Job Hazard Assessment:
A Comprehensive Approach

By ROLIN GERONSIN

The pressure to increase profitability, improve performance and enhance quality is constant in today's workplace. This emphasis is accompanied by a call for SHE staff to be more proactive and create programs and processes to help companies avoid liability and unfavorable press. In addition, more businesses are scrutinizing workgroups to determine how each impacts the bottom line.

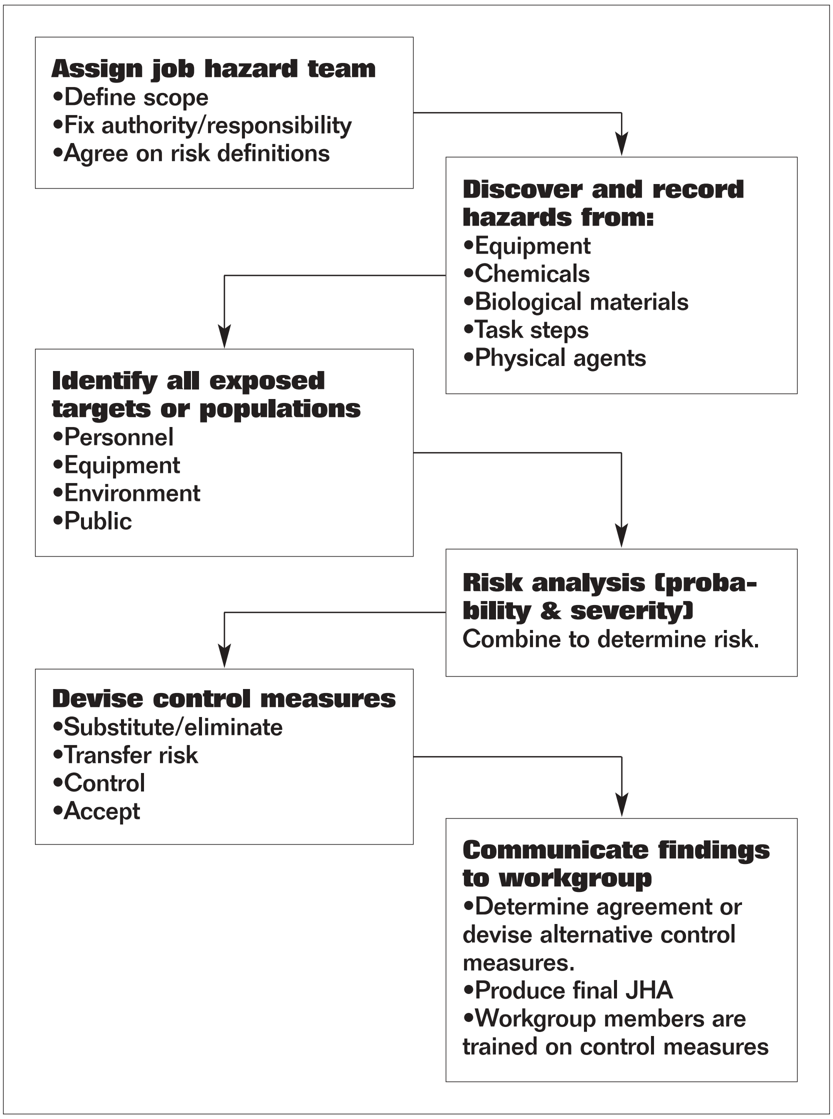
To these ends, new methods are being considered and old processes and tools modified. One such time-tested tool is the job hazard assessment (JHA). Historically, JHAs have been used almost exclusively to identify and understand the nature of safety hazards in the workplace. Manuele reviewed the principles and existing literature in "Task Analysis for Productivity, Cost Efficiency, Safety & Quality."

By adding principles and techniques from related areas and expanding traditional JHA techniques, the process can be transformed into a comprehensive instrument to help meet today's business challenges.

