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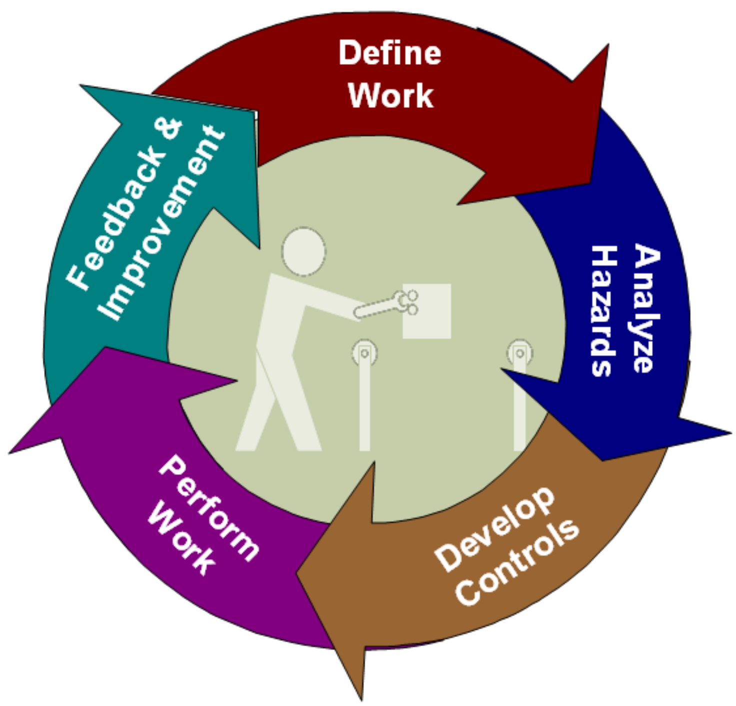
Integrated Work Management: Overview

COURSE 31881



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Contents

Introduction

Course Overview

IWM is not just a "safety" thing . . . it is how we do work.

Integrated work management (IWM) is the process used for formally implementing the five-step process associated with integrated safety management (ISM) and integrated safeguards and security management (ISSM) at Los Alamos National Laboratory (LANL). IWM also directly supports the LANL Environmental Management System (EMS).

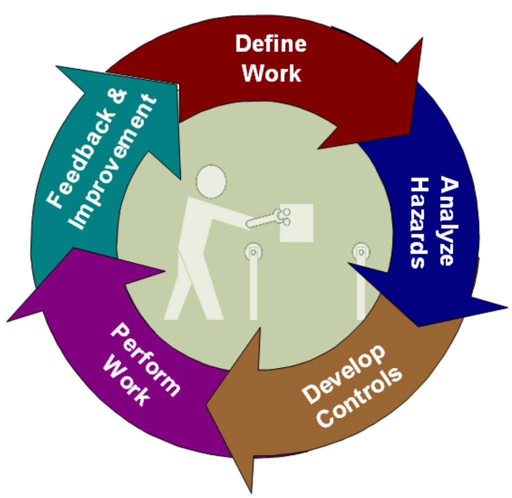
IWM helps all workers and managers perform work safely and securely and in a manner that protects people, the environment, property, and the security of the nation.

The IWM process applies to **all work** activities at LANL, from working in the office to designing experiments to assembling and detonating explosives. The primary LANL document that establishes and describes IWM requirements is Procedure (P) 300, *Integrated Work Management*.

Course Objectives

After you have completed this course, you will be able to

- Recognize the IWM process
- Identify IWM requirements
- Recognize IWM roles and responsibilities



The five steps of ISM and ISSM.

Investigation of a Tragedy—Xcel Energy Company

No Way Out—Five Workers Die in Confined-Space Tunnel Fire

On October 2, 2007, five people were killed and three others injured when a fire erupted 1000 ft underground in a tunnel at Xcel Energy Company's hydroelectric power plant in Georgetown, Colorado, located approximately 45 miles west of Denver. Contractors from RPI Coating, Inc., were using waterproof epoxy to resurface the tunnel walls and floor of a 1530-ft-long steel portion of a 4300-ft-long enclosed penstock (tunnel) when the chemical fire broke out.

The cause of the fire is believed to have been a static spark that ignited the flammable solvent (methyl ethyl ketone [MEK]) used to clean the epoxy application equipment in the open penstock atmosphere. Figure 1 shows the overall layout of the Xcel plant, and Figure 2 shows the configuration of the penstock, which directs water from an elevated reservoir to the turbines in the powerhouse. The fire quickly grew as it ignited the buckets of solvent and substantial amounts of combustible epoxy material used in the project.

Figure 1. Arrangement of power plant, reservoirs, and penstock pathway.

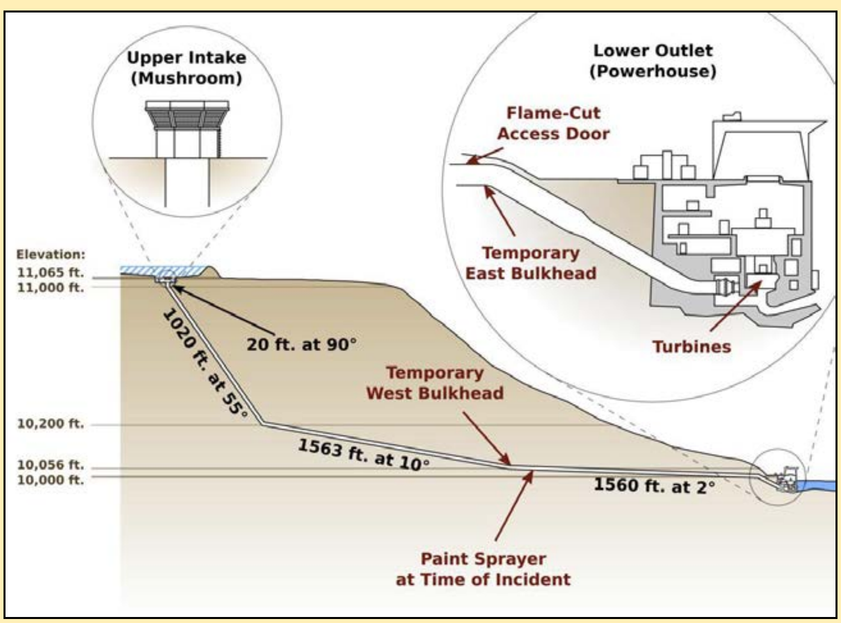


Figure 2. Overall penstock configuration (upper-right inset shows location of the flame-cut access door–the only traversable escape route in the penstock).

Figure 3. Access door cut into the penstock for recoating work.

Five of the eleven workers were blocked from accessing the single point of escape within the penstock, a flame-cut access door made by the contractors for moving supplies and equipment into the tunnel. See Figure 2 for a graphic of the door's location in relation to the plant configuration (upper right inset) and Figure 3 for a photograph showing the actual construction. Workers not trapped by the fire scrambled for extinguishers at the tunnel's entrance but were unable to fight the thick smoke and intense heat. Fourteen community response teams responded to the incident. The five trapped workers used handheld radios to communicate with coworkers and emergency responders for approximately 45 minutes before they succumbed to smoke inhalation.

On the day of the accident, workers had finished sandblasting the old epoxy from the tunnel walls and floor and shifted to applying new epoxy in the afternoon. After moving 95 buckets of epoxy and cleaning solvent (MEK) into the confined space, the RPI painters began applying the epoxy with wands connected to the spraying equipment (Figure 4) but quickly found that the epoxy was not adhering evenly. Because they believed the epoxy applicator lines were clogged, the painters repeatedly flushed the epoxy sprayer system with the MEK, as is customary in epoxy application; what is not customary is that this process took place in a confined space.

Figure 4. Depiction of contractors working with the sprayer immediately before the flash fire.

The Chemical Safety Board (CSB) investigated this accident. Although several possible ignition sources were examined, according to the CSB's final accident investigation report, it was concluded "that the fire inside the penstock was most likely ignited by a static spark that originated from the electrically isolated (ungrounded) metal swivel connector attached to one end of the nonconductive hose hand held inside the base hopper of the sprayer as MEK was being flushed through." The CSB calculated that the MEK concentration in the vapor surrounding the connector was well within flammable limits, leading the board to finally conclude that "MEK circulation flow through the sprayer was likely capable of developing a charging current, accumulating stored energy on the electrically isolated metal swivel connector and producing incendiary sparks of sufficient magnitude to ignite the flammable MEK vapor."

“Confined Space” vs “Permit-Required Confined Space”

CSB investigators determined that Xcel had approved RPI’s plan to use flammable solvents as cleaning agents in the penstock atmosphere, but neither company had applied for “permit-required” status of the confined space, which would have required a rescue team trained in confined space rescue and flammable solvent fire treatment to be on immediate standby at the penstock entry point.

The Occupational Safety and Health Administration (OSHA) defines “confined space” as an area that has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or a floor that slopes downward and tapers to a smaller cross section. OSHA regulations stipulate that once a hazardous substance is brought into this defined area, the classification of a confined space must be upgraded to a “permit-required confined space.”

Single Point of Escape

Weeks before work began, Xcel’s consulting engineer had identified the need for a second entrance, which resulted in the 4-ft by 6-ft, flame-cut access door being built into the download side of the penstock (Figure 3), near the base of the horizontal section and 1450 ft from where the work was being conducted. According to the CSB, this new entry apparently mitigated the concern raised by Xcel’s consulting engineer about there being only a single point of escape for workers; the only other possible escape route was an existing 24-inch-diameter manhole at the top of the penstock’s mushroom access hatch, a 2300-ft climb to the top at a 55-degree angle.

