



Synthesizing Current Challenges in Aging Infrastructure for Mechanical Heat and Frost Insulation Workforce

Survey Results Report

Prepared for:

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SUMMARY

This study conducted a survey to explore the challenges faced by the mechanical insulation workforce in retrofitting aging mechanical systems in the U.S. and Canada. The survey collected responses from 369 mechanical insulators, of whom 56% had over 20 years of experience. Respondents primarily worked on industrial insulation (73%), plumbing and piping (72%), and HVAC systems (69%). The salient findings are summarized here:

- **Common Challenges:** The most frequent issue in aging mechanical systems is the shortage of documentation, followed by mold issues, regulatory challenges, health risks related to hazardous materials, and difficult retrofitting. The ranked frequency of these challenges was consistent across participants in the U.S. and Canada, based on insulator experience level and the types of mechanical systems they worked on
- **Documentation:** Incomplete or inaccurate historical documentation is a common issue, with 70% of insulators encountering it frequently or occasionally. Due to incomplete or inaccurate historical documentation, 46% of participants experienced a moderate to significant impact on work efficiency. They also require additional time for accurate repairs and upgrades of aging mechanical systems. Moreover, 78% of participants, regardless of their experience level, consider the assistance of experienced insulators to be highly valuable and helpful
- **Mold:** Half of the insulators reported encountering mold frequently. While mold issues exist in both aging and newer mechanical systems, this issue is more frequent (10% increase) in aging mechanical systems. The primary concerns related to mold are health risks (72%) and insulation material degradation (67%). Mold is reported to be encountered by insulators more frequently in the U.S. (58%) than in Canada (32%). Furthermore, insulators working on refrigeration and HVAC systems face mold most frequently due to high humidity and condensation.
- **Regulations:** The three most challenging regulations for working on aging mechanical systems are safety regulations (29%), environmental standards (27%), and energy compliance (27%). Environmental compliance is more challenging in the U.S., whereas safety regulations are the primary concern in Canada. Experienced insulators found energy compliance more challenging, while less experienced ones reported greater difficulty with safety regulations.
- **Confined Spaces:** The top three challenges related to confined spaces are difficulty maneuvering (28%), physical strain (23%), and poor ventilation (22%). Half of the respondents reported that confined spaces significantly impact retrofitting in aging mechanical systems compared to newer ones. Furthermore, 61% noted insufficient safety measures in Collective Bargaining Agreements (CBAs).
- **Hazardous Materials:** Insulators encounter hazardous materials in both aging and newer mechanical systems, although their frequency is 10% higher on aging ones. Among participants working on aging mechanical systems, 90% reported exposure to hazardous materials, and 30% experienced health issues.
- **Noise Issues:** Around 60% of mechanical insulators reported higher noise exposure in aging mechanical systems. The top noise-related issues are communication difficulties (80%) and safety concerns (77%).
- **Training:** The top training needs for working on aging mechanical systems are safety training (38%), retrofitting techniques (32%), and regulatory compliance (28%). Moreover, less experienced insulators emphasize retrofitting skills (38%). Almost 80% of insulators are satisfied with their training. However, 68% of insulators believe additional training is necessary, particularly in handling hazardous materials, improving safety protocols, and understanding aging system designs.

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Overview

The main goal of this study is to investigate the challenges faced by the mechanical insulation workforce, specifically in retrofitting aging mechanical systems. To achieve this, a survey was designed using Qualtrics, and the survey link was distributed publicly among mechanical insulators in the U.S. and Canada. A total of 860 participants started responding to the survey, and 369 completed it, representing a completion rate of 43%. The analysis focused on these 369 completed responses, with 68% (250 participants) from the United States and 32% (119 participants) from Canada. Respondents varied in experience, age, and professional focus within mechanical insulation systems. The findings are categorized into nine main areas: (1) general information, (2) common challenges, (3) incomplete or inaccurate historical documentation, (4) mold issues, (5) regulatory challenges, (6) hazardous materials, (7) confined spaces, (8) noise issues, (9) training, and open-ended question.

1. General Information

This section collects demographic and professional background details of respondents in the mechanical insulation industry. It includes location data to determine whether participants work in the U.S. or Canada, providing insights into geographic trends related to challenges faced when working on aging mechanical systems. Experience levels range from less than 1 year to over 20 years, providing insight into the workforces' expertise distribution. Age groups (18-24 to 65+) are also recorded, offering a generational perspective on the industry. These details support a comprehensive understanding of the industry demographics and workforce trends. Additionally, respondents specify the mechanical insulation systems they frequently work on, such as HVAC, refrigeration, plumbing, industrial systems, energy systems, etc. This highlights areas of specialization within the industry.

Figure 1 illustrates the survey participants' general information, such as years of experience, age groups, and mechanical systems that they work on. Most mechanical insulator respondents (56%) reported having over 20 years of experience, offering valuable insights into industry challenges due to their extensive expertise. Additionally, nearly 30% of survey participants are middle-aged (45–54 years), while younger age groups, such as those aged 18–34, account for only 14% of respondents. This distribution highlights a potential sustainability challenge for the industry: with fewer young individuals entering the field, there is a growing need to attract and train new mechanical insulators to ensure the replacement of the aging and highly experienced workforce. Otherwise, this industry could encounter a shortage of skilled professionals, emphasizing the need for targeted recruitment and training. Furthermore, nearly 70% of participants reported frequently working on industrial insulation, plumbing, and HVAC systems, reflecting these as the core focus areas within the field. Refrigeration and energy systems had a moderate presence of approximately 45%.

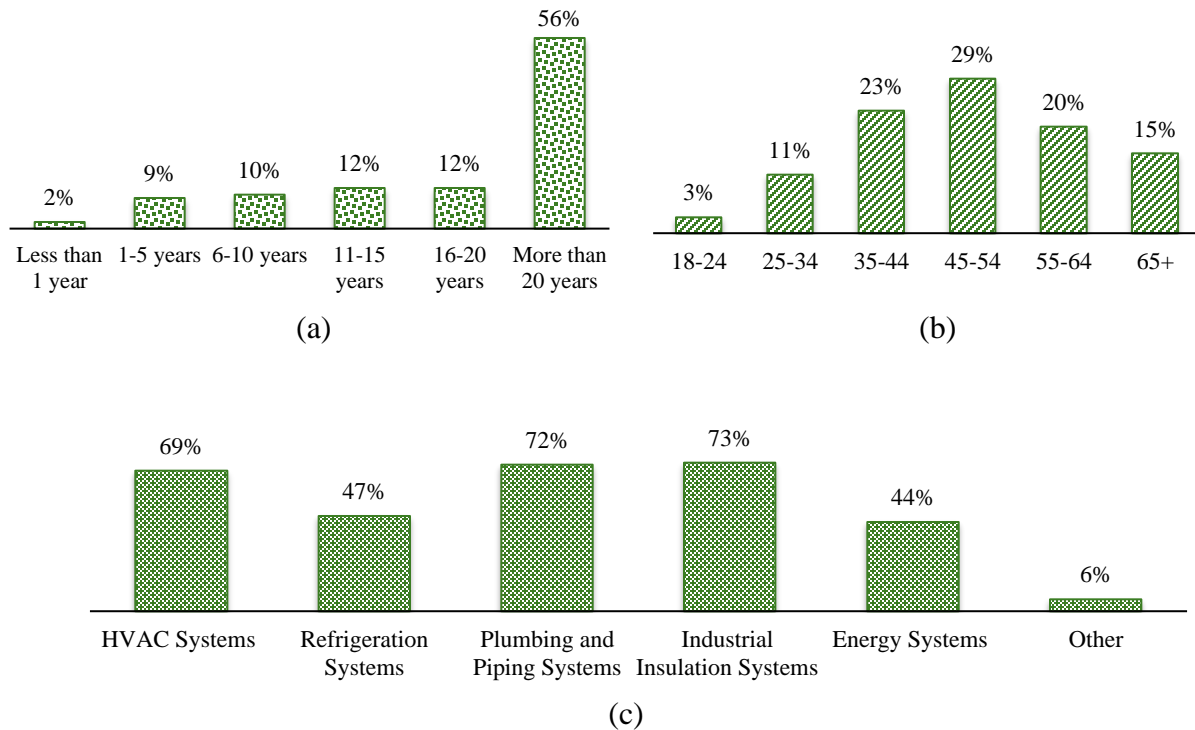


Figure 1. General information about the survey participants (a) years of experience (b) age group (c) Mechanical Insulation Systems Most Frequently Worked On

The participants' general information is also compared according to their geographical location, the U.S. and Canada. 61% of U.S. participants have more than 20 years of experience, compared to 45% of Canadian participants. Both countries show similar age group representation, with the largest group being 45–54 (29%). They also have similar involvement in Plumbing, Piping, HVAC, and Energy Systems. However, differences are observed in Refrigeration Systems, where U.S. participants are more involved (18% vs. 8%), and in Industrial Insulation, which Canadian participants more frequently work on (32% vs. 20%). The detailed graphs of participants' general information across the U.S. and Canada can be found in Appendix [Figure A-1](#).

The most notable differences in participants' involvement based on their experience levels are observed in plumbing/piping systems and energy systems. Less experienced participants are more involved in plumbing/piping systems (28% compared to 22%), while experienced participants are more engaged in energy systems (15% compared to 8%). [Figure A-2](#) in the Appendix presents the detailed graph of mechanical insulation systems that insulator participants most frequently work on, based on their experience levels.

2. Common Challenges

This section identifies the frequency of common challenges mechanical insulators face when working on aging mechanical systems. These include challenges in retrofitting, health risks due to hazardous materials (e.g., asbestos, lead), regulatory compliance issues, mold problems caused by condensation and dirt, and shortages of documentation for value engineering.

Figure 2 illustrates the frequency of challenges insulators face in aging mechanical systems. The most frequently occurring challenge is the shortage of documentation, ranked one. Mold issues are ranked two, as they occur often. Regulatory challenges are ranked three and are reported to happen sometimes. Health issues are ranked four, being encountered occasionally. Difficult retrofitting is the least frequent challenge, ranked 5, occurring rarely. Moreover, an analysis of the frequency of challenges faced by insulators from the U.S. and Canada, as well as their experience levels (more than 20 years and less than 5 years), reveals similar ranking trends. The shortage of documentation is the most frequently reported issue, followed by mold problems, regulatory challenges, health risks, hazardous materials, and difficult retrofitting. (The graphs in the Appendix include data for the U.S. and Canada in Figure A-3 and data based on experience levels in Figure A-4.)

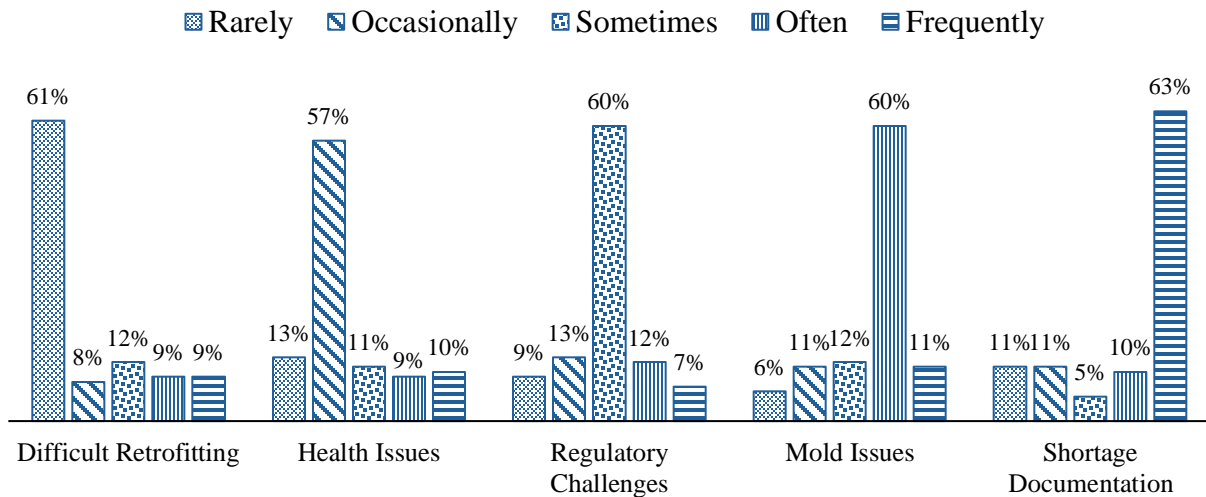


Figure 2. Frequency of challenges encountered by mechanical insulators when working on aging mechanical systems

3. Incomplete/inaccurate Historical Documentation

This section addresses the challenges of incomplete or inaccurate documentation when working on aging mechanical systems. It explores how often these issues arise, their impact on work efficiency, and the extent of delays or errors caused. Provided feedback on the helpfulness of collaborating with experienced mechanical insulators to resolve these challenges, offering insights into potential solutions.

Figure 3 shows the frequency of encountering incomplete or inaccurate historical documentation in aging mechanical systems among all insulator participants. It can be seen that incomplete or inaccurate historical documentation is a common challenge for insulators working with aging mechanical systems, as a total of 40% of participants encounter these issues frequently ("very often" or "often"), and 30% experience them "sometimes." The consequences of this issue influence mechanical insulators' work efficiency, which varies among them. Figure 4 illustrates the impact of incomplete or inaccurate historical documentation on insulators' work efficiency as reported by all participants. According to the data, 14% of participants report significant disruptions, such as delays and errors, while the majority (68%) consider its impact manageable, rating it as 'slight' or 'moderate.' This suggests that most participants can adapt to incomplete or inaccurate documentation effectively, potentially reflecting the positive influence of training or extensive experience in mitigating these challenges.

Figure 5 illustrates the impact of experienced mechanical insulators on addressing challenges caused by incomplete historical documentation. Based on these results, the role of experienced mechanical insulators is crucial in addressing challenges with incomplete or inaccurate historical documentation. Notably, 78% of participants rate experts' assistance as "very helpful" or "helpful."

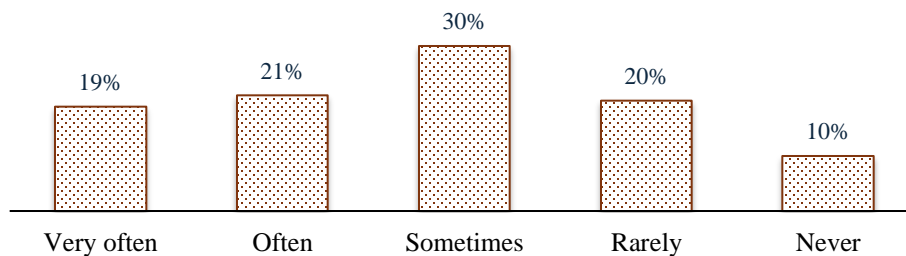


Figure 3. Frequency of issues encountered due to incomplete or inaccurate historical documentation in aging mechanical systems among all insulator participants

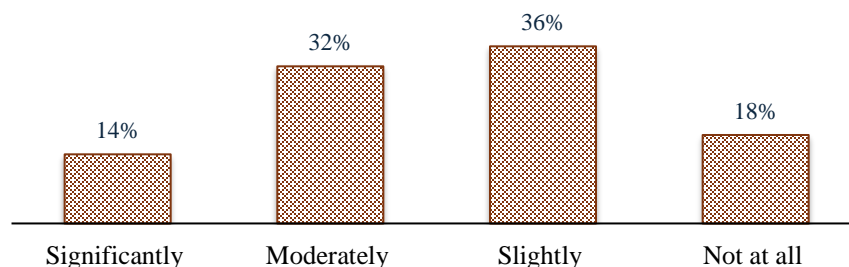


Figure 4. Impact of incomplete or inaccurate historical documentation on efficiency in repairing and upgrading aging mechanical systems among all insulator participants

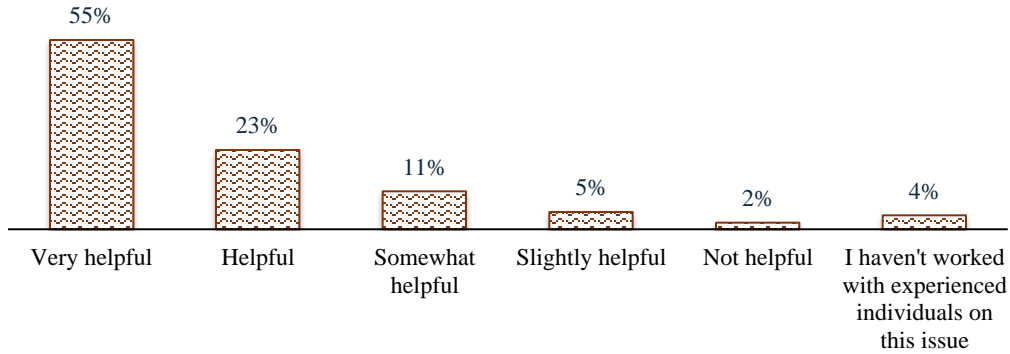


Figure 5. The impact of experienced mechanical insulators in addressing issues arising from incomplete historical documentation among all insulator participants

Exploring results related to incomplete or inaccurate historical documentation across participants in the U.S. and Canada reveals similar patterns to the trend among all participants' responses (for more detail, see [Figure A-5](#), [Figure A-6](#), and [Figure A-7](#)).

