Design-In Health and Safety Specification

Global Common

SD-012

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Forward

This manual supports the Lean Manufacturing initiative and is to be used by Nexteer Automotive Manufacturing Engineers Worldwide as a specification for Manufacturing Equipment Design. In addition, to ensure a safe work environment for all personnel, the following **Lean Vision** was used as a guiding principal in the development of this document:

> Least complicated machine, process, and safety system that protects all personnel from injury and illness.
>
> The intent is to use a common method and consistent implementation worldwide to prevent occupational injuries and illnesses while simplifying equipment. This shall be accomplished by using a risk assessment analysis to identify equipment and process hazards. The “Hierarchy of Health and Safety Controls” shall be followed to eliminate exposure to these hazards. The ultimate goal is to support the operator.

The Manufacturing Engineering Leadership Team supports the Lean Manufacturing initiative because it results in reduced costs, increased customer satisfaction, and our being a stronger company; while at the same time ensuring a safe work environment for our people. We support this specification and expect you to use it in performing this important work.

1. General

1.1. Scope

This specification contains health and safety principles, guidelines, and requirements for the design and redesign of industrial equipment and systems used in processing or manufacturing at Nexteer Automotive. This specification applies, but is not limited to assembly workstations/cells, standard/custom built machines, conveyors, spray booths, ovens, process equipment, material handling equipment, robotic systems, and all related manufacturing systems. This document should be considered a guideline for development, prototype, validation, or lab equipment.

This specification is organized into four segments as follows:

- M&E Design & Design-In Safety Process (sections 1-3)
- Human Interface Applications (sections 4-7)
- Specific Hardware Applications (sections 8 - 9)
- Specific Manufacturing Process Applications (sections 10 - 11)

1.2. Purpose

The purpose of this specification is to provide the Nexteer Automotive manufacturing community—including engineers, skilled trades, safety personnel, and equipment suppliers with the knowledge, tools, and methods to achieve a safe operating environment for all personnel.

1.3. Informative References

See Annex F for a list of informative references. Users of this document shall consult applicable Federal, State, and Local laws, regulations, and standards in addition to those listed in Annex F.

1.4. Application

The requirements of this specification shall be applied to all new Machinery & Equipment (M&E) and manufacturing systems as defined in section 1.4.1, *New M&E and Manufacturing Systems*. Compliance to this specification is not required for existing M&E or manufacturing systems undergoing changes as defined per section 1.4.2, *Existing M&E and Manufacturing Systems*.

1.4.1. New M&E and Manufacturing Systems

New M&E includes the design, engineering, construction, and functional test of the equipment. This new M&E shall follow the Design-In Safety Process outline in this section.

New manufacturing systems shall follow the Design-In Safety Process. Equipment utilized in a new manufacturing system includes:

- Newly manufactured M&E purchased for the new system, or
- Remanufactured M&E that has been upgraded from its original state to meet the requirements of the new system, or
- Existing M&E, which already meets the requirements of the new system, or
- Existing M&E, which has been modified to meet the requirements of the new system.

1.4.2. Existing M&E and Manufacturing Systems

1.4.2.1. Redeploy Manufacturing System

For existing manufacturing systems that are being retooled or mechanically rebuilt and redeployed, it shall be the responsibility of the lead manufacturing engineer to work with Health and Safety to complete the plant's H&S Checklist. This checklist is available on the H&S web site, machine safety checklist. Where H&S issues exist, this document should be used as a guideline to update the safeguarding.

1.4.2.2. Remanufactured M&E

Remanufactured M&E is equipment that is being mechanically, electrically, and fluid power rebuilt to an as-new state. This M&E shall follow the Design-In Safety Process and meet the requirements of this specification.

1.4.2.3. Retooled M&E

For existing M&E that is being retooled or mechanically rebuilt and redeployed, it shall be the responsibility of the lead manufacturing engineer to work with Health and Safety to complete the plants H&S Checklist. Where H&S issues exist, this document should be used as a guideline to update the safeguarding.

1.4.2.4. Modifications to M&E

When making modifications to existing M&E that impact the safeguarding of the equipment, the lead manufacturing engineer and controls engineer are to work with H&S to identify the tasks and hazards impacted by this change. A risk assessment for these task hazard combinations should be completed and the safeguarding upgraded consistent with the agreed risk reduction method (refer to Section 3, *Risk Assessment*, for further detail). **Note:** This document is a guideline for these changes and is not to be used as a requirement.

1.5. Deviations

Any deviations from this standard shall be addressed during Safety Design Reviews and risk assessment with alternative solutions documented and approved by the Engineer in Charge, controls engineer, and H&S representative. Any approved deviations shall only apply to that specific instance, and they shall not be considered a change to this specification or acceptable for future M&E purchases.

1.6. Design-In Safety Process and Associated Tools

1.6.1. Definition and Purpose

The *Design-In Safety* process is an engineering-based closed loop communication process utilizing the Bill of Process (BOP), Best Practice database information, risk assessment, Safety Design Reviews, and Validation information to procure M&E and systems. This process will ensure a common approach for designing best practice safety systems into new and existing M&E and systems.

1.6.2. Design-In Safety Process

The process utilizes Design Reviews for safety including both risk assessment and Validation—as shown in Figure 1-1. The process incorporates existing efforts for Safety Designs that engineering groups are currently performing (e.g. MSD, DFM, PFMEAs, Safety Run-offs, and Safety Sign-off Tag procedures).

Each division is responsible for integrating this Design-In Safety Process with their PDP / equipment procurement process. It is the responsibility of the manufacturing engineer to ensure compliance to this process.

1.6.2.1. Concept/Specifications

At the start of a new program, develop the process/equipment concept consistent with the Global Bill of Process (BOP) and the Manufacturing System Design (MSD). Each type of equipment is to have a section in the M&E purchase specification outlining any appropriate design-in safety requirements for the equipment to be purchased for this process. Feedback from Health & Safety on similar types of equipment, new program implementations, safety design reviews, and risk assessment data will be vital input for continuously improving these M&E purchase specifications.

Where the equipment is well defined, a risk assessment should be conducted at this stage to ensure safeguarding approach is appropriate.

This is the responsibility of the Manufacturing Engineer (ME) in charge (i.e. the ME responsible for purchase of the equipment) and the assigned Controls Engineer (CE).

Figure 1-1: Design-In Safety Process

	Responsibility
Concept/Specifications Focus: Design out hazards and develop specifications based on similar equipment lessons learned.	ME, CE
Quote Equipment	Purchasing
Pre-Award - Quote Review Focus: Ensure supplier commited to Design-In H&S Specification. Note: For off-the-shelf equipment, complete risk assessment prior to puchase	Purchasing ME, CE
Issue Purchase Order	ME Purchasing
Risk Assessment Focus: Complete risk assessment early in the supplier design phase (~2 weeks) - design out hazards, identify safeguarding and cycle initiation	ME, CE H&S
Equipment - Detail Design (Supplier)	
Design Review / Design Approval Focus: Hazards eliminated or designed out, safeguarding design consistent with risk assessment and Design-In H&S Specification.	ME
Build Equipment (Supplier)	
Safety Buy-off Focus: Verify hazards have been designed out or appropriate safeguarding is in place, meets safe distance requirements and implemented consistent with risk assessment. Complete H&S checklist. Documentation to be included with machine run-off data.	ME, H&S
Install equipment on Delphi plant floor	ME Operations
Validation Verify safeguarding in place and functional, recheck H&S checklist, and when complete ME, H&S and Operations to sign off on Safety Sign-off procecure (i.e. red tag procedure) If Controls Lockout Solution is used, follow local validation procedure	ME, H&S Operations

1.6.2.2. Pre-Award – Quote Review

This review occurs after the supplier's quotes have been reviewed and a preliminary supplier selection has been made. The design concept is to be reviewed for consistency with design-in safety requirements outlined in the M&E purchase specifications and is considered the initial safety design review. If the supplier has presented an alternative design approach, the design-in safety requirements may need to be revisited.

For standard off-the-shelf equipment, a risk assessment should be completed prior to equipment purchase to verify that the safeguarding is appropriately implemented.

Note: Where suppliers indicate that their equipment meets national / international standards, a risk assessment should be completed to verify that the safeguarding has been appropriately implemented.

This is the responsibility of the ME in charge, the assigned CE and purchasing.

1.6.2.3. New Equipment Risk Assessment

A "New Equipment" risk assessment is a joint activity conducted on new M&E designs that have proceeded through the initial safety design review, the purchase order has been issued, and the supplier has provided a detailed design concept for review (Reference Section 3, *Risk Assessment*). This risk assessment must be conducted prior to the supplier moving to the detailed design phase. Once the risk assessment has been completed on this new equipment design, this same design can be applied at all other Nexteer Automotive locations. This risk assessment will be stored in the Design-In Health & Safety for Machinery & Equipment Risk Assessment database. Only facility differences where the equipment will be located or how the equipment is tooled would possibly require the existing risk assessment be revised to address those differences.

The two main objectives for this risk assessment are to identify hazards / design them out and to allow plant personnel who will eventually operate and maintain the equipment an opportunity to provide valuable input into the safety systems of the new design. The team consists of engineers from the supplier and Nexteer Automtoive, plant hourly personnel (i.e. operator, jobsetter, skilled trades), and local joint Health and Safety representatives.

This is the responsibility of the ME in charge to ensure that the risk assessment is completed.

The joint training activities, from the technical, safety, and job-related fields will become involved as needed with the risk assessment.

1.6.2.4. Design Review / Design Approval

After the detailed design is submitted for approval, a second safety design review is to take place. This is to ensure that the design is consistent with the design-in safety requirements, the risk assessment for the equipment,and the Design-In concepts outlined in this document.

This is the responsibility of the ME in charge and the assigned CE.

1.6.2.5. Safety Buy-Off

The third and final safety design review normally occurs during or prior to equipment run-off at the supplier or integrator site or as specified in the purchase order. ME and Health and Safety personnel are to ensure that the M&E Safety Checklist, all safety elements outlined in the safety design reviews, and the risk assessment have been implemented appropriately.

1.6.2.6. Validation

The validation process is conducted at the plant to validate that the key safety deliverables have been completed. Validation activities shall be conducted and passed before the equipment or system is released for production. The risk assessment outputs of Lockout, Controls Lockout Solution (CLS), Engineered Controls, and Other Safety Measures will be used in the validation process to ensure that all safety items meet their intended use related to a specific task(s). The ME and local Health and Safety personnel will complete the Equipment Safety Sign-Off (e.g. red tag) procedure, review the M&E Safety

Checklist, and validate the final placards. For automated Robotic and Machining Cells, refer to Annex B - Test Sequence Design Requirements to field test Lockout and CLS.

To assist in validation of safety components and circuits, refer to SD-011, Specification for Safety Circuits. This information could also be used for preventative maintenance verification of safety components and circuits or for annual safety system checks. In addition, they could be used for verification of the safety system after safety components are replaced.

1.6.3. Feedback & Design Improvement Link

The application of the best safety practices for new equipment designs is essential to the Design-In Safety process. The risk assessment for the equipment will be stored in the Design-In Health & Safety for Machinery & Equipment risk assessment database for future reference.

2. Hierarchy of Health and Safety Controls

The hierarchy represents the fundamental principles that govern the application of safety designs, which eliminate or reduce risk caused by exposure to hazard(s) based on specific task(s) performed. This specification is based on the hierarchy principles.

The hierarchy consists of five levels—arranged in order from the most effective to the least effective—as shown in Figure 2-1. The preferred method of controlling hazards is via a level 1 or 2 control.

Figure 2-1: Hierarchy of Health and Safety Controls

Table 1 indicates the effectiveness of health and safety controls and the associated value and costs.

Table 1: Effectiveness of Health and Safety Controls

Effectiveness	Control Solutions	Value	Costs
Most	Eliminate or Substitute	Hazards are eliminated or reduced.	Long-term costs reduced or eliminated.
⇩	Engineering Controls	Exposure to hazards is controlled.	Potential for higher initial costs, however, offset by reduced long term costs.
⇩	Warnings	Alerts people that hazard(s) exist.	Costs to maintain and implement.
⇩	Training and Procedures (Administrative Controls)	Only trained personnel operate and maintain equipment. Safe operating practices and procedures are established.	Costs associated with training/retraining. Resources to establish Safe Operating Practices.
Least	Personal Protective Equipment	Provides a personal/last resort barrier to hazards.	Recurring operating costs associated with the use and maintenance of personal protective equipment.

2.1. Applying the Hierarchy of Health and Safety Controls

The basic thought process must recognize the work to be done, evaluate the hazards and exposures associated with the tasks, and provide the most effective H&S control solutions.

Safety for all processes, cells, and machines shall be addressed through the Hierarchy of Health and Safety Controls. The following examples are intended to provide a better understanding of the hierarchical approach. Refer to Annex D for illustrations of these examples.

1. Elimination or Substitution:
   a. Eliminate equipment
   b. Simplify equipment
   c. Improve initial equipment design
   d. Remove/minimize human interaction with equipment
   e. Eliminate pinch points
   f. Eliminate or simplify material handling
   g. Place adjusting devices and other requirements for human interaction outside the hazard area
   h. Substitute less hazardous processes and/or chemicals
2. Engineering Controls:
   a. Perimeter guards
   b. Light curtains
   c. Safety mats
   d. Interlocks
   e. Safety relays, switches and other control devices
   f. Ventilation, local or point of operation exhaust
   g. Automatic/Manual material handling (e.g. lift for ergonomics issue)
   h. Movable interlocked guard
3. Warnings:
   a. Lights, beacons and strobes
   b. Computer warnings
   c. Signs
   d. Markings indicating a restricted space on the floor
   e. Equipment start-up alarms, beepers and horns
   f. Labels
4. Training and Procedures (Administrative Controls)
   a. Safe operating practices and procedures
   b. Standardize Work
   c. Job rotation
   d. Written training programs

   Note: Written training, procedures, and administrative controls are used when higher-level alternatives are not feasible, and when the risk is adequately controlled. Personnel must be properly trained before operating and maintaining equipment. This includes being provided with up-to-date and accurate written instructions (Safety, Standardized Work, Set-up, Start-up, Run, Stop, etc.). The training and instructions must be implemented, enforced and followed.

5. Personal Protective Equipment (PPE):
    a. Face shields
    b. Safety glasses
    c. Hearing protection
    d. Gloves
    e. Protective sleeves
    f. Respirators
    g. Welding screens
    h. Expendable tools

3. Risk Assessment

A task based risk assessment is a systematic process for evaluating all operation and maintenance tasks and their associated hazards. Task-hazard pairs are analyzed for risks in the hazardous area where environmental (work area) conditions (i.e. equipment motion paths and speed, blind spots, fumes, mists, etc.) could potentially cause harm to the person performing the task. Group recommendations are then captured based on the above analysis.

Figure 3-1: Risk Assessment Process

3.1. Requirements

A number of methodologies are available to do a risk assessment. The following risk assessment process is one methodology that meets the requirements for an accurate and thorough risk assessment. This process is consistent with ANSI B11.TR3 and the future direction of ISO 14121.

The requirements for the risk assessment are listed below:

1. Nexteer Automotive personnel and the supplier shall perform the risk assessment early in the design process. Every effort shall be made to design-out hazards and design-in safety.
2. Nexteer Automotive and the supplier shall ensure that the risk assessment accurately represents the equipment, as delivered to Nexteer Automotive. Where the supplier deviates from the original risk assessment, Nexteer Automotive approval is required.
3. The steps in a risk assessment include the following:
   a. Assume that no safeguards are installed and identify all task-hazard combinations per 3.2.
   b. Determine the level of risk for each task-hazard combination per 3.3.
   c. Determine the risk reduction category for each task-hazard combination per 3.4.
   d. Design-out the hazard and if not possible, select the safeguard performance and/or circuit performance per 3.5.
   e. Document the risk assessment per 3.6.

3.2. Task and Hazard Identification

The requirements for the task and hazard identification are listed below:

1. Identify all reasonably foreseeable tasks associated with the equipment and/or process (e.g. users: material handler, operator, set-up person, skilled trades, passer-bys).
2. Identify hazards associated with each task. Hazards shall be identified in all aspects of equipment operation including, but not limited to:
   a. Equipment unexpected and expected motions (e.g. advance, raise, close, rotate, etc.) that the user is exposed to, if the motion creates a bump, pinch, crush, cut, sever, puncture, entanglement, etc.
   b. Material handling tasks where the user is exposed to:
      - Ergonomics
      - Thermal – hot parts, hot surface
      - Part handling – sharp edge or burr, oil on part, coolant on part
      - Slips/trips/falls/egress
   c. Process hazards:
      - Chemical/toxicity - oil, coolant, mist, etc.
      - Noise
      - Projectile – flying chips, weld splatter, parts, tools, hot plastic, etc.
      - Weld flash, lasers, etc.

