovebox techniques.

3.1.6.2. Human factors shall be taken into consideration and a modular design approach shall be implemented to ensure ease of equipment setup, operation, maintenance, and removal.

3.1.6.3. Those portions of the equipment which are subject to being removed or replaced inside a confinement (either CCC or other confinement) for preventative maintenance or repair, shall incorporate features to facilitate the use ofcommon glovebox techniques.

3.1.6.4. Those portions of the WD&C equipment subject to being contaminated and requiring gross decontamination shall be designed to avoid cracks, crevices, or enclosed voids, which can entrap contamination and impair decontamination efforts.

3.1.7. Materials and Processes:

3.1.7.1. Materials and processes used in fabrication of the WD&C components shall enable the equipment to comply with all design requirements specified in this document, including design life, operating and storage environments, and decontamination operations.

3.1.7.2. Materials and processes shall be in accordance with widely recognized American standards common to industries utilizing such materials and processes.

3.1.7.3. The WD&C equipment may use either electric, pneumatic, or hydraulic actuation. However, the tank environment severely restricts the discharge of organic compounds during operation and all possible failure modes. The maximum credible loss of hydraulic fluid in an accident scenario shall be less than five (5) gallons.

3.1.8. Site Utilities:

The utilities available on-site for support of the WD&C equipment are:

3.1.8.1. Electrical power will be distributed at 480 V, three phase, 60 HZ, grounded or ungrounded; 120/208 V, three phase, 60 Hz, with grounded neutral; and/or 120/240 V, single phase, 60 Hz with grounded neutral.

3.1.8.2. Process water will be provided at the site via the plant process water system, reservoir and/or tanker truck if required. The pressure, flow rate and line size will be arranged to meet WD&C requirements. Purity requirements must be addressed in the WD&C system specifications.

3.1.8.3. Instrument air is available at the site from plant supply. Purity requirements must be addressed in the WD&C system specifications.

3.2. SPECIAL DESIGN REQUIREMENTS:

The following requirements are in addition to the general design requirements specified in section 3.1.

3.2.1. Waste Dislodging End Effector (WDEE):

3.2.1.1. The WDEE, with WCS attached, will be inserted into and removed from a tank by passing through the riser (see section 3.1.5.2) by means of the WD&C deployment system. During operation the WDEE will dislodge waste and cause it to enter into the WCS. The WDEE and WCS will be moved about inside the tank by the MLDUA and GEE.

3.2.1.2. The WDEE, working in conjunction with the WCS and DS, shall have provisions to allow it to be attached to and detached from the GEE and detached from the WD&C DS, inside the tank. All such attachment/detachment operations shall be accomplished by the GEE and the WD&C deployment boom, with the WDEE being passive. When the WDEE is released by the GEE, the DS, WDEE and WCS must reliably assume a configuration that permits the WD&C system to be retracted from the tank.

3.2.1.3. The ability to detach the GEE from the WDEE must be given special consideration to be failure free, since their failure to separate may greatly impair the ability of both the MLDUA and WD&C to retract from the tank.

3.2.1.4. Because the WDEE is brought into operating position on the waste, and moved about the waste by the MLDUA, it must achieve all its operating requirements within the performance capabilities of the MLDUA. The applicable MLDUA performance capabilities are as specified in Appendix A of this document.

3.2.1.5. The WDEE shall have variable power, capable of removing 35 MPa (5000psi) gunite (3 parts sand : 1 part cement) concrete from the walls and floor of the tank, to a minimum depth of up to 9mm (0.38 inch) in a single pass when operated at maximum power. The range of power shall be sufficient to allow dislodging of wastes from degraded concrete of uncertain resistance (greater than that of the waste) without degrading the concrete. The operations plan and procedural controls shall ensure that the process shall not penetrate through the tank wall (or floor), nor destroy the structural integrity of the tank wall (or floor), in those regions having damaged or severely deteriorated gunite.

3.2.1.6. The WDEE may use air, water (or other allowable fluids), mechanical means, or any combination of these methods, to dislodge waste or gunite.

3.2.2. Waste Conveyance System (WCS):

3.2.2.1. The WCS shall achieve transfer of the waste, supernate, or process media from the WDEE to the BOP interface. The media of conveyance shall be either air, water (or other allowable fluids), or mechanical, or any combination thereof.

3.2.2.2. In general, the system shall be able to accommodate large variations in waste feed rate without plugging or stopping. Should plugging occur, the system shall be designed to be restarted without damage.

3.2.2.3. Pieces of waste or ITH of sufficient size to lodge and create a flow blockage within the WCS are likely to be encountered by the WDEE. The WCS and WDEE shall include means of either processing such large material so that it may pass through the WCS, or be automatically rejected from entry into the WCS.

3.2.3. WD&C Deployment System (DS):

3.2.3.1. The DS shall deploy the WDEE, with WCS conduit, utility hoses and electrical cables attached, into the tank through the designated tank riser (see 3.1.5.2).

3.2.3.2. The DS shall control deployment of the conveyance conduit, utility hoses, and cabling to the WDEE at all times, such that additional loads are not imposed on the WDEE during operation that will cause the total allowable loads on the MLDUA to be exceeded (see Appendix A, section 2.0). NOTE: total loads on the MLDUA encompass loads from all sources, including static, dynamic, frictional or operating loads caused either directly by the WDEE, or imposed by any equipment attached to the WDEE.

3.2.3.3. The DS shall include a conduit, hose, and cable management mechanism to accommodate the large variation in distance between the WDEE and the above-ground equipment as the WDEE operates between the most proximate and the furthermost reaches of the tank. Manual means of paying out or retracting conduit, hoses and cables are acceptable, providing adequate safety precautions are taken.

3.2.3.4. The DS shall be designed to facilitate flow through the WCS by minimizing sharp bends and by strategic conduit, hose and cable positioning throughout waste retrieval operations.

3.2.3.5. The DS shall support and position the WDEE such that the MLDUA with the GEE can engage/disengage with it inside the tank. The DS must withstand loads generated by such operations and be able to extend to a zone within the reach envelope of the MLDUA (see Appendix A).

3.2.3.6. The WDEE must be attached to the DS at all times. The mechanism for securing the WDEE to the DS shall permit the full range of motion of the WDEE relative to the DS required to present the WDEE normal to all targeted tank and waste surfaces, shall not interfere with the functionality of the WCS, and shall, when the WDEE is released by the GEE, allow the WDEE and WCS to dangle from the DS in a position which will permit retraction of the WD&C equipment through the riser.