Comparing responses from insulators with different experience levels shows that those with over 20 years of experience are more likely to frequently report incomplete historical documentation, with 45% indicating they encounter these challenges "very often" or "often," as shown in [Figure 6](#). In contrast, only 31% of insulators with less than 5 years of experience report encountering these issues "very often" or "often." This difference may be attributed to the nature of their tasks, as experienced workers often handle more complex projects and face challenging situations, increasing their likelihood of encountering issues related to incomplete or inaccurate documentation. On the other hand, less experienced workers may be assigned more straightforward tasks, potentially reducing their exposure to such challenges. Additionally, experienced mechanical insulators are better at identifying and addressing specific problems, while newer insulators may treat some challenges as part of the learning process, reporting them less frequently. These factors highlight the influence of experience on how challenges are understood and reported.

Both experience groups reported similar impacts on work efficiency, with 60% indicating "moderate" or "slight" impacts, and approximately 70% of participants rated assistance from experienced insulators as "very helpful" or "helpful." This emphasizes the value of experienced insulators in bridging documentation gaps and improving team efficiency, regardless of individual experience levels (See Appendix [Figures A-8](#) and [Figure A-9](#)).

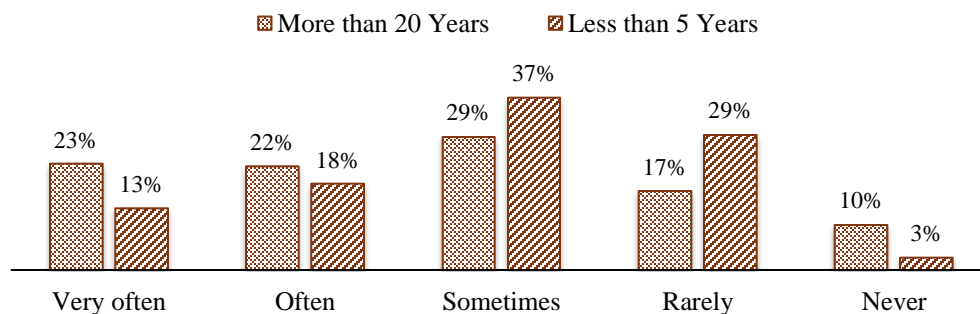


Figure 6. Comparing the frequency of issues encountered due to incomplete or inaccurate historical documentation in aging mechanical systems based on insulator experience levels

4. Mold Issues

This section highlights the frequency and locations of mold growth encountered during insulation work, particularly in confined spaces. It examines the differences in mold existence between aging and newer mechanical systems and identifies related challenges, such as insulation damage, health risks, and complications in retrofitting. Additionally, it evaluates the effectiveness of mold-resistant insulation materials in both aging and newer mechanical systems to understand their performance and impact on final work efficiency.

By analyzing all participants' responses, it can be seen that mold issues are a common challenge during retrofits and insulation installations, particularly in confined or limited-access areas. [Figure 7](#) demonstrates the frequency of mold issues encountered by insulators, showing that half of the participants face mold issues "very often" or "often" and 32% "sometimes," indicating that mold is a widespread issue across many projects.

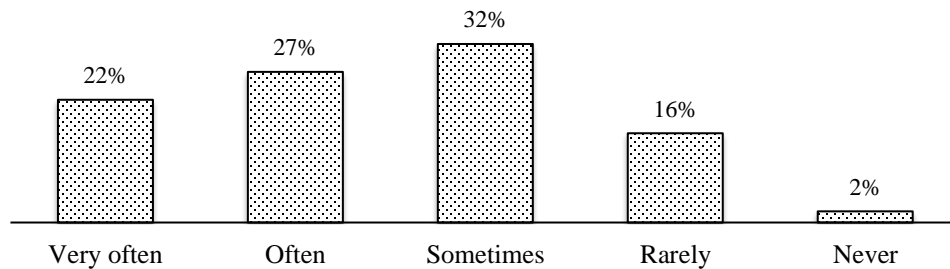
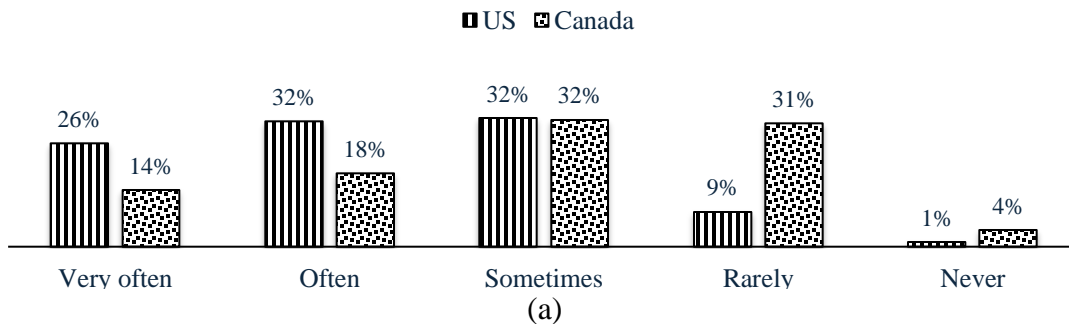


Figure 7. Frequency of mold issues encountered during retrofits and insulation installations in confined spaces

The analysis highlights differences in mold issues based on geographical location and experience levels, as shown in [Figure 8](#). In the U.S., 58% of respondents reported facing mold issues "very often" or "often," compared to 32% of Canadian insulators ([Figure 8a](#)). Furthermore, participants with more than 20 years of experience report encountering mold issues "very often" or "often" at an 11% higher rate than less experienced participants ([Figure 8b](#)). This trend may be due to highly experienced participants working on older mechanical systems where mold issues are more common.



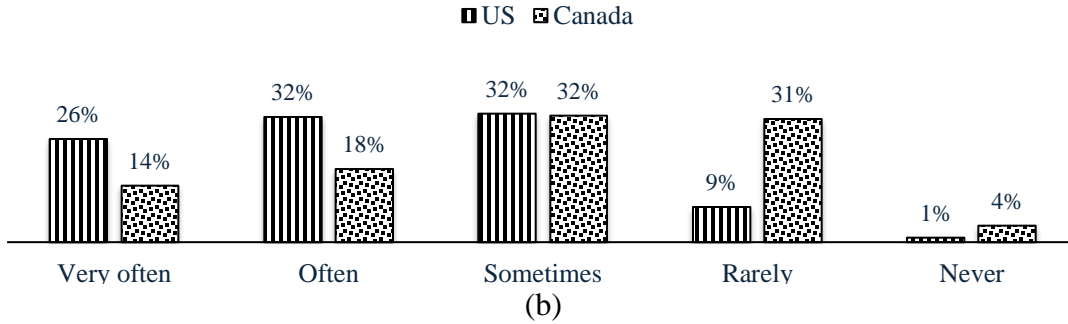


Figure 8. Comparing frequency of mold issues encountered during retrofits and insulation installations in confined spaces (a) in the U.S. and Canada (b) based on insulators' experience levels

When comparing mold issues in mechanical systems, 54% of participants notice differences between aging and newer systems. Meanwhile, 46% do not observe any difference; therefore, it seems that mold issues exist in both aging and newer mechanical systems. The survey responses reported that aging mechanical systems have more mold issues. This is due to prolonged exposure, outdated materials, and deteriorating vapor barriers. Over time, wear and tear further compromise these systems. On the other hand, newer mechanical systems experience fewer issues because of improved materials and better insulation practices. However, poor installation or maintenance can still lead to mold in newer systems. These findings highlight the importance of proper maintenance, high-quality materials, and professional installation to reduce mold growth in both aging and newer mechanical systems.

Figure 9 compares mold issues in aging compared to newer mechanical systems in the U.S. and Canada and among insulator experience levels. The U.S. participants are 9% more likely than Canadians to notice mold differences between aging and newer mechanical systems. This may be influenced by environmental conditions, maintenance practices, or system age. On the other hand, 74% of insulators with less than five years of experience reported no noticeable differences in mold issues between aging and newer mechanical systems, suggesting a need for better training or awareness for newer insulators.

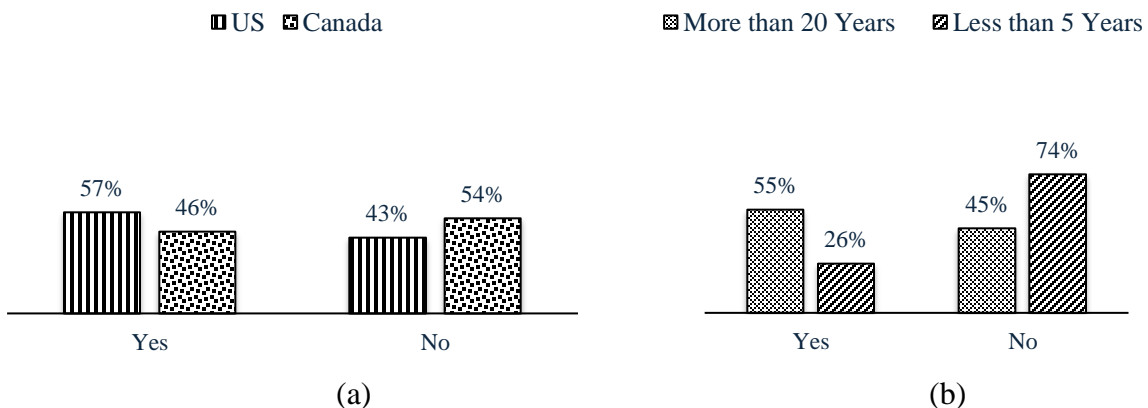


Figure 9. Comparing differences in mold issues between aging and newer mechanical systems (a) in the U.S. and Canada, (b) based on insulators' experience levels

Figure 10 illustrates the common locations of mold growth during retrofits and installations. The majority of participants (72%) report mold growth directly on the insulation material itself, while 48% identify mold on the surface of pipes or ducts. A smaller group (18%) of participants noted mold growth in other areas. Specific examples include:

- **Walls and Surfaces:** Mold commonly found on walls, drywall, ceilings, and damp surrounding areas.
- **Insulation Materials:** Observed on ASJ, canvas wraps, jacketing, and old pyrogel insulation.
- **HVAC Components:** Found on duct lining, condenser housings, and silicone caulking at PVC joints.
- **High-Humidity Environments:** Caused by inadequate or damaged insulation systems in humid areas.
- **Building Materials:** Affects ceiling tiles, wooden blocks, and drywall exposed to moisture.
- **Crawl Spaces and Restricted Areas:** Mold was reported in crawl spaces, wall chases, and hard-to-access locations.
- **Specific Environments:** Prone areas include schools, food facilities, older buildings, and portable classrooms.
- **Rare and Miscellaneous Cases:** These include mold on insulation paper, vapor barriers, and plants growing in insulation.

Mold is often linked to vapor barrier failures, inadequate insulation thickness, or exposure to high humidity. Insulation failures and older materials were frequently cited as contributing to mold growth, particularly in areas where insulation does not fit properly. Results related to the mold issues, as discussed, emphasize the need for improved insulation systems, better moisture management, and enhanced maintenance practices to reduce mold growth in both insulation materials and surrounding surfaces.

Regarding mold growth locations, the patterns are similar in both countries and among insulators with more and less experience levels. A majority of participants identified the insulation material itself as the most common area for mold growth, and the surface of pipes or ducts is the second most common location. (see Appendix Figure A-10)

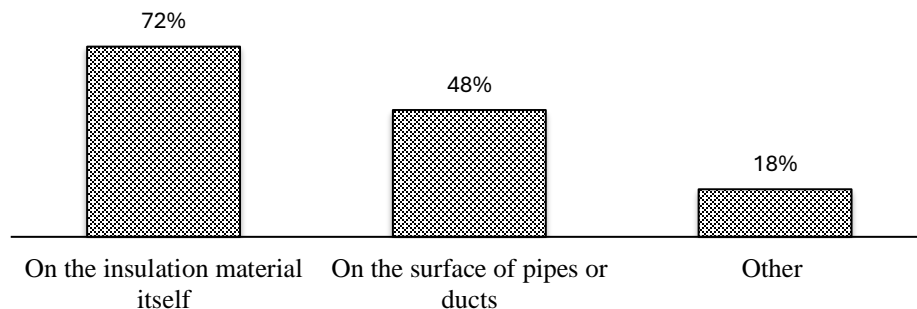


Figure 10. Locations of mold growth observed during retrofits and installations

Figure 11 shows the challenges associated with mold growth during heat frost insulator work. "Health risks" stand out as the most reported concern, with 72% of participants citing this issue. "Degradation of insulation material" follows closely at 67%, reflecting the direct impact on project quality. Additionally, 45% of participants highlight the "spread of mold to other areas," complicating remediation efforts, while 40% point to "difficulties in retrofitting" due to mold-affected insulation. Other challenges based on insulators' responses include job site shutdowns, poor air quality around moldy insulation, and corrosion of materials. Some participants also noted difficulties in determining the extent of mold removal and the lack of mold in certain industrial settings.

The ranking of these challenges was consistent in both countries and among insulators with different experience levels. Health risks remained the top concern, followed by the degradation of insulation materials. The next challenge was mold spreading to other areas, further complicating remediation. The last challenge was the difficulty of retrofitting mold-affected insulation. (See Appendix Figure A-11)

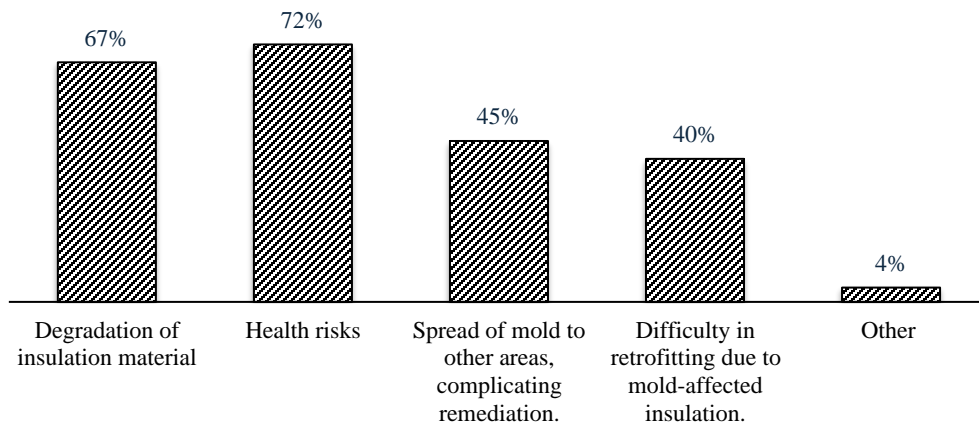


Figure 11. Challenges related to mold growth encountered during work among all mechanical insulator participants

Figure 12 illustrates the comparison of mold resistance in insulation materials between aging and newer mechanical systems. The majority (39%) of respondents believe insulation materials are "significantly more resistant in newer mechanical systems," while 22% consider them "slightly more resistant in newer mechanical systems." A smaller portion (16%) finds the resistance of insulation materials to be about the same in both systems. This indicates a better preference for newer mechanical systems due to their improved insulation materials' resistance against mold. These results were almost similar by looking at the U.S. and Canada and based on insulators' experience level. (see more detail in Appendix Figure A-12)

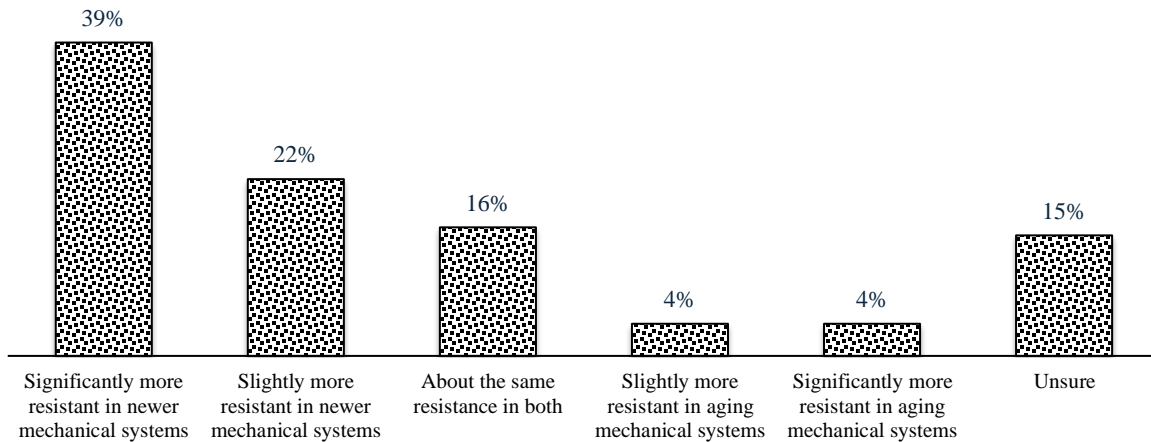


Figure 12. Comparison of mold resistance of insulation materials in aging mechanical systems versus newer ones

Mold issues are also associated with insulators working on various mechanical system types, including HVAC systems, refrigeration systems, plumbing and piping systems, industrial insulation systems, and energy systems (Figure 13). Refrigeration systems were found to be the most affected by mold, with 63% of participants reporting mold issues "often" or "very often." This is likely due to the constant presence of moisture and condensation, which create ideal conditions for mold growth. HVAC and plumbing/piping systems followed closely, with 57% of participants experiencing mold issues "very often" or "often." Both systems are exposed to frequent temperature fluctuations, humidity, and water flow, leading to condensation buildup and moisture retention, which promote mold growth. Energy systems showed moderate mold issues, with 54% reporting frequent mold occurrences. Industrial insulation systems had the lowest occurrence among the analyzed categories, with 50% of participants encountering mold issues "very often" or "often."