3.3. Risk Estimation

For each task-hazard combination, determine the level of risk using severity, exposure, and avoidance factors per Table 2. Where multiple criteria can apply, use the most restrictive criteria.

Table 2: **Hazard Severity/Exposure/Avoidance Categories**

FACTOR	CATEGORY		CRITERIA
Severity	**S2**	Serious injury	Normally irreversible including death (3.3.1)
	S1	Slight injury	Normally reversible (3.3.1)
Exposure	**F2**	Frequent exposure	Frequent to continuous (greater than once per hour) or the exposure time is long (greater than 15 min) (3.3.2)
	F1	Infrequent exposure	Seldom to less often (less than once per hour) and the exposure time short (less than 15 min) (3.3.2)
Avoidance	**P2**	Not likely	Scarcely possible (3.3.3)
	P1	Likely	Possible under specific conditions (3.3.3)

3.3.1. Severity of injury

In estimating the risk arising from a failure of a safety function, slight injures (normally reversible) and serious injuries (normally irreversible) and death are considered.

To make a decision the usual consequences of accidents and normal healing processes should be taken into account in determining S1 and S2. For example bruising and/or lacerations without complication would be classified as S1, whereas an amputation or death would be S2.

3.3.2. Frequency and/or exposure to a hazard

F2 should be selected if a person is frequently or continuously exposed to the hazard. It is irrelevant whether the same or different persons are exposed to the hazard on successive exposures, for example the use of lifts. The frequency parameter should be chosen according to the frequency and duration of access to the hazard.

Where the demand on the safety function is known by the designer, the frequency and duration of this demand on the safety function can be chosen instead of the frequency and duration of access to the hazard. In ISO 13849, the frequency of demand on the safety function is assumed to be more than once per year.

The period of exposure to the hazard should be evaluated on the basis of an average value which can be seen in relation to the total period of time in which the equipment is used. For example, if it is necessary to reach regularly between the tools of the machine during cyclic operation in order to load/unload parts, then F2 should be selected. If access is only required from time to time, then F1 should be selected.

For operator tasks like load/unload, a reach by the operator into a hazardous area away from the load/unload point should be considered as an infrequent exposure (F1) because reaching beyond the load point would not take place very frequently. If there is always exposure to a hazard, this would not apply (for example running chain, belt & pulley, etc.).

3.3.3. Possibility of avoiding the hazard or limiting the harm

It is important to know whether a hazardous situation can be recognized and avoided before leading to an accident. For example, an important consideration is whether the hazard can be directly identified by its physical characteristics, or recognized only by technical means, for example indicators. Other important aspects, which influence the selection of parameter P include, for example:

- Operation with or without supervision;
- Operation by experts or non-professionals;
- Speed with which the hazard arises (for example quickly (> 250 mm/sec (10 in./sec)) or slowly);
- Possibilities for hazard avoidance (for example by escaping);
- Practical safety experiences relating to the process.

When a hazardous situation occurs, P1 should only be selected if there is a realistic chance of avoiding an accident or of significantly reducing its effect. P2 should be selected if there is almost no chance of avoiding the hazard.

Note: If exposed to a hazard that is not in plain view, P2 is to be selected (for example such as working in a robot cell facing the cell tooling with the robot behind you).

When loading to the point of operation, the tooling design and part handling determine if the operator is likely to avoid exposure to hazardous motions. The tooling should be designed to reduce exposure to the hazardous motions and the operator trained to handle the parts such that it is likely to avoid hazardous motions (P1).

3.4. Risk Reduction Determination

Using the Severity, Exposure and Avoidance factors for each task hazard combination obtained from Table 2, follow across Table 3 to determine both the safeguard category and circuit performance.

Table 3: **Risk Reduction Decision Matrix - Safeguard Category / Circuit Performance**

<table>
<tr><th>SEVERITY</th><th>EXPOSURE</th><th>AVOIDANCE</th><th>SAFEGUARD CATEGORY</th><th>CIRCUIT PERFORMANCE</th></tr>
<tr><td rowspan="4">S2 Serious injury (normally irreversible)</td><td rowspan="2">F2 Frequent exposure</td><td>P2 Not Likely</td><td>R4</td><td>Cat 4</td></tr>
<tr><td>P1 Likely</td><td rowspan="4">R3</td><td>Cat 3</td></tr>
<tr><td rowspan="2">F1 Infrequent exposure</td><td>P2 Not Likely</td><td rowspan="2">Cat 2</td></tr>
<tr><td>P1 Likely</td></tr>
<tr><td rowspan="4">S1 Slight injury (normally reversible)</td><td rowspan="2">F2 Frequent exposure</td><td>P2 Not Likely</td><td rowspan="2">Cat 1</td></tr>
<tr><td>P1 Likely</td><td rowspan="2">R2</td></tr>
<tr><td rowspan="2">F1 Infrequent exposure</td><td>P2 Not Likely</td><td rowspan="2">Cat B</td></tr>
<tr><td>P1 Likely</td><td>R1</td></tr>
</table>

Note: This table assumes that no safeguards are installed.

3.5. Safeguard Selection

All effort shall be made to eliminate or reduce hazards to the lowest possible risk category level. If hazard elimination or substitution through equipment design is not possible, then use the risk reduction category determined by Table 3, follow across Table 4 to determine the minimum required safeguard and/or circuit performance.

Table 4: **Safeguard Selection Matrix**

CATEGORY	SAFEGUARD PERFORMANCE
R4	Hazard elimination or hazard substitution (3.5.1)
R3	Engineering controls preventing access to the hazard, or stopping the hazard (3.5.2): • prevent access - fixed barrier or interlocked guard/door • stop the hazard – two hand control, light curtains, safety mats, or other presence sensing devices
R2	Non-interlocked barriers, clearance, warnings, and training & procedures (3.5.3)
R1	Personal Protective Equipment (3.5.4)

Note 1: Application of the Safeguard Selection Matrix (Table 4) is primarily intended for machinery and equipment related task and hazard combinations. Certain task and hazard combinations such as material related tasks that include exposure to sharp parts, thermal, and ergonomic hazards require the application of the most effective level of feasible safeguarding based on the hierarchy of controls (Figure 2-1, Section 2) and fall outside the scope of Table 4. Appropriate standards and regulations should also be consulted. The only acceptable means of addressing category R4 and R3 hazards is first by elimination/substitution and then by engineering controls.

3.5.1. Category R4 Risk Reduction

Risk reduction shall be accomplished by hazard elimination or hazard substitution that does not create an equal or greater hazard. When hazard elimination or substitution is not possible, all provisions of a category R3 risk reduction shall apply and provisions of categories R2 and R1 shall be used for safeguarding residual risk.

3.5.2. Category R3 Risk Reduction

Safeguarding shall be by means that prevent access to the hazard, or cause the hazard to cease. Provisions of categories R2 and R1 may be used for safeguarding residual risk.

3.5.3. Category R2 Risk Reduction

Safeguarding, at a minimum, shall be by means of non-interlocked barriers, clearance from the hazard, warnings (audio/visual), and administrative controls (training and procedures). Provisions of Category R1 may also be used for safeguarding residual risk.

3.5.4. Category R1 Risk Reduction

Safeguarding, at a minimum, shall be by personal protective equipment if applicable.

3.5.5. Circuit Performance

The circuit performance, as determined in Table 3, is consistent with ISO 13849-1 (EN 954-1). Refer to definitions as outlined in Annex E. Safety circuits shall be implemented per SD-011, Specification for Safety Circuits.

3.6. Documentation

The risk assessment will be documented and updated as required during the equipment design, build, and safety run-off. At a minimum, the file must contain lists of tasks, hazards, risk reduction category, and safeguards selected to validate and record the risk assessment requirements of 3.1 through 3.5. This assessment will be passed on to the successor responsible for installation/integration and be incorporated in the manufacturing systems risk assessment where appropriate. Risk assessment data is to be stored in the Design-In Health & Safety for Machinery & Equipment risk assessment database.

4. Workstation Design/Operator Interface

Ergonomics-related-injury/illness is a major subset of all health & safety incidents especially realized in industrial and manufacturing environments. A key strategy for reducing the number of ergonomics related injuries/illnesses is to integrate ergonomics guidelines early in the design stages of equipment and processes. Not only will the early integration of ergonomics guidelines minimize injury risk factors, it will also improve the performance factors of all those who operate or interact (maintenance, skilled trades, and material handlers) with the equipment/process.

To provide a standardized approach for all Nexteer Automotive locations worldwide, a requirements document, implementation tools, and training have been developed and are documented on the Nexteer Automotive ergonomics website.

4.1. Two Steps to Safe and Efficient Ergonomic Designs:

4.1.1. Know the requirements

Design-In & Ergonomics Integration Requirements document outlines the activity that standardizes the integration of ergonomic specific activity. This required document also defines the roles and responsibilities of all parties involved. It is located on the Nexteer Automotive ergonomics website.

4.1.2. Use the tools

The *Design-In Ergonomics Guidelines* (DEG) quantifies the basic ergonomic design criteria for new products, processes, and equipment. The tool that corresponds to the DEG is the *Design-In Ergonomics Checklist*. The intent of the seven step checklist is to address commonly missed ergonomics concerns and to function as a 'thought-starter' for unique or special circumstances that may exist.

The seven steps of the Design-In Ergonomics Checklist are:

1. Gather Lessons-Learned
2. Product Design
3. Equipment/Workstation Design
4. Hand Tool Design
5. Material Handling
6. Total System/Process Design
7. Containers/Packaging Design

Finally, the ergonomics analysis of 'what-if' scenarios is recommended during the design stage. For this activity, second-level analysis tools are available. These second-level tools are computer-aided programs that are quick and easy to use and provide data outputs to specific data inputs. Types of activities that can be analyzed include: one and two handed lifting/lowering, material handler routes, push/pull/carry activity, forceful exertion and awkward posture analysis, and energy expenditure.

5. Maintenance

This section provides design guidelines to enhance safety as it pertains to the maintenance of machinery and equipment. The focus is on providing safe, easy, and quick access for operators, skilled trades, and other personnel who may perform machinery maintenance.

5.1. Requirements

The following requirements enhance safety while performing maintenance on work cell equipment. The supplier shall work with the responsible engineer to ensure the following requirements are met:

1. All energy-isolating devices on each piece of equipment shall be placed at the access points to minimize the time and travel required for a proper system/safety lockout and restart.

   Note: These devices should be located at a maximum height of 5½ feet (1.7 m) from the floor/platform level. For minimum height, reference SD-017, *Design-In Ergonomics Guideline* (DEG). Recommended mounting heights are between 16 and 66 inches (406 and 1680 mm). International references include ISO 9241, 11226 and 11428.

2. Provide safe access and working space as well as clear visibility within and around all control panels.

   Note: This should apply to all controls including electrical, pneumatic, hydraulic, and mechanical.

3. Locate and mount the system function controls and monitoring devices outside the hazardous area while ensuring clear visibility, reference Lean Equipment Design. Ergonomic factors regarding posture and visual requirements shall be considered, reference SD-017.

   Examples of these devices are as follows:
   - Lubrication fill and monitoring
   - Valves and flow controls
   - Meters and gages
   - Diagnostic equipment
   - Hydraulic units
   - Operator interface device

   Note: Recommended mounting heights are between 16 and 66 inches (406 and 1680 mm).

4. Equipment design shall consider the following mechanical safety issues:

   a. Eliminate the potential for stored energy, such as:
      - Hydraulic
        - Accumulators
      - Pneumatic
        - Pilot operated checks
        - Blocked center valves
        - Standard ball valves
      - Spring Loaded (coil, torsional, etc.)
      - Vertical Loads
        - Counter balance valves
        - Pilot operated checks
        - Rod brakes
        - Shot pins

   b. Eliminate sharp edges on all surfaces except where required (e.g. tooling)

   c. Counter-balance weights and cables

5. Eliminate/control exposure to hazardous motion for tasks that require the equipment to be in the automatic mode in order to perform the task (e.g., vibration analysis requires either safe access for measurement or permanently mounted transducers, infrared diagnosis, etc.).

   Note: By eliminating or controlling personnel exposure to hazardous motion, analysis, troubleshooting, or planned maintenance procedures can be safely performed.

6. Design to eliminate maintenance tasks that require climbing to or working at an elevated location. If this is not possible, other fall prevention and/or protection measures must be provided, reference the specifications listed in Section 6*, Falls and Working Surfaces*.
7. Provisions shall be made for direct, task (maintenance) lighting as part of a system to provide greater visibility during routine maintenance and service, reference SD-017.
8. Identify hazard zones (e.g., areas that are not completely enclosed within safeguards) by utilizing the following methods, as applicable:
   a. Painted floor markings
   b. Column markings
   c. Flashing lights to indicate the unsafe area

   This identification reduces the potential for injury in areas of risk outside the normal traffic patterns.
9. Specify the detailed training for proper maintenance and service techniques on all equipment and/or systems. In the interest of both safety and efficiency, proper preventive maintenance and repair training are a necessity.
10. Provide a detailed list of preventive maintenance tasks including specific safety precautions to be added to the site P. M. recordkeeping system.
11. To ensure that maintenance and service tasks can be safely performed, training shall be provided for all new manufacturing systems. Specific equipment training shall be identified by the supplier and / or the risk assessment team during the design-in risk assessment.

5.2. Design for Electrical Safe Work Practices

To enhance safety while performing maintenance on electrical equipment, the design shall include hazard control for identified electrical maintenance and troubleshooting tasks. These hazards typically include electrical shock and/or arc flash/blast.

Safe Work Practices for the control of electrical hazards include, but are not limited to, the following:

1. SOP,
2. Establishing safe approach distances,
3. Electrical testing, and
4. Use of appropriate PPE.

Electrical equipment shall be designed to control the exposure to shock and arc flash hazards. The following items may be part of the design:

1. Arc-flash limiting devices
2. Low voltage control system
3. Proper safety grounding
4. Protective shields and barriers
5. Touch-safe components
6. Physical separation of hazardous voltage levels
7. Access for programming/diagnostics to be provided external to enclosure, reference SD-004 section 11.3.5.1

For additional information on electrical safe work practices, see Nexteer Automotives *Standard for Electrical Safe Work Practices – ESWP.*

6. Falls and Working Surfaces

This section identifies the design requirements for the prevention of falls and the control of fall hazards.

Historical data from the last 30 years indicates that falls are a leading cause of occupational fatalities and serious injuries. The vast majority of these incidents occurred while employees were climbing or working at elevations. Consideration of potential fall hazards during the design stage with a focus on fall prevention vs. fall protection will eliminate or reduce hazards and future retrofit costs. It will also facilitate quick preventive maintenance task completion.

6.1. Fall prevention and protection from elevations

Whenever performance of any task would allow a worker to fall a distance of 1.8 m (6ft.) or more, fall prevention or protection measures must be designed-in to prevent the potential for a fall. Tasks that expose a worker to a fall hazard from > 1.8 m (6ft.) to 0.4 m (16 inches) shall use fall prevention techniques, such as hand rails, to eliminate the potential for a fall unless other wise specified in the M&E purchase specification. Work platforms that are 0.4 m (16 inches) and higher must have appropriate means of access. Stairs are the preferred means of access.

Note: Please consult the Nexteer Automotive, Facilities Group *Fall Prevention Program Requirements & Safety Systems* Version 2 for additional specific requirements.

The following shall be considered during the fall prevention design-in process:

1. The shutoff valves, controls, monitoring equipment, maintenance service apparatus, and similar items should be located at readily accessible floor or grade levels.

   If this is not possible, fall arrest systems including approved anchorage points shall be established in order to protect personnel working at elevations.

2. Overhead equipment or machinery on rails shall be designed so that it can be positioned for maintenance or repair in an area where fall hazards are controlled.

3. A means of access/egress shall be designed for maintenance and service that cannot be performed at readily accessible floor or grade levels. The design shall provide a means for safe access that reflects an anticipation of unplanned maintenance events and engineering of fall prevention measures.

4. The following climbing devices shall be used in the order listed below. These devices shall meet all applicable laws and regulations:

   a. Fixed stairs

   b. Alternating tread-type stairs

      These stairs should be used in limited space applications. They are designed at inclines of 50°-70° and equipped with handrails.

   c. Vertical ladders

      These ladders are the least desirable devices. They should only be used for infrequently (once or twice per week) accessed maintenance locations where floor space for fixed or alternating tread-type stairs is not available.

   Stairways, guarded platforms, and ramps provide safer access than portable lifting devices and ladders. All steps, ladder rungs, ramps, and working surfaces should have a “non-slip” surface.

