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Staubli TX-90XL Robot Qualification at the Light Initiated High Explosives Facility (U)

Timothy Todd Covert

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Staubli TX-90XL Robot Qualification Results at LIHE (U)

Timothy Todd Covert
Energetic Component Engineering
Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico 87185-MS1454

Abstract

The Light Initiated High Explosive (LIHE) Facility uses a robotic arm to spray explosive material onto test items for impulse tests. In 2007, the decision was made to replace the existing PUMA 760 robot with the Staubli TX-90XL. A qualification plan was developed and implemented to verify the safe operating conditions and failure modes of the new system. The robot satisfied the safety requirements established in the qualification plan. A performance issue described in this report remains unresolved at the time of this publication. The final readiness review concluded the qualification of this robot at the LIHE facility.

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NOMENCLATURE

ANSI	American National Standards Institute
E-Stop	Emergency stop
DOE	Department of Energy
IP	Ingress Protection
LIHE	Light Initiated High Explosive
MCP	Manual Control Pendant
RIA	Robotic Industries Association
SASN	Silver Acetylide Silver Nitrate (explosive)
SNL	Sandia National Laboratories

1. INTRODUCTION

The Light Initiated High Explosive (LIHE) Facility conducts impulse tests on various targets. The impulse loading is achieved by the simultaneous detonation of a sensitive primary explosive. Due to the sensitivity of the explosive material used in this testing, a robotic arm is used to apply explosive material onto the test targets. A PUMA 760 robotic system was installed in the LIHE facility in 1984. This system was successfully used until the facility was closed in 1992. When the facility was re-opened in 2001, the original PUMA arm was retrieved from storage and made operational. This PUMA robot was again used to spray explosive material from 2004 until 2007. Due to increasing scarcity of replacement parts and expertise, the condition of the robot resulted in significant programmatic risk should a failure occur. In 2007, the decision was made to replace the PUMA 760 with the Staubli TX-90XL robotic system. Due to the unique hazards and operating conditions of the robot at the LIHE facility, a formal qualification plan was developed and documented in the Explosives Technology Group Administrative Process ETG-AP-0519, “2550 Staubli TX-90XL Robot Qualification Plan at LIHE (U).” This report documents the qualification results of the Staubli robot to spray explosive material in support of LIHE test requirements.

2. MECHANICAL HAZARDS AND MITIGATIONS

2.1 Safety Barriers, Devices, and Indicators

The robotic arm is located inside the spray booth at the LIHE facility as shown in Figure 1. In nearly every operating case, the robot operator is located in the adjacent spray control room. From the spray control room, the operator can watch robot operation through the blast window or using the facility video cameras. The substantial construction of spray booth and blast window provides adequate protection to the operator from mechanical hazards associated with the robot. Therefore the spray booth is the primary safety barrier. The only case where the robot is powered with the operator attending operations from within the booth is discussed in the “Attended Operations” section below.

The doors to the spray booth are interlocked to prevent personnel from entering the robot hazard area. With the exception of attended operation described below, the booth pedestrian door and booth double doors must be closed in order to power the arm. If any personnel attempted to access the robot hazard area by opening either door, the interlock circuit would remove power to the arm.

Any time the robot arm is powered, there are flashing lights activated outside the pedestrian door and the booth double doors. Signs adjacent to the flashing lights indicate the robot hazard is present inside the booth when the lights are flashing.

Arm power is removed and arm brakes are applied when an **Emergency Stop button** is pressed. An **Emergency Stop button** is located on the manual control pendant (MCP) which is under direct control of the operator. A second **Emergency Stop button** is located prominently on the spray booth blast window. Once depressed, these buttons must be reset before arm power can be restored.

In **Manual Mode**, arm motion can be directed by the operator using the MCP. The safety devices included in the system are designed to minimize the hazard potential for the operator. Safety features of the MCP will either prevent the operator from powering the arm from within the hazard area, or will sense jeopardy to the operator removing arm power. In order for the arm to power-up, the pendant must be in its cradle (verified by a sensor in the MCP) to verify the operator is not located in the robot hazard area. Alternatively, the MCP will sense jeopardy to the operator to maintain arm power. The MCP must be hand held with the **Handle switch** in its middle position. If the handle is released due to operator trouble, arm power is removed. If the handle is squeezed in a panic, arm power is removed. In manual mode, arm motion will only occur while the operator holds the **Move/Hold button**. If the **Move/Hold button** is released, then the arm motion is halted. Since arm motion will only occur at the direct command of the operator through the **Move/Hold button**, unintended arm motion cannot occur in **Manual Mode**.

In **Local Mode**, a preprogrammed sequence of events is initiated by the operator. The robot then continues the prescribed operations without operator action. In **Local Mode** attended operation is prohibited and prevented by the interlock configuration. In **Local Mode** the spray booth doors must be closed. In **Local Mode** the full robot arm speed is allowed. The robot program can be interrupted by operator command at the MCP. The arm power can be interrupted by the **Emergency Stop buttons**. Opening the door interlock will also interrupt the power to the arm.