3.2.3.7. The WD&C in-tank equipment must be deployable within the tank without requiring immersion of any part in the tank contents or contact with the waste surface by any component except the WDEE. The WD&C equipment must tolerate inadvertent immersion in supernate and suspensions of waste while deploying or operating and be readily decontaminated in the event of inadvertent immersion.

3.2.4. Confinement and Contamination Control (CCC):

3.2.4.1. All portions of the WD&C equipment subject to gross decontamination operations shall be designed to withstand high pressure water spray of 3.4MPa (500 psig) maximum delivered through round jet nozzles at a rate of 6 l/m/nozzle (1.5 gpm/nozzle) from a distance not greater than 100mm (4 in)

3.2.4.2. The WD&C equipment must be capable of complying with on-site transportation requirements. To meet this need, the CCC shall provide means of cleaning the WDEE and contaminated portions of the WCS by means of the spray ring. as they are withdrawn from the riser and prior to dismantling of the WD&C from the riser.

To be in compliance with decontamination levels acceptable for on-site transportation, transported equipment shall not:

- have removable contamination levels on the external of the package above 1000 dpm/100 cm^2 beta/gamma and 20 dpm/100 cm^2 alpha
- have an overall dose rate in excess of 200 mrem/h at contact and 10 mrem/h at 2 m
- have a dose rate where employees operate (e.g. control stations, vehicle cab area, etc.) that does not exceed 0.5 mrem/h.

3.2.4.3. At site installation, all portions of the WD&C system which are radiologically contaminated must be contained within a confinement barrier. The zone within this confinement barrier shall be maintained at a constant negative pressure relative to the ambient environment or any zone that has potential of being occupied by personnel. The interior of the confinement barrier will share atmosphere with the tank interior, with a pressure gradient established by tank ventilation such that make-up air will flow through the CCC into the tank, thereby preventing migration of contaminated or corrosive mist into the CCC.

3.2.4.4. The WD&C system shall include confinement and shielding as required, around all above ground portions which come into contact with the waste, either directly or indirectly. Such confinement and shielding shall be in accordance with Reference 13 taking into consideration that the WD&C system is an outdoor, temporary facility.

3.2.4.5. The CCC shall provide means of assuring that applicable Federal, State, and site regulatory objectives are achieved (see section 4.0).

3.2.4.6. The CCC will include means to minimize overspray from its decontamination system from spreading contamination to other zones within confinement, and also to mitigate the entry of air from the riser into the CCC.

3.2.5. Instrumentation and Control:

The WD&C ICS will include the necessary controls and sensors required for each of the WD&C subsystems:

3.2.5.1. Subdivision
Instrumentation and process control will potentially be divided into three physically separated areas. The first area will include the tank and immediately adjacent WD&C subsystems. The second area will be the WD&C Operator Control Console (OCC) and the operators environment. The third area will be the Balance of Plant Interface and will include the interfaces to utilities and the tanks, pipelines, etc. for disposal of the retrieved waste.

3.2.5.2. Define OCC
Process monitoring and control shall be primarily accomplished through the OCC which shall operate as the WD&C supervisory control and data acquisition system. Alarms reported by any subsystem shall be displayed at the OCC.

3.2.5.3. Physical Interfaces
The I&C system shall be designed to minimize physical interfaces between the OCC and the WD&C subsystem controller(s). Safety, ease of installation, reliability and ease of maintenance shall be functional requirements.

3.2.5.4. Password
There shall be a password security system written into the control program to ensure that only qualified operators have access to the OCC operating system and WD&C process controls.

3.2.5.5. Standards
All instrumentation and process control equipment will comply with applicable industry standards and practices.

3.2.5.6. Range
Instrumentation shall be designed to adequately detect and display 150% of anticipated abnormal range for all system parameters.

3.2.5.7. Failure Modes
Essential subsystems shall have enough local control and alarm monitoring capability to insure safe shutdown in the event of the loss of the OCC. Subsystem controller(s) will be designed to fail in a fail-safe condition in the event of the loss of power or loss of the OCC. All process and deployment system controls and critical instrumentation shall fail to a safe condition and shall be safely recoverable from power supply failures. Position and status encoders and indicators shall preserve absolute calibrations and not require re-indexing or adjustment of calibration after a power failure.

3.2.5.8. Point of Control
Interlocks and control logic shall allow control of any system from only one point at any time and require that control be relinquished by one station before it can be taken at any other. Failure of the currently active point of control shall not prevent switching to alternate points of control.

3.2.5.9. Safety Class Items
Any Safety Class items will be identified and redundant systems will be incorporated where necessary.

3.2.5.10. Safety Class Alarms
Any Safety Class alarm functions shall be routed to a common, separate alarm panel with visual and audible indicators at the OCC.

3.2.5.11. Interlocks
Software and hardware interlocks will be incorporated on some critical subsystems to insure that conflicting/undesirable events cannot occur.

3.2.5.12. Testing and Calibration
The system shall be designed for periodic in-place testing and calibration of instrument channels and interlocks. The design shall allow testing of protective functions such as "fault tolerant" systems.

3.2.5.13. Process Control Display
The process control system will be schematically displayed at the OCC. The OCC will display values of process variables (sensor readings, control signals and control settings) essential to safe and productive manual-control operation in real time.

3.2.5.14. Video Monitoring
Video cameras and associated video displays shall be incorporated into the OCC to provide the operator with a means of verifying system operation. Collision avoidance will be the responsibility of the WD&C operators. All video shall be recorded on tape medium with time coding synchronized with the OCC system clock.

3.2.5.15. Subsystem Communications
Communications between the OCC and the WD&C subsystem controller(s) shall be updated at a rate sufficient to meet control and monitoring requirements.

3.2.5.16. Computing & Data Storage
The OCC shall have sufficient computing power to simultaneously perform all control and monitoring functions, maintain and update a 3D graphical display as the user interface with refresh rate sufficient to meet control and monitoring requirements, and perform data storage. On-line (immediately accessible) data storage capacity shall be sufficient to allow for logging and archiving of all process control settings, DS joint positions, significant sensor readings and resolved WDEE position along with time indexing linked to the MLDUA control system clock for one 8-hour shift. Removable data storage media shall provide archiving capacity for the entire GAAT TS campaign. On-line data shall be archived in real time.