   When ladders are included in the design, all tasks performed shall provide the capability for a worker to continuously maintain a three-point contact.

   Methods for moving tools and equipment to elevated areas shall be a part of the design.

5. A means of anchorage shall be designed for personal fall arrest systems when fall hazards cannot be eliminated or controlled.

   a. Proper anchorage / attachment points must be on the “anticipated” tasks list of things to be performed.

b. A qualified person who is knowledgeable of the design requirements for fall protection equipment shall determine the proper equipment and appropriate anchorage. Designed and installed anchorage points are the responsibility of the equipment supplier. Anchorage points must be clearly labeled per the Nexteer Automotive Facilities Group *Fall Prevention Program Requirements & Safety Systems* Version 2.

6.2. Fall Prevention & Protection from the same grade or floor level

1. All equipment shall be manufactured with the expectation that it will not leak equipment fluids and process fluids.
2. Provisions shall be made to capture, contain, or eliminate any coolant fluids and/or mists that might contribute to slips and fire hazards.
3. All equipment / machine installations shall minimize tripping hazards. Consideration shall be given to covering cables, pipes, and conduits or routing them overhead. Flexible drops shall be installed neatly per Nexteer Automotive Controls Best Practice - *Flexible Utilities Connections,* CEBP9801.
4. Newly poured or painted floors must have a coefficient of friction that will provide a safe walking and working surface. Reference OSHA 1910.22.
5. Holes in floors and platforms shall be properly marked and guarded appropriately for the severity of the hazard. Proper guardrails (42 inch (1.06 meter) guard rail with mid rail) and/or load rated covers shall be provided in industrial vehicle traffic areas. Floor covers must be rated to support the weight of the heaviest industrial vehicle, including any load the vehicle may carry. Floor covers must be marked with the maximum floor load rating.

6.3. Fall Hazard Control on Roofs

Consideration shall be given to reducing the number of equipment installations and stand-alone enclosures on the roof. Where roof-mounted equipment is necessary, the following requirements shall be followed:

1. Equipment shall be located at least 10 feet (3 meters) from the edge of the roof.
2. Perimeter guarding of roofs shall be installed for new buildings, additions, or major renovations.
3. The need for skylights, heat-release vents, and other roof openings shall be eliminated whenever possible.
4. Heat-release vents shall have guarding installed under the vent capable of withstanding 40 lbs per square foot or 1000 lbs concentrated load for personnel fall protection. This guarding shall not impede airflow.
5. Guarding shall be provided at all hoisting areas.
6. Roof areas shall be designed to eliminate the need for a worker to step across roof openings.
7. Access / egress to the roofs shall be provided by fixed stairs and properly marked doors.
8. Safeguarding shall be designed to protect workers from exposure to electrical shock from wires alongside or near the building.

7. Industrial Hygiene

This section of the specification provides the design engineer with basic information on new chemical approval and usage. If design questions arise, contact your divisional industrial hygienist.

7.1. Chemical Management

Requirements associated with bringing chemical materials onto a Nexteer Automotive site are highlighted below. All chemical materials proposed for use in production, research, and/or maintenance activities shall be approved prior to their purchase and use.

1. Obtain an updated Material Safety Data Sheet (MSDS) from the manufacturer / supplier.
2. Review the MSDS. Eliminate the use of chemical materials that require atmospheric controls, personal protective equipment, or costly disposal measures when possible.
3. Minimize the potential for employee exposure to chemical materials (i.e. through inhalation, ingestion, or by skin contact).
4. Utilize the Chemical Material Assessment Procedure (CMAP), CPR 12.5.4-1. (See the link to the CMAP on the Nexteer Automotive Business Systems Common Procedure Requirements web page.)
5. Obtain and complete a CMAP Request Form and submit it along with the MSDS to Nexteer Automotive Facilities Group.
6. A completed CMAP review, highlighting employee exposure, personal protective equipment, fire protection, environmental issues, etc. associated with the chemical will be returned.
7. Submit the CMAP review to the local HMCC, or whoever reviews/approves chemicals at the site, for review and approval.
8. Hazardous material information must be communicated to the user prior to using the material. This includes non-hazardous materials, which can release hazardous materials when used (e.g. grinding, welding).
9. Chemical approvals apply only to the specific use for which it was approved at a given site. Approval does not automatically transfer to include the use of the same material at another location. Separate approvals are required for each proposed use at each proposed location.
10. Process changes requiring the introduction of new chemical materials or process changes that could reasonably increase the potential for exposure to existing chemical materials shall be approved in advance.

7.2. Ventilation/Exhaust

This section provides guidance on the proper design, installation, and operation of process ventilation systems.

All new operations and/or processes that are potential sources of airborne contaminants shall be thoroughly reviewed to determine the need for supply and exhaust ventilation. Sufficient conditioned make-up air must be provided in order to maintain equal pressurization within the work facility with respect to the outside, and to ensure other building ventilation systems operate at peak efficiency. Contact your facility engineer or industrial hygienist for assistance.

If a review affirms the need, local exhaust ventilation shall be the preferred method for the removal of airborne contaminants, especially when: contaminants are hazardous in nature; emission rates are high and variable; workers are located next to emission sources; and the contaminant type requires it (particulates). General ventilation for the purpose of contaminant dilution is an option provided: the contaminants are of a low hazard nature; emission rates are low and uniform; the emission source(s) is remote from the worker(s); and the contaminant type is a gas or vapor.

The final step in the installation process must be testing and documentation. This will verify that the ventilation system is functioning as intended, and operating parameters such as airflow, static pressure, fan amps, and filter differential pressure are recorded for future reference. There must also be a drawing of the entire installation. The drawing must show how and where all measurements were taken.

When controlling contaminants through process ventilation, personal exposures shall be reduced to a maximum of 1/10th of the applicable permissible exposure limit.

Process ventilation shall be designed in accordance with established principles of air flow following a recognized method, such as found in "*Industrial Ventilation: A Manual of Recommended Practice"*, published by the American Conference of Governmental Industrial Hygienists (ACGIH). Canopy exhaust hoods are not appropriate at employee workstations because of their tendency to draw contaminants through a worker's breathing zone. Exhaust stack height, location, and exit velocity shall be designed to minimize the reintroduction of exhaust emissions into the facility.

A system performance monitor, such as an aneroid static pressure gauge, should be located at or near the operator's work station. This gauge shall be color-coded to indicate the following:

- Normal operating condition (recommended color – green)
- Change filter condition (recommended color – yellow)
- Immediate service condition (recommended color – red)

In general all process ventilation exhaust should be exhausted to the outside. Air that is re-circulated from process ventilation shall meet the criteria described in ANSI Z9.7, *Recirculation of Industrial Process Exhaust Systems*. Ventilation systems shall be designed and installed so as to reduce or eliminate additional health and safety hazards that may be created, for example, during periodic maintenance (falls, confined spaces, etc).

7.3. Mist Control

Significant respiratory effects have been associated with worker exposure to the mist / aerosol generated by production machining operations. These effects include symptom complaints such as cough, sinus, shortness of breath, cross shift lung function drop, occupational asthma, and hypersensitivity pneumonitis.

In order to minimize worker exposure, the following design issues should be addressed and considered in order to reduce mist generated by production machining operations:

1. Fluid delivery:
   a. Select intrinsically safe fluids with low misting characteristics.
   b. Cycle coolant on and off as required for machining or flushing chips.
   c. Minimize fluid delivery pressure (velocity) and flow rate (GPM).
   d. Minimize and remove contaminants in order to preserve the tools.
   e. Coolant tanks should be covered
2. Machine tool design:
   a. Employ efficient chip shedding and control methods.
   b. The following machine design parameters correlate directly with increased misting levels: tool speed, wheel speed, and worn tooling.
   c. Consider alternatives to metalworking methods that require high pressure.
3. Machine enclosure design:
   a. The machine enclosure must be capable of containing within its envelope the mist and vapor produced within that envelope while operating under the design airflow.
   b. Enclose the process as completely as possible to minimize exhaust requirements while allowing for easy access to maintain the machine and provide tool changes.
   c. Automatic opening and closing doors shall be considered where possible for loading and unloading parts.
   d. Use a perimeter slot draw where possible across the highest point on the machine enclosure, not single one-hole entries.

e. Make-up air inlets shall be strategically placed and below the point of metal cutting with a minimum in-draft velocity of 250 feet (76 meters) per minute. Inlets location and design should not allow coolant to splash out or become obstructed with chips. Exhaust volume requirements should be determined to ensure that all cracks and un-sealable openings have an in-draft velocity of 250 feet (76 meters) per minute.

4. Ductwork design:
   a. Design the system to be leak-free (no spiral duct or duct with mechanical seams)
   b. Employ industrial construction (~16-18 gauge) should the duct fill with liquid. All gasket and seal materials should be compatible with the metal working fluids.
   c. Slope the ductwork toward the mist collector where possible to minimize the use of traps or airlocks. If traps are required design with consideration for easy sludge and chip removal.
   d. Airflow and air velocity should be designed for mist control, not chip removal. Duct transport velocity between the machine tool / equipment and main branch should be maintained at or below 2000 feet (610 meters) per minute. Main branch velocities can be increased, as necessary for system balance.
   e. Only use flexible duct at the machine tool / equipment connection, and keep as short as possible.
5. Mist collector design:
   a. Only collectors providing 95% filtration efficiency or greater shall be specified.
   b. The most efficient collector designs are (typically) multiple-stage. The collector design, however, should not permit the re-entrainment of mist between filtering stages.
   c. The collector housing / plenums should be designed for equal airflow across each filter element.
   d. Only collectors requiring minimal manual maintenance shall be specified. First stage separators shall be of the self-cleaning mechanical type, and designed for cleaning while in operation. Maintenance on the final stage shall be performed from the exterior of the unit (not requiring housing entry).
   e. The collector housing design shall be air and water tight; shall withstand a differential static pressure of 4000 Pa (about 10” w.c.); shall have a sloped bottom with drains and airlock to facilitate removal of liquids and solids.

7.4. Noise Control

Nexteer Automotive has developed a *Sound Level Specification* SL 1.0 For The Purchase Of New, Rebuilt and Relocated Machinery, Powertools and Equipment. This design-in specification establishes:

1. Sound Level limits for all NEW, REBUILT and RELOCATED machinery, power tools and equipment.
2. Measurement procedures, measurement instrumentation requirements, machine operating conditions, and the format for reporting machine certification data.
3. Supplier and Purchaser responsibilities.
4. Procedures for approving equipment at variance with the specified limit.

It is the responsibility of the design engineer to ensure that the SL 1.0 specification and any supplemental local sound level specifications are issued with the Request for Quotation for all machinery and equipment, which generates noise in its normal mode of operation.

It is expected that feasible noise controls, whether by elimination, substitution, and/or engineering will be an integral part of the safety design and build of equipment -- not an optional add-on at an additional (and often premium) charge/cost. The fulfillment of this expectation on the part of the Machinery/Machine Tool/Equipment builder should be a major consideration in the supplier selection process (*See Health and Safety Common Core Element – Hearing Conversation and Noise Control Program*).

A current version of the SL 1.0 specification can be found on the nexteersuppliers.com website. A summary of the major requirements are provided here:

1. Equipment suppliers shall perform a runoff noise level check following the technical procedures outlined in the Specification.
2. Using sound data forms and sheets included in the Specification the supplier shall certify that the noise levels have been met. It is expected that site Safety or Engineering staff will also use the Specification to confirm the noise levels during the equipment release / sign-off process.
3. Unless specified elsewhere in the Specification, the 8-Hour Time-Weighted Average (TWA) A-weighted sound level shall not exceed 80 dB(A) at ANY of the designated measurement locations on the machine measurement envelope and in the Operator's Hearing Zone, during the operating time of the machine. Tooling and material handling related noise must be included.
4. Impulse sound pressure levels shall not exceed the un-weighted true peak value of 130 dB at any measurement location on the machine measurement envelope and in the Operator's Hearing Zone, during the operating time of the machine.
5. If noise levels can not be engineered out < 80 dB(A), a waiver must be signed by the supplier, Engineering, and the plant Manager before the equipment is shipped or accepted. This waiver indicates all engineering controls options have been explored and deemed not feasible. The design engineer shall provide a copy of the waiver to the site Safety staff and Noise Control Committee.

7.5. Laser Equipment

All facilities using Class 3b or 4 lasers or laser systems that have an embedded Class 3b or 4 laser shall have a Laser Safety Officer (LSO) local to the facility.

Lasers are given hazard classifications in order of severity (i.e. Class 1, 1M, 2, 2a, 2M, 3a, 3R, 3b, and 4). Class 2a is obsolete, but is listed for possible existing equipment.

Reference ANSI Z136.1, ANSI Z136.2, ANSI Z136.4 and ANSI Z136.7 (or IEC 60825-1, IEC 60825-2, IEC 60825-4 and IEC TR60825-14 in Europe) for laser safety requirements. (ANSI Z136.1 and IEC 60825-1 are the main standards).

7.5.1. Laser Safety Considerations for the Manufacturing Engineer

The Laser Safety Officer (LSO) shall approve all new lasers, laser systems, and machines that contain lasers before purchase.

The modification, relocation, or reinstallation of existing laser equipment shall have the same requirements as a new laser purchase.

Class 1 Lasers or laser systems and CO_2 lasers are preferred. CO_2 lasers are preferred over other types of lasers due to the protection that standard plastic safety eyewear provide the eye.

Work with the LSO to:

1. Complete the requirements of the Laser Safety Minimum Program requirements (lsminprog.doc)
2. Complete the Laser System Datasheet form (LSDATA.XLS). Pictures should be taken for future reference.
3. Complete the Laser Inventory form (lsinv.xls).
4. Verify the laser classification with the manufacturer.
5. Provide the LSO with any information needed to specify:
   a. Optical Density (OD) for each laser.
   b. Nominal Hazard Zones (NHZ) for each laser.
      - The NHZ includes direct, lens and diffuse hazards.
   c. Complete the Laser Safety Placard form (lsplac.xls).

- The placard shall be posted on the machine and filed in the laser safety records.

d. Viewing ports

e. Laser safety eyewear.

f. Temporary laser controlled area and its protective barriers/curtains for all class 3b or 4 lasers or embedded laser systems.

g. Wording and location of laser safety signs, laser safety labels, and guarding labels.

6. Submit control measures for lasers and laser systems (Guarding, interlocks, keys, warning systems, etc.) to the LSO.

   a. The LSO will make recommendations and give final approval of the control measures.

7. Submit the standard operating, maintenance, and alignment procedures for LSO approval.

8. Record and implement appropriate safeguards/safe practices, etc. to address other identified hazards (e.g. High Voltage, inadequate guarding, or open beam systems).

9. Assure that employees are receiving the proper laser safety training.

   a. Laser Safety Awareness – Operator. (CTIS# 28587)

      - Example training (olsa.ppt with olsa.doc summary sheet)

   b. Laser Safety Awareness – Maintenance/Service. (CTIS# 28586)

      - Example training (mlsa.ppt with mlsa.doc summary sheet)

   c. Laser Maintenance/Service Training

10. Work with the training department and supervision to ensure that an accurate record of employee laser training is maintained.

11. Coordinate with Divisional or Regional Industrial Hygiene for an assessment of:

    a. Laser Generated Air Contaminants (LGAC), filters, and ventilation systems.

    b. Lasing chemicals and cleaning fluids.

12. Work with the medical staff to specify the medical surveillance program. See Laser Operator Medical Surveillance Evaluation. (055 Clin 7.7)

13. Work with the LSO to complete the safety signoff procedure.

7.6. Radiation

This section provides the design engineer with basic information on possible sources of radiation that will need to be reviewed when developing new equipment and processes that contain or generate radiation. Radiation can be separated into two categories, ionizing and non-ionizing radiation.

Ionizing radiation is a general term applied to both electromagnetic waves and/or particulate radiation capable of producing ions by interaction with matter. Gamma rays are photons produced from nuclear transition emission. Those photons produced from electron transitions in high atomic mass nuclides are called x-rays.

Ionizing radiation can be produced by man-made devices (x-ray machines, nuclear reactors, accelerators etc.) or by naturally occurring radioactive material (Co-60, C-14, Am-241, Sr-90, Po-210, etc.) used in exit signs, thickness gauges, and static eliminators. It will be the responsibility of the engineer to ensure that all country, state, or local regulations are applied to the design and registration/licensing of equipment capable of emitting radiation.

1. The design engineer / supplier must develop safe operating procedures for the proper installation, maintenance, and disposal of radiation sources.