The wiring diagram for the safety devices, interlock, and indicators is included in Appendix A: Safety Devices, interlock, and indicator wiring diagram

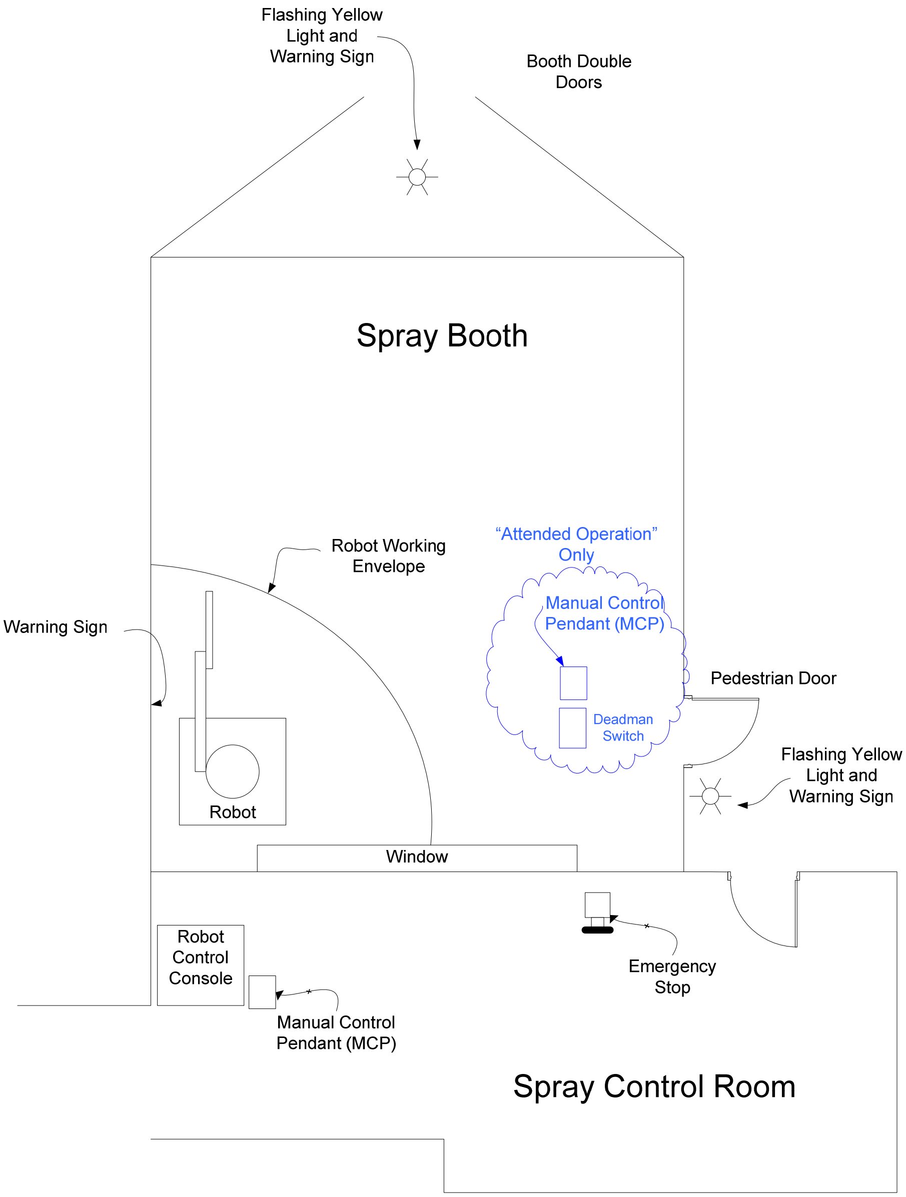

Figure 1. Barriers, devices, and indicators pertinent to robot operations.

2.2 Attended Operation

For most operations, the robot operator will be located in the spray control room. However the possibility and provision exists to manually operate the robot from within the spray booth. Due to the proximity of the operator to the robot hazard, additional safety measures are required. For attended operation, a safety observer is required to be in the spray control room ready to depress the **Emergency Stop button** satisfying the two-man-rule for hazardous operations. The operator must remain outside of the reach of the robot. The operator’s hand may extend into the working envelop of the robot to make measurements, etc. A **Deadman switch** will be placed on the floor outside the robot working envelope. This switch requires the operator to maintain foot pressure on the **switch** in order to apply power to the robot arm. The pedestrian door must be open to facilitate egress. The booth double doors remain closed to prevent inadvertent personnel access to the robot hazard area. The interlock circuitry verifies the pedestrian door is open, and booth double doors are closed, and the **Deadman Switch** is activated to apply power to the arm.

For attended operation, the robot must be in **Manual Mode** as selected on the MCP. In **Manual Mode**, the **Move/Hold button** must be held down for arm motion to occur. Therefore arm motion will not occur without operator command. The operator in the spray booth must be in possession of the MCP. The MCP has a three-position **Handle switch** that must be maintained in the middle position for arm power to be applied. If the MCP **Handle switch** is released or if the MCP **Handle switch** is squeezed in a panic, arm power is immediately removed from the arm and arm brakes are applied. In **Manual Mode**, the maximum speed of the arm is restricted to less than 250mm/s by the robot controller.

As a result of the qualification plan, a safety vulnerability was identified and corrected. For **Attended Operation** the interlock circuit has been modified to ensure the robot is only operated in **Manual Mode**. As a result, any attended operation has additional safety precautions ensured including reduced arm speed and preventing inadvertent arm motion (operator must hold the **Move/Hold button** for arm motion to occur).