On the day of the incident, no climbing equipment was available to facilitate an escape through the manhole entry point; therefore, given the narrow configuration of the tunnel and the burn radius of the fire, the workers who were trapped from reaching the newly cut entry door had no other way out.

CSB Findings

In its 15-point finding, the CSB recounted that Xcel and RPI failed to conduct adequate hazardous work planning before authorizing contractors to use a flammable solvent as a cleaning agent in a confined space without applying for permit-required confined space status of the area. The CSB also found that Xcel provided inadequate contractor selection when it chose RPI, a contractor with a zero safety performance rating by Xcel’s own bid evaluation standards, to perform the work. Other causal factors leading to the Xcel Cabin Creek hydroelectric plant fatalities and injuries as identified by the CSB included the following:

- Highly flammable MEK was used in proximity to ignition sources that were not eliminated or controlled.
- Xcel and RPI managers did not perform a hazard evaluation of the full epoxy recoating work and thus did not evaluate or implement effective controls.
- Neither Xcel nor RPI reevaluated work hazards in the space when activities shifted from abrasive blasting in the morning to epoxy application in the afternoon.
- Neither Xcel’s nor RPI’s corporate confined-space program adequately addressed the need for a monitoring plan or the need for continuous monitoring in the work area where flammables were being used.
- None of the 14 teams responding to the Xcel accident had the appropriate training for confined space rescue and flammable solvent fire handling.

According to OSHA's Permit-Required Confined Space Rule, the very nature of confined space work requires additional planning for potential hazards. RPI workers had moved from blasting activities to recoating work in the space of 2 hours on the day of the accident, yet CSB investigators found that the pressure to continue work without reassessing the hazards associated with the change in processes and tasks had exposed workers to a number of hazardous conditions within the penstock, including

- dust from abrasive blasting,
- flammable atmospheres from the use of solvents,
- welding fumes from hot work, and
- accumulated toxic carbon monoxide fumes from the internal combustion engine of an all-terrain vehicle used in the penstock to transport materials to the work area.

Each time one of these hazards was introduced or encountered in the confined space, work permits should have been updated to reflect the hazard and the appropriate safeguards to protect entrants and ensure that proper entry conditions were maintained. Introducing a flammable solvent into the confined space where electrical equipment is in use and oxygen is limited increases the potential for creating a hazardous environment in which workers could easily be overcome.

Although it is standard practice to use cleaning solvents to flush sprayer equipment and lines, when working in confined spaces, less-hazardous cleaning agent alternatives should be considered. One such option, cited by the CSB, is citrus-based solvents, which have higher flash points than flammable solvents. Another hazard control that should have been implemented was cleaning epoxy application equipment outside of the confined space. The epoxy application equipment used by contractors at the Cabin Creek site was repeatedly flushed inside the confined space, some 1400 ft from the single usable point of escape.

Lessons Learned

This event reinforces the need for proper escape planning that factors in the "What if's" of confined space work before entry. Questions that managers and workers should ask include

- What is the work to be done?
- What equipment and materials am I taking in, and how do they "behave" in a closed environment?
- What if the work changes or is added to after entry?
- What is the escape plan in case of an emergency?

In addition, appropriate training of emergency management personnel for all possible emergencies related to the planned work activity should be verified before work begins.

The final CSB report (issued in August 2010) can be found at http://www.csb.gov/assets/document/Xcel_Energy_Report_Final.pdf.

A video reenactment of the accident scene and circumstances can be found at http://www.csb.gov/videoroom/detail.aspx?VID=46.

~paraphrased from Department of Energy (DOE) Office of Health, Safety and Security, Office of Analysis, Operating Experience Summary, Issue No. 2011-01, Article 2 (February 2, 2011).

Target Audience

LANL responsible line managers (RLMs) determine which of their employees are required to take this introductory course. The curriculum is especially helpful to those who are

- Directly involved in creating and/or working under an integrated work document (IWD)
- Working as a qualified worker for approved qualified-worker activities

Depending on your job, your RLM may require you to take other IWM courses, such as

Course Name/Number	Description
Integrated Work Management: FOD/RLM (COURSE 31882)	Provides information for the roles of facility operations director (FOD) and RLM for the IWM process.
Integrated Work Management: Preparer (COURSE 31883)	Provides information for the role of planner/preparer for the IWM process.
Integrated Work Management: PIC (COURSE 31884)	Provides information for the role of person in charge (PIC) for the IWM process.

For additional information about training requirements, see P300, *Integrated Work Management*, Section 6.0, Training. For course availability, go to the LANL training website and log into UTrain.

Worker Qualification and Authorization

The Employee Development System (EDS), along with several other training enterprise applications, including the Worker Qualification (WQ) and Authorization System (WQAS), was replaced by UTrain on August 15, 2011. This new application provides a single, integrated approach to training management, including worker qualification and authorization, which is now implemented through WQ curricula. Additional information on UTrain, including training on its features and functions, can be found through the LANL training website.

Applicability

This document applies to all Laboratory workers, and the requirements contained in this document apply to work activities performed at the Laboratory; it does not apply to subcontractors and activities because they are governed by Exhibit F. Work conducted offsite at a non-Laboratory site must ordinarily follow that site's work-control mechanisms. For work at locations that have inadequate work-control processes, the appropriate LANL IWM implementation process requirements are expected to be implemented to the extent practical, as defined by the RLM.

Research and Development (R&D)

Work management in R&D activities is organized in accordance with P300-1, *Integrated Work Management for R&D*.

Facilities and Maintenance

Follow P950, *Conduct of Maintenance* and associated AP-WORK procedures.

Operations

For nonroutine work, follow the processes in P300, Section 3.0.

For routine operations, follow Section 3.0; however, technical procedures may be developed as IWD-equivalent work control documents (WCDs) in accordance with Attachment 16 of P315, *Conduct of Operations Manual*, and FSD-315-16-001, *Technical Procedure Writer's Manual*.

Subcontractors

LANL subcontractors are subject to P101 *ES&H Requirements for Subcontractors*. This document establishes Environment, Safety and Health (ES&H) criteria for subcontractors and describes the use of Exhibit F for establishing requirements for individual subcontractors

Security

Follow SD200, *Integrated Safeguards and Security Management*.

Emergency Circumstances

The requirements of P300 do not apply to activities performed under emergency circumstances; however, once emergency situations are stabilized, the IWM process must be applied to recovery and follow-up activities.

Course Limitations

This introductory course to LANL's IWM process is the first part of the IWM curriculum. For more information about IWM courses, videos, tools, and contact personnel, go to http://int.lanl.gov/safety/integrated_work_management/toolbox/training.shtml.

About This Self-Study Course

Integrated Work Management: Overview (COURSE 31881) consists of an introduction, two modules, a conclusion, and a quiz. To receive credit in UTrain for completing this course, you must score 80% or better on the 10-question quiz. Directions for initiating the quiz are appended to the end of this training manual.

***Note:** In this course, the term "IWD" refers to any IWD or equivalent WCD(s). The term "preparer" also refers to the term "planner" in some organizations.*

Definitions

Activity – A subset of a project describing floor-level work, made up of one or more tasks.

Activity Hazard – An ES&H/Security and Safeguards (S&S) hazard inherent to an activity and not specific to the location of the activity.

Controls – Preventive measures, administrative and engineered features, and personal protective equipment (PPE) applied to work for the purpose of protecting people, the environment, property, and/or national security.

Emergency – Actions/work completed during a situation involving an imminent threat of death, serious injury, or illness of a member of the public or LANL; severe damage to the environment beyond the boundaries of LANL; imminent threat to security; or major damage to a facility (see PD1200-1, *Emergency Management*, for details).

Environmental Management System (EMS) – A systematic method for assessing mission activities, determining the environmental impacts of those activities, controlling those impacts, prioritizing improvements, and measuring results.

Equivalent Work Control Document – Technical procedures that have information equivalent to an IWD (e.g., tasks, hazards, controls, pre-job briefing documentation, and appropriate signature approvals).

Facility – An area, physical structure, or combination of structures together with the associated support infrastructure that forms the envelope in which work is accomplished.

Facility Safety Plan (FSP) – Defines and establishes the safety basis for a facility or area. This plan describes the activities performed in the associated structures, as well as identifies and assesses the hazards associated with these activities. Safety controls are also identified to manage, i.e., mitigate, the hazards.

Hazard – Any source of ES&H danger or safety-significant (SS) threat or vulnerability with the potential to cause harm to people, the environment, property, and/or national security.

Hazard Analysis – A technique(s) that focuses on job tasks in such a way as to identify a hazard before it occurs. It focuses on the relationship between the worker, the task, the tools, and the work environment.

Integrated Work Document (IWD) – A worker-friendly document that describes the work activity, identifies the hazards, and links them to specific controls. The IWD may be a subset of a larger work package that includes other documents and information that do not address hazards and controls for that activity.

Non-Tenant Activity – An activity conducted by workers who are not resident in the facility and therefore may not be familiar with the facility hazards and associated controls or the facility entrance and work coordination requirements.

On-the-Job Training (OJT) – Activity-level training that is a systematically designed instructional experience in which hands-on training is conducted and evaluated in the work environment.

Operations Manager – An individual designated by the FOD who provides coordination of activities within a specific facility on a daily basis and concurs with work-release when stipulated by the FOD (see P315-3, *Laboratory Institutional Operations Program*).

Person in Charge (PIC) – The person assigned responsibility and authority by the RLM or designee for overall validation, coordination, execution, and closeout of a work activity in accordance with IWM.

Post-Job Review – Review by the PIC and workers to capture lessons learned when an activity is terminated or fully completed as a function of ISM feedback and improvement.