2. All facilities using radioactive sources or radiation generating equipment must have a Radiation Safety Officer (RSO) or designee before installation, use or maintenance of radiation sources or generating equipment.

3. For application detail, the design engineer shall adhere to all country, state, local, and Nexteer Automotive policies governing the purchase, installation, and use of radiation generating equipment. A completed license or registration form may be required by the local governing body.
4. The design engineer / supplier must notify the Nexteer Automotive Industrial Hygienist, prior to receiving all naturally occurring and generating radiation. Complete the X-Ray Equipment Inventory & Survey Data Sheet.
5. A “Notice to Employees” must be posted in the area where radiation sources are present. The design engineer / supplier must provide proper posting of the area with the radiation symbol and other appropriate information to aid individuals in minimizing exposure to radiation.
6. A secured and controlled storage area must be established for radiation material not in use. The design engineer / supplier must supply the proper SOP for handling and storage.
7. The design engineer / supplier must conduct radiation surveys prior to start-up to ensure that exposures are within acceptable levels. Personal monitoring may be required. Documentation of survey results must be supplied to Safety, Engineering, and the Divisional Industrial Hygiene Manager.
8. The design engineer / supplier must provide wipe samples as specified by the regulating authority on all naturally occurring radioactive sources. Documentation of the results of test must be supplied to Safety, Engineering, and the Divisional Industrial Hygiene Manager.
9. The design engineer / supplier must work with the RSO to assure the aforementioned items have been completed prior to shipping or receiving radiation material.

Non-ionizing radiation is electromagnetic radiation, which is the propagation or transfer of energy through space and matter by time-varying electric and magnetic fields. Photons with energies less than 12.4 eV are considered to have insufficient energy to ionize matter, and therefore are non-ionizing in nature. Non-ionizing radiation ranges from sub-radiofrequency magnetic and electric fields (ELF), radiofrequency (RF) and microwave radiation, light and infrared (IR) radiation, ultraviolet (UV) radiation, and including lasers. Sources of non-ionizing radiation may be found with the following operations; electric furnaces, induction heaters, power plants, arc lamps, Hg-HID lamps, welding operations, UV curing operations, heat sealers, microwave generating equipment, microwave ovens, and lasers as examples.

The design engineer / supplier must provide information on the following, which is specific to non-ionizing radiation:

1. The design engineer / supplier must develop safe operating procedures for the proper installation, maintenance and disposal of non-ionizing radiation equipment.
2. All facilities using non-ionizing radiation equipment must have a designated person responsible for periodic review of the equipment before installation, use, or maintenance.
3. For application detail, the design engineer shall adhere to all country, state, local, an Nexteer Automotive policies governing the purchase, installation, and use of non-ionizing radiation generating equipment. A completed license or registration form may be required by the local governing body.
4. The design engineer / supplier must notify the Nexteer Automotive Industrial Hygienist, prior to receiving all non-ionizing radiation generating equipment, for assistance.
5. A “Notice to Employees” must be posted in the area where radiation generating equipment is present. The design engineer / supplier must provide proper posting of the area and other appropriate information to aid individuals in minimizing potential exposure to radiation.
6. The design engineer / supplier must conduct radiation surveys prior to start-up to ensure that exposures are within acceptable levels. Personal monitoring may be required. Documentation of survey results must be supplied to Safety, Engineering, and the Divisional Industrial Hygiene Manager.
7. The design engineer / supplier must work with the safety department to assure the aforementioned items have been completed prior to shipping or receiving radiation equipment.

7.7. Water Quality

Nexteer Automotive processes utilize many different water systems including water-cooling towers, humidification systems, domestic hot water systems, parts washers, and potable drinking systems. The primary importance of good water quality is to minimize bacterial contamination.

The following basic guidance is provided for new installations:

1. All equipment shall be designed to minimize the generation of aerosols.
2. Once systems are installed, regular monitoring of the water systems shall be scheduled based on information from the water quality specialist and corporate guidelines.
3. A program for routine maintenance and cleaning of the specific systems shall be developed and provided to the facility.
4. Where applicable, local regulations for discharge of water to sanitary sewer or surface drainage must be adhered to.

The design engineer / supplier shall review the best available methods for operation and treatment of water systems to ensure a cost effective program to maintain systems and control bacterial growth levels.

References:

1. Water Systems Quality Control Procedure, Best Practice
2. Drinking Water
3. Metal Removal Fluids

7.8. Confined Space

One of Nexteer Automotives major health and safety concerns is the un-authorized entrance of employees into confined spaces. Each year un-authorized entries into un-safe confined spaces kill hundreds of workers worldwide. Although Nexteer Automotive has issued corporate guidelines to assist sites in the development of site specific confined space programs, our primary goal is to design machinery, equipment, and facilities without confined spaces (see Health and Safety Common Core Element – Confined Space Entry).

By definition, a confined space is a space that:

- Is large enough for an employee to bodily enter (typical entry) and perform the assigned work. In addition, this includes situations where only head or upper body only may enter the space.
- Has limited or restricted means for entry or exit; and
- Is not designed for continuous employee occupancy, or
- All of the above and is an open-top tank or pit.

Based on the potential risks associated, the responsible engineer should consider the following into any future designs:

1. To the extent feasible/possible, design machinery, equipment, or the facility WITHOUT confined spaces.
2. Entrances and exits to confined spaces shall be designed to the maximum access size possible. The minimum access size shall allow:
   a. Personnel to pass through while wearing any required support devices (e.g., self-contained breathing apparatus), and
   b. The transfer of rescue equipment through the access passage.
3. Specifying doors instead of access ports and stairs instead of ladders will facilitate unrestricted egress. This will aid in not creating a confined space.
4. The entrances and exits to confined spaces should be designed to eliminate fall hazards. If fall hazards exist, anchorage points shall be provided and identified.

5. Hazardous conditions shall be designed out of the confined space to the extent possible (e.g., designed-in forced air ventilation may lessen the requirements when confined space entry is required).
6. Energy control devices shall be located outside the confined space and shall be located at floor level, where possible. For example, a hazardous material traversing a confined space through piping may create an immediately dangerous to life condition if the line ruptures. Provisions to control the hazardous material shall be located outside the confined space. Examples of these valve schemes are blank or blind, breaking line, or double block and bleed.
7. All potential hazards and hazardous conditions shall be identified, evaluated, and recorded on the facilities Confined Space Log. It is the responsibility of the design engineer to notify the local health and safety staff to ensure this is complete.

8. Safeguarding

This section provides design-in fundamentals and general principles for safeguarding of manufacturing equipment.

8.1. Fundamentals for Safeguarding

Safeguarding refers to the protection of personnel from hazards by using guards, safeguarding or awareness devices, safeguarding methods, or Safe Operating Procedures (SOP's).

Guard refers to a barrier that prevents exposure to an identified hazard.

Safeguarding Device refers to a device that detects or prevents inadvertent access to a hazard.

Awareness Device refers to a barrier, signal (i.e. audio or visual), or sign that warns individuals of an impending, approaching, or present hazard.

Safeguarding Methods refers to the protection of individuals from hazards by the physical arrangement of the machine to ensure that a person cannot reach the hazard.

Safe Operating Procedure (SOP) refers to formal written instructions developed for the user to describe how a task is to be performed safely.

The safeguarding methods listed in this section should only be utilized after efforts to eliminate the hazards have been considered. The guarding solution options will be determined by the results of the risk assessment. See Section 2, *Hierarchy of Health and Safety Controls*, and Section 3, *Risk Assessment* for further information.

For equipment guarding and cycle initiation, refer to *Guarding/Cycle Initiate Methodology*.

8.2. Guard Design

8.2.1. Point-of-Operation/Machine Guarding

This section covers point-of-operation/machine guarding of hazards on all machinery and equipment (including transport/handling).

Barrier/pinch point guards shall be designed to:

1. Prevent reaching over, under, around, or through a barrier into the point of hazardous motion
2. When frequent access is required, the guard shall be interlocked when determined by risk assessment and/or other applicable standards
3. When infrequent access is required, a tool shall be required to install/remove the guard

   Note: As a good design practice, guards should not result in a hindrance to production. If a guard were to be considered a hindrance, the result may be that the guard is wrongly removed or defeated, placing employees at serious risk of injury. One solution is to "design-in" a window where a guard would otherwise obstruct visual access.
4. Contain hazardous process byproducts (e.g., coolant spray, sparks, and chips). See Section 7, *Industrial Hygiene*, of this specification for further information.

Note: Presence Sensing Devices (e.g. light curtains) are acceptable as Point of Operation Guarding, provided they are implemented per the circuit performance requirements determined by the risk assessment. If the PSD is to also be used as a cycle initiation device, see the Controls Engineering white paper, *Application Guideline for the Presence Sensing Device Initiation (PSDI) using Light Curtains* or further guidance.

8.2.2. Thermal Hazard Guarding

Thermal hazard guards should be designed to:

1. Keep personnel from contacting components in their normal work areas, which could cause burns
2. Prevent personnel from contacting surfaces that could cause a reaction, which could result in injury

8.2.3. Perimeter Guarding

The purpose of perimeter guarding is to prevent unauthorized personnel from entering into the work area and to contain any material or equipment that has the potential to be ejected from or dropped outside the work area. There are two types of perimeter guarding allowed – hard guarding and Presence Sensing Device (PSD).

8.2.3.1. Perimeter Hard Guarding

All work areas where a hazard exists—due to the ejection of material or equipment—shall have hard mechanical barrier guarding.

Hard guarding shall be designed to:

1. Prevent inadvertent access
2. Contain parts and/or equipment that may be ejected
3. Allow cleaning of the floor at the perimeter
4. Be of a height suitable to contain the hazard
5. Allow visibility into the equipment or work areas
6. Require a tool to install/remove the guard

When frequent access is required, movable gates shall be provided. These gates may be required to be interlocked when determined by the risk assessment.

All access gates should be located as to prevent direct entry into the path of hazardous motions. Gates should not swing inward.

8.2.3.2. Perimeter PSD Guarding

For work areas posing no hazard from material or equipment ejection, perimeter-guarding methods that use presence-sensing devices are acceptable (refer to section 8.3.2 *Presence Sensing Devices* for more information on device requirements).

8.2.3.3. When a PSD is used for Perimeter Guarding applications, the following requirements shall be met:

1. A keyless reset switch for the safety circuit shall be located near each PSD that is used as a perimeter guard. This requirement does not apply to a reset switch (provided by the device manufacturer) that requires a tool in order to open a cover to gain access.

   Note: Additional reset switches are allowed as long as they meet requirements 3, 4, and 5 below.

2. The reset switch shall be positioned so that it cannot be reached from within the guarded area without interrupting the PSD.
3. The entire area that is protected by the PSD should be visible from the reset switch location. If the entire protected area is not visible from the reset location, multiple hardwired-reset devices shall be installed. These reset locations shall be positioned collectively to allow the entire protected area to be viewed. The number of reset locations should be minimized, and they shall be reset within a maximum specified time. The reset devices shall be properly connected to the safety circuit. When a specific reset sequence is required, the control circuitry should force this reset sequence and the control system shall have the ability to prompt for it.
4. When the device is powered-up, the cell's perimeter guard safety circuit shall be in a faulted (e.g., tripped) condition and shall require a local reset before the resumption of automatic operation.
5. Resetting the photoelectric device shall not—by itself—restart the machinery or equipment.

8.3. Safeguarding Devices

The following fundamentals shall be utilized when designing safeguarding devices into systems. These devices shall be used at a position that meets the safe distance formulas (located in Annex A).

8.3.1. Safety Interlocks

Safety interlocks shall be designed, constructed, and installed using the following guidelines:

1. Safety interlocks are to be designed into guard and gate approaches as determined by risk assessment.

   Note: Gate interlocks for specific applications are covered in more detail in Section 10, *Robotic Cell* and Section 11, *Servo Controlled Equipment and Machining Cells*.

2. Safety interlock systems for guards and gates shall:

   a. Be a safety rated device and implemented as specified by the risk assessment circuit performance.

   b. Be tested or cycled per plant procedures and manufacturer recommendations.

      Note: This requirement shall be included in plant preventive maintenance.

   c. Prevent the use of unauthorized and/or unintentional bypass devices.

      Note: A manual bypass may be required based on the defined task (e.g., solenoid override for cell access in a power-off condition).

   d. Be hardware-based.

      Note: The hardware shall take priority over any software signals used to control the manufacturing process. In addition to this requirement, software monitoring of the safety interlock is allowed.

   e. Be used where hinged or sliding doors provide access to hazards as determined by risk assessment, and any applicable standards.

      Note: Where interlocks are utilized for other than safety reasons, the requirements of this section do not apply.

8.3.2. Presence Sensing Devices (PSD)

1. A PSD (e.g., light curtain or safety mat) shall meet the requirements as specified by the risk assessment circuit performance. The PSD shall be capable of being incorporated into the machinery and equipment control system and shall initiate a stop or prevent hazardous operation of the machine when any object is detected in the sensing field. The PSD may be muted or bypassed at times when no hazards exist for the operator.

   Note: Where a PSD reset switch is required to reset a fault or during power up, the reset switch shall be keyless.

2. The PSD shall be installed to prevent personnel from going over, under, or around to get into the hazardous area or be trapped. The supports shall be substantial enough to resist deflection and shall be mounted to avoid a pinch point where material or a material carrier enters or exits a cell.

3. Various PSDs employ different sensing and adjustment techniques. The point at which a device responds to an intrusion may vary. The devices shall be located and/or adjusted per the safe distance formula, ensuring that any hazard is controlled upon intrusion (See Annex A, Safe Distance Formulas). Multiple devices may be required to accomplish a “protected area”.

   a. The effective sensing field shall be of adequate height, width, and depth to guard the area.

   b. The response time of the PSD used in the safe distance formula shall be the maximum response time—taking into account the impact of object sensitivity adjustments and environmental changes.

   c. The PSD resolution shall be appropriate to the design application. (The point-of-operation guarding should be hand-safe. Perimeter guarding should be body-safe).

   d. Indicator lamps shall be provided on all PSDs in order to indicate that the device is functioning.

e. For devices used for operator protection, when the PSD is muted and the operator may be exposed to a hazard, an indicator shall be provided to alert the operator when the device is muted. PSD outputs may be bypassed if no hazard is present or another safeguarding device is protecting the operator from the hazard. In this case, no indicator is required.

f. The PSD shall not be affected by ambient conditions (e.g., smoke, dust, haze, or vibration) or light sources decay such that an increase in response time or object sensitivity occurs.

g. The PSD shall at no time fail to respond to the presence of any person's body parts.

h. If there is a loss of power to the PSD, the device shall initiate an immediate stop command to the machinery and equipment control system.

i. The PSD shall be capable of being incorporated into the machinery and equipment control system in order to stop or inhibit hazardous motion when the device detects an object in its field.

j. A plastic safety chain and signs may be hung outside the light curtain to identify the light curtain perimeter.

4. The PSD shall be appropriately rated to an applicable safety standard, per SD-011, .Specification for Safety Circuits.

8.3.3. Two-Hand Control Devices

When using two-hand control devices in safeguarding design, the device shall:

1. Be protected against unintentional operation
2. Be arranged by design and either construction or separation to require the concurrent use of both hands to initiate the machine cycle
3. Possess an anti-repeat feature, when used in single-cycle mode
4. Require the release of both hands and the reactivation of both control devices before a machine cycle can be reinitiated (anti-tie down)
5. Be located and anchored at least the minimum safe distance from the nearest point-of-operation hazard in order to prevent the operator from reaching the hazard zone either with a hand or another body part (See Annex A, Safe Distance Formulas).
6. Stop normal cycle action or retract hazardous motion if one or both of the operator's hands are removed at any point in the cycle where a reach-in hazard exists

8.3.4. Single-Hand Control Devices

When using single-hand operator controls as the sole safeguarding device, the device shall:

1. Be protected against unintentional operation
2. Possess an anti-repeat feature, when used in single-cycle mode
3. Be fixed in place at a distance such that no part of the person's body can reach the hazard when the button is released, based upon the safe distance formula (See Annex A, Safe Distance Formulas).

Note: These requirements do not apply when the single-hand operator control, is used as a cycle initiation, in conjunction with another safeguarding device (e.g. a whisker switch on a machine which is protected by a light curtain)

8.4. Operator Interface Devices

The following parameters shall be adhered to in the design, construction, and installation of the operator interface control panels.

These devices shall:

1. Be readily identifiable and appropriately marked or labeled as to their function
2. Be located in proximity to the operator and properly placed in order to keep the operator from reaching past moving parts that are likely to cause injury

3. Be protected from unintentional operation by normal movement of the operator or flow of work pieces, material, or tooling through the manufacturing process
4. Not initiate any motion unrelated to its designation

Stopping devices shall be clearly marked and require only momentary actuation to stop machine motion.