3. EXPLOSIVE HAZARDS AND MITIGATIONS

The explosive hazards associated with spraying explosive material are addressed in detail in procedure, “Spraying Silver Acetylide-Silver Nitrate Explosive at the Light Initiated High Explosive (LIHE) Facility,” ETG-OP-0318. An in-depth strategy has been developed to mitigate the probability of explosive detonation occurring in the Spray Booth as well as reducing the consequence of any possible explosion. The explosive hazard is also addressed in ETG-OP-0320, “Operating Procedures (OPs) for Operation of Robotic Arms at the LIHE Facility/Building 6715.” The explosive safety aspects of robot operation are summarized as follows.

- There shall be no personnel permitted in the Spray Booth during explosive spray operations. “Attended Operation” of the robot spraying explosive material is forbidden. The spray booth is rated to contain the allowable explosive quantity. Therefore no hazard to personnel is caused by robot spray operations.
- The Spray Booth ventilation system maintains the concentration of flammable vapors to much less than the lower explosive limits. Operation of the ventilation system is verified before and during spray operations. An explosive vapor environment could only occur as a result of ventilation system failure.
- The robot is pressurized with nitrogen to ensure positive pressure relative to the Spray Booth. Therefore any flammable vapors or explosive dust are prevented from infiltrating into the robot and being ignited by either mechanical or electrical means within the robot.
- The robot monitors internal temperature of its motors and brakes. The robot will automatically remove arm power if any component exceeds 120 degrees (º) Celsius (C). (Normal operating conditions of the arm under severe operating conditions is less than 80º C.) This safety feature of the robot prevents excessive heating of internal components thereby reducing the ignition hazard. Note the autoignition temperature of silver acetylide silver nitrate (SASN) explosive is 300º C, acetone 465º C, and acetylene 305º C.
- Experience indicates explosive dust accumulation on the robot during a spray is minimal. Explosive accumulation is prevented by extensive cleaning operations after each and every spray operation. The arm has a rating of IP65 (wrist is IP67) meaning it can be washed with sprays of water to ensure effective cleaning. Thorough and extensive cleaning of the arm reduces the hazard of explosive dust accumulation. Additionally, an annual inspection using an open flame verifies the effectiveness of the cleaning rigor (see Inspection for Explosive Residue Using a Portable Propane Burner, ETG-SWP-0318-01 for details of this inspection).

4 QUALIFICATION RESULTS

4.1 Qualification Summary

The readiness plan was incremental with phased implementation. Beginning with the simplest step, the robot was installed, integrated, programmed, and tested. This report documents qualification for the Staubli arm to spray explosive material for a LIHE impulse test. Table 1 lists the qualification objectives and summarizes the results.

Table 1. Qualification objectives and results summary.

	Objective	**Results**
1.	Demonstrate power-up with factory supplied shorting connector	• Robot arm was powered successfully. • Robot moved in **Manual Mode**.
2	Demonstrate power-up with facility safety systems integrated	• Arm was powered when safety interlocks were satisfied. • Arm would not power on when safety interlocks were not satisfied. • Robot was moved in **Manual Mode**.
3	Demonstrate flat spray program	• Robot program was developed to approximate typical flat spray operations. • Flat spray program was utilized for a mock spray with no problems identified. • Robot actuated spray gun. Activation of spray gun was captured on the LIHE monitor computer system. • The robot displayed spray gun velocity and showed an unexpected velocity gradient.
4	Demonstrate conical spray program	• Robot program was developed to approximate typical conical spray operations. • Conical spray program was utilized for a mock spray with no problems identified. • Robot actuated spray gun. Activation of spray gun was captured on the LIHE monitor computer system. • Robot successfully commanded the turning fixture controller and received communication from the controller signifying the completion of the commanded operation.

	Objective	**Results**
		- A variable velocity profile was programmed into the robot. This velocity profile was modified without interrupting the execution of the spray program. The robot displayed spray gun velocity. An unexpected departure from the programmed velocity profile was observed. A correction factor was introduced to correct the velocity departure.
5	Demonstrate failure modes and recovery	- Arm behavior is predictable in failure modes. - Operation recovery is understood for failure modes.
6	Complete robot readiness review	- This report documents the results of the qualification plan. - A review of this plan and its results has been conducted with the LIHE team including department 2552 management.

Objective 1: Demonstrate Power-Up with Factory Supplied Shorting Connector.

The robotic system was factory supplied with an interlock bypass connector. **The bypass connector shall not be used under normal conditions.** The bypass connector shall only be used for the initial start-up described here or for diagnostic trouble shooting with management authorization. The robot was initially powered with the interlocks bypassed to preclude an interlock problem resulting in a misdiagnosis of a robot problem. With the interlocks bypassed, the functionality of the **Emergency Stop button** located on the MCP was verified. With the bypass connector installed, the arm was powered. Each joint of the robot was moved slightly to demonstrate proper operation of the arm. Objective 1 was successfully achieved. The bypass connector was removed from the spray control room and stored.

Objective 2: Demonstrate Power-Up with Facility Safety Systems Integrated.

Once the robot operation had been verified, it was essential to verify the operation of the required safety systems. This objective verified the proper functioning of each of the safety devices used by the robot system. Each of the interlock devices listed in Table 2 was placed in their normal operating condition: doors closed and emergency stops reset. Then one switch at a time was opened to verify the arm power was interrupted.

