SAFE WORK PRACTICE
SIMULTANEOUS OPERATIONS (SIMOPS)

DISCLAIMER

This Safe Work Practice (SWP) is one in a series of SWPs published by the Center for Chemical Process Safety (CCPS). It is sincerely hoped that the information presented in this document will lead to an even more impressive safety record for the entire industry. However, the American Institute of Chemical Engineers, its consultants, the CCPS Technical Steering Committee and Subcommittee members, their employers, their employers' officers, and directors, do not warrant or represent, expressly or by implication, the correctness or accuracy of the content of the information presented in this document. As between (1) American Institute of Chemical Engineers, its consultants, CCPS Technical Steering Committee and Subcommittee members, their employers, their employers' officers, and directors, and (2) the user of this document, the user accepts any legal liability or responsibility whatsoever for the consequences of its use or misuse.

ACKNOWLEDGMENTS

The American Institute of Chemical Engineers (AIChE) and the Center for Chemical Process Safety (CCPS) express their appreciation and gratitude to all members of the Safe Work Practices Project Committee and their member companies for their generous efforts and technical contributions to the development of the Safe Work Practices. The volunteer team of authors and reviewers who developed this SWP are listed below.

Brian Farrell	CCPS Consultant
Andrew Bartlett	Sphera
Rajender Dahiya	AIG
Cheryl Grounds	CCPS Consultant
Jerry Keezer	Bostik
Aamish Junaid Khan	ADNOC Gas Processing
Siva Menedi	Petroleum Development Oman
Andrew Moulder	Inter Pipeline Ltd.

The Center for Chemical Process Safety was established by the American Institute of Chemical Engineers in 1985 to focus on the engineering and management practices to prevent and mitigate major incidents involving the release of hazardous chemicals and hydrocarbons. CCPS is active worldwide through its comprehensive publishing program, annual technical conference, research, and instructional material for undergraduate engineering education. For more information about CCPS, please call (+1) 646-495-1371, e-mail ccps@aiche.org, or visit www.aiche.org/ccps

This document is made available for use with no legal obligation or assumptions. Corrections, updates, additions, suggestions, AND recommendations should be sent to Dr. Anil Gokhale, Sr. Director CCPS at ccps@aiche.org. If you are reading this offline, you may not be reading the latest version. Please check on the CCPS web site for the current release. https://www.aiche.org/ccps/publications/safe-work-practices

Table of Contents

SAFE WORK PRACTICE
SIMULTANEOUS OPERATIONS (SIMOPS)

FUNDAMENTAL INTENT

This Safe Work Practice (SWP) is intended as a guideline to identify and manage hazards associated with Simultaneous Operations, or SIMOPs. CCPS developed this SWP to complete an action assigned by the U.S. Chemical Safety and Hazard Investigation Board (CSB) following their investigation into the November 2020 hydrogen chloride release at the Wacker Polysilicon North American facility in Charleston, Tennessee [1].

The Action assigned to CCPS by the CSB was as follows.

“Develop and publish a safety product on Safe Work Practices, including detailed and practical guidelines for evaluating simultaneous operations (SIMOPs). The guidelines, at a minimum, should:

a. Address the content found in CCPS’s website resource for implementing Safe Work Practices
b. Discuss guidelines for a SIMOPs life cycle, including:
    1. Methods to identify SIMOPs
    2. Methods to conduct a SIMOPs hazard assessment
    3. Safeguards and controls pertaining to SIMOPs
    4. Preparation for SIMOPs
    5. SIMOPs execution

In developing this safety product, consider the findings presented in the CSB report titled *Fire During Hot Work at Evergreen Packaging Paper Mill* [2] and this CSB report, titled *Equipment Fracture and Fatal Hydrogen Chloride Release at Wacker Polysilicon North America [1]*.”

SIMOPs are described by Baybutt [3] as *“…situations where two or more operations or activities occur close together in time and place. They may interfere or clash with each other and increase the risks of the activities or create new risks…”* In this context, operations refers to a wide variety of activities including maintenance, construction, commissioning, and facility operation.

In the August 2023 Process Safety Beacon [4], CCPS described SIMOPs as *“…referring to activities being done by multiple groups (e.g., operations, contractors, maintenance, or others) in the same area at the same time.”*

SIMOPs often present a higher risk by introducing new hazards resulting from interactions among activities compared to activities that are carried out separately. The increased risk is due to several factors which can include:

1. Not having a single person responsible for the different activities carried out during the SIMOPs period leading to a lack of coordination and communication.
2. Not recognizing that one activity may create a risk impacting the safety of personnel participating in the other activity.
3. Inadvertent mixing of chemicals from parallel jobs
4. Emergency response plans of one job may be compromised by presence/tools/ inventories of another job.

SIMOPs often involve workers from more than one contractor, or two different crews from the same contractor, working on the same or different projects in proximity to one another. These operations can interact in unexpected ways increasing the risk to those doing the work, such as the interaction of incompatible chemicals through a common drain system. One of the most common examples of SIMOPs is when maintenance or other mechanical work is being performed on an operating plant. Another common example is having two different teams working on equipment in close proximity to one another, including at different elevations (one crew working above another crew). But SIMOPs do not need to include an operating facility. SIMOPS also occur when two contractors undertake different jobs on the same non-operational process unit or piece of equipment, or on separate equipment items that are inter-connected.

This SWP will describe a SIMOPS Hazard Identification and Risk Analysis (SIMOPS HIRA) process consisting of the following steps (excerpted from Process Safety Progress article by Paul Baybutt [3]).

1. Identify potential SIMOPS activities in the facility
2. Collect information for SIMOPS activities
3. Identify possible adverse interactions between activities
4. Identify possible hazardous consequences
5. Identify existing safeguards
6. Identify new safeguards needed for hazard control
7. Develop a plan to govern the performance of SIMOPs
8. Communicate the plan to employees and contractors
9. Execute the plan and the SIMOPS activities
10. Conclude the SIMOPS activities
11. Audit the work process and execution of the plan to identify improvement areas

Steps 1-7 represent the actions taken in a SIMOPS HIRA process to develop a SIMOPS plan. Steps 8-10 represent the implementation of the SIMOPS plan. Step 11 is the final step in the SIMOPS life cycle and provides an opportunity to improve the work process and plan execution.

NEED / CALL TO ACTION

SIMOPs will continue to present an increased risk in plant operations and maintenance activities because simultaneous operations cannot be avoided in some cases. Recognizing that SIMOPs are going to occur necessitates that a strategy be developed and implemented for managing them safely, which is the subject of this SWP. If the hazards inherent in SIMOPs are not adequately identified and controlled, incidents with serious consequences can occur. The incident that prompted the development of this SWP is described below.

INCIDENTS CONTINUE TO HAPPEN

Wacker Polysilicon – SIMOPs Identified as Contributor to Incident Consequence [1]

Incident Description: In November 2020 seven workers were exposed to an anhydrous HCl release during maintenance activities (SIMOPs) at the Wacker Polysilicon North America facility in Charleston Tennessee. One worker was fatally injured and three workers sustained serious injuries. The incident occurred when gaseous HCl released from a crack that formed in the vapor outlet nozzle of a heat exchanger in HCl service. The crack formed after a contractor pipefitter inadvertently over-tightened (torqued) flange bolts installed on the heat exchanger. The heat exchanger was located on a fifth-floor platform, which was equipped with a single staircase for access and egress. The platform was approximately 70 feet (21 meters) above the ground.

There were two contractor crews on the fifth-floor platform at the time of the incident. One crew of four team members was there to do insulation work and wore standard PPE. The bolt tightening crew of three people was aware of the potential hazard of an HCl release and wore chemical-protective clothing and full-face respirators, per their company policy. The HCl release resulted in a vapor cloud that impaired visibility and separated the workers from the single means of egress. Three of the insulation crew workers (who were wearing standard PPE) attempted to escape the platform by climbing down piping on the side of the structure. All three workers fell to the ground in this attempt to escape. One was fatally injured and the other two were seriously injured.