8.5. Emergency Stop Function and Devices

Each machine shall be provided with one or more emergency stop devices.

Emergency stops shall:

- Override all other functions and modes of operation
- Remove power to the machine actuators as quickly as possible without creating other hazards
- Be reset at the point of interrupt
- Not initiate restart when reset

The emergency stop function, if required for personnel safety as determined by risk assessment, shall be implemented consistent with the safeguard circuit performance and be operational at all times and in all operating modes.

Resetting an emergency stop function shall be a deliberate action.

The activation of the emergency stop function shall not require a decision by the operator regarding the effects of the emergency stop signal.

A manually operated emergency stop device shall:

- Be provided at each operator station
- Be hardwired into the emergency stop circuit
- Function independently from the system controller

Emergency stop device design shall consider the following:

1. Clear identification
2. Easy and non-hazardous access
3. Ease of operation
4. Red buttons that have a yellow background

   Note: The buttons shall be mushroom-shaped, not shrouded, and larger than other stop controls.
5. Maintained contact-type buttons that require deliberate action in order to reset
6. Push bars or similar devices
7. Not be used for lockout
8. Cables or ropes

   Note: Cables should be as tight as possible.

   The following requirements apply:

   a. The cables or ropes shall be clearly marked to ensure visibility.
   b. In the event of rope or cable breakage, loss of tension or disengagement, the E-stop command shall be initiated.
   c. The points of reset should be located, where possible, such that the entire length of the cable or rope is visible from that location.
   d. The E-stop shall be activated from any part of the cable. (The application may require switches at both ends of the cable.)

Consideration should be given to the following:

a. The amount of deflection required to generate the E-stop command and the maximum deflection possible

b. The minimum clearance between the cable(s) or rope(s) and the nearest component

c. The force required to activate the E-stop device

8.6. Awareness Barriers

This barrier method of protection is a lower order of controls (warning). See Section 2, *Hierarchy of Health and Safety Controls*.

Awareness barriers (e.g., guardrails and chains on posts) shall:

1. Make personnel aware that they are entering or reaching into a hazardous area
2. Provide a point of physical contact before entering the hazardous area
3. Create no pinch points between themselves and other stationary or moving parts of machinery or tooling

8.7. Awareness Devices/Signals

Awareness devices or signals shall be designed, constructed, and located to provide a recognized signal—audible, visual, or a combination—of an approaching or present hazard.

Consideration shall be given to the following:

1. Lamp failure
2. Color blindness
3. Hearing ability
4. Separation from paging systems
5. Sufficient number of lights for large areas
6. Distinctive and intense enough sound to rise above ambient noise level
7. Annoyance level—as it relates to the likelihood of disconnection

9. Energy Control and Lockout

The principles of lockout and Controls Lockout Solutions (CLS), as applied to hazardous energy control, are included in this section.

Hazardous energy control is a key consideration in system concept and design (see Health and Safety Common Core Element – Machine / Equipment Energy Control).

9.1. General Principles

9.1.1. Energy-Isolating Devices

1. The control circuit and energy-isolating devices shall be designed and installed to provide safe system access for service and maintenance tasks.
2. For stand-alone equipment, the primary energy-isolating control devices shall be designed and installed in proximity to each other (e.g. electrical disconnect, air shutoff valve, hydraulic shutoff valve).
3. When cells or transfer lines are utilized, the primary energy-isolating control devices shall be designed and installed in proximity to each other and preferably located outside of the cell or transfer line.
   a. The devices shall be located for easy access.
   b. The devices should be in plain view and identified with symbols and letters.
4. Supplemental lockout/isolating devices—which may be permitted for programmable equipment (e.g., CPU or PLC) where loss of data or communication capability may introduce additional hazards—shall not interfere with the operation of the primary disconnects in the lockout of machine motion.
5. Lockout/energy control placards that identify the stored energy sources and the safeguards against their release shall be provided.
6. On systems with stored energy—where isolation does not guarantee energy control when the system is initially locked out—special warnings (e.g., placards/signs) shall be provided at all key lockout points.

   Note: Detailed steps for controlling the stored energy condition shall be part of the system's operation manual. If stored energy is needed to perform a task, additional engineering controls shall be included to safeguard all personnel.
7. Emergency stop buttons or emergency pull cables shall be located at all operator control stations as well as other locations where an emergency shutdown may be needed.

9.2. Hazardous Energy Control-Lockout

The main lockable disconnects for all hazardous energy sources shall be located outside the safeguarded area. Through-the-door electrical disconnect switches with rod actuators that allow the operating handle to become disengaged from the switch when the panel door is open are not permitted. Reference SD-004, Electrical Specification for Industrial Machinery – Addendum.

115-volt systems that use plugs as the disconnecting means shall use a lockable plug-enclosing device (e.g. Hubbell Lockout Device).

Periodically, suppliers will provide lockable disconnects on the equipment to control minor motion. These disconnects shall be connected in series with the primary disconnects and utilized per a risk assessment.

Note: Secondary auxiliary lockable disconnects (e.g., motor safety switches) are allowed inside the cell when required to perform specific tasks. These disconnects must be wired in series with the primary disconnect. An auxiliary contact on the safety switch to de-energize the motor starter for undervoltage protection shall be provided. ,*Electrical Equipment of Industrial Machines – General Requirements* IEC 60204-1 section 7.5.

Master lockable shut-off valves (e.g., pneumatic and hydraulic) shall be installed on the service side, outside of the cell. Lockable shutoff valves must also be self-relieving type to bleed all air/hydraulic in the system.

In some cases, additional auxiliary shut-off valves may be desired inside the cell to perform a specific service function as described in a Safe Operating Procedure (SOP). Their use is permitted as long as they are connected in series to a main shut-off that is located outside the cell. These valves must also be lockable and self-relieving. Reference the Nexteer Automotive Lockout/Energy Control Program.

9.2.1. Motion Power Source

Motion Power Source is defined as that power source that results in motion on a machine (e.g. electrical power for motors, pneumatic power for cylinders, or hydraulic power for cylinders)

1. The primary motion power system shall be fed through mechanically interrupted disconnect switches. When disengaging an electrical disconnect could result in restart problems, the designer should consider adding an early break auxiliary contact on the disconnect switch to provide an orderly shutdown.

   Note: In applications where the station/cell extends to both sides of a conveyance system, consideration shall be given to locating power disconnects on both sides of the line—based on station/line size. When using a second set of disconnects, the set shall be wired in series with the main disconnects.

2. The motion power of a part conveyance system that is not integrated into the part processing equipment (e.g., buffering or accumulating systems) shall have independent lockout provisions.

9.2.2. Stored Energy

Where stored energy exists, a warning sign is to be posted on the machine/equipment.

9.2.2.1. Gravity

Wherever dropping or drifting of equipment/parts presents a hazard, devices shall be installed to prevent the hazard. Examples of gravity drifting prevention devices may include, but are not limited to the following: cylinder rod brakes, piloted check valves (for light loads) shot pins, safety pins, or blocks.

9.2.2.2. Mechanical

Tension or pressure that can cause a hazard (e.g., springs on a mechanism, brakes, check valves on pneumatic/hydraulic lines, blocks, and auto shot pin systems) shall be capable of being released or controlled.

9.2.2.3. Electrical

Provisions need to be provided to discharge all stored electrical energy (e.g. capacitors, static electricity).

9.2.3. Kinetic Energy

If hazards exist due to kinetic energy (e.g., momentum of a grinding wheel) after lockout, those hazards shall be guarded to prevent inadvertent contact.

Devices (e.g., cylinder rod brakes, solenoid gates with delays, and guards) may be used to control kinetic energy hazards.

9.2.4. Placards

For all placards that show energy source locations, the means to lockout and/or lockout verification procedures shall be in accordance with the Nexteer Automotive lockout energy control policies. The machine tool manufacturer or integrator shall provide all placard information for the machine/equipment, including the location of all lockout points and details for appropriate safe operating practices.

Placards shall be developed in parallel with the equipment design and build.

Full-color laminated placards with appropriate Safe Operating Procedures (SOPs) shall be attached at their final location on the equipment prior to shipment of the equipment from the original equipment manufacturer (OEM).

9.3. Controls Lockout Solutions (CLS) in Lieu of Lockout

The term Controls Lockout Solutions refers to a Hazardous Energy Control system used on rare and specific equipment/processes. This concept is typically used on processes having multiple pieces of equipment arranged in a cell. To perform a simple task, such as changing a weld tip on a robot weld gun, would require locking out multiple energy isolating devices prior to entering the cell. Locking out each piece of equipment requires significant operator/maintenance effort and the productivity loss is significantly longer than the time required to perform the change/repair task. This type of cell typically involves design and implementation of additional energy isolating control systems to effectively isolate all equipment without having to independently lockout all pieces of equipment. The intent of a Controls Lockout Solution is to provide a control reliable safety system for personnel to enter a work cell or work on equipment when it is not practical to lockout the equipment (e.g. robotics cell).

CLS is recognized by OSHA as an *alternative measure* (safeguarding means) to lockout/tagout per 1910.147, section a.2 (ii)B. **Note:** Exception to paragraph (a)(2)(ii).

Note: 3rd Party machine or system validation may be required in certain US facilities.

9.3.1. Elements

Controls Lockout Solution (CLS) is a systems design approach that removes all hazardous motion energy from devices/equipment/machinery in a designated area (e.g., zone or cell).

CLS has four key elements:

1. Redundancy in circuit design must be provided to assure that the hazardous motion stops when required.
2. Monitored safety stop circuits must be provided to detect a single failure and stop or prevent startup of the equipment when a failure is detected.
3. Fail-to-safe condition with a self-testing capability (e.g., does not allow the next cycle to occur until the safety system is fixed)
4. Implemented in hardware and unable to be bypassed by other control circuitry or software.

The application of CLS for specific tasks can only be determined after a risk assessment has been conducted.

Note: The design of the system shall consider all energy sources (e.g., electrical, mechanical, hydraulic, gravity, and pneumatic).

CLS utilizes safety devices that are designed to:

- Stop the machine/equipment
- Directly control the hazardous motion energy to the machine
- Take precedence over other machine control hardware and software

9.3.2. Circuit Design Requirements

CLS designs shall meet the ten requirements identified in this section.

1. In CLS applications where electrical energy controls the motion identified as hazardous by a risk assessment, electrical power devices shall be used to switch “off” the electrical power to all hazardous motion.

   These devices shall be:

   a. Duplicated to ensure that the equipment stops safely

b. Monitored so that further operation is prevented when a failure of any device in the CLS is detected

Note: For electrical applications, redundant contactors or relays are required. Some of the ways this redundancy can be accomplished are:

- Redundant master contactors/relays in series
- A combination of one master contactor/relay in series with the process control contactors/relays
- Redundant contactors/relays (e.g., safety relays)

Where hydraulic or pneumatic energy controls the motion identified as hazardous by a risk assessment, the fluid power shall be controlled by either:

a. Removing the energy by turning off the equipment that is generating the fluid power (e.g., hydraulic pump or air compressor)

b. Utilizing fluid power devices to switch "off" the fluid power to all hazardous motion

These devices shall be:

- Duplicated to ensure that the equipment stops safely
- Monitored so that further operation is prevented when a failure of any device in the CLS is detected

Note: For pneumatic or hydraulic applications, where the energy is <u>not</u> removed by turning off the equipment generating the fluid power, redundant valves are required. Some of the ways this redundancy can be accomplished are:

- Redundant master valves in series
- A combination of one master valve in series with the process control valves
- Redundant valves (e.g., safety valves)

2. The CLS shall be hardware-based. The hardware shall take priority over any software signals used to control the manufacturing process. The CLS cannot rely on software-controlled inputs or outputs to safely stop hazardous motion. However, software inputs can be used to monitor the status of the CLS.

3. Power devices shall be rated for the maximum-switched load available at any time. The control devices that control the primary energy must be sized to handle the maximum-switched load. Power factor, duty cycle, and switch load vs. life should be taken into account when selecting safety components. In an electrical circuit, the protective devices (e.g., fuses or circuit breakers) determine the maximum loads that can exist at any time. In a hydraulic circuit, consult *Hydraulic Fluid Power - General Rules Relating to Systems, ISO 4413* or the applicable standard. In a pneumatic circuit, consult *Pneumatic Fluid Power - General Rules Relating to Systems, ISO 4414* or the applicable standard.

4. The contacts used in the CLS (i.e., hardwired circuits) to monitor power devices shall be positive – opening contacts. They shall be either integral to the device or on a screw-on (not snap-on) contact block. Switches used to monitor valve spool position shall change state each time the valve is operated (i.e., each switch shall cycle on-off-on or cycle off-on-off). If a snap-on block is used, it must be used for a power leg and not the monitoring circuit. Switches monitoring valves must be wired such that they must make and break each cycle. Monitoring each state change will detect if the switch becomes detached from the device it is monitoring.

5. Every start and reset circuit used in the CLS shall be designed to prevent tie-down. Push buttons with one Normally Open (NO) and one Normally Closed (NC) contact can be used if they are wired so that the NO contact must close and NC contact must open to obtain reset. Single contact push buttons can be used when wired such that they must be pushed to make contact and released to open the contact before a reset is obtained.

6. All safety status indicators for the CLS shall be fail-safe. The CLS indicator shall be labeled “CLS Active – OK to Enter”. This requirement prevents lamp failure, temporary power loss, cable faults, fuse faults, or other faults in the signaling system from indicating CLS is active.

   Note: If the indicator is ON, the equipment is under CLS control. If the indicator is NOT ON, the equipment is not under CLS control.

7. Safety status indicators for CLS shall be controlled by hardwired devices (e.g., auxiliary contacts of contactors, safety relays, or valve position sensors). These hardwired devices must take priority over any software driven outputs. Software outputs in series—and overridden by the hardware devices—are acceptable.

   Note: The power devices cannot be in two states (i.e., "on" and "off") at the same time. The "true" status of the power source will be indicated only when all power devices are "off."

8. Audible start-up signals shall not sound if CLS has disabled any equipment. There should be input from CLS to the system controller that inhibits any "equipment start" warning signals (e.g., horns) when the circuit has disabled any equipment.

9. The control circuit shall not indicate AUTO if CLS has disabled any equipment. If the CLS has disabled any equipment, there should be input from CLS to the system controller to inhibit AUTO mode.

10. All CLS mode control devices shall have the capability to be locked in position or be housed in a lockable enclosure. These mode control devices that disable/enable motion when the gate is open must be able to be locked in position or be located behind a cover that can be locked to prevent access. This requirement will prevent changing the mode (allowing motion) of the equipment until all personnel have removed their locks.

9.3.3. CLS Task Placards

A CLS task placards shall be posted at each entry gate into the cell or equipment. Each placard has three major sections showing the tasks that can be performed under CLS, the tasks to be performed under Lockout Energy Control, and the hazards that may be encountered when in the safeguarded area. For example, see Annex C.

9.4. Hazardous Energy Control - Part Transfer Systems

Hazardous motion from part transfer and/or conveyance systems (that are an integral part of the work cell) shall be stopped by the energy control system. This requirement ensures that no motion may occur, which could cause injury to anyone servicing part of the production system. Reference *Safety Standard for Conveyors and Related Equipment,* ANSI/ASME B20.1 or ISO/TR 8435 – *Safety code for belt conveyors*

10. Robotic Cell

A robotic cell is the safeguarded area defined by safeguarding that surrounds the robot(s), the end-effector(s), and other associated machinery and equipment.

Note: Any robot(s) that is an integral part of a machining cell shall be governed by the requirements for a machining cell as outlined in Section 11, *Servo Controlled Equipment and Machining Cells*.

Reference the *American National Standard for Industrial Robots and Robot Systems -- Safety Requirements,* ANSI/RIA R15.06 or *Manipulating Industrial Robots – Safety* or *Manipulating industrial robots – Safety,* ISO 10218.

10.1. Safety Design Requirements for Robotic Cells

10.1.1. General Layout Requirements

The layout shall include all facility features and equipment intended in the robotic cell including, but not limited to, the following:

1. Perimeter guarding,
2. Cell entrances,
3. Operating spaces (including path of the end-of-arm tooling and any carried parts and materials),
4. Restricted spaces at operator load/unload stations (reference Section 10.1.4.2.2),
5. Auxiliary equipment located within the cell guarding (e.g., weld tip dressers),
6. Location on the plant floor facility equipment and/or obstructions in the cell (e.g. building columns), and
7. Tooling and transfer systems.

Potential pinch points shall be identified and eliminated as practicable. If not practicable, appropriate safeguarding or controls shall be implemented as determined by the risk assessment.

