ADDENDUM A

GENERAL DESIGN AND PURCHASING GUIDELINES

1. **Purpose**
   1.1. This document provides general technical requirements and guidelines for the design, build, and purchase of equipment and fixtures.
2. **Scope**
   2.1. This document applies to the Arlington manufacturing facility in Campbell, IL.
3. **References**
   3.1. AR-15—General Safety Standards
   3.2. AR-19—Procedure for Processing Purchase Requisitions and Purchase Orders
4. **Definitions**
   4.1. None.
5. **Material and Equipment**
   5.1. Any relevant material or equipment as needed.
6. **Responsibilities**
   6.1. All Arlington associates in the Campbell manufacturing facility must adhere to the guidelines provided in this document when purchasing new equipment or modifying existing equipment.

Advanced Safety Management: Focusing on Z10 and Serious Injury Prevention, Second Edition. Fred A. Manuele.

7. **Requirements**

7.1. Purchasing—Follow the guidelines for purchasing as found in AR-19.

7.2. Safety

7.2.1. Machine guarding—Refer to AR-57 Machine Guarding Procedure for Safety.

7.2.2. Guarding for construction—Follow AR-62.

7.2.2.1. Give consideration to the best appropriate finish of all parts, including functionality and aesthetic purposes.

7.2.2.2. Use stainless steel or ceramics for parts that contact the product. Approval of any parts/material that contact product must be obtained on a case-by-case basis.

7.2.2.3. Anodize aluminum parts.

7.2.2.4. Use industrial paint or primer when the painting of steel is necessary.

7.2.2.5. Finish all surfaces to prevent corrosion.

7.2.2.6. Consider material compatibility for long component life and the prevention of corrosion.

7.2.2.7. Allow no direct contact of the product with aluminum, bronze, lead, or oil.

7.2.2.8. Use steel or aluminum framing for large transparent doors in high stress or vibration areas.

7.2.2.9. Use only polycarbonate materials such as RAND or a similar material for transparent doors and guards since Plexiglas materials often become brittle and shatter upon impact.

7.2.2.10. Make all exposed edges (i.e., where contact with a body part may occur during operation of equipment) with a 3/16-inch radius (minimum).

7.2.2.11. Method of fastening panels to framework:

1. Use only "TORX" screws.
2. Use through bolt, flat washers, and anti-vibratory nut, if possible—Tapping into transparent panels is NOT ACCEPTABLE.
3. Place bolts spaced not more than 6 inches center to center.
4. Use hinged panels with captive-style fastener for the latch.

7.2.3. Signage—Clearly identify all controls and devices with appropriate warning signs, labels, and tags.

7.3. Industrial Hygiene

7.3.1. Noise

7.3.1.1. Make the maximum noise level of the equipment 80 dBA, 8-Hour Time Weighted Average when measured on the "A" scale of a standard sound level meter or noise dosimeter within 3 feet of the equipment.

7.3.1.2. Make the maximum peak noise level 115 dBA when measured on the "C" scale of a standard sound level meter, within 3 feet of the equipment.

7.3.2. Ventilation—Use a systematic approach when designing or modifying exhaust ventilation systems.

7.3.2.1. Refer to "Industrial Ventilation—A Manual of Recommended Practices," published by the American Conference of Governmental Industrial Hygienists (ACGIH), Section 6.0, which presents a systematic approach for designing or modifying exhaust ventilation systems.

7.3.2.2. As a baseline, design to a minimum of 90 fpm and a maximum of 150 fpm face velocity at point source of exhaust.

7.3.2.3. Equip each exhaust flow vent system with a continuous air flow monitoring device to detect any loss in air flow: Tie the system into the site emergency power system.

7.3.3. OSHA Hazard Communication

7.3.3.1. Submit a Material Safety Data Sheet to site safety representative for approval prior to design and build of any new or upgraded equipment or process that requires the use of solvents, chemicals, or other fluids.

7.3.3.2. An investigation will be conducted to determine if the equipment or process will pose any physical or health hazard.

7.3.3.3. Measures will then be recommended to minimize the risk. This includes descriptions of features and safeguards protecting the operator from direct or fugitive exposure to chemicals, solvents, or generated waste streams.

7.4. Ergonomics

7.4.1. General Workstation Design—Consider the following ergonomic guidelines for general workstation design as optimal dimensions and are not intended to restrict or limit your ability to design effective workstations. Above all, general workstation design should factor in the amount of risk employees will be subjected to when using workstations.

7.4.1.1. Typical risk factors associated with industrial designs include but are not limited to:

1. excessive forces
2. poor body postures
3. high repetition
4. vibration

7.4.1.2. Design workstations, when possible, to allow operators to work in both sitting and/or standing positions.

7.4.1.3. Make work surface height for a sit/stand station 38" to 40".

7.4.1.4. "Seated only" work surface height shall be 28–30" (28" is preferred) when "sit/stand" workstation is not feasible.

7.4.1.5. Minimize work surface thickness, including underside support members (1" preferred, 2" maximum).

7.4.1.6. Design work fixtures to allow hands to be positioned no higher than 4" above the work surface. The total dimension

from the underside of the workstation to the point where the work is performed should not exceed 6". If visual requirements necessitate higher work positioning, arm rests should be provided.

7.4.1.7. Provide unobstructed leg room for the operator to sit comfortably, (24" wide, 26" from the floor to the underside of work surface, 18" deep from the front edge of work surface).

7.4.1.8. Allow a 4" × 4" toe cut-out at the bottom of the station when Standing Stations are used.

7.4.1.9. Design equipment/fixtures to be adaptable for convenient use by right- or left-handed operators, wherever possible.

7.4.1.10. Round all leading edges which the operator may come into direct contact with whenever possible. Try to recess the external hardware like hinges, door pulls, knobs, etc. as much as possible, to avoid contacting the operator.

7.4.1.11. Minimize equipment/fixture size to limit forward bending or reaching, as much as possible, to allow for tote pans and/or parts trays to be positioned in front of the operator. All operator/equipment interaction issues must be considered.

7.4.1.12. When fixed (non-adjustable) features are included into the design, the following principles are important to remember:

1. Design clearance dimensions for a tall operator (74" in height).
2. Design reaching dimensions for a short operator (60" in height).
3. Design fixed height dimensions designed for an average operator (66" in height).

7.5. Machine and Process Control

7.5.1. Master Control Relay—Provide Master Control Relay for emergency shutdown.

7.5.1.1. Hardwire emergency Stop pushbuttons and all Safety Switches in series to the Master Control Relay.

7.5.1.2. If any of these devices opens, the Master Control Relay should de-energize and remove power from the control circuit.