3.2.5.17. Sensors
Appropriate sensors (contact, flow, pressure, force/torque, distance measuring, etc.) shall be included in the WD&C as needed to assure proper performance, protection of personnel, environment and equipment, and accomplishment of WD&C functions.

3.3. INTERFACES:

The following requirements are in addition to the general requirements specified in section 3.1 and the special requirements specified in section 3.2.

3.3.1. Waste Dislodging End Effector:

3.3.1.1. Interfaces Between the WDEE and the WCS:

a) The point of attachment/detachment between the WCS and the WDEE shall be close to the WDEE, to allow the WDEE to be replaced with minimum secondary waste generated.

b) The method of attachment/detachment between the WCS and the WDEE shall be accomplished with simple hand tools, using manual glovebox techniques.

c) The WCS shall remain attached to the WDEE as the WDEE is moved about inside the tank within the WDEE operating envelope by the MLDUA (see Figure 6).

3.3.1.2. Interfaces Between the WDEE and the Tank:

The WDEE shall operate inside the tank within the envelope shown in Figure 6.

3.3.1.3. Interfaces Between the WDEE and the MLDUA:

The WDEE design shall include an appropriate attach point(s) with which the GEE may engage (see Appendix A, section 6.0). NOTE: the weight and length of this gripper end effector must be taken into consideration when evaluating loads at the MLDUA TIP interface (see Appendix A, section 2.0).

3.3.2. Waste Conveyance System:

3.3.2.1. Interface Between WCS and the Tank:

Gases or liquids exiting from the WCS in excess of what can be accommodated by the BOP, shall be returned to the tank through the designated riser.

3.3.2.2. Interface Between WCS and the Waste Transport System:

a) The WCS shall include terminate in a 2 inch nominal diameter, raised-face, class 150#, pipe flange per ANSI B16.5-1968, as an interface to the BOP.

b) The parameters of the flow induced by the WCS must be compatible with the BOP inlet conditions existing at their interface during steady state flow. These BOP inlet conditions are equivalent to an orifice restriction having a Cv (for water) of (TBD024) with a downstream pressure of 0.0" to -0.5" H_2O.

3.3.3. WD&C Deployment System:

3.3.3.1. Interface Between DS and the WDEE:

The DS shall include means of attaching to the WDEE and holding it in position(s) for engagement/disengagement with the GEE. The DS shall control the motions of the WDEE, utility hoses and cables to facilitate:

- insertion/retraction into/from the tank
- mating the WDEE to the GEE
- manipulation of the WDEE by the MLDUA during waste retrieval.

3.3.3.2. Interface Between WD&C Deployment System and the WCS:

a) The DS shall deploy and support the WCS in a manner that the total combined loads from all sources (WCS, WDEE, GEE, etc) do not exceed the allowable loads for the MLDUA (see section 3.2.3, 3.2.3.2, Appendix A).

b) In-tank portions of the WCS are supported and positioned by the DS as the WDEE is moved about within its in-tank operating envelope by the MLDUA (see Figure 6, Figure 7). The range of travel of the WCS and DS must be compatible with this WDEE operating envelope.

c) Above-ground portions of the WCS within the protective confines of the CCC, are supported, controlled and managed by the WD&C deployment system to minimize wear and pressure drop caused by bends, friction, etc.

3.3.3.3. Interface Between WD&C Deployment System and the MLDUA:

Although the DS does not directly make contact with the MLDUA, it shall be required to position the WDEE within the reach envelope of the MLDUA and hold the WDEE such that the MLDUA can engage/disengage with the WDEE using the GEE (see Figure 6). DS position information is provided to the World Model to support prevention of "inadvertent interfacing" of the DS with the MLDUA

3.3.4. Confinement and Contamination Control:

3.3.4.1. Interface Between CCC and the WCS:

a) Above-ground portions of the WCS which are directly subject to contamination shall be enclosed within the CCC for purposes of contamination control.

b) All static and live loads from the WCS shall be transferred to the CCC either directly or through the DS.

3.3.4.2. Interface Between CCC and the DS:

a) Above-ground portions of the DS which are directly subject to contamination will be enclosed within the CCC for purposes of contamination control.

b) All static and live loads from the DS will be transferred to the CCC.

3.3.4.3. Interface Between CCC and WD&C In-Tank Components:

All in-tank portions of the WCS, DS, and WDEE must be capable of passing through the decontamination zone of the CCC. These WD&C components shall be cleaned during any retraction with "low" pressure water spray, after which they shall remain fully operational.

3.3.5. Instrumentation and Control Interfaces:

3.3.5.1. Interface Between WD&C System Controller and WDEE:

a) The WDEE I&C shall safely monitor and control the operational parameters for dislodging the waste from the tank and mobilizing it into the waste conveyance system.

b) Fluid pressure sensor(s) shall be incorporated into the WDEE hydraulic supply to adequately assess the performance of the system. Sensor information shall be provided to the OCC through the WD&C controller responsible for controlling the output of the WDEE pump(s).

c) Fluid flow sensors (inlet and bypass) shall be incorporated in the WDEE pump units. The net flow in the high-pressure output shall be calculated by the OCC to allow the operator to assess the condition of the WDEE orifices.

d) WDEE pumping equipment shall be equipped with sensors to monitor power, temperature, and filter differential pressure. This information shall be supplied to the OCC through the WD&C controller. This information may be in the form of two-stage switch outputs providing for alarms/indicators of values greater than normal and secondary alarms or E-stops for values reaching critical levels.

e) Rotational speed of the WDEE nozzle array shall be monitored and controlled. The rotational frequency shall be supplied to the OCC through the WD&C controller.

f) All instrumentation hardware shall include the required signal conditioning electronics to complete the interface to the local control system. All instrumentation hardware, including sensors, signal conditioning units, wiring and cabling shall adhere to standards applicable to the environment.

g) Appropriate sensors (contact, standoff distance measuring etc.) to maintain an adequate level of control shall be included on the WDEE.