A design goal shall be to maximize visibility into the cells. Floor standing cabinets that are 5-feet or greater in height shall be positioned to maximize the view of the cell. Angling the placement of a floor standing cabinet may be an effective method of maximizing visibility.

Hard stops shall be located to limit the robot's reach to all anticipated operating and maintenance positions. Software stops shall be incorporated to prevent collision with the hard stops.

Refer to Figure 10-1 for robot space definitions.

Figure 10-1: Robot Space Definition

10.1.2. Personnel Access Gate Control

In order to provide safe access to equipment requiring service and to facilitate the use of lockout and/or energy control by CLS, interlocked entrance gates shall be utilized.

10.1.2.1. Robot Cell Entrance Gate

In order to provide exclusive control of the robot's hazardous motion within the cell, the entrance gate area shall be equipped with provisions for lockout or CLS energy control. At least one entrance gate shall be provided for a cell. When the robot cell occupies both sides of a line and access across the line is hazardous (as determined by the risk assessment), an entrance gate on each side of the line shall be provided.

10.1.2.2. Cell Entrance and Exit Procedures for an Interlocked Gate

The typical entrance and restart procedures for robotic cells are as follows:

1. Stop the system at the next logical stopping position of the current cycle by actuating a control device (e.g., end-of-cycle stop pushbutton or HMI input screen).
2. Follow lockout procedure or CLS energy control procedures. Open the interlocked gate and enter the cell. Reference Section 8.3.1, *Safety Interlocks* for design requirement.

   Note: Entry from one cell into an adjacent cell through a PSD is not a normal entrance and violates lockout or CLS energy control procedures.
3. In order to reactivate automatic operation, the following actions shall occur within normal start-up procedures:
   a. Removal of all service equipment and tools,
   b. Notification of affected and authorized personnel,
   c. Closure of all gates,
   d. Resetting of the gate interlock circuits,
   e. Restoration of all the other safeguards required for automatic operations, and
   f. Deliberate cell restart action

10.1.3. Outside and Inside Cell Safeguarding

10.1.3.1. Outside the Cell Safeguarding

Hard guarding (e.g., fences, gates, walls, and doors) and presence sensing devices (PSD) guarding are approved methods for cell perimeter guarding (Reference Section 8.2.3, *Perimeter Guarding*).

Perimeter hard guarding shall be located at a minimum of 150mm (6 in.) outside of the robot's operating space and shall provide safeguarding from exposure to any hazard inside the cell (including a reach-in hazard) provided that the robot has the following design-in features or equivalent features due to new technology:

1. Collision detection,
2. Axes limits,
3. Over-current protection, and
4. Following error monitoring.

If the above requirements cannot be met, then alternative safeguarding shall be determined by the risk assessment.

PSD perimeter guarding shall meet the requirements of Section 8.3.2, *Presence Sensing Devices (PSD)*.

10.1.3.2. Inside the Cell Safeguarding

If a person is not required to be inside the safeguarded area to teach a robot or perform Attended Program Verification (APV), then no additional safeguarding is required other than the cell perimeter guarding. However, this requires that the gate interlock(s) prevent all hazardous robot motion when any personnel access gate is open.

If a person needs to be inside the safeguarding area to teach a robot or perform APV, the potential pinch point hazard between the robot and no-process related obstructions (e.g., Sections 10.1.3.2.1, *Teach and Slow-Speed APV Operations*, and 10.1.3.2.2, *High-Speed APV Operations*.

10.1.3.2.1 Teach and Slow-Speed APV Operations

Teach and slow-speed APV is defined as the robot speed limited to 250 mm/sec (10 in./sec).

Each person shall have a single point of control (e.g., teach pendant) that is capable of stopping all robot hazardous motions. An SOP may be required as determined by the risk assessment. Reference Section 10.2.1, *Robot Teach, Slow- and High-Speed APV*.

10.1.3.2.2 High-Speed APV Operations

High-speed APV is defined as the robot speed greater than 250 mm/sec (10 in./sec)

For high-speed APV tasks, only one person shall be allowed in a cell at any one time. This person shall have a single point of control (e.g., teach pendant) that is capable of stopping all hazardous motion within the cell. An SOP shall be provided to identify the safe positions(s) to stand within the cell for these types of tasks. Reference Section 10.2.1, *Robot Teach, Slow- and High-Speed APV*.

10.1.4. Shared Workspace Safeguarding

A shared workspace is the space or work area that the robot reaches during normal automatic operation. It is also the space or work area that, at a different time, an individual accesses as part of the normal production operation.

10.1.4.1. Presence Sensing Devices

When loading and unloading operation cannot be designed to completely remove the operator from the shared workspace, this space or work area shall be safeguarded to prevent a robot and person occupying the same space simultaneously. Typically a PSD is used to safeguard the operator; however, moveable interlock barrier guards can also be used.

1. The PSD shall be positioned to meet the following requirements:
2. The robot-restricted space shall not extend beyond the operator PSD.
3. The location of the PSD shall comply with the safe distance formula (reference Annex A) to the nearest point-of-operation hazard for the operator implemented consistent with the risk assessment.
4. When a worker is present (the operator PSD is tripped/interrupted), the robot end-of-arm tooling and/or the part being carried shall be prevented from entering the shared workspace. Other associated hazardous motion (e.g., tool clamps, weld guns) shall be controlled and/or abated. One of the following methods shall be used (based on the risk assessment):
5. A PSD for detecting the position of the robot shall stop the robot from entering the shared workspace when a person is in the shared workspace.
6. Switches or sensors that detect robot position shall be implemented to comply with the control reliable (reference Section 3.5.5.4) design and shall stop the robot from entering the shared workspace.

The operator PSD may be muted by a hardware-based, control reliable safety circuit when another safeguarding device (e.g., robot PSD) indicates there is no hazard from the robot. This circuit allows the operator to reach inside the workspace when the robot is in a safe position within the robot cycle. If the robot approaches the shared workspace while the operator is present or the operator attempts to enter the shared workspace (envelope) when the robot is present, the robot shall stop immediately. During the

machine cycle, an indicator (e.g., green status light) that is visible from the operator's workstation shall indicate the point in the process cycle when the operator can reach into the shared workspace without stopping the process.

The location of the safeguarding devices on the robot side of the shared workspace shall be installed in a manner that stops the robot before any part of its tooling or the part being carried enters into the shared workspace.

10.1.4.2. Limiting Devices

Limiting devices that establish the restricted space for a robot shall be used as defined below.

10.1.4.2.1 Mechanical and Non-mechanical Limiting Devices

The robot-restricted space is defined based on the placement of the mechanical (e.g., hard stops) and /or non-mechanical (e.g., PSDs) limiting devices. Building columns and other physical barriers (e.g., equipment, tooling) may also define the restricted space, per the risk assessment. The cell designs shall allow the operator to remain safe after the cycle start device has been activated. The non-mechanical limiting devices shall be implemented as specified by the risk assessment circuit performance.

10.1.4.2.2 Robot Restricted Space and Dynamic Limiting Devices (DLD)

Through the use of DLDs, the robot's restricted space can be automatically changed during a portion of the robot's cycle to allow manual loading/unloading tasks performed while the robot is clear from the operators work area. Control devices such as, but not limited to, cam operated limit switches or light curtains may be utilized to limit robot movement when the operator is interrupting the operator PSD while the robot performs its task program. The device(s) shall be positioned so that the robot stops before entering the shared workspace. DLDs shall be integrated as specified by the risk assessment circuit performance. The DLD shall not be used as the operator PSD. See the example in Figure 10-2.

Figure 10-2: Operator Loading/Unloading Task

When teaching the robot, the operator PSD and/or DLDs may be bypassed in a control reliable manner to allow the teacher to stand close to the equipment or tooling to perform the task.

10.2. Robot Cell Requirements

10.2.1. Robot Teach, Slow- and High-Speed APV

All cell control systems shall be designed to provide each person in the cell with the capability to stop hazardous motion while motion power is available. This requirement can be met through the use of a robot teach pendant or an enabling device.

A method shall be provided to limit the speed of the robot to a maximum of 250 mm/sec (10 in./sec) when in teach mode, slow-speed APV with a person inside the cell.

A design goal shall be to eliminate the need of high-speed APV with a person inside the cell.

Note: The need for high-speed APV with a person inside the cell may be eliminated by: (1) equipment/process selection, (2) locating the process requiring high-speed APV to be visible outside the cell, or (3) eliminating the ability of high-speed APV to run with any personnel access gate safety interlock open.

However, if high-speed APV is required the following items shall be made available prior to its initial use on any given system:

1. Layout showing the robot's restricted and operating spaces,
2. Risk assessment covering the high-speed APV tasks and associated hazards, and
3. SOPs for the high-speed APV task.

The SOP should include a requirement to run the path at slow speed before enabling high speed and identify safe teacher positions for high-speed APV.

10.2.2. Material Handling Applications

For a gravity hazard concern, a material handling robot shall retain the material in its end-effector in the event of a loss of energy to the robot servos. For a vacuum cup application, end-effector part retention (e.g., a vacuum lock) shall be provided when personnel enter the safeguarded area. The plan shall have an ongoing maintenance procedure in place for end-effector tooling.

Material handling robotic cells shall utilize perimeter hard guarding when material ejection poses a hazard (reference Section 8.2.3.1, *Perimeter Hard Guarding*)

11. Servo Controlled Equipment and Machining Cells

This section lists the specific safety requirements for individual Servo Controlled Equipment and also machining cells. Servo Controlled Equipment is any machine that utilizes servo systems for machine motion. This would include multi-axis assembly machines and individual Computer Numerically Controlled (CNC) metal removing equipment. Individual CNC metal removing equipment include machine tools in which the principle movement is the rotation of the workpiece against a stationary tool (i.e. lathe) or a machine tool in which the principle movement is a rotating tool against a stationary workpiece (i.e. machining center). In both cases, the machine operates under computer numerical control. A machining cell is a cell/system that incorporates industrial machinery and related devices and equipment. This related equipment is linked by material handling devices and operated by programmable electronic systems. These electronic systems are capable of being reprogrammed for the manufacturing of discrete parts or assemblies. The applications within the cell may include manual or automatic drilling, milling, boring, turning, grinding, etc. as well as limited subassembly operations.

Reference: Manufacturing Systems/Cells-Safety Requirements for Construction, Care and Use, ANSI B11.20.

This section is divided into safety design requirements for individual servo controlled equipment and then machining cells.

11.1. Safety Design Requirements for Individual Servo Controlled Equipment

This section discusses the General Requirements for Servo Controlled Equipment safety and then discusses safety issues related to the operator and maintenance personnel.

11.1.1. General Safety Requirements for Servo Controlled Equipment

1. All servo-controlled machines shall be designed so that loss of electrical power or voltage surges or changes in oil/air pressure will not result in a hazard.
2. A means for isolating any electrical, mechanical, hydraulic, or pneumatic energy source and any stored energy associated with the servo controlled equipment shall be provided in accordance with Section 9, *Energy Control and Lockout*, of this document. Access to any energy isolating device must not be inhibited by other hardware associated with the servo controlled equipment (e.g. electrical panel mounted directly above a self contained coolant system) or means shall be provided to gain access to the energy isolating device (i.e. a movable platform rolled into place over coolant system in previous example).
3. Actuating controls that initiate motion shall be located to prevent inadvertent operation (i.e. guarded pushbutton or two-hand control). In addition, controls and equipment requiring access during automatic operation of the servo-controlled equipment shall be located outside the safeguarded area in accordance with Section 8.3, *Safeguarding Devices*, of this document.
4. All **safeguarding** devices utilized for protection against the hazards associated with the operation and maintenance of servo controlled equipment shall be applied as specified by the risk assessment circuit performance in accordance with Section 3.5.5 of this document. Additional information in regards to methods of selecting and implementing appropriate safeguarding can be found in Section 8, *Safeguarding*, of this document. It should be noted that safeguarding devices are installed only after all opportunities for designing out the hazard have been effectively considered and/or eliminated.
5. All operator/maintenance stations, including remote pendant enabling devices, on servo controlled equipment shall have Emergency Stop devices installed in accordance with Section 8.5, *Emergency Stop Function and Devices*, of this document. These E-stop devices shall cause all moving parts of the machine to stop and remove all drive power from the servo drives.
6. Software and firmware based controllers used in place of hardware based components with safety-related devices shall require approval by the Controls Engineer and must meet the following requirements:
   a. Be designed such that any single safety related component or firmware failure shall:

- Lead to the shutdown of the system in a safe state, and
- Prevent subsequent automatic operation until the component failure has been corrected.

b. Supply the same degree of safety achieved by using hardwired/hardware components per Section 3.5.5. For example, this degree of safety may be achieved by using microprocessor redundancy and self-checking.

7. Electrical connectors that could cause a hazard if they are separated, or if they break away, shall be designed and constructed as to guard against such unintended separation.

11.1.2. Operator Safety Requirements for Servo Controlled Equipment

11.1.2.1. Operator Workstation Interface

1. **Load/Unload Devices.** When selecting the interface between an operator and automatic equipment, operator safety and ease of use are primary concerns. Throughput, station area, equipment complexity, and maintenance requirements are additional concerns. All these factors must be part of the design. Turntables, shuttles, and other load/unload mechanisms implemented as workpiece transfer devices that completely remove the operator from the servo controlled equipment hazards should be considered when designing operator load/unload stations. However, turntables, shuttles, etc. may present additional hazards and require special safeguarding (i.e. two hand control), refer to Section 8, *Safeguarding,* of this document for Safeguarding Options. All safeguarding for workpiece transfer devices shall be implemented as specified by the risk assessment circuit performance in accordance with Section 3.5.5 of this document. Where access is required to the workpiece transfer device with the guards open, the safeguard devices suspended, and powered motion is necessary for adjustment or maintenance, such motion shall be initiated with a hold-to-run device as a function of the main operator console or remote pendant enabling device as described in Section 11.1.3 below.

2. **Presence Sensing Devices (PSDs).** When the loading and unloading operations cannot be designed to completely remove the operator from the servo controlled equipment hazard, the shared workspace on the operator's side shall be protected by a PSD (refer to Section 8.3.2, *PSD)* of this document) or movable interlocked barrier guard. The intent of utilizing PSDs or a movable interlocked barrier guard is to prevent any motion of the servo controlled machine while the operator is loading/unloading the machine. Both the PSD and movable interlocked barrier guard shall be implemented as specified by the risk assessment circuit performance in accordance with Section 3.5.5 of this document.

3. **Automatic Tool Changers.** When the servo controlled equipment is equipped with an automatic tool changer, access to hazardous movements of the tool changer shall be prevented by fixed and interlocked movable guards implemented as specified by the risk assessment circuit performance in accordance with Section 3.5.5 of this document. When the interlocked movable guard is open, the tool magazine drive power shall be positively disconnected by means of a category 1 stop (see 9.5.2 of NFPA 79). Means shall be provided to allow viewing of the movement of the tool changer while the guard is closed.

11.1.3. Maintenance Personnel Safety Requirements for Servo Controlled Equipment

Most maintenance activities for servo controlled equipment shall be done with energy sources powered down and lockouts applied in accordance with Section 9, *Energy Control and Lockout,* of this document. However, certain tasks (i.e. spindle alignment, tool changer alignment, clearing part jams, qualifying fixtures, etc.) may require power to remain in an energized state to perform the task. The maintenance person must have single point of control of the servo-controlled equipment in order to perform these tasks with drive power enabled. Single point of control shall include:

1. Provisions to move a single axis at a time and at a reduced speed not to exceed 2 meters/minute.
2. Providing a hold-to-run device which when held in an actuated position shall allow motion to occur and also disable motion when released.
3. Disabling Automatic Operation of the servo controlled equipment when single point of control activated.

Two options are available for providing single point of control. These options are:

1. If the maintenance person can safely and effectively perform the required maintenance task with drive power enabled while standing on the floor at the main operator's station, then controls can be provided in the main operators console for satisfying single point of control items listed above.
2. If the maintenance person **cannot** safely and effectively perform the required maintenance task with drive power enabled while standing on the floor at the main operators station, then a remote pendant enabling device shall be installed on the machine to provide single point of control. The remote pendant enabling device shall include controls for all items listed above for single point of control and shall incorporate these additional features:
   a. Physically disable the main operator's console when the remote pendant enabling device is actuated. This disabling of the main operators console shall be accomplished via hardwiring and not through simple software techniques.
   b. An Emergency Stop device implemented in accordance with Section 8.5, *Emergency Stop Function and Devices*, of this document.
   c. The remote pendant enabling device shall be implemented as specified by the risk assessment circuit performance in accordance with Section 3.5.5 of this document.