During the course of the qualification activities, vulnerability in the safety systems was identified. For **Attended Operation**, the operator could inadvertently power the arm while in **Local Mode** resulting in increased hazard to the operator. In **Local Mode**, the additional protections of restricted arm speed and the requirement to hold the **Move/Hold button** for arm motion were absent. In consultation will the robot manufacture engineer, a modification of the interlock circuitry corrected the vulnerability. The robot cannot be powered in **Local Mode** during **Attended Operations**.

Table 2. Interlock operation and results

Mode	Pedestrian Door	Double Doors	Deadman Switch	MCP Cradle Switch	MCP Handle Switch	Arm Power	Result
Manual	Closed	Closed	No	Yes	No	No E-Stop	OK
Manual	Open	Closed	No	Yes	No	No	OK
Manual	Closed	Open	No	Yes	No	No	OK
Manual	Closed	Closed	No	No	No	No	OK
Manual	Closed	Closed	No	Yes	No	Yes	OK
Manual	Closed	Closed	No	No	Yes	Yes	OK
Manual	Closed	Closed	No	No	Panic	No	OK
Manual	Open	Closed	Yes	No	Yes	Yes	OK
Manual	Open	Closed	No	No	Yes	No	OK
Manual	Open	Closed	Yes	No	No	No	OK
Local	Open	Closed	Yes	No	Yes	No	OK
Local	Closed	Closed	No	Yes	No	Yes	OK

Objective 3: Demonstrate Flat Spray Program.

The robot was now operational for non-explosive related operations. The robot was programmed to conduct a mock spray. This mock spray was programmed to traverse a flat area representative of a typical LIHE test, approximately 42 inches wide by 24 inches tall. The robot program included all the necessary parameters required for an LIHE impulse test such as constant travel velocity, book keeping of spray passes, spray wait time, rest position, and gun wash position. Mock spray parameters are shown in the Table 3. During LIHE spray operations, the robot was required to interface with ancillary equipment such as the spray monitor computer and spray gun.

Table 3. Mock spray parameters

Parameter	Value
Number of pass locations	12
Spray pass spacing	2 inches
Spray pass length	42 inches
Spray gun start delay	2 inch
Spray gun stop spacing	3 inches
Spray pass wait time	40 seconds
Spray gun traversing velocity	5 inches per second
Number of spray passes	26 sets

During the mock spray, spray gun traversing velocity was displayed on the robot MCP. The displayed velocity appeared to be constant over the length of the pass. The velocity of the spray trajectory was also measured using a string displacement gauge (Celesco Model DV301). This transducer measures both displacement and velocity. Measured velocity as a function of displacement is shown in Figure 2 below. Although the spray trajectory was programmed at 5 inches per second, a significant velocity gradient was measured. The robot program was repeated at multiple velocities ranging from 3 inches per second to 7 inches per second as shown in Figure 3. Both Figure 2 and 3 indicate comparable trajectory velocity gradients. The calibration and response of the string displacement transducer was verified. Consultation with the Staubli technical representative did not resolve the velocity error. At the time of this writing the velocity gradient has not been resolved. To facilitate testing operations in the interim, the velocity gradient is corrected though the introduction of a velocity correction factor into the robot program. With the modified robot program, sufficiently uniform velocity can be obtained.

The robot was able to successfully execute the required flat spray operation. The robot was able to interface with the required ancillary equipment, perform the necessary recording keeping, and achieve a uniform velocity using a velocity correction.