CSB Report on Wacker Polysilicon Chemical Release

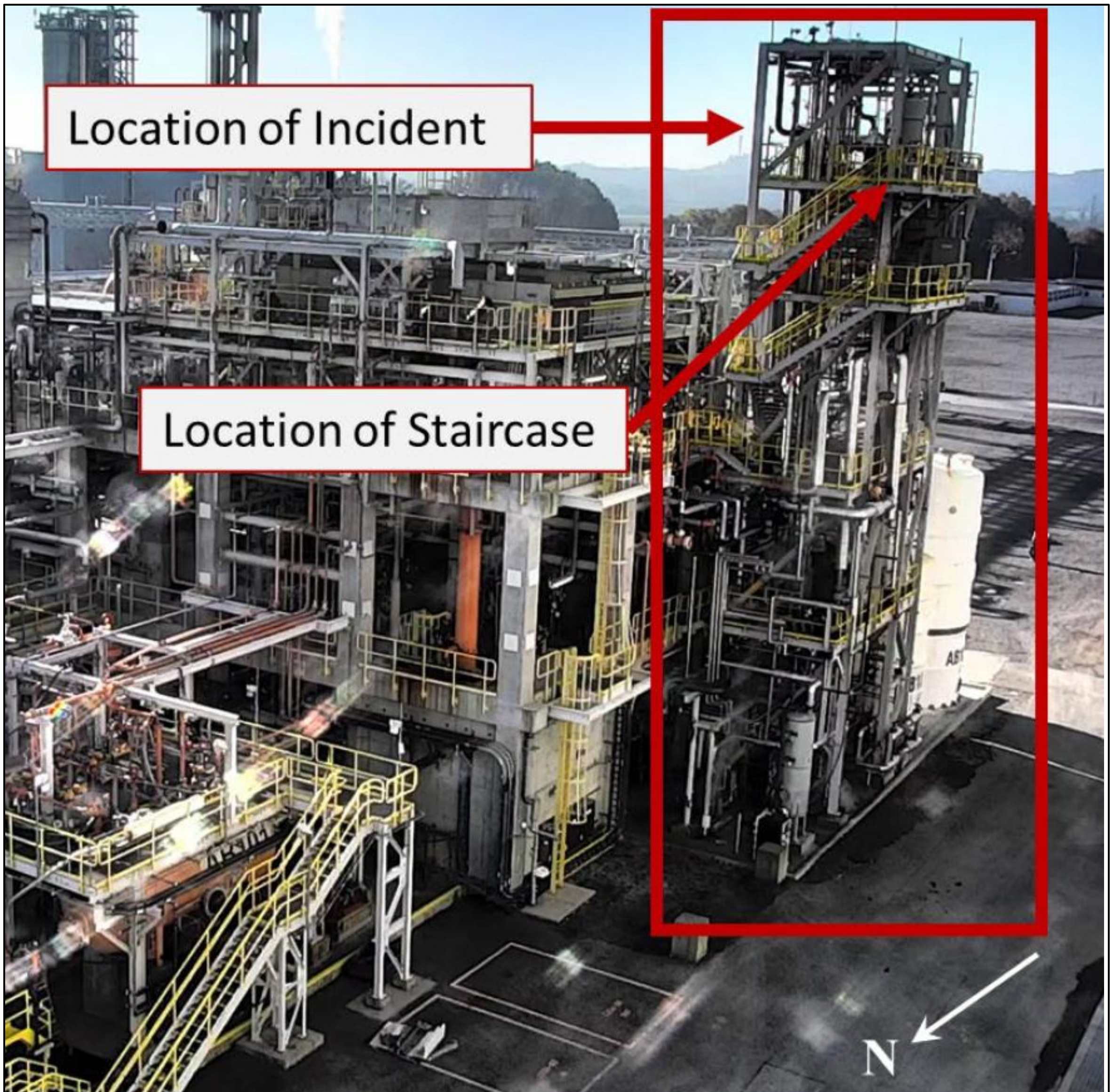

Figure 1: Photograph of HCl Release Location at Wacker Polysilicon [1]

Evergreen Paper Packaging Mill – SIMOPS Implicated in Incident [2]

Incident Description: According to the CSB report, "On September 21, 2020, a paper mill operated by Evergreen Packaging (Evergreen) in Canton, North Carolina, was undergoing a planned shutdown, and associated maintenance and capital project work was ongoing throughout the facility. In one of Evergreen's pulp bleaching units, two contract companies (Universal Blastco, or "Blastco," and Rimcor) were performing simultaneous maintenance work inside two connected process vessels, called an "upflow tower" and a "downflow tower." The upflow tower was constructed of fiber-reinforced plastic (FRP), and Blastco's repair work in the upflow tower required the application of flammable epoxy vinyl ester resin and sheets of fiberglass to the inside walls of the vessel. However, cool ambient temperatures in the area on the night of the incident caused the resin to harden slower than the Blastco workers anticipated, resulting in the newly applied resin and fiberglass sliding down the walls of the vessel. The Blastco workers attempted several means of addressing the issue but were ultimately unsuccessful." Blastco workers then used a portable electric heat gun to enable the resin to warm and harden faster. The Rimcor crew and Evergreen were not aware of the use of the heat gun as this information was not communicated by Blastco.

Use of the heat gun placed a source of ignition in the immediate vicinity of the flammable resin. A fire started when the heat gun fell into a bucket containing resin. Blastco workers were able to evade the fire and evacuate from the tower. Smoke and flames from the fire quickly spread to the connected downflow tower resulting in fatal injuries to the Rimcor workers due to smoke inhalation (the smoke contained toxic carbon monoxide). The Rimcor workers were working on a suspended scaffold and were unable to safely egress from the platform before being overcome by the smoke.

CSB Report on Evergreen Packaging Paper Mill - Fire During Hot Work

Figure 2: Fire damage at Evergreen Packaging upflow (left) and downflow (right) towers. The fatally injured workers were in the lower portion of the downflow tower and were prevented from reaching the emergency egress point by smoke and flames. The egress location is the manhole located at the bottom of the arch. [2]

The SIMOPS Hazard Identification and Risk Analysis (SIMOPS HIRA) process described in this SWP can be applied to identify potential SIMOPS and minimize the likelihood of SIMOPS incidents occurring. The Wacker Polysilicon and Evergreen Paper Packaging Mill incidents will be re-visited in the *Incidents* section of this SWP to demonstrate how the SIMOPS HIRA methodology could be applied to prevent those incidents.

POTENTIAL HAZARDOUS CONSEQUENCES

The consequences resulting from SIMOPS are broadly grouped into personnel injury, property damage, and environmental/community impact, as discussed immediately below. Specific hazardous consequences that can arise from SIMOPS are presented in Table 4. Consequences resulting from SIMOPS activities may be more severe than consequences from "normal" plant activities, as the installed safeguards that manage hazards from "normal" activities may not provide the same level of risk reduction for SIMOPS work, and more workers may be present. Further discussion of identifying simultaneous activity hazards, evaluating potential increases in consequence levels, and thus, increases in the overall risk, is included in the SIMOPS HIRA section of this SWP.

PERSONNEL INJURY

An improperly managed SIMOPS situation may increase the consequence or severity of a hazardous material release, resulting in personnel exposure to the released material, with the following consequences.

- Exposure to a fire due to a release of ignited flammable materials causing burns.
- Exposure to an explosion due to a release of ignited flammable or explosive materials causing blunt force trauma.
- Exposure to corrosive materials (acid or caustic) causing chemical burns.
- Exposure to toxic materials.
- Exposure to hot or cold materials causing thermal burns.

SIMOPs may present other types of personnel hazards including:

- Loss of containment due to impact between the equipment or material being lifted with operating equipment with a resultant release of flammable, toxic, or corrosive materials or pressure energy.
- Being hit by objects that fall to a lower level or ground. Examples include equipment falling from a crane lift, or a tool without a tool lanyard falling from a scaffold.
- Impact injuries resulting from movement of materials or equipment in the area where work is being performed, such as backing a fork truck into an active work area.
- Restriction or blockage of an escape route
- Increased probability of ignition due to increased vehicular activity or hot work
- Performing hot work in proximity to line opening activities
- Performing hot work within a confined space entry
- Lifting equipment under pressure/strain from one team can impact another team in close proximity
- Collapse of an active scaffold can impact teams working below the scaffold

PROPERTY DAMAGE

There are many types of property damage that can be caused by SIMOPs activities in which the hazards are not recognized or controlled. Examples include:

- Release of flammable materials leading to a fire and/or explosion
- Objects falling onto operating equipment during lifts or overhead work
- Vehicles and transport devices colliding with plant equipment
- Damaging underground infrastructure/cables during excavation activities
- Scaffold collapse causing damage to equipment below
- A crane boom or load contacting nearby equipment and causing damage

ENVIRONMENTAL / COMMUNITY IMPACT

SIMOPs activities that cause a release of hazardous material have the potential to escalate into an incident with environmental and/or community impacts. Such an incident has far-reaching consequences for organizational reputation and may affect a facility's "license to operate." The extent of on-site and off-site consequences is related to material properties such as flammability and toxicity, the quantity of released material and dispersion properties. These potential consequences include:

- Chemical release to the neighboring community.
- Contamination of land, potable water, and underground aquifers.
- Declaration of a "Shelter in Place" by local authorities
- Media coverage of the incident.

SIMOPS LIFE CYCLE

SIMOPs have been defined by Baybutt [3] as "*involving the conduct of two or more operations that occur together at a time and place, and may interfere with each other, increase the risk of either activity, or introduce new risks to one or more of the operations.*" Based on this definition, SIMOPS are transitory in nature, existing only when two or more operations can interact, and ceasing to exist when one or both operations has come to an end. For this reason, SIMOPS tend to be short duration events, but this does not necessarily mean that SIMOPS have a short life cycle. As described below, the identification and safe management of SIMOPS will often require more time than the SIMOPS itself. Figure 3 introduces the SIMOPS life cycle which encompasses the process steps listed in the *Fundamental Intent* section.

