



**Effectiveness Review Report for the
June 7, 2018, Liquid Nitrogen Injury
Corrective Action Plan**

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Effectiveness Review Report for the June 7, 2018 Liquid Nitrogen Injury Corrective Action Plan

Description of Issue

On June 7th, 2018, a group of potential new liquid nitrogen fill station users at building 70/70A were receiving on-the-job training (OJT) to use the fill station. The trainees had completed all required online safety training and were authorized to work with cryogenic liquids on a Work Planning and Control (WPC) Activity. The instructor and lead researcher for the trainees demonstrated the fill procedure for the group, and then provided supervision as one of the trainees conducted a fill. The trainee was wearing all required personal protective equipment (PPE) during the procedure. Following the instructions of the lead researcher, the trainee inserted a metal funnel into a liquid nitrogen transfer Dewar, placed the fill hose into the funnel, adjusted the funnel to allow air to vent during the fill, and opened the liquid nitrogen valve to begin filling the Dewar. The funnel and fill hose were unstable, and so the trainee used their gloved hands to hold the funnel (with the left hand) and fill wand (with the right hand) in place during the fill. The instructor observed the process from a few feet away. The entire filling operation lasted only 4-5 minutes. Later when the trainee removed their cryo gloves, the trainee and lead researcher noticed that the trainee's fingers were unusually pale. The onsite emergency number was called, and an ambulance responded. The trainee was transported to a local hospital where they stayed under observation until June 10th due to the nature of the injury.

Immediate compensatory actions were taken, including a stop-work to all cryogenic liquid work at LBNL locations, a review of all liquid nitrogen fill stations and PPE provided at the fill stations, and the requirement for a mandatory restart plan and retraining of all liquid nitrogen fill station users before work resumed.

Effectiveness Review Conclusion

On August 13th, 2020, the Cryogenic Liquids Subject Matter Expert (Cryo SME) convened a team and began an Effectiveness Review (ER) to determine if the corrective actions implemented as documented in the Liquid Nitrogen Injury Corrective Action Plan properly addressed the root causes of the incident, prevent similar incidents from occurring, and demonstrate sustainability. This effectiveness review focused on the corrective actions that could reasonably be expected to show observable results by the time of this review, and which were directly related to the root causes identified in the causal analysis.

Overall, this review found that many of the corrective actions had been completed as written, but were not sufficiently effective to prevent recurrence. Corrective action effectiveness is summarized as follows:

- 10239-1: This corrective action was analyzed in conjunction with 10239-4 because both of these corrective actions involved changes to the WPC Activity Manager Hazard and Control records. Taken together, these corrective actions were determined to be Effective. The hazards and controls for both cryogenic liquid safety and pressure safety were evaluated to determine any gaps, and changes were made to correct those gaps. All of the hazards and controls for both categories were also edited for clarity to help Activity Leads select the appropriate hazards during Activity creation and renewal.
- 10239-2: This corrective action was deemed as Partially Effective. The listening tour was conducted as described and objective evidence was provided. However, no additional corrective actions were established based on the findings of the listening tour. Additionally, the documented recommendations that were provided to EHS upon completion of the listening tour were not adequately disseminated or adopted into EHS practice.
- 10239-3: This corrective action was deemed as Partially Effective. The resources produced are all of excellent quality and are useful to a broad audience of Principal Investigators (PIs) and Activity Leads. However, none of the researchers and Activity Leads interviewed were aware of the existence of the OJT website where many of the resources are hosted, and members of this effectiveness review team were unable to find the OJT

website through the A-Z index, the WPC Activity Manager system, or the EHS website.

- 10239-4: See 10239-1. This corrective action was deemed Effective.
- 10239-5: This corrective action was deemed as Partially Effective. Only approximately half of the individual group Activities audited were acceptable for authorization of fill station use. However, all of the centralized work authorization processes were found to be adequate and these centralized authorization documents cover a large number of fill station users. This corrective action stemmed from the fact that the researcher who was injured was not authorized to use the liquid nitrogen fill station at building 70 on their WPC Activity. Despite the improvement seen in the authorization processes for fill station use, if another incident were to occur at a fill station, it is still possible that the associated WPC Activity would be found to not clearly authorize the work at the fill station.
- 10239-6: This corrective action was deemed Ineffective. The corrective action as written required that LBNL develop inspection and maintenance requirements and a schedule for these requirements. A plan was developed that listed all required inspection and maintenance, and a time interval was set, but the jobs were never scheduled within the Facilities Division work management system, which is necessary for the inspection and maintenance to be carried out. Because the maintenance work is not actively being documented as being performed during this review, this corrective action did not improve performance and is not sustainable.