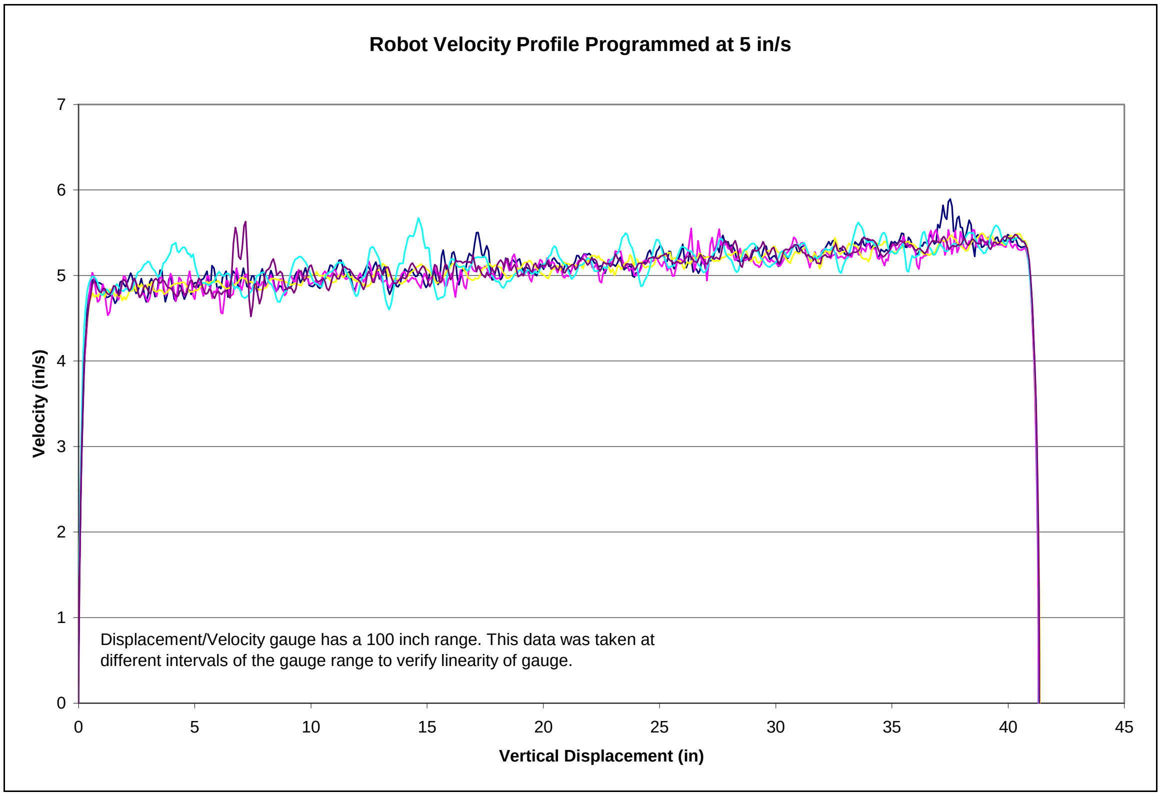

Figure 2 Measured robot velocity for 6 spray passes programmed at 5 in/s showing a velocity gradient.

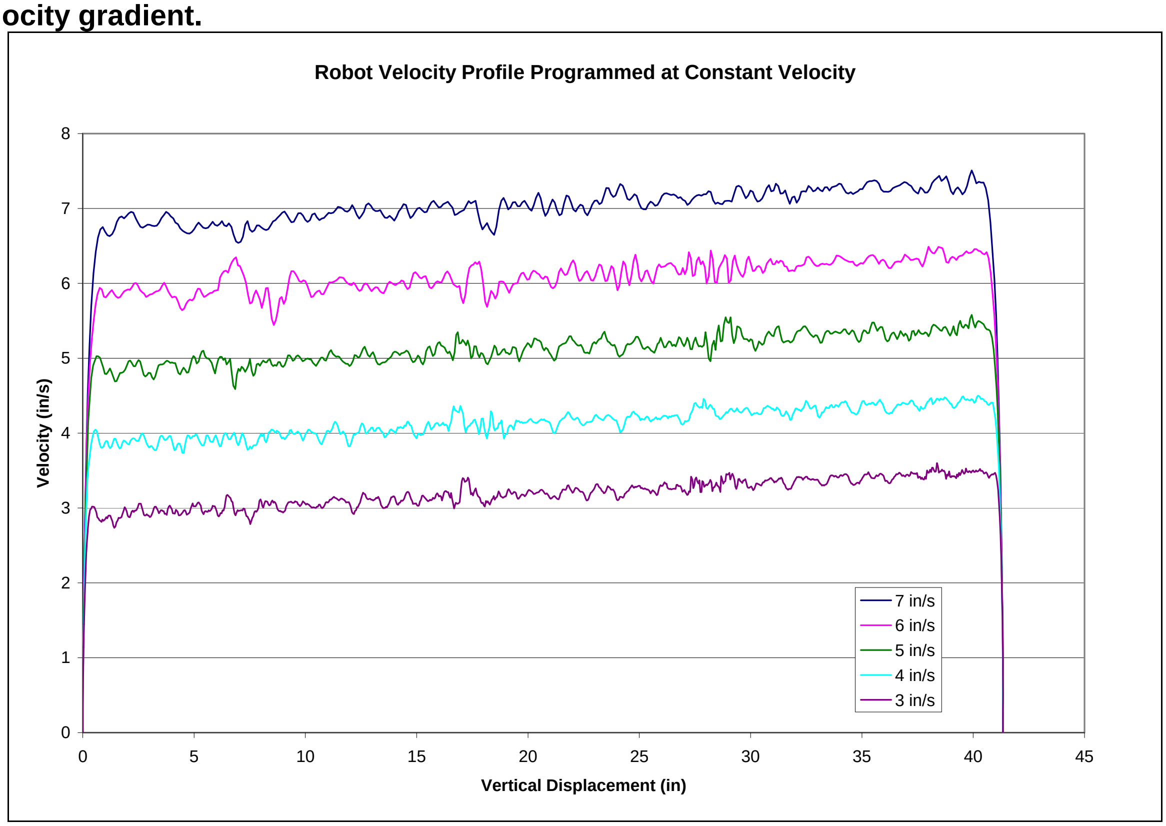

Figure 3 Measured robot velocity programmed at 3 inches per second to 7 inches per second.

Objective 4: Demonstrate Conical Spray Program.

A robotic program was developed to conduct a mock spray on a conical geometry target. For a conical spray, the robot makes straight line passes at indexed angular positions. The robot controls a rotary table to index through the required spray locations to achieve the required deposition. This mock spray was programmed to traverse a straight line typical of a LIHE conical test, approximately 42 inches long and a cone angle of 7 degrees. To achieve a uniform axial spray deposition along the decreasing conical cross sectional area (aft to nose), an increasing spray trajectory velocity is used. This spray trajectory velocity is defined by a polynomial equation incorporated into the robot program. As an operational necessity, the robot program must allow for modification of the velocity profile during program execution. The robot program included all the necessary parameters required for an LIHE impulse test such as velocity profile, book keeping of spray passes, spray wait time, rest position, and gun wash position. During LIHE spray operations, the robot interfaced with ancillary equipment such as the spray monitor computer, test unit rotational fixture, rotational potentiometer and spray gun. The parameters of the mock spray are listed in the Table 4.