Understanding the nature of all hazards present in and around the work environment requires a comprehensive approach to hazard analysis and control. Bird expounded on this principle in *Management Guide to Loss Control* and in *Practical Loss Control Leadership.*

A comprehensive JHA is performed in a team-based environment. It includes an assessment of safety hazards, including occupational health issues, and environmental impacts and aspects, and an assessment of associated risk; it then provides an organized listing of appropriate control measures to mitigate the risk.

FIGURE 1 JHA Process



Adapted from Mansdorf, Z. "Risk Assessment: Focusing on the Operator"; and Clemens, P.L. "Hazard Analysis and Risk Assessment."

The addition of risk assessment to the JHA process allows the corporation to focus hazard control measures or resources on those areas where the most-significant risk is present.

The addition of risk assessment to the JHA process allows the SHE analyst and, consequently, the corporation to focus hazard control measures or resources on those areas where the most-significant risk is present. Finally, the comprehensive JHA process links established SHE guidelines, required training, regulatory requirements and affected staff.

As noted by Mansdorf in "Risk Assessment: Focusing on the Operator," the comprehensive JHA process (Figure 1) begins with establishment of a hazard assessment team (93-94). This team defines the scope for the assessment. The team should include individuals who can describe hazards inherent within the process and associated risks. SHE staff should also be represented on the team, as should the system/process owner or supervisor.

The team should first define the project's boundaries or scope. In many cases, the scope is bound by time, geography, a series of tasks or work steps, or a piece or set of equipment or materials. However the scope is defined, the team should consider a set of tasks that is easily visualized or which represents natural work boundaries.

Next, the team should identify all components within the system. This discovery phase can be completed in various ways using several techniques. For example, an intuitive or experiential technique can be used to detail all components or steps. Or, the team could benchmark against activities of another facility or workgroup. Interviews with end-users or an inspection of the work area is a particularly powerful tool during this step.

A task analysis worksheet (Figure 2) enables the team to systematically capture relevant data (Roughton 41+). Such a worksheet can be used to capture data relevant to task steps, materials, equipment and other relevant factors. All task steps, materials, equipment, chemicals, biological materials, physical agents and other items used in or contained within the project's scope should be tabulated and briefly described.

Any data that would ensure a thorough description or understanding of the process should also be collected and reviewed. Any piece of equipment or chemical may introduce a hazard to the work environment. For example, a chemical may be caustic, toxic, flammable or some combination. Hazards should be considered from all sources, as should their potential impact on all targets or exposed populations, all parts of the system, all configurations and all phases of operation.

Once system components have been completely detailed, each component's inherent hazards should be analyzed. In addition to identifying hazards noted earlier, all environmental aspects should be identified. These impacts may be identified through a mass-balance assessment of the process; an analysis of any impact to the land, air or water; or any materials that add to a wastestream. When developing the list of environmental impacts and aspects, the team

FIGURE 2 Task Analysis Worksheet

Location (Bldg., room no. or area): Solution Prep. **Date:** ______
System owner(s): Tim, Lara, Jeremy **Task:** Solution Prep.
Analysis completed by: Rolin Geronsin

Individual Step Description	Associated Materials/Equipment/Instruments
1. Material transfer: Chemicals are collected in the buffer prep area in advance of transfer to tanks.	1. Hydrochloric Acid Liquid, 37%, 300 L tote 2. Glacial Acetic Acid 98%, Liquid, 300 L tote 3. Bis Tris Solid, 12 kg buckets 4. Urea Solid, 90 – 12 kg buckets 5. Buffer Salts Solid, 12 kg buckets
2. Batch preparation: Totes lifted by crane to elevated platform. HCI and Glacial Acetic are transferred via flex hoses while suspended from cranes. Totes are vented to atmosphere.	1. Hydrochloric Acid Liquid, 70-90%, 300 L tote 2. Glacial Acetic Acid 98%, Liquid, 300 L tote 3. Overhead crane
3. Batch preparation: Chemicals are carried up one flight of stairs to elevated platform, then transferred into tanks.	1. Bis Tris Solid, 12 kg buckets 2. Urea 90 – 12 kg buckets 3. Buffer Salts Solid, 12 kg buckets 4. HCI 100 ml aliquots—up to 7 containers
4. Tank pH sampling	1. Caustic mixture (pH >9) 2. Elevated sample point (approx. 5 to 6 ft.)
5. Tote cleaning: Totes are transferred to cleaning area (station 2). A spray ball is inserted into the tote and a flex hose is attached. Another flex hose is attached to the bottom of the tote, then into the return. Tote is vented to the room.	1. Tote is rinsed and cleaned through 8 cycles 2. Hot water (80°C)