7.5.2. Emergency Stop—Provide Emergency Stop pushbuttons in an obvious location and within easy reach of either hand of the operator.

7.5.2.1. Design the E-stop such that to restart after Emergency shutdown it is necessary to pull out the E-STOP button and then press the appropriate buttons to initiate normal operation.

7.5.2.2. Design the E-STOP to interrupt power from the outputs, drives and other powered devices.

7.5.3. Interrupt DC Power Supply—Use DC power supply, interrupted on the DC side for faster response.

7.5.4. PLC Power—Wire power to the PLC outputs through a set of master control relay contacts.

7.5.5. Interlocks—Design machine to not be capable of running in continuous RUN mode with interlocked guards out of position or removed.

7.5.6. Mechanical Design:

1. No sharp edges or corners.
2. No shear points or pinch points.
3. Design turntable machines to not catch arms, hands, fingers, or clothes and with filled access areas.
4. Consider torque or force limiting devices for any part-moving device such as turntables, carriages and slide assemblies, etc. (for instance, magnetic couplings used for emergency breakaway on linear shuttle assemblies).
5. Use four-way, spring-centered, pneumatic valves for equipment working off of two hand controls.

7.6. Environmental Impact/Hazard Evaluation

7.6.1. Have materials used for all new or upgraded equipment and processes that are to be located in the facility evaluated to assure that they comply with Arlington's Policy and Governmental Regulations concerning such materials. This applies particularly to chemicals and generated waste streams.

7.6.1.1. Environmental Impact—Have any equipment or process which may release any chemicals to the environment evaluated for environmental impact. All information necessary for this impact study must be submitted to the site environmental coordinator early enough in the development stage to avoid costly rework or delays.

7.6.1.2. Material Safety Data Sheets—Have any chemical proposed for a new process approved by the site safety representative. A Material Safety Data Sheet (MSDS) and any other hazard data information must be submitted for evaluation prior to release of any purchase order for new equipment.

8. Procedure

8.1. Use this document as a guide whenever purchasing new (or modifying existing) equipment.

8.2. Codes and Standards

8.2.1. At a minimum, all equipment shall comply with the latest revisions of the applicable specifications, codes, and standards. When deemed applicable by Engineering, documentation/labeling of said compliance shall be provided. *Note*: In case of conflicting specifications, the more stringent shall apply.

8.3. Equipment/Fixture Design

8.3.1. Make sure that all surfaces that may come into contact with the operator's body are free of sharp edges and corners (minimum 3/16" radius).

8.3.2. Tilt or orient fixtures to allow the operator to perform all work with a neutral body posture.

8.3.2.1. A general guideline is to tilt the fixture 15° toward the operator to enhance access and visibility, and to minimize awkward postures.

8.3.2.2. Specific recommendations will be made upon review of the job function in question.

8.3.3. Locate frequently accessed controls in front of and close to the operator to minimize reach distances.

8.3.4. Minimize repetitive reaches in front of the body to never exceed 16".

8.3.5. Repetitive reaches above chest height, below work surface height, or behind the body are not acceptable.

8.3.6. Design repetitively used control buttons (e.g., cycle start buttons) to require nominal activation of 1 pound or less. Where possible, it is also desirable for the pushbutton to be 2–3" in diameter.

8.3.7. Provide control knobs and handles with a nominal diameter of 1¼ inch. Clearance must be provided in equipment to avoid bumping the fingers or hands when parts are being positioned.

8.4. Mechanical—Design and Construction

8.4.1. Design equipment in a manner to prevent operator mistakes. *Note*: This includes preventing incorrect installation of tooling for set-up, incorrect loading of parts, installing wrong parts or incomplete parts. The goal is to make the machine capable of producing zero defects without relying on correct operational procedure.

8.4.2. Materials/Finishes

8.4.2.1. Materials "IN" Contact with the Product

Approval of any parts/material which contact product must be obtained on a case-by-case basis. Listed below are some guidelines to aid in choosing a material.

1. Use nonabrasive and non-marring materials.
2. Use Stainless Steel—300 series is preferred, 400 series in specific applications. Passivation and/or electropolish finish.
3. Use Aluminum—hard anodize only.
4. Use Plastics—fluorocarbons, polycarbonates, acrylics, ABS, polypropylenes, polyethylenes, and nylons, with approval of site project coordinator.

8.4.2.2. Materials "NOT" in Contact with the Product

1. Use Carbon Steels—properly prepared and painted, flash chromed, or electroless nickel plated.
2. Use Stainless Steels—anodize.
3. Use Aluminum—anodize.

8.4.2.3. Miscellaneous Finishes

1. Cover any tabletop surface or equipment that comes in contact with product with either stainless steel or

laminate (see specifications for requirements). Approval of any parts/material which contact product must be obtained on a case-by-case basis.

2. Do not use Wood Products in the manufacturing area.

8.4.3. Equipment Size and Weight Restrictions

8.4.3.1. Free-Standing Equipment—No restriction

8.4.4. Tooling Requirements

8.4.4.1. Locating Datum—Dimension all tooling from and locate the part from the primary datum of the component part. Features—Design tooling with the following features.

1. Interchangeability—Use dowels, bushings, and standard dowel patterns for locating to the equipment when practical all like tooling.
2. Quickchange—Use quickchange features on tooling to accomplish the changeover within the time requirement and in a repeatable manner. Quickchange techniques or devices such as single fastener size, quarter-turn fasteners, locking knobs, slotted holes, setup blocks, special tools, etc. may be used.
3. Adjustment/Installation—Design tooling to be fixed and not adjustable to the equipment. Adjustment features should be incorporated into the equipment (locking slide) rather than the tooling (slotted holes) if possible.
4. Design tooling to assure the correct installation of the tooling onto the equipment, using asymmetrical dowel patterns or similar feature.

8.4.5. Hardware Items

8.4.5.1. Include one (1) resettable stroke counter and one (1) non-resettable stroke counter with each piece of automatic equipment.

8.4.6. Working Environment

8.4.6.1. Design all equipment to operate in a Class 100,000 working environment unless otherwise specified.

8.4.7. Preferred Mechanical Components

8.4.7.1. The following Preferred Components are listed in two groups, "A" and "B". "A" components are preferred as "first choice" and "B" components as "second choice."