Table 4. Spray deposition parameters for conical target geometry

Number of angular pass locations	17	
Spray pass angular spacing	10 degrees	
Spray pass length	42 inches	
Spray gun start delay	1 inch	
Spray gun stop spacing	1 inches	
Spray pass wait time	40 seconds	
Number of spray passes	Angular location	Spray sets
	+/-80	3
	+/-70	4
	+/-60	6
	+/-50	7
	+/-40	8
	+/-30	9
	+/-20	9
	+/-10	10
	0	10
Spray gun velocity gradient (inches per second)		
$V(x)=3.7171+1.1565\cdot10^{-1}\cdot x-1.3109\cdot10^{-3}\cdot x^{2}+3.0058\cdot10^{-5}\cdot x^{3}$		

The conical spray geometry was executed as expected. The robot successfully communicated with ancillary equipment including the rotary table used to index the spray positions. The robot accurately recorded the applied spray passes at the prescribed angular positions. Similar to the flat spray test results, the velocity deviated from the programmed velocity profile as shown in Figure 4. At the time of this writing the velocity issue had not been resolved. As with the constant velocity departure, a correction factor was developed an incorporated into the robot program. The velocity profile is defined incrementally along the spray pass. Therefore the variable velocity correction factor is defined incrementally along the spray pass. Through the use of an appropriate correction, a sufficiently accurate velocity profile can be obtained.

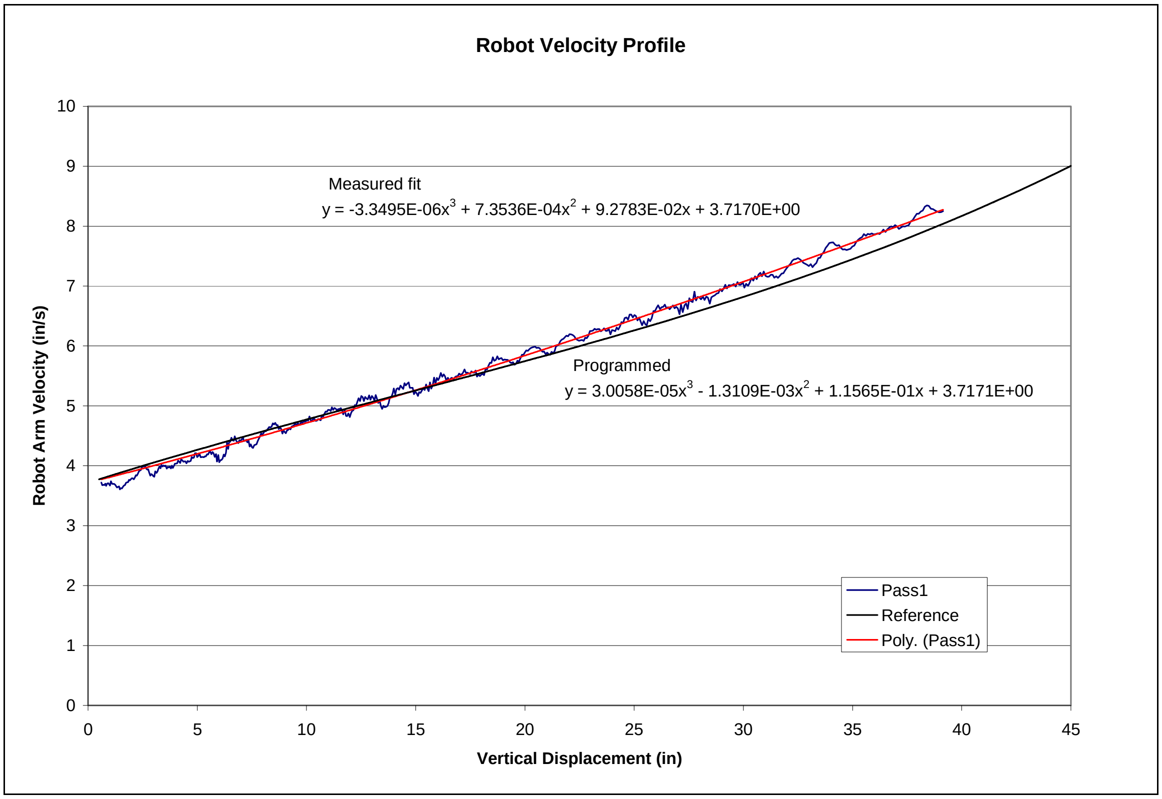

Figure 4 Measured velocity deviation from a programmed velocity profile.

Objective 5: Demonstrate Failure Modes and Recovery.

Once the normal operating mode of the robotic system has been determined, it is essential to understand the robot response in abnormal environments. In this objective, the robotic system was subjected to abnormal conditions to determine the robot response as well as recovery steps. The objective assessed the predictability of the robot response as well as the robustness of the programming. These scenarios were discussed with the Staubli application engineer during the on-site support. Many of these scenarios were incorporated into the spray program. The scenarios described in this objective are plausible to varying degrees.