Pre-Job Brief – Review by the PIC and workers of a work activity immediately before release, at a minimum, to ensure understanding of the IWD and agreement on how to execute the work.

Preventive Measures – Incorporation of alternative materials, processes, or work steps into an activity to reduce or avoid pollution, exposure to hazards, or security threats.

Program – A set of related projects or ongoing operations managed to execute LANL missions.

Project – A subset of a program undertaken to create a defined product or service within a specified schedule.

Qualification – A formal program that defines the required education, experience, training, examination, and any special conditions necessary to ensure that personnel can perform their assigned duties in a safe and reliable manner.

Release – The final, formal approval by the PIC to initiate execution of an activity based on all prerequisites and preparation being completed.

Research and Development (R&D) – "Any creative systematic activity undertaken in order to increase the stock of knowledge, and the use of this knowledge to devise new applications" (after a definition used by the Organization for Economic Cooperation and Development and the United Nations Educational, Scientific and Cultural Organization (UNESCO). See also SD601, *Conduct of Research and Development*, *Section 9*).

Risk – The quantitative or qualitative expression of possible harm or loss that considers both the probability that an event will occur and the consequences of that event.

Scoping Walk-Down – A walk-down of the worksite to identify hazards or potential hazards, controls, equipment, PPE and entry requirements, and any other pertinent information that may exist or may be required as pertaining to the IWD, procedure, or work instruction being developed. The need for scoping walk-downs is determined jointly by the RLM and the PIC.

Subject Matter Expert (SME) – An individual who has been identified as being competent in a given specific functional area and within the respective ES&H or technical discipline as defined below:

- **SME, Environment, Safety, and Health (ES&H)** – Designated organizational expert representing LANL core safety programs [e.g., radiological control technicians (RCTs); industrial hygienists; Environmental Protection Division (ENV) or Environmental Safety, Heath, and Quality (ESH&Q) support; or waste management coordinators, as well as electrical safety officers, laser safety officers, chemical hygiene officers, etc.]. Their involvement may be specifically mandated by other requirements or may be indicated because of desirable expertise relative to the nature of the work.
- **SME, Technical** – Independent technical experts who have knowledge relevant to the hazards involved in the work.

Step – A subset of a task, typically sequenced into an IWD, procedure, or work instruction, having a discrete set of related hazards and controls.

Task – A subset of an activity made up of one or more steps and often having hazards different from other tasks within the activity.

Tenant Activity – An activity conducted by the tenants of a facility and/or workers who are very familiar with the facility hazards and associated controls. Such activities must be carefully reviewed to ensure that they do not produce inadequately controlled aggregate or co-located hazards.

Unreviewed Safety Question (USQ) Process – The mechanism for keeping a nuclear facility safety basis current. The process involves formally reviewing any changes to facility configuration, processes, or activities; reporting these issues to DOE; and determining the final approval authority for any changes.

Validation Walk-Down – An onsite, documented review of the work area to ensure that work conditions are consistent with the IWD. Includes a review of the tasks and steps to ensure "workability"; that hazards have been identified; and that required controls are in place, operational, and functional.

Vulnerability – Susceptible or exposed to a threat or to a loss of control of classified material, safety, or environmental protection.

Work-Area Hazard – An ES&H/S&S hazard specific to the location of a work activity and not a hazard inherent in the activity itself.

Worker Authorization – The combination of the line manager's determination of assigned worker competence (including knowledge, skills, and abilities) and commitment to perform the work in a safe, secure, and environmentally responsible manner and the RLM's or PIC's confirmation of the worker's qualifications and fitness during the pre-job brief.

Work Planning – All aspects of the work cycle, including setup, work, maintenance, cleanup, waste disposal and material disposition, and the use of other LANL-permitting systems, such as the Project Review and Requirements-Identification (PR-ID) (see PD400, *Environmental Protection*).

Acronyms

ADNHHO	Associate Director for Nuclear and High-Hazard Operations
ADPSM	Associate Directorate of Plutonium Science and Manufacturing
CSB	Chemical Safety Board
DOE	Department of Energy
DSO	Deployed Safety Officer
EDS	Employee Development System
EMS	Environmental Management System
ENV	Environmental Protection Division
EOC	Emergency Operations Center
ES&H	Environment, Safety and Health
ESH&Q	Environment, Safety, Health, and Quality
FOD	Facility Operations Director
FSP	Facility Safety Plan
HAZOP	Hazard and Operability Analysis
ISM	Integrated Safety Management
ISSM	Integrated Safeguards and Security Management
IWD	Integrated Work Document
IWM	Integrated Work Management
LANL	Los Alamos National Laboratory
MEK	Methyl Ethyl Ketone
NIOSH	National Institute for Occupational Safety and Health
OJT	On-the-Job Training
OSHA	Occupational Safety and Health Administration
P	Procedure
PIC	Person in Charge

PPE	Personal Protective Equipment
PR-ID	Project Review and Requirements-Identification
R&D	Research and Development
RAD	Responsible Associate Director
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
RLM	Responsible Line Manager
RWP	Radiological Work Permit
S&S	Security and Safeguards
SIWD	Standing Integrated Work Document
SME	Subject Matter Expert
SPL	Security Program Lead
SWCD	Standing Work Control Document
SME	Subject Matter Expert
SS	Safety Significant
UNESCO	Organization for Economic Cooperation and Development and the United Nations Educational, Scientific and Cultural Organization
USQ	Unreviewed Safety Question
WCD	Work Control Document
WMS	Work Management System
WQ	Worker Qualification
WQAS	Worker Qualification and Authorization System

Module 1: What Is IWM?

IWM Expectations

All LANL work is governed by the five steps, or core functions, of ISM and ISSM. IWM is the process used to formally implement the five steps associated with ISM and ISSM, which are to:

1. Define the work
2. Identify and analyze hazards
3. Develop and implement preventive measures and controls
4. Perform the work safely, securely, and in an environmentally responsible manner
5. Provide feedback
6. Strive for continuous improvement

IWM emphasizes the following concepts:

- Using management and worker accountability
- Applying the worker's knowledge, experience, skills, and training
- Providing integrated, worker-friendly documentation that includes defined work tasks/steps linked to specific hazards and unambiguous controls
- Identifying a single PIC for each work activity
- Providing independent oversight and facility coordination
- Formally validating, releasing, and closing out work activities

As the levels of risk posed by the hazards and work complexity increase, IWM requires documentation and a more rigorous process. To guide this process, activities must be graded as *low hazard*, *moderate hazard*, or *high hazard/complex*. Those employees involved in grading activities must use P300, Attachment B, *Hazard Grading Table*, to determine the appropriate category.

Basic Principles of Work Management

All work at the Laboratory is planned work.

No work should be performed by anyone who is not certified/qualified (if required) or otherwise determined by the RLM or PIC to be competent to perform the work assigned.

Regardless of how work is planned, the work planners will always consider first what the workers need at the worksite to safely and correctly perform their work.

The work planning effort is characterized by the participation of workers, supervisors, planners, and SMEs. Worker involvement is a key to ensuring consistent and reliable WCD development. Worker involvement is most effective in the scoping and initial planning stages.

- Because personnel actually assigned to perform work may not be available to participate in the work planning process, planners and managers must be actively engaged whenever required to ensure that workers and supervisors scheduled to perform the work fully understand the activity hazards and controls, as well as the area hazards and controls, before they begin work.
- It is imperative that work planners understand their role in ensuring that the proper and necessary SME approvals are obtained and that the final WCDs are backed up by high-quality staff work such that workers and their field supervisors know precisely what is expected.

Workers and their supervisors are expected to pause work (or to not start work) any time an area or activity hazard is identified that has not been adequately controlled or when hazards or conditions change. Workers must perform their work within established controls, continuously monitor hazards and conditions for changes, continuously evaluate the effectiveness of these controls, and pause work if their control adequacy cannot be ascertained or if the work cannot be performed as written.

IWM allows management judgment, tailoring, and decision making to address the broad range of hazards and complexity of work at the Laboratory. For all work, the FODs (or a FOD representative) and RLMs must:

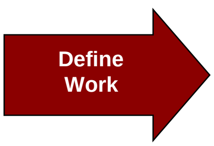
- Establish processes that ensure the implementation of the requirements of ISM, with early emphasis on defining the scope of the work, identifying hazards, and establishing controls to eliminate or mitigate the hazards

- Ensure that a process is in place that determines the competence of workers to perform work in a safe, secure, and environmentally responsible manner. The competence of workers is defined under the term “Competent Worker” in Section 9.1 of P300
- Ensure that operations, hazards, and controls are assessed with sufficient regularity to identify needed continuous improvements

IWM Process

This section describes the general IWM process. Roles and responsibilities of the key participants are presented in Module 2.

1. Define the Work



Work components and processes must be defined in sufficient detail to identify and analyze hazards and the circumstances in which they could cause harm. Defining the work generally requires that each of the tasks and work steps within an activity be identified, defined, and planned so that the associated hazards can be mitigated adequately. The work definition should include factors such as the:

- Planned envelope in which the activity will be performed
- Facility and/or location where the work will be performed
- Configuration and use of equipment
- Method of work (e.g., scraping, grinding, and sanding)
- Use of classified or sensitive information or components
- Effects on the environment, including chemical and materials use, waste streams, and other potential environmental impacts
- Impacts to all involved workers (e.g., support and colocation)

One RLM must be identified as responsible and accountable for the safety, security, and environmental compliance of each work activity. The RLM for the activity is responsible for defining the work in sufficient detail to identify and analyze the hazards. The RLM and/or PIC should engage appropriate SMEs to assist in planning work activities, defining the scope and method of work, and ensuring the appropriate level of detail (subject to further refinement in subsequent steps of defining the work). The RLM and PIC determine jointly whether work-planning activities require a scoping walk-down.