8.4.7.2. Use of "B" components shall require the approval of the Equipment Engineer.

8.4.7.3. Use Preferred Components except when their use is not practical or jeopardizes project delivery.

8.4.7.4. Obtain approval from Equipment Engineer prior to substitution for Preferred Components.

8.4.7.5. Use standard commercially available components wherever possible.

8.4.7.6. General Equipment and Machinery

[In a resource for this Addendum, a chart appears listing equipment items and brand names categorized in the aforementioned groups "A" and "B." It is not duplicated here.]

8.5. Electrical—Design and Construction

8.5.1. Enclosures

8.5.1.1. Use enclosures properly rated for the environment for which they will be exposed.

8.5.1.2. Equip the main control enclosure with a fusible and lockable disconnect. Alternatively, if appropriate, a fusible lockable disconnect may be provided directly upstream of the main control enclosure. It shall be readily accessible as stated in the NEC.

8.5.1.3. **If any live circuit should exist by design in the system after opening the main disconnect, the main disconnect and the enclosure(s) containing that live circuit shall be obviously labeled stating this condition and the source and voltage of the live circuit.**

8.5.1.4. Provide spare space in the electrical enclosure for future additions.

1. Allow for panels less than 500 square inches: a minimum of 40% spare capacity shall be provided.
2. Allow for panels greater than 500 square inches, a minimum of 15% spare capacity shall be provided.

8.5.1.5. Do not mount control equipment on the door or sides of the enclosure except devices such as pushbuttons, pilot lights, selector switches, meters and instruments.

8.5.1.6. Mount terminal strips on inside enclosure sides and door, when appropriate. All terminal strips must be permanently, mechanically affixed—not glued or attached with a sticky strip.

8.5.1.7. Appropriately protect all wiring against excessive flex and pinching as a result of enclosure door operation.

8.5.1.8. During operation, the control enclosure interior temperature shall not experience a rise in temperature greater than 40° Fahrenheit over ambient temperature. Should the installed equipment cause this condition to occur in a static environment, filtered forced air shall be provided to maintain this temperature requirement. Appropriate alarms on this air flow must be provided.

8.5.2. Transformers

8.5.2.1. Use control transformers, where applicable, sized for 10% to 25% spare capacity (but not less than 100 VA).

Transformers 2 KVA and larger shall be of the dry type and shall be mounted externally.

8.5.2.2. Supply Source for the main control transformer shall be taken from the load side of the main disconnecting device. The isolated secondary of the main control transformer shall provide, nominally 120 VAC, single phase, and shall provide a bonded ground.

8.5.2.3. Fusing—Provide on primary and secondary.

8.5.3 Component Mounting

8.5.3.1. Use meters and operating controls placed so as to conform with Arlington ergonomic and AR-19 methods. Discuss with the electrical engineering representative.

8.5.3.2. Make all panel-mounted components removable without having to remove the control panel.

8.5.3.3. Identify control equipment mounted on the machine by use of engraved Lamicoid-type labels. Labels shall be permanently secured to the machine in order to facilitate their identification and location on wiring diagrams.

8.5.3.4. Identify control equipment mounted internal to the control cabinet by Brady labels or its equivalent. Dymo-type labels shall not be used.

8.5.3.5. Permanently label all components (relays, transformers, fuses, terminal blocks, etc.) mounted on the equipment and in the control enclosures according to a scheme agreed upon by an electrical engineering representative. Labels must be affixed so that replacing parts does not remove or change the intended identification.

8.5.4. Push Buttons

8.5.4.1. Use "Start" of the fully guarded momentary contact type on equipment or operations sensitive or very dangerous in the event of inadvertent start-up. Otherwise, flush momentary type buttons shall be used.

8.5.4.2. Use Normal "Stop" buttons of the extended momentary contact type.

8.5.4.3. Locate the "Stop" button near the start push button.

8.5.4.4. Use Emergency stop push buttons of the illuminated, maintained type when depressed.

1. Arrange the circuit so that depressing an emergency stop pushbutton will inhibit all machine motions and drop out the hardwired start/stop circuit. The E-stop light will be wired independent of other E-stop lights so that any depressed E-stop can be identified regardless of the position of any other E-stop pushbutton.

8.5.4.5. Pushbutton Colors

Color	Typical Function	Example
Red	Stop	Stop motors
	Emergency stop	Master stop
Green	On/start	Start of a cycle or motor
	Autocycle	
Black	Inch, Jog	Inching
	Horn silence	Jogging
Yellow	Return, reset	Return of machine to safe or normal condition
White	By approval only	
Gray	By approval only	
Blue	By approval only	
Orange	By approval only	

8.5.5. Position Sensors—Digital: Solid-state optical or proximity sensors are preferred to electromechanical limit switches. Sensors with built-in status indicating lights are preferred to those without.

8.5.6. Sensors/Signal Conditioners—Analog: Use solid-state sensors or signal conditioners with a 4–20 mA DC output.

8.5.7. Power Distribution

8.5.7.1. Power Supply Protection—Provide suitable power supply protection/conditioning equipment if the equipment is susceptible to power brownouts, voltage surges/spikes, or line conducted electromagnetic interference.

8.5.7.2. Surge Suppression—Include an MOV or diode in parallel located as close to the load as practical on all inductive loads—motor starters, solenoids, relays, transformers, etc.

8.5.7.3. Overloads—Use overloads of the manual reset type. Overload reset buttons shall be installed in the panel enclosures to allow manual reset, unless specifically provided for in separate motor starter control boxes.

8.5.8. Wiring Practices

8.5.8.1. Remote Interlocks—See Section 8.5.13.1 for labeling and Section 8.5.11 for color coding, for installations and equipment containing different sources of power.

8.5.8.2. Failsafe Operation—Utilize sensors, controls, and logic in such a manner that their failure or loss of power would produce the least undesirable consequences. In case of power failure, circuits must be manually re-energized to restart. The overall start and stop function must be hardwired, which eliminates the dependence on an electronic device or controller.

8.5.8.3. Push-To-Test Devices—Use pilot lights of the push-to-test type. However, if they are originating from a programmable logic controller (PLC) output, then a dedicated pushbutton input to the PLC shall be utilized to test all of such PLC output pilot lights. All other devices, such as displays and horns, must be tested by a push-to-test function, and should be wired to the dedicated push-to-test button where possible.