3.3.5.2. Interface Between WD&C System Controller and WCS:

a) The WCS I&C shall include sensors and instrumentation to safely monitor and control the operational parameters for waste conveyance to the BOP.

b) The WCS I&C shall provide sensors and instrumentation sufficient to detect blockage of the conveyance line at any point and allow the operator to infer the

general location of the blockage (eg; in the inlet, the WDEE, the discharge line or the BOP interface...).

c) Working fluid flow rate (inlet and bypass) and pressure sensors (supply and output) shall be incorporated at the WCS pump. Fluid pressure/flow information will be provided to flow controllers and to the OCC. Net fluid flow to the pump shall be calculated and displayed at the OCC. "Loss of Fluid Flow" alarms shall be provided at the OCC.

d) WCS pumping equipment shall include power monitoring and temperature sensors for the motor(s).

e) The WCS system shall accomodate a back flushing capability, using pumping and fluid supply provided by the BOP, to clear anticipated system blockages. Back flush operation shall be initiated by the operator at the OCC in the event of a system blockage. Backflush pressure shall be limited to prevent damage to system components. Control of the BOP equipment used for back flushing shall be a responsibility of the BOP operators.

f) All sensors and other instrumentation shall include the required signal conditioning electronics. WCS status will be displayed at the OCC. Wiring and cabling shall comply with applicable standards for the environment.

3.3.5.3. Interface Between WD&C Controller and WD&C DS:

a) The WD&C DS I&C shall safely monitor and control DS system functions: inserting the DS, WDEE and CS equipment into the tank, positioning the WDEE for mating to the GEE and providing in-tank management of CS hardware.

b) The WD&C DS will be remotely operated to configure it within the tank to present the WDEE in a position such that the MLDUA can mate the WDEE to the GEE inside the tank. The movement of the DS during deployment will be active, while movement of the DS during operation may be active, passive, or a combination therofn. During operations, the WD&C operator will position the DS to reduce the dynamic and static loads mechanically imposed on the MLDUA. DS movement may be accomplished by the WD&C system controller, and may be coordinated with the motion of the MLDUA and WDEE.

c) The DS will incorporate joint position sensors and linear displacement sensors to provide position feedback to the WD&C system controller and the World Model. The DS operator shall have a graphical user interface providing rendered viewing of the World Model from at least two simultaneous operator-controllable viewpoints.

d) The WD&C operator has the responsibility for coordinating and approving the movement of the DS. The WD&C operators primary concern is collision prevention between the WD&C, the MLDUA and internal tank components.

e) Hardware interlocks shall be incorporated to prevent unanticipated/undesired movement during constrained phases of operation such as insertion through the riser.

f) Proximity sensors may be required at strategic positions to assist in mating with the GEE and to preclude contacting the MLDUA and tank support structures during operation.

g) The WD&C DS system controller shall have provisions for manual operation from local controls independent of the OCC. During manual operation, essential sensor information shall be displayed locally.

h) The WDEE shall be properly secured and oriented to the DS prior to entering or exiting the tank. This status shall be indicated at the OCC and verified by the operator. Hardware or software interlocks will be incorporated for transfer of the WDEE to the GEE to require that the WDEE be attached to one or the other at all times during that transfer.

3.3.5.4. Interface Between WD&C System Controller and CMS:

a) The WCS I&C shall safely monitor the payout and retrieval of hoses, conduits and/or cables by the CMS subsystem in coordination with the motions of the DS.

b) The CMS may be a passive system requiring only limited sensor information. If the CMS requires more elaborate actuators (winches, motors, etc.) appropriate subsystem control shall be implemented.

c) Position encoders and load sensors shall be incorporated where appropriate and configuration/load information provided to the WD&C controller and displayed on the OCC. Alarms and interlocks shall assist the operator in preventing the tearing of cables or hoses during CMS operation.

d) Temperature and power sensors shall be incorporated to monitor the operating status of those CMS motors and winches subject to high loading or high duty cycles.

3.3.5.5. Interface Between WD&C System Controller and CCC Subsystem:

a) The CCC I&C shall safely monitor and control the operation of the CCC. Functions and conditions to be controlled and/or monitored include:

- Internal pressure, to be monitored by site operations personnel and equipment. A port shall be provided for connection of that equipment.

- Radiation levels at service access points shall be checked by site operations personnel with portable equipment. Provisions must be made for insertion of the measuring equipment and for securing it in place inside the CCC at appropriate locations.

- Leak detection of WDEE utilities (high-pressure water) and conveyance line inside the CCC.

- Control of the gross decontamination operation during retraction of WD&C components from the tank is required. Decontamination spray at the bottom of the riser is to be actuated automatically by retraction of any in-tank WD&C equipment. Limited control functions will be required during other cleaning operations and will be accomplished primarily by the CCC subsystem controller operating in stand-alone mode.

3.3.5.6. Interface Between WD&C System Controller and MLDUA World Model:

a) The WD&C Controller shall provide WD&C position to the MLDUA World Model. Motion of WD&C DS or CMS shall require update of the MLDUA World Model

b) Similarly, the World Model may provide collision control information to the WD&C Controller for collision control during movement of the DS.

3.3.6. Interfaces With Tank:

3.3.6.1. Interfaces Between Tank and the CCC:

a) The CCC is the primary interface between the WD&C equipment and the tank

b) The CCC shall seal against the designated riser through a compliant connection. The riser is defined by Reference 23.

c) The geometric sum of all axial and lateral loads imposed on the riser by the CCC shall be less than 50 lb. The geometric sum of all bending moments and axial torsion applied to the riser shall be less than 100 in-lb.

d) When supported over the tank by a platform, the CCC shall not impose loads on the platform in excess of 15,000 lbs total, distributed as shown in Reference 16.

3.3.6.2. Interfaces Between Tank and the WD&C Deployment System:

The in-tank portions of the WCS, with the WDEE attached, must be capable of passing through the designated riser by means of the DS.

3.3.7. Interfaces With WD&C Internal System Utilities

Components of the WD&C may be pneumatically, hydraulically, or electrically actuated. The energy may be transmitted directly from site utilities or indirectly through a prime mover, such as a pump, generator or compressor. Any prime movers and all conduits (cables, hoses, etc) used to transmit energy to the WD&C equipment are defined as WD&C Utilities. These WD&C utilities shall interface with the WD&C equipment in accordance with the following paragraphs of this section.

