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Nanotechnology: Assessing Awareness and Training Needs Among California Construction Trades

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Nanotechnology: Assessing Awareness and Training Needs Among California Construction Trades

ABSTRACT:

Purpose: The purpose of this study is to evaluate the current understanding and use of nanotechnology applications in heavy industrial/commercial construction among union leaders, apprenticeship program staff and employers. Our specific goal was to survey representatives from a cross-section of California construction trades to determine to what extent they are aware of nanotechnology, if they have received or delivered training related to nanotechnology, if they recognize any nano-enabled products listed in the "eLCOSH Construction Nanomaterials Inventory" (eLCOSH Inventory) and their perception of potential benefits or concerns about use of nanotechnology in construction.

This study relates to NIOSH's NORA Construction Sector Strategic Goal #11, which covers building recognition and awareness of construction hazards and the means for controlling them by strengthening and extending the reach of quality training and education in the construction industry. Information gathered through our online survey and key informant processes specifically addresses Subgoals 11.1 (construction safety and health training needs assessment) and 11.2 (surveying current training programs about gaps in training on this topic).

Methodology: We collected feedback from our target audience through a 31-question on-line survey and 21 follow-up key informant phone interviews with a subset of survey respondents. Our goal was to obtain 100 survey responses; we actually received 253 completed surveys to include in our evaluation. It was a priority that we obtain feedback from a cross-section of crafts. Participants were asked to identify their affiliation from a list of 25 crafts; all but one of these crafts (Pile Drivers) were represented through completed surveys. We selected 21 key informant subjects based upon one or more of the following criteria present in their survey responses: recognition of nanotechnology terms; having either received or delivered training related to nanotechnology; indicating worker or environmental safety concerns related to nano-enabled materials; on-the-job experience with nano-enabled construction materials; recognition of products from the eLCOSH Inventory. Interview length averaged 23 minutes (range: 9-46 minutes) per subject. Additionally, we conducted phone interviews with 5 individuals from 4 California government agencies; each interview took 30-60 minutes.

Key Findings:
1. Knowledge and Awareness: While there was far greater interest in participating in this study than we originally anticipated, the level of understanding—both defining key terms and how nanotechnology may pose risks to workers in the construction industry—is quite shallow. Survey respondents and key informants voiced concern about this new technology; respondents could see the potential benefits that nanotechnology could bring to construction, but their past experience with products like asbestos and silica

made them question whether long-term consequences may exist. For many, this survey was their first introduction to nanotechnology, particularly as it pertains to construction. The survey itself sparked in many participants an interest to learn more.

2. Knowledge of materials listed in eLCOSH Inventory: Reviewing the 500-plus product list generated interest and raised awareness of nanotechnology and could be a useful tool if used more broadly. However, given our small sample size, and the fact that some of the entries on the inventory were very generic, we really weren't able to draw too many conclusions.

3. Current status of training: Comprehensive nanotechnology training is virtually non-existent. Barely 2% of survey participants had received training and most of these were Insulators who were being trained by a product manufacturer on proper techniques for applying the product rather than understanding the nano-enabled aspects of the material. However, the majority of study participants were interested in being trained about nanotechnology and believe it would be of value to construction workers.

4. Government agency monitoring, control, and information: There was a surge of public sector activity around nanotechnology over the last 15 years, but this seems to have slowed now that the initial wave of funding and research has run its course. Two California agencies have the potential to gather information from nanomaterial manufacturers and make that information public, however neither is doing anything with nanomaterials at this time. They have some products on a watch list, but need more data to raise those to the action phase.

Recommendations:
A strategic plan to increase awareness and improve understanding of nanotechnology and nanomaterials in the construction industry must include a combination of research, outreach, training, and stakeholder collaboration. Information gaps need to be filled; the most basic first step is to develop clear and agreed-upon definitions of the terminology related to nanotechnology. Data are needed about how nanomaterials are currently being used in construction, the exposures workers are experiencing and the subsequent risks they face of potential health effects. Collaboration with public agencies, researchers, manufacturers, trainers and end-users is essential to accomplishing these goals.

Additional steps include developing a multi-craft training curriculum that includes the use of video and utilizing the eLCOSH Inventory as both an awareness tool and a way to learn more about products currently in use.

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Acknowledgements

State Building and Construction Trades Council Project Coordinator Laura Boatman served as Principal Investigator for this small study. She conceptualized the project, developed the survey instruments and conducted and wrote up the study analysis.

State Building and Construction Trades Council Director of Special Programs Debra Chaplan served as co-Principal Investigator. She helped conceptualize the project; reviewed all aspects of the project; did initial analysis of the online survey results and edited the study.

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A. INTRODUCTION

Construction has the distinction of being the "number one" industry for many health and safety hazards, including falls, electrocutions and respirable crystalline silica. Our building and construction trades unions, apprenticeship programs and employers must constantly keep pace with control strategies, standards and training for a myriad of hazards to protect workers from harm. This can be challenging, even for hazards that have been recognized and researched for decades, or, as in the case of silica, centuries. Unions are at the forefront, advocating for workers' rights and protections, engineering controls, policies and procedures, and personal protective equipment that will keep workers safe.

Over a century ago, California construction unions joined together to form the State Building and Construction Trades Council of California, AFL-CIO (SBCTC), a multi-craft association whose mission is to "improve the health, jobs, safety and economic conditions of the members of its affiliates, and all working men, women, and minors in the construction industry." SBCTC is the California affiliate of North America's Building Trades Unions (NABTU) and has collaborated with the Center for Construction Research and Training (CPWR) on the topics of noise and hearing loss prevention, silica, and ergonomics. For more than twenty years, SBCTC has developed numerous health and safety education programs with funding from the federal OSHA Susan Harwood training grant program. This work has established the SBCTC as a leader in construction health and safety, enabling us to build a network of safety trainers in California and become a trusted source for health and safety information among unions, apprenticeship programs and contractors.

We learned from CPWR and other sources that the construction industry was seeing increased use of applications of nanotechnology and nano-enabled materials. The field of nanotechnology is growing exponentially, accompanied by claims of amazing benefits, not only for society, but specifically for construction. Nanotechnology could potentially improve our building materials, promising to make them lighter, stronger, more durable, energy efficient, and engineered to provide solutions for public health hazards from sequestering air pollution to controlling bacteria in hospitals. While the spotlight has been focused on the research and development (R&D) side of nanotechnology and nano-enabled materials, what remains largely unknown are the potential downstream impacts these new materials may have on the environment and on the trades workers who must handle, cut, drill, grind, and apply them in their daily work, and eventually remove them at the end of their life-cycle.

It became clear that only a small amount of information had been gathered regarding levels of awareness, understanding and training about this emerging technology among construction stakeholders. Indeed, over the years of conducting needs assessments and offering programs on various health and safety topics, nanotechnology and nanomaterials had never surfaced within our training sphere. Anecdotally, the mention of "nanotechnology" or "engineered nanomaterials" in conversations with union reps, apprenticeship staff and contractor reps,

would elicit responses ranging from a blank stare, a "what's that?", cautious trepidation about potential new regulatory standards, and awareness limited to knowledge that it exists.

With California boasting the sixth largest economy in the world, being a global hub for new technology R&D and innovative green building technologies, as well as a national leader in worker health and safety and environmental protection standards, we may expect that our construction industry would be informed about the benefits and concerns relating to nanotechnology. But, in reality, we had no organized feedback stream to indicate whether these innovations were on anyone's "radar screen" at all.

When CPWR researchers informed us that an online list already existed, the "eLCOSH Construction Nanomaterials Inventory" (eLCOSH Inventory), identifying over 500 construction products currently available on the commercial market in the U.S., we agreed to propose a small study project to survey a target population of SBCTC affiliates, our trainer network and contractors to better understand their level of nanotechnology awareness. Several questions surfaced immediately as we considered this topic:

- To what extent is there awareness of nanotechnology applications in construction?
- Are unions or apprenticeship programs addressing nanotechnology in their trade?
- Are any specific concerns surfacing about use of nano-enabled materials?
- Do union leaders and trainers recognize products in the eLCOSH Inventory?
- Is training about nanomaterials being made available to union workers?

Our study attempted to obtain feedback on these questions using both an online survey platform that could be easily accessed by our target audience and follow-up key informant interviews with a small subset of survey respondents. We knew at the outset that the scope of our study would be small, but it is a beginning exploration that we hope will inspire future work and assist researchers and construction stakeholders by exposing potential gaps in awareness and identifying next steps needed to bridge those gaps. CPWR had made similar efforts in other parts of the nation and we saw an opportunity to build upon their work and contribute to the existing data pool.