The conclusions of effectiveness for the specific corrective actions are summarized below.

<p>Corrective Action number and statement: 10239-1</p> <p>In collaboration with stakeholders, the pressure and cryo SMEs will review risks associated with pressure and cryo work and determine if the risk is properly identified and properly graded in Activity Manager. If not, SMEs will work with stakeholders to make the appropriate adjustments. The SMEs in collaboration with stakeholders will then seek ways to encourage communication between relevant stakeholders when a change involving higher risk work is planned. At a minimum, this will include identifying the appropriate points-of-contact to contact with questions or issues. This may also include new control language to select hazards in Activity Manager. This may include new language in training materials. This may include new signage at points-of-use encouraging communication and clarifying the appropriate points-of-contact. This may include usage logs with columns for comments/notes where issues can be noted.</p> <p>Corrective Action number and statement: 10239-4</p> <p>LBNL Pressure Safety SME, Cryogen SME, and Pressure Safety SMC, in collaboration with key stakeholders, will evaluate the cryogen and pressure hazards in Activity Manager that triggers Pressure Safety SME review and determine if the criteria cover all scenarios that the SMEs and stakeholders believe should be covered or if there are gaps. If there are gaps, the SMEs, in collaboration with stakeholders will propose new hazards or reword existing hazards to address the gaps and follow the requirements management process to update hazards within the Activity Manager. As part of this effort, hazards will be reviewed for clarity and modified as needed to improve clarity.</p>	<p>Effectiveness Rating:</p> <p>Effective</p>
<p>This corrective action was deemed Effective because the hazards and controls for both cryogenic liquid safety and pressure safety were evaluated to determine any gaps, and changes were made to correct those gaps. All of the hazards and controls for both categories were also edited for clarity to help Activity Leads select the appropriate hazards during Activity creation and renewal.</p>	

The cryogenic liquids subject matter expert (SME) and the pressure safety subject matter coordinator (SMC) reviewed all hazards and controls relating to these two subject areas in the WPC Activity Manager system and documented deficiencies. The list of hazards and controls was then expanded and edited to correct these deficiencies and ensure that all appropriate EHS reviews would be triggered for Activities that warrant it. The hazards and controls were also edited for clarity at the same time to provide better access to important safety information and to make it easier for Activity Leads to select the correct hazards when creating or renewing an Activity. Hazards in both Pressure and Cryogenics categories now reference associated hazards in the other category to help Activity Leads select all of the relevant hazards. Additionally, the risk level 3 hazard for “Use of cryogenic liquids in custom-built or modified equipment, or equipment not designed for cryogenic liquid use” triggers a review by the cryogenic liquids SME, who can then ensure that the appropriate Pressure hazard for “Cryogen systems: Operation of a customized system or a modified commercial system that utilizes or transports cryogen” is selected. Conversely, the selection of the corresponding Pressure hazard triggers a review by the Pressure Safety SMC, who can ensure that the Cryogen hazard is selected.

Interviewees indicated that the list of hazards is now more explicit and more extensive. Cryogenic liquid and pressure Activities no longer rely on the Activity Lead to be solely knowledgeable about the appropriate controls or which hazards to select in the Activity Manager interface. This removes a lot of the ambiguity that was present before, and better defines the parameters of the Activities for line management.

The Team found that the updates do improve clarity and add substantially more hazard and control information, and agreed that if implemented properly and followed, these changes will help to prevent recurrence.

However, it was noted that whether or not the hazards are appropriately selected and controls properly followed by the end-user is not a certainty. The proper implementation of these changes requires reinforcement by line supervision and for the Activity Lead and/or designated OJT provider(s) to be familiar enough with the hazards and controls to provide effective OJT. These issues were addressed in corrective actions 10239-3 and 10239-5 below.

The Team identified the following opportunities for improvement:

- EHS to continue routine program assurance with review of the Cryogenic Liquids and Pressure Safety hazards and controls in WPC Activity Manager, and update hazards and controls as needed on the basis of feedback and changing work environments.
- EHS to ensure that training and other resources are updated regularly to reflect current policy and work practice.

Corrective Action number and statement: 10239-2

LBNL will contract with an external consultant to conduct a listening tour to understand staff’s perspective and insight on the current culture. A component of this effort will be understanding issues or barriers to reporting concerns to management. Additional corrective actions or initiatives to enhance a reporting culture will be generated based on the findings of the listening tour. As part of the listening tour or as a separate action, LBNL will assess existing reporting mechanisms to determine if enhancements are necessary to ensure adequate reporting tools are readily available, LBNL workers know how to report issues, and robust processes are in place to respond to reported issues.