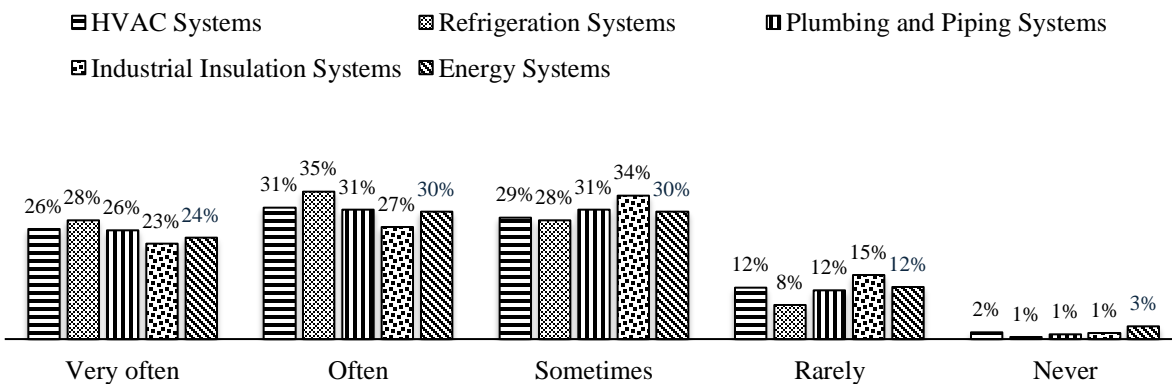


Figure 13. Frequency of mold issues encountered during retrofits and insulation installations in confined spaces based on the type of mechanical systems that insulators work on

5. Regulatory Challenges

This section highlights the challenges of meeting regulatory and compliance requirements when working on aging mechanical systems compared to newer ones. Common issues include navigating complex building codes, ensuring safety standards, addressing environmental regulations, and upgrading systems to meet energy efficiency standards.

Figure 14 highlights the most challenging rules and regulations faced by insulators when working on aging mechanical systems compared to newer ones. "Safety regulations" are identified as the most challenging, cited by 29% of participants. This emphasizes the significant difficulty in ensuring worker and user safety during retrofitting processes. "Environmental regulations" and "energy compliance" are closely followed, each accounting for 27%, reflecting the complexity of meeting modern sustainability and efficiency standards in aging mechanical systems. "Building codes" are reported as less challenging, with only 14% of participants citing them as an issue. "Other" challenges, mentioned by 3% of respondents, include concerns such as prioritizing cost over efficiency in value engineering, clients demanding shortcuts, and outdated designs complicating compliance.

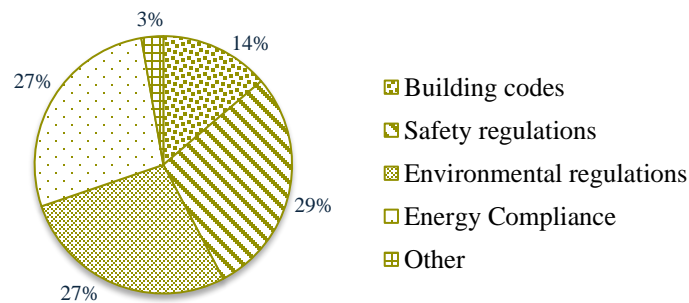


Figure 14. Most challenging rules or regulations when working on aging mechanical systems compared to newer ones among all insulator participants

Responses in the U.S. and Canada regarding rules and regulations challenges were then analyzed. Figure 15 demonstrates the most challenging rules and regulations for insulators when working on aging mechanical systems compared to newer ones in the U.S. and Canada and based on insulators' experience level and insulators' working area. In the U.S., environmental regulations (30%) are the biggest challenge, followed by energy compliance (28%) and safety regulations (27%). Building codes (13%) and other regulations (2%) have the least impact. In Canada, safety regulations (32%) are the most challenging, while environmental regulations (23%) and energy compliance (25%) are less of a concern than in the U.S. (see Figure 15a)

Less experienced insulators find safety regulations (32%) and environmental regulations (30%) the most challenging, indicating that compliance may be more difficult for those new to the field. More experienced insulators are more affected by energy compliance (29%), suggesting that long-term professionals may face stricter efficiency standards. Environmental regulations (27%) and safety regulations (27%) are still significant challenges, though slightly less than for newer insulators. Furthermore, building codes are consistently seen as less challenging across both experience levels. (see Figure 15b).

Safety regulations (38%) and energy compliance (38%) are the most challenging for insulators who work on energy systems. Environmental regulations impact insulators working on all systems similarly (27-28%), except for those working on energy systems, which show a lower challenge at 4%. For insulators working on HVAC, industrial insulation, refrigeration, and plumbing/piping systems, regulatory challenges are more evenly distributed. Safety regulations (26-28%) and environmental regulations (27-28%) impact all insulators working on these systems at similar levels. Furthermore, building codes (13-16%) are the least concerning across insulators working on all mechanical system types (see Figure 15c).

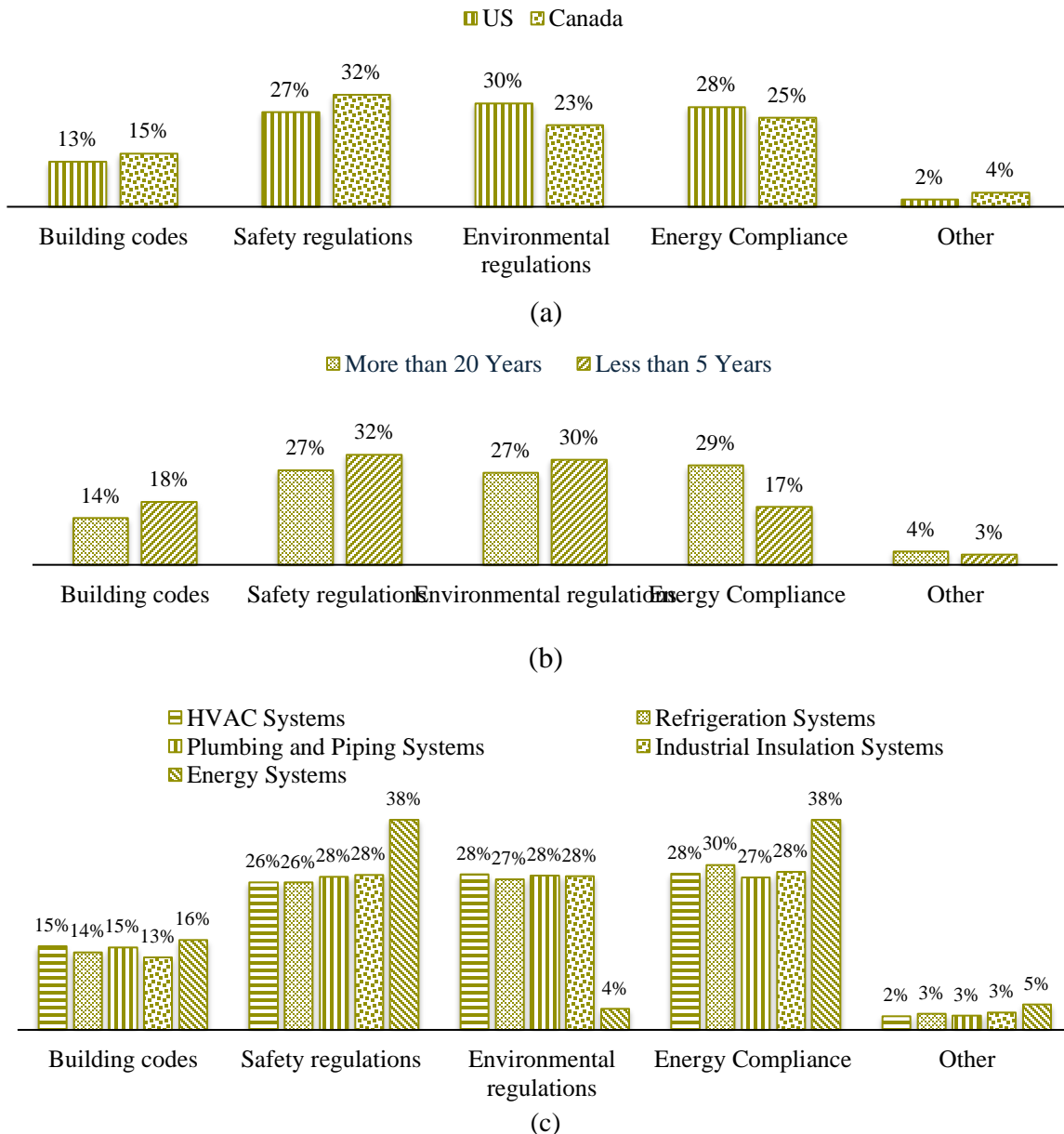


Figure 15. Most challenging rules or regulations when working on aging mechanical systems compared to newer systems (a) in the U.S. and Canada, (b) based on insulators' experience levels, (c) for insulators working on different mechanical systems frequently

Regarding the experiences of 369 participants with regulatory or compliance challenges, they highlighted specific issues when working on aging mechanical systems compared to newer ones. These reported challenges are categorized into seven groups: cost constraints, space limitations, health and safety risks, outdated designs, weak regulatory enforcement, time and scheduling difficulties, and communication gaps.

- **Cost and Value Engineering**

Many respondents observed that cost-cutting measures frequently compromise proper insulation practices. They reported that contractors often prioritize cheaper materials or implement minimal solutions, sacrificing long-term efficiency for immediate savings. Additionally, value engineering practices were cited as a common issue, where insulation thickness is reduced, resulting in suboptimal installations. Furthermore, older systems are often patched instead of being fully upgraded, which negatively impacts both safety and performance.

- **Space and Accessibility Constraints**

Space limitations were frequently identified as a significant challenge, particularly when retrofitting to meet newer insulation standards. Participants noted that there was often insufficient clearance to accommodate the thicker insulation required by modern codes. Additionally, accessing older systems proved difficult due to tight, congested areas or inadequate pathways. Many mechanical systems were originally designed without consideration for the space needed for insulation, further complicating efforts to upgrade or retrofit these systems effectively.

- **Health and Safety Concerns**

Hazardous materials and unsafe conditions were highlighted as significant challenges when working on aging systems. Participants reported exposure to dangerous materials such as asbestos, mold, and dust, which are often present in older installations. They also noted increased risks associated with corroded or deteriorating materials, which compromise the integrity and safety of the systems. Furthermore, poor ventilation and the presence of live systems frequently create unsafe working environments, adding to the complexity and risks of maintenance or retrofitting efforts.

- **Outdated Designs and Compatibility Issues**

Older systems frequently lack compatibility with modern materials and standards, posing significant challenges during maintenance and retrofitting. Participants noted misalignment between old and new insulation specifications, making it difficult to achieve seamless integration. Additionally, inadequate or outdated designs in older systems further complicate retrofitting efforts. Inconsistencies in the availability of materials compatible with aging systems were also highlighted, making it challenging to maintain or upgrade these systems effectively.

- **Lack of Regulatory Enforcement**

Participants identified the weak application of regulations and inconsistent oversight as significant issues. They noted limited adherence to building codes and insulation specifications, often leading to inadequate installations. Additionally, there was a frequent focus on short-term cost savings over compliance with energy efficiency and safety standards, reducing the overall quality and long-term effectiveness of projects.

- **Challenges with Time and Scheduling**

Time constraints and rushed schedules often disrupt proper insulation practices, creating significant challenges. Participants highlighted that limited time before system start-ups frequently results in incomplete insulation work. Additionally, insulation tasks are often given low priority during project planning, which negatively affects both safety and the overall quality of the installation.

- **Stakeholder Communication and Training**

Poor communication and a lack of understanding among stakeholders create significant challenges in insulation projects. Participants noted a lack of collaboration between engineers, contractors, and mechanical insulators, which reduces coordination and effectiveness. Additionally, limited training for mechanical insulators to manage hazardous materials and follow proper procedures adds to the difficulties, increasing risks and impacting the quality of the work.

6. Confined Spaces

This section examines the challenges of retrofitting, removing, and reinstalling insulation in confined spaces or areas with limited access, particularly in aging mechanical systems. It explores the frequency, physical difficulty, and extra time required for these tasks. Additionally, this section assesses the challenges of working in confined spaces and how these conditions affect both productivity and safety. It also evaluates whether Collective Bargaining Agreements include protective measures and whether insulators are aware of these provisions.

The comparison of working in confined spaces during insulation retrofitting for newer and aging mechanical systems among all participants is shown in [Figure 16](#). The results indicate that insulators encounter confined spaces in both new and aging mechanical systems in a nearly similar manner. However, the proportion of participants who "often" work in confined spaces is slightly higher for aging mechanical systems (35%) compared to newer mechanical systems (29%).

A similar pattern in comparing the frequency of working in confined spaces in aging and newer mechanical systems during insulation exists across the U.S. and Canada, as well as among insulators with different experience levels. However, U.S. participants and insulators with more than 20 years of experience encounter confined spaces slightly more often (5–10%). See [Appendix Figure A-14](#) for more details.

Generally, the data indicates that confined spaces are a common and impactful challenge during insulation retrofitting, especially for aging mechanical systems. Addressing these challenges is critical to improving efficiency and safety in retrofitting processes, particularly in countries like the U.S., where mechanical insulators may face these conditions more frequently.