Analyze Hazards

2. Identify and Analyze Hazards

Hazards and accident scenarios that could cause harm must be identified and analyzed using a graded approach to determine what controls are needed to eliminate or reduce the hazards to manage risks to an acceptable level.

IWDs and equivalent WCDs should include only the information necessary for the worker(s) to perform the work and any required information (e.g., permits). Other information necessary to adequately perform the hazard analysis and develop the IWD, such as

- *Facility drawings*
- *Sketches,*
- *Photographs,*
- *Safety basis documents,*
- *Surveys, and*
- *Exposure assessments,*

should be maintained in a file and be readily available.

- The RLM or designee will, in conjunction with the work planners, determine the hazard grading level, with input from the workers or worker representatives and the SMEs.
- As part of this determination, RLMs will consult with the appropriate ESH SME, as necessary, to determine the complexity of a work activity and its impact on the determination of hazard level and risk.
- The RLM makes the final decision on the hazard level based typically on input from SMEs, unless the RLM is also an SME relative to the work to be performed.
- The impact of the planned work on co-located activities and workers must be considered and addressed.

The *Hazard Grading Table*, Attachment B of P300, must be used by the RLM or designee (who in most cases is the PIC) to assign the hazard level of each activity. Attachment B designates three IWM hazard levels: low, moderate, and high/complex; each has specific requirements. (***Note:*** *The examples listed in the table are meant to be illustrative and do not represent a complete set of hazards.*)

- When answering the hazard grading questions, both activity and work-area hazards must be considered, such as when a low-hazard activity is performed in an area where it is co-located with high-hazard/complex work activity hazards.
- When in doubt about the appropriate grading level, use the next higher level.

- Consult with SMEs who have specific process knowledge or knowledge of the applicable hazards to assist with hazard classification.

LANL has implemented an institutional Work Management System (WMS) that provides an inventory of work activities at LANL, facilitates a primary hazard screening, and will document activity-hazard-level determinations and their basis. https://esh-p2.lanl.gov/apex/f?p=CTSWMS:154000:2737823491609 Work activities should be entered into the WMS. Attachment D of P300 can also be used to facilitate a primary hazard screen. Attachment B, the Hazard Grading Table, must be used to determine the hazard level of the activity.

Low-Hazard Work

Low-hazard work involves only those everyday hazards that could cause negligible harm and that can be controlled by means well known to the workers. For low-hazard work, a complete IWD or WCD is not required unless stipulated by the RLM and FOD, and neither a formal hazard identification nor an analysis is required.

All low-hazard activities are subject to facility-specific access, facility postings, coordination, and scheduling requirements and must apply work-area controls required by the FOD. Low-hazard work can be controlled by the implementation of other processes; however, the RLM and FOD may require that a complete IWD or equivalent WCD be developed based on their review of hazards and controls.

Note: *The IWM Toolbox, located on the IWM website, contains a Risk Matrix Work Aid (located under Tools > Hazards Analysis) that may be used in evaluating and determining residual risk and hazard levels.*

Moderate-Hazard Work

Moderate-hazard work involves hazards that inherently could cause moderate harm, such as an injury requiring medical attention or leading to temporary disability and/or a spill or unplanned release to the environment of hazardous material. Moderate-hazard work as determined by use of the Hazard Grading Table requires an IWD, and a systematic hazard analysis must be performed to determine the hazards associated with potential accidents or incidents and how harm might be caused.

- The analysis should be graded based on the complexity of the activity, ranging from a relatively quick “brainstorming” for simple activities to a formal hazard analysis method, such as the “what-if” checklist or hazard and operability analysis (HAZOP).
- Workers representative of those involved in the activity are expected to contribute to the analysis.

High-Hazard/Complex Work

High-hazard/complex work involves

- Hazards that inherently could cause critical or catastrophic harm to people, property, national security, the environment, or the institution, such as:
  - Severe or fatal injuries, life-shortening disease, or permanent disability
  - Major environmental contamination or permit violation
- Unfamiliar hazards or a combination of moderate hazards (as defined above) and significant complexity

For high-hazard/complex work:

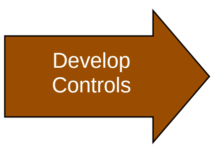
- An IWD is required
- A documented "what if," HAZOP, or other effective hazard analysis technique must be used
- A hazard analysis team, including appropriate SME involvement, must perform the hazard analysis:
  - This analysis is expected to be performed by a hazard analysis (HA) team with appropriate depth and breadth of expertise to identify and analyze the hazards thoroughly and to determine how to achieve effective hazard mitigation.
  - The hazard analysis team must include workers or a representative set of workers, dependent upon activity scope.
  - In some cases, such as maintenance work activities, individuals technically qualified and knowledgeable of the work activity can participate on the hazard analysis team as a representative for the workers who may be assigned to the work.
  - The names of the team participants must be documented (such as on Form 2100 or equivalent work control document) unless specifically exempted by the RLM and FOD.

Environment, Safety, and Health (ES&H) SME Involvement			
Hazard Level	**Activity**		
	Hazard Category	Define Work	Hazard Analysis
High/Complex	SME recommended	SME recommended	SME mandatory
Moderate	SME recommended	SME recommended	SME recommended/ mandatory*
Low	SME recommended	SME recommended	n/a

**SME participation is mandated by specific requirements when moderate-hazard (and high-hazard/complex) work involves, but is not limited to, activities such as energized electrical, explosives, radiological, beryllium, confined space, hot work, and/or environmental.*

SMEs may reside in ESH divisions or may be deployed to the various FODs. In addition, there are programs where the SME resides within the line organizations (e.g., electrical, explosive, and laser safety officers).

3. Develop and Implement Controls



Controls must be defined and implemented, as needed, to reduce the hazards associated with the work to an acceptable level. To mitigate the hazards effectively, the hazard analysis team must:

- Identify all requirements and controls applicable to the planned work
- Input appropriate controls into the WCDs based on the outcome of the hazard analysis
- Use controls selected based on their ability to reduce the probability and/or consequence of adverse events
- Establish controls based on the following hierarchy:
  1. Elimination or substitution of the hazards where feasible and appropriate
  2. Engineering controls where feasible and appropriate
  3. Work practices and administrative controls that limit worker exposures
  4. PPE
- Analyze, with a rigor commensurate with the hazard level, potential failures of controls, equipment, utilities, facility systems, procedures, or human factors, and establish enhancements and/or alternatives as needed
- Develop permits, plans, or special procedures required for the work, as specified by institutional procedures such that conflicts

in hazards and controls and inconsistencies between documents, including the WCD, are resolved

Examples of types of required permits, plans, or procedures include

- An energized electrical work permit
- Excavation/fill/soil permit identification
- The National Environmental Policy Act
- Air
- The Resource Conservation and Recovery Act (RCRA)
- A penetration permit
- A spark- or flame-producing permit
- A confined-space entry permit
- Lockout/tagout specific written procedure
- A radiological work permit (RWP)
- A fall protection plan

Documentation Requirements

Standing IWDs (SIWDs) may be used for repetitive moderate-hazard and high-hazard/complex work in single or multiple facilities. This document is a standardized, previously developed and approved IWD, Part 1, combined with an appropriate Part 2 for each facility listing the work area information. In each case, the person who prepares the IWD or equivalent WCD must ensure that the activity-specific and work-area requirements are all included and do not conflict.

Low-hazard work performed by a worker who has been determined by the RLM to be competent for the defined scope of work does not require an IWD or an equivalent work document. For moderate-hazard and high-hazard/complex activities, the work process, hazards, and controls must be documented in an IWD or WCD, such as a technical procedure. IWDs and WCDs help workers understand when and how the controls are to be used. IWDs and equivalent WCDs must systematically describe the work activity, the associated hazards, and the controls necessary to mitigate the hazards.

The IWD must

- Focus on the information needed by the worker
- Be sufficiently detailed to ensure that the worker can understand the hazards and controls
- Have the tasks/steps listed sequentially when that sequencing contributes to safety
- Have hazards and associated controls linked to specific activity tasks/steps when that linkage is beneficial
- Address activity and work area hazards

- Have specific not generic descriptions of hazards and associated controls
- Have UTrain curricula, permits, and area postings referenced if they are required controls

Note: *Qualified Worker Activities (defined in the LANL Definition of Terms), supported by qualification and training requirements, do not require a separate IWD.*

The FOD is responsible for documenting and communicating work-area information, including the hazards associated with the facility or location in which the work is performed. The work area information will be documented in IWD Part 1, IWD Part 2, or an equivalent WCD.

The FOD (or representative) and the RLM/preparer must work together to ensure that the work can be performed safely, securely, and in an environmentally responsible manner within the facility or at the location designated for the work. If an IWD is not being used, an equivalent WCD would be managed in a similar way.

Work Control Document/Integrated Work Document Validation

Before any work is released, a “validation walk-down” of the IWD or equivalent WCD must be performed to review tasks and steps for workability and to ensure that the hazards and controls are described effectively. The walk-down should be performed at the work site when possible and as close in time as feasible to the actual start of the work. This validation walk-down of the IWD must involve the PIC and workers (or qualified worker representatives of those who will participate in the work) and SMEs for high-hazard/complex work or when determined to be appropriate by the RLM and/or PIC.