Effectiveness Rating:

Partially Effective

This corrective action was deemed as Partially Effective because the documented recommendations that were provided to EHS upon completion of the listening tour were not adequately disseminated or adopted into EHS practice.

The objective evidence (OE) submitted provides evidence that the listening tour portion of the corrective action was met. However, the result of this listening tour was a set of actionable items, suggestions, and recommendations for the improvement of safety culture and the EHS/research community working relationship, and these were never distributed to the people who could act upon them, nor translated into additional/traceable corrective actions (CAs). Furthermore, the SME can't find any record of these documents existing anywhere except as OE in the CATS database. Because the recommendations were never followed up on and no subsequent CAs were issued, the existence of recommendations and guidelines does not prevent recurrence of this issue or provide any improvement to our safety and reporting culture.

With follow-through on the recommendations and guidelines produced by this corrective action, and a commitment to change on the part of EHS staff, this could greatly improve the safety culture and working relationship between EHS and the research community. With renewed attention on this issue, we still have the opportunity to implement the recommendations provided as a result of the listening tour and effect positive change.

The Team recommends the following corrective actions:

- EHS Management to review the listening tour recommendations and enter them in CATS and provide justification for not taking action on any recommendations that are not translated to CAs.
- EHS to complete a follow-up Effectiveness Review once those supplementary CATS items are completed.

Corrective Action number and statement: 10239-3

EHS will review OJT-related tools and resources and update these to communicate basic expectations for OJT including qualifications for instructors. EHS will also review hazard-specific OJT requirements and ensure adequate guidance is available to divisions. EHS will also generate one or more videos demonstrating how to properly fill dewars at manual fill stations.

Effectiveness Rating:

Partially Effective

This corrective action was deemed as Partially Effective. The resources produced are all of excellent quality and are useful to a broad audience of Principal Investigators (PIs) and Activity Leads. However, none of the researchers and Activity Leads interviewed were aware of the existence of the OJT website where many of the resources are hosted, and members of this effectiveness review team were unable to find the OJT website through the A-Z index, the WPC Activity Manager system, or the EHS website.

The OE submitted meets the wording of the corrective action as written. The video of how to fill Dewars at the building 70/70A fill station has been distributed and is easily accessible as a just-in-time resource as a QR code link on a sign at the fill station. The video and sign for the building 30 fill station are ready but the sign has not yet been posted.

All of the other OJT guidance that was developed is hosted on a website. Unfortunately, this website is not currently linked from any other resource or database, and is therefore inaccessible to those it might help. Members of the team were unable to navigate to the OJT home page from the EHS website, the A to Z index, and from WPC Activity Manager. None of the cryogenic liquid fill station users or providers of OJT knew of the existence of this resource, but all indicated that they would find such a resource useful.

The Team finds this corrective action to be partially effective on the basis that the video demonstration at building 70/70A is available and will help to prevent a similar incident in the future, and that the OJT resources are well written and provide useful guidance on providing OJT. However, these resources must be readily accessible and known to the cryogenic user community in order for this corrective action to be fully effective.

The Team recommends the following corrective actions:

- EHS to make the OJT website readily accessible, promote/advertise the website via channels such as Elements, and work with the Lab's Communications group as necessary to promote this resource.
- EHS, in collaboration with the training group, to create signs with videos for multi-division fill stations where there is more turnover in those providing OJT and more opportunity for drift (B2, 30, 62)
- EHS, in collaboration with the training group, to add links from EHS 0170, Cryogen Safety, to the OJT homepage and to OJT qualifications in particular.

Corrective Action number and statement: 10239-5

EHS will partner with user groups for each fill station and determine the best method to authorize the work. As part of this effort, EHS and user groups will identify appropriate system owners/points of contact and appropriate signage for fill stations. In addition, based on learning from this effort and/or on interviews with applicable stakeholders, LBNL will generate best-practice guidance on shared equipment ownership and work authorization.

Effectiveness Rating:

Partially Effective

This corrective action was deemed as Partially Effective. Despite some Divisions showing very robust methods of authorization for use of fill stations, it was found that overall authorization practices and documentation were inconsistent and many were still inadequate.