8.5.8.4. Interconnections/Terminals

1. Provide all components such as sensors, temperature sensors, heaters, and small motors which require frequent replacement with an appropriately designed quick disconnecting means. Terminals are one acceptable means.
2. Package and terminate all panel-mounted solid-state devices and/or components (resistors, diodes, etc.) to be easily removable with the use of hand tools. They must be installed to allow easy access for troubleshooting and testing. They shall not be mounted near large heat-producing components such as transformers. They shall not be soldered and/or "butt-spliced."
3. Calibrate critical process control variables on a regular basis. Where applicable and practicable, provide banana jacks/switches or accessible quick disconnects to allow convenient access for calibration. Discuss calibration requirements with the Electrical Engineer or an Instrument Mechanic. A calibration label shall be affixed to the device (or in close proximity), indicating the equipment I.D., calibration date, calibrator, and calibration due date.
4. Terminate devices external to any control enclosure at a terminal block in the control enclosure. Wiring from external devices shall not be connected directly to a device in the control enclosure. However, 440-volt motors may be wired directly to the motor starter. Thermocouples and similar very low voltage signal-carrying conductors may be terminated directly on the device to which it interfaces. If terminals are used, they must be of a special type appropriate to signals being conducted. One terminated and identified wire shall be returned for test purposes from a connection between limit switches, pushbuttons, or other devices connected in series. This test point termination may be in field junction boxes where easily accessible if appropriate.
5. Wire control circuit voltage reference points to a terminal in each terminal enclosure external to the control panel. All terminals shall be marked to correspond with terminal markings as specified on wiring diagrams.
6. Protect sensor devices with cord leads such that the leads cannot be damaged. Open wiring is not permitted.

7. Do not make electrical connection to control devices with soldered connections or wire nuts. Sensors shall be terminated on terminals in a junction box. A field junction box should be mounted to provide terminals if necessary.
8. Use terminal blocks with terminal clamp screws with no more than two wires under one screw.
9. Wire terminal blocks and mount so that internal and external wiring does not cross over the terminals.
10. Provide spare terminals in each terminal enclosure including enclosures external to the control panel. The number shall be at least 10% of the total in use or a minimum of six, whichever is greater. If fewer than 10 terminals are used and space prohibits, then less than 6 spares are adequate. There shall be spares appropriately spaced on each terminal block. A general rule would be to include 2 to 3 spares for each 10 terminals.
11. While maintaining functional appearance, placement of conduit and sealtite runs shall not restrict access for repair or replacement of machine parts. All conduit and sealtite shall be secured to permanent fixtures, walls, or bracing to avoid loose and damageable runs.

8.5.9. Circuit Installation

8.5.9.1. Separate AC wiring from DC wiring on both inside control panels and in wire runs, and signal wiring shall be separated from power wiring. Signal wiring shall be properly shielded. Thermocouple wiring shall be run separately unless shielded in which case it may be run with signal wiring. Where AC and DC wiring must be crossed, the wires or wire bundles shall cross at 90° to each other.

8.5.9.2. Sufficiently loop wiring to components mounted on doors to allow easy opening of the door and protect form excessive flex or pinching.

8.5.9.3. Use stranded copper of type MTW or THHN on all control wiring.

8.5.9.4. Wireways, sealtight, and conduit must meet NEC requirements and provide for adequate spares without overfilling. Conduit or sealtight is required for machine wiring.

8.5.9.5. Use appropriately sized cable/wire anchors that are permanently affixed to the surface. Self-adhesive anchors are not acceptable unless mounted by screws.

8.5.9.6. All cable/wire straps shall be appropriately sized, spaced, and tensioned to avoid cable/wire insulation deformation/damage and provide adequate support.

8.5.9.7–9. Not included.

8.5.9.10. Replace nicked or cracked wire insulation.

8.5.9.11. Use a plug-type removable terminal block at all locations to be separated for shipment where large equipment with interconnecting control panels are required, in order to minimize installation wiring.

8.5.9.12. Protect all wiring running alongside or over sharp edges.

8.5.9.13. Shield and ground all low-voltage DC (signal) wires and cable to prevent noise interference.

8.5.9.14. Utilize a ground fault circuit Interrupter (GFCI) whenever the process is a wet process. (See the NEC.)

8.5.10 Maintenance Considerations

8.5.10.1. **Give consideration to accessing electrical equipment for maintenance troubleshooting**. This may involve maintenance bypass switches for certain interlocks. However, the machine should not be allowed to run production in the maintenance bypass mode. The equipment should be so designed to provide access to sensors, switches, and motors, etc. for preventive maintenance procedures performed on a regular basis.

8.5.10.2. Provide all wiring with a service loop sufficient to re-make the connection at least three times.

8.5.10.3. Label all wire ends as indicated on the wiring diagrams. Where no wiring label is indicated, a to/from designation shall be used. Jacketed power wiring which is color coded can have the labeling on the jacket.

8.5.11. Wire Colors

8.5.11.1. Three-Phase Power and Motor Wiring

Volt	A = L1	B = L2	C = L3	Neutral	G=Ground
480	Brown	Orange	Yellow	Gray	Green
240	Black	Red	Blue	White	Green
208	Black	Black	Black	White	Green

8.5.11.2. One-Phase Power and Motor Wiring

Volt	Phase	N=Neutral	G=Ground
480(277)	App. Phase	Gray	Green
240(120)	App. Phase	White	Green
208(120)	App. Phase	White	Green
120	Black	White	Green

8.5.11.3. AC Control Wiring

Volt	Phase	N=Neutral	G=Ground
5 to 60	Pink	White/pink	Green
61 to 120	Red	White/red	Green

8.5.11.4. DC Control Wiring and DC Motor Leads

Volt	(+)	(–)
0 to 11	Purple	White/blue
5 to 60	Blue	White/blue
61 to 120	Blue/black	White/blue

8.5.11.5. Use green or green w/yellow tracer for grounding circuits ONLY.

8.5.11.6. Cable sheathing and noise suppression conductors do not suffice for fault-carrying conductors. A separate ground shall be used.

8.5.11.7. For external power or control wiring which is not de-energized when the equipment main disconnect is opened, color code is as follows: use a wire with a yellow tracer—the base color being that which corresponds to the circuit voltage in use.

8.5.11.8. Make any temporary wiring or jumpers yellow or orange and installed in a manner indicating that this is obviously the purpose.

8.5.11.9. Select appropriate conductor and jacket insulation for the environment and the service intended. All low voltage conductor insulation shall be 300 volts minimum while high voltage conductor insulation shall be 5 × the nominal conductor voltage or 600 volts minimum. The insulation shall be appropriately selected to withstand the minimum bend radii expected and the effects of the environment (UV, ozone, oil, etc.).

8.5.11.10. "HI-POT" test all power wiring should be at the appropriate voltage/duration for the nominal conductor voltage carried.