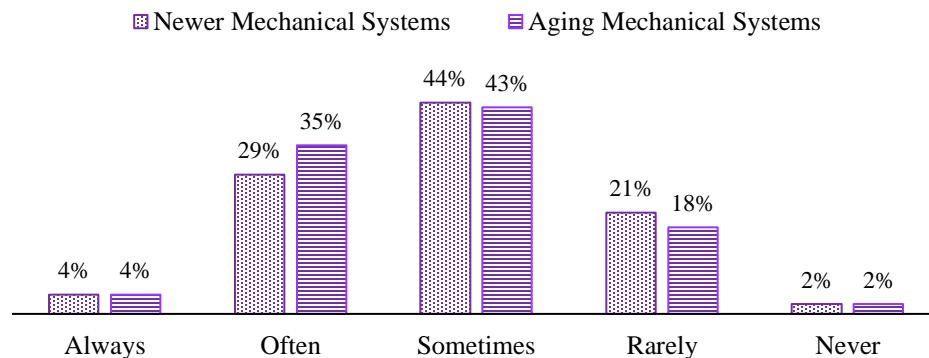


Figure 16. Frequency of working in confined spaces during insulation retrofitting for newer and aging mechanical systems among all insulator participants

[Figure 17](#) illustrates the impact of confined spaces on the mechanical insulator efficiency of retrofitting insulation in aging mechanical systems compared to newer systems. Most participants reported that confined spaces "moderately" (38%) and "significantly" (38%) affect their efficiency, indicating that these conditions pose a substantial challenge to productivity. This is similar among insulators in both countries. Moreover, the data highlights that the impact of confined space challenges is consistent for insulators regardless of experience levels. However, less-experienced mechanical insulators are approximately 10% more likely to consider the impact as extreme. (See [Appendix Figure A-15](#))

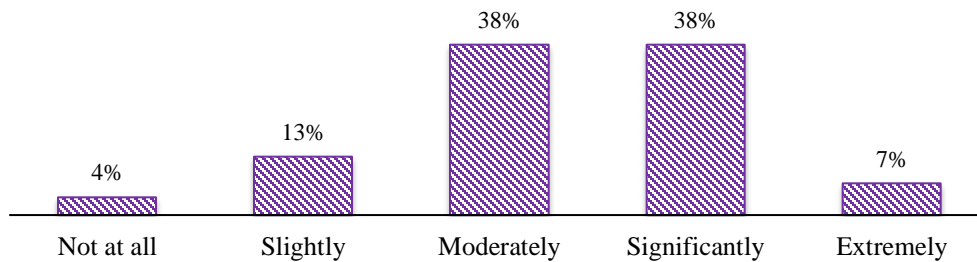


Figure 17. Impact of confined spaces on mechanical insulator efficiency for retrofitting insulation in aging mechanical systems compared to newer systems among all insulator participants

Retrofitting insulation in aging mechanical systems within confined spaces presents significant challenges among all insulators. According to [Figure 18](#), the most frequently reported issue is difficulty maneuvering or using tools in tight spaces, which affects 28% of respondents. Insufficient ventilation is another major concern, reported by 23%, indicating poor air quality during work. Increased physical strain, cited by 22%, emphasizes the demanding nature of tasks in these environments. Additionally, 16% of mechanical insulators faced a heightened risk of musculoskeletal injuries due to awkward positions. Psychological stress impacts 9% of mechanical insulators, reflecting the mental strain of confined conditions.

The "Other" responses highlight several challenges encountered when working in confined spaces on aging mechanical systems. These include environmental and access issues, such as limited ventilation, poor lighting, high temperatures, and restricted access, which make tasks more difficult. Aging insulation often disintegrates into dust, complicating its removal and requiring extensive cleanup. Safety and health concerns, including exposure to asbestos, mold, and harmful dust, as well as challenges in maintaining safety protocols, pose significant risks. Structural challenges, including weak or rusted equipment, further increase complexity, necessitating additional modifications and careful handling. Moreover, poor visibility, the use of protective equipment, and the labor-intensive nature of cleaning and waste removal add to the difficulty. These interconnected challenges emphasize the need for improved safety measures, advanced tools, and comprehensive planning to address the demands of confined space work effectively.

It should be noted that mechanical insulators in both the U.S. and Canada, regardless of experience levels and the mechanical systems they work on, report similar rankings for common challenges in retrofitting insulation for aging mechanical systems in confined spaces. This indicates that working on aging mechanical systems in confined spaces presents uniform challenges under varying conditions (see Appendix, [Figure A-16](#) for more details).

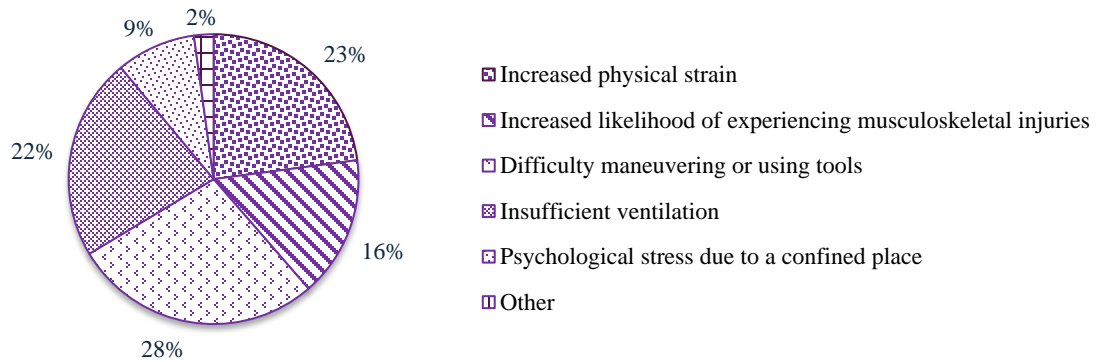


Figure 18. Common challenges in retrofitting insulation for aging mechanical systems in confined spaces among all mechanical insulator participants

The physical difficulty and extra time required for removing insulation and reinstalling insulation in aging mechanical systems compared to newer ones are outlined below.

Figure 19 and Figure 20 compare the physical difficulty and extra time required, respectively, for removing and reinstalling insulation in aging mechanical systems compared to newer ones.

For physical difficulty (Figure 19), 75% of participants found removing insulation in aging mechanical systems to be 'much more difficult' or 'more difficult' compared to newer ones, which is slightly higher (7%) than reinstalling.

When comparing the extra time needed, Figure 20 indicates that 76% of respondents required 'much more time' or 'more time' to remove insulation compared to newer mechanical systems, which is 6% higher than reinstalling.

Based on the results, it can be concluded that both removal and reinstallation tasks in aging mechanical systems are more difficult and more time-consuming than in newer mechanical systems. However, removal appears slightly more physically demanding and more time-consuming than reinstallation. These findings emphasize that the combination of confined spaces and aging mechanical systems increases the physical effort and time required for retrofitting tasks. This is a similar pattern regardless of the geographical region and experience level.

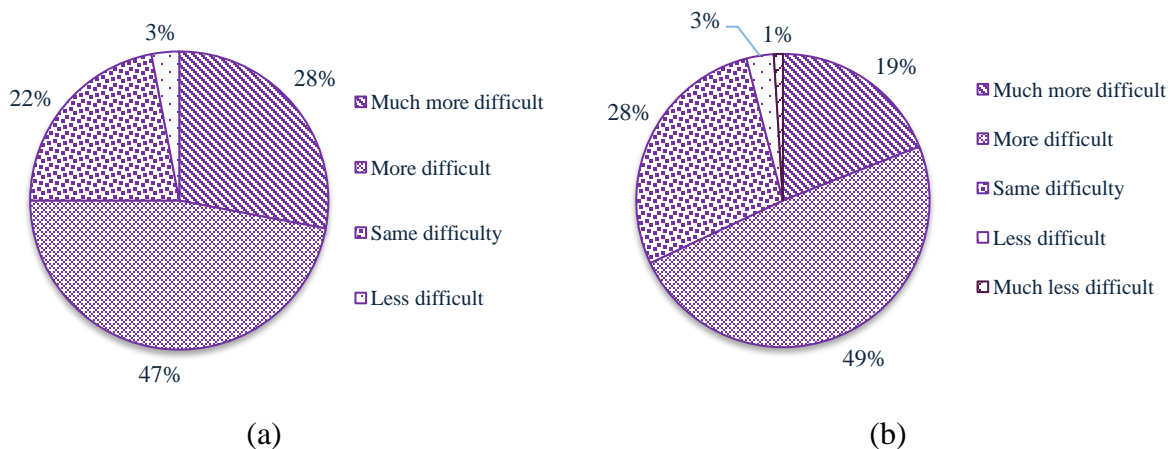


Figure 19. Physical difficulty of (a) removing insulation and (b) reinstalling insulation in aging mechanical systems compared to newer ones

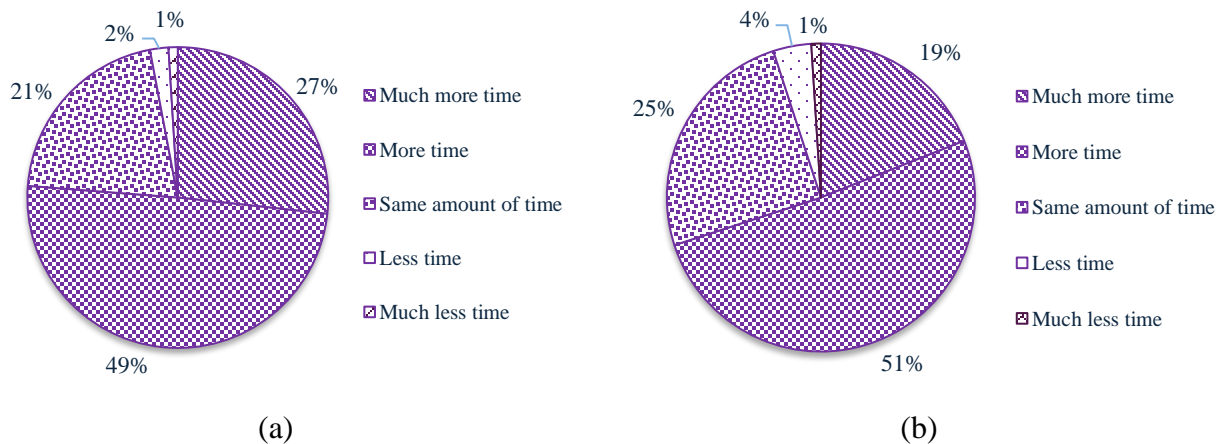


Figure 20. Extra time required for (a) removing insulation and (b) reinstalling insulation in aging mechanical systems compared to newer ones

Regarding the presence of safety measures in activities covered by the Collective Bargaining Agreement (CBA), 61% of participants reported no safety measures, while 39% confirmed their presence. Insulators who reported safety measures exist noted that weight limits are set at 50 lbs for most tasks, with heavier items requiring two people or mechanical assistance for safety. Additionally, respirators are provided upon request, particularly in hazardous conditions, and mechanical insulators are trained in proper lifting techniques, including the use of two-person lifts for heavier items. Personal protective equipment (PPE), such as masks, suits, and other safety gear, is made available as needed. The guidelines align with the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and provincial regulations, which establish limits on lifting and enforcing safety protocols. Mechanical insulators are also encouraged to assess their personal physical tolerances and seek assistance whenever necessary to prevent injury.

A consistent pattern regarding the existence of CBA is observed across the U.S. and Canada, as well as among insulators with varying levels of experience. This consistency highlights the critical need for improved safety protocols, regardless of working location or experience level.

7. Hazardous Materials

This section examines exposure to hazardous materials such as asbestos, lead, fiberglass, and mineral wool encountered during work on mechanical systems. It evaluates the frequency of exposure in both aging and newer mechanical systems and investigates the potential health impacts, identifying health issues that may be linked to hazardous materials in mechanical systems. The findings emphasize safety concerns and underscore the importance of implementing protective measures in the mechanical insulation industry.

Figure 21 compares the frequency of hazardous material exposure between aging and newer mechanical systems. The data shows that hazardous exposure generally exists in both mechanical systems, but it is more frequent in aging mechanical systems as they have higher percentages in the "always" or "often" categories. A similar pattern is observed in both the U.S. and Canada. However, it should be noted that in the U.S., 60% of insulators reported "always" or "often" facing hazardous materials in aging and newer mechanical systems. In Canada, this rate is slightly lower at 51% (see Appendix Figure A-17). Furthermore, analysis by experience level shows that mechanical insulators with less than five years of experience report higher exposure to hazardous materials, 24% more in aging mechanical systems and 8% more in newer ones. (see Appendix Figure A-18). These findings show that less-experienced mechanical insulators may face greater risks, potentially due to limited knowledge or insufficient safety training

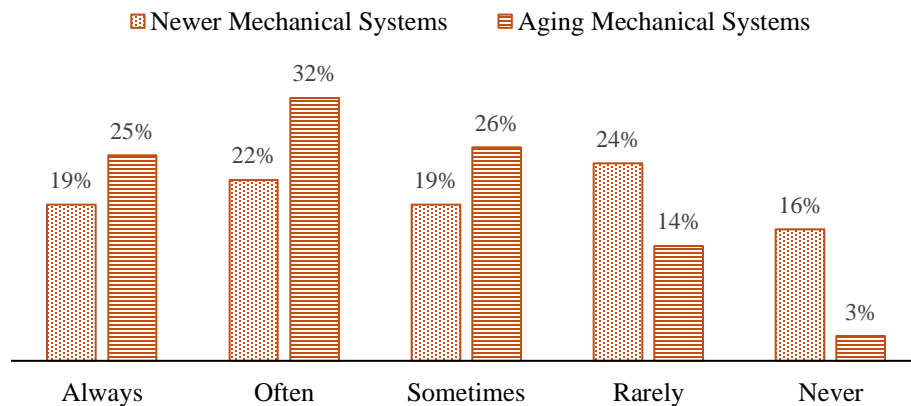


Figure 21. Frequency of hazardous material exposure in aging and newer mechanical systems among all mechanical insulator participants

Exposure to hazardous materials, including fiberglass and mineral wool, is common when working on aging mechanical systems. Overall, 90% of mechanical insulators confirm exposure, and only 10% report no contact with these materials. Additionally, 30% of them experience health issues that they believe are linked to hazardous materials such as asbestos, lead, or other toxins in aging mechanical systems. These findings highlight the significant health risks associated with hazardous material exposure in aging mechanical systems, affecting a large portion of mechanical insulators. This trend is similarly observed regardless of the insulators' working country and their experience levels.

It should be noted that the detailed experiences shared by participants are gathered and categorized to highlight several important points regarding exposure to hazardous materials, as explained below.

- **Frequent Exposure to Asbestos and Other Materials:** Many respondents noted regular exposure to asbestos, particularly in older buildings, power plants, refineries, and mechanical rooms. This exposure often occurred during the removal or repair of insulation. Mechanical insulators also reported encountering hazardous materials such as mineral wool, fiberglass, and lead in various forms.
- **Unintentional and Hidden Exposure:** A significant number of participants mentioned accidental exposure due to hidden asbestos under cladding or improperly labeled insulation. Some described starting jobs without realizing the presence of hazardous materials, only to discover them later during the work.
- **Historical Practices and Lack of Protection:** Mechanical insulators with decades of experience recalled periods when proper safety measures were not in place. For example, some reported installing and removing asbestos-containing materials without masks or protective gear during earlier stages of their careers.
- **Challenges in Removal and Safety:** Participants frequently highlighted the challenges of safely removing hazardous materials, including asbestos and fiberglass. Dusty conditions and improper abatement processes were common concerns, even when using personal protective equipment (PPE).
- **Health Concerns and Long-Term Risks:** Several responses emphasized the health risks associated with prolonged exposure, including asbestosis, respiratory issues, and the cumulative impact of handling hazardous materials over decades. Many noted that even indirect exposure, such as being in the same room as asbestos or other materials, posed risks.
- **Prevalence in Older Systems:** Aging mechanical systems were reported as major sources of hazardous materials. These systems often contain outdated and dangerous materials, such as asbestos pipe wraps and loose-fill insulation, which are rarely found in newer installations.
- **Industry-Specific Exposure:** Mechanical insulators in industries such as power plants, oil refineries, and schools frequently encounter hazardous materials due to the age of the facilities and the scope of their work, including retrofits, maintenance, and insulation upgrades.

8. Noise Level

This section examines survey findings on the differences in noise levels between aging and newer mechanical systems, as well as the impact of high noise levels on mechanical insulator work.

59% of mechanical insulators reported experiencing differences in noise levels when working on aging mechanical systems compared to newer ones, indicating that older systems may generate more or different types of noise. However, 41% do not report a significant difference, which means noise exposure may not always be directly related to system age and could depend on factors like work environment, insulation quality, or individual sensitivity. This response trend is almost similar in both the U.S. and Canada and among insulators with more and less experience levels (see appendix [Figure A-19](#))

The impact of loud noise on the work effectiveness of mechanical insulators is shown in [Figure 22](#). The most common issue reported is communication difficulties among team members, affecting 80% of participants. Additionally, 77% noted that loud noise necessitates extra safety measures to ensure worker protection in noisy environments. Noise also serves as a distraction, with 39% of mechanical insulators stating that it reduces their focus and productivity. Furthermore, 30% reported that noise extends the duration of tasks, likely due to interruptions and reduced insulators' work efficiency. These challenges ranked similarly in both the U.S. and Canada and based on insulators' experience levels (see Appendix [Figure A-20](#)). Besides that, insulators highlight the additional impacts of loud noise on their ability to work effectively. They reported health concerns, including headaches, fatigue, ear damage, and psychological strain. Some mechanical insulators noted that extended noise exposure continues to affect them even after the workday ends. Safety concerns are also significant, as loud noise can prevent mechanical insulators from hearing alarms or recognizing safety risks, creating personal hazards. Task efficiency is impacted as well, with extended task durations reported due to communication challenges.