Going into this project, we truly did not know what to expect. We assumed that response levels would likely be low, and that awareness would be limited. With the many priorities that our target population deals with every day, we did not know if they would be willing to take the time to participate in this study, or if they would perceive other health and safety issues and training needs as more important. We hoped to get 100 completed surveys and were pleasantly surprised when we actually got more than twice that number. We also found that key informant candidates were very willing to participate in interviews. We learned that simply participating in our study sparked a greater interest in nanotechnology among interviewees.

Another aim of our study was to interview representatives from key California state agencies to determine if they are currently working on any monitoring, control, regulation or educational

outreach related to nanotechnology or nanomaterials. We were able to accomplish this to an extent, but it was more challenging than expected. The results of these interviews are summarized in aggregate later in this report.

This study relates to NORA Construction Sector Strategic Goal #11, which covers building recognition and awareness of construction hazards and the means for controlling them by strengthening and extending the reach of quality training and education in the construction industry. Information gathered through our online survey and key informant processes specifically addresses Subgoals 11.1 (construction safety and health training needs assessment) and 11.2 (surveying current training programs about gaps in training on this topic).

B. METHODOLOGY

Our purpose for conducting this study was to gather feedback from within the California unionized construction sector relating to nanotechnology and nanomaterials and to determine current involvement of state public agencies in monitoring nanomaterials. We would collect this information through a combination of online survey and key informant interviews. Our questioning centered around five topics:

1. Awareness levels among union/apprenticeship staff and contractors
2. Training
3. Concerns about the new technology
4. End user product recognition
5. Public agency monitoring, research, enforcement, outreach

In regard to awareness, training, and concerns among union representatives, similar work had been done previously by CPWR through voluntary completion of written surveys. Our goal was to expand upon their work by distributing our own survey questionnaire to SBCTC affiliates, apprenticeship programs and our network of safety program participants (primarily apprenticeship instructors and contractor health and safety trainers). Our survey was disseminated through the popular online *SurveyMonkey* platform which, for several years, we have used successfully to obtain feedback for our health and safety training programs. Participation in the survey was completely voluntary.

The online survey method offered the most efficient means for us to reach a larger pool of study participants. Online surveying has many positive aspects such as:

- An online survey link is easily shared electronically;
- Participants can complete the survey from any location at their own convenience;
- Easy to collect demographic information;
- Results can be tracked and viewed immediately;
- *SurveyMonkey* analytics can be used to compile and organize data;
- Summary results are easily accessed/shared among the research team.

The main drawback to this type of online questionnaire is that it best lends itself to closed, multiple choice, short fill-in-the-blank questions or answer drop-down menus. Also, survey design is limited to the options available through the *SurveyMonkey* platform. Survey results would successfully give us a static snapshot of our target population, but we also wanted to include a process for doing more in-depth follow-up with participants who might have more detailed information to share. For this purpose, we designed a key informant interview protocol for selecting a sub-set of survey participants to be interviewed by phone.

The online survey and key informant interview processes are described in more detail in sections B2 and B3 below. The three questionnaires used for the online survey and key informant interviews are included in the Appendices (Section G) of this report. Each

questionnaire was reviewed and approved for use by a CPWR Institutional Review Board (IRB) for protection of human subjects.

B1. Recruitment

Study participants were recruited from our pool of SBCTC union and trainer networks. The SBCTC has a 50-member Executive Board (E-Board), 22 affiliated local building trades councils (BTCs), over 140 local union affiliates (Locals) from 14 different crafts. Additionally, more than 125 union apprenticeship programs (JATCs) are linked to these affiliates and are on our communication listserv. Individuals who have participated in our health and safety train-the-trainer program (TOT participants) make up a second group of potential study subjects. These include many union apprenticeship instructors as well as employer representatives such as General Foremen, Superintendents, Safety Managers, Project Managers, and risk management specialists from various-sized contracting companies.

The SBCTC maintains an electronic listserv that acts as our main conduit for communications to our E-Board, BTCs, Locals and JATCs. Communications are regularly issued in the form of a *Bulletin* that goes directly to individual email accounts. At the beginning of June 2017, we released a *Bulletin* requesting that SBCTC affiliates participate in our study project and share the recruitment information with their signatory contractors. The announcement described the study as "related to new emerging technology in construction" and intentionally avoided use of the terms nanotechnology, nanoparticles, nano-enabled materials and engineered nanomaterials that were to be assessed in the survey. Mention of these terms in the recruitment process may have created some bias favoring participants with interest in, or prior knowledge of, the topic over those who might perceive it as something that doesn't apply to them. Our goal was to obtain feedback from a balanced cross-section of the target audience, not just people who already had awareness of nanotechnology.

The announcement disclosed that the study is funded entirely through a grant from the Center for Construction Research and Training (CPWR) as part of SBCTC's ongoing work to promote state-of-the-art training and the safety and health of California building trades workers. The following statements were included to inform potential participants about the study:

- **Purpose:** To assess levels of awareness and use of specific new technologies within California construction unions. There are no right or wrong answers, all responses are significant.
- **Potential Benefits:** Findings of this study will be shared nationally in a final report to CPWR to provide information and guidance for training and risk assessment for construction workers.

We also indicated the online platform that would be used, estimated time required to complete the survey, and that strict confidentiality protocols were in place to protect individual participant identities. A hyperlink was provided in the *Bulletin* that would take participants directly to the online survey.

For the TOT participant pool, we sent an invitation with a hyperlink similar to the *Bulletin* via email. In addition to this electronic outreach, we also made direct presentations to the E-Board, and to attendees at SBCTC trainings. We also reached out to the leaders of safety committees at three construction contractor associations by email and personal phone calls asking for their support in distributing our survey invitation to their affiliates. These associations were the Construction Employers Association (CEA), the United Contractors (UCON), and the Associated General Contractors (AGC). The CEA responded that it is their policy not to ask affiliates to take surveys from outside organizations and that they would not be able to help us recruit participants. The AGC indicated that they would be willing, but we never received confirmation that they actually distributed the information. UCON did not give a formal response, however our Project Coordinator distributed survey recruitment flyers at a silica training she presented to their safety committee.

Through June and July, the first two months the survey was open, we received 139 survey responses. At the beginning of August, we released a second SBCTC *Bulletin* reminding affiliates to participate in the study. In August and September we received another 179 survey responses, and one more late survey came in December before we closed the online link. Of the total 319 surveys received, 66 of them were either incomplete, blank or duplicates and did not qualify for the study. This left 253 viable surveys that are included in the study.

B2. Online Survey

The questionnaire used for the online survey included 31 questions. A blank copy of the survey is included in the Appendices. These questions followed specific topics of interest as outlined in Table 1.

TABLE 1—TOPICS COVERED IN ONLINE SURVEY	
Topic	**Question #**
Confidentiality Agreement/Consent	1
Demographic information and work experience	2-11
Awareness of nanotechnology	12-14
Training related to nanotechnology	15-19
Benefits and concerns related to nanotechnology	20-25
Information sources and need for training	26-28
eLCOSH Inventory	29-31

CPWR shared a sample of an 11-question written survey "OPCMIA Survey—Nanotechnology in Construction April 16, 2014" they had used previously when doing similar investigation. We incorporated 10 of their 11 questions into our online survey so that direct data comparisons could be made based on the results of our study. These survey questions related to: experience in the trades; application of nanotechnology in construction; training addressing nanotechnology; benefits and concerns related to nanotechnology (Likert-type scale); concern for specific nanoparticle types. We collected additional demographic information such as:

contact information; age group; current affiliation; job title; company/organization size. We also collected additional information about training experience, recognition of nanotechnology terms, information sources, and the eLCOSH Inventory.

Upon opening the survey, respondents view an information and confidentiality agreement and must actively indicate their acknowledgement and consent by clicking a checkbox. It is here that participants learn that the study topic is nanotechnology. Only when they agree, can they move forward with the survey. Participants navigate through five sections matching the topics identified in Table 1. The first eleven questions ask for basic demographic data. At question 12, nanotechnology terms are introduced for the first time. The survey design employs skip logic to automatically navigate participants through the questionnaire based on their responses to specific questions. For example, if a respondent indicated they had never heard of any of the four terms (nanotechnology, nanoparticles, nano-enabled materials, engineered nanomaterials), skip logic advanced them directly to the Product List section, as all questions in between would be moot.

No questions required an answer; participants could skip any questions that they did not want to answer. The most complex survey question was the eLCOSH Inventory review. We were committed to testing the list to determine to what extent these products are recognized within our target audience. To our knowledge, this has not been done before and this information could be helpful for future research. In order to include a list with more than 500 entries for review, it was necessary to insert it as an image. It would have been preferable to have participants review it as a checklist; however *SurveyMonkey* did not have a format that would support a list of this size.