Documentation of the validation walk-down is required on Form 2103, *IWD Part 3, Validation and Work Release*. For high-hazard/complex work, the validation walk-down must also involve appropriate SMEs, and subsequent walk-downs will be determined by the RLM or PIC based on the hazards and complexity of the activities. Any issues identified during the validation walk-down must be resolved before the work is started.

Worker Authorization

The RLM is responsible for the work activity and must authorize workers, including workers from other organizations, to perform work activities.

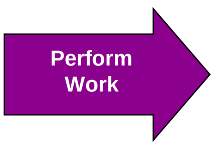
The RLM is directly responsible for the work activity and is responsible for determining whether each worker (including those deployed by other RLMs) is competent and authorized, meets facility access requirements, and is fit to perform the work. This determination may be delegated by the RLM.

Each worker is responsible for keeping required training current and for ensuring authorization and fitness to perform the work. The PIC's signature on Part 3 of the IWD or on an equivalent WCD verifies that the assigned workers are authorized and fit to perform the work.

Security

Managers and workers must also examine the security aspects of work being performed and determine the appropriate training required to perform the work.

Deployed security workers, such as deployed security officers (DSOs) and security program leads (SPLs), are available to assist managers and workers in evaluating safeguards and security issues related to work.



4. Perform Work Safely, Securely, and in an Environmentally Responsible Manner

After the work has been formally released, it may be performed. Work must be executed in strict accordance with the tasks/steps, controls, and preventive measures established in the IWD/WCD. If changes occur, work must be paused or stopped, reevaluated, and not restarted until any issues are resolved in accordance with P101-18, *Procedure for Pause/Stop Work*.

Work Approval, Authorization, and Release

A work activity must be approved, authorized, and released before the activity begins. At the completion of work planning, the RLM approves the work activity by reviewing and signing the IWD Part 1 (Form 2100) or equivalent WCD and documenting confidence that the IWD/WCD was properly prepared, the hazard grading determination is appropriate, a PIC is assigned, and the work will be performed in accordance with the IWD/WCD. The FOD's signature indicates that the work is appropriate to be conducted in the facility, the work is within the documented safety analysis, and the work to be performed in accordance with the IWD/WCD will meet applicable environmental, safety, and security requirements and DOE Orders and regulations.

Pre-Job Brief and Release of Work

Additional guidance for conducting a pre-job brief is included in Attachment C, *Error Precursor Card and Task Preview Work Aids* and also in the IWM Toolbox. A pre-job briefing and a post-job review video are available in the IWM Toolbox. For maintenance, pre-job briefings are covered in AP-WORK-004, *Work Performance*.

For moderate-hazard and high-hazard/complex activities, the PIC must perform a pre-job brief with the workers immediately before beginning work or when resuming work where conditions or process parameters have or may have changed. At a minimum, the questions listed in Part 3 of the IWD must be covered. The PIC is encouraged to perform a pre-job briefing for low-hazard work. The PIC must then formally release the work by performing the following steps:

1. Verify that the RLM and FOD/representative have signed the WCD
2. Conduct a validation walk-down
3. Confirm that the required controls are in place and functioning and that the initial conditions are as expected
4. Confirm that each assigned worker has the required competencies and authorization to perform the activity
5. Ensure coordination with any operations manager or other FOD-designated interface point of contact when required by the FOD
6. Sign the WCD work release section

If permits are required for the work activity, applicable portions of each permit must be included in the pre-job brief.

Depending on the scope of the planned activity, the nature of the hazards, the associated work controls, and/or the population of workers, the pre-job brief may be conducted for different phases of work to ensure that clear instruction is provided to affected workers. If this approach is taken as determined by the PIC, it is important to capture the date and signature of the workers for each pre-job brief in Part 3 of the IWD or in the equivalent WCD, which validates worker agreement and confirms worker authorization, qualifications, and fitness to perform the work.

Work Execution

Workers must perform the work in strict accordance with the approved WCD. If unexpected conditions arise, work must be paused or stopped and then reevaluated. If the conditions indicate a hazard that is not effectively mitigated by the existing controls, the work must not be restarted until adequate controls have been established, as defined in P101-18, *Procedure for Pause/Stop Work*. For cross-organizational work, a single RLM must be designated for work execution.

The PIC must observe work execution to the extent required to ensure it is performed in accordance with the WCD. The PIC must be readily available to workers to resolve issues and to answer questions. The PIC must remain at the immediate work site for all high-hazard/complex work activities. It is understood that some complex activities could involve more than one location. In those circumstances, the PIC will determine the optimum location and establish communications as necessary so that the PIC is readily available to all affected workers. For all other activities, the PIC should spend enough time at the job site to ensure that the work activity is carried out in accordance with the specifications of the WCD.

The RLM may designate alternate PICs to oversee a work activity if the primary PIC is unavailable or if work extends across work shifts. However, there must never be more than one PIC or RLM for an activity at any given time. The alternate PIC must sign the WCD the first time the alternate acts as PIC to acknowledge the responsibilities. When assuming these responsibilities, the alternate PIC must confer with the previous PIC to obtain all required information associated with the handoff and ensure that the workers have been notified of the change in PIC. If the original PIC returns to the worksite to resume PIC responsibilities, the PIC will conduct another turnover with the alternate PIC to ensure continuity of control. Shift turnover must follow conduct of operations requirements.

Readiness Checks during Work

The PIC and each involved worker are encouraged to perform frequent checks to confirm that conditions remain within planned parameters while work is in progress. Readiness checks at the start of the workday, the next shift, and the next task are considerations. These checks should determine whether the needed personnel, tools, and materials are available and whether any changes in the operating conditions or work environment have occurred. The option to pause work to resolve questions is always available.

The PIC may address minor changes with revisions to the IWD or equivalent WCD on the job site with worker input by lining out and/or adding text, initialing and dating the revision, and notifying all affected workers of the changes.

Minor revisions are not to be used where the change would increase the safety risk to personnel; create a difference to a source document requirement; require a variance to continue work; alter the purpose or the scope of the procedure; eliminate any required reviews or approvals; impact the safety basis of the facility or exceed established facility-operating limits; or alter the operating, technical, design, process, regulatory, or quality control requirements of a procedure.

Provide Feedback and Strive for Continuous Improvement

The RLM, PIC, and workers are expected to monitor in-progress activities and to capture needed improvements as part of the Lessons Learned Program. Moderate-hazard and high-hazard/complex activities require a post-job review soon after completion to close out the job. If the work activity is ongoing and is covered by an SIWD or other standing WCDs (SWCDs) such that work will not be completed in the near future, then lessons learned should be collected throughout the duration of the work and improvements implemented as needed to ensure safety, security, and environmental compliance. The post-job review and collection of lessons learned should involve a discussion among workers and the PIC to capture the positive aspects of the activities, including human performance improvement concepts; identify inefficiencies, problems during the activity, procedural deficiencies, coordination issues, unanticipated conditions, and near misses; and develop recommendations for improvement. The post-job reviewer should also verify that the activity is complete, make notifications required by the FOD, and ensure that follow-through actions (e.g., cleanup, recycle, waste disposal, equipment removal, and secure storage) are completed.

The PIC is expected to document the post-job review and ensure that lessons learned of value to future activities are communicated to affected workers and the RLM for feedback into the Lessons Learned and Operating Experience Archive in accordance with PD323, *LANL Operating Experience Program*. For ongoing work activities, feedback and lessons learned should be obtained during the normal course of the work.

Periodic Reviews

IWDs and other equivalent WCDs should be reviewed periodically to ensure that the WCDs, work activities, and work practices are aligned and to ensure integrated implementation of the ISM System and IWM programs, as well as the adequacy of IWD and hazard identification. Periodic reviews should be established by the RLM or FOD as deemed necessary. Review periods may vary in frequency from monthly to a maximum of 3 years.

Case Study—Goodyear Tire and Rubber Company

The following case study details a tragic incident in which a heat exchanger rupture and ammonia release killed one employee and injured six others at a synthetic rubber production facility. As you read the case study, consider the following issues:

- Hazard identification
- Work control documents
- Communication

Heat Exchanger Rupture and Ammonia Release in Houston, Texas

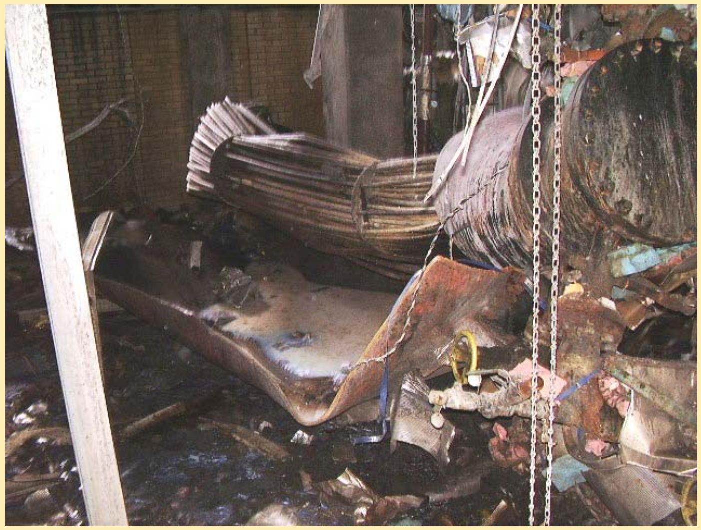
(One Killed, Six Injured)

On June 11, 2008, a heat exchanger rupture and ammonia release occurred at the Goodyear Tire and Rubber Company plant in Houston, Texas. The rupture and release injured six employees. Hours after plant responders declared the emergency over, the body of an employee was discovered in the debris next to the heat exchanger.