Individual experiences with noise exposure vary; some mechanical insulators mention issues like sound distortion or report no problems when using ear protection, while others find noise to be a persistent source of stress. These findings underscore the widespread impact of noise on mechanical insulators, regardless of mechanical system age.

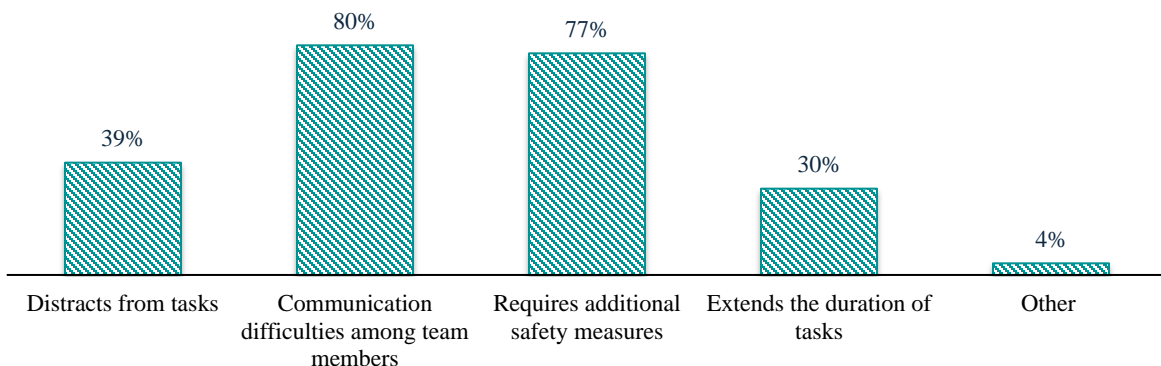


Figure 22. Impact of loud noise on work effectiveness of mechanical insulators among all mechanical insulator participants

9. Training

This section focuses on the specific training needs identified through survey responses for mechanical insulators working on aging mechanical systems. It highlights the types of training required to address the unique challenges that aging mechanical systems present, including safety protocols for handling hazardous materials, retrofitting techniques for integrating modern technologies, and compliance with regulations specific to older systems. Moreover, the section examines if additional training is needed to work more effectively on aging systems than newer ones. It also highlights gaps in current training and identifies the knowledge required to address the unique challenges of aging mechanical systems.

Figure 23 shows the types of training considered necessary for working on aging mechanical systems based on the responses from all participants. "Safety training" is identified as the most important, with 38% of participants selecting it. "Retrofitting techniques" are next, with 32% of mechanical insulators emphasizing the need for skills to integrate modern technologies into aging mechanical systems. "Compliance with regulations" is also significant, with 28% identifying it as an essential area for training.

The "Other" responses for training requirements, highlight a range of needs and concerns when working on aging mechanical systems. Some participants emphasized the importance of technical training, such as identifying hazardous materials and inspecting insulation materials to ensure proper installation. Revisiting application methods from previous years is also seen as valuable for improving safety and efficiency. Practical knowledge and hands-on experience are essential, as mechanical insulators emphasize the importance of identifying system failures, such as rusted or weakened piping, to ensure safety. Safety-focused training is another priority, with suggestions to include methods for limiting exposure to hazardous materials and using specialized tools like vacuums and tents in confined spaces. Additionally, mechanical insulators point to the importance of general skills like time management and coordination, particularly in temperature-sensitive environments, and understanding the purpose of specific insulation materials.

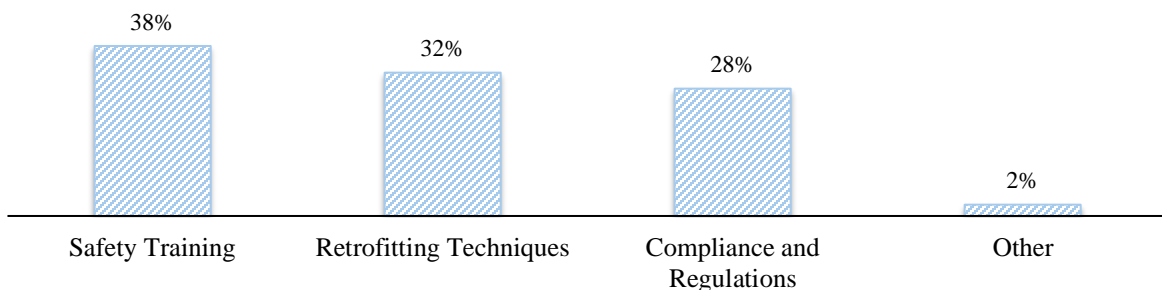


Figure 23. Types of training needed for working on aging mechanical systems among all mechanical insulator participants

Insights from the U.S. and Canada regarding the types of training needed for working on aging mechanical systems are similar to the responses from all participants. This shows common challenges in both countries, regardless of location. However, when comparing insulators by experience level, a different trend emerges. Mechanical insulators with less than five years of experience place greater emphasis on retrofitting techniques (38%) than on safety training (34%) and compliance with regulations (26%). In contrast, insulators with more than 20 years of

experience prioritize safety training (39%) before retrofitting techniques (30%) and compliance with regulations (28%) for working on aging mechanical systems (see Appendix, [Figure A-21](#)). It can be concluded that training programs should be customized based on experience levels. Newer insulators may need more technical and practical training on retrofitting, and experienced insulators may require more advanced safety and regulatory compliance training.

[Figure 24](#) demonstrates satisfaction levels with existing training programs when working on aging mechanical systems. The majority of participants (86%) expressed at least some level of satisfaction with their training. A significant 54% are highly satisfied (Significantly or Extremely), suggesting that the training is generally effective. However, 14% report low satisfaction, indicating room for improvement in training programs. While training appears to be generally effective, efforts can be made to enhance it further, particularly for those who are less satisfied.

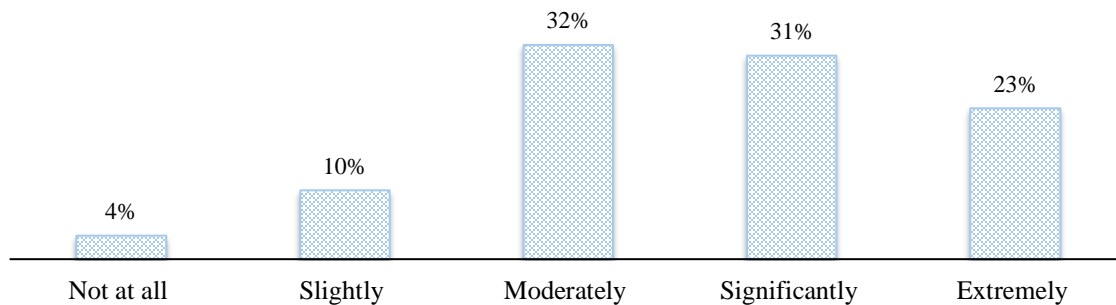


Figure 24. Satisfaction with training for working on aging mechanical systems among all mechanical insulator participants

[Figure 25](#) compares satisfaction with training for working on aging mechanical systems between participants from the U.S. and Canada. As shown in [Figure 25a](#), the U.S. participants report lower dissatisfaction, 14% (not at all or slightly), compared to those in Canada, 26% (not at all or slightly), suggesting a greater need for training improvements in Canada. Moderate satisfaction levels are similar, with 32% in the U.S. and 28% in Canada. However, the U.S. has a higher overall satisfaction rate of 54% (significantly or extremely) than Canada, 47% (significantly or extremely). Overall, participants in both countries reported moderate to significant satisfaction, highlighting the effectiveness of current training efforts while indicating potential areas for improvement to address specific challenges faced by mechanical insulators working with aging mechanical systems. This is especially relevant in Canada, where a greater proportion of participants report dissatisfaction or only moderate satisfaction. Addressing these differences could enhance training programs and ensure that workers in both countries receive adequate preparation for working on aging mechanical systems.

According to [Figure 25b](#), the key difference is that extreme satisfaction is higher among more experienced insulators (22%) compared to less experienced ones (16%). Apart from this difference, the other satisfaction levels (Slightly, Moderately, and Significantly) are quite similar between both experience groups.

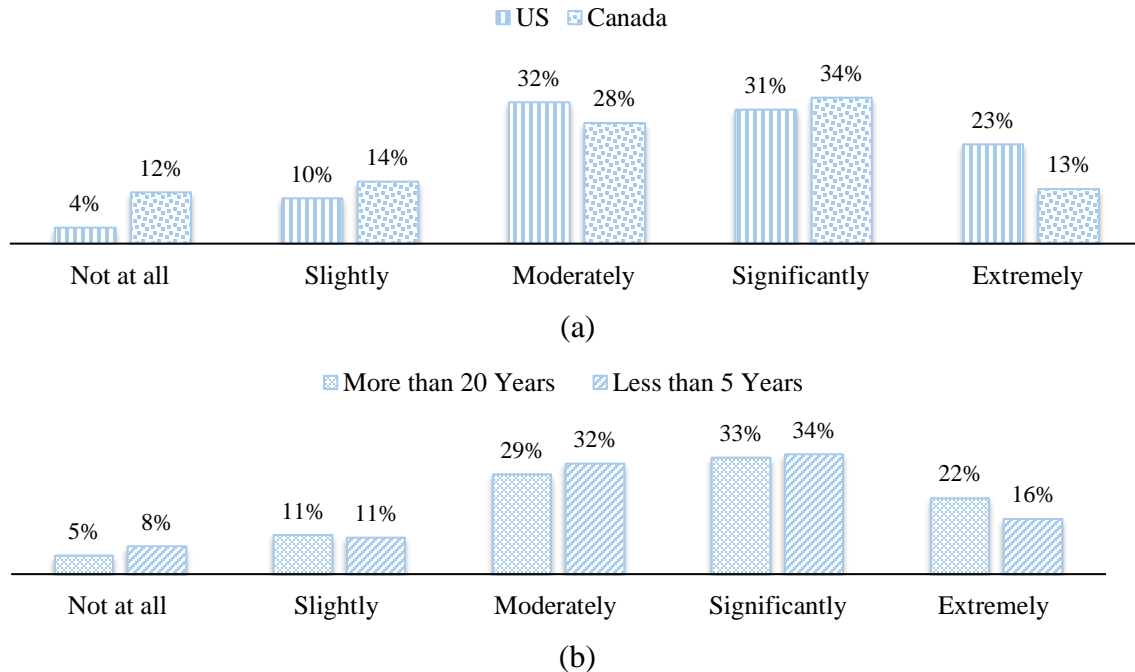


Figure 25. Comparing satisfaction with training for working on aging mechanical systems (a) in the U.S. and Canada, (b) based on insulator experience levels

Regarding the need for additional training, the majority of participants (68%) believe that more training is necessary to address the challenges of aging mechanical systems effectively. Meanwhile, 32% of participants feel the current training is sufficient. These results are almost similar across the U.S. and Canada and among insulators with different experience levels. (see [Figure A-22](#))

Those emphasizing the need for more training highlight the importance of specialized education for handling hazardous materials such as asbestos, mold, and lead. It is mentioned that training should focus on identifying, managing, and safely disposing of these materials. Safety remains a key concern, with respondents stressing the need for proper tools, personal protective equipment (PPE), and enhanced job site safety protocols to reduce risks and improve efficiency. A strong focus is also placed on understanding aging mechanical system designs and techniques, which often require specialized tools and methods to maintain system integrity. Continuous learning and regular refresher courses are seen as essential, particularly as materials and industry practices continue to evolve. Training programs should address knowledge gaps, especially for newer mechanical insulators, by providing practical, task-specific instruction and adapting older methods with modern standards. They also indicate the necessity of improving existing training to better meet the needs of professionals in this field.

Generally, these findings indicate that experience significantly influences both the types of training required and satisfaction levels. Less-experienced mechanical insulators prioritize retrofitting techniques and report slightly higher dissatisfaction, while more-experienced mechanical insulators emphasize safety training and exhibit greater satisfaction overall. This highlights the importance of designing training programs that address the specific needs and expectations of mechanical insulators at different experience levels.

Open-ended Question

This section allowed respondents to share additional insights and challenges beyond the structured survey. It captures mechanical insulators' detailed perspectives and provides a comprehensive view of the issues faced when working with aging mechanical systems. Respondents shared a variety of experiences, offering valuable feedback on topics such as workforce preparedness, safety concerns, system design inefficiencies, and the broader impact of these challenges on efficiency and sustainability. By analyzing these responses, the following categories, including workforce and training challenges, safety concerns, system design and Installation Issues, financial and management obstacles, environmental and efficiency concerns, and the need for better industry practices, were identified, which reflect the collective expertise and experiences of mechanical insulators.

- **Workforce and Training Challenges**

Knowledge Gaps in Younger Workers: Many respondents noted that younger insulators lack experience with aging systems. This underscores the need for mentorship and training to ensure they are equipped to handle future renovations and upgrades.

Importance of Apprenticeships and Unions: Structured training, on-the-job experience, and union support have been critical for many in successfully navigating challenges with older systems.

Decline in Trade Standards: There has been a decline in respect and quality within the trade over the years, which has been attributed to non-union labor and industry changes.

Continuous Learning: The evolving industry requires constant retraining to keep up with new materials, tools, and techniques.

- **Safety Concerns**

Exposure to Hazardous Materials: Workers frequently encounter risks from asbestos, mold, dust, and chemical exposure. Many respondents stressed the urgency of removing these hazards.

Neglect of Safety Protocols: Supervisors and contractors sometimes prioritize production over safety, creating unsafe working conditions.

Hazardous Work Environments: Confined spaces, dirty conditions, and poorly maintained older systems add to the safety challenges.

- **System Design and Installation Issues**

Insufficient Space for Insulation: Engineers and contractors often overlook insulation requirements in their designs, leaving inadequate space for proper installation.

Complexity of Retrofitting: Renovating aging systems can be difficult due to tight spaces, corroded components, and outdated designs.

Insulation as an Afterthought: Many general contractors undervalue insulation, treating it as a secondary priority in projects.

- **Financial and Management Obstacles**

Cost Constraints: Facilities often delay or avoid retrofitting due to budget limitations despite the long-term cost savings of proper insulation.

Pressure for Speed Over Quality: Tight project timelines force workers to compromise on quality, resulting in inefficient systems.

Lack of Strategic Planning: Poor project assessments and blueprint inaccuracies add to the challenges, particularly when unforeseen obstacles arise during installation.

- **Environmental and Efficiency Concerns**

Impact of Poor Insulation: Inadequate or aging insulation increases energy costs, reduces efficiency, and generates more greenhouse gases.

- **Need for Better Industry Practices**

Inter-Trade Collaboration: Improved coordination between trades (e.g., engineers, pipefitters) can reduce inefficiencies and design flaws.

Advocacy for Regulation: Respondents highlighted the need for stronger policies to enforce high-quality insulation practices and improve industry standards.

Focus on Craftsmanship: Emphasizing quality over cost and speed can lead to better outcomes, including energy efficiency and reduced maintenance needs.