11.2. Safety Design Requirements for Machining Cells

The specific machining cell design-in requirements are listed in the following sections.

11.2.1. Process Layout Analysis

Placement of the guarding, cell entrances and limiting devices shall be established during the pre-tool design phase.

The process layout shall include all facility features and equipment that are intended to be included in the machining cell. This process analysis shall be performed by a Engineer in Charge and, if applicable, by the machine tool builder/integrator.

This layout shall include, but not be limited to, the following features:

1. Guarding that includes the perimeter
2. Cell entrances that lead into hazardous zones
3. Hazardous zones
4. Location of all energy control devices
5. Auxiliary equipment (e.g., measurement/gauging systems, transfer systems)
6. Process equipment
7. PSDs
8. Actual location on the floor
9. Tooling access points
10. Locations of both the operator and maintenance tasks
11. Material stock bins/containers

Electrical disconnects shall be placed in a manner that provides an adequate amount of space to stand to the side of the electrical enclosure.

Note: When multi-axis machines are utilized in the process, simulation may be necessary to adequately design a safe system as determined by manufacturing/process engineering.

A hardcopy of the completed process layout analysis shall be available for use during the risk assessment process.

11.2.2. Entrance Gate Safety Interlocking

The following entrance gate safety-interlocking approach for machining cells shall serve as the preferred method of interlocking.

In addition to meeting the requirements of Section 8.3.1, *Safety Interlocks*, the entrance gate shall be designed as follows:

1. Normal entrance into a cell shall require operator selection of the manual mode or the system to reach the end of its cycle.
2. The interlock shall prevent the gate from opening until all hazardous motion has stopped.
3. Inadvertent access into the cell shall be prevented by a solenoid switch that locks all the gates while in automatic mode or during a “power off” condition.
4. Reactivating the automatic operation requires the following start-up procedures:
   a. Closure of all the gates
   b. Resetting the gate interlock circuits
   c. Restoration of all the other safeguards
   d. Deliberate cell restart action

11.2.3. Robots Within Machining Cells

When robots are used within a machining cell, risk assessment shall be performed on the cell to determine which requirements shall be applied from Section 10, *Robotic Cell*, of this specification.

Annex A: Safe Distance Formulas

A1. **General formula:** The following general safety distance formula should be used to calculate the minimum safe distance to mount the safety device from the hazardous motions. Note that adaptations of this formula for single-device initiation, safety mats and light curtains are listed separately. This is the formula suggested in ANSI B11.19.

$$D_S = K \times (T_S + T_C + T_r + T_{bm})$$

D_S = Minimum safety distance between the device and the nearest point of operation hazard in inches.

K = Hand speed constant of 63 inches per second

T_S = Stopping time of the equipment at the final control element (seconds).

T_C = Response time of the control system (seconds).

T_r = Response time of the safeguarding device (seconds). This response time is available from the manufacturer of the device.

T_{bm} = Additional time required in press applications for the brake monitor to compensate for variations in normal stopping time. Refer to ANSI B11.1 for information on press brake monitors.

Note: T_S and T_C are usually measured by a stop-time measurement device such as the Gemco model 1999 Semelex SE-3-E Safetimeter test set or equivalent.

A2. **Single-device initiation and safety mats:** The following safety distance formula shall be used to calculate the minimum safe distance to mount the safety device from the hazardous motions. This formula applies to safety mat applications and initiation device in single-device initiation applications where the initiation device is used as the safeguard. Consideration of an individual's stride, reach, and point-of-entry to the hazard should be used in determining the safe distance. This formula is suggested in ANSI B11.19 and EN 999.

$$D_S = K \times (T_S + T_C + T_r + T_{bm}) + C$$

C = 66 for single-device initiation applications, and safety mat applications where the individual being protected might be approaching the safety mat in-stride. The typical operator reach is approximately 66 inches.

C = 48 for safety mat applications where the individual being protected does not approach the safety mat in-stride, i.e., the individual's first step toward the hazard is also directly onto the safety mat.

A3. **Light curtains:** The following safety distance formula shall be used to calculate the minimum safe distance to mount the light curtain from the hazardous motions. This is the formula suggested in ANSI B11.19-1990.

$$D_S = K \times (T_S + T_C + T_r + T_{bm}) + D_{pf}$$

D_{pf} = Added distance due to the penetration factor as shown on Chart 1. The minimum object sensitivity is stated by the light curtain manufacturer. If beam blankouts or floating-window features are used, these figures should be added to the object sensitivity figure before using chart 1.

CHART 1

BLANKED DIMENSIONS OR MINIMUM OBJECT SENSITIVITY IN INCHES
2.5
2.0
1.5
1.0
0.5
0.0
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
PENETRATION FACTOR D_{pf} IN INCHES

Annex B: Test Sequence Design Requirements

When a design is not Nexteer Automotive common (i.e. SD-011), a new test sequence shall be developed at the component level. This new test sequence shall be developed by the responsible controls engineer using the design requirements listed below. After the test sequence is complete, send it to the divisions Controls Engineering COE representative for review and approval.

B1. Cell lockout

This test proves that the cell can be locked out.

- Referencing the posted placard, locate the lockout disconnects for each piece of equipment within the cell.
- Follow Nexteer Automotive lockout procedures in order to lock out the cell and verify that all live energy has been removed.

Note: Verify that all energy sources (i.e., electrical, pneumatic, hydraulic) to each piece of equipment are disconnected and no energy is available at the equipment.

B2. Perimeter guarding

This test determines the following:

- No access into the cell/work area via unauthorized routes can be attained
- Perimeter guarding is located at a safe distance from hazardous motion to prevent pinch points

Visually inspect the cell to:

1. Verify that the perimeter guarding properly prevents access into the cell and that the guarding prevents persons from reaching into a hazardous area
2. Confirm that all access gates are equipped with safety interlocks and do not open into the cell
3. Verify that the perimeter guarding is located at a safe distance from all hazardous motion

   Note: If there is not sufficient clearance and a pinch point exists, verify that other safeguarding devices (e.g., safety mats, light curtains) prevent access or stop hazardous motion if someone is in the pinch point area. These devices shall be tested as outlined in Step 9 of this annex.
4. Verify that all material entrance points do not create pinch/crush areas or allow undetected access into the cell.

B3. E-stop, reset and power on

This test ensures that all of the equipment can be stopped with an emergency stop device and the equipment will not re-start until it receives specific instructions to do so. The tests in this step shall be carried out on individual pieces of equipment in the cell before groups of equipment are tested, when applicable. All equipment that passes into, across, or out of the cell/work area shall pass this test before continuing the validation process.

1. Every manual E-stop control device shall be tested to ensure it stops all hazardous motion within its span of control.

   Note: Conduct this test in the manual, automatic and teach mode for each E-stop device. All of the equipment should be in motion in order to ensure that each E-stop affects every piece of equipment. For robots, the teach pendant E-stop shall function identically to all other E-stops in the cell.
2. Each E-stop device shall be tested to ensure that no motion occurs when it is returned to its normal position (i.e., E-stop push button is pulled out).
3. No motion shall occur when each safety system is reset (e.g., station reset push button is depressed).
4. All safety system resets shall be tested for anti-tie down capability.

Note: This test is typically performed by holding the reset button in and trying to start the equipment. No motion should occur when the reset button is held in. Conduct this test in both the manual and automatic mode.

5. All power on and start control devices that initiate hazardous motion shall be tested for anti-tie down capability.

   Note: With all safety systems reset, operate the power on or start control device and hold in the depressed (on) state. No motion should occur. Conduct this test in both the manual and automatic mode. If the start device cannot be held "in" (e.g., HMI input), skip this step.

B4. Power device duplication and monitoring

This test proves that the power devices that are used to control the energy (which creates hazardous motion) are also duplicated and monitored. Also, this test shows that a failure of either device will remove hazardous motion and prevent further operation.

Use the risk assessment data summary sheet for CLS as well as the final "as built" control circuit drawings to identify which power devices (e.g., contactors and valves) control hazardous motion. All power devices that are part of the CLS and used to control the energy (which creates hazardous motion) shall be duplicated.

1. To test for duplication, verify that the redundant devices control all hazardous motion in the CLS and that both devices de-energize when a safety device (e.g., E-stop, gate switch) is actuated. If any equipment comes standard with redundant control devices (e.g., a control reliable robot), check one of each model to ensure they meet this requirement.
2. To test the monitoring of power devices, check each power device individually to ensure that when it is in a failed state the safety systems cannot be reset. This verification can be performed by holding each device in the failed state (i.e., hold contactor "in") while trying to reset the safety systems.
3. To test the monitoring of control devices, check each control device individually within each safety circuit to ensure that when it is in a failed state the safety systems cannot be reset. This verification can be performed by holding each single device in the failed state (e.g., hold relay "in") while trying to reset the safety systems.
4. To test the functionality of CLS circuit design status indicator, verify that it is <u>not</u> illuminated if any CLS controlled power device is in the failed state.

B5. Perimeter guard interlock

This test verifies that the safety interlocks on the perimeter guarding stop all hazardous motion in the safeguarded area.

The following actions shall be taken to verify the perimeter guard interlock:

1. Test each perimeter guard interlock device by opening each gate or tripping each perimeter guard light curtain with every piece of equipment in motion.

   Note: When actuated, each device (e.g., gate switch or light curtain) shall stop and prevent a restart of all hazardous motion in the cell. Conduct this test for each perimeter guard interlock device in the automatic mode.

2. Test that the automatic mode cannot be obtained under any condition while any gate is open or perimeter guard is tripped.
3. Test that no motion occurs when the gate safety interlock system is reset.
4. Review the functionality of the gate to determine under which conditions hazardous motion can continue when the gate is opened. For example, with the selector switches on the gate box in the correct position and either a teach or enabling pendant in use, hazardous motion may be allowed to continue when the gate is open.
   a. For conditions in which no hazardous motion is allowed in the cell, ensure that all hazardous motion stops when the gate is opened.
   b. Test each position of every selector switch to ensure it only enables the motion intended.

Note: Conduct this test in both the manual and teach mode because when the gate is open, hazardous motion is only permitted in these modes.

c. Test every safety device (e.g., E-stop buttons, gate switches, and light curtains) that stops hazardous motion in the cell to ensure it causes the hazardous motion power devices to open (i.e., de-energize) and remain open.

B6. Teach pendant verification

This test verifies that the robot teach pendant(s) or machine pendant cannot be overridden by any other control device. It also ensures that the teach pendant provides exclusive control of the equipment, and it does not unintentionally enable the equipment.

The following actions shall be taken to verify the robot teach pendant:

1. With a gate open, verify that each teach pendant initiates servo motion only when the switches located on the gate box are in a position that permits robot servo motion.
2. Test each teach pendant to ensure that no robot motion is allowed until the hold-to-run switch is engaged.
3. Test each teach pendant to ensure that all robot motion controlled by the teach pendant stops when the hold-to-run switch is released.
4. Test each teach pendant to ensure that no robot motion occurs when the hold-to-run switch is engaged until motion is initiated by a separate action (i.e., joystick).
5. In the teach mode, ensure that robot motion cannot be initiated by any other control device.

B7. Enabling pendant

This test verifies that the enabling pendant(s) cannot be overridden by any other control device. It also ensures that the enabling pendant provides exclusive control of the equipment, does not unintentionally enable any piece of the equipment, and only enables the equipment in its intended span of control.

With the switches on the gate control console in the correct position, an enabling pendant permits motion in the safeguarded area while a gate is open.

1. With a gate open, test that each enabling pendant only enables the motion indicated by the switches on the gate control console.
2. Test each enabling pendant to ensure that no motion is allowed until the hold-to-run switch is engaged.
3. Test each enabling pendant to ensure that all motion enabled by the pendant stops when the hold-to-run switch is either squeezed or released.
4. Test each enabling pendant to ensure that no motion occurs when the hold-to-run switch is engaged until motion is initiated by a separate action (e.g., HMI input).

B8. Point-of-operation safeguarding device

This test verifies that the point-of-operation safeguarding device(s) are mounted in the correct position, and that the equipment will safely stop before any person reaches the hazardous area.

1. Verify that the safeguarded zone is sufficiently sized to prohibit any person from contacting the hazardous motion.
2. Verify that barriers or other safeguarding devices prevent a person from passing through the safeguarded area into the hazardous area.
3. Verify that no access (e.g., reaching over, under, or around the safety device) to a danger point exists.
4. Verify that the safety device is securely mounted and that it cannot be adjusted or removed without the use of tools.
5. For all devices guarding hazardous motion, verify that the device is dual channel (i.e., control reliable).

6. Test that the hazardous motion (which the operator may be exposed to) stops when the safeguarded area is entered and before the operator is exposed to it (reference Annex A: Safe Distance Formulas).

   Note: Conduct this test only in the automatic mode.

7. Test that no motion occurs when the safeguarding device is reset.

B9. Pinch point safeguarding device

This test verifies that pinch point safeguarding devices inside the safeguarded area are mounted in the correct position and that no hazardous motion can be initiated when the devices are actuated.

1. Verify that the safeguarded area is sufficiently sized so that the operator cannot be present in the pinch point area without actuating the safeguarding device.
2. Verify that the safety device is securely mounted and that it cannot be adjusted or removed without the use of tools.
3. For all devices guarding hazardous motion, verify that the device is dual channel (i.e., control reliable).
4. Test that the hazardous motion creating the pinch point cannot be initiated when a person is in that pinch point area.

   Note: Conduct this test only in the manual mode.

5. Test that no motion occurs when the safeguarding device is reset.

Annex C: Example CLS Placard

CLS Task Placard

CONTROLS LOCKOUT SOLUTION

CLS removes electrical power from the devices that can cause motion. The robot is the only device in the cell under CLS. In CLS, enter the cell only if the 'CLS ACTIVE - OK TO ENTER' light is on.

The following tasks in the cell can be performed with the robot under CLS:

Lathes:
- Operate in Local mode
- Startup machinery
- Change tools
- Push chips
- Clear run-time faults
- Cycle lathes to bring parts to size
- Change lathe inserts
- Change lathe jaws - (With lathe power removed)
- Vibration analysis
- Part program development

Parts Presenter:
- Operate in Local mode
- Clear miscellaneous faults

Misc:
- 5S activities

Robot:
- Jog/Program/Teach robot
- Adjust gripper proxes

LOCKOUT

When performing tasks not listed above or when you have exposure to other than motion hazards, the LOCKOUT procedure must be followed.

HAZARD AWARENESS

The following hazards may be encountered when working in this cell. Always remember safe work practices; visually assess the work area, identify any hazard and use the training you have received.
Wear your personal protective equipment.

- Trips/Slips
- Sharp Edges/Cuts
- Head Obstructions
- Falls (Use platform step ladders or aerial lifts, wear fall protection equipment)
- Fires From Cutting and Welding
- Burns
- Chemical Reaction from Lubricants, Sealers, etc. (Review Safe Use Instructions)
- Gravity (Use safety pins/blocks, follow rigging techniques)

If you have any questions contact your supervisor

Annex D: Hierarchy of Controls – Solution Illustrations

The basic thought process must recognize the work to be done, evaluate the hazards and exposures associated with the tasks and provide the most effective H&S control solutions.

Safety for all processes, cells and machines shall be addressed through the Hierarchy of Health and Safety Controls. The following examples are intended to provide a better understanding of the hierarchical approach.

D1. Elimination or Substitution:

a. Eliminate equipment

b. Simplify equipment

c. Improve initial equipment design

d. Remove/minimize human interaction with equipment

e. Eliminate pinch points

f. Eliminate or simplify material handling

g. Place adjusting devices and other requirements for human interaction outside the hazard area

h. Substitute less hazardous processes and/or chemicals

D2. Engineering Controls:

a. Perimeter guards

b. Light curtains

c. Safety mats

d. Interlocks

e. Safety relays, switches and other control devices

f. Ventilation, local or point of operation exhaust

g. Automatic/Manual material handling (e.g. lift for ergonomics issue)

h. Movable interlocked guard

Light Curtain

Safety Gate Switch

Safety Relay

Emergency Stop Pushbutton

D3. Warnings:

a. Lights, beacons and strobes
b. Computer warnings
c. Signs
d. Markings indicating a restricted space on the floor
e. Equipment start-up alarms, beepers and horns
f. Labels

Laser Equipment

Ionizing Radiation Equipment

Stack Light

European Safety
per
European Directive 92/58/EEC and ISO 3864

D4. Training and Procedures (Administrative Controls)

a. Safe operating practices and procedures

b. Standardize Work

c. Job rotation

d. Written Training Programs

Note: Written training, procedures and administrative controls are used when higher-level alternatives are not feasible, and when the risk is adequately controlled. Personnel must be properly trained before operating and maintaining equipment. This includes being provided with up-to-date and accurate written instructions (Safety, Standardized Work, Set-up, Start-up, Run, Stop, etc.). The training and instructions must be implemented, enforced and followed.