Before presenting the list, we explain how the list is organized and warn respondents that it is quite long. We ask them to note any product they have heard about, seen on-the-job or actually worked with. After reading this information, respondents are asked to check a box indicating if they are willing to review the inventory list or prefer to skip the list. This helps us to know whether respondents made an active choice about the list versus just skipping the question. A majority (70%) of survey participants opted to review the list. CPWR provided the eLCOSH Inventory list to us in Excel format. The list was organized into categories by type of product. We assigned a letter code for each category and a number code for each product in that group. If a participant recognized a product, they would need to note the code letter and number and, in the next question, enter that information into the appropriate field for each category. This was not our preferred way of handling the inventory list, but it was the best way we could make it work given the limitations of the survey program.

Judging by the strong number of completed responses, we believe the survey design worked well. Most questions could be answered quickly and easily. We did not hear any negative feedback about the survey project from affiliates. Results of the survey are presented in Section C.

B3. Key Informant Questionnaires

Our study plan called for doing 20 key informant interviews with survey participants and three with staff from California government agencies. We created two questionnaires to be used for oral interviews in this study. Samples of both questionnaires are included in the Appendices. The first was for survey respondent follow-up interviews and the second for government agency representative interviews.

Survey follow-up

The purpose of these key informant interviews was to obtain more detailed information from a subset of survey participants who met one or more of the following selection criteria based on their questionnaire responses:

- Awareness of nanotechnology terms
- Recognized or used products identified in the eLCOSH Inventory
- Had received and/or delivered nanotechnology-related training
- Indicated concerns over potential risks of nanotechnology or nanomaterials

We analyzed the survey results and identified potential key informants. Once we identified a pool that met the above criteria, we narrowed the selection to achieve a balance of trades, and representation from union staff, apprenticeship, and employers. We reached out to members of this group and found 21 who agreed to be key informants. The demographics of this final group are summarized in section B4.

The informant questionnaire is written in a scripted format so that the interviewer could assure consistency between interviews. The interviewer begins by reading a disclosure explaining the purpose for the interview, that it is voluntary, can be stopped at any time, how results will be reported, the confidentiality agreement and informed consent. We also ask permission to digitally record the interviews to assure we capture informants' responses accurately. All 21 interviewees agreed to be recorded.

Questioning begins with demographic information: occupation; trade; employment status; job title; years in the trade. Since this interview is being conducted in follow-up to the interviewee's survey responses, the questions match the topics covered in the online survey. There are a total of 24 questions that relate to nanotechnology awareness and knowledge, eLCOSH Inventory, training, risks and concerns. Key informants are only asked questions that are relevant to their survey responses, so not all 24 questions are covered with each interviewee. Our hope was that we could prompt key informants to describe their thoughts related to nanotechnology and provide more details about their experiences. The length of these interviews averaged 23 minutes (range: 9-46 minutes) per subject.

Government Agency Representatives

The purpose of these interviews is to find out what's being done within key California public agencies related to oversight of nanotechnology, hazard information, protections for workers, monitoring, tracking, and regulation. These key informants are staffers working within

Cal/OSHA, the Department of Public Health (DPH), and the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC) sharing their perspectives on nanotechnology. The interview included 13 questions pertaining to the role different agencies serve with regard to nanotechnology, current programs, enforcement, education, collaboration and data sharing. We explored interviewees' knowledge of applications of nanotechnology in construction and if any specific issues or concerns have surfaced. We also wanted to learn who their trusted sources are for information about nanotechnology and nanomaterials. These interviews ranged from 30-60 minutes in length.

B4. Demographics

This information is summarized separately for online survey respondents and key informant interviewees, the two main groups addressed in this study. In the online survey we asked for quite a lot of demographic information. This is useful not only to assure we met our target population goals, but also to look for any trends that may emerge among subgroup relationships with nanotechnology. Since key informants were a subgroup of survey respondents, we simply asked for their occupation, trade, and how many years they had worked in construction.

B4a. Online Survey Overview

- **Contact Information:** We collected participant names, e-mails and phone numbers so that we could contact candidates for key informant interviews.

- **Age Groups:** Respondents were asked to check one of five predefined age groups. Almost three quarters of the survey group were over 45 years of age. This is not atypical of our target population of union and apprenticeship staff. Most of these positions are filled by journeymen craft workers who transition from working "with the tools" into leadership, administrative, and instructor roles.
  - 41% (n=103) were over 55 years of age
  - 31% (n=78) were 45-54 years of age
  - 21% (n=52) were 35-44 years of age
  - 6% (n=16) were 25-34
  - 1% (n=3) were 18-24 years old.

- **Affiliation:** Respondents were asked to identify their current affiliation from a list of five options, including "other" in which they could write-in their own description. While 17% of respondents chose the "other" option, they wrote-in affiliations covered by one of the four options we had listed. These responses have been allocated to the appropriate category in the summary below.
  - 40% Union Apprenticeship Representative (n= 101)
  - 30% Union Representative (n= 76)
  - 19% Construction Craft Worker (journeyman/apprentice)—includes 8 retirees (n= 49)
  - 9% Construction Contractor Representative (n= 22)
  - 2% Other (risk management, safety consultant, educator) (n= 4)

This list meets our target audience for the study. It makes sense that the strongest participation (70%) came from union and apprenticeship staff given that this is the core group the SBCTC represents. We have a strong working relationship with union apprenticeship programs and have built a solid reputation for offering health and safety training to their instructors and coordinators. We believe that these individuals have a lot to offer to this study as they are responsible for teaching their craft and providing health and safety training to both apprentice and journey level workers. We had hoped to get more participation from employers, but they seemed reluctant to buy into the project.

- **Job Titles:** We received 246 responses to this fill-in-the-blank question, 7 chose to skip. Our respondents represent a good cross-section of positions within our target audience. These are individuals who have influence over training, deal with workers' concerns and issues at their job sites, manage health and safety protocols and make decisions about materials. We would expect these leaders to be well positioned to provide feedback on innovations and new technologies that impact their crafts and job sites.

Category	Job Titles Summary
Apprenticeship	Administrator; Training Director; Coordinator; Instructor; Facility Supervisor
Union	Business Manager; Assistant Business Manager; Business Agent/Rep; District Rep/Trustee; Compliance Officer; Secretary/Treasurer; President; Vice President; Organizer;
Construction Management	Safety Coordinator/ Director/Manager; Senior Safety Engineer; Site Safety Manager; Project Executive/Manager/Estimator; General Foreman; Superintendent; Logistics Superintendent;
Craft Workers	Foreman; Journeyman; Apprentice; Technician; Installer; Retiree
Risk Management	Senior Risk Consultant; Owner Safety Consulting

- **Company Size:** Respondents were asked to identify the size of their company/organization by selecting from a range of five options. There was also an "I Don't Know" option available. More than half (52%) of the 250 respondents who answered this question indicated they worked for companies/organizations with more than 200 employees. The next largest group (12%) represented companies with less than 20 employees. The third largest group (10%) fell into the "I Don't Know" category. The remaining responses were almost evenly spread among the other options as follows: 9.6% 100-200 employees; 8.8% 20-50 employees; 7.6%

50-100 employees. It is difficult to interpret the significance of these numbers because we don't know how respondents interpreted the question. For union reps they may be referring to the number of members in their local. Apprenticeship program instructors can work full-time for the training center or work full-time in their craft and also teach nights or weekends at training centers.

- **Crafts Represented:** One of our goals for this study was to gather feedback from a cross-section of construction trades. All survey respondents (n=253) answered this question, none opted to skip. The survey questionnaire asked respondents to identify their primary trade by choosing from a list of 25 crafts. In addition to this list, respondents could choose an "Other" option and write-in their own description or select "I have not worked in a trade." Some of the responses given in the "Other" category actually fit into one of the 25 listed crafts. We have added those responses to the totals for these respective crafts. Only 4 individuals (2% of respondents) indicated that they had not worked in a trade.

  The breakdown of responses by individual craft is as follows:

  33% Electrical Workers (n=83)
  22% Plumbers/Pipefitters/Steamfitters (n=55)
  11% Heat and Frost Insulators (n=27)
  6% Iron Workers (n=14)
  4% Operating Engineers (n=9)
  3% Sheet Metal Workers (n=7)

  For crafts that had four or fewer respondents, results are summarized here in aggregate:

  - 4 respondents each: Cement Masons; Drywall Finishers; Painters; Roofer/Waterproofers. (n=16)
  - 3 respondents each: Boilermakers; Carpenters; Floor Covering Installers; HVAC; Laborers; Plasterers. (n=18)
  - 2 respondents each: Elevator Constructors; Glaziers; Tile Layers/Finishers; Bricklayers. (n=8)
  - 1 respondent each: Drywall Lathers; Millwrights; Teamsters (n=3)

  9 people clicked the “Other” box; those we couldn’t add to our list of crafts included 5 in construction safety, one tradeshow installer, one in IT, and 2 general contractors.