3.3.7.1. Interface Between WD&C Utilities and WDEE:

a) The point of attachment/detachment between the WDEE and the utilities it requires for operation, should be close to the WDEE, to allow the WDEE to be replaced with minimum secondary waste generated.

b) The method of attachment/detachment of the WDEE to its utilities shall be accomplished with simple hand tools, using manual glovebox techniques.

c) The attachment and routing of utilities to the WDEE should impose minimal constraints on the maneuvering of the end effector and mating of the end effector to the DS or the GEE.

3.3.7.2. Interface Between Utilities and the DS:

Utilities required by the WDEE, DS or in-tank portions of the WCS, should be routed along (and supported by) the DS.

3.3.7.3. Interface Between Utilities and the CCC System:

Utilities to WD&C components contained within the CCC system shall have the capability of being manually connected/disconnected from the CCC confinement housing at both sides of the confinement wall (to facilitate replacement of components within confinement and assure modularity of the WD&C hardware).

4.0 REGULATORY REQUIREMENTS:

The following State and National regulatory codes are applicable to the WD&C system:

a) 10CFR 1021 National Environmental Policy Act (NEPA)

b) 40CFR 61 Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPS).

c) DOE Order 5400.1, Preoperational Monitoring of Facilities, Sites, and Operations.

d) DOE Order 5400.5, Radiation Protection of the Public and the Environment

e) Resource Conservation and Recovery Act of 1976 (RCRA)

f) Atomic Energy Act of 1954

g) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

h) National Electric Code

i) OTHERS as cited in Reference 12

5.0 SAFETY AND QUALITY ASSURANCE

5.1. SAFETY:

The design of the WD&C equipment shall be governed by Reference 12, GAATT TS Engineering Criteria Packages 1 - 4 (Rev A) (Draft) ET# GAAT 066

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5.2. QUALITY ASSURANCE:

Quality assurance requirements are defined in Reference 12, GAATT TS Engineering Criteria Packages 1 - 4 (Rev A) (Draft) ET# GAAT 066

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11. Martin Marietta Energy Systems, Inc. Results of Fall 1994 Sampling of Gunite and Associated Tanks at the Oak Ridge National Laboratory, Oak Ridge, Tennessee. ORNL/ER/Sub/87-99053/7

12. ORNL; GAATT TS Engineering Criteria Packages 1 - 4 (Rev A) (Draft) ET# GAAT 066

13. ORNL; GAAT OU TS Work Package (Number TBD 025)

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15. ORNL; GAAT TREATABILITY STUDY; SITE PLAN; C3E020339A008

16. ORNL; GAAT TREATABILITY STUDY; GENERAL STRUCTURAL NOTES; A3020339A002

17. ORNL; GAAT TREATABILITY STUDY; GAAT PLATFORM FRAMING PLAN AND DETAILS FOR TANKS W3 & W4; A3E020339A003

18. ORNL; GAAT TREATABILITY STUDY; GAAT PLATFORM FOUNDATION PLAN & DETAILS FOR TANKS W3 & W4; A3E020339A004

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20. ORNL; GAAT TREATABILITY STUDY; GAAT REINFORCED CONCRETE SECTIONS & DETAILS; A3E020339A006

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26. Spar Aerospace Ltd, M. Elzeki; Engineering Worksheet; "LUDA ARM TIP DYNAMIC LOAD LIMITS"; SPAR-MISC-STR 88, 8/11/95

27. MLDUA Technical Specification ORNL-ML95-047 Rev. 1; Oak Ridge National Laboratory

28. Specification for the Lght Duty Utility Arm System; WHC-S-124 Rev. 3

29. DOE/ID-10500, DOE Hoisting and Rigging Manual

7.0 TBD/HOLD REPORT:

TBD Number	Reference Paragraph	Description of TBD	Comment/Impact of TBD	Responsible Organization	Resolution Due Date
TBD017	Figure 1	Specify the minimum distance between the bottom of the riser and the top of the waste surface, within which the WD&C system may have to be deployed.		ORNL	7/17/9515
TBD024	3.3.2.2, Item b)	Specify the inlet conditions (flow rate, and back pressure) of the BOP at its interface with the WCS during steady state flow.	The design of the BOP and its resistance to flow will greatly impact the design of the WCS.	ORNL	7/17/95

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FIGURES

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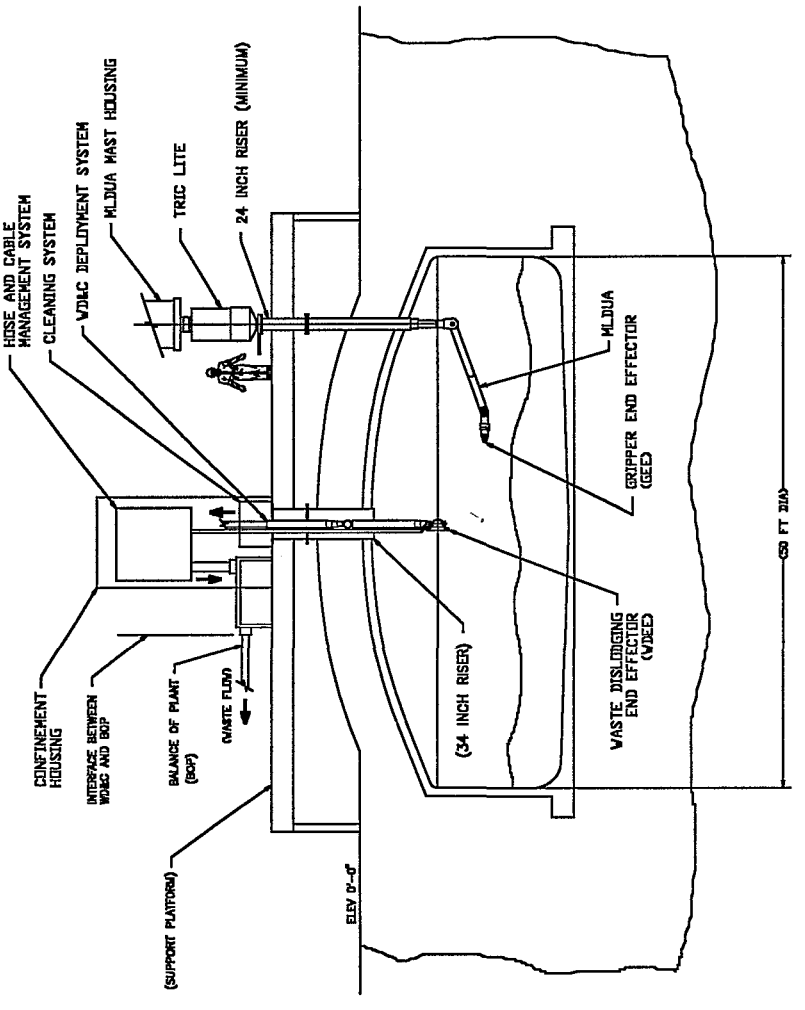