1.0 Incident Description

Goodyear uses pressurized anhydrous ammonia in the heat exchanger to cool the chemicals used to make synthetic rubber. Process chemicals pumped through tubes inside the heat exchanger are cooled by ammonia flowing around the tubes in a cylindrical steel shell.

On June 10, 2008, Goodyear operators closed an isolation valve between the heat exchanger shell (ammonia-cooling side) and a relief valve to replace a burst rupture disk under the relief valve that provided overpressure protection. Maintenance workers replaced the rupture disk on that day; however, the closed isolation valve was not reopened.



Above: Debris resulting from heat exchanger rupture and ammonia release.

On the morning of June 11, an operator closed a block valve isolating the ammonia pressure control valve from the heat exchanger. The operator then connected a steam line to the process line to clean the piping. The steam flowed through the heat exchanger tubes, heated the liquid ammonia in the exchanger shell, and increased the pressure in the shell. The closed isolation and block valves prevented the increasing ammonia pressure from safely venting through either the ammonia pressure control valve or the rupture disk and relief valve. The pressure in the heat exchanger shell continued climbing until it violently ruptured at about 7:30 a.m.

The catastrophic rupture threw debris that struck and killed a Goodyear employee who was walking through the area. The rupture also released ammonia, exposing five nearby workers to the chemical. Another worker was injured while exiting the area.

Figure 1. Location of fatality.

Immediately after the rupture and resulting ammonia release occurred, Goodyear evacuated the plant. Medical responders transported the six injured workers.

Although debris blocked access to the area immediately surrounding the heat exchanger, management declared the incident over the morning of June 11. Plant responders managed the cleanup while other areas of the facility resumed operations.

Goodyear management believed all workers had evacuated the affected area, but the employee tracking system had failed to account for all workers. Several hours later, after plant operations had resumed, a supervisor assessing damage in the immediate incident area discovered the body of a Goodyear employee located under debris in a dimly lit area (Figure 1).

2.0 Background

2.1 Goodyear

Goodyear is an international tire and rubber manufacturing company that was founded in 1898 and is headquartered in Akron, Ohio. North American facilities produce tires and tire components. The Houston facility, originally constructed in 1942 and expanded in 1989, produces synthetic rubber in several process lines.

Process Description

The facility includes separate production and finishing areas. In the production area, a series of reactor vessels process chemicals, including styrene and butadiene. Heat exchangers in the reactor process line use ammonia to control temperature. Piping carries product from the reactors to the product finishing area.

Ammonia Heat Exchangers

Ammonia is a commonly used industrial coolant. Goodyear uses three ammonia heat exchangers in its production process lines. The ammonia cooling system supplies the heat exchangers with pressurized liquid ammonia. As the ammonia absorbs heat from the process chemical flowing through tubes in the center of the heat exchanger, the ammonia boils in the heat exchanger shell (Figure 2). A pressure control valve in the vapor return line maintains ammonia pressure at 150 psig in the heat exchanger. Ammonia vapor returns to the ammonia cooling system, where it is pressurized and cooled, liquefying the ammonia.

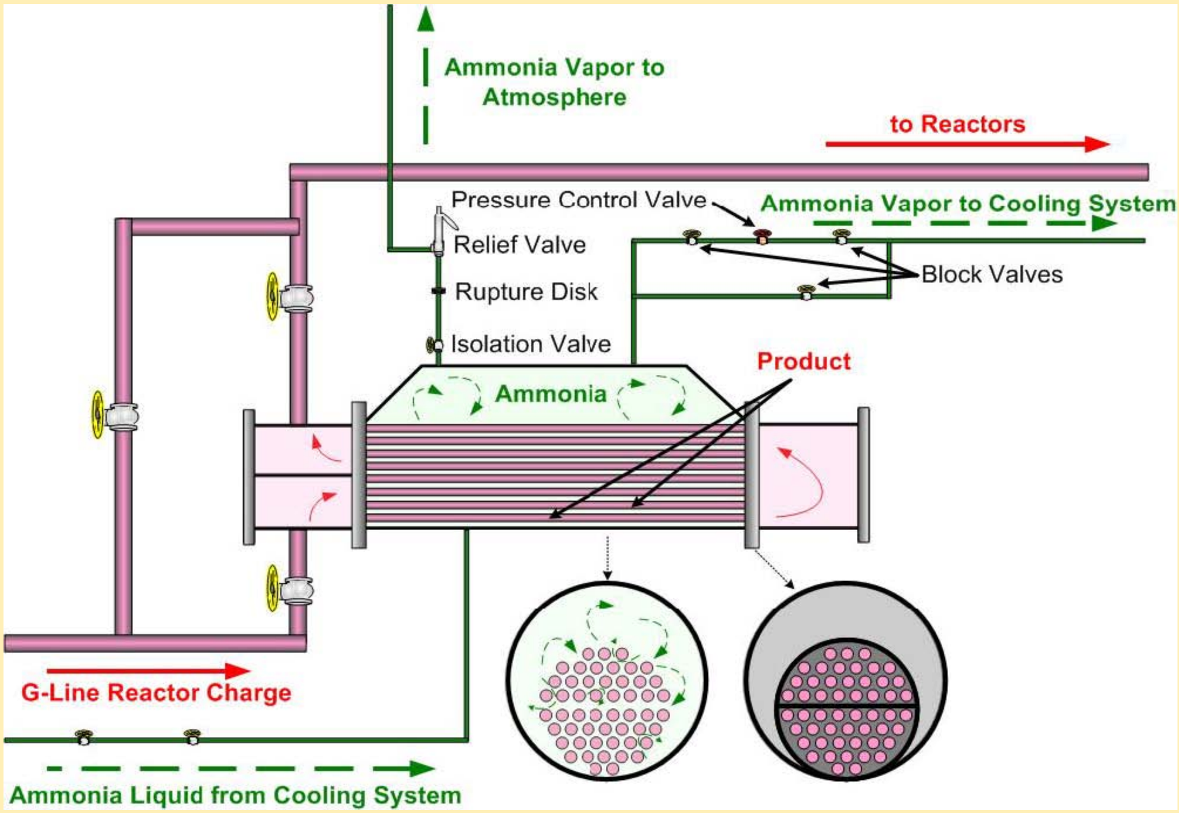


Figure 2. Ammonia heat exchanger.

The process chemicals exiting the heat exchanger flow to the process reactors. Each heat exchanger is equipped with a rupture disk in series with a pressure relief valve (both set at 300 psig) to protect the heat exchanger from excessive pressure. The relief system vented ammonia vapor through the roof to the atmosphere.

2.2 Ammonia Properties

Anhydrous ammonia is a colorless, toxic, and flammable vapor at room temperature. It has a pungent odor and is hazardous when inhaled or ingested or if it contacts the skin or eyes. Ammonia vapor irritates the eyes and respiratory system and makes breathing difficult.

Liquefied ammonia causes frostbite on contact. One cubic foot of liquid ammonia produces 850 cubic feet of vapor. Because ammonia vapor is lighter than air, it tends to rise. The vapor can also remain close to the ground when it absorbs water vapor from air in high-humidity conditions.

The Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) limit worker exposure to ammonia to 25 and 50 parts per million (ppm), respectively, over an 8-hour, time-weighted average. Ammonia is detectable by its odor at 5 ppm.

3.0 Analysis

3.1 Emergency Procedures

Onsite Emergency Response Training

Goodyear maintained a trained emergency response team, which attended offsite industrial firefighter training, conducted response drills based on localized emergency scenarios, and practiced implementing an emergency operations center (EOC). Other employees received emergency preparedness training primarily as part of their annual computer-based health and safety training.

Although Goodyear procedures required that a plant-wide evacuation and shelter-in-place drill be conducted at least four times a year, workers told the Chemical Safety Board (CSB) that such drills had not been conducted in the 4 years before the June 11, 2008, incident. Operating procedures discussed plant-wide alarm operations and emergency muster points for partial and plant-wide evacuations; however, some employees had not been fully trained on these procedures.

Plant Alarm System

Some workers reported that Goodyear's plant-wide alarm system was unreliable when workers were not immediately made aware of the nature of the incident. Emergency alarm pull-boxes located throughout the production unit areas sound a location-specific alarm. However, ammonia vapor released from the ruptured heat exchanger and water spray from the automatic water deluge system prevented responders from reaching the alarm pull-box in the affected process unit. Supervisors and response team members were forced to notify some employees by radio and word-of-mouth of the vessel rupture and ammonia release.

Accounting for Workers in an Emergency

Facility operating procedures also outlined Goodyear's worker emergency accountability scheme. Supervisors were to account for their employees by using a master list generated from the computerized electronic badge-in/badge-out system. However, a malfunction in the badge-tracking system delayed supervisors from immediately retrieving the list of personnel in their area. Handwritten employee and contractor lists were generated, listing the workers only as they congregated at the muster points or sheltered in place. Later, EOC personnel compared the lists against the computer record of personnel who remained badged in to the production areas.

Additionally, although emergency response team members were familiar with the employee accountability procedures, not all supervisory and security employees who were to conduct the accounting had been trained on them. In fact, some of the employees responsible for accountability were unaware before the incident that their jobs could include this task in an emergency. Because the fatally injured employee was a member of the emergency response team, area supervisors did not consider her absence from the muster point unusual.

The EOC declared all Goodyear employees accounted for at about 8:40 a.m. Accounting for the contract employees continued until about 11:00 a.m., at which time the EOC ended the plant-wide evacuation and disbanded. Only the immediate area involved in the rupture remained evacuated. At about 1:20 p.m., an operations supervisor assessing the damage to the incident area discovered the victim buried in rubble in a dimly lit area and contacted City of Houston medical responders.