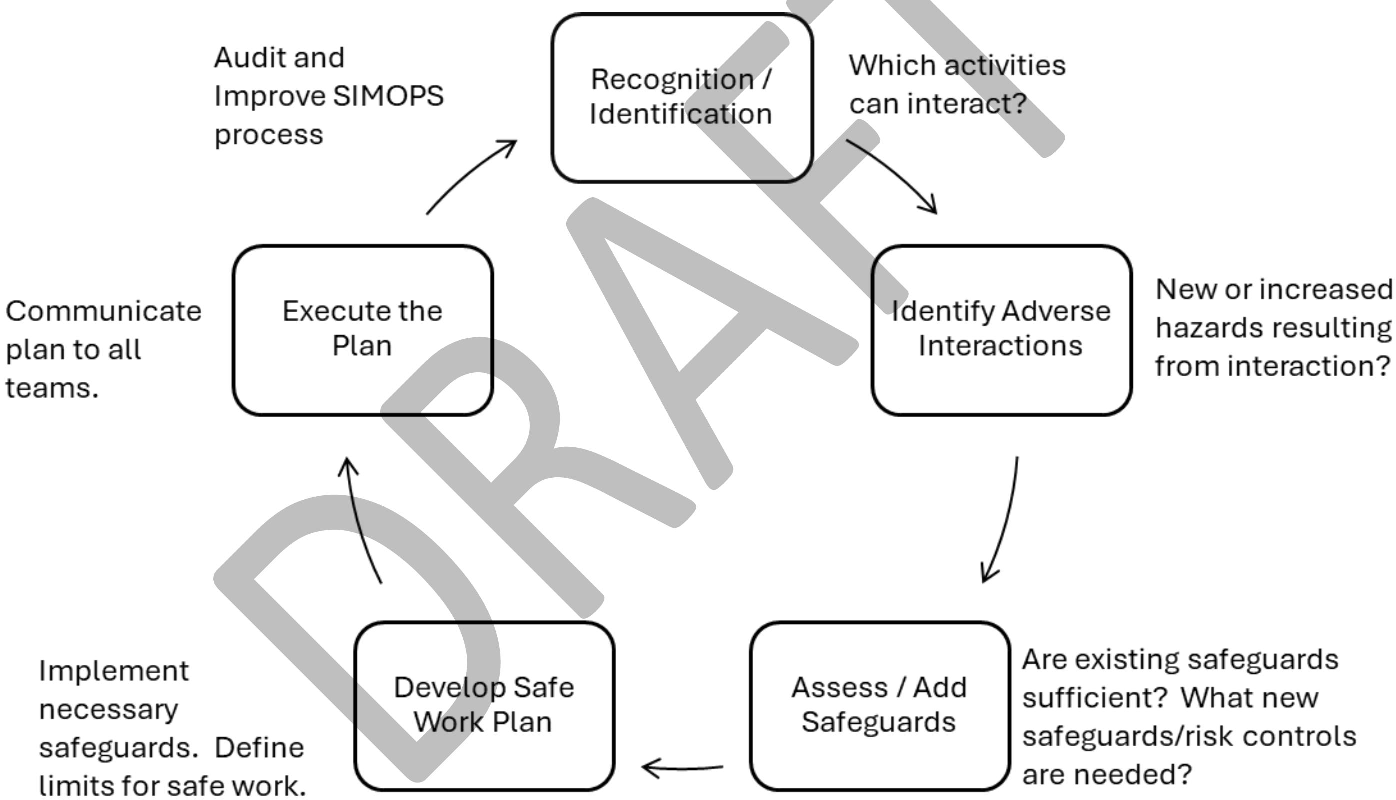

Figure 3: SIMOPS Life Cycle

The SIMOPS life cycle is consistent with the life cycle normally associated with standard Hazard Identification and Risk Analysis (HIRA) used for plant operations. A SIMOPS HIRA uses many of the same practices and techniques as a standard HIRA, with the main difference being that the focus in a SIMOPS HIRA is on the new or increased risk that can result from the interactions of two simultaneous operations. For this reason, the steps that comprise the SIMOPS life cycle will appear familiar.

The first step is recognition and identification that a SIMOPS situation exists. The most critical part of the SIMOPS HIRA is Hazard Identification, which is often absent when SIMOPS activities are undertaken. If the new or hazards resulting from SIMOPS are not identified before the work starts, these hazards cannot be risk-assessed. Without risk assessment, new preventive or mitigative safeguards will not be identified nor implemented. The SIMOPS HIRA process outlined below provides guidance on how to identify hazards resulting from SIMOPS activities so that these hazards can be managed.

The identification step is then followed by a risk assessment step. Risk assessment for SIMOPS focuses on the new or increased level of risk that can result from the interaction of two or more operations, rather than on the baseline risk level that was the focus of the standard HIRA. Existing safeguards are then evaluated for effectiveness in controlling the increased risk resulting from SIMOPS, and new safeguards and controls are developed to reduce the risk from SIMOPS to a tolerable level. A Risk Matrix can be used for this evaluation [5]. Additional Administrative Controls are often insufficient to control SIMOPS hazards to a tolerable level. In most cases, additional Engineering Controls will be necessary.

A SIMOPS Plan is then developed that incorporates the new/improved safeguards and controls. The SIMOPS Plan should also identify limits that cannot be exceeded, include new or updated operating procedures or work procedures in effect during SIMOPS, Emergency Response plans, and related items. The SIMOPS Plan should be developed with the employee and contractor teams who will be involved in the SIMOPS, and shared with all workers who will be involved with the SIMOPS. The approval of the area authority and SIMOPS Coordinator must also be obtained prior to starting work.

After the SIMOPS have been successfully concluded, the SIMOPS Plan can be audited to identify potential improvements to the SIMOPS HIRA process, or to the way in which the Safe Work Plan was executed.

The next several sections provide a more detailed look at how to identify and safely manage SIMOPS, detailing the steps to follow in a SIMOPS HIRA to develop a SIMOPS plan, in executing the SIMOPS plan, and finally in auditing the effectiveness of the SIMOPS plan.

STEP 1 – IDENTIFY POTENTIAL SIMOPS ACTIVITIES IN THE FACILITY

The first step in identifying SIMOPs is the recognition that two or more activities may interact, resulting in new or increased risk. SIMOPs need to be identified prior to commencement of work so that appropriate safeguards and controls can be implemented.

The operations involved in SIMOPs may be governed by Operating Procedures, Work Permits, Safe Work Practices, Job Safety Analyses (JSA), and/or Management of Change (MOC). The preparation and use of these documents can serve as the initiator for the identification of SIMOPs activities. Because SIMOPS can involve plant operations, maintenance activities, and/or construction activities, it is recommended that companies add a specific section for SIMOPS to work control documents such as MOC, Maintenance Work Orders, and Work Permits. The SIMOPS-section can serve as the initiator for invoking the SIMOPS HIRA work process.

In addition to adding a SIMOPS section to work control documents, Permit Issuers and approvers should receive specific training to identify SIMOPS when developing or approving permits. This SWP can be used as a means to provide training on SIMOPS identification and management.

Table 1 provides a list of activities that can be added to work control documents to help identify situations in which SIMOPS may exist. Whenever two or more of the listed activities occur in close proximity or on interconnected equipment simultaneously, the conditions exist for SIMOPS. Use of Table 1 is the start of a structured approach, that specifically looks for potential interactions between a "second" activity with an already existing "first" activity.

- Normal Plant Operations
- Shutdown Plant Operations
- Startup Plant Operations
- Transfer of control of facilities or equipment
- Maintenance work
- Construction / Demolition work
- Material transfer from process equipment to storage equipment, and vice versa
- Material loading and off-loading activities from rail or trucks
- Movement of materials (e.g., catalyst, chemicals) through the facility via ground transport
- Lifting of equipment or materials
- Equipment draining, purging, and cleaning
- Activities covered by Safe Work Practices or Work Permits, including:
    - Confined Space Entry
    - Hot Tapping
    - Hot Work
    - Line Opening
    - Energy Isolation – Lock Out Tag Out
    - Temporary Instrumentation and Controls Bypass
    - Temporary Isolation of Pressure Relief Devices
- Emergency operations and emergency response
- Returning a unit operation to service after modification or maintenance activities
- Trial runs for new products
- Work activities by different teams being conducted on same equipment, node, or circuit

Table 1: Selected List of Plant Activities Involved in SIMOPs

It is recommended that companies use Table 1 as a starting point and add entries that are specific to their facilities or operations.

An effective method to aid in the identification of SIMOPS activities is to develop job plans for each activity and compare them to an overall work schedule for all activities. Doing so will identify simultaneous activities that have the potential for interaction and increased risk levels. This method can also be used to identify opportunities to change the timing or sequence of overlapping work activities thereby eliminating the SIMOPS situation. For activities that cannot be separated, this method will identify when simultaneous activities begin and end, and for how long a SIMOPS situation will exist.

STEP 2 – COLLECT INFORMATION FOR SIMOPS ACTIVITIES

Following the determination that two or more activities will occur simultaneously, the second step in the SIMOPS HIRA process is to collect information related to those activities. Gathering relevant Process Knowledge and Process Safety Information is a necessity. Table 2 provides a list of documents and information to include in a SIMOPS HIRA.