FIGURE 1

General Arrangement

South Tank Farm Configuration

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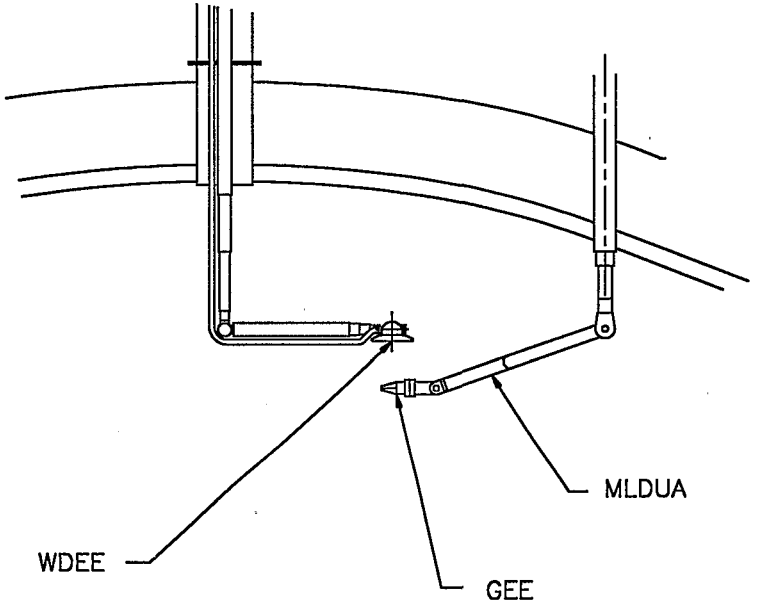