Appendix A

I. General Information

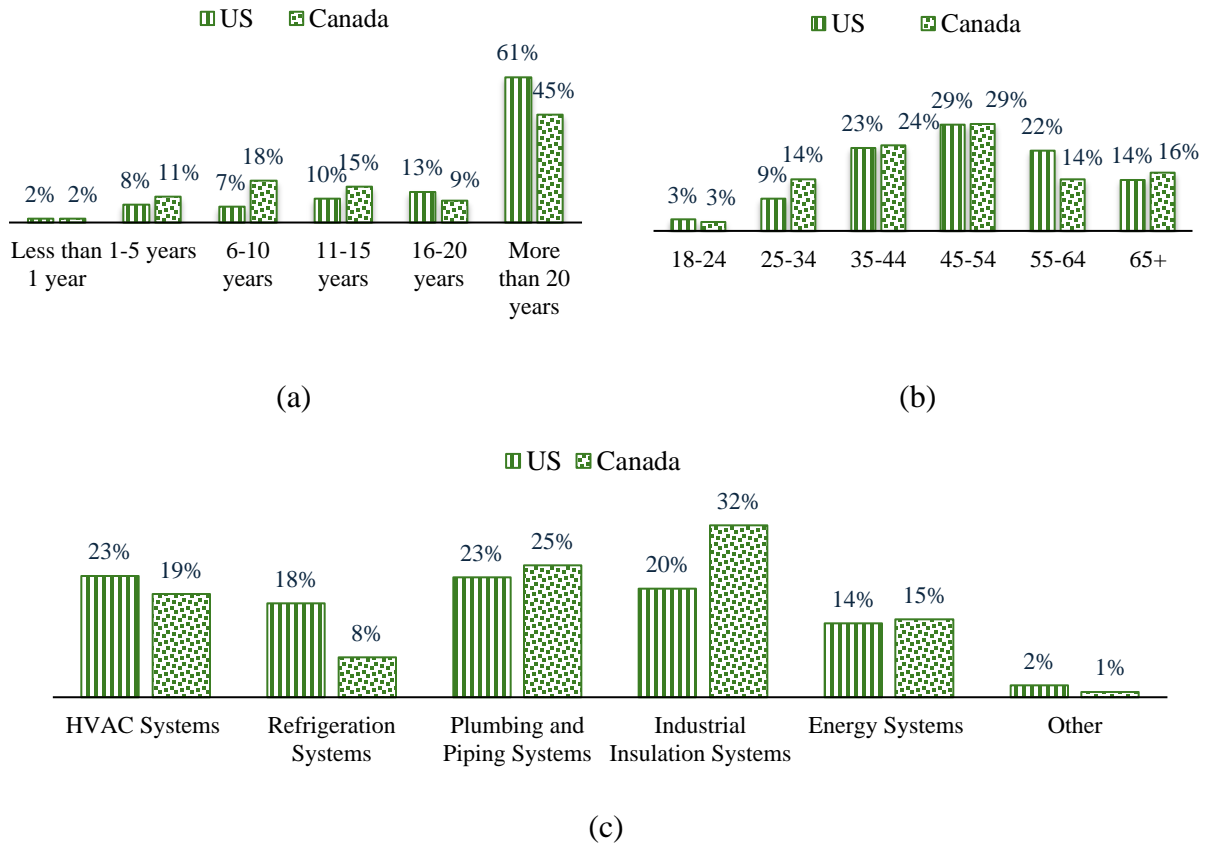


Figure A-1. General information about the survey participants across the U.S and Canada (a) years of experience (b) age group (c) Mechanical Systems Most Frequently Worked On

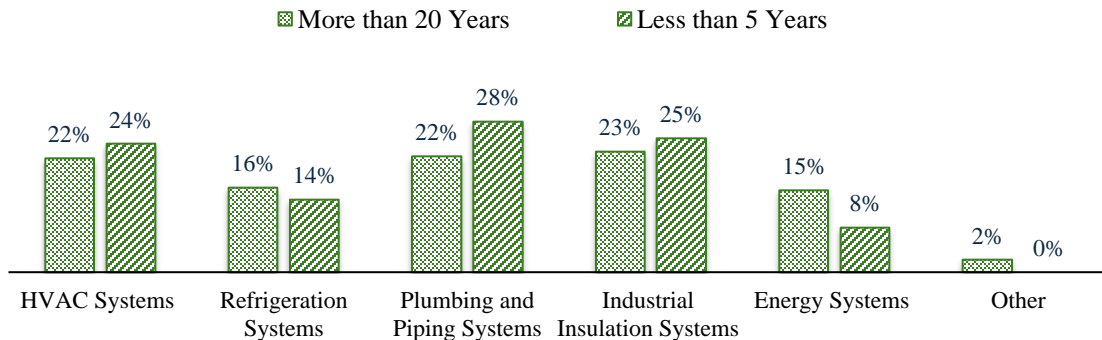
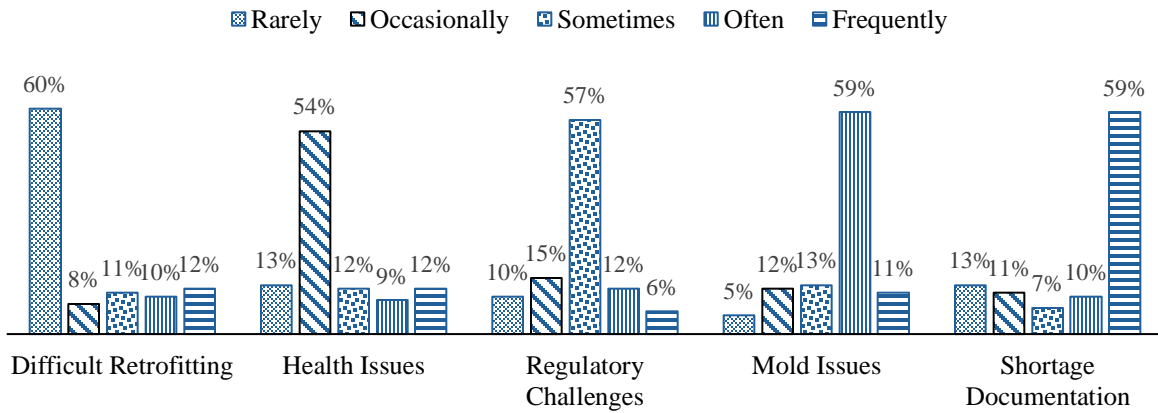
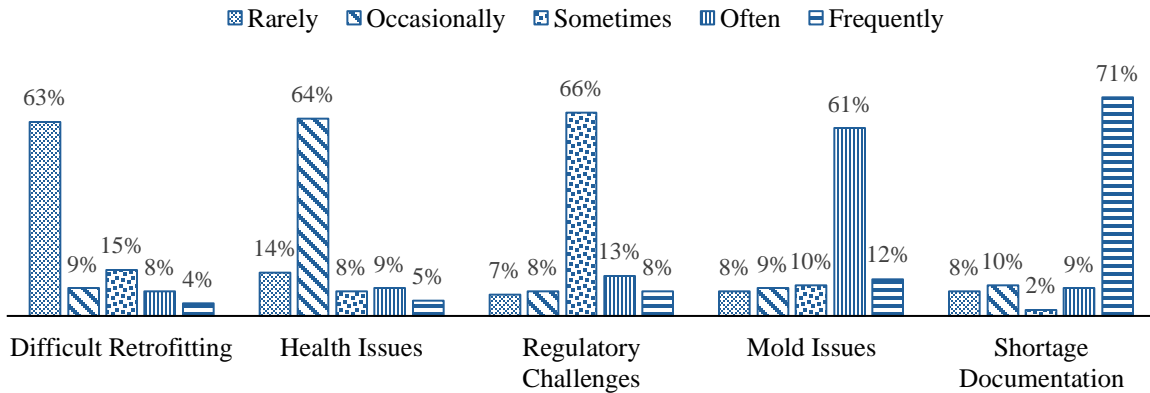


Figure A-2. Mechanical insulation systems that insulator participants work on most frequently based on their experience levels

II. Common Challenges

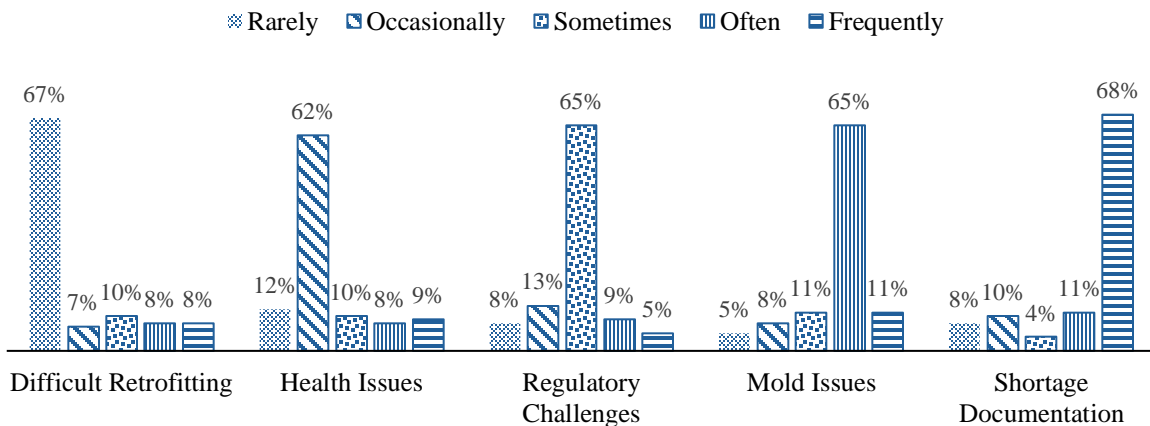


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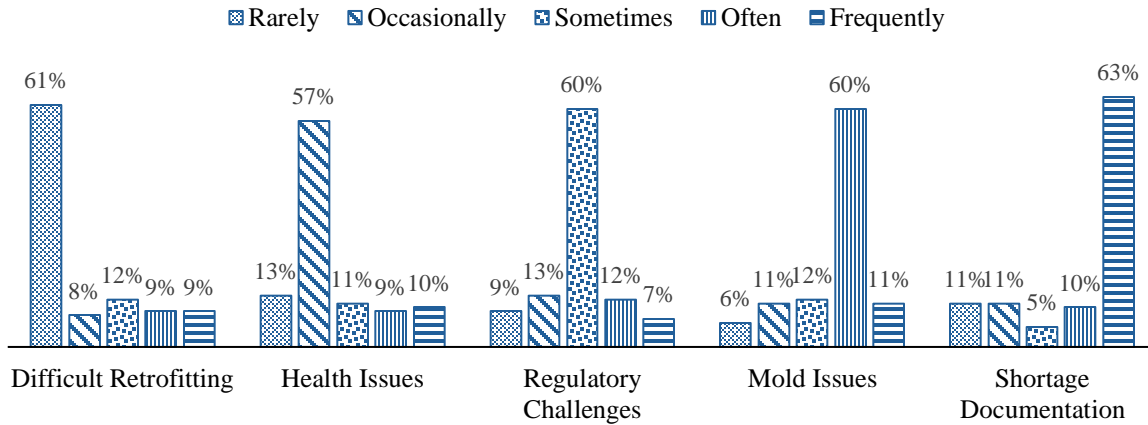


(b)

FigureA-3. Frequency of challenges encountered by mechanical insulators when working on aging mechanical systems in (a) the U.S. and (b) Canada



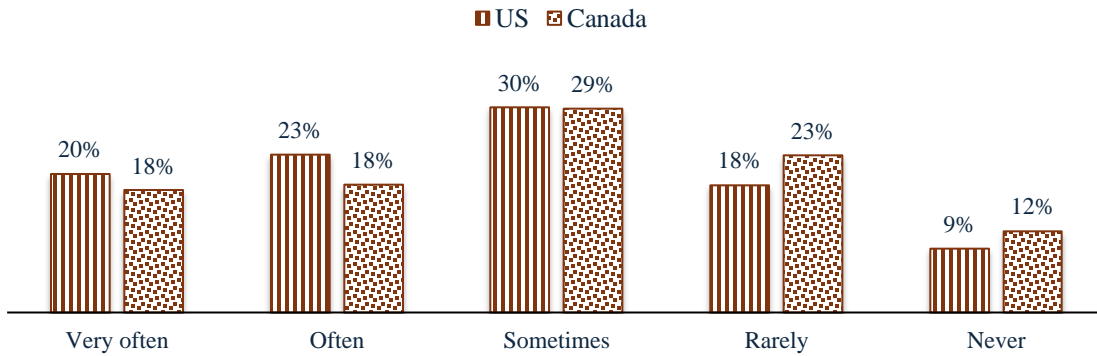
(a)



(b)

Figure A-4. Frequency of challenges encountered by mechanical insulators when working on aging mechanical systems, categorized by experience levels (a) more than 20 years experience and (b) less than 5 years experience

III. Incomplete/inaccurate Historical Documentation



FigureA-5. Comparing the frequency of issues encountered due to incomplete or inaccurate historical documentation in aging mechanical systems in the U.S. and Canada

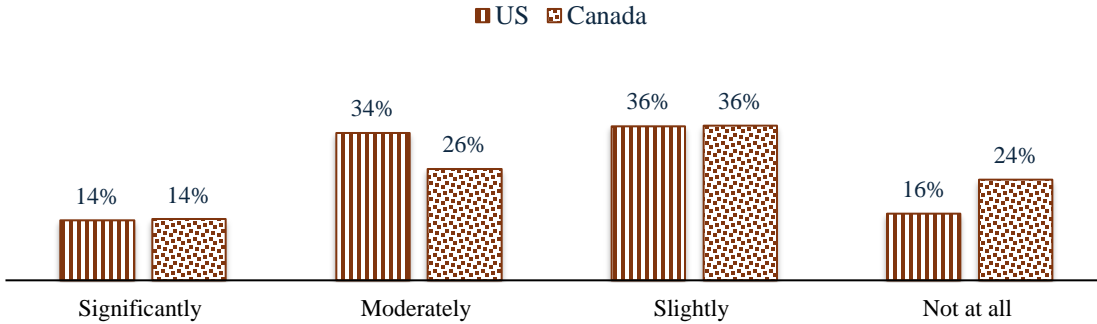


Figure A-6. Comparing the impact of incomplete or inaccurate historical documentation on efficiency in repairing and upgrading aging mechanical systems in the U.S. and Canada

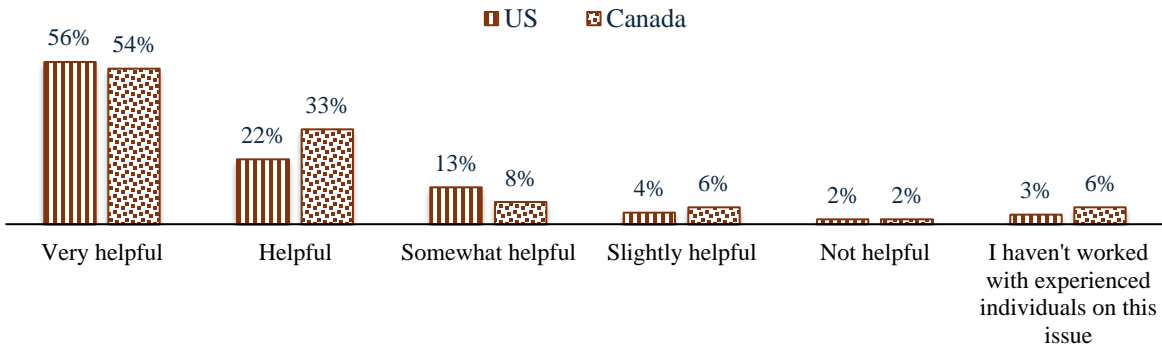


Figure A-7. Comparing the effect of experienced mechanical insulators on solving issues from incomplete historical documentation in the U.S. and Canada

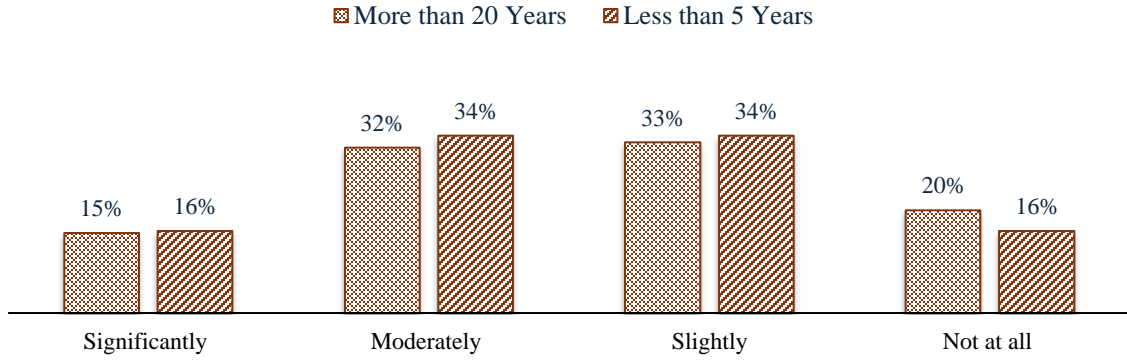


Figure A-8. Comparing the impact of incomplete or inaccurate historical documentation on mechanical insulators' efficiency in repairing and upgrading aging mechanical systems based on insulator experience levels