3.2 Maintenance Procedures

Training requirements for operators in the production area included standard operating procedures specifically applicable to the rupture disk maintenance performed on June 10:

- use of the work order system, including obtaining signature verification both before the work started and after job was completed; and
- use of lockout/tagout procedures for equipment that was undergoing maintenance.

The CSB found evidence of breakdowns that contributed to the incident in both the work order and lockout/tagout programs:

- Although the procedure required a signature before work commenced and after work had been completed, operators reported that maintenance personnel did not always obtain the required signatures. Also, work order documentation was not kept at production control stations.
- Operators used lockout/tagout procedures to manage the work on the heat exchanger rupture disk but did not clearly document the progress and status of the maintenance. Information that the isolation valve on the safety relief vent remained in the closed position and locked out was limited to a handwritten note.

Although maintenance workers had replaced the rupture disk by about 4:30 p.m. on June 10, they did not reopen the valve isolating the rupture disk. No further activities involving the rupture disk or relief line occurred on the night shift or the day shift on June 11, and the valve remained closed. Goodyear's work order system for maintenance requires the process operator to sign off when the repairs are completed. However, whether this occurred during the June 10 dayshift is unclear, and Goodyear was unable to produce a signed copy of the work order.

Heat Exchanger Rupture

As Figure 2 shows, a rupture disk and a pressure relief valve in series protected the ammonia heat exchanger from overpressure. An isolation valve installed between the rupture disk and the heat exchanger isolated the rupture disk and relief valve for maintenance. However, when the valve was in the closed position, the heat exchanger was still protected from an overpressure condition by the automatic pressure control valve.

The next day, when operators began a separate task to steam clean the process piping, they closed a block valve between the heat exchanger and the automatic pressure control valve. This step isolated the ammonia side of the heat exchanger from all means of overpressure protection. Steam flowing through the heat exchanger increased the ammonia temperature and the pressure in the isolated heat exchanger. Because the overpressure protection remained isolated, the internal pressure increased until the heat exchanger suddenly and catastrophically ruptured.

4.0 Lessons Learned

4.1 Worker Headcounts

The morning of the incident, Goodyear erroneously accounted for all of its workers and declared the emergency over. Hours later, workers discovered the victim buried in the rubble near the ruptured vessel. Her absence had not been noted because of lack of training and drills on worker headcounts.

Companies should conduct worker headcount drills that implement their emergency response plans on a facility-wide basis. Procedures must account for breakdowns in automated worker tracking systems to ensure that all workers inside a facility can be quickly accounted for in an emergency. Drills that simulate such malfunctions should be conducted to verify that all lines of responsibility and alternate verification methods will account for workers in a real situation.

4.2 Maintenance Completion

Although maintenance workers had replaced the rupture disk by about 4:30 p.m. on June 10, the primary overpressure protection for the heat exchanger remained isolated until the heat exchanger ruptured at about 7:30 a.m. on June 11.

Communicating plant conditions between maintenance and operations personnel is critical to the safe operation of a process plant. Good practice includes formal written turnover documents that inform maintenance personnel when a process is ready for maintenance and operations personnel when maintenance is completed and the process can be safely restored to operation.

4.3 Isolating Pressure Vessels

Goodyear employees completely isolated an ammonia heat exchanger, including the overpressure protection, while steaming a process line through the heat exchanger. Workers left the pressure relief line isolated for many hours following completion of the maintenance.

In accordance with the ASME Boiler and Pressure Vessel Code, overpressure protection shall be continuously provided on pressure vessels installed in process systems whenever there is a possibility that the vessel can be overpressurized by any pressure source, including external mechanical pressurization, external heating, chemical reaction, and liquid-to-vapor expansion. Workers should continuously monitor an isolated pressure relief system throughout the course of a repair and reopen blocked valves immediately after the work is completed.

~paraphrased from Goodyear Houston Case Study, 2008-06-I-TX January 2011
U.S. Chemical Safety and Hazard Investigation Board

How could the IWM process have been applied to Goodyear's work to prevent this horrific accident?

Managing Work Control Documents

All LANL WCDs are expected to be reviewed every 3 years unless determined otherwise by the RLM or FOD. WCDs for work activities in multiple FOD jurisdictions require those respective FOD or FOD representative approvals, as applicable.

If specific work activity procedures, such as detailed operating procedures, standard operating procedures, and work instructions, that are considered equivalents or part of the IWD expire before the WCD expiration date, then the WCD is potentially no longer valid. If a revision of a referenced document does not impact an IWD/WCD, then the IWD/WCD remains valid.

Standing Integrated Work Documents (SIWDs) and Other Standing Work Control Documents (SWCDs)

For repetitive, moderate-hazard and high-hazard/complex work activities in single or multiple facilities, an SIWD or SWCD may be used, provided that the RLM and preparer have considered risk factors. Risk is defined as the qualitative (e.g., “high” or “low”) expression of the possibility of an event occurring based on the probability that a hazard will cause harm and the consequences of that event. Risk considerations include the frequency and complexity of the work activity, as well as the hazards of the work and the environment.

Hazards, as used here, include sources of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to a person (workers or the public) or damage to a facility or to the environment.

Changing work entry conditions have the potential to affect the risk of the activity. RLMs need to ensure that the initial work scope analysis, associated documentation, and related actions are commensurate with the complexity of the work, performance risk, and activity-specific and facility-specific conditions. If changing work entry conditions make the risk unacceptable, the work planner and RLM should reanalyze the hazards.

Although risk generally increases as complexity increases, complexity with or without risk factored in may still require an entirely different strategy in the graded approach to the development and field evaluations of SIWDs and SWCDs. For example, the work may become more complex with increases in the numbers of work hazards, workers, conflicting controls, or permits required.

SIWDs and SWCDs consist of a standardized, previously developed, and approved IWD Part 1 (or equivalent), including the appropriate work area information (e.g., specific facility entry and coordination requirements and work-area hazards) or Part 1 combined with an appropriate Part 2 (if used) for each facility listing the work area information. In each case, the person who prepares the IWD or equivalent WCD must ensure that the activity-specific and work-area requirements are all included and do not conflict. In addition, at the time the work is scheduled to begin, the PIC must give consideration to whether work entry conditions need to be specified in the SIWD or SWCD and include them if appropriate.

Activities covered by SIWDs/SWCDs require the PIC to walk down the actual system or equipment and conduct a pre-job brief before beginning work. Only one pre-job brief is required if the work is performed repetitively in the same location with the same workers. A new pre-job brief is required when resuming work where conditions or process parameters have or may have changed. However, high-risk/high-complexity activities require a pre-job brief before each evolution.

The following are examples of how risk and complexity may be addressed:

- **Low Risk and Low Complexity** – Worker is trained to perform the work and recognizes specific hazards and how to control them.
- **Medium Risk and Low Complexity** – Worker is trained to perform the work, but the RLM may want to have oversight by the PIC to help ensure that workers recognize and control the hazards.
- **High Risk and Low Complexity** – Workers may require the assistance of SMEs in eliminating or mitigating the risks the first time; these controls then are captured in procedures or WCDs to ensure that the risks are eliminated or mitigated.
- **Low Risk and High Complexity** – Workers and PICs may use work steps (detailed in work orders, facility service requests, or low-hazard procedures, for example). Because of its complexity, the job could hide developing hazards or unsafe conditions from the worker. A complex task can involve any of the following situations:
  - Multiple interactions with equipment controls
  - Simultaneous activities or use of multiple procedures
  - Multiple interpersonal interactions needing significant coordination
  - Major changes in equipment conditions
  - Unusual system or equipment configurations, limitations of tools and resources, or difficult physical constraints
- **Medium Risk and High Complexity** – SME involvement should be sought in support of the review of tasks and identification of hazards and controls required to perform the work in the procedures or WCDs.

- **High Risk and High Complexity** – SME involvement must be sought in support of the review of tasks and identification of hazards and controls required to perform the work.

Tailored Approaches for Implementing IWM

P300, *Integrated Work Management,* defines the requirements and expectations for conducting, authorizing, and coordinating all activity-level work at LANL. Because of the diversity of activities, one specific approach cannot be optimal for all situations. Therefore, P300 allows the implementation to be tailored to meet more specific organizational needs.

Access the IWM websites at *http://int.lanl.gov/org/padops/adnhho/operations-support/IWM/index.shtml* and http://int.lanl.gov/safety/integrated_work_management/index.shtml

This flexibility has enabled the incorporation of additional process-specific requirements that either supplement or provide alternate, tailored approaches for meeting P300 requirements. For instance, templates for IWDs, Parts 1, 2, 3, and 4 are provided on the IWM website and in the LANL Forms. Users may use these templates or develop their own equivalent WCD, as long as it meets P300 requirements and incorporates equivalent data, including authorizations identified in the current P300 forms.

When a more specific approach has been developed to address organizational or process needs, the tailored requirements should be followed during the conduct of affected work activities. The following modes of work, organizational implementation, and supplemental requirements are recognized in P300:

- Research and Development (R&D)
- Facilities and Maintenance
- Operations
- Subcontractors
- Security

P300, Section 2.2, *Applicability*, provides additional details and requirements for each of these implementation approaches.

In addition to the approaches discussed in P300, a variety of organizational and facility-specific approaches has been developed for implementing the IWM process. For instance, IWM implementation within the Associate Directorate of Plutonium Science and Manufacturing (ADPSM) relies on a system of detailed operating procedures and the document control system Documentum. You will need to check with local ES&H staff, line management, and/or facility personnel to ensure that you are meeting local requirements.

Test Your Knowledge

Test Your Knowledge
(Answers are shown on the next page.)