Adapted from Roughton, J., "Job Hazard Analysis."

must consider any nonroutine activities or processes that might occur; this could include start-up activities, cleaning, validation or testing activities, and shutdown procedures.

Figure 3 depicts a hazard/risk analysis form that can facilitate this step. This form contains fields to record task steps and associated hazards. Column 3 provides a place to record identified or potential environmental impacts. Data from the risk analysis should be tabulated (column 4). Any additional data or information deemed necessary to the review process is recorded in column 5.

The JHA team should consider the impact of each hazard on each population or target of concern. Clemens advises the team to "choose or pick targets with care," warning that "too few or the wrong targets will create an ineffective program, while too many targets will be burdensome" (Clemens). Exposed populations or targets may include personnel; the environment (air, water, land, wildlife); physical facilities; process or system downtime; the product or service; equipment/instruments; and the public or public opinion. For example, a corrosive chemical in a process pipeline

FIGURE 3 Hazard/Risk Analysis Form

Location (Bldg., room no. or area): Solution Prep. **Date:** ________
System owner(s): Tim, Lara, Jeremy **Task:** Solution Prep.
Analysis completed by: Rolin Geronsin

Process/Task/Materials/Equipment	Hazard Description	Env Impact Assessment	Risk			Recommendations*
			Sev	Prob	Rank	
Material Transfer Step 1. Hydrochloric Acid (liquid, 37%, 300 L tote) 2. Glacial Acetic Acid (liquid, 98%, 300 L tote) 3. Bis Tris (solid, 12 kg buckets) 4. Urea (solid, 90 – 12 kg buckets) 5. Buffer Salts (solid, 12 kg buckets)	1. Corrosive 2. Corrosive, combustible 3. Nonhazardous 4. Hazard to POTW (ammonia) 5. Nonhazardous Little or no hazard in this step. Materials are simply transferred (pushed or rolled) from receiving into prep area.	Minor opportunity for spills Urea must not be placed in process drain, hazard to POTW	1	1	C	Reduce the chance of spills by handling materials carefully. Position spill clean-up supplies in general area.
Batch Prep (totes) 1. Hydrochloric Acid (liquid, 37%, 300 L tote) 2. Glacial Acetic Acid (liquid, 98%, 300 L tote) 3. Overhead crane	1 and 2. Little or no chemical hazard, closed system. 3. Impact hazard from elevated object.	Plastic bucket waste Potential spills	3	3	B	Collect air samples during HCI and Acetic Acid transfer to determine the necessity of respiratory protection. Collect plastic buckets for recycling. Maintain spill materials for clean up. Discharge of urea to sanitary sewer is prohibited. Protect drains from potential spills.
Batch Prep (12 kg containers) 1. Bis Tris (solid, 12 kg buckets) 2. Urea (solid, 90 – 12 kg buckets) 3. Buffer salts (solid, 12 kg buckets) 4. HCI (100 ml aliquots – up to 7 containers)	1, 2 and 3. Lifting and carry hazard. Manual transfer of more than 1,000 kg of material 2x per day up one flight of stairs. 4. Chemical – Corrosive, irritant, inhalation, reactive with water.	Potential for spills.	2	3	B	Provide alternate method of moving urea containers up to platform. Consider transfer of buckets by crane inside closed container. Always add acid to water. Maintain spill cleanup materials. Prevent urea from discharging to the sanitary sewer.
Sample collection 1. Caustic mixture (pH >9)	1. Chemical – Skin and eye irritant, mild inhalation hazard. Potential for eye and/or face exposure.	NA	2	2	C	Consider the use of a face shield and/or skin protection.
Cleaning 1. Hot water (80°C)	1. Physical – Burn hazard	Wastewater generated from cleaning. Residual urea remaining in buckets.	3	3	B	Provide training and warning signs. Collect air samples during tote cleaning to determine the necessity of repiratory protection. With the exception of urea, cleaning wastes can be discharged to the sanitary sewer. All residual urea should be collected for off-site disposal.