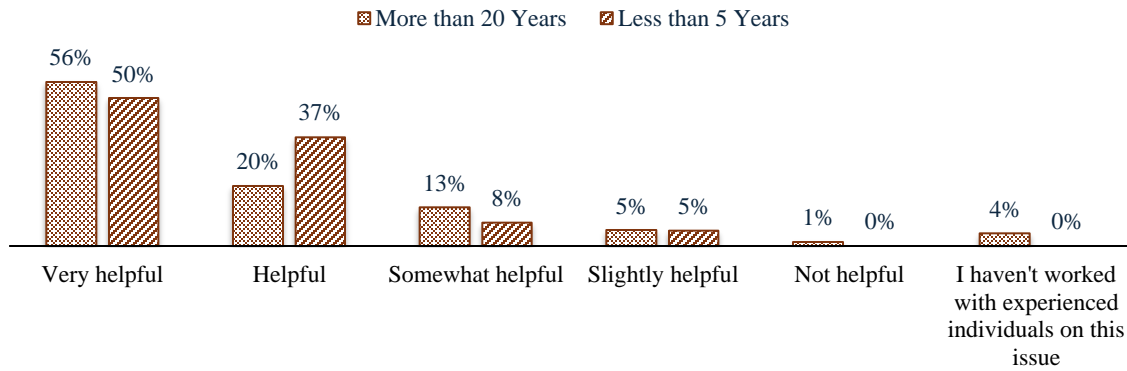
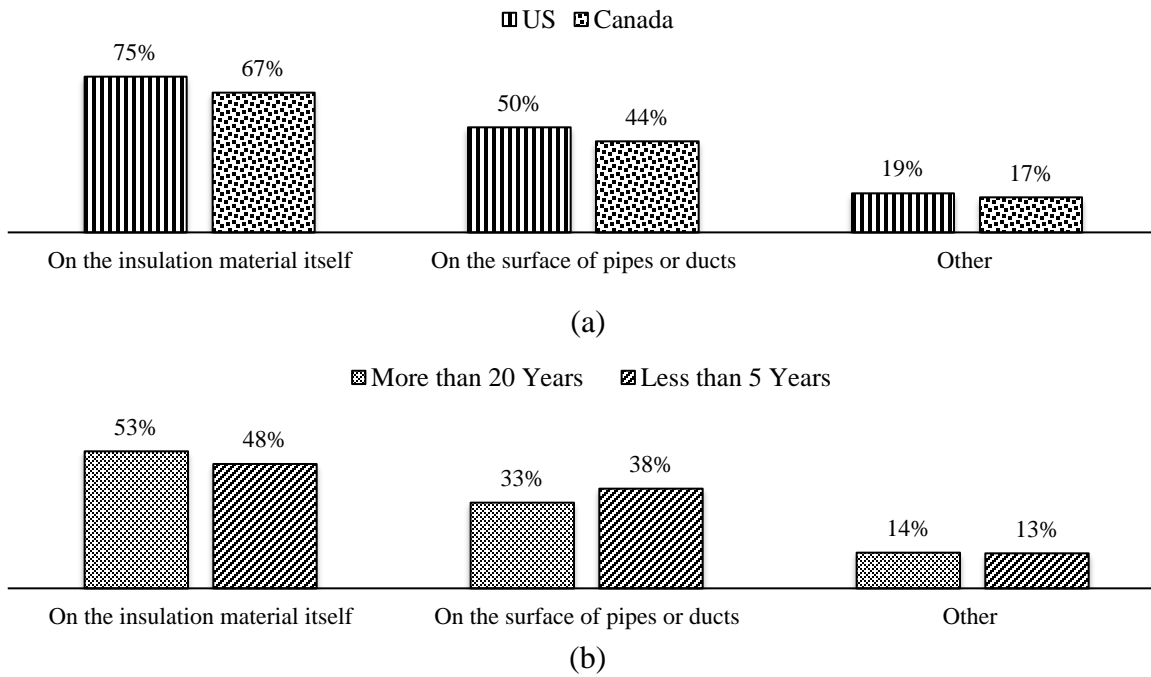


Figure A-9. Comparing the effect of experienced mechanical insulators on solving issues from incomplete historical documentation based on insulator experience levels

IV. Mold Issue



FigureA-10. Comparing common locations of mold growth observed during retrofits and installations (a) in the U.S. and Canada and (b) based on insulator experience levels

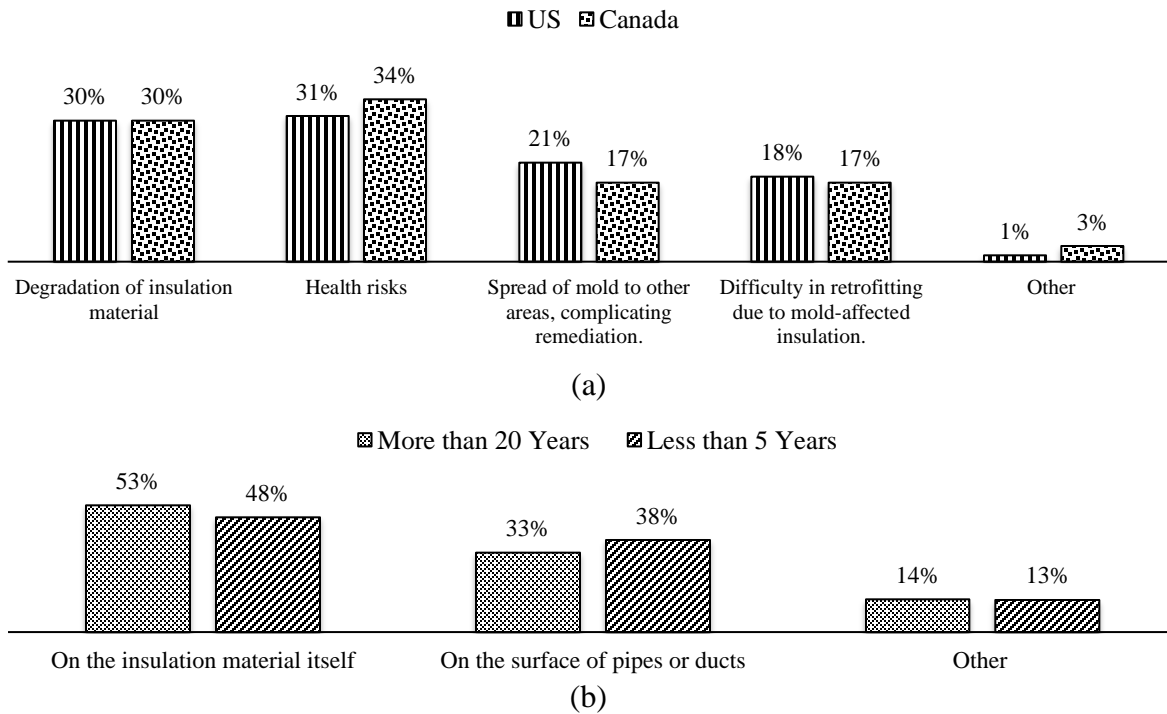
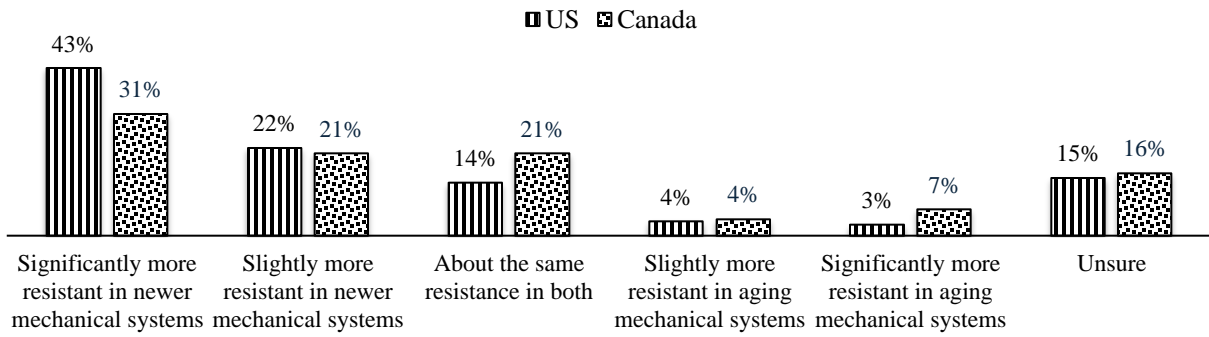
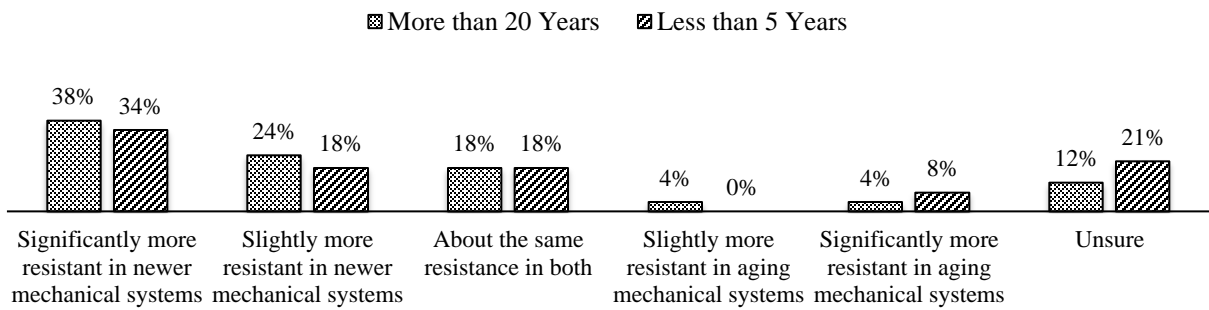


Figure A-11. Comparing challenges related to mold growth encountered during work (a) in the U.S. and Canada (b) based on insulators' experience levels



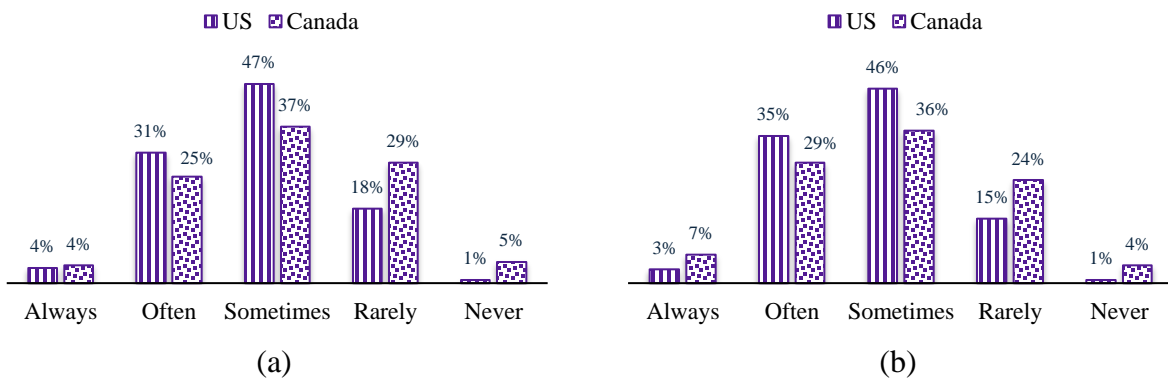
(a)



(b)

Figure A-12. Comparing mold resistance of insulation materials in aging mechanical systems versus newer ones (a) in the U.S. and Canada (b) based on insulators' experience levels

V. Confined Spaces



(a)

(b)

Figure A-13. Comparing frequency of working in confined spaces during insulation retrofitting for (a) newer mechanical systems and (b) aging mechanical systems in the U.S. and Canada

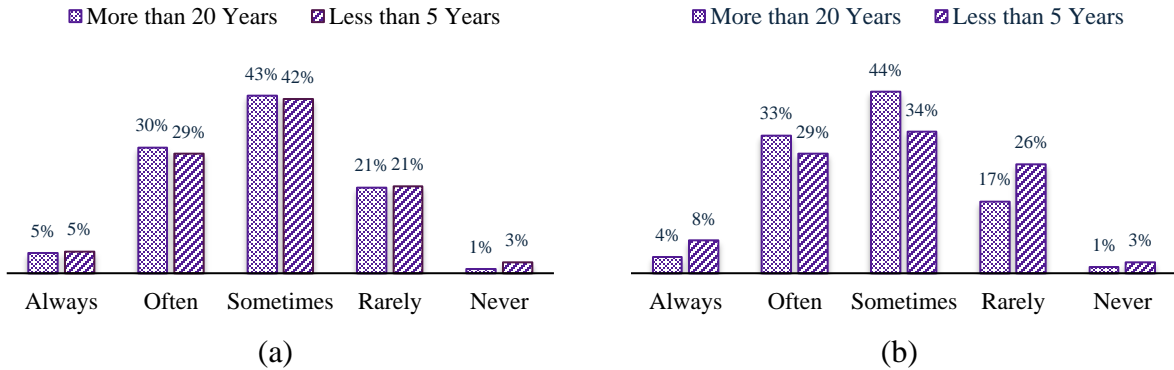


Figure A-14. Comparing frequency of working in confined spaces during insulation retrofitting for (a) newer mechanical systems and (b) aging mechanical systems based on insulator experience levels

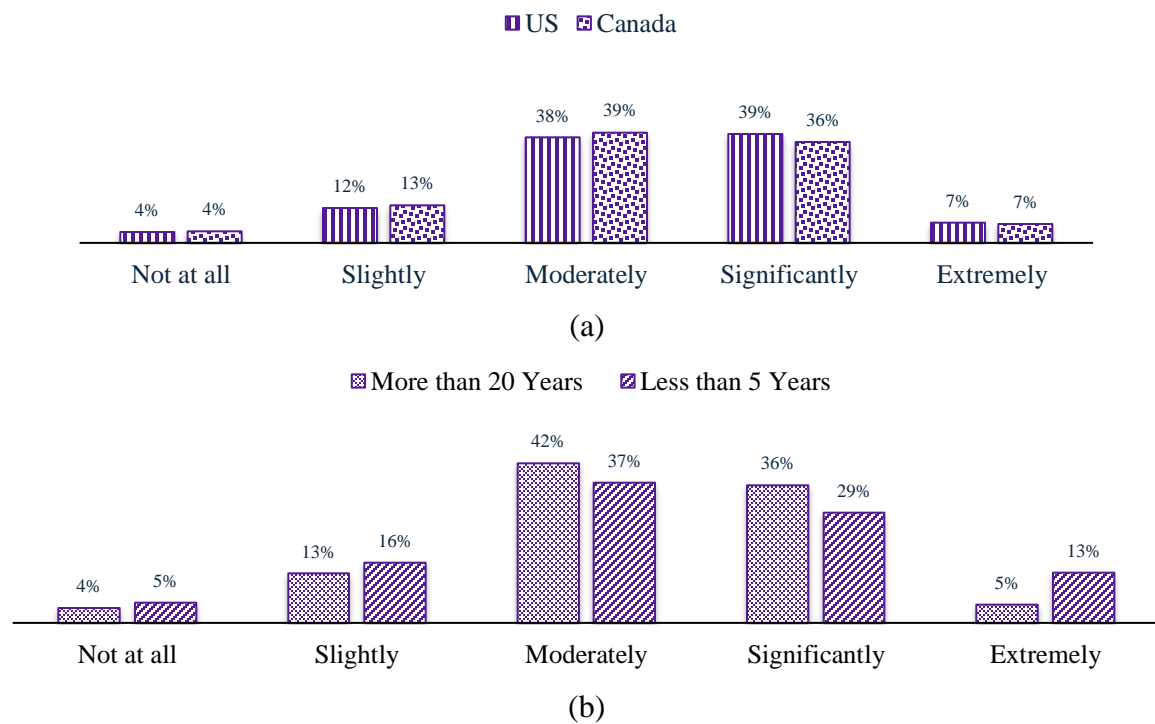
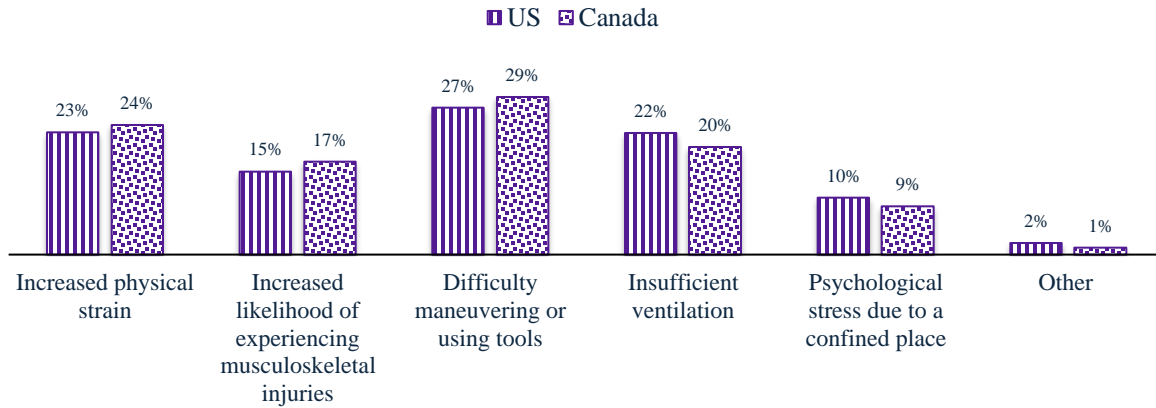
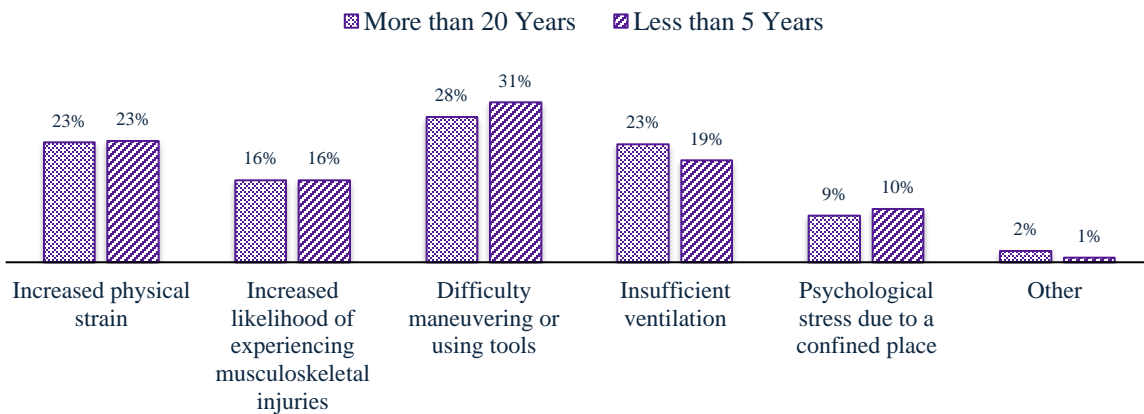