8.5.11.11. Allowed Exceptions

1. Intrinsically safe wiring may require all conductors to be blue. Under certain conditions, sheathing may be the acceptable fault current conductor in intrinsically safe wiring. (See the NEC.)
2. If AC and AC neutrals or AC and DC neutrals are tied together, then the color of the corresponding AC neutral of the highest voltage will be used on all those common neutrals.
3. Wiring on devices purchased completely wired.
4. Where insulation is used that is not available in the colors specified.
5. Equipment for use outside of the United States when the above color coding is not in agreement with the established local electrical codes.

8.5.12. Methods of Grounding

8.5.12.1. Use a separate grounding conductor for grounding of equipment. A stranded or braided copper conductor shall be used for grounding where subject to vibration.

8.5.12.2. Grounding by attaching the device enclosure to the machine with bolts or other approved means shall be considered satisfactory if all paint and dirt are removed from joint surfaces. Moving machine parts having metal-to-metal bearing surfaces shall not be considered as a grounding conductor.

8.5.12.3. Do not use the grounded neutral conductor of a circuit for the grounding of equipment. No neutral shall be grounded, unless electrically isolated from the plant power distribution system in or immediately adjacent the equipment in question. This is to prevent current imbalances in the power distribution system which would affect ground fault detection.

8.5.12.4. Do not mix signal and power grounds.

8.5.12.5. Terminate signal grounds at one central location whenever possible to eliminate ground loops and noise.

8.5.13. Remote Interlocks

8.5.13.1. Attach caution labels, for installations and equipment containing different sources of power, adjacent to the main disconnects stating:

CAUTION: THIS PANEL CONTAINS MORE THAN ONE SOURCE OF POWER

DISCONNECT THE FOLLOWING SOURCES BEFORE SERVICING:
(Identity and location of all disconnects shall be shown on the label)

8.5.13.2. Use labels of red Lamicoid with white lettering or of equivalent quality, secured in place by screws or rivets. Where practical, the remote sources of power shall be interlocked with the disconnect means. If not, a manual means shall be provided to quickly disconnect these sources.

8.5.13.3. Make all ungrounded wiring which contain remote sources of power yellow throughout the control panel.

8.5.14. Operator Interface—Apply Human Engineering criteria (Ergonomics) to the design of the operator interface. Except on the smallest systems, message board-type status and alarm indicators are preferred to an array of indicator lights and associated Nameplates.

8.5.15. Variable Speed Motor drives—Above 1/4 hp, solid-state variable frequency AC motor drives are preferred to solid-state variable voltage

DC motor drives. Below 1/4 hp stepper motor drives are preferred to variable voltage DC drives. The selection should be discussed with the electrical engineering representative to provide standardization when possible.

8.5.16. Programmable Controllers

8.5.16.1. Discuss the type of PLC, CPU version, and I/O selection with the electrical engineering representative.

8.5.16.2. Ensure that the supplier follows all design criteria established by the PLC manufacturer for installation of PLCs.

8.5.16.3. Ground I/O cards according to function (i.e., DC inputs, AC input, AC outputs, etc.), and spare slots should be left between these function groupings.

8.5.16.4. At least one hardwired Emergency Stop function shall be generated to create an emergency shutdown independent of the PLC and shall function even if a component of the PLC fails. The Emergency Stop function shall be interlocked in to the PLC software. The E-Stop hardwiring shall open appropriate power circuits to PLC outputs.

8.5.16.5. Shield low-voltage DC wiring with the following: Below 15 volts which interfaces to I/O modules, sink or source currents less than 8 mA, or input signal delay times less than 10 mA.

8.5.16.6. Maintain the shield continuity throughout the system when shielded cable is used.

8.5.16.7. Provide a minimum of 20% spare slots for future expansion.

8.5.16.8. Not included.

8.5.16.9. PLC Digital Inputs—Use input modules of 110 VAC or 24 V (first preference is for AC, with DC being the second preference). Discuss with the electrical engineering representative.

8.5.16.10. PLC Digital Outputs—Use 24 V for indicator lights and alarms. AC is first preference, DC is second preference. For pneumatic or hydraulic solenoids and motor starters, 115 VAC modules can be used. Solenoids should be rated for continuous duty.

8.5.16.11. PLC Analog Inputs/Outputs—The preference is 4–20 mA DC. Should 1–5 VDC input/output be required, precision 250-ohm resistors (1%) shall be used and installed at the terminating location.

8.5.16.12. Communication—In order to achieve the goal of integrating manufacturing machine raw data, components and process parameters should be shareable to the higher level of the computer system, and a communication system shall be provided. It includes an interface module, communication

software, and communication ports. Coaxial cable and twisted pair wire are common for the communication media; however, the optic fiber cable is preferred for the working environment with high electrical noise.

8.5.17. Instrumentation—All instruments and measuring devices used must be approved by an electrical engineering and/or instrumentation technician prior to use. Special considerations must be given to standardization, precision and accuracy, calibration requirements, and maintenance. All original manuals and specifications shall be provided.

8.5.18. Machine Installation Drawings

8.5.18.1. General—Include an installation drawing showing physical dimensions for mechanical, electrical, and service requirements with respect to the space needed for proper installation for each machine that is to be installed.

8.5.18.2. Service Requirements—Clearly indicate the appropriate electrical service (i.e., 480 V, 3 phase) for operation on the drawing.

8.5.19. Machine Documentation

8.5.19.1. ANSI/USAS Y32.10-1967 drawing symbols should be used. The electrical designation and descriptions on related pneumatic/hydraulic piping diagrams shall match those on the electrical diagrams.

8.5.19.2. Provide a P&ID diagram if appropriate.

8.5.19.3. Provide electrical control drawings in AUTOCAD in all cases. Formats, numbering systems, symbology, details, annotation to be discussed with the electrical engineering representative. Examples will be provided. Standard symbols generally follow standard ABCD.

8.5.19.4. All programs for drives, PLCs, etc. shall be sufficiently annotated and correspond accurately to electrical drawings.

8.5.19.5. Include all original manuals for components with machinery such as the following: motor drive manuals, operator interfaces, special programming devices, message displays, etc.

8.5.19.6. Provide a Bill of Materials with detailed parts description, manufacturer, and part number. The format should be discussed with the electrical engineering representative. Examples can be provided.

8.5.20. Preferred Electrical Components

8.5.20.1. The following Preferred Components are listed in two groups, "A" and "B". "A" components are preferred as "first choice" and "B" components as "second choice" if no "A" components are applicable.