*Recommendations may include IH monitoring, occupational health exams, standard hazard control measures, etc.

becomes hazardous upon contact with human skin, an incompatible filter membrane at the downstream treatment works or an incompatible gasket in a piece of process equipment.

Once all hazards and targets are identified, a risk assessment should be conducted. This step is a key added component in a comprehensive JHA. Risk assessment allows the team to understand where the most-significant risk exists within a system so it can determine what level of control should be recommended.

Risk assessment is the process of estimating the probability of an event's occurrence and the magnitude or severity of adverse effects. For each hazard/target combination, the probability (or likelihood) of an event's occurrence should be evaluated through whatever means will generate the most-credible data.

This step may be facilitated by factors such as the team's analysis of previous incidents, inspection results and team member experience. Jaycock provides risk assessment definitions and a discussion of the risk assessment paradigm (Jaycock, et al).

Table 1 shows a probability definition key that can be used during this phase. Table 2 shows a severity definition key that should be used to deter-

TABLE 1 Probability Matrix

Definition	Probability Descriptor
Hazard or impact likely to occur more than once during life of the system.	Probable (4)
Hazard or impact likely to occur sometime in system life cycle.	Occasional (3)
Hazard or impact not likely to occur in system life cycle, but possible.	Remote (2)
Hazard or impact occurrence cannot be distinguished from zero.	Improbable (1)

Adapted from Clemens, P.L., "Hazard Analysis and Risk Assessment."

TABLE 2 Severity Matrix

Severity Descriptor	Category	Safety Implications or Definition	Environmental Implications
Catastrophic (4)	Hazard/Impact Severity:	Results in death or dismemberment. Results in >$1 million in damage to facility or equipment.	Irreversible/off-site impact on the environment.
	Compliance Status:	Lack of compliance leading to IDLH condition. Condition leading to permit revocation, fines >$1 million.	Lack of compliance, leading to irreversible impact on the environment, loss of permit, large financial or criminal penalties imposed by regulatory agencies.
	Public Image of Impact:	Severity negative; result in negative publicity.	Severely negative; result in negative publicity.
Critical (3)	Hazard/Impact Severity:	Loss of limb use or function; long-term illness; irreversible illness. Damage to facility or equipment between $250,000 and $1 million.	Irreversible/onsite impact on the environment.
	Compliance Status:	Lack of compliance, likely to result in serious injury or long-term illness.	Lack of compliance; likely to result in irreversible impact on the environment, permit restrictions or fines.
	Public Image of Impact:	Negative public reaction possible; regulatory agency notification necessary.	Negative public reaction possible; regulatory agency notification necessary.
Marginal (2)	Hazard/Impact Severity:	Requiring immediate medical attention; short-term reversible illness. Damage to facility or equipment between $100,000 and $250,000.	Minor/reversible environmental impact.
	Compliance Status:	Likely to go out of compliance.	Likely to go out of compliance.
	Public Image of Impact:	Neutral	Neutral
Negligible (1)	Hazard/Impact Severity:	Minor or no injury. Damage to facility or equipment less than $100,000.	Minimal or no environmental impact.
	Compliance Status:	Non-regulated	Non-regulated
	Public Image of Impact:	No public concern	No public concern

Adapted from Clemens, P.L., "Hazard Analysis and Risk Assessment."

mine which term best describes the "worst credible" occurrence. If the team recognizes that multiple target populations can be affected by a given hazard, each combination should be analyzed. The severity descriptor selected from the multiple combinations should represent the most-severe potential outcome from among the chosen combinations.