  We were thrilled to have all but one craft (Pile Drivers) represented in our study even though many crafts had only 1-2 participants. We were surprised to have as many Electricians and Plumbers/Pipefitters/Steamfitters respond. This may be attributed to them having large union locals and bigger training centers that could distribute our survey invitation to a larger pool. The Insulators have a keen interest in the topic of nanotechnology and they distributed the survey invitation to their international union which is why we got responses from outside of California.

- **Years in the trade:** This question seeks to measure levels of experience among respondents. Of the 246 respondents who answered this question, 41% had been in construction for 30+ years; 28% were in for 20-29 years; 21% for 10-19 years; 5% for 5 less than four years; and just under 5% for 5-9 years.

- **Training of others:** Since training is one of the key topics of interest in our study, we wanted to know what percentage of survey respondents actually provide training to others in construction. The majority of respondents, a little more than 77% (n=196) indicated that they provide training to others. Less than a quarter of survey participants were non-trainers.

  The trainer subgroup was then asked to indicate primarily who they train from a list of six options. Respondents could select more than one option. They could also select "Other" and fill in their own answer. The top answer was "Apprentices at a union JATC" receiving 74%. The second most selected option at 43% was "Journeymen at a union JATC" followed by "Front-line workers on-the-job" at 26%, “Foremen" at 19%, "Union staff" at 11%, and "Management" at 9%. Responses in the "Other" option totaled 5% and included: other trainers; those who train “all of the above;” union members; college students; project management teams.

  We also wanted to know respondents' level of experience as trainers. Those who train were fairly evenly spread across the number of years they’ve been training. A slight majority (29%) had been training for 10-19 years, followed by 27% who had trained less than 4 years, and next 25% who had trained from 5-9 years. It is notable that a little over 10% had been training for 30 years or more, and just under 10% for 20-29 years. Close to half of survey participants who are trainers have more than 10 years of experience at delivering construction training.

This concludes the demographic information collected through the online survey. Results of the remaining survey questions are reported in "Section C. Results/Data Summary." We feel we met our target population goal, reaching a diversity of trades and a balance of apprenticeship and union representatives. Of note, we had fewer contractors respond than we anticipated. We did significant outreach to contractor organizations that we had worked with in the past to help us disseminate the survey to their members. The response to this outreach could be described as "lukewarm" with one association declining outright our request to share the survey with their members. Other associations showed slight interest but did not actually follow through in disseminating the survey request to their members. The contractor representatives who did participate in the study were, for the most part, individuals who had attended health and safety training programs that we offer.

B4b. Key Informant (Survey Follow-Up) Overview

The 21 survey respondents interviewed as key informants came from 13 different crafts. In choosing these individuals from the pool of eligible candidates, we selected for a cross-section of crafts and for those whose questionnaire answers met multiple aspects of our selection criteria. Given the scope of this study project, it was feasible only to interview a small number of key informants. We realized from the outset that it would not be a statistically relevant sample size representative of any one group. Therefore, we were most interested in hearing several different perspectives from a variety of participants who had many years of experience working in construction. Through these conversations we hoped to gain further insight into their understanding of nanotechnology generally as well as give them the opportunity to describe any specific experience in their own words. The following demographic information describing this subset was derived from a combination of their interview and survey responses.

- **Age Groups**
  57% (n=12) were over 55 years of age
  29% (n=6) were 45-54 years of age
  5% (n=1) was 35-44 years of age
  10% (n=2) were 25-34

- **Current Affiliation:** We noted that many had changed roles in their careers, often moving from positions in apprenticeship programs to union staff or vice versa.
  52% (n=11)—Union Apprenticeship representatives
  24% (n=5)—Union Staff
  14% (n=3)—Contractor/Management
  10% (n=2)—Multiple roles (Apprenticeship/Union officer; Craft worker/Union staff)

- **Job Titles:** Administrator; Business Agent; Business Manager; Business Rep; President; Coordinator; Director; General Foreman; Instructor; Superintendent; Safety Manager; Journeyman

- **Company Size:** The demographics of this subgroup closely mirror those of the larger survey group, with more than half working for companies/organizations with more than 200 employees, the second largest group for companies with less than 20 employees. The breakdown is as follows:
  >200 employees (n=13)
  <20 employees (n=3)
  100-200 employees (n=2)
  50-100 employees (n=1)
  20-50 employees (n=1)
  Didn't know (n=1)

- **Crafts Represented:** The trades with the most representation in the online survey were electricians, plumber/pipefitters/steamfitters, and insulators. We factored this into key

informant selection along with the other criteria. The following trades were represented by key informants:

Insulators (4)
Plumber/Pipefitter/Steamfitters (3)
Electricians (2)
Cement Masons (2)
(All remaining had 1)
Boilermakers
Carpenters
Drywall/Lathers
Elevator Constructors
Millwrights
Plasterers
Roofers/Waterproofers
Sheet Metal Workers
Tile Layer/Finisher

- **Years in the Trade:** Key informants had a high level of experience working in construction, with 67% (n=14) having worked 30 or more years in the industry. Of the remaining 7 individuals, 4 had been in construction for 10-19 years and 3 for 20-29 years. Most had worked their way up the ranks from front-line craft worker to positions in apprenticeship programs, union staff positions, or management. Of the 21 individuals in the key informant subgroup, 3 still actively worked in their trade at construction job sites, 86% were no longer "working with the tools." It is important to note that this reflects our target audience for the scope of this study project; we did not plan to recruit journey level or apprentice front-line workers.

- **Training of Others:** Within our key informant subgroup, 90% are actively involved in training workers either on-the-job or through apprenticeship programs. Only 2 individuals indicated they did not train others. The level to which union construction stakeholders are receiving or giving training relevant to nanotechnology is one of our topics of exploration through this study.

In summary, the survey follow-up key informant group includes highly-experienced construction professionals who hold leadership positions and have control over worker training programs. While they may not work with the tools anymore, they are the people responsible for educating union workers to perform their craft, managing joint programs with employers, addressing health and safety training and concerns, and preparing new workers just entering the profession for using cutting-edge technologies and products in the heavy industrial/commercial construction sector. Their understanding and perception of nanotechnology can be expected to influence the workforce in a significant way.

B4c. Key Informant (Government Agency) Overview

We were able to get five individuals serving on staff at three California government agencies to agree to be interviewed for our study. The agencies represented are: Cal/OSHA; Department of Public Health (DPH) Health and Human Services (HHS) and Occupational Health Branch (OHB) sectors; CA Environmental Protection Agency Department of Toxic Substances Control (DTSC).

These individuals have held the following job titles: Senior Safety Engineer; Toxicologist; Research Scientist; Chief of Site Assessment; Deputy Director; Chief Scientist.

Three of the five people interviewed had worked at their agencies in various capacities for 25-30 years, and the remaining two for 2-6 years. All had some level of experience with nanotechnology and nanomaterials. None of the interviewees participated in our study as official public information spokespersons for their agencies, but rather, were sharing their personal experience working as professionals within the public sector. We will consider the input they shared to be their own and not necessarily reflective of the position of their agency. Results of these interviews will be presented in aggregate to protect the confidentiality of individual respondents.

C. RESULTS/DATA SUMMARY

The information we collected in this study falls under these key topic areas as identified in Section B2 Table 1:

- Awareness of nanotechnology
- Training related to nanotechnology
- Benefits and concerns related to nanotechnology
- Information sources and need for training
- eLCOSH Inventory

These topic areas apply to both the survey and follow-up interview data we collected, however, because these two methods are very distinct, it is most efficient to present the results separately. Online survey results are summarized first in Section C1 and then follow-up key informant interview feedback in Section C2.

Key informant interviews of government agency staff followed a different line of questioning that was more appropriate to their experience level. Results of these interviews are summarized in aggregate in Section C3 and are organized by individual question rather than general topics.

C1. Online Survey Results

The following is a summary of data collected from the 253 surveys completed online through the *SurveyMonkey* platform. The demographics for this group of respondents was described previously in Section B4a.

C1a. Awareness of nanotechnology

There were three questions (#s 12-14) designed to determine to what extent study subjects had basic awareness or recognition of nanotechnology. These related to nanotechnology terminology, applications in construction, and personal experience with nano-enabled materials.

Question #12 asked participants to indicate if they had heard any of these four terms:

Nanotechnology
Nanoparticles
Nano-enabled materials
Engineered nanomaterials

They were instructed to select all that applied. Respondents could also indicate that they had never heard of any of the terms or that they were not sure if they had heard them or not. All 253 survey participants responded to this question. At this point, two distinct groups immediately emerged, those with and without knowledge. 81% (n=205) of survey participants responded in the affirmative, recognizing one or more of these terms or indicating that they weren't sure if they had heard them. These respondents continued forward to the next survey question.