- Mechanical and Process Specifications for equipment and piping
- Basic process control narratives for unit operations involved in SIMOPs
- Identified hazards and existing safeguards – existing HIRAs
- Facility plot plans
- Electrical area classification drawings
- Restricted access areas
- Required PPE in different plant areas
- Safety data sheets
- Safeguards, risk controls, and layers of protection
- Work location
- Emergency response plans
- Piping and Instrumentation Diagrams (P&ID)
- Existing HIRAs for the activities involved in the SIMOPS including LOPAs, Fault Trees, dispersion analyses, and fire/explosion analyses
- Vents in the vicinity of SIMOPS work locations
- MOCs for equipment involved in SIMOPS
- Temporary instrumentation and safeguard bypasses for equipment involved in SIMOPS
- Safety Data Sheets
- Job Safety Analysis
- Safe Work Practices such as Confined Space Entry or Hot Work
- Crane Lift Plan
- Disabled Systems or Equipment

Table 2: Process Safety Information and documents used in Identification of SIMOPs

SIMOPS activities typically involve contractor and/or employee work teams. Information related to work teams and activities that should be collected, includes:

- Work schedule and deadlines
- Location and duration of SIMOPS activities
- Location of workers during SIMOPS activities
- Location of tools
- Emergency egress routes for workers
- Number of personnel required to complete SIMOPS activities
- Skill sets and competency levels of personnel involved in SIMOPS activities
- Operating and maintenance procedures related to SIMOPS activities
- Plot plan of equipment/spares/on-site storage/portable buildings and welfare facilities from all work crews

The most likely consequences resulting from SIMOPS activities are injury and fatality to the people assigned to work on SIMOPS. Understanding the number of people, skills, equipment, and experience needed to safely execute SIMOPS work is a fundamental requirement.

STEP 3 – IDENTIFY POTENTIAL ADVERSE INTERACTIONS BETWEEN ACTIVITIES

SIMOPs incidents occur due to adverse interactions between simultaneous activities, which increase already-identified risks or introduce new risks. The third step in a structured approach to manage SIMOPs is the development of a list of contributing factors that can result in adverse interactions, as shown in Table 3.

- Mechanical failure
  - Loss of containment of hazardous material
  - Failure of Safety Critical Device
  - Failure of Isolation
- Unintended interconnection of process equipment or piping
- Mixing of incompatible chemicals
- Loss of Utility or Stored Energy
  - Electric
  - Steam
  - Instrument Air
- Fire or explosion in the facility
- Uncontrolled vehicular traffic
- Loss of means of communication
- Crews from diverse backgrounds that speak different languages
- Lack of, or unclear, communication between work teams
- Human Factors
  - Fatigue
  - Staffing Levels
  - Complexity of Manual Procedures
  - Skill sets and competency level of workers
- Adverse weather conditions
- Single means of emergency egress
- Work Permits and Work Orders that do not identify SIMOPS
- Use of unapproved equipment for SIMOPS activities

Table 3: Contributing Factors to Adverse Interactions Between SIMOPS Activities

The Contributing Factors listed in Table 3 can by themselves result in a hazardous consequence. When two or more of these factors occur simultaneously, the consequence can be much greater than for either single factor.

Facilities and organizations can develop a SIMOPS Matrix which maps activities of the facility and indicates whether the activity can be conducted safely under different conditions, such as during a thunderstorm. For the purposes of the SIMOPS matrix, a condition (such as a thunderstorm) is considered as a second activity. A SIMOPS Matrix commonly addresses whether two activities can be conducted safely at the same time subject to a given set of conditions.

The SIMOPS Matrix typically uses a traffic light system.

Green: Activities and conditions combinations that *are permitted*
Yellow: Activities and conditions combinations that *are permitted with precautions*
Red: Activities and conditions combinations that *are **not** permitted*

A SIMOPS Matrix can be used by the SIMOPS HIRA Leader and SIMOPS coordinators when developing a SIMOPS Plan for a set of simultaneous activities.

Two examples of SIMOPS Matrices are included in Appendix A. Table A-1 includes six conditions that can be considered as a second simultaneous activity in an example SIMOPS matrix. Table a-3 presents a SIMOPS matrix that uses a protocol that is similar to a Chemical Compatibility Matrix.

STEP 4– IDENTIFY POSSIBLE HAZARDOUS CONSEQUENCES

Table 4 shows examples of Hazardous Consequences that may result from SIMOPS. These examples are not meant to be exhaustive, but rather illustrative – there are many more SIMOPS situations with Hazardous Consequences. Consider the first example of an equipment lift occurring simultaneously with normal plant operations. All equipment lifts come with the potential consequence of dropping the full load or a partial load. If the material that drops impacts a roadway that has been closed, then minimal damage will result and there will likely be no injuries sustained. The most significant consequence in this case would be damage to or loss of the material being lifted.

Now consider the case of an equipment lift over operating equipment in a facility. Any load that drops has the potential to damage operating equipment in the facility, which could result in loss of containment of process fluids and/or damage to operating equipment necessitating a plant shutdown. Such an incident occurred in a refinery in 1987, leading to the release of 6500 gallons (24,600 liters) of hydrofluoric acid, with subsequent evacuation of 4000 people and 1000 people who required medical treatment [6].

Examples are the hazardous consequences that can result from SIMOPS are shown in Table 4.

Activity 1	Activity 2	Hazardous Consequence
Equipment lift	Normal plant operations	Load being lifted may fall, causing equipment damage and release of hazardous material, or block emergency response or egress routes.
Hot Work	Line Breaking	Line breaking may release flammable substance that is ignited by nearby Hot Work activities resulting in fire or explosion.
Maintenance activity 1	Maintenance activity 2	Maintenance crews working in close proximity may not be aware of the hazards presented by the work of the other crew. See description of *Equipment Fracture and Fatal Hydrogen Chloride Release at Wacker Polysilicon North America* in the Need/Call to Action section.
Movement of materials or chemicals	Normal Plant operation	Movement of materials or chemicals through an operating facility may result in a collision between the materials being moved and a live operating unit. See *Formosa Plastics* incident description in the Incidents section.
Hydraulic fracking of well into an existing reservoir	Conventionally drilled wells in the same reservoir.	Adverse interaction between fracking activities and existing wells resulting in a release of hydrocarbons Adverse interaction that negatively impacts volumetric flow or pressure from existing wells
Working at Height	Adverse Weather Condition	Scaffold collapse Equipment blown off scaffold

Table 4: Hazardous Consequences Arising from SIMOPs

It is recommended that companies use Table 4 as a starting point and develop a similar table of Hazardous Consequences that are specific for their company or facility.

Tables 1-4 can be used with a series of questions to identify SIMOPs when “second activities” are being planned.

- Which activities will occur simultaneously (Table 1)? For how long will these activities occur simultaneously?
- Are existing safeguards (Table 2) sufficient to prevent or mitigate the potential consequences of adverse interactions? Are new safeguards needed?
- Which adverse interactions can occur between the activities (Table 3)?
- What are the potential new or increased consequences of these adverse interactions (Table 4)?
- Are SIMOPS activities marked on a map/plot plan for all involved to see?
- Will the SIMOPS have an impact on Emergency Response?
- What response and actions should be taken by SIMOPS work crews when an Emergency Response is initiated in the facility?
- Can the work of one team impact the emergency egress route for another team?

STEP 5 – IDENTIFY EXISTING SAFEGUARDS

STEP 6 – IDENTIFY NEW SAFEGUARDS NEEDED FOR HAZARD CONTROL

Operating facilities have safeguards installed to either prevent hazards from occurring or to mitigate the consequences should a hazard be realized. These safeguards may not be sufficient to prevent or mitigate the hazards associated with SIMOPS. Additional safeguards and hazard controls are required to bring the risk from SIMOPS to a tolerable level. Steps 5 and 6 are to identify existing safeguards and to recommend any new safeguards or controls that are needed for the SIMOPS operations. These two steps should be completed simultaneously as the need for new safeguards cannot be assessed without understanding the safeguards that already exist.

It is instructive to think about the Hierarchy of Controls when assessing the need for new safeguards to effectively manage SIMOPS. The US National Institute of Occupational Safety and Health (NIOSH) [7] and CCPS [8] list the Hierarchy from most effective to least effective means to protect workers from hazards.