The descriptors chosen for probability and severity (Table 1 and 2) should then be combined on the risk assessment matrix (Table 3). The result is a risk code assessment for the hazard/target combination under review. This assessment code should be recorded on the hazard/risk form (Figure 3) and subsequent JHA forms. This assessment develops a "baseline" risk or risk that is a combination of agreed-upon severity and probability descriptors. Baseline risk does not take into account the use of control measures. The estimate of baseline risk should be recorded in column 4 of Figure 3.

Following the risk assessment, the team should identify control measures that will help reduce or minimize unacceptable risks. An unacceptable risk is any hazard/target combination that results in a risk code of B or A. Asfahl describes an industry-accepted control measure hierarchy (Asfahl).

Following this protocol, the team should first try to avoid or eliminate the risk. For example, will eliminating a chemical or substituting a non-hazardous alternate eliminate the danger? If this method cannot be used or is impractical, then control measures appropriate to the process and personnel involved should be recommended. These could include engineering controls, administrative controls (such as warning devices, specific handling or work practices), personal protective equipment and environmental controls.

As each control measure is considered, the risk associated with the task step should be evaluated for reduction to an acceptable level. Assessment of this second risk factor should be considered a "residual" risk—one that exists after all appropriate hazard control measures are described.

This analysis allows affected employees to understand the nature of risks they face when completing a given task and the impact of properly using control measures. Residual risk is developed in the same manner as baseline risk except that the impact of controls is considered. The team should also review the impact of each recommended control measure and its potential to introduce new hazards to the process.

TABLE 3 Risk Assessment Matrix

Severity of Consequences	Probability of Mishap			
	Improbable	Remote	Occasional	Probable
Catastrophic	C	B	A	A
Critical	C	B	B	A
Marginal	C	C	C	B
Negligible	C	C	C	C

Risk Code Assessment A = Imperative to suppress risk to lower level
B = Action should be taken to minimize risk or team should document reasons for inaction
C = Operation permissible

Adapted from Clemens, P.L., "Hazard Analysis and Risk Assessment."

All data developed during the later stages of the risk assessment should be captured on the final JHA form (Figure 4) (Clemens). This form brings together all previously described steps that form the "comprehensive" JHA process. It allows employees to easily see and understand what process is covered, who was involved in the analysis, when the work was completed and when it should be reviewed.

The JHA form thoroughly ties the mechanics of the examined system to 1) the inherent or associated hazards; 2) estimated risk of harm; 3) a systematic listing of appropriate control measures; and 4) an estimate of any residual risk. It also allows the corporation to tie all applicable standards or guidelines and training to the work being performed. This eliminates redundant or incomplete work authorizations. The acceptance signatures from all affected workgroup members emphasize the team-based nature of the process.

Applying the combination of baseline and residual risk in this manner allows affected employees to clearly see the impact of control measures on risks associated with the completion of their given tasks.

The outcome of this process can be used to train new or transferred employees or to retrain current staff after an inspection. The comprehensive JHA process quickly and efficiently shows workers the hazards present and the effect of control measures.

Once the team has completed its analysis, findings should be shared with the workgroup. The team should meet with affected employees to develop a level of understanding, acceptance and agreement. Risk assessments should be analyzed and recommended control measures scrutinized until a consensus document is produced.

SUMMARY

The comprehensive JHA tool described in this article can be used to proactively and efficiently understand the nature of all workplace hazards. Capturing safety and environmental hazards or impacts in one process eliminates redundant work by SHE staff and end-users. Incorporating risk assessment into the JHA process allows the corporation to target resources for greatest benefit.

The team-based nature of the process also ensures that ownership of hazard control measures will lie with the end-users—not with SHE staff. Such team-based activity produces several positive benefits. For example, employee involvement and input into the process of understanding risks and their control promotes a sense of self-control and ownership. This leads to enhanced productivity and morale.

Another benefit of completing the residual risk assessment emerges after the JHA has been in place for a period of time. Using the comprehensive JHA as a guide, an auditor can assess whether employees are actually using agreed-upon control measures. Similarly, the auditor can determine whether those control measures are actually reducing risk in the workplace.