Since there were no personnel within the robot envelope during any of these operations, there were no personnel exposed to hazards. There was however a risk to the robot. These abnormal conditions may cause unexpected behavior however the consequences of any unexpected behavior experienced during this readiness plan were significantly less than unexpected behavior experienced during an actual explosive test. Therefore these abnormal conditions were investigated using extreme care. An observer was available for all activities requiring the arm to be powered. The observer was ready to push the **Emergency Stop button** should erratic motion occur. **None of these operations were performed as “Attended Operations.**”

Scenario 1: Program Paused using the Move/Hold button.

- Condition: A flat spray program was executed. While the arm was in motion the Move/Hold button was depressed.
- Result: The arm motion stopped. Arm power remained on. Spray gun turned off. Spray program is paused. Any operator input to the program while paused will not go into affect until after the currently paused motion is completed. If the “quit” button is pushed while the program is paused, then when the arm motion is restarted the arm will return to the first startpass location and the program returns to the main spray menu.
- Recovery: Depress the Move/Hold button again and arm motion resumes. Program continues to spray previously commanded spray passes. The spray gun does not turn on for an incomplete spray. The spray gun is activated for the next programmed spray. The spray program retains all spray parameters.

Scenario 2: Arm Power Turned Off During Program Execution, While Robot is not in Motion.

- Condition: A flat spray program was executed. While the arm was not in motion, waiting for operator input for example, arm power was removed by depressing the **Arm Power button** on the MCP.
- Result: Arm powered off. Spray program is paused. Any operator input to the program while paused will not go into affect until after the currently paused motion is completed. If the “quit” button is pushed while the program is paused, then when the arm motion is restarted the arm will return to the first startpass location and the program returns to the main spray menu.
- Recovery: Depress the arm power button. Press the Move/Hold button to re-initiate arm motion. Program continues to spray previously commanded spray passes. The spray gun is activated for the next programmed spray. The spray program retains all spray parameters.

Scenario 3: Arm Power Lost During Program Execution, While Robot is not in Motion.

- Condition: A flat spray program was executed. While the arm was not in motion, waiting for operator input for example, arm power was removed by breaking the interlock.
- Result: Arm powered off. Spray program is paused. Any operator input to the program while paused will not go into affect until after the currently paused motion is completed. If the “quit” button is pushed while the program is paused, then when the arm motion is restarted the arm will return to the first startpass location and the program returns to the main spray menu.
- Recovery: Clear the interlock fault. Clear the error message on the MCP. Depress the arm power button. Press the Move/Hold button to re-initiate arm

motion. Program continues to spray previously commanded spray passes. The spray gun is activated for the next programmed spray. The spray program retains all spray parameters.

Scenario 4: Arm Power Lost During Program Execution, While Robot is in Motion.

- Condition: A flat spray program was executed. In the middle of a programmed move, the interlock was broken.
- Result: Arm powered off. Arm motion immediately stopped. Spray program is paused. Any operator input to the program while paused will not go into affect until after the currently paused motion is completed. If the “quit” button is pushed while the program is paused, then when the arm motion is restarted the arm will return to the first startpass location and the program returns to the main spray menu.
- Recovery: Clear the interlock fault. Clear the error message on the MCP. Depress the arm power button. Press the Move/Hold button to re-initiate arm motion. Program continues to spray previously commanded spray passes. The spray gun does not turn on for an incomplete spray. The spray gun is activated for the next programmed spray. The spray program retains all spray parameters.

Scenario5: Complete System Power Lost During Program Execution, While Robot is in Motion.

- Condition: A flat spray program was executed. In the middle of a programmed move, the robot controller was turned off simulating a facility power failure.
- Result: Arm powered off. Arm motion immediately stopped. Controller was powered off.
- Recovery: Re-boot of the robot controller. Reloading of spray program. The robot no longer remembers spray parameters that may have changed during spray operations. Robot no longer remembers completed spray passes. All parameters may be manually changed. Operator may manually enter completed spray passes. Operator may continue spray operations. Even if the arm stopped at any location on the spray pattern, the operator may initiate a spray pass causing the arm to move the desired startpass location.

Scenario 6: Arm Motion Crosses a Joint “Singularity.”

A singularity occurs when there is not a unique set of joint orientations to represent a particular location. For example, if joint 5 on the robot is straight, then multiple combinations of joint 4 and 6 orientations result in the same resulting position. In older robot systems, approaching a singularity causes erratic behavior. However according to the robot manufacture, modern robots such as the TX-90XL are immune from this problem.

Working with the Staubli application engineer, the robot was programmed to move through a singularity condition. When the robot was commanded to move through the programmed singularity, an error message was displayed on the MCP and the arm would not attempt to complete the move.

Using manual motion command with the MCP, jogging, the operator attempted to force the robot through a singularity. As the arm approached the singularity, the arm speed decreased significantly. After moving through the singularity, normal arm speed was resumed.

Objective 6: Complete Robot Readiness Review.

On April 2, 2008, a robot readiness review was conducted. This review focused on the operational safety of the robotic operations. The safe operating procedures in force at that time were reviewed. The qualification results obtained to date (documented in a memorandum date 4-2-2008) were also reviewed. At that time, all safety issues had been adequately addressed. Authorization to begin explosive spray operations using the Staubli TX-90XL arm was documented in work authorization form number 2008-03-31-TC. Though work authorization was granted, additional investigations were conducted to resolve the velocity deviations previously discussed. However, those velocity issues remain unresolved at the time of this writing.