The Team's audit of authorization practices for use of the liquid nitrogen fill stations included follow-up on the Division-reported methods of authorization for fill station use, according to the evidence submitted for the corrective action. The bulk of the review focused on the most common practice for authorizing fill station use: individual group WPC Activities. The Team's audit of existing Activities with cryogenic liquid hazards reveals that many do not clearly state the requirements for users to use the fill station, and many do not clearly provide documented authorization for the users to use the fill station. Previously audited activities have by and large not been updated, with the notable exception of the Physics Division, which is the Division in which the injury occurred. Overall, the quality and depth of individual group WPC Activities was highly variable, from one Activity that consisted of four sentences, to a handful of Activities that were exceptionally well written with clear documentation of hazards, controls, procedures, and OJT requirements. Only approximately half of the individual group Activities audited were acceptable for authorization of fill station use. However, all of the centralized work authorization processes were found to be adequate and these centralized authorization documents cover a large number of fill station users. Despite the improvements seen in the authorization processes for fill station use, if another incident were to occur at a fill station, it is still possible that the associated WPC Activity would be found to not clearly authorize the work at the fill station.

At the Advanced Light Source (ALS), Emery Station East (ESE), the Molecular Foundry/National Center for Electron Microscopy (NCEM), and Potter Street, work authorization for use of liquid nitrogen fill stations is centralized such that there is a single authorizing document for each liquid nitrogen fill station setup that is used, and all researchers who utilize a particular fill station are authorized on the same document. These documents were reviewed and it was found that all of them were up-to-date and well-written with requirements for training, clear language describing what work is authorized, descriptions of the hazards and controls, and complete lists of authorized users. Documents reviewed included BS-0033, BS-0037, BS-0038, AL-0352, and MF-0124 in WPC Activity Manager, and the [ESE LN2 Training List](#) on Google Docs.

In all other Divisions, WPC Activities unique to each group were the sole method of authorization for liquid nitrogen fill station use. It was found that these Activities varied greatly in quality and effectiveness for the purposes of authorizing fill station use. Some Activities were found to be very well-written with clear language indicating what work is authorized and the hazards and controls for that work; however, the vast majority of Activities lacked crucial information necessary to clearly authorize the work. In some cases, the Description of Work did not even mention liquid nitrogen use, despite the Activity having multiple cryogenic liquid Hazards selected. The review process for WPC Activities of Risk Level 2 varies from Division to Division. Some Divisions require the Division Safety Coordinator (DSC), Project Lead, and Activity Lead to review and approve

Risk Level 2 Activities while others only require the review and approval of the Activity Lead and Project Lead. It is clear that many Activities are getting through this review process that are not comprehensive enough to identify the work and the hazards and provide clear controls and authorization.

The Team recommends the following corrective actions:

- EHS, in collaboration with the Divisions, to complete an assessment of the condition of WPC Activity work authorization of cryogenic liquid work with respect to missing information in the description of work, appropriate selection of hazards, and OJT requirements.
- EHS, in collaboration with the Divisions, to evaluate current assurance mechanisms and review processes for cryo Activities, and if necessary, modify existing reviews and assurance, or develop and implement an assurance process that will ensure that cryo Activities are complete and adequate for the work authorization intended.
- The cryogenic liquids SME to distribute and promote templates for cryo Activities to facilitate updates to existing Activities and to provide examples of what is expected.

Corrective Action number and statement: 10239-6

LBNL (EHS, Facilities and stakeholders) will identify and document maintenance and inspection requirements for fill stations including requirements for pressure relief devices. Specific divisions/programs that own fill stations will implement or verify that appropriate maintenance/inspection programs are in place. Fill stations serving a single division / program will be assigned division / program owner if an owner is not already established For fill stations serving multiple divisions / programs, Facilities will assume ownership of maintenance/ inspection requirements, develop preventive maintenance procedures and develop a schedule for maintenance execution.

Effectiveness Rating:

Ineffective

This corrective action was deemed as Ineffective because a plan was developed that listed all required inspection and maintenance, and a time interval was set, but the jobs were never scheduled within the Facilities Division work management system, which is necessary for the inspection and maintenance to be carried out. Because the maintenance work is not actively being documented as being performed during this review, this corrective action did not improve performance and is not sustainable.

The Preventive Maintenance (PM) plan that was created meets the stated requirement of the corrective action. However, because the work was never scheduled in the Facilities Division work management system, the work was never performed on the planned schedule.

Observations of the bulk tanks on site revealed that some pressure relief devices (PRDs) have been replaced, but without a full audit of PRDs by someone with the expertise to determine the age of each device based on its stamped code, it is impossible to know whether PRDs are being inspected and/or replaced on time and whether any have exceeded their service life. Although there are records of corrective maintenance since the event, development and rollout of the PM activities was never completed. Without PM activities being scheduled for the Crafts workers, this action does not prevent recurrence.

The Team recommends the following corrective actions:

- Facilities to schedule PM in Maximo and perform the preventative maintenance on required cryo fill stations according to the set schedule.