FIGURE 2

GEE and MLDUA prepare to engage

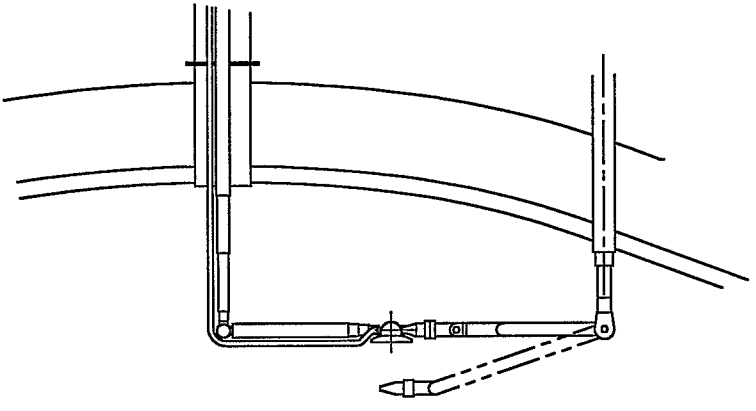


FIGURE 3

MLDUA engages to WDEE

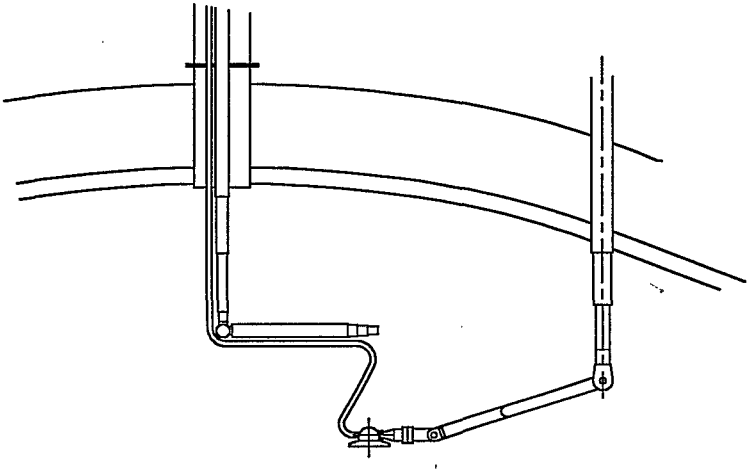


FIGURE 4

WDEE deployed in tank by MLDUA

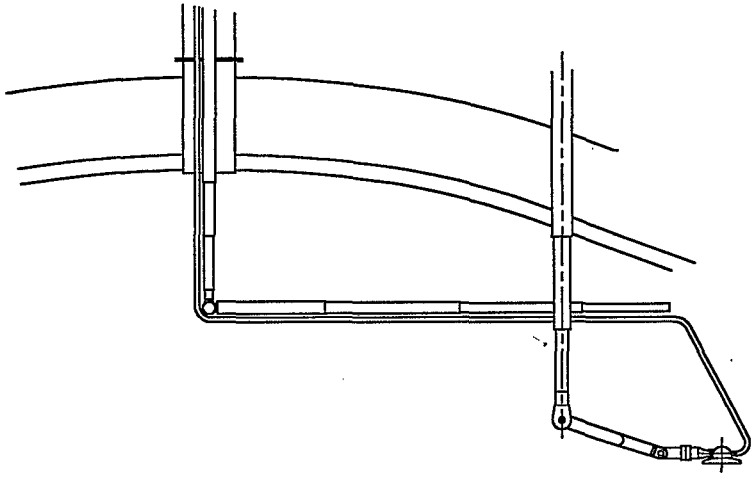


FIGURE 5

WDEE deployed in tank by MLDUA

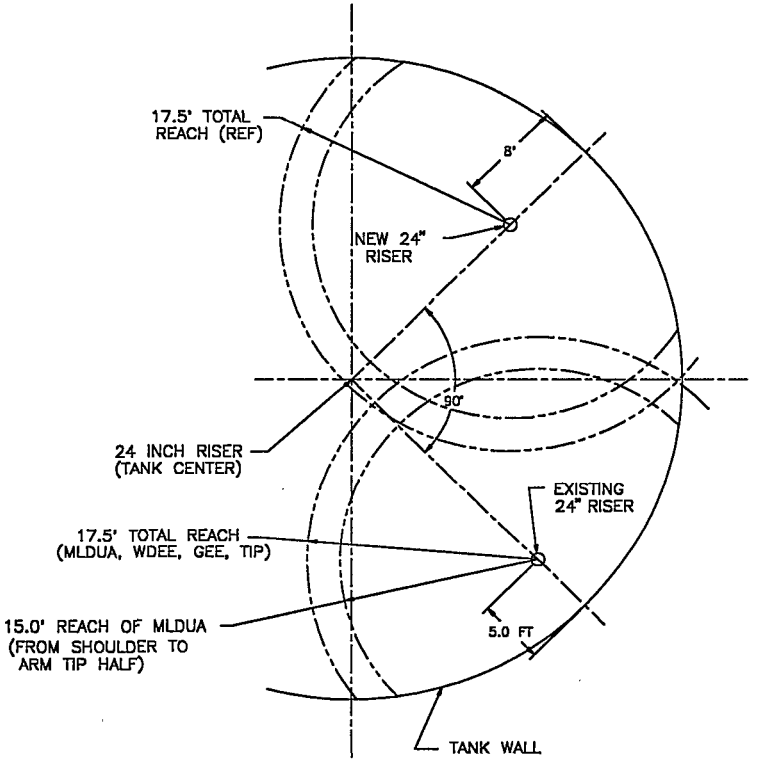


FIGURE 6

Reach Envelope in 50 foot Diameter Tank
(applicable from waste surface to tank bottom)

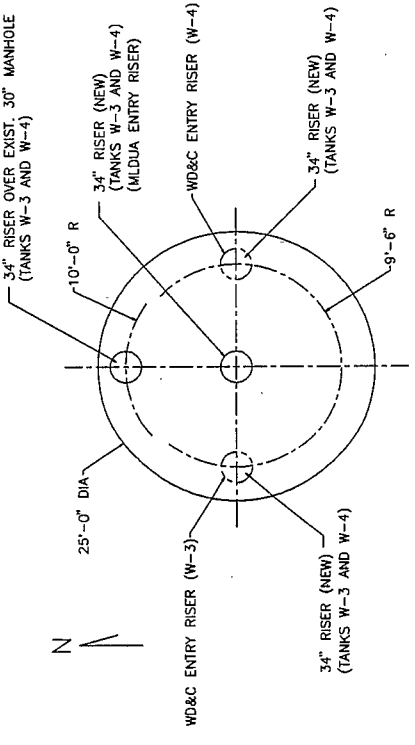


Figure 7
Deployment Riser Locations, Tanks W-3, W-4

APPENDIX A

MLDUA PERFORMANCE CAPABILITIES

This appendix identifies the most significant MLDUA parameters and limitations which may have impact on the design of the WDEE or WCS. For additional information on the MLDUA see ORNL-ML95-047, Technical Specification for the Light Duty Utility Arm System. In the event of any conflict between the information shown in this appendix with the ORNL technical specification, the technical specification shall be assumed correct. The MLDUA and Gripper End Effector (GEE) are not part of the WD&C system and are beyond the scope of this document.

1.0 USEABLE DEPLOYMENT ENVELOPE:

The MLDUA is a seven-degree-of-freedom mast-mounted arm which has the dexterity to reach beyond obstructions while providing substantial orientation and positioning capability of the end-effectors. The MLDUA has a 15.0-foot minimum horizontal reach, as measured from the center line of the mast to the Tool Interface Plate (TIP). This minimum useable envelope extends from the bottom of the Vertical Positioning Mast (VPM) housing to 37 feet below grade (as measured from the end of the mast housing to the center-line of the arm's shoulder pitch). The minimum usable envelope also includes at least a 4-foot reach below the center line of the shoulder pitch. Within the minimum useable envelope, the MLDUA is able to orient the end-effector perpendicular to any surface that is within plus or minus 30 degrees from the horizontal, and has the ability to work in constrained space between riser and wall as shown in Figure A-1. Within the minimum useable envelope, the positional accuracy of the MLDUA under static conditions is plus or minus 0.5 inches. The system shall be designed with features to compensate for errors in end-to-end accuracy of the whole MLDUA system, for example, a feature to eliminate mast deflection and apply a control factor via the control system. The MLDUA, within the minimum useable envelope, is able to be configured such that the end-effector is the lowest point on the MLDUA.

Since access to the tank may be through a riser near the periphery of the tank, the MLDUA is capable of being deployed through a riser that ends 6 feet above the tank waste (vertical clearance below the riser) and centered 5 feet from the vertical tank wall, without contacting the waste (disregard additional clearances required for the end-effector) or the wall while having the required dexterity and reach away from the wall (see Figure A-1).

To support end effector changes, the MLDUA system allows individual arm joints to be moved with the deployment mast tubes retracted in the VPM housing once the joints have cleared the deployment mast or VPM housing. This activity shall support the configuration shown in Figure A-1. The MLDUA system shall have the capability to position the robot side of the TIP within the confinement system and at any desired vertical position with accuracies and repeatabilities same as within tank.

2.0 ALLOWABLE LOADS:

The LDUA shall be designed for an end effector which can have a maximum static payload (including gripper ene effector) of 200 lb located 2 feet from the TIP mating plane and 2 inches off the wrist roll centerline. The robot side of the TIP shall be considered part of the robot and shall not be included in the above load requirements. The End Effector side of the TIP shall be treated as part of the End Effector and will therefore be included in the above load capacity. The 200 pound payload shall be considered to be 130 lb inertial load and 70 lb dynamic load which could be applied in any direction. (Reference 27, Section 3.1.1.3 "Load Capacities")

3.0 ARM VELOCITY:

The MLDUA shall provide the operator with infinitely variable speed control. The maximum speed of the arm will not be less than 5 inches per second at the End Effector exchange plate (TIP) with End Effector gravitational load only. For any velocities above 5 in/sec the payload requirement shall be reducedto the weight of the TIP and the GEE only.
(Reference 27 , Section 3.1.1.2 "Arm Velocity")

4.0 POSITIONING CAPABILITIES:

The positioning capabilities of the MLDUA are interlinked with the mass of the WDEE and the dynamics of the arm, and are determined to be as shown in Table A-2, below:

TABLE A-1

Positioning Capabilities of MLDUA Arm

Payload, W (lbs)	*Accuracy (inches)	*Repeatability (inches)	Resolution (inches)
200	±0.5	±0.2	±0.05

* Assuming a moment loading (M) of 4800 in-lb, torsion loading (T) of 400 in-lbs, mast deployed in a plumb riser, under static conditions after settling of system motions.