FIGURE 4 Job/Hazard Assessment Form

Task/Method: ______________________

Description: ______________________

Work Group: ______________________ **EH&S Representative:** ________________ **Analysis Date:** _____

Affected Personnel:

Printed Name **Signature** **Date Trainec**

Task Steps, Materials, Equipment	Hazard Classification	Baseline Risk	Engineering Controls (Substitutions)	Warning Devices
Material Transfer Step 1. Hydrochloric Acid (liquid, 37%, 300 L tote) 2. Glacial Acetic Acid (liquid, 98%, 300 L tote) 3. Bis Tris (solid, 12 kg buckets) 4. Urea (solid, 90 – 12 kg buckets) 5. Buffer Salts (solid, 12 kg buckets)	1. Corrosive 2. Corrosive, combustible 3. Nonhazardous 4. Hazard to POTW (ammonia) 5. Nonhazardous Little or no hazard in this step. Materials are simply transferred (pushed or rolled) from receiving into prep area.	C	Use mechanical transfer devices such as forklifts, carts, etc.	Container labels
Batch Prep (totes) 1. Hydrochloric Acid (liquid, 37%, 300 L tote) 2. Glacial Acetic Acid (liquid, 98%, 300 L tote) 3. Overhead crane	1 and 2. Little or no chemical hazard; closed system. 3. Impact hazard from elevated object.	B	No special requirements	Warning signs indicating crane operations. Operational area for crane should be marked on floor.
Batch Prep (12 kg containers) 1. Bis Tris (solid, 12 kg buckets) 2. Urea (solid, 90 – 12 kg buckets) 3. Buffer salts (solid, 12 kg buckets) 4. HCI (100 ml aliquots – up to 7 containers)	1, 2 and 3. Lifting and carry hazard. Manual transfer of more than 1,000 kg of material 2x per day up one flight of stairs. 4. Chemical – Corrosive, irritant, inhalation, reactive with water.	B	Lift totes to platform with crane, placing materials inside a steel or plastic crate	Warning signs indicating crane operations
Sample collection 1. Caustic mixture (pH >9)	1. Chemical – Skin and eye irritant, mild inhalation hazard. Potential for eye and/or face exposure.	C	No special requirements	Container labels
Cleaning 1. Hot water (80°C)	1. Physical – Burn hazard	B	No special requirements	Sequence label "Caution HOT" should be placed on tote

Training:	**Principal participant:**
	Incidental participant:
Applicable Standards and Guidelines:	
Applicable Regulations:	

Certification: This document has been completed in conjunction with representatives of the department or workgroup listed a the covered task or activity.

Adapted from Clemens, P.L., "Hazard Analysis and Risk Assessment."

Using sound regulatory-based compliance programs as building blocks, the comprehensive JHA process allows employers to concentrate on areas that pose the most-significant risk.

PPE	Handling/Work Practices	Env. Controls	Residual Risk
Nitrile gloves Safety glasses	Totes are heavy—consider two-person movement.	None required	C
Nitrile gloves Hard hat (crane operation) Half-face respirator with combination cartridges	Avoid breathing vapors	None required	C
Nitrile gloves Hard hat (crane operation)	Avoid muscle strain through proper lifting and carry technique	Collect urea waste for off-site disposal. Recycle plastic containers.	C
Nitrile gloves Safety glasses Face shield	No special requirements	None required	C
Thermal gloves with Nitrile as secondary Half-face respirator with combination cartridges	Be sure cycle has completed prior to flex hose disconnect	Collect urea waste for off-site disposal.	C

above and serves as a comprehensive assessment of the hazards present in

Based on these inspections, the auditor can develop an understanding of "manifest" risk or risk that is actually present. For example, suppose a work task requires use of a chemical fume hood, yet the auditor finds the task being completed on a bench. An appropriate follow-up action would be to determine what caused this deviation. In this example, the employee is "manifesting" a risk to him/herself (and possibly to coworkers) by not performing the operation properly.