1. Elimination
2. Substitution
3. Engineering Controls
4. Administrative Controls
5. Personnel Protective Equipment

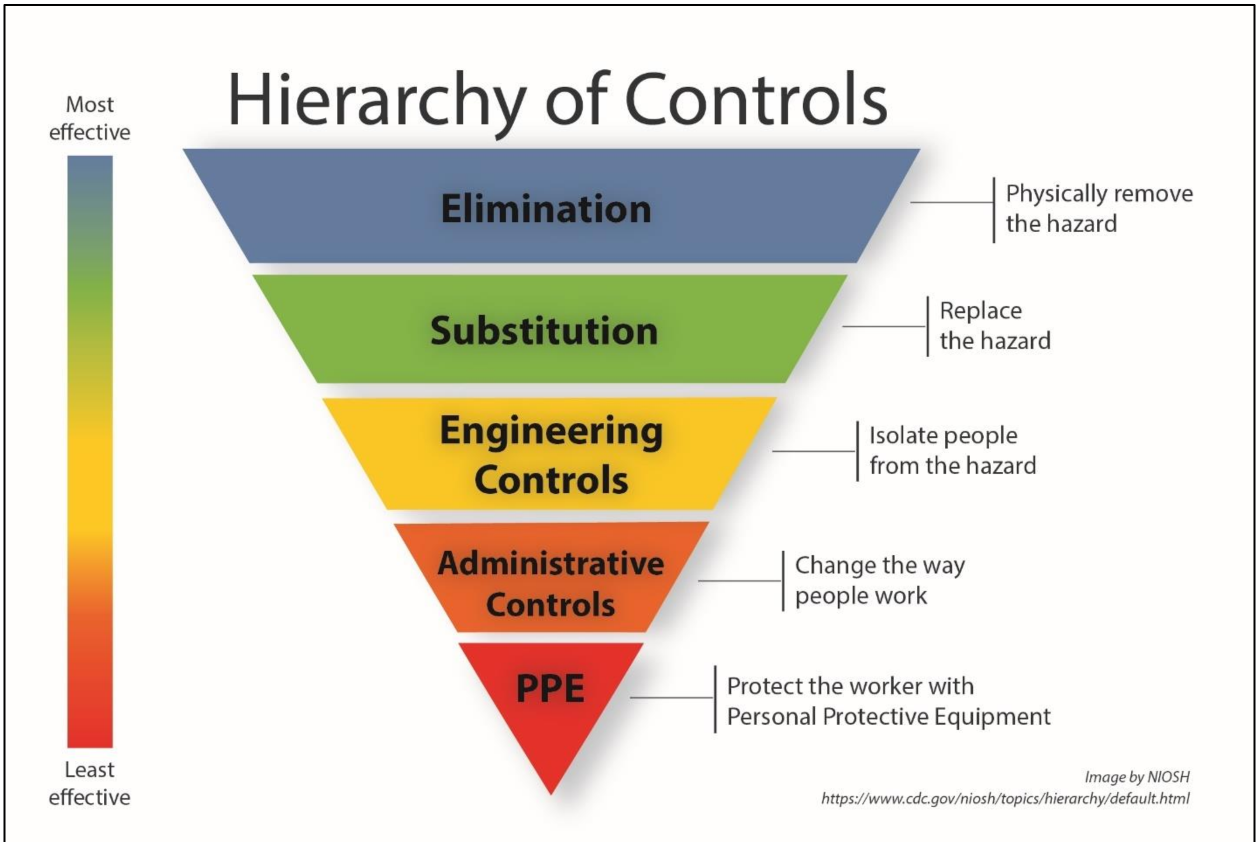

Figure 4: Hierarchy of Controls [7, 8]

Elimination – when the hazard is physically removed or eliminated – is the most effective way to control the SIMOPS hazard. By moving one of the operations to take place at a different day or time, there is no longer a simultaneous operation. For example, consider the Evergreen Packaging Paper Mill incident described above. The simultaneous operations involved two separate contractor work crews engaged in two separate maintenance activities which occurred in a single large unit operation. This SIMOPS situation could have been eliminated by separating the two maintenance activities so that they took place on different days. In this way, the activities of one work crew could not have adversely the other work crew. Alternatively, the Blastco crew could have performed the work during the warmer day shift, eliminating the need to heat the resin with a heat gun in the upflow tower.

While Elimination is the most effective means of risk control, it is not always possible to eliminate a hazard. When Elimination is not possible, then other risk control methods need to be developed.

A combination of controls from the hierarchy is often the most effective way to protect workers from SIMOPS hazards. In the CSB report on the Evergreen incident, the causes cited by the CSB included deficiencies in Engineering Controls (i.e., did not use of ventilating fans to provide fresh air inside the tower), Administrative Controls (i.e., failure to identify the heat gun as a source of ignition, Failure to use drum heaters to heat the resin outside of the upflow tower, insufficient pre-job planning, inadequate coordination and communication between the two contract work crews by Evergreen) and insufficient understanding of Process Safety Information (i.e., inadequate understanding of the flammable material hazards inherent in the resin and in the material of construction of the upflow tower). Safe completion of the simultaneous operations involved in the Evergreen incident could have been accomplished by a thorough application of Engineering and Administrative Controls.

The identification and implementation of new hazard controls, where needed, is an essential step to safely managing SIMOPS and needs to be a part of every SIMOPS hazard assessment. New hazard controls are often necessary to control the increased risk level introduced by simultaneous operations. The CSB report on the Evergreen incident [2] mentioned additional hazard controls, that if they had been implemented, could have averted the incident.

- Providing a drum heater external to confined space to heat resin to a suitable temperature.
- Coordinating and communicating between the two contract work crews
- Providing emergency services for the confined space work

A typical starting point for a SIMOPS HIRA is a compilation of the HIRAs that pertain to each of the individual SIMOPS activities. A challenge when developing a SIMOPS HIRA starting from existing HIRAs is that the Risk Matrix inputs (frequency and consequence) used in the original HIRAs may not apply for the SIMOPS HIRA. The potential adverse interactions between SIMOPS activities may require changing either the frequency or consequence ratings for hazards to different values. The SIMOPS HIRA should review and adjust the Risk Matrix inputs to arrive at a new Risk Rating for existing hazards (those identified in the individual HIRAs) and for new hazards arising from SIMOPS. The new and revised Risk Ratings can then be used to determine the adequacy of existing safeguards and/or the need for new or improved safeguards to reduce risk to a tolerable level.

A partial list of additional safeguards and controls that may be necessary to control SIMOPS hazards is provided below.

- Controlling and restricting personnel access to areas where simultaneous activities are taking place
- Ensuring that ergonomic factors (such as small or cramped work areas, frequency of breaks) have been considered and addressed
- Developing and implementing a communication plan so that all affected individuals and crews are kept informed as the simultaneous activities proceed
- Adding a barrier between activities to maintain separation between work crews and their actions
- Installing additional isolation points using blinds, locked and tagged valves, or car seals
- Re-routing traffic flow within the facility during SIMOPS operations
- Developing alternate emergency egress and emergency response routes
- Removing inventory from equipment prior to overhead lifts

STEP 7 - DEVELOP A PLAN TO GOVERN THE PERFORMANCE OF SIMOPS

The steps in a SIMOPS hazard assessment that have been described thus far have the objective of identifying the SIMOPS situation, determining the new or increased risks that arise from the SIMOPS, and identifying appropriate controls for these risks. The next step is to develop a plan that encompasses all this information into a blueprint for safely conducting the SIMOPS activities. The SIMOPS work plan should be developed with representatives from all contractor and employee groups who will do the SIMOPS work.

The attributes of a SIMOPS plan are like other work processes used to control hazardous work activities safely. The SIMOPS plan should make use of existing work processes and practices such as Job Safety Analysis (JSA), Permit to Work (PTW), and Safe Work Practices. The recommended way to manage SIMOPS is through the issuance of a Work Permit that is specifically written for the SIMOPS activities.

An important aspect of the Work Permit system is to define the necessary Engineering and Administrative Controls necessary to perform work safely, along with confirmation that those controls are installed and functional before work commences. The Work Permit will list those controls and designates an individual (or individuals) to confirm their functionality. A SIMOPS plan should include a Work Permit that lists the additional hazard controls related to the SIMOPS and names the individual(s) responsible for confirming that the controls are installed and functional. Periodic audits of the work sites are also recommended, and these audit intervals can be specified in the SIMOPS Work Permit.

The recommended material and information to include in the SIMOPS Work Permit includes:

- Designation of an individual to coordinate simultaneous activities - the SIMOPS Coordinator
- Definition of the roles and responsibilities of personnel involved
    - Employees
    - Contractors
- Identification of coordination actions
- List of activities and the order in which they should occur, including authorizations required to proceed
- Actions required if activities take longer than anticipated
- Criteria for Stop Work authority to halt simultaneous activities
- Preventive and mitigative safety measures that must be implemented prior to commencement of the simultaneous activities
- Reference to procedures to govern the simultaneous activities including Safe Work Practices such as Confined Space Entry, Hot Work, and Energy Isolation – Lock Out Tag Out
- Reference to JSAs for all tasks that are part of the simultaneous activities
- Communication protocols, emergency response procedures and contingency plans

STEP 8 - COMMUNICATE THE PLAN TO EMPLOYEES AND CONTRACTORS

One of the most important components of the SIMOPS work plan is that every individual, each contractor work crew, and each employee work crew understand how their work can impact others and how the work of others can impact them. A Tool Box talk [9] can be used to convey this information along with discussions of the additional hazards associated with the SIMOPS and the extra controls that have been added to control those hazards. The communication of the SIMOPS plan should be a two-way exercise, with the attendees encouraged to ask questions for clarification or added information. The Tool Box talk should be conducted in more than one language, if needed, to ensure that the entire work crew understands how to proceed safely. For SIMOPS activities that extend over more than one work shift, a Tool Box talk should be conducted at the start of each work shift with all groups involved with the SIMOPS activity to update the participants on progress and feedback from prior shifts.

The Tool Box talk should focus on the bullet points listed in Section 7. It is a recommended practice to require participants to acknowledge that they understood the information conveyed to them, typically via a signature sheet at the end of the Tool Box talk.

The Tool Box talk should emphasize learning from previous incidents, such as those summarized in this document, to educate the work force on the potential consequences that may occur. SIMOPS work teams should be reminded to remain vigilant and maintain a sense of vulnerability. The Tool Box talk can also be used to empower work teams with "Stop Work" authority whenever conditions related to the project deviate from conditions listed in the Work Permit.

STEP 9 - EXECUTE THE PLAN AND THE SIMOPS ACTVITIES

The execution of the SIMOPS plan may begin after completing the Tool Box talk and getting the required signatures on the work permit. A recommended practice is to assign an employee to each crew at the start of the work period to ensure that the permit requirements are met and that the crew is executing the work as planned. Assigning an employee to each work crew also provides the opportunity for members of the work crew to ask for clarification when needed. The role of the assigned employee is to ensure that the work starts positively. The assigned employee is not meant to stay with the work crew for the duration of the work shift.