The Team also identified the following opportunity for improvement:

- During the course of the review, the Team learned that the primary technician responsible for maintenance and repair to cryogenic liquid systems will be retiring from the Lab soon. This has the potential to leave the Lab without a technician who is qualified and authorized to perform cryogenic liquid system maintenance and repair, which could result in significant loss of operational capacity and delays to critical research projects. The Team recommends that Facilities evaluate options for continuity in cryogenic liquid system maintenance and repair to address the imminent retirement of critical personnel.

Recommended Corrective Actions

The following corrective actions are recommended to address partially effective corrective actions as well as other process improvements:

10239-2:

- EHS Management to review the listening tour recommendations and enter them in CATS and provide justification for not taking action on any recommendations that are not translated to CAs.
- EHS to complete a follow-up Effectiveness Review once those supplementary CATS items are completed.

10239-3:

- EHS to make the OJT website readily accessible, promote/advertise the website via channels such as Elements, and work with the Lab's Communications group as necessary to promote this resource.
- EHS, in collaboration with the training group, to create signs with videos for multi-division fill stations where there is more turnover in those providing OJT and more opportunity for drift (B2, 30, 62)
- EHS, in collaboration with the training group, to add links from EHS 0170, Cryogen Safety, to the OJT homepage and to OJT qualifications in particular.

10239-5

- EHS, in collaboration with the Divisions, to complete an assessment of the condition of WPC Activity work authorization of cryogenic liquid work with respect to missing information in the description of work, appropriate selection of hazards, and OJT requirements.
- EHS, in collaboration with the Divisions, to evaluate current assurance mechanisms and review processes for cryo Activities, and if necessary, modify existing reviews and assurance, or develop and implement an assurance process that will ensure that cryo Activities are complete and adequate for the work authorization intended.
- The cryogenic liquids SME to distribute and promote templates for cryo Activities to facilitate updates to existing Activities and to provide examples of what is expected.

10239-6

- Facilities to schedule the preventive maintenance (PM) in Maximo and perform the PM on required cryo fill stations according to the set schedule.
- Facilities Division to document any maintenance that is done as a result of Praxair inspection reports.

Process Improvement Recommendations

10239-1 and 10239-4:

- EHS to continue routine program assurance with review of the Cryogenic Liquids and Pressure Safety hazards and controls in WPC Activity Manager, and update hazards and controls as needed on the basis of feedback and changing work environments.
- EHS to ensure that training and other resources are updated regularly to reflect current policy and work practice.

10239-6:

- During the course of the review, the Team learned that the primary technician responsible for maintenance and repair to cryogenic liquid systems will be retiring from the Lab soon. This has the potential to leave the Lab without a technician who is qualified and authorized to perform cryogenic liquid system maintenance and repair, which could result in significant loss of operational capacity and delays to critical research projects. The Team recommends that Facilities evaluate options for continuity in cryogenic liquid system maintenance and repair to address the imminent retirement of critical personnel.

General Process Improvements:

- The Team recommends that EHS and the training group update EHS 0170 Cryogen Safety to incorporate recent lessons learned and better communicate the results of these Corrective Actions.
- Many interviewees indicated that they took EHS 0170 a long time ago and could not remember what was in the training. The team recommends that EHS evaluate the potential need for a short refresher course to focus on the most important aspects of cryo safety and keep users of cryogenic liquids up-to-date on recent incidents and lessons learned.

- Given that quality OJT is absolutely critical for the safety of new cryogenic liquids users, the Team recommends that EHS evaluate the potential need for an optional in-person Train the Trainer course for Cryo OJT.

Rating Definitions - Corrective Actions

- **Effective (Yes)** - Corrective actions are implemented as intended, have addressed the causes of the issue/finding, will prevent recurrence of the issue/finding, and demonstrate sustainability. No new corrective actions are recommended.
- **Partially Effective (Partially)** - Corrective actions are implemented as intended, and have partially addressed the causes of the issue/finding, but do not prevent recurrence or demonstrate sustainability. Revised or new corrective actions are recommended to enhance the effectiveness of the correction action.
- **Ineffective (No)** - Corrective actions were not implemented as intended, do not address the causes of the issue/finding, do not effectively prevent recurrence of the issue/finding, and do not demonstrate sustainability. New corrective actions are recommended to achieve effective resolution.