8.5.20.2. Use of "B" components shall require the approval of the equipment engineer.

8.5.20.3. Obtain approval for substitution of Preferred Components from the equipment engineer.

8.5.20.4. Electrical Components

[This section contains a list of electrical components and brand names for "A" and "B" choices. It is not duplicated here.]

8.6. Pneumatics—Design and Construction

8.6.1. Air Supply—Operate equipment from a single incoming air supply drop. Maximum Supply Pressure—110 psig; Design Pressure—60 psig recommended where possible.

8.6.2. Hardware/Circuit

8.6.2.1. Non-Lubricated System—Use pneumatic devices and circuits which do not require lubrication.

8.6.2.2. Disconnect—Design equipment/fixture to operate from a single quick disconnect (with exhausting, locking valve).

8.6.2.3. Cylinders

1. Use ports with lockable flow control valves.
2. Cylinders used in the vertical orientation and which could pose a hazard to the operator during an air dump shall have a pilot-operated check valve in the exhausting port to keep the cylinder from lowering during an air dump.
3. Use cylinders of the permanently lubricated type.
4. Adjustable cushioning at both ends is preferred.
5. Use rods with self-aligning rod end coupling.

8.6.2.4. Exhaust—to be reclassified, filtered, and directed away from the operator and conform to Class 100,000 working environment.

8.6.2.5. Directional Valves—Modular packages or manifold style are preferred.

8.6.2.6. Do not use Air Over Oil or Air Pressure Intensifiers.

8.6.2.7. Fittings—Use plastic, stainless or brass.

8.6.2.8. Ports—Make all ports NPT wherever possible. If NPT is not available, then BSP shall be used. Devices with ports other than NPT shall be labeled to indicate the port type.

8.6.3. Labels—Clearly identify all devices. Labels shall be located on the structure of the equipment next to the device so that the label remains when the device is changed. Bi-lingual labeling considerations are to be addressed at the discretion of Site Project Coordinator.

8.6.4. Preferred Pneumatic Components

8.6.4.1. The following Preferred Components are listed in two groups, "A" and "B". "A" components are preferred as "first choice" and "B" components as "second choice" if no "A" components are applicable.

8.6.4.2. Use of "B" components shall require the approval of the equipment engineer.

8.6.4.3. Use Preferred Components except when their use is not practical or jeopardizes project delivery.

8.6.4.4. Obtain approval for substitution for preferred components of the equipment engineer.

8.6.4.5. Use standard commercially available components (ISO Standard Preferred) wherever possible.

8.6.4.6. Pneumatic Components

[This section lists pneumatic components and the names of "A" and "B" supplier companies. It is not duplicated here.]

8.7. Software

8.7.1. PLC Software Control Philosophies

8.7.1.1. Logic Location/Recovery—Locate all start/stop logic and equipment control logic in the PLC. This logic shall be retained in PLC memory while the system is down due to normal or emergency stop, or due to power failure. The goal of the PLC logic will be zero recovery; i.e., after a failure has been corrected, restarting the system shall be accomplished by pushing the "start" button.

8.7.1.2. Event Driven—Write software to sequence on events (switch closures) rather than time. Counters, Timers, and One-Shots shall be used only if necessary. If they are used, use as many conditions as practical.

8.7.1.3. Structure—Write PLC software in modules, using tables wherever possible, and arranged in the following order:

1. System start-up
2. Non-motion logic (lights, horns, alarms)
3. Motion logic (solenoids, motors)
4. CIM/HMI interface logic

8.7.1.4. All alarms shall be latched. Alarms shall be cleared by use of an acknowledge button.

8.7.2. Testing Objectives: Test software to ensure proper operation in the following areas.

8.7.2.1. The system performs in compliance with the statement of requirements.

8.7.2.2. The software is error free and executes correctly as defined by the process specifications.

8.7.2.3. That operating faults, alarms, interlocks, and error conditions are detected, and recover as specified.

8.7.2.4. That automatic and manual abort and recovery functions perform as specified.

8.7.2.5. That operator interfaces are correct as specified.

8.8. Machine Guarding
  8.8.1. Refer to MG2468-18 for guarding requirements and suggested types.

9. Appendices
  9.1. Appendix I – Operation and Maintenance Manual
  9.2. Appendix II – Codes and Standards

Appendix I Operation and Maintenance Manual [To be provided by the equipment supplier.] An Operation Maintenance Manual is required for all Automatic Equipment to the extent appropriate to communicate proper operation and maintenance activities. The scope of the manual may range from one page of instructions for simple equipment to a full comprehensive manual for complex equipment.

Appendix II This appendix lists certain Codes and Standards to which the supplier is to adhere.

ADDENDUM B

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A complete copy of these WHS (Workplace Health and Safety) purchasing guidelines can be found at http://us.yhs4.search.yahoo.com/yhs/search?p=HRD-WHS-GUI-070.9+WHS+Purchasing+Guidelines+2013+&hspart=att&hsimp=yhs-att_001&type=att_lego_portal_home.

A footnote on the first page says: "Hardcopies of this document are considered uncontrolled. Please refer to UOW website or intranet for latest version." This is the latest version, having a 2013 March date.

Contents

Advanced Safety Management: Focusing on Z10 and Serious Injury Prevention, Second Edition. Fred A. Manuele.

1 INTRODUCTION

The purpose of this guideline is to ensure that suitable consideration is given when purchasing equipment, materials, facilities, or substances which may have an adverse impact on health and safety. The most effective method of reducing the risk of a hazard in the workplace is through the process of eliminating the hazard from the workplace. Many hazards can be eliminated before they are introduced into the workplace by conducting a risk assessment prior to purchase and upon receipt of goods.

In essence, there are two questions which need to be asked during the procurement process to ensure potential risk of goods and services are identified and controlled before being introduced into the workplace:

- What WHS risks does the intended purchase pose to health & safety?
- How are the WHS risks managed for the intended item to ensure health & safety? e.g., What is the supplier or University required to implement in order to eliminate or minimize the risks associated with the proposed purchase?

2 SCOPE

This guideline is to be applied in conjunction with the University's Purchasing and Procurement Policy and related procedures and applies to any item purchased by the University via orders, tenders, contracts, petty cash, and credit card transactions. The guidelines apply to any purchase of equipment, materials, or substances, including those which are hired, leased, or donated to the University. The purchase of services and/or labor hire should refer to the WHS Contractor Management Guidelines.

3 RESPONSIBILITIES

Deans, Directors, Heads, and Managers of Units are to ensure that the WHS Purchasing Guidelines are implemented within their area of responsibility. Any person in the University who purchases, leases, or hires goods is responsible for identifying WHS requirements for any item which may pose a reasonably foreseeable injury in the workplace and upon receipt, verify that WHS specifications or control measures are in place to eliminate or reduce the risk.