Lockout / Tag-out Placard

D5. Personal Protective Equipment (PPE):

a. Face shields

b. Safety glasses

c. Hearing protection

d. Gloves

e. Protective sleeves

f. Respirators

g. Welding screens

h. Expendable tools

Welding Screen

Safety Glasses

Ear Plugs

Face Shield

Annex E: Safety Circuit Performance Requirements

RIA 15.06	ISO13849-1 (EN954-1)	Interpretation of Circuit Requirements
Simple	Category B	Control as per basic specifications.
Single Channel	Category 1	Use of well-tried and tested components and principles.
Single Channel w/ Monitoring	Category 2	Safety function shall be tested/checked at suitable intervals (frequency determined according to application). Single fault may cause the loss of the safety function.
Control Reliable	Category 3	A single fault must not cause the loss of the safety function. The fault should be detected whenever reasonably practicable. An accumulation of faults may cause the loss of the safety function.
	Category 4	A single fault must not cause the loss of the safety function. The fault shall be detected at or before the next demand of the safety function. An accumulation of faults must not cause the loss of the safety function.

Notes:

1. The above information is derived from Table 3, page 8, ANSI B11.TR4, 2004.
2. The ANSI B11 series of machine tool safety standards include a note within an explanatory annex stating that control reliability for machine tools is not directly comparable to the requirements of ISO 13849-1 and exceed a Category 2.
3. The Nexteer Automotive task based risk assessment process is based on the robot risk assessment per ANSI/RIA R15.06. Further, ANSI/RIA R15.06 (clause 4.5) includes a note that states that the ISO 13849-1 Categories are different from the performance criteria within R15.06, and exceed Categories B, 1, 2, and 3. Control reliability for robots typically exceeds a Category 3, but is not necessarily intended to be a Category 4. Circuits that are “dual channel with monitoring” and safeguarding devices with dual safety outputs that are certified for Category 3 usage, such as safety mats and area scanners, are generally accepted for use in robot applications that require Control Reliable safety performance, as defined in that standard.

Annex F: References

The references used in the development of this specification are listed below.

Note: Users of this specification shall consult applicable Federal, State, Country, and Local laws, regulations and standards in addition to those listed below. Reference the most current version of the specifications / standards listed below.

Nexteer Automotive Documents:

Manufactuirng Engineering **Website:** nexteersuppliers.com

- SD-004, Electrical Specification for Industrial Machinery, addendum to IEC 6020401
- SD-011, Specification for Safety Circuits
- SD-013, Hydraulic fluid power - General rules relating to systems, addendum to ISO 4413
- SD-014, Pneumatic fluid power - General rules relating to systems, addendum to ISO 4414
- SD-015 Lean Equipment Design
- SD-016, Lean Equipment Controls Design
- Guarding/Cycle Initiate Methodology

Design-In Ergonomics **Website:** Ergonomics - Design-In

- SD-017, Design-In Ergonomics Guidelines (DEG)

Health & Safety **Website:** Health & Safety Homepage

- Industrial Hygiene Policies and Procedures
- Lockout/Energy Control Program–1993, UAW/Nexteer Automotive National Agreement
- SL1, Sound Level Specification for the Purchase of New and Rebuilt Machinery, Power tools and Equipment
- SL2, Uniform Plant Sound Survey Procedure
- SL3, Program for Occupational Hearing Conservation and Noise Control
- Fall Prevention Program Requirements & Safety Systems, Version 2

Other Documents:

- LS1, General Motors Lubrication Standard for Industrial Equipment and Machine Tools

National Documents:

ANSI – American National Standards Institute **website:** www.ANSI.org

- ANSI/ASME B15.1, Mechanical Power Transmission Apparatus
- ANSI/ASME B20.1, Safety Standard for Conveyors and Related Equipment
- ANSI B11.1, Machine Tools – Mechanical Power Presses – Safety Requirements for Construction, Care, and Use
- ANSI B11.19, Machine Tools, Safeguarding when referenced by the Other B11 Machine Tool Safety Standards - Performance Criteria for the Design, Construction, Care, and Operation
- ANSI B11.20, Manufacturing Systems/Cells-Safety Requirements for Construction, Care, and Use
- ANSI B11.23, Machining Centers - Safety Requirements for Construction, Care, and Use
- ANSI/RIA R15.06, American National Standard for Industrial Robots and Systems – Safety Requirements

- ANSI Z136.1, American National Standard for the Safe Use of Lasers
- ANSI Z244.1, Lockout/Tagout of Energy Sources
- ANSI Z9.7 (when available), Recirculation of Industrial Process Exhaust System

NFPA – National Fire Protection Association **website:** www.NFPA.org

- NFPA 79, Electrical Standard for Industrial Equipment, 2002 Edition

OSHA – Occupational Safety & Health Administration **website:** www.OSHA.gov

- OSHA 29 CFR 1910 (applicable provisions)
- OSHA 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout); The Ontario Occupational Health & Safety Act; the Quebec Occupational Health & Safety Act; the Ontario Hydro Act.

International Documents

HSC – Health & Safety Council **website:** www.HSE.gov.uk

New Approach Directives **website:** www.Newapproach.org

- 73/23/EEC – Low Voltage Directive
- 93/68/EEC
- 89/336/EEC – Electromagnetic Compatibility Directive (EMC)
- 98/37/EEC – Machinery Directive
- 98/79/EEC
- 2003/10/EC – Noise Directive regarding the exposure of workers
- 89/655/CEE – Health & Safety Directive

IEC – International Electro-Technical Commission **website:** www.IEC.ch

- IEC 60204-1, Electrical Equipment of Industrial Machines - General Requirements
- IEC 60034-9, Rotating Electrical Machines – Noise Limits

BSI – British Standards Institute **website:** www.BSI-Global.com

- BS EN 999, Safety of machinery – The positioning of protective equipment in respect of approach speeds of parts of the human body.
- BS EN 574, Two Hand control device
- BS EN 292, Safety of machinery; basic concept, general principles for design
- BS EN 294, Safety distances to prevent danger zones being reached by the upper limbs
- BS EN 953, Guards
- BS EN 954-1, Safety related parts of control systems
- BS EN 982, Safety of Machinery – Safety requirements for fluid power systems and their components. Hydraulics
- BS EN 983, Safety of Machinery – Safety requirements for fluid power systems and their components. Pneumatics
- BS EN 1050, Principles for risk assessment
- BS EN 1088, Interlocking devices associated with guards
- BS EN 1760, Pressure sensitive protective devices
- BS EN 12101-2, Specification for natural smoke and heat exhaust ventilators

- BS EN 14122-2, Safety of Machinery -- Permanent means of access to machinery, working platforms, and walkways
- BS EN 14122-3, Safety of Machinery -- Permanent means of access to machinery, stairways, step ladders, and guard rails
- BS EN 61496-1, Electro-sensitive protective devices
- COSHH – Control of substances hazardous to health **website:** www.hse.gov.uk

ISO – International Standards Organization **website:** www.ISO.org

- ISO 1819 -- Safety code for continuous mechanical handling equipment
- ISO 4413, Hydraulic fluid power - General rules relating to system.
- ISO 4414, Pneumatic fluid power - General rules relating to systems.
- ISO/TR 5045 -- Safety code for belt conveyors
- ISO 11014-1, Safety data sheets for chemical products
- ISO 11553, Safety of Machinery – Laser processing safety requirements
- ISO 9612, Acoustics – Guidelines for the measurement and assessment of noise in a working environment
- ISO 10218, Manipulating industrial robots – Safety
- ISO 13849-1, Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
- ISO 14159, Safety of Machinery - - Hygiene requirements for the design of machinery
- ISO 14121, Safety of machinery – Principles of risk assessment
- ISO 14159, Safety of Machinery – Hygiene requirements for the design of machinery

International specifications are available from their respective publisher but there are also a number of general distributors who provide specifications from multiple publishers. Some of these are listed below.

Global Engineering Documents **website:** http://www.global.ihs.com/
15 Inverness Way East
Englewood, Colorado 80112
303 – 397-7956

National Resource for Global Standards **website:** www.nssn.com
11 West 42nd Street
New York, New York 10036
212 – 642-4980

Annex G: Definitions

actuators: A power mechanism used to affect the motion of the robot by converting electrical, hydraulic or pneumatic energy.

anti-repeat: The function of the control system that limits the machine to a single cycle with the actuating control(s) held in the operating mode.

anti-tie down: 1) With a two-hand control device, the function of the control system that requires the release of all actuators before the machine operation can be reinitiated. 2) With a safety circuit reset, the function of the safety circuit that requires the reset signal to cycle on and off with each circuit reset.

attended program verification (APV): The act of verifying the robot's programmed tasks at the programmed speed while within the safeguarded area.

automatic mode: Any operating mode that produces continuous cycling.

awareness barrier: An attachment that, by physical contact, warns personnel of a present or approaching hazard.

awareness device: A device or signal that, by means of audible sound or visible light, warns personnel of a present or approaching hazard.

barrier: A device or object that provides a physical boundary to a hazard.

cell: An area surrounded by a defined perimeter that contains part processing machines, robots, and transfer equipment.

chemical: Any element, chemical compound, or mixture of elements and/or compounds.

concurrent: Acting in conjunction, this term is used to describe a situation where two or more controls exist simultaneously in an operated condition, but are not necessarily executed simultaneously.

control devices: Any piece of control hardware providing a means for human intervention in the control of a machine or system (e.g., an emergency stop button, start button, or selector switch).

control reliability: A method of ensuring the integrity of performance of the safety devices or control systems. As a result, a single component failure within the device, interface, or system shall not prevent the normal stopping action from taking place, but shall prevent a successive machine cycle.

control system: Sensors; manual input and mode selection elements; interlocking and decision-making circuitry; and output elements to the machine or robot operating devices and mechanisms comprise the control system.

cycle: A complete movement of the machine or robot from its initial start position back to that same start position. This may include feeding and removal of the material or workpiece(s).

design-in safety: The process by which health and safety processes, tools, methods, and requirements are integrated early in the design phase to improve safety, quality, cost and productivity.

disconnect (mechanically interrupted): An electrical-energy interrupting device that uses mechanical linkage to force a break in the power supply to an individual piece of equipment.

dynamic limiting device (DLD): A limiting device that may be activated or muted in the course of executing the application program of a robot; thereby, redefining the safeguarded space.

enabling device: A manually operated device that permits motion when continuously activated.

end-effector: An accessory device or tool specifically designed for attachment to the robot wrist or tool mounting plate to enable the robot perform its intended task (e.g. gripper, spot weld gun, arc weld gun, spray paint gun, or any other application tools).

emergency stop: The immediate or controlled stopping of all hazardous machine motion, which is usually accompanied by the removal of the source power to the machine.

ergonomics: The evaluation, design or redesign of facilities, environments, jobs, job tasks, training methods and equipment to match the capabilities of people.

exclusive control: A station or pendant control on any piece of equipment that allows an individual to operate it in a manual mode. In addition, the operation cannot be overridden from any other location.

firmware: The executive control program (e.g. operating system) code provided by the manufacturer of the component in a non-volatile internal storage mode and is not changeable by the user.

guard: A barrier that prevents entry into the point-of-operation or any other hazardous area.

hard stop: A mechanical device that restricts the robot's or machine tool's ability to move to its full capability.

hazard: A condition or set of circumstances that can cause physical harm to exposed personnel.

hazard area: An area or space that poses an immediate or impending physical hazard.

hazardous motion: Motion of the equipment or a release of energy that can pose as a hazard.

hazardous zone: See hazard area.

hierarchy of health and safety controls: Health and safety control solutions that are listed in the order of effectiveness from most to least (i.e., elimination or substitution, engineering controls, warnings, training and procedures, and personal protective equipment).

industrial equipment and systems: A physical apparatus (e.g., welder, conveyor, machine tool, fork truck, turn table, positioning table, or robot) that is used to perform industrial tasks.

industrial hygiene: The anticipation, recognition, evaluation, elimination, and control of chemical, biological and physical hazards.

interlock: A means or device that allows a hazardous condition to exist only when a predetermined set of conditions is met.

interlocked barrier guard: A barrier, or section of a barrier, interlocked with the [machine] control system to prevent inadvertent access to the point of operation during normal [machine] operation.

light curtain: A device that creates a sensing field or plane to detect the presence of an individual or object.

limiting device: A device that prevents a machine or machine elements from exceeding a designed space limit.

lockout: A lock placed on an energy isolating device (e.g., a disconnect switch or shut-off valve) in accordance with Union/Nexteer Automotive lockout energy control procedures.

machine tool: A power-driven tool used for machining.

manual mode: Any operating mode of the machine or system that requires the operator to initiate and maintain the motion of the machine or system during the cycle, or portion of the cycle, by use of the actuating control.

MSDS: Material Safety Data Sheet.

muting: The automatic temporary bypassing of any safety related function(s) of the control system or safeguarding device.

operating space: The part of the work (maximum) space that is used by a robot, including a workpiece, during automatic operation.

operating modes: The systems of operating machines, robots, and other equipment for various operations generally consisting of automatic, manual, and jog/inch/set-up modes.

perimeter guard: A barrier at the perimeter (or segment of the perimeter) of a machine or production system.

pinch point: Any point at which it is possible for a portion of the body to be caught between two moving physical devices or between one moving and one stationary physical device.

placard: A form of quick reference documentation placed on the equipment or at the entrances into the safeguarded areas. This documentation identifies the machine name, number, location, location of energy control devices, energy sources, methods of energy control, and methods of verification for locking out and controlling energy.

point-of-operation: The location in the machine where the material or workpiece is positioned and work is performed.

positive-guided relay: Relay designed to eliminate any springing of the contacts to ensure a true making and breaking of contacts and, in the case of a failure, to ensure that a minimum clearance of 0.5 mm between the open contacts is maintained. These relays are sometimes called guided-contact, captive-contact, direct-drive, force-guided-contact, or forced-contact relays.

positive-opening contacts: The achievement of contact separation as a direct result of a specified movement of the switch actuator through non-resilient members (i.e., not dependent upon springs).

presence sensing device (PSD): A device (e.g. light curtain, scanner, safety mat) that creates a sensing field, area, or plane that detects the presence of an individual or object.

Programmable Electronic System (PES): An electronic system that performs logical, decision-making or arithmetic functions by executing instructions in a specific manner. The system usually includes input and output elements (ports) and is usually re-programmable.

redundancy: Duplication or repetition of elements in electronic or mechanical equipment that provides alternative functional channels in case of a failure(s).

restricted space: The maximum distance that a robot, including the workpiece, can travel in all directions after a limiting device has been installed.

risk: The potential for injury based on exposure to a hazard(s) during a given task.

safe distance: A minimum distance from a hazard that safeguarding shall be located to prevent persons from exposure to the hazard.

safe operating procedure (SOP): A specific written procedure that must be followed when it is determined that the equipment design prohibits a particular task from being performed in accordance with either the plant lockout procedure or CLS procedure. (Reference Union/Nexteer Automotive lockout implementation guidelines.)

safeguarding: Methods of protecting personnel from hazards by using guards, safeguarding devices/methods or safe work procedures.

safeguarding device: A means (device) that detects or prevents inadvertent access to a hazard.

safety interlock: A means or device that prevents entry into a zone or cell while hazardous conditions exist. Entry can be attained only when a predetermined set of conditions is met.

shall: Denotes a requirement that is to be strictly followed in order to conform to this specification.

should: Denotes a recommendation, practice, or condition among several alternatives or a preferred method or course of action.

single component failure: Relates to a redundant control system whereby the failure of any one component of the system will have no effect on the stopping action of the system.

single point of control: The ability to operate the machine or robot such that initiation of machine or robot motion from one source of control is only possible from that source and cannot be overridden from another source.

stop device: A part of the machine operating system (e.g., emergency stop button, presence sensing device, pull cord, monitored power circuitry, or a cycle stop/hold button) that causes the cycle to stop when it is either automatically or manually activated.

stored energy: Any source of energy (e.g., hydraulic systems, air cushions, springs under pressure, or gravity) that could still present a hazard after a piece of equipment or process has been stopped from performing its normal function.

two-hand control device: A device that requires the concurrent use of both of the operator's hands to initiate and continue the machine cycle during the hazardous portion of that cycle.

RECORD OF REVISIONS

Revision #	Date	Section	Description
001	17DE10	All	Initial release of SD-014 – based on Delphi Design-In Health and Safety Specification.
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