Assurance Effectiveness Review for the June 7, 2018 Liquid Nitrogen Injury Corrective Action Plan

CA #	Corrective Action Description	Inherent Risk	CA Effectiveness	Assurance Effectiveness	Residual Risk	Recommended Actions
<p>10239-1 10239-4</p>	<p>10234-1: In collaboration with stakeholders, the pressure and cryo SMEs will review risks associated with pressure and cryo work and determine if risk is properly identified and properly graded in Activity Manager. If not, SMEs will work with stakeholders to make the appropriate adjustments. The SMEs in collaboration with stakeholders will then seek ways to encourage communication between relevant stakeholders when a change involving higher risk work is planned. At a minimum, this will include identifying the appropriate points-of-contact to contact with questions or issues. This may also include new control language to select hazards in Activity Manager. This may include new language in training materials. This may include new signage at points-of-use encouraging communication and clarifying the appropriate points-of-contact. This may include usage logs with columns for comments/notes where issues can be noted.</p> <p>10234-4: LBNL Pressure Safety SME, Cryogen SME and Pressure Safety SMC, in collaboration with key stakeholders, will evaluate the cryogen and pressure hazards in Activity Manager that triggers Pressure Safety SME review and determine if the criteria cover all scenarios that the SMEs and stakeholders believe should be covered or if there are gaps. If there are gaps, the SMEs, in</p>	<p>High The Activity Manager system is used for work planning and selection of proper controls. It relies on risk grading and proper selection of hazards during the Activity creation process to ensure that the appropriate line management, EHS personnel, and subject matter experts (SMEs) are involved. If the hazards are not properly risk graded and the appropriate SMEs are not automatically added to review of the Activity, then there is significant risk that an Activity will have insufficient review to properly assess all of the hazards and determine all of the appropriate controls. This leaves the Lab vulnerable to personnel injury and property damage from incidents resulting from work that is inadequately planned and reviewed.</p>	<p>Effective</p>	<p>Effective The following assurance mechanisms are in place to ensure that the cryogenic liquid and pressure hazards are properly risk graded, appropriate stakeholders and SMEs are involved in review, and the hazards and controls are written clearly:</p> <ul style="list-style-type: none"> • The Cryogenic Liquids SME reviews the cryo program, including the Activity Manager hazards and controls, on a regular basis as part of routine program assurance with the EHS Division. • The Pressure Safety Subject Matter Coordinator (SMC) reviews the pressure program, including the Activity Manager hazards and controls, on a regular basis as part of routine program assurance with the EHS Division. 	<p>Low Although routine program assurance will never catch every issue, the current state of the cryogenic liquids and pressure safety hazards and controls in WPC Activity Manager has been greatly improved, and feedback from cryogenic liquid users did not include any concerns or recommendations for improvement. This portion of the cryogenic liquids program is working as intended and regular review should be adequate to ensure that it continues to do so.</p>	<p>Opportunities for improvement:</p> <ul style="list-style-type: none"> • EHS to continue routine program assurance with review of the Cryogenic Liquids and Pressure Safety hazards and controls in WPC Activity Manager, and update hazards and controls as needed on the basis of feedback and changing work environments. • EHS to ensure that training and other resources are updated regularly to reflect current policy and work practice.

<p>collaboration with stakeholders will propose new hazards or reword existing hazards to address the gaps and follow the requirements management process to update hazards within Activity Manager. As part of this effort, hazards will be reviewed for clarity and modified as needed to improve clarity.</p>	<p>LBNL will contract with an external consultant to conduct a listening tour to understand staff's perspective and insight on the current culture. A component of this effort will be understanding issues or barriers to reporting concerns to management. Additional corrective actions or initiatives to enhance a reporting culture will be generated based on the findings of the listening tour. As part of the listening tour or as a separate action, LBNL will assess existing reporting mechanisms to determine if enhancements are necessary to ensure adequate reporting tools are readily available, LBNL workers know how to report issues, and robust processes are in place to respond to reported issues.</p>	<p>High Safety culture is essential to safe work at the Lab and to ensuring that issues are reported and addressed promptly. When workers do not feel safe and empowered to speak up about safety concerns, or when those safety concerns are not addressed, the Lab is at increased risk of personnel injury or property damage from safety issues that were known to the workers but not addressed and corrected.</p>	<p>Partially Effective</p>	<p>Partially Effective The following assurance mechanisms are in place to ensure that safety issues are brought to attention and promptly addressed: <ul style="list-style-type: none"> • The Safety Concerns program provides a phone number (x7233 "SAFE"), an email address (safetyconcerns@lbl.gov), and convenient askUS portal to report any safety concerns. • Many research groups around the Lab hold regular group meetings that include a "safety minute" portion dedicated to discussing safety related topics. • The monthly Division Safety Coordinators (DSCs) Meeting includes a roundtable where DSCs bring up safety issues and recent incidents in their Division for awareness and discussion. • For larger issues that are not being addressed, the Lab has a Whistleblower/Employee Concerns Program and employees may reach out to Human Resources for help addressing their concerns or complaints. • The Lab's Stop Work policy empowers and </p>	<p>Partially Effective The following assurance mechanisms are in place to ensure that safety issues are brought to attention and promptly addressed: <ul style="list-style-type: none"> • The Safety Concerns program provides a phone number (x7233 "SAFE"), an email address (safetyconcerns@lbl.gov), and convenient askUS portal to report any safety concerns. • Many research groups around the Lab hold regular group meetings that include a "safety minute" portion dedicated to discussing safety related topics. • The monthly Division Safety Coordinators (DSCs) Meeting includes a roundtable where DSCs bring up safety issues and recent incidents in their Division for awareness and discussion. • For larger issues that are not being addressed, the Lab has a Whistleblower/Employee Concerns Program and employees may reach out to Human Resources for help addressing their concerns or complaints. • The Lab's Stop Work policy empowers and </p>	<p>High The presence of reporting mechanisms does not ensure that those mechanisms will be used. There are many underlying cultural reasons that a worker may choose not to report an issue, or that a worker may bring up an issue in casual discussion and be dissuaded from pursuing it further. Therefore issues and concerns can still go unreported because the cultural issues have not been addressed, merely identified.</p>	<p>Supplemental corrective actions:</p> <ul style="list-style-type: none"> • EHS Management to review the listening tour recommendations and enter them in CATS and provide justification for not taking action on any recommendations that are not translated to CAs. • EHS to complete a follow-up Effectiveness Review once those supplementary CATS items are completed. 	
<p>10239-2</p>								