Persons responsible for purchasing activities and payments are to complete the internal training course "Introduction to eProcurement (Purchasing and Payment) System." Persons undertaking the purchase of goods should have the capability to ensure that the item being received is fit for purpose by identifying WHS requirements prior to purchase and then verifying those requirements upon receipt.

Knowledge of this document shall be the base skill, experience, or qualifications used for the safe purchase of products. Other skills, experience, or qualifications for the identification of WHS requirements of specific goods are outlined in Appendix 1.

4 PROCEDURE

Figure 20.B1 illustrates the procedure for identifying WHS requirements and specifications in the procurement process.

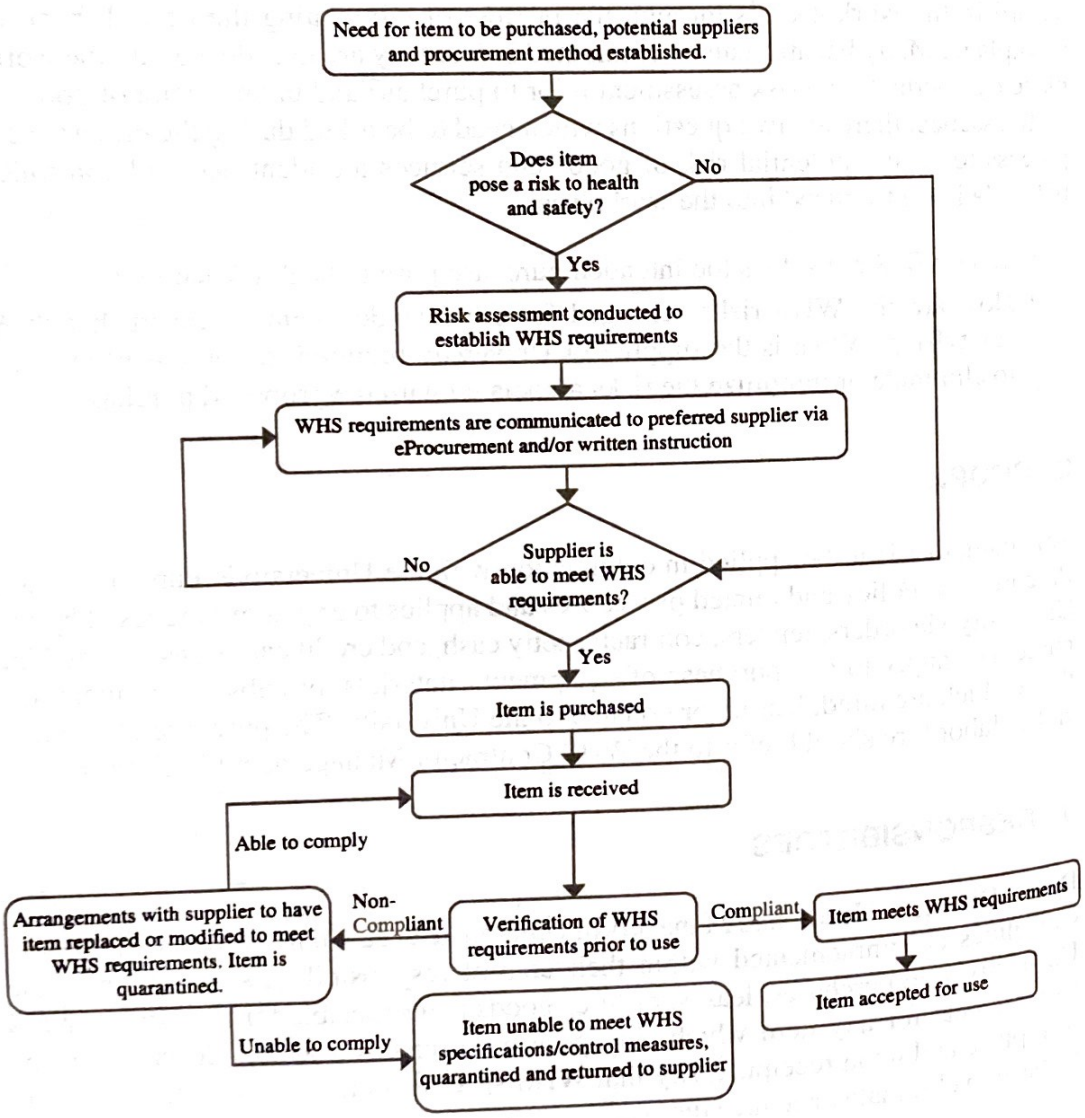

FIGURE 20.B1 Procurement process.

4.1 Determining If an Item Impacts Health and Safety

Any item to be purchased should be evaluated to determine whether the item poses a risk to health and safety. The following questions are an aid in determining whether the item could raise an WHS issue:

- Could a reasonably foreseeable injury or incident occur in the course of normal or unanticipated storage or transport of the item to be purchased?
- Are there any specifications which are required to ensure safe operation or use?
- Does the item need to comply with legislation, codes of practice, or Australian Standards?
- Will a safe work procedure need to be developed to ensure health and safety?

If the answer to any of the above is "yes", then WHS requirements are to be identified to ensure that all safety-related specifications are communicated to the supplier and verified upon receipt.

4.2 Risk Assessment

In some instances the risk assessment is a straightforward process where the WHS specifications or control measures can easily be determined.

Where the item being purchased requires a detailed risk assessment to be undertaken, the appropriate *risk assessment form* shall be used. Examples of when the formal risk assessment is to be used for items which have a risk to health and safety include, but is not limited to:

- Lasers;
- Radiation apparatus;
- Radiation isotopes;
- Biological substances;
- Hazardous substances that are colour coded red on ChemAlert or if the substance is going to be used outside the scope of the MSDS;
- Medical and scientific equipment;
- Mobile vehicles, i.e., forklifts, carts;
- Machinery and plant, i.e., lathes,
- Construction plant and equipment;
- Personal protective equipment, i.e., safety glasses, safety boots, face shields, gloves;
- Ergonomic equipment, i.e., chairs, seating, desks, etc.;
- Custom built equipment;
- Heavy and awkward items which pose a manual handling risk;
- Items which have an "extreme" or "high" risk after completing the UOW Risk Matrix in consultation with users.

The risk assessment should consider the following:

- legal requirements,
- codes of practice or relevant standards,
- potential impact on affected personnel,
- training requirements,
- changes to work procedures,
- personal protective equipment:
- technical data or information.