The second group comprising 19% (n=48) of survey participants indicated that they had never heard of any of the terms. This effectively tells us they have no awareness of nanotechnology at all. At this point, these respondents were automatically advanced to the final set of questions regarding the eLCOSH Inventory product list, skipping the bulk of the survey in between. We felt that it would be fruitless to have participants go through a lot of questions about which they likely had no knowledge but believed it would be significant to know if they recognized any nano-enabled products from the inventory, whether or not they were aware of nanotechnology generally. We will look at results from this smaller sub-group first.

Subgroup Indicating No Awareness

While our survey gathered much more information from study participants who indicated some level of knowledge about nanotechnology, we were equally interested in examining the makeup of the group who did not indicate any awareness. This information can be very useful for targeting future outreach and education efforts.

The 48 survey respondents who indicated no awareness of nanotechnology terms came from 14 different trades as shown below. For most of these trades, these individuals represented only a portion of total survey respondents from their craft. These percentages are shown in column two. The one exception is Floor Covering Installers; 100% of whom indicated they had not heard of terms.

Trade	**% of Total Respondents Surveyed from That Trade (=n)**
Floor Covering Installer	100% (3)
Drywall Finisher	50% (2)
Operating Engineer	44% (4)
Carpenter	33% (1)
HVAC	33% (1)
Laborer	33% (1)
Plumber	30% (6)
Cement Mason	25% (1)
Painter	25% (1)
Iron Worker	21% (3)
Electrician	16% (13)
Sheet Metal Worker	14% (1)
Pipefitter/Steamfitter	11% (4)
Insulator	11% (3)

With regard to affiliation, this subgroup closely matched the composition of the general survey group. Shown below is the breakdown within the subgroup and the percentage of total survey respondents they represent:

Affiliation	% of Subgroup	% of Larger Survey Pool w/Same Affiliation
Union Apprenticeship	46% (n=22)	22%
Union Representative	27% (n=13)	17%
Construction Craft Worker	19% (n=9)	18%
Construction Contractor	8% (n=4)	18%

We discovered that three of the respondents who self-identified their affiliation as Union Apprenticeship Representatives concurrently hold positions for contractors as safety managers and foremen. It is not atypical in the union construction sector for individuals to hold more than one position, working on jobsites during the day and instructing apprentices at evening or weekend classes. We trust that study participants chose the affiliation that best represents them.

More than half of this subgroup were from large companies/organizations with over 200 employees and over 83% provide training to others. All but two have worked in their trade for 10 years or more, with over 36% having more than 30 years of experience. Positions held by these individuals are: Safety Manager; Project Manager; Senior Safety Engineer; General Foreman and Foreman; Instructor; Apprenticeship Coordinator; Business Manager; Journeyman; Apprentice; Business Rep; District Rep.

We did not find signs from this information to indicate that this subgroup stands-out as significantly differing from the larger pool of survey respondents. The sample size is simply too small to infer any general conclusions. When looking at only a few individuals, differences may be attributed to any number of personal factors that influence awareness. What is interesting is that, for the majority of these trades (12 out of 14), more respondents had heard of nanotechnology than not, even though other factors (affiliation, company size, job title, years of experience, trainer status) were consistent.

Regarding affiliation, just under a quarter of all survey respondents representing apprenticeship training programs indicated no awareness of nanotechnology terms. Most of this subgroup are trainers yet have no awareness. It also seems surprising that employer representatives in high level positions relating to safety, project management and worker supervision are among those with no awareness of nanotechnology.

Almost a quarter (n=11) of these 48 study participants, while having no awareness of nanotechnology, recognized products in the eLCOSH Inventory. These findings will be covered in Section C1e.

Subgroup Indicating a Level of Awareness

Of the 205 who gave affirmative answers to Question 12, only 19% (n=47) were “not sure” if they’d heard of any of the terms. Of the four terms tested, "Nanotechnology" topped the list for recognition with "Nanoparticles" being the second most recognized.

Awareness of terms diminished each time they became more specific such as "Engineered nanomaterials" and "Nano-enabled materials." We did not randomize choices on this survey question; nevertheless the last two terms were not selected in the order listed. Here are the results for this subgroup:

- Nanotechnology 77% (n=157)
- Nanoparticles 45% (n=93)
- Engineered nanomaterials 29% (n=59)
- Nano-enabled materials 27% (n=55)

Because it was a "check all that apply" question, 48% (n=98) of respondents selected multiple terms. Of those, 41 recognized all four terms, 11 recognized three terms, and 46 recognized two terms from the list.

The 41 who demonstrated the greatest awareness of terms came from these trades in descending order: Electricians; Insulators; Pipefitter/Steamfitters; Roofer/Waterproofers; Iron Workers; Plasterers; Plumbers; Cement Masons; Glaziers; Sheet Metal Workers; Tile Layers/Finishers. There were also 4 contractor representatives in this group who were not affiliated with any trade. All 205 participants advanced to the next awareness questions. Questions #13 and #14 of our survey ask for the same data that was covered in four questions on 2014 OPCMIA survey provided to us by CPWR.

Question #13 asked if respondents were aware of nanotechnology being applied in the construction industry and/or that products containing nanomaterials are commercially available in the United States. Within this subgroup of 205 participants, 44% (n=90) answered no and 31% (n=63) said yes. The remaining 25% (n=52) were not sure. At this point, those respondents who checked "no" were automatically advanced to Question #20 relating to Nanotechnology Benefits and Concerns, skipping past the personal experience and training questions. Logically, if these respondents had seen or used nano-enabled products on-the-job or received/delivered training about nanotechnology in construction, we could infer that they would have answered this question affirmatively. The remaining 115 respondents continued on to the next series of questions.

With Question #14 we tried to delve deeper to learn if the 115 respondents had any personal experience with nano-enabled products. 22 said that they had “noticed product(s) incorporating nanotechnology or marketed with the word "nano" on-the-job. 13 said they had actually worked with a nano-enabled product first-hand. 25 knew other workers who had used nano-enabled products but had not themselves. 51 had no experience of nano products and 25 did not know. This was a "check all that apply" question and some individuals checked multiple boxes.

Looking more closely at the responses of the 13 who knew they had actually worked first-hand with nano-enabled materials, we learned that the majority (11) are Insulators. The remaining 2 are a Painter and a Pipefitter/Steamfitter. It is significant to note that this group represents only 5% of all online survey participants.

Those who had used products were asked to describe them in a comment box. The Insulators, who were hyper-aware of one specific group of nano-enabled insulation products, provided the most comments (7) about the materials. These products caused them great concern and we hear about them throughout the survey and key informant interviews. Their concerns are discussed later in Section C1c. Two other comments were made by non-Insulators, one mentioning new orbital welding machines with "nano heads," while the other referenced having worked as a mechanical contractor in the semi-conductor and pharmaceutical industries but did not actually identify any specific products.

Awareness of nanotechnology among the majority of our survey population appears to be fairly general, and primarily related to recognition of commonly used terms. We cannot know from this level of research if that knowledge comes from their construction experience or from other sources unrelated to their work. Nor does it tell us the depth of their understanding of these terms. The number of survey participants who have more specific awareness decreased each time we asked more detailed questions, and dropped significantly when we looked for first-hand, personal experience using actual applications of nanotechnology in construction. In fact, that experience was clearly dominated by one craft.
We cannot discern from the survey responses how many participants may unwittingly be exposed to nanotechnology and nano-enabled products in construction. The next section continues on with the 115 respondents to explore levels of training they had given or received.

C1b. Training Related to Nanotechnology

Survey questions 15-19 attempt to determine what levels of training individuals experience on the topic of nanotechnology and nano-enabled products. This is similar to a line of questioning used in the 2014 OPCMIA survey provided to us by CPWR.

Question #15 asks participants if they have received and/or delivered training related to nanotechnology or nanomaterials in construction. We received 114 answers to this question. A vast majority of 89% had never had training (n=88) or were not sure if they had training (n=13). These respondents advanced to Question #19, skipping the training detail questions.

Only 5 respondents (4 Insulators and 1 contractor safety consultant) indicated they had received training, accounting for only 4% of the group. The 4 Insulators received training from the company manufacturing and marketing the nano-enabled insulation products. Although we were not able to gather specific details about this training in the online survey, we gathered feedback from Insulators in the follow-up key informant interviews. The safety consultant had

attended a Stanford University research presentation; it was unclear as to whether this related to construction or more generally to nanotechnology.

A total of 8 people (7 insulators and 1 electrician) said they had delivered training on the topic of nanotechnology. Question #16 asked these respondents to describe the training materials they used. Answers included: videos; handouts; Safety Data Sheets; product brochures and product materials; CPWR research material. In Question #17 respondents identified their training material sources as follows: CPWR; product manufacturer materials delivered by company reps; the internet; the environmental health and safety division (no further details were given with this entry). Question #18 asked respondents to use a Likert-type scale to rate usefulness of their current materials ranging from "not useful" to "very useful": 6 felt the materials were useful; 1 rated them very useful; and 1 said they were somewhat useful.