5. CONCLUSIONS

Due to the hazardous, high consequence operations performed by the robotic system at the Light Initiated High Explosive (LIHE) Facility, a robust qualification plan was developed and implemented for this system. An in depth hazard mitigation strategy was developed. The explosive hazards pertinent to the robot have been mitigated ensuring personnel safety. The safety barriers, devices, and indicators ensure safe robot operation. An extensive investigation of failure modes and system responses has been completed. A readiness review has been completed resulting in authorization to proceed with explosive work using the Staubli TX-90XL. Based on results of this qualification plan, all safety issues relative to the robot have been satisfactorily resolved. However a performance issue remains. The measured robot velocity deviates from the programmed velocity as shown in this report. Inaccurate spray trajectory velocity affects the LIHE impulse testing. To overcome this velocity issue, a process to correct the velocity has been developed and is incorporated into the robot program. With the velocity correction employed, the Staubli TX-90XL has demonstrated adequate performance and necessary safety to complete the required explosive operations at the LIHE facility.

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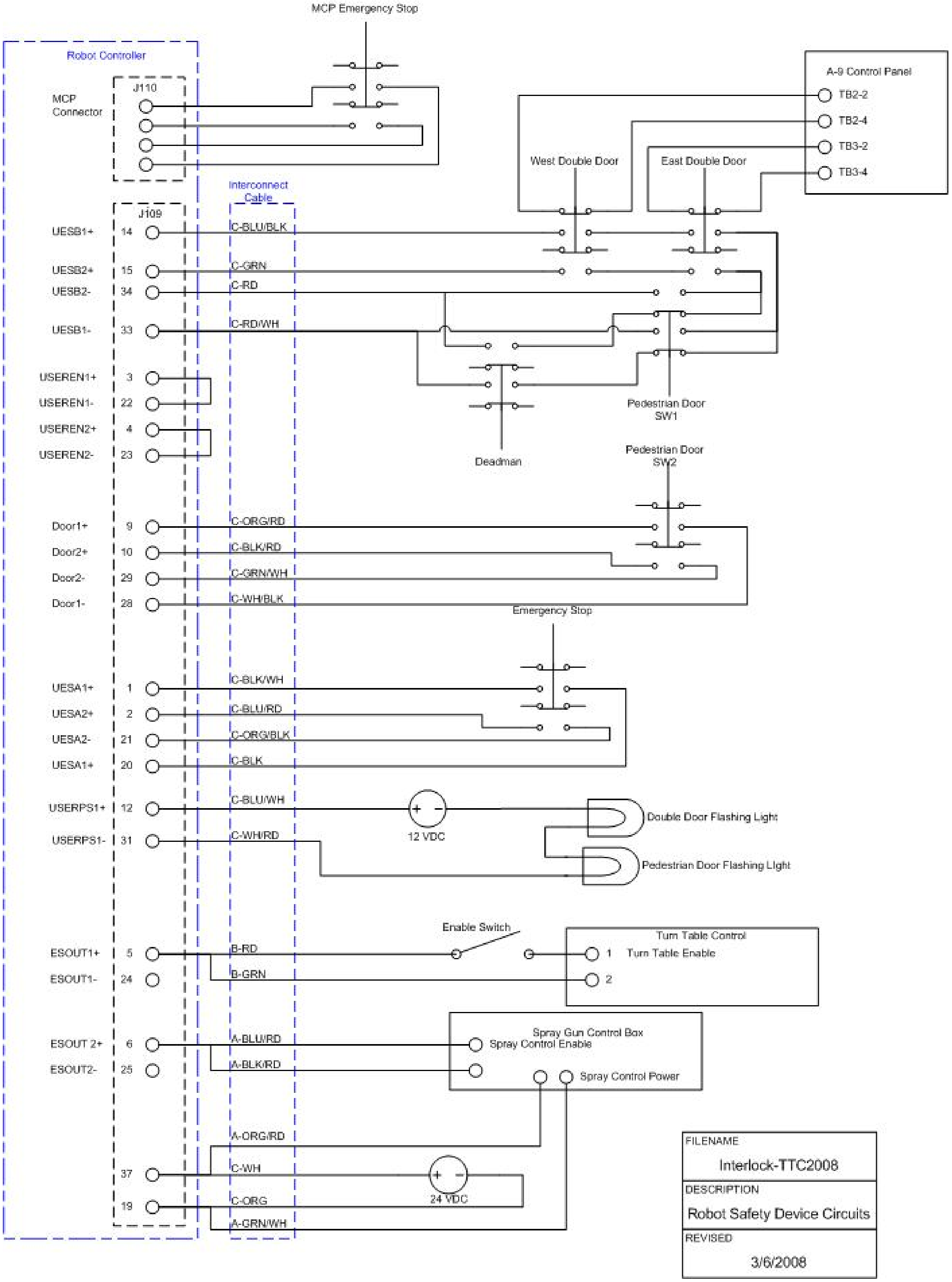
APPENDIX A: SAFETY DEVICES, INTERLOCK, AND INDICATOR WIRING DIAGRAM



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