The SIMOPS Coordinator should check in with each work crew at regular intervals to understand how the work is progressing and to answer questions that may arise. The SIMOPS Coordinator may also conduct field inspections periodically for the same purposes. The SIMOPS Coordinator and the work crews are empowered with Stop Work Authority if any of the conditions of the SIMOPS plan can no longer be satisfied. If Stop Work Authority is invoked, the SIMOPS Coordinator communicates to all the work crews so that all activities related to the SIMOPS activities are stopped until the plan is revised allowing work to re-commence safely.

During the execution of the SIMOPS work, the following steps are recommended.

- Hold a Tool Box talk at the start of each work shift to update workers on progress, changes, or additions to the SIMOPS work plan
- Update and re-issue the SIMOPS Work Permit, as needed, after the Tool Box talk
- Verify tools and equipment are inspected, approved and are compliant with Hazardous Area Classification requirements
- Ensure hazard controls are in place and functioning correctly prior to each work shift
- Ensure workers are wearing required personal protective equipment
- Conduct periodic inspections of the work area and work crews to ensure the requirements of the SIMOPS plan are met
    - Confirm authorized and trained personnel are doing the work
    - Assure housekeeping is performed to keep the area safe for work
    - Ask for feedback from the work crews to understand which aspects of the plan are working as expected and which aspects of the plan could be improved
- Close out all permits at the end of each work shift

STEP 10 - CONCLUDE THE SIMOPS ACTIVITIES

At the conclusion of SIMOPS activities, all permits related to the activities should be closed. The permits should include closing requirements such as returning the facility or area to a clean state of housekeeping, removal of all tools and equipment used for SIMOPS work, removal of locks from isolations or lock boxes, and handing over the facility in a safe condition for return to normal operation. The SIMOPS Coordinator is responsible for ensuring that all closing requirements are satisfied. The SIMOPS Coordinator is also responsible for communicating with plant operators and other personnel that the SIMOPS are concluded and providing the teams that participated in the SIMOPs with all relevant paperwork related to the closure of the SIMOPS.

STEP 11 - AUDIT THE WORK PROCESS AND THE EXECUTION OF THE PLAN

The final step in the SIMOPS life cycle is to conduct an audit of the work process and the execution of the SIMOPS plan to identify improvement opportunities. It is recommended that the audit be carried out by an independent party not associated with the SIMOPS (e.g., the shift supervisor from another area of the facility). Participants should include the SIMOPS Coordinator, and members of each work crew involved in the SIMOPS. Audit findings should be shared with the facility management team and with the personnel who worked on the SIMOPS project. Further guidance and recommended practices related to audits can be found in the CCPS book, *Guidelines for Risk Based Process Safety [10]*.

The application of the SIMOPS HIRA process described in Steps 1 through 10 could have led to different outcomes for the Wacker Chemical Release Incident and the Evergreen Paper Packaging Mill Hot Work Incident, as described next.

WACKER POLYSILICON – APPLICATION OF THE SIMOPS SWP

Safety Issues: The CSB report on the Wacker Polysilicon HCl release cited four safety issues that contributed to the incident [1].

1. Written Procedures
2. Control of Hazardous Energy
3. SIMOPS
4. Means of Egress

Application of SIMOPS SWP: The work process outlined in this SWP could have prevented this incident from occurring. Wacker did not have a specific bolt torque procedure and this contributed to the over-torque and subsequent failure of bolts on live operating equipment, leading to the HCl release. The Job Safety Analysis and Permit to Work SWPs in the CCPS SWP series discuss the importance of analyzing each job task and writing procedures so that work can be done safely. Control of Hazardous Energy is covered in the CCPS Energy Isolation SWP [11]. One of the tenets in the Energy Isolation SWP is to minimize the number of people in proximity to work being carried out on live operating equipment.

Recognition that a SIMOPS exists is the first step in safely managing the SIMOPS hazards. Wacker did not recognize that a SIMOPS situation was present. Had the SIMOPS situation been recognized, a SIMOPS HIRA could have been developed resulting in the following changes to the way the work was done.

1. A SIMOPS HIRA could have concluded that the best option was elimination of the SIMOPS situation by separating the work activities into two distinct time periods. Wacker had just started a two-week outage at the time of the incident. The bolt torque work and insulation work could have been separated so that both work crews were not on the platform at the same time.
2. If the two work activities could not be separated in time, then the SIMOPS HIRA could have been used to identify additional safeguards to protect the work crews.

Four safeguards are listed that could have lessened or eliminated the severity of the incident if they had been applied. Several of the safeguards are preventive (prevent the incident from occurring) and several are mitigative (reduce the consequence of a release incident).

Safeguard 1 (Preventive): As stated in the CSB's investigation report, Wacker lacked a procedure for bolt torqueing. A preventative safeguard is to develop a torque procedure and then use it to train the torque crew from applying excessive torque to the bolts. A chemical release occurred due to over-torque being applied to the bolts. The generic safeguard is to develop a procedure for all work activities on hazardous systems or processes.

Safeguard 2 (Preventive): De-inventory the exchanger of HCl and isolate the exchanger according to principles outlined in the CCPS Energy Isolation SWP prior to starting the bolt tightening work. Eliminating the HCl eliminates the possibility of an HCl release. The generic safeguard is to reduce or eliminate the inventory of hazardous materials or energy before starting work on a system or equipment.

Safeguard 3 (Mitigative) Limit the number of workers on the platform to the minimum needed. This safeguard is both specific to this incident and generic to all work activities on hazardous systems or processes.

Safeguard 4 (Mitigative): Train members of both work crews on the hazards of an HCl release and discuss safe egress from the platform following an HCl release as part of a Tool Box talk held prior to the start of work. The generic safeguard is to train workers on the hazards they may encounter for a particular activity and how to safely evacuate from those hazards if they are realized.

EVERGREEN PAPER PACKAGING MILL – APPLICATION OF THE SIMOPS SWP

Safety Issues: The CSB report on the Evergreen fire [2] cited four safety issues that contributed to the incident.

1. Hot Work
2. Pre-Job Planning
3. Confined Space Entry
4. Combustible Materials of Vessel Construction

Application of SIMOPS SWP: The SIMOPS work process could have been used to prevent this incident. Evergreen, Blastco, and Rimcor all developed work permits for the work being conducted in the connected upflow and downflow towers, but failed to recognize that a SIMOPS situation was present.

Similar to the Wacker Polysilicon incident, identification that a SIMOPS existed could have initiated the SIMOPS HIRA process resulting in the implementation of additional safeguards.

Safeguard 1 (Preventive): Eliminate the SIMOPS. A SIMOPS HIRA could have pointed out that that the work activities of either work crew could imperil the other work crew in the tower. The SIMOPS could have been eliminated by separating the work so that only one crew was in the connected tower system at any given time.

Safeguard 2 (Preventive): Elimination of the source of combustion from the Confined Space. The Blastco crew used a heat gun inside the tower to warm the resin and this heat gun served as the ignition source when it fell into a bucket of flammable resin. Safer alternatives such as using drum heaters outside the tower to heat the resin or doing the work during daylight hours when the ambient temperature was warmer (thereby eliminating the need to heat the resin) could have been identified as safeguards by a SIMOPS HIRA.

Hot Work and Confined Space Entry are common work activities in chemical processing plants that can subject workers to substantial hazards. CCPS has published SWP [11] on these topics to provide guidance on techniques and methods to manage the risks associated with Hot Work and Confined Space Entry. When Hot Work and Confined Space Entry are combined into a single work activity, the combination should initiate a SIMOPS review.

The application of this SIMOPS SWP in combination with the Hot Work and Confined Space Entry SWP could have been effective in identifying and safely managing the additional hazardous consequences resulting from having two work crews doing jobs in the same unit operation at the same time. A SIMOPS HIRA could have pointed out that emergency egress for the Rimcor work crew was cumbersome and time-consuming, resulting in a requirement to eliminate all ignition sources in the Confined Space.

Safeguard 3 (Preventive): Improved communication between the work crews. Neither work crew was fully aware of the work being done by the other crew nor the potential hazards involved. There was no direct line of communication between the crews and apparently no exchange of information prior to the commencement of work. A SIMOPS Plan and Tool Box talk could have been used to exchange information between the work crews and establish a direct line of communication between the crews.

Safeguard 4 (Mitigative): According to the CSB report, "the Blastco crew did not have a fire extinguisher immediately available and Evergreen did not require Blastco to have one available." A SIMOPS HIRA in combination with a Hot Work Permit would have identified the potential for a fire inside the upflow tower due to the presence of combustible materials. A fire extinguisher could then have been required as a Mitigative Safeguard to quench a fire at the incipient stage before it spread and became uncontrollable. The Blastco workers had no effective means to put out a fire as described in the report.

The next section of the SWP presents a sample workflow and job responsibilities for those involved in SIMOPS activities. Alternative workflows and responsibilities can be developed by companies that match their organizational constructs and to meet their particular SIMOPS objectives.