A final question concludes the training section of the survey. At this point we get back to the group of 115 respondents who were aware of nanotechnology applications in construction. Question #19 asks if respondents are interested in getting new training materials regarding nanotechnology in construction. A large majority (75%) were interested. Only 6 were not interested, and 24 were not sure.

What we learned from this section of the survey is that very few respondents have received any training about nanotechnology or nano-enabled products. The 5 respondents who had been trained represent barely 2% of all online survey respondents. Based upon survey results, the only trade that seems to be receiving and delivering training are the Insulators. The training they receive is primarily being presented by company representatives from a manufacturer specific to their product. It is difficult to determine from the survey responses to what extent this training includes general education about nanotechnology applications in construction or health and safety information versus training on how to use their product. More details are revealed from Insulators in the key informant interviews as well as input from other trades that may not have been captured in the survey. We also learned that there is strong interest in new training materials about nanotechnology.

C1c. Benefits and concerns related to nanotechnology

In this section, we return to gathering information from the larger subgroup of 205 respondents who indicated some awareness of nanotechnology through recognition of terms. Our interest here is to explore perceptions and attitudes about nanomaterials and nanotechnology generally. We are looking for any trends in positive, negative, or neutral opinions about possible benefits and effects from nanotechnology applications.

Survey questions #20-23 were taken directly from the 2014 OPCMIA survey provided to us by CPWR. The first three ask respondents to use a Likert scale with 8 choices ranging from "strongly disagree" to "strongly agree" or an "I don't know" option to describe their level of agreement with statements about nanotechnology. Question #23 provides a list of known nanoparticles and asks respondents to check any that raise health and safety concerns. There is

also an "I don't know" option. Question #24 asks respondents who checked items on the list to explain their concerns about these nanoparticles.

About half of survey participants who answered each question chose "I don't know" as their response. Of those who chose a rating from the scale, a slight majority of our respondents were neutral, neither agreeing nor disagreeing with the statements. For those who were not neutral, the propensity was towards agreement to each question. The strongest agreement was that nanotechnology could provide significant environmental and public benefit. Next was that occupational exposures could pose a significant health risk. And last was that nanotechnology in construction could potentially harm the environment. These are the results for each question.

Strongly Disagree	Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Agree	Strongly Agree	I don't know

Occupational exposures to nanomaterials likely pose a significant health risk to construction workers.

2	5	7	39	9	24	13	106

Discounting the 106 people who marked “I Don’t Know” the weighted average of those who answered is 5.94, which is just shy of “Agree.”

Use of nanotechnology in construction has the potential to provide significant environmental and public benefit.

2	7	1	30	15	43	8	99

Discounting the 99 people who marked “I Don’t Know” the weighted average of those who answered is 6.36, which is a strong “Agree” moving toward “Strongly Agree.”

Use of nanotechnology in construction has the potential to significantly harm the environment.

0	8	4	45	12	20	3	113

Discounting the 113 people who marked “I Don’t Know” the weighted average of those who answered is 5.52, which is midway between Slightly Agree and Agree.

When asked whether specific nanoparticles raise occupational health and safety concerns, 66% (n=133) of 201 respondents said, “I don’t know.” The remaining 68 respondents noted concern about each of the items on the list as follows:

Nanoparticles	**Number of Responses**
Zinc Oxide	52
Aluminum Oxide	50
Titanium Dioxide	42
Cerium Oxide	36

Copper	34
Carbon Nanotubes	34

Question #24 asks these respondents to further describe their concerns about these nanoparticles in a write-in comment box. 57 of our respondents explained their concerns as follows:

- 13 responses expressed concern about generic "health effects." Comments:
  "Coming from an industry that dealt with the asbestos issues, members are scared."
  "So small you can't see, similar to silica."
- 14 responses cited respiratory programs, lung damage, and inhalation.
- 12 responses were about the "unknown." These included:
  "Past history leads me to be cautious of materials I am not completely familiar with. What you don't know can kill you."
  "If you are asking the questions, I need to know and be informed."
  "I don't know how they are being applied."
  "That materials will be used without proper testing."
  "My concern would be that we don't necessarily know enough about these different materials and their potential risk to workers now or in the future due to prolonged exposure."
  "That most workers will not know their exposure levels until it is too late."

- Other concerns were about different types of health effects. These included:
  - Dust and material that does not wash or may be air blown coming in contact with skin or other body surface;
  - Ingestion of small particulates;
  - Eyes, lungs and skin;
  - Nanoparticles crossing a cell membrane and causing harm to cellular mechanisms;
  - Cancer or Alzheimer's disease;
  - "Safety practices to limit airborne exposure and the health risks of exposure"

- 2 people mentioned specific concern about aluminum, one about titanium, and one about carbon nanotubes.
  - Any amount of metal exposure can be a potential for poisoning if precautionary measures fail. As well as certain nanoparticles being a key contributor to the possible creation of adenocarcinomas cancer cells in the human lungs.
  - Coating air molecules with various elements that have the capability to move through humans. My first train of thought is always about what is left behind or what did not make its way out.
  - Environmental runoff and overall lack of training by installers and end users.
  - None….not really sure what risks they pose if they have been cleared by government?

- If any of these become or are ingredients in any of the materials that the cement mason uses.
- Need to educate myself on this subject before I am opinionated.

In Question #25 we ask respondents if they are aware of any worker health issues or complaints related to working with nanomaterials. Of the 198 people who answered this question, a large majority 92% (n=183) answered "no" with only 15 individuals saying yes. Of these 15 who said they were aware of complaints, 12 were insulators, and the others were a sheet metal worker, electrician, and a plumber/pipefitter. When asked to describe the issues/complaints, 10 were specifically concerned about dry skin, bloody nose, can't wash it off; drying out skin and eyes; difficulty breathing; the immediate health effects such as moisture absorption to your entire body. Two people mentioned Mesothelioma. One said that the workers hate the product, but this was mostly because it was difficult to get a professional finish and to clean up.

C1d. Information sources and need for training

In this section of the survey we seek to learn more about where our study subjects would likely search for information and if they would have interest in being provided with nanotechnology information in the future. We also are interested in knowing their opinion regarding the value of future training on this topic.

Survey Questions #26-28 applied to our 205-respondent subgroup. These respondents were asked to check (from a list of 10) which sources they would trust most if they wanted to learn about potential hazards of working with nanomaterials. In descending order, these were:

Cal OSHA (127)
Federal OSHA (98)
Union (96)
CPWR (73)
NIOSH (68)
Internet Search (60)
Trade/Employer Association (40)
Industry journals (39)
Colleagues (31)
My employer (25)
Other (please specify) (11) Respondents wrote-in: independent studies; the SDS; the Canadian Ministries of Labour and Health; environmental organizations.

74% of our respondents indicated that they would be interested in getting more information about nanotechnology or nanomaterials in construction. 16% were not sure and 10% were not interested in further information.

When asked if providing training about nanomaterials in construction would be valuable, 67% (n=136) of our respondents felt that it would and 31% indicated they were not sure. Only four people said that there would be no value.

C1e. eLCOSH Inventory

As part of the study, we wanted to find out if people had awareness of any nano-enabled products. The final three survey questions address respondents' awareness of products listed in the eLCOSH Inventory. We got the list from CPWR and it numbered more than 500. We were challenged by how to present such a large list in a way that enabled respondents to most easily find the products that might relate to their craft. A further challenge was that *SurveyMonkey* design options did not let us include any kind of check boxes next to the product names. We dealt with these challenges by clearly headlining each product group and numbering each product. Respondents were then instructed to jot down the number assigned to each product that they recognized, and list those numbers at the end. No doubt, we lost several responses with this process.

All 253 survey participants had the option of answering these questions. Participants first indicated if they were willing to review the rather lengthy list of products. 71% (n=179) of respondents agreed to review the list. The remaining 74 survey participants who preferred to skip the list review advanced past the remaining questions to the end of the survey.

Of the 179 participants who reviewed the list, 32% (n=57) said that no products looked familiar and 24% (n=43) were not sure. 44% (n=79) responded that some products stood out as ones they recognized or had used. Out of these 79, there were 68 respondents from our subgroup of participants with awareness of nanotechnology and 11 from the subgroup with no awareness of nanotechnology. We will review the eLCOSH Inventory findings for each of these groups separately beginning with those who had never heard the nanotechnology terms.