5.0 HARMONIC RESPONSES:

Should the WDEE cause a sudden deflection/or release of the arm, the arm will begin to oscillate at its natural frequency, which will vary depending on arm extension. The effect of such arm oscillation on the functions of the WDEE will depend on the amplitude and duration of oscillation, and the degree of sensitivity of the WDEE to changes in its standoff distance from the waste. The effects may be worsened should the WDEE induce excitation forces near a natural frequency of the arm. The design and operations of the WD&C equipment, particularly the WDEE, must consider the dynamic loading generated and the response of the MLDUA.

A preliminary analysis of the MLDUA harmonic response is provided in Reference 26.

6.0 GRIPPER END EFFECTOR:

The gripper end effector (GEE) will be used to enable the MLDUA to engage with the WDEE and deploy it in an operating mode for waste retrieval. The GEE will include a tool TIP half and will be manually installed to the arm TIP half at the end of the MLDUA before its entry into the tank. To enable the GEE to engage with the WDEE, the WDEE must have appropriate handle(s) which the GEE can engage. One or more of these handles shall be incorporated in the design of the WDEE.

7.0 IN-TANK VIEWING:

An overview TV camera with lights will be provided by ORNL to be installed in the mast shoulder, to assist the operator with in-tank operations. Overview vision will be provided by a second camera and lighting to be inserted through a different riser than the MLDUA.

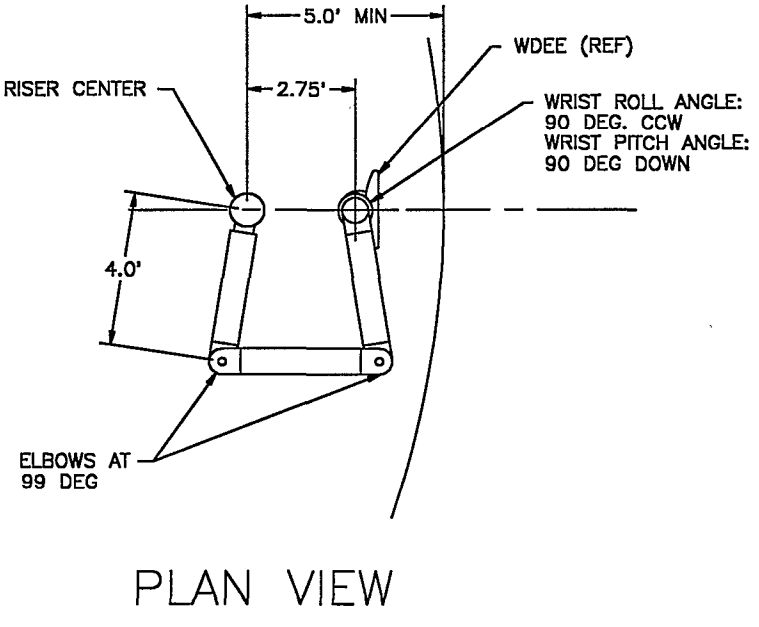
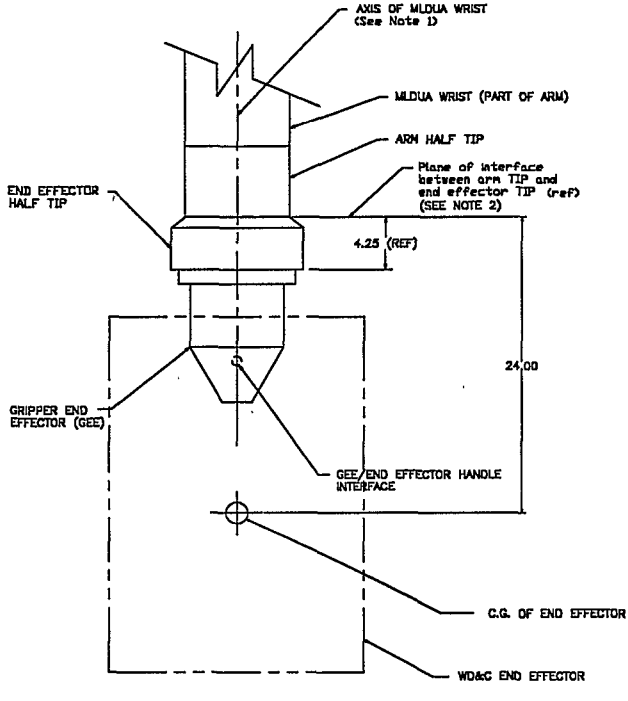


FIGURE A-1

Minimum Arm Deployment Clearance Configuration



NOTES:

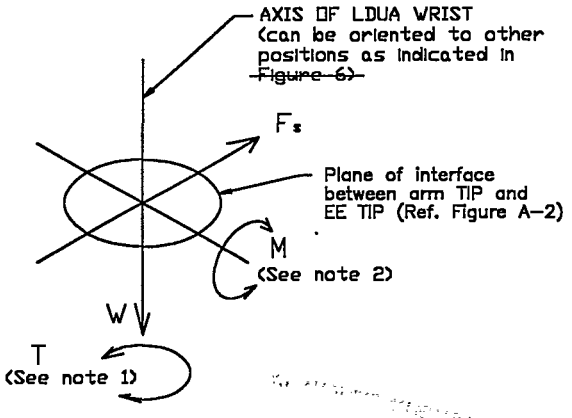
1) Although shown in a vertical position, the MLDUA wrist can be oriented to positions from vertical to horizontal.

2) The maximum allowable loads which may be imposed on the MLDUA by the Waste Dislodging End Effector, are reacted at the plane of interface between arm TIp and end effector TIP, and are as specified in Table A-1.

3) All dimensions are in inches.

FIGURE A-2

Gripper End Effector Dimensions



NOTES:

1. "T" is the torque about the axis of the LDUA wrist.
2. "M" is the moment loading about any axis lying in the plane of interface between the two TIP halves.
3. "Fs" is the shear load in any direction along the plane of interface between the two TIP halves.
4. "W" is the axial load in either direction along the axis of the LDUA wrist.
5. See Table A-1 for load values.

FIGURE A-3

MLDUA Wrist Load Legend

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