SAMPLE WORKFLOW AND RESPONSIBILITIES

Key Actions - SIMOPS	SIMOPS Coordinator	HIRA Leader	SIMOPS Work Teams	Auditor
• Identify potential SIMOPS activities in the facility				
• Collect information for SIMOPS activities				
• Identify possible adverse interactions between SIMOPS activities				
• Identify possible hazardous consequences				
• Identify existing safeguards				
• Identify new safeguards needed for hazard control				
• Develop SIMOPS Plan that addresses control of SIMOPS hazards				
• Conduct Toolbox Talk and communicate the plan with work teams • Complete joint inspection of work sites prior to start of work				
• Execute the plan and SIMOPS activities • Review, approve and issue SIMOPS JSAs / Work Permit • Confirm that permit conditions have been met prior to start of work • Monitor job sites while work is underway • Update plan and permits as needed at each shift change				
• Perform work according to the Permit				
• Complete the work. Clean job site.				
• Confirm work is complete and site housekeeping satisfactory • Close the Permit				
• Audit the process and execution of the SIMOPS Plan				

SIMOPS CORDINATOR
Person responsible for the SIMOPS activities being carried out. This is typically a Site Supervisor or Shift Supervisor whose responsibilities include:
• Identifying that a SIMOPS situation exists and initiating the SIMOPS work process
• Coordinating work activities with other Supervisors and/or the Facility Manager
• Collecting the necessary information to conduct a SIMOPS HIRA.
• Identifying additional hazards that may arise from SIMOPS. Understanding existing safeguards. Recommend additional safeguards to manage SIMOPS hazards.
• Participating in the Hazard Identification and Risk Analysis (HIRA), and JSA, associated with the work task preparations.
• Developing the SIMOPS Plan and associated SIMOPS Permit. Updates the Permit as needed based on feedback from teams doing the work.
• Ensuring competent people fulfil the specified roles defined in the SIMOPS Plan.
• Ensuring any intended deviations from approved procedures are carefully planned and approved by the appropriate Technical Authorities.
• Ensuring the daily workload is capable of being safely executed by the available employee and contractor resources.
• Checking the SIMOPS Permit Receiver is authorized to receive the permit and trained to do the required work.
• Conducting a Tool Box talk with all SIMOPS work teams prior to the start of each work shift.
• Managing the conduct of the work in accordance with the Permit through periodic surveillance of the worksite and ongoing work activities (may be delegated to a Field Verifier)
• Maintaining open lines of communication with all work crews working on the SIMOPS
• In case of site emergency or if adverse climate conditions are deemed unsafe for continuing work, ensures the work stops immediately, the worksite is made safe, and the work party goes to their muster point.
• Confirming that the worksite is safe, clean, and tidy after the SIMOPS activities are complete.
• Closes out the SIMOPS Permit. Informs Operations personnel that the SIMOPS is complete.
• Participating in the SIMOPS audit.

SIMOPS COORDINATOR or FIELD VERIFIER (FIELD ACTIVITIES)
The SIMOPS Coordinator is responsible for inspecting the work site while work is underway. Work site inspections may be delegated to a Field Verifier. Responsibilities include:
• Verifying all appropriate control measures are in place before work starts and that the worksite is safe for the work activities specified in the SIMOPS Permit.
• Ensuring isolations are in place as determined in the isolation plan.
• Managing the field check of controls to address identified hazards.
• Performing the operations/production part of the joint site inspection.
• Ensuring that a competent person completes atmospheric testing (if required), and results are provided to the SIMOPS Coordinator.
• Monitoring the job site to ensure JSA compliance.
• Verifying work is performed safely and correcting any unsafe work practices or conditions
• Identifying and correcting any deviations from the PPE required in the SIMOPS Permit
• Performing an inspection of the work area after work is completed to confirm the system is ready to be brought back into service.

HIRA LEADER
Person with experience and expertise in Hazard Identification and Risk Analysis (HIRA) methods. Responsible for leading the SIMOPS HIRA. managing a Process Unit or section of the Plant. This person is typically a Plant Process Engineer or Process Safety Engineer whose responsibilities include:
• Working with the SIMOPS Coordinator to identify potential adverse interactions, hazards, and consequences arising from SIMOPS.
• Identifying existing safeguards and developing new safeguards to manage the SIMOPS hazards.
• Leading the SIMOPS HIRA
• Obtaining required engineering and technical personnel to participate in the SIMOPS HIRA.
• Developing the SIMOPS plan to safely manage work activities related to the SIMOPS
• Participating in the SIMOPS audit.

SIMOPS WORK TEAMS (EMPLOYEES or CONTRACTOR)
Person(s) responsible for performing the work described in the SIMOPS Permit. May be either Employees or Contractors. Each SIMOPS Work Team will have a Team Lead. Responsibilities include:
• Participating in a JSA or work risk assessment associated with the work task preparations.
• Receiving briefing instructions from the SIMOPS Coordinator about hazards and controls in place for the permitted work
• Receiving the SIMOPS Permit when issued and ensuring that all requirements and instructions of the Permit are followed.
• Maintaining the worksite in a safe and tidy manner during the work activities. Ensuring the site is cleared of all tools and thoroughly cleaned when work is complete. Returning the SIMOPS Permit to control point at the end of each shift or when work is complete.
• Attending a "Toolbox Talk" with all work party members. Each Team Lead will ensure that their team members understand the work instructions and the conditions of the SIMOPS Permit. Working with the SIMOPS Coordinator, each Team Lead will discuss specific hazards and describe how they will be managed for the duration of the work activity. Explaining contingency plans in the event of an emergency. Ensuring all work party members sign on to the Permit.
• Understanding communication protocols, emergency response procedures and contingency plans as described in the SIMOPS Plan and SIMOPS Permit. This information will be conveyed during the Tool Box talk.
• Every work team member will sign their name to indicate that they have been trained on the SIMOPS Plan and understand the plan.
• Completing the work in accordance with the SIMOPS Permit.
• In case of site emergency or if adverse climate conditions are deemed unsafe for continuing work, the work teams will immediately stop work, make the worksite safe, and proceed to their muster point.

AUDITOR
Person responsible for auditing the SIMOPS work process and the application of the SIMOPS Plan after the SIMOPS is complete. This person should have experience in the audit process. Responsibilities include:
• Auditing the SIMOPS work process and execution of the SIMOPS Plan to find areas for improvement.
• Ensuring the SIMOPS Coordinator and members of every work crew participate in the audit.
• Writing an audit report and sharing the report with facility management and the SIMOPS Coordinator.

INCIDENTS

The incidents in this section are included as further examples of SIMOPS activities for which the SIMOPS hazards were not identified and controlled, resulting in incidents with significant consequences.

DUPONT YERKES SIMOPS INCIDENT

Incident Description: The CSB investigated an explosion that occurred during repair work to an agitator support atop an atmospheric storage tank at the DuPont Yerkes chemical plant in Buffalo, NY in November 2010 [12]. An explosion occurred when flammable vinyl fluoride (VF) vapor from interconnected, in-service process tanks flowed undetected into the storage tank and ignited due to the welding repair work atop the tank. A contract worker doing the repair was fatally injured from blunt force trauma when the explosion blew the top almost completely off the tank. A second contract worker received first-degree burns and minor injuries.

Discussion: The SIMOPS activities in this incident were (1) hot work to repair an agitator support and (2) the agitator support being located on a tank connected to an in-service system. A SIMOPS HIRA could have identified the potential for an adverse interaction between hot work and equipment that was not isolated. The SIMOPS Plan would have included a provision for isolating all penetrations to the storage tank and inerting the tank prior to the commencement of Hot Work. The components of the plan would have formed the basis of a SIMOPS Permit. The straightforward steps outlined here could have avoided this incident if enacted.

[CSB Report on Fatal Hot Work Explosion Occurring During SIMOPS]

Figure 5: Photo of atmospheric storage tank flowing the explosion. The top of the tank which was almost completely blown off due to the explosion, can be seen on the left side. [12]

FORMOSA PLASTICS SIMOPS INCIDENT

Incident Description: A hydrocarbon release at the Formosa Plastics facility in Point Comfort, Texas resulted in a fire and explosions in October 2005 [13]. Fourteen workers sustained minor injuries and the plant experienced significant damage, with some units out of production for 5 months. Flames from the fire rose to 500 feet. The hydrocarbon release occurred when a trailer was being towed by a forklift through a live operating area. The trailer got caught on a small drain valve in a liquid propylene system resulting in a release of pressurized liquid propylene. The released propylene rapidly vaporized and formed a flammable vapor cloud which subsequently ignited.

Discussion: The SIMOPS activities in this incident were (1) movement of a trailer through the facility combined with (2) pressurized liquid hydrocarbons contained in operating equipment along the route used by the trailer. A SIMOPS HIRA could have identified the potential for an adverse interaction between movement of the trailer through live operating equipment and developed additional safeguards which may have included:

Finding an alternate route that did not pass through live operating equipment, thereby eliminating the SIMOPS situation.

If it was not possible to eliminate transport through operating equipment, then the SIMOPS HIRA could be used to develop another alternative with additional hazard controls.