Subgroup Indicating No Awareness

From the subgroup of 48 respondents who had not heard of nanotechnology or other related terms, 11 recognized or had used products listed in the eLCOSH Inventory. Of these, 7 identified specific products in the following 20 out of the possible 33 categories:

- Coatings (Paints)
- Coatings (mineral surfaces)
- Coatings (Glass/Ceramic)
- Coatings (Multi-surface)
- Coatings (Wood)
- Coatings (metal)
- Lumber
- Drywall
- Metal
- Weatherproofing membranes
- Additives for concrete/cement
- Additives for Asphalt
- Additives for coatings
- Adhesives
- Caulking

- Cement-based
- Flooring
- Patching compounds
- Surface preparation
- Thermal spray coating materials

A table listing the specific products identified in each category is included in the Appendices. The 7 respondents came from the following 6 trades: Carpenters; Cement Masons; Drywall Finishers; Floor Covering Installers; Iron Workers; Plumbers. The most frequently recognized product listings in the eLCOSH Inventory are generic such as: exterior/interior paint; treated lumber; shower and tile treatment. Unless 100% of these available products on the market are nano-enabled, it is not clear whether respondents are using nano or non-nano products.

Subgroup Indicating a Level of Awareness

From our subgroup of 205 respondents who had heard of one or more nanotechnology terms, 68 recognized or had used products listed in the eLCOSH Inventory and 58 of these actually listed the products they recognized. This group represented 18 different crafts (listed below), a safety consultant and a General Contractor Safety Director.

Boilermakers
Carpenters
Cement Masons
Drywall Finishers
Drywall/Lathers
Electricians
Elevator Constructors
Glaziers
Insulators
Iron Workers
Millwrights
Operating Engineers
Painters
Pipefitters/Steamfitters
Plasterers
Plumbers
Sheet Metal Workers
Tile Layers/Finishers

The two categories with the highest responses were Insulation and Lumber with 21 and 18 responses each. The categories with recognized products are listed below in descending order.

- Insulation
- Lumber
- Drywall
- Caulking

- Coatings (Glass/Ceramic)
- Coatings (Paints)
- Coatings (mineral surfaces)
- Coatings (metal)
- Weatherproofing membranes
- Adhesives
- Weld Overlays
- Coatings: Multi-surface
- Coatings: Wood
- Cement-based
- Joint Sealants
- Additives for concrete/cement
- Metal
- Patching Compounds
- Flooring
- Fuel Additives
- Surface preparation
- Roofing
- Additives for Asphalt
- HVAC
- Additives for coatings
- Lubricants
- Thermal Spray coating materials
- Glass and solar panels
- Miscellaneous

For the following categories, respondents entered information that did not match our coding system, so their answers are not clear. Each of the first 3 categories have only one product so it is possible that respondents meant to identify that. There are multiple products listed in the "Prepregs" category so we're not sure which of these respondents were trying to identify.

- Fasteners
- Interior design
- Boiler Additives
- Prepregs

It is interesting that, if we count the 4 categories with unclear responses, survey participants identified products in all 33 categories that were included in the eLCOSH Inventory. In total, 65 survey participants made the effort to note specific products that stood out to them from the eLCOSH Inventory. This represents 36% of respondents who claimed they reviewed the list and 26% of all survey participants. A majority of our survey participants did not identify specific products for reasons unknown. The list may have been too long and complicated. The method we needed to use to note products may have been too cumbersome. For some who had never

heard of nanotechnology, looking at a long list may have seemed fruitless even though we did not say the products on the list were nanomaterials. This is a first attempt at bringing the eLCOSH Inventory to our target audience. The response level we achieved was better than we had expected. Additionally, the key informant follow-up interviews helped us learn more about this question with 16 of our 21 subjects having participated in the eLCOSH Inventory review. These individuals represent 9 different crafts and a contractor. These results will be presented in the next section on key informant interviews.

C2. Key Informant Follow-Up Interview Results

The 21 respondents who participated in key informant interviews were selected because their online survey responses indicated they possessed some knowledge and/or direct experience with nanotechnology/nanomaterials, had received training on the topic, or held some concern about its use in construction. Our line of questioning used in these interviews was divided into four segments related to the topics covered in our online survey:

- Awareness—We asked questions that would draw out more detail about the respondents' general knowledge of nanotechnology, their understanding of its meaning, their ability to describe it to others, and its application in construction. Also, in this section, we explore their perspective on nanotechnology's impact on construction and any information they would like to have on the topic.
- Product Experience/eLCOSH Inventory—In this segment, our questioning refers back to products respondents identified from the eLCOSH Inventory, their history and experience with these materials, product-related training they may have received, and their reaction to using these materials in their trade.
- Training about Nanotechnology—Respondents are asked to describe any training they have either received and/or delivered as well as ideas for what information they feel should be covered in new training that may be developed on the topic.
- Risk and Concerns Related to Nanotechnology/Nanomaterials—This section provides respondents the opportunity to open-up and express any fears and concerns, either perceived or based on experience, related to nanotechnology and the use of new nanomaterials and to share what they have done to address these issues. We also seek to identify awareness of any standards and controls that apply to use of nanomaterials and hear what they believe to be the most important things workers and employers need to know to use nanotechnology safely in construction.

We interviewed 4 Insulators, more than from any other single craft, because our survey results indicated that they have the most experience with actual usage of nano-enabled products and training. We thought it was worth hearing about their experience from more than 1 or 2 individuals to see if there are consistencies or differences. Since we also had a larger group of survey participants from the Plumbers/Pipefitters/Steamfitters, we spoke with 3 individuals from that craft. There were 3 crafts (Cement Masons, Tile Layer/Finishers, Electricians) from which we had 2 viable candidates each. The remaining 7 crafts from which we had only 1 informant each, and the single contractor representative are aggregated together into the "Other" group. Here is the affiliation breakdown for these key informants:

Union Apprenticeship representatives—(n=11)
Union Staff—(n=5) Contractor/Management—
(n=3)
Multiple roles (Apprenticeship/Union officer; Craft worker/Union staff)—(n=2)

We found it useful to organize responses to certain questions by craft so that we could determine if themes emerge across all trades or remain specific to one craft. In other cases, where individual craft delineations did not seem significant, we present the findings in aggregate. The findings are reported according to the four topic segments described previously.

C2a. Awareness of nanotechnology

This is the core topic of our study, attempting to discover to what level members of the union construction sector are aware of nanotechnology. We spent a good part of each interview on this segment, asking a variety of questions to draw out reactions, experiences, knowledge and applications related to nanotechnology and nano-enabled products. Findings for each question are presented with a summary followed by a table of actual responses, organized by craft, so that the words of the respondents are in the record.

First Thing That Comes to Mind

Interviews for the awareness section began with the simple question, "What's the first thing that comes to mind when I say nanotechnology?" This would give us an immediate sense of respondents' basic perception of nanotechnology. Informants' answers were quite varied; there was no single consistent answer that would indicate a common, shared knowledge of the meaning of nanotechnology. Frequency of repeated themes are listed here in descending order, including the number of times they were mentioned:

- Very small size (9)
- New products/processes (5)
- Particles (4)
- Computers/automation/robots/AI (3)
- Future/futuristic (3)
- Don't know (2)

Aside from a few who gave short, direct answers, many informants seemed to exhibit a somewhat vague sense of what nanotechnology means, stretching to come up with an explanation. A couple of Insulators immediately associated the term with their experience of a specific product and manufacturer. We weren't looking for a right or wrong answer here, but rather an initial reaction to the term. Individual responses illustrate the variety of awareness. Quotes are organized by craft and listed in the table below.

Question: **What's the first thing that comes to mind when I say nanotechnology?**	
Trade Group	**Key Informant Quotes**
Insulators	• "I don't know, something that goes in your body and fights off cells or something like that, I don't know" • "Itty-bitty microscopic fibers that make material far more efficient" • "Headaches" *[The informant went on to explain that this comment refers to challenges experienced as a member of a health and safety committee trying to usher union workers into a specific new nano-enabled material about which]* "their mindset was completely negative out-of-the-gate" and "it's always a complaining mechanism from the members" • "The first time I ever heard the word, was a company *[name redacted]*… they came out with a product, it's been out for a while, but we just started seeing it, and they said it was nanotechnology. And I go, 'What's nanotechnology?' didn't even know what it was"
Plumbers/Pipefitters/ Steamfitters	• "Quite honestly, I'm not really sure I know the true definition of it, so nothing really comes to mind" • "It's a cutting-edge technology like something on the forefront is what I first think of when I hear that" • "Nanotechnology has to do with the automation and the use of computers and grading data having to do with making construction more sustainable, raising the bar if you will, and then the other part of it has to do with micro-contamination"
Cement Masons	• "Sounds small. I don't really know that much about it yet. I did a little bit of research online, but it sounds more…I don't really know what it pertains to. I would think initially, nanotechnology would be, like, almost robotic in a sense or nano or like AI or something. Or maybe they're designing things…in a contemporary way to…better protection or whatnot. I don't know how it relates to construction but, I'm sure it's out there in a computer sense" • "Small"
Electricians	• "First thing would be particles that are unrecognizable or pretty much invisible" • "Very, very small things"
Tile Layers/Finishers	• "All the new that we have to get used to…and understanding what we do, equipment, materials. Basically adapting to all the new technology. What is really amazing to me that I've got to understand what nanotechnology really is and how does it fall into what I do or what our guys do out in the field, in the trade. So, for me, it's educating myself and so that I can go ahead and educate