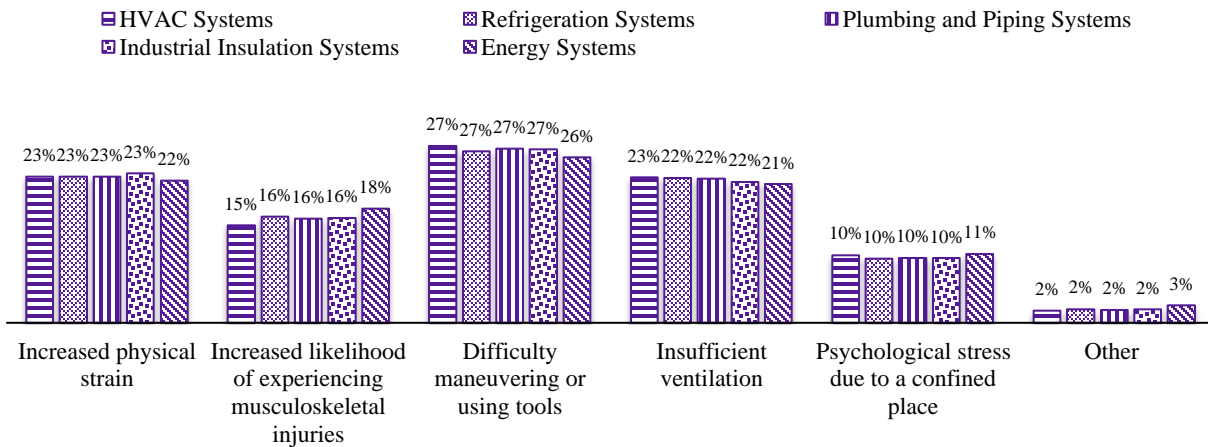
Figure A-15. Comparing the impact of confined spaces on mechanical insulator efficiency when retrofitting insulation in aging mechanical systems compared to newer systems based on insulator experience levels



(a)



(b)



(c)

Figure A-16. Comparing challenges in retrofitting insulation for aging mechanical systems in confined spaces based on the type of mechanical systems that insulators work on more frequently

VI. Hazardous Materials

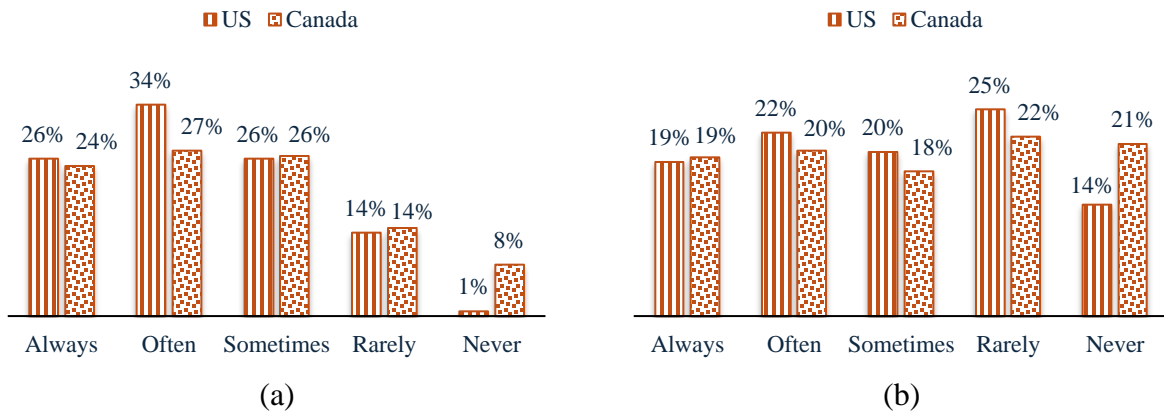


Figure A-17. Comparing the frequency of hazardous material exposure across the U.S. and Canada in (a) aging mechanical systems and (b) newer mechanical systems

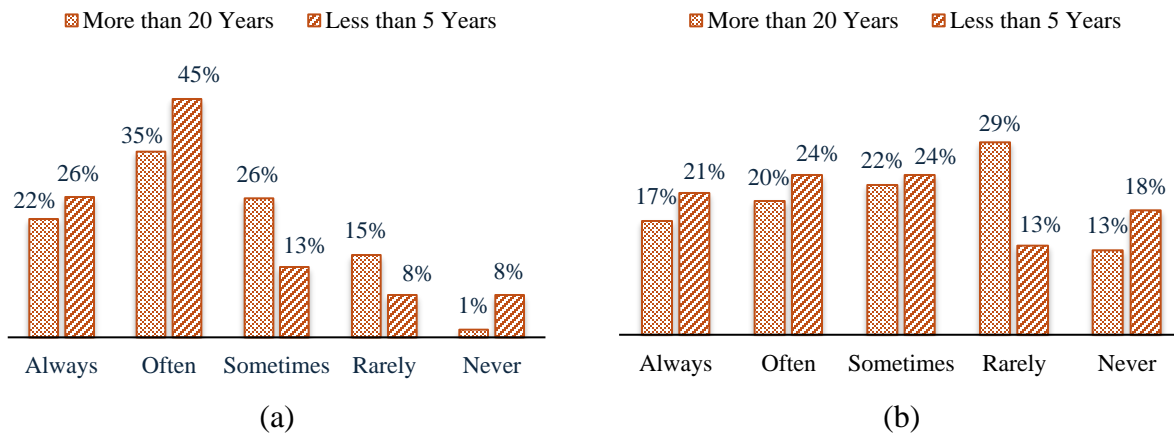


Figure A-18. Comparing the frequency of hazardous material exposure based on insulator experience levels in (a) aging mechanical systems and (b) newer mechanical systems

VII. Noise issue

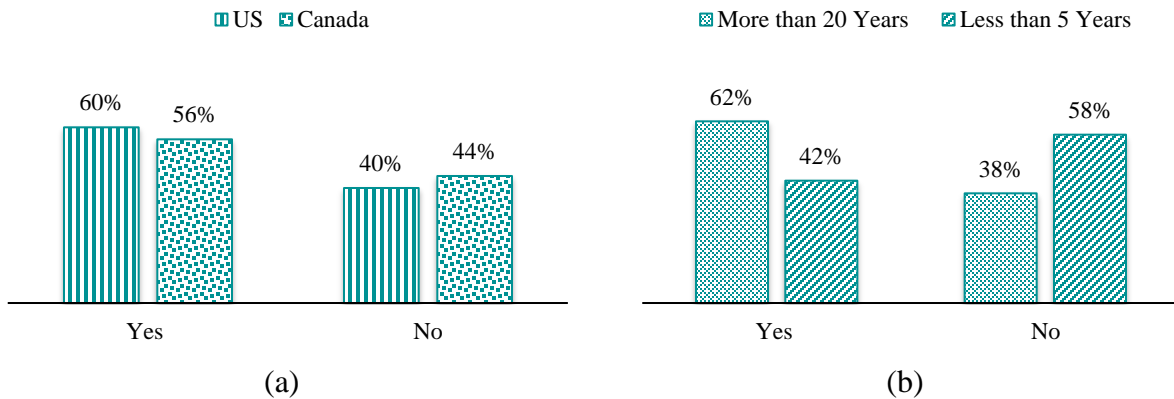


Figure A-19. Comparing the experience of different noise levels during insulation work on aging mechanical systems compared to newer ones based on insulator experience levels

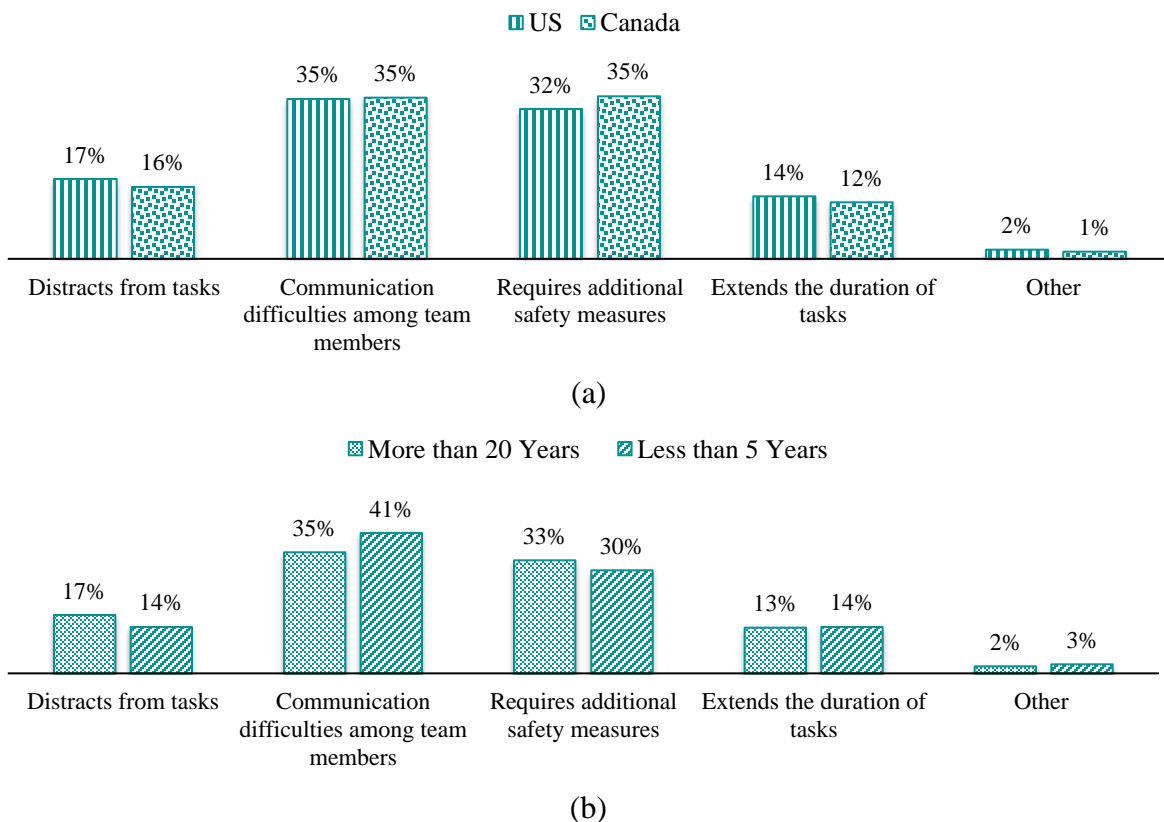
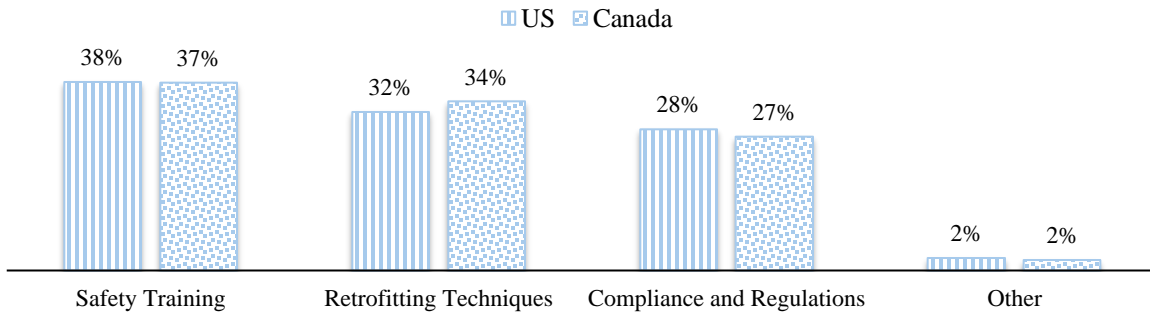
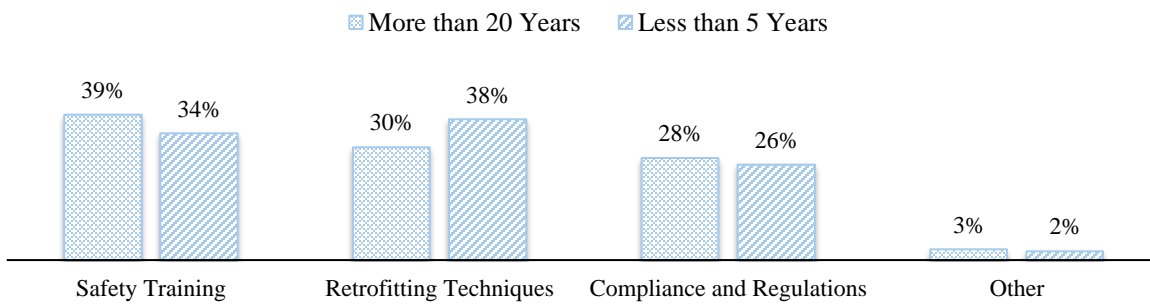


Figure A-20. Comparing impact of loud noise on the work effectiveness of mechanical insulators based on insulator experience levels

VIII. Training

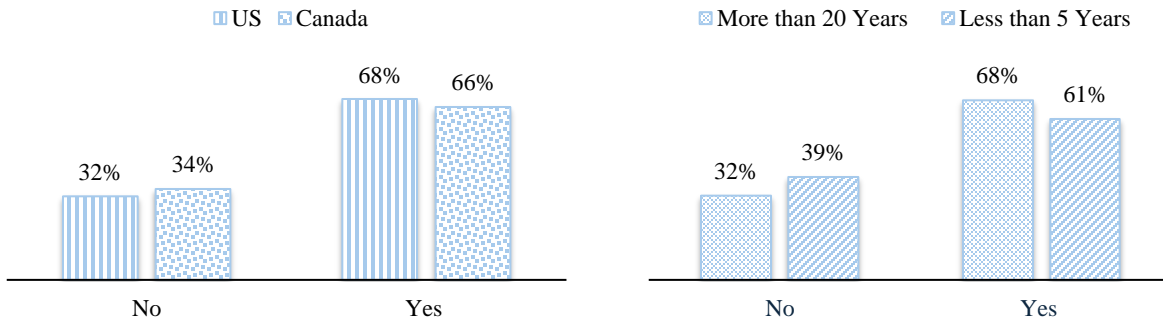


(a)



(b)

Figure A-21. Comparing types of training needed for working on aging mechanical systems based on insulator experience levels



(a)

(b)

Figure 22. Comparing the need for additional training for aging mechanical systems based on insulator experience levels.