Finding an alternate route that minimized the length of the route passing through live operating equipment, combined with

1. *Walking the route with plant operators prior to moving the trailer to identify and mark potential snag points*
2. *Identifying shut-off valves and other means of isolation prior to the move in case there was a collision and release*
3. *Using a spotter throughout the move to ensure clearance was maintained between the trailer and snag points*
4. *Coordinating the timing of the move with plant operators so that they would be prepared to close shut off valves if needed.*

CSB Report on Formosa Plastics Propylene Explosion

REFERENCE MATERIALS

[1] U.S. Chemical Safety and Hazard Investigation Board (CSB), *Wacker Polysilicon Chemical Release*, CSB Report on Wacker Polysilicon Chemical Release

[2] U.S. Chemical Safety and Hazard Investigation Board (CSB), *Evergreen Paper Packaging Mill – Fire During Hot Work*, CSB Report on Evergreen Packaging Paper Mill - Fire During Hot Work

[3] *"Simultaneous Operation (SIMOP) Review: An Important Hazard Analysis Tool",* Paul Baybutt, Process Safety Progress, 11 November 2016, 62-66.

[4] Center for Chemical Process Safety, Process Safety Beacon, *"Simultaneous Operations (SIMOPS)",* Process Safety Beacon - August 2023, August 2023.

[5] Center for Chemical Process Safety, *Guidelines for Risk Based Process Safety*, John Wiley and Sons, Inc., 2007, Figure 9.3.

[6] UK Health and Safety Executive (HSE), Control of Major Accident Hazards (COMAH), Release of Hydrofluoric Acid from Marathon Petroleum Refinery

[7] National Institute of Occupational Safety and Health (NIOSH), Hierarchy of Controls

[8] Center for Chemical Process Safety, *Guidelines for Inherently Safer Chemical Processes: A Life Cycle Approach, 3rd Edition,"* John Wiley and Sons, Inc., 2019, Figure 2-1.

[9] Center for Chemical Process Safety, Process Safety Beacon, Process Safety Beacon Archives

[10] Center for Chemical Process Safety, *Guidelines for Risk Based Process Safety*, John Wiley and Sons, Inc., 2007, Chapter 21.

[11] Center for Chemical Process Safety, Safe Work Practices.

[12] U.S. Chemical Safety and Hazard Investigation Board (CSB), *DuPont Fatal Hotwork Explosion*, CSB Report on DuPont Fatal Hotwork Explosion

[13] U.S. Chemical Safety and Hazard Investigation Board (CSB), *Formosa Plastics Propylene Explosion*, CSB Report on Formosa Plastics Propylene Explosion

APPENDIX 1: EXAMPLE SIMOPS MATRICES

	Operate Wells	Construction Activities	Hot Work	Crane Operations over equipment	Excavation Activities	Work at Height	Maintenance involving breach of containment	Confined Space Entry	Plant/ Item Start-Up
Heavy Wind > 20kts	Y	1	1	N	1	N	1	1	1
Sandstorm	Y	1	1	N	N	1	N	N	1
Night-time working (during darkness)	Y	3	3	3	N	3	3	3	Y
Heavy Rain	Y	3	1	N	N	N	N	N	2
Lightning / Thunderstorm Cyclone	3	N	N	N	N	N	N	N	2
High Ambient Temperature	Y	4	4	4	4	4	4	4	Y
Drilling	N	6	Y	Y	Y	Y	Y	Y	Y
Intrusive Maintenance	Y	3	3	3	Y	3	Y	3	3
Non-Intrusive Maintenance	Y	Y	Y	3	Y	Y	Y	Y	Y
Construction	Y		Y	Y	Y	Y	Y	Y	Y
Hot Work	10	3		3	3	Y	3	3	Y
Heavy Lifts	N	Y	Y		3	Y	Y	Y	Y
Radiography			3	3	3	3	3		N
Cold Flaring		N					N		N
LPG Loading	Y	Y	N	N	Y	Y	N	Y	Y

Table A-1: Example SIMOPS Matrix 1. See Table A-2 for color coding and numerical coding.

Color	Description
Y	Yes - Activity is permitted subject to normal controls and procedures (e.g., Permit to Work system)
I	Permitted subject to meeting the numbered requirements presented in this table
N	Activity is not permitted while adverse condition remains

Number	Requirement
1	All non-essential operations and maintenance activities shall be stopped. Essential activities/ operations in progress are permitted to finish. Indoor/enclosed area activities permitted subject to PTW, Job Safety Plan (JSP), Method Statement and risk assessment. No new activities operations or activities will commence until acceptable weather conditions are available. It is the responsibility of the Production Co-ordinator to assess weather conditions to determine whether they are acceptable or adverse.
2	Only emergency activities permitted. Subject to night driving approval and risk assessment.
3	Permitted subject to PTW, including all necessary risk assessments, certificates and emergency arrangements. Consider whether the following are required or applicable: · Area is Suitably lit, using zone approved light · Breach of containment assessment, including RPE and PPE requirements · Conflict between activities / plant or equipment conditions. · Hot Work Permit · Gas Testing · Confined Space Entry Certificate · Isolations in place · Dropped Object Exclusion Zones · Lifting plans · Method Statement · Access restrictions
4	Continued works subject to heat stress evaluation. Schedule works during cooler part of day provide forced ventilation, shaded areas and cold water.
5	Drill rig shall be excluded 50m from fence line of station
6	If construction works are within 50m of drilling rig, Rig PTW system is to be followed.
7	Permitted subject to review and application of restrictions identified in rig transportation method statement, rig up rig down procedure or rig movement HSE Case. Clearance certificate issued by asset for all rig moves or heavy machinery (including cranes) with requirement for goalposts to be installed before crossing lines.
8	No hot work permitted in vicinity of pig launcher/receiver during launching/ receiving operations
9	New construction activities on site are subject to PTW and HAZID process. Major construction activities to be justified within SIMOPS Procedure.
10	Permitted subject to hot work PTW on well pads. No hot work on well head permitted unless fully isolated. Area Classification requirements addressed by PTW.

Table A-2: Example SIMOPS Matrix 1. Color Coding and Numerical Coding.

	Break Containment - HC	Break Containment - Non HC	Confined Space Activity	Crane and Vehicle Operations	Diving & Marine Operations	Excavation work	General Cold Work	Handling Hazardous Substances	Handling Radioactive Source	Hot Work	Hydro and Abrasive blasting	Leak and Pressure Testing	Lifting Operations	Manual Handling	Non Standard Isolations	Overside Working	Spark Potential Work	Well Services Operations	Working at Height	Working on Electrical Systems	Working on Safety Systems	Work on pressurized equipment
Break Containment - HC	*	A	P	R	A	R	A	R	A	P	P	R	R	A	R	A	P	P	R	R	R	P
Break Containment - Non HC	A	*	R	A	A	R	A	R	A	R	R	R	R	A	R	A	R	P	R	R	R	P
Confined Space Activity	P	R	*	A	A	R	A	R	R	R	R	R	R	A	R	A	R	P	R	R	R	P
Crane and Vehicle Operations	R	R	A	*	A	R	A	R	R	R	R	R	A	A	R	A	R	P	A	R	R	P
Diving & Marine Operations	R	A	A	A	*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	R	R	A
Excavation work	R	A	R	R	A	*	A	R	R	R	R	R	R	A	R	A	R	P	A	R	R	P
General Cold Work	A	A	A	A	A	A	*	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Handling Hazardous Substances	R	R	R	R	R	R	R	*	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Handling Radioactive Source	R	R	R	R	R	R	R	R	*	R	R	R	R	R	R	R	R	R	R	R	R	R
Hot Work	P	R	R	R	R	R	R	R	R	*	R	R	R	R	R	R	R	R	R	R	R	R
Hydro and Abrasive blasting	P	R	R	R	R	R	R	R	R	R	*	R	R	R	R	R	R	R	R	R	R	R
Leak and Pressure Testing	P	R	R	R	R	R	A	R	R	R	R	*	R	R	R	R	R	P	R	R	R	R
Lifting Operations	R	R	R	R	R	R	A	R	R	R	R	R	*	A	R	R	R	R	R	R	R	R
Manual Handling	A	A	A	A	A	A	A	R	R	R	R	R	R	*	R	R	R	R	R	R	R	R
Non Standard Isolations	R	R	R	R	R	R	R	R	R	R	R	R	R	R	*	R	R	R	R	R	R	R
Overside Working	R	R	R	R	R	R	A	R	R	R	R	R	R	R	R	*	R	R	R	R	R	R
Spark Potential Work	P	R	R	R	R	R	A	R	R	R	R	R	R	R	R	R	*	R	R	R	R	R
Well Services Operations	P	R	R	R	R	R	A	R	R	R	R	R	R	R	R	R	R	*	R	R	R	R
Working at Height	R	R	R	R	R	R	A	R	R	R	R	R	R	R	R	R	R	R	*	R	R	R
Working on Electrical Systems	P	R	R	R	R	R	A	R	R	R	R	R	R	R	R	R	R	R	R	*	R	R
Working on Safety Systems	R	R	R	R	R	R	A	R	R	R	R	R	R	R	R	R	R	R	R	R	*	R
Work on pressurized equipment	P	R	R	R	R	R	A	R	R	P	R	R	R	A	R	R	R	P	R	R	R	*

A	ALLOWED - The two operations can be carried out simultaneously as long as a level one risk assessment is performed SIMOPs process is in place and all normal control activities are followed.
R	RESTRICTED - Concurrent operations are allowed with level 2 risk assessment and additional controls in place, approval at OIM level.
P	PROHIBITED - Concurrent operations of the two activities are never allowed.

Table A-3: Example SIMOPS Matrix 2