Figure 5 depicts a completed inspection using the concept of residual and manifest risk. In this example, workgroup members have not been wearing half-face respirators and have been carrying heavy buckets to an elevated work platform. These changes to the work process and elimination of an agreed-upon control have produced a manifest risk that is higher than the residual risk. Using this information, the inspector can discover the root cause for these changes and help the group mitigate this "manifested" risk.

Manifest risk can also be used as a metric to determine the overall impact of SHE programs. If hazard control measures are designed and used appropriately, manifest risk should be similar to residual risk. If it is greater, the organization can pinpoint control measures that are not being utilized and consider corrective action.

Regulations are structured to control materials, activities and equipment that have, in the past, caused or been suspected to cause injuries. The key element of this statement is "in the past." Few companies will succeed by focusing efforts on what has already occurred.

To succeed in today's environment, firms must remember the past but look to the future. Using sound regulatory-based compliance programs as building blocks, the comprehensive JHA process allows employers to concentrate on areas that pose the most-significant risk to workers, the community and the environment. This will help reduce injuries and positively impact the company's bottom line. ■

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FIGURE 5 Hazard/Risk Inspection Form

Task/Method: ________________
Description: ________________
Work Group: ____________ Inspector: ____________ Inspection Date: ____________

Task Steps, Materials, Equipment	Engineering Controls (Substitutions)	Warning Devices	PPE	Handling/Work Practices	Env. Controls	Residual Risk	Manifest Risk	Findings/ Recommendations
Material Transfer Step 1. Hydrochloric Acid (liquid, 37%, 300 L tote) 2. Glacial Acetic Acid (liquid, 98%, 300 L tote) 3. Bis Tris (solid, 12 kg buckets) 4. Urea (solid, 90 – 12 kg buckets) 5. Buffer Salts (solid, 12 kg buckets)	Use mechanical transfer devices such as forklifts, carts, etc.	Container labels	Nitrile gloves Safety glasses	Totes are heavy—consider two-person movement.	None required	C	C	Control measures used as agreed. No findings for this task step.
Batch Prep (totes) 1. Hydrochloric Acid (liquid, 37%, 300 L tote) 2. Glacial Acetic Acid (liquid, 98%, 300 L tote) 3. Overhead crane	No special requirements	Warning signs indicating crane operations. Operational area for crane should be marked on floor.	Nitrile gloves Hard hat (crane operation) Half-face respirator with combination cartridges	Avoid breathing vapors.	None required	C	B	Respirators not being used. Respirator cartridges not replaced after expiration date. New cartridges issued. Cartridges scheduled for routine replacement.
Batch Prep (12 kg containers) 1. Bis Tris (solid, 12 kg buckets) 2. Urea (solid, 90 – 12 kg buckets) 3. Buffer salts (solid, 12 kg buckets) 4. HCI (100 ml aliquots – up to 7 containers)	Lift totes to platform with crane, placing materials inside a steel or plastic crate.	Warning signs indicating crane operations	Nitrile gloves Hard hat (crane operation)	Avoid muscle strain through proper lifting and carry technique.	Collect urea waste for off-site disposal. Recycle plastic containers.	C	B	Urea buckets are being carried to second-story platform. Significant potential for slip/trip and ergonomic impact. Purchase sling or tote that will allow crane to lift urea buckets to platform.
Sample collection 1. Caustic mixture (pH >9)	No special requirements	Container labels	Nitrile gloves Safety glasses Face shield	No special requirements	None required	C	C	Control measures used as agreed. No findings for this task step.
Cleaning 1. Hot water (80°C)	No special requirements	Sequence label "Caution HOT" should be placed on tote.	Thermal gloves with Nitrile as secondary Half-face respirator with combination cartridges	Be sure cycle has completed prior to flex hose disconnect.	Collect urea waste for off-site disposal.	C	B	Respirators not being used. Respirator cartridges not replaced after expiration date. New cartridges issued. Cartridges scheduled for routine replacement.