Once the hazards have been identified, attempts to eliminate the risk from being introduced into the workplace should be attempted prior to supply. Where this is not possible, risk control measures shall be determined to minimise the risk of injury or illness.

Control measures are the requirements which are needed to reduce the risk associated with the hazard to an acceptable level to prevent injury or illness. The method of risk control shall follow the hierarchy of control as outlined in the *WHS Risk Management Guidelines*.

Examples of controls may include substituting the item for something less hazardous which will perform the same function, guarding of moving parts, provision of training and competency assessment, licensing requirements, signage, development of or modification to safe work procedures, or identification of personal protective equipment.

4.3 Risk Control Measures

Requirements and/or risk control measures for WHS are be detailed on the eProcurement purchase order form and provided to the supplier. See Appendix 1 for examples of WHS requirements for common items.

When items are purchased outside the eProcurement system the supplier is to be provided with details of any WHS requirements or risk control measures in writing. This may include WHS requirements listed on either of the following:

- purchase order,
- via a completed risk assessment, or
- a letter outlining specifications.

A list of applicable legislation and WHS specifications is provided in Appendix 1, Examples of WHS Specifications and Control Measures.

4.4 Supplier's Capacity to Comply

It is necessary to ensure that the supplier can meet the requirements as stated in the WHS specifications or control measures. This can be derived through discussions with the supplier on the required WHS specifications in the pre-purchase stage of procurement to ensure the item is fit-for-purpose.

The process of measuring the capacity of a supplier to meet the WHS specifications related to an item shall be documented on the purchase requisition form or other

supporting documentation. The process of measuring a supplier's capacity to meet WHS specification includes checking to ensure that the supplier can meet or exceed the WHS specifications or control measures through the risk assessment process or specifications as outlined in Appendix 1. Should the supplier not have the capacity to comply with identified WHS requirements, the purchase is to be made through another supplier capable of meeting the requirements. Alternatively, the selection of another item that is capable of meeting the WHS requirements could be explored.

4.5 Verification of WHS Requirements

The verification of WHS requirements is required upon arrival of goods to ensure that the WHS requirements or control measures have been met as detailed on the purchase order or risk assessment. Verification should be conducted by the person who ordered the item and/or who conducted the risk assessment to determine the WHS requirements. Verification of WHS specifications are to be documented by the person receiving the goods within eProcurement and included in the risk assessment form.

Examples of verification may include:

- checking to ensure that containers are clearly labelled;
- checking that an item is labelled to indicate that it has been made to comply with the relevant Australian Standard;
- checking the compatibility of the item to be stored in compliance with the dangerous goods requirements,
- ensuring that an item is fitted with physical control measures such as guarding of moving parts.

When WHS requirements or control measures cannot be verified, the item must be quarantined and/or tagged out until the verification is complete. Items that are unable to be verified must be returned to the supplier.

If a hazard is not identified prior to purchase but becomes apparent once the item has been received or used, a hazard report shall be lodged using SafetyNet. The hazard report shall detail the corrective actions required to eliminate or minimise the risk of injury to an acceptable level.

4.6 Repeat Purchases

A risk assessment can be re-used for repeated purchases of the same item or where the supplier has previously demonstrated compliance to WHS requirements. However, if the use or quantity of the item differs and has a greater impact on health and safety, the risk assessment should be reviewed and modified accordingly.

4.7 Standing Orders

Where a standing order has been raised with a supplier, the supplier must indicate in writing via a Memorandum of Understanding that all products being supplied to the University will conform to applicable legislation, codes of

practice, or Australian Standards not limited to those outlined in Appendix 1 of these Guidelines.

Where WHS requirements are identified outside of the Memorandum of Understanding, these shall be outlined in writing to the supplier using the *risk assessment form* prior to purchase.

Products received by the University from a supplier with a standing order are required to be verified for compliance to WHS requirements prior to use.

4.8 Credit Card/Petty Cash Purchases

To ensure compliance with these guidelines the preferred purchase method for items with WHS considerations is the eProcurement process in preference to credit card or petty cash transactions.

When materials or substances are required to be purchased using a credit card or petty cash, the person purchasing the item shall consider the potential for the equipment, material, facility, or substance to pose a risk to health and safety. In particular, prior to the purchase of:

- hazardous substances, the Material Safety Data sheet (MSDS) should be consulted to ensure that controls can be put in place to minimise the risk;
- Personal Protective equipment (PPE) items must comply with relevant Australian Standards.

This will be documented using the *risk assessment form* prior to purchase.

4.9 Consultation

Any proposed changes to the working environment that could place a risk to health and safety must be communicated to all employees who are likely to be affected. This can be achieved via email notification, or as a standing agenda item in the local area's WHS Consultation Structure.

5 RELATED DOCUMENTATION

Use the links below for the following related documentation:

- *Purchasing and Procurement Policy*
- *Risk Management Guidelines*
- *Risk Assessment Form*

6 PROGRAM EVALUATION

In order to ensure that these guidelines continue to be effective and applicable to the University, these guidelines will be reviewed regularly by the WHS Unit in

consultation with the WHS Committee. Conditions which might warrant a review of the guidelines on a more frequent basis would include:

- reported hazards or injuries;
- non-conforming systems;
- WHS Committee concern.

Following the completion of any review, the program will be revised/updated in order to correct any deficiencies. These changes will be communicated via the WHS committee.

7 VERSION CONTROL TABLE

Author's note: Example recordings only appear here.

Version Control	Date Released	Approved by	Amendment
4	February 2008	WHS Manager	Inclusion of training requirements and expansion of Section 4
9	March 2013	WHS Manager	WHS Unit name change and incorporation of Section 4.9

8 APPENDIX 1, EXAMPLES OF WHS SPECIFICATIONS AND CONTROL MEASURES

Author's note: This is a four-page listing of items (Personal Protective Equipment, Hazardous Substances, and Dangerous Goods, Plant, and Equipment) for which Pre-purchase WHS Requirements are recorded that are to be forwarded to the supplier. Also, "Y" or "N" indicators are to be entered in columns indicating, upon receipt, training is needed, inspection and testing is to be done, or there are licensing and registration requirements. Examples follow.

		Upon Receipt		
Item	Pre-purchase WHS Requirement (Forward to Supplier)	Training	Inspecting and Testing	License and Registration
Eye protection	AS 1337: Eye protection for industrial applications	Y	N	N
Radioactive sources	Qualification Required: License to use	Y	N	Y
Machinery	AS 4024.1: Safeguarding machinery—general principles	Y	Y	N