10239-3	<p>EHS will review OJT-related tools and resources and update these to communicate basic expectations for OJT including qualifications for instructors. EHS will also review hazard-specific OJT requirements and ensure adequate guidance is available to divisions. EHS will also generate one or more videos demonstrating how to properly fill dewars at manual fill stations.</p>		<p>High Work with hazardous materials, including cryogenic liquids, involves not only an academic knowledge of the hazards, but a deep understanding of the behavior of the materials and the skill to respond appropriately to any potential off-normal situations. This type of work can be intricate and involve subtleties that cannot be learned in a classroom setting. OJT is therefore critical for preparing workers to perform their jobs safely and to recognize potentially dangerous situations in time to intervene. When OJT is not given, or is not thorough enough to impart that understanding and skill, workers are at a significantly increased risk of injury or incident.</p>	<p>Partially Effective</p>	<p>Partially Effective The following assurance mechanisms are in place to ensure that quality OJT is provided to those who work with hazardous materials:</p> <ul style="list-style-type: none"> • LBNL Training includes mandatory subject area training. • A new training course for Activity Leads, EHS 0011, emphasizes the need for quality OJT and provides detailed guidance on how to provide effective OJT as well as ongoing supervision for workers that need it. • Many research groups have standard operating procedures (SOPs) that may be documented in their WPC Activities or elsewhere, and which provide ongoing guidance as needed for workers who are new to a task. <p>It must be noted that a second cryogenic liquids injury occurred in December of 2020 while this Effectiveness Review was ongoing, and during a new worker's OJT and early supervision phase. While this new injury does not appear to have shared root causes with the 2018 liquid nitrogen injury, it did still stem from an unrecognized hazard during OJT and early supervision.</p>	<p>encourages everyone to stop work when the situation is perceived to be unsafe, without repercussions or retaliation.</p>	<p>High There are many limitations to the current assurance mechanisms:</p> <ul style="list-style-type: none"> • The Activity Lead training, EHS 0011, is a fairly new rollout, and many of the well established researchers at the Lab did not have a chance to take the training during the earlier and more formative months and years of their career. • The Activity Lead training course is only delivered as a requirement to Risk Level 2 and 3 Activity Leads in 9 Divisions, and Risk Level 3 Activity Leads only in one Division. The remainder of the Divisions have chosen to leave the course as optional. • Standard Operating Procedures are not a substitute for quality OJT, in much the same way that online subject matter training is not. Additionally, these SOPs are passive documents that do not provide active feedback the way ongoing supervision would, and it is impossible in many cases to convey the skill necessary for hands-on work through text and photographs. • The Lab relies heavily on postdocs as the primary workforce in the laboratory working 	<p>Supplemental corrective actions:</p> <ul style="list-style-type: none"> • EHS to make the OJT website readily accessible, promote/advertise the website via channels such as Elements, and work with the Lab's Communications group as necessary to promote this resource. • EHS, in collaboration with the training group, to create signs with videos for multi-division fill stations where there is more turnover in those providing OJT and more opportunity for drift (B2, 30, 62) • EHS, in collaboration with the training group, to add links from EHS 0170, Cryogen Safety, to the OJT homepage and to OJT qualifications in particular.
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<p>10239-5</p>	<p>EHS will partner with user groups for each fill station and determine the best method to authorize the work. As part of this effort, EHS and user groups will identify appropriate system owners/points of contact and appropriate signage for fill stations. In addition, based on learning from this effort and/or on interviews with applicable stakeholders, LBNL will generate best-practice guidance on shared equipment ownership and work authorization.</p>			<p>Moderate Many of the individual group Activities for fill station use are still inadequate for work authorization. This puts the Lab in noncompliance with its own policies, and opens up the Lab to reputational damage and/or external review. However, about half of the individual group Activities audited were adequate, and all of the centralized authorization methods are adequate.</p>		<p>Supplemental corrective actions:</p> <ul style="list-style-type: none"> EHS, in collaboration with the Divisions, to complete an assessment of the condition of WPC Activity work authorization of cryogenic liquid work with respect to missing information in the description of work, appropriate selection of hazards, and OJT requirements. EHS, in collaboration with the Divisions, to evaluate current assurance mechanisms and review processes for cryo Activities, and if necessary, modify existing reviews and assurance, or develop and implement an assurance process that will ensure that cryo Activities are complete and adequate for the work authorization intended. The cryogenic liquids SME to distribute and promote templates for cryo activities to facilitate updates to existing Activities and to provide