Use the following questions to review Module 1:

1. What are the five steps of the IWM process?
2. What are the three hazard levels defined in P300, Attachment B?
3. Why is a scoping walk-down performed?
4. Who is responsible for defining the work in Step 1?
5. In Step 2, who determines the hazard grading level of the activity based on input from those who will participate in the work?
6. Who should perform a “validation walk-down” as described in Step 3?
7. What is the purpose of the IWD?
8. In Step 4, who must observe work execution to ensure that it is performed in accordance with the IWD?
9. Who must document the post-job review in Step 5?
10. What roles have responsibilities in the post-job review?

Answers

1. Define work, analyze hazards, develop controls, perform work, and feedback and improvement
2. Low hazard, moderate hazard, and high hazard/complex
3. To better prepare for work-planning activities
4. RLM for the activity
5. RLM or designee
6. The PIC, workers, and SMEs (for high-hazard/complex work)
7. To describe the work activity, identify the hazards and link the hazards to specific controls
8. PIC
9. PIC
10. PIC and workers

Module 2: Roles and Responsibilities

Key Roles in the IWM Process

The following positions play roles in the IWM process:

- RLM
- FOD
- Preparer
- Worker
- Work supervisor/PIC
- SME

One person may perform multiple roles in the IWM process. An individual may serve as the RLM, preparer, and PIC or as the preparer, PIC, and worker.

In practice, the RLM typically delegates responsibility and authority to the PIC and the preparer to carry out specific IWM tasks. For example, the preparer develops the IWD/WCD as delegated by the RLM. Also, the PIC oversees the execution of work activities on behalf of the RLM.

Any leader in the IWM process who delegates work activities or tasks to others in the IWM process delegates the authority to the delegate to make decisions within defined parameters and holds the delegate responsible for all actions taken and decisions made. However, ultimate accountability always rests with the RLM who engaged in the delegation of those assigned duties.

The following sections list the responsibilities of each of the key roles in the IWM process.

Responsible Line Manager (RLM)

The RLM is the line manager (or group-level manager or equivalent subcontractor line manager) having the responsibility, authority, and accountability to plan, validate, coordinate, approve, execute, and close out work activities in accordance with IWM.

The RLM ensures that:

- Work is defined in sufficient detail to assess the safety, security, and environmental compliance risks
- Work and environmental hazards have been identified, analyzed, and graded to determine IWM and environmental control requirements
- Effective controls are established to reduce risks to an acceptable level and documented in IWDs or alternative WCDs so that the workers can understand when and how they are to be used
- An inventory of work within the RLM organization is maintained. The inventory should contain the name of the activity, the owner, and the location
- All workers possess the knowledge, skills, abilities, and training required to handle the hazards and effectively use the proposed controls

The RLM is accountable to the FOD and responsible associate director (RAD) to ensure that activities are conducted within the safety envelope of the facility and do not place the public, co-located workers, or environment at risk.

The RLM provides approval by signing the IWD, Form 2100, or other WCD based on confidence that the IWD/WCD has been properly prepared and that the work can be performed in accordance with the IWD/WCD, within ESH/ S&S requirements, and within facility requirements and capabilities.

The RLM ensures that work proceeds in a safe, secure, and environmentally responsible manner.

The RLM considers appropriate lessons learned and operating experience for the work being performed.

Facility Operations Director (FOD)

The FOD is accountable to the RAD and Associate Director for Nuclear and High-Hazard Operations (ADNHHO) for the effective implementation of institutional programs, including this document.

The FOD:

- May delegate IWM-related roles and authority to representatives but cannot delegate responsibility or accountability
- Serves as the senior line manager who provides facility owner stewardship with responsibility for overall facility operations
- Provides organizational leadership for Facility Maintenance, Operations, ESH&Q, S&S, Waste Services, and Facility Engineering
- Coordinates the efforts of the respective managers to ensure that all facility and programmatic activities are performed in a safe and compliant manner
- Directs facility operations-related deployed personnel to report through the FOD; exceptions for unique reasons will be reported through the RAD
- Controls and manages activities within their facility to ensure that the facility complies with Laboratory, DOE, and governmental orders and requirements, including institutional Safety Management Programs
- Establishes and maintains the authorized facility safety basis(es) and authorization agreements
- Determines the need for a new activity review per SBP-111-3, *New or Changed Activity Approval Process*
- Reviews all WCDs and authorizes all programmatic and facility work to provide assurance that applicable regulatory, contractual, and institutional programs and requirements are fully implemented. Work document reviews include the following considerations:
  - Work is appropriate to be conducted in the facility
  - Work area hazards have been addressed
  - The activity is within the scope of the facility safety basis

- Governmental and institutional requirements, including Safety Management Programs, have been fully implemented through hazard identification and the use of appropriate controls
- Appropriate SME reviews have been completed

Preparer

The preparer is assigned by the RLM and has the responsibility and authority to establish and document the risk management envelope for a work activity. The preparer is encouraged to identify the roles and responsibilities of the persons performing every step within a WCD.

The Preparer:

- Is accountable to a line manager and has authority to control and manage the planning of WCD, including the resolution of comments and coordination of approvals. The preparer may be a subcontractor
- Is technically competent to prepare the WCD or ensures that technically competent personnel are called upon to assist in the development of the WCD
- Takes into account appropriate lessons learned and operating experience applicable to the specific planned activity in preparing WCDs as directed by the RLM

Worker

The worker is responsible for actually performing work. As such, the worker must be considered by line management to be competent. The RLM or designee must ensure that all workers have a complete understanding of what constitutes competency as the term applies to the task and to the identified hazards and controls (see Section 9.1 of P300 for the definition of Competent Worker).

Work Supervisor/Person in Charge (PIC)

The PIC is the person assigned responsibility and authority by the RLM for overall validation, coordination, release, execution, and closeout of a work activity in accordance with IWM.

The work supervisor/PIC:

- Is responsible for facilitating the release of work in accordance with facility-specific protocol (e.g., Plan of the Day and Plan of the Week)
- Is responsible for supervising the performance of work in accordance with approved documents and has the authority to control and manage activities and work based on organizational assignments. The PIC is expected to reiterate the first three steps of ISM by verifying that the scope of the task is well defined, that the hazards have been identified and reviewed with the work team, and that the controls in place adequately address the identified hazards
- Is accountable to a line manager
- Ensures SME engagement as required

Subject Matter Expert (SME)

SMEs:

- Provide support to FODs, RLMs, PICs, preparers, subcontractors, and workers in work definition, hazard identification and analysis, risk assessment, and control selection
- Identify governmental and institutional requirements, including Safety Management Program requirements applicable to specific work activities, as appropriate, to the FODs, RLMs, PICs, preparers, and workers

Note: *The SMEs are involved, as necessary, during all phases of IWM, including work planning, validation, release, and execution to help ensure that applicable requirements, including controls, are implemented.*

Additional IWM Information

The IWM website and Toolbox are resources for links to relevant requirements, job aids, and examples supporting IWM implementation.

Additional materials and suggestions that would benefit IWM implementation are always welcome. Contact the IWM program manager or IWM SME through the IWM website at http://int.lanl.gov/org/padops/adnhho/operations-support/IWM/index.shtml.

Test Your Knowledge

Test Your Knowledge
(Answers are shown on the next page.)

Use the following questions to review Module 2:

1. What are the six positions that play a role in the IWM process?
2. Which two positions may not have the same role for a single activity in the IWM process?
3. Who must ensure that work is defined in sufficient detail to assess the safety, security, and environmental compliance risks?
4. Who may delegate IWM-related roles and authority to representatives but cannot delegate responsibility or accountability?
5. Who is assigned by the RLM and has the responsibility and authority to establish and document the risk management envelope for a work activity?
6. Who is accountable to the RAD for the effective implementation of institutional programs, including this document?
7. Who is responsible for actually performing work and as such must be considered by line management to be competent?
8. Who is assigned the responsibility and authority by the RLM for the overall validation, coordination, release, execution, and closeout of a work activity in accordance with IWM?
9. Who provides support to FODs, RLMs, PICs, preparers, subcontractors, and workers in work definition, hazard identification and analysis, risk assessment, and control selection?
10. Who is technically competent to prepare the WCD or ensures that technically competent personnel are called on to assist in the development of the WCD?

Answers

1. RLM, FOD, preparer, worker, PIC, and SME
2. The FOD must be different from the RLM for each single activity
3. RLM
4. FOD
5. Preparer
6. FOD
7. Worker
8. PIC
9. SME
10. Preparer

Conclusion

What Have You Learned?

Now that you have completed this overview course, you should be able to

- Recognize the IWM process
- Identify IWM requirements
- Recognize IWM roles and responsibilities

By applying the techniques presented in this course, *Integrated Work Management: Overview* #31881, to your work, you will be implementing the five-step process associated with ISM and ISSM at LANL.

Remember, the IWM process applies to **all work** activities at LANL, ranging from a preventive maintenance operation with a set of well-defined steps to a large, one-time research experiment. The process helps all employees perform work safely and securely and in a manner that protects people, the environment, property, and the security of the nation.

Depending on your role in the IWM process and the hazards involved, your RLM may require you to take additional IWM training to prepare you to meet LANL's IWM expectations. For more information, refer to the primary LANL document that establishes and describes IWM requirements, P300, *Integrated Work Management*.

What Is IWM?

- IWM is the process at LANL for doing all work
- IWM is a safety, security, and environmental integration effort
- IWM provides a sound basis for mitigating risks
- IWM increases accountability by identifying a single PIC
- IWM involves workers directly
- IWM promotes "critical thinking"