10239-6	<p>LBNL (EHS, Facilities and stakeholders) will identify and document maintenance and inspection requirements for fill stations including requirements for pressure relief devices. Specific divisions/programs that own fill stations will implement or verify that appropriate maintenance/inspection programs are in place. Fill stations serving a single division / program will be assigned division / program owner if an owner is not already established. For fill stations serving multiple divisions / programs, Facilities will assume ownership of maintenance/ inspection requirements, develop preventive maintenance procedures and develop a schedule for maintenance execution.</p>		<p>High Bulk liquid nitrogen tanks and associated fill stations hold significant amounts of stored energy in the form of pressure buildup from the boil-off gases of the cryogenic liquids within. Without adequate and functional pressure relief on every isolatable portion of the system, pressures may build to an excess of 20,000psig resulting in a boiling liquid expansion vapor explosion, or BLEVE. Such an explosion has the potential to result in loss of life and massive property damage.</p>	Ineffective	<p>Not Effective The following assurance mechanisms are in place to ensure that fill stations are regularly inspected and maintenance is performed on schedule:</p> <ul style="list-style-type: none"> Praxair Inc. inspects all of the bulk liquid nitrogen fill stations on an annual basis for defects in plumbing and valves, and for pressure relief devices that are past their expiration date. A report is sent to the Facilities Division for each inspection so that LBNL can address any problems that are found. <p>LBNL has no assurance mechanisms in place at the moment to ensure that the results of Praxair inspections are followed up on.</p> <p>LBNL has no assurance mechanisms in place to ensure that routine inspection and preventive maintenance are performed as required.</p>	High There is still no documentation of inspections by Facilities personnel or of preventive maintenance to ensure the adequate functioning of all pressure relief devices. Because the work was never scheduled in the work management system, there is no assurance that it is being performed. Additionally, there is no readily accessible documentation to indicate that corrective maintenance work is being done to address issues found during Praxair inspections. Also, all maintenance on cryogenic liquid systems at LBNL is performed by one Facilities preventive maintenance technician who has the expertise and knowledge to perform this work. This particular technician is due to retire from the Lab soon, and there is no transition plan in place to ensure adequate knowledge transfer and continuity of service.	<p>examples of what is expected.</p> <p>Supplemental corrective actions:</p> <ul style="list-style-type: none"> Facilities to schedule the preventive maintenance (PM) in Maximo and perform the PM on required cryo fill stations according to the set schedule. Facilities Division will document any maintenance that is done as a result of Praxair inspection reports. <p>Opportunities for Improvement:</p> <ul style="list-style-type: none"> Facilities to evaluate options for continuity in cryogenic liquid system maintenance and repair to address the imminent retirement of critical personnel.
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Rating Definitions - Assurance Systems

- Effective (Yes)** - Robust mechanisms are in place to assure that risks/issues and adverse trends are identified and corrected (or acknowledged/tracked with compensating controls) before becoming (or to avoid) significant exposures.
- Partially Effective (Partially)** - Some mechanisms are in place to monitor performance, but there is a risk that issues and adverse trends will not be caught and materialize into recurring issues or significant exposures.
- Ineffective (No)** - No mechanisms are in place to assure that risks/issues and adverse trends are identified and corrected before becoming significant exposures.

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