	the workers" • "It's something very, very small like an atom or, you know, like a particle. Or something really, really small, maybe almost like an atomic type of thing, you know, like an atom"
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "Very, very tiny little robots that aid. So honestly what comes to mind is healing things, putting things together. Constructing things very tall, tiny and microscopic" • "Particles, small type particles that they can do work for us" • "There's scientific…what do I want to say, scientific experiments and technology that's going on to supposedly make everything wonderful. But we don't know that for a fact. It's new technology. Whenever something new comes out…but we do see that, or I see it, in about every phase of construction that I've dealt with…to some extent I see it" • "I think of like, almost futuristic, or technology that's being observed or…it's new technology…I mean I go on a job site I see something new and I think, 'Oh, how did that come about?' It's just new technology. Something that's being tried to make it safer for the worker. I see it from the employer's point of view. It's something that maybe makes the job go quicker, helps protect them, but I hope it's a positive thing" • "Well, nanotechnology sounds really like something futuristic. But, unfortunately, a lot of us working on the trades, we don't realize that there are already some products maybe on the market or maybe already used into construction that is already surrounding us, and, by not being aware of it, we might be exposed to maybe some kind of hazards by working with this nanotechnology" • "It would have to be more involved in new products that are coming about, and then also, new processes to either install these products or maintain these products" • "Future" • "Finer and finer particles being used to create products without thought of how it will impact the end-user or the guy milling it and forming it or putting the building together"

First Awareness

Next, we wanted to know how and when respondents first became aware that nanotechnology was being used in construction. Five out of the 21 interviewed indicated their first awareness came through participation in this study. For others who could recall when they became aware, most indicated it had been within the last 3-8 years. One person, a Plumber, thought they had first heard of it in construction as far back as 1986 related to "medical gas" work, but were not sure it was called nanotechnology. One safety professional had actually studied

nanotechnology in an industrial hygiene course as part of training for Construction Health and Safety Technician (CHST) certification.

Insulators demonstrated the most in-depth knowledge and actual personal experience with material known to be nano-enabled. These respondents consistently focused around a couple of specific products from one manufacturer that had been introduced to their field about 8 years ago. They were the only interviewees that actively engaged about the pros and cons of using a specific nano-enabled material in construction, receiving feedback from front-line workers, actively discussing worker health and safety concerns, training, and exposure control strategies. They stood out from all other trades as having the most to say about application of nanotechnology in construction and expressed passionate concerns about its use in their craft. The concerns they voiced are peppered throughout their interviews and crossover the four topics we explored.

As for other trades, we found a more generic understanding of nanotechnology, with some respondents indicating a basic awareness of how nanomaterials are entering their craft. A few examples surfaced in the interviews as shown below:

- Roofing—Photovoltaic technology integrated into roofing materials (tiles and liquid-applied membranes) to create solar power-generating grids that are built into roofs.
- Tile Layers/Finishers—Lasers; preserve or refurbish stone cleaning
- Millwright—additives to oil and lubrication systems; hydraulics—help analyze viscosity in real-time
- Plumbers/Pipefitters/Steamfitters—computerized orbital welding; beam modeling and trimble process, BIM (Building Information Modeling); robotics; microbial/bacterial contamination control

No detail was given related to specific personal experience with these applications. The respondents who mentioned them did exhibit an awareness that nanotechnology plays or may play a role in these applications, but information breaks down quickly beyond that recognition. Some awareness is a result of reading trade magazines and information provided by manufacturers or attending trade conferences and hearing about applications being developed for use in the future. With regard to lasers, one respondent said, "At the training center back in Maryland…that's when I first heard about it, and I was made aware…laser technology had a lot to do with nanotechnology." This is a good example of the lack of depth of awareness indicated. Respondents recognize that a new technology is bringing new equipment and processes to construction but speculate about specific impacts. We note that respondents often spoke about nanotechnology in the third person using phrases like "they use," or "they are able to" versus in the first person that would indicate a more personal, direct experience. Actual quotes of responses to this interview question are listed below.

Question: **When did you first become aware that nanotechnology was being used in construction?**	
Trade Group	**Key Informant Quotes**
Insulators	• "When I filled out your survey. Because it asked me questions about the products I used." • About 3 years ago, part of steering committee responsible for developing curriculum to be used across the US and Canada. Had experience with deep cryogenics at JPL NASA, simulated outer space extreme temperatures. Aspen Aerogel reached out when they learned they were developing cryogenic curriculum. Wanted to be part of presentation, had product they wanted in hands of professionals. Discovered they had materials to be used in petrochemical refineries and power plants that was non-corrosive to pipe, also wanted to introduce cold product. First time aware of nanotech use in insulation materials. Started marketing product to Plant Managers on basis that material did not absorb any moisture and pipe was not going to corrode 10, 15, 20 years down the line. • "It arrived as an application method in Ontario, Canada roughly 8 years ago, around 2008. Became large application within petrochemical facilities" • [Aerogel] "5-7 years ago, somewhere in that range, the first time that I've heard of the product. Aspen came to my facility and did a demonstration."
Plumbers/Pipefitters/ Steamfitters	• "Not knowing exactly what it is, I would be speculating, but I would say that when BIM modeling and trimble process started when they were using the robotics satellites to spatially, globally position you on a job site using electronic technology and being able to input that into computer models and make changes and kind of build the building on a computer." • "I did this process called computerized orbital welding, and so I've been working at these manufacturers like Intel and different pharmaceuticals where I see what's on the forefront of something that's going to make it to market. Being aware of what's going on with lasers being in construction. It's all electronic world that you're putting information into." • "Applied in construction, I would say it had to do when I took my first installer and then instructor and inspector medical gas coursework…would have been fall of 1986. It was raising the bar to protect people within hospitals and doctors' offices…I don't remember honestly if they called it nanotechnology…it was basically microbial and bacterial contamination."

Cement Masons	• "Really just this survey. I read the trade magazines…a lot of it is machinery…there is a lot of progress in that respect where they're inventing machines to help in production and make the company more money and just be more streamlined. I don't really know where exactly nanotechnology and construction, where they meet." • "About five years ago there was a group or a consortium out of Santa Clara that was involved with nanotechnology. Somehow, I was linked into this email and there was communication going back and forth…that is really my first knowledge of it. They were having meetings, I just didn't really understand what it was, and I didn't get too involved. It was more on the business side of things and how it could affect construction."
Electricians	• "I think it was my OSHA 30 class. They briefly talked about it, particles that were unrecognizable or invisible to the eye. That was about a year-and-a-half ago. • "I'm actually not very familiar of how it's being used in construction, but, you know, there's a lot of nanotechnology research that occurs here in the lab *[refers to respondent's job as an Electrician at Lawrence Berkeley Lab]*
Tile Layers/Finishers	• "I'm involved in the tile industry nationwide. The Tile Council of North America pretty much dictates mostly what happens in our tile trade and we have to understand the products, so that means I read a lot about how the products are manufactured. A lot of it is involved in the mastics. Understanding the technical data sheets for the products is part of what I do." Started hearing about it 5 years ago. • "At the training center back in Maryland…that's when I first heard about it, and I was made aware of…laser technology had a lot to do with nanotechnology. It was just introduced to us and made us aware of nanotechnology and how they were using it to preserve, or refurbish stone cleaning."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• Through this SBCTC survey • "We're industrial mechanics…there's additives they're putting in the oil and lubrication systems, and other additives that's helping them analyze the viscosity real-time of a piece of equipment…like a hydraulic arm or pneumatic actuator, it helps regulate…can help with resistance. With nanotechnology they're able to pick up millisecond differences and actually assign a maintenance guy to go over and look at it before it becomes a serious problem." • "There's a lot of different layers in the sheet metal industry when you're coating material. From galvanized to paint lock, to aluminum to all the different cladding and coloring materials…we fight the

	elements being on a roof and different things to where either the ultraviolet rays, let alone insulation factors, let alone the heat…so when I hear about nano I'm thinking they're trying to produce something that is going to keep our material together or adhering…I also know that they do it in cement." • "Just by visiting job sites…seeing things that were new and different for me that I hadn't grown up with when I was in the industry. It's been the last couple of years for sure." • "Five years ago, I was reading an article on photovoltaic systems, something used a lot in the roofing trade. Some of these photovoltaic systems are integrated as part of the roof…I pull a piece of tile…when I flip the piece on the other side it has a photovoltaic panel integrated into the single piece. Every single piece has a male and a female connector that when you're putting those on the roof, you connect…to create a grid. They're gonna come out now with this product which uses photovoltaic systems, that means nanotechnology where it's a liquid-applied membrane composed with nanotechnology that according to the heat of the sun doing that some of the nanos on the product will know how to behave as a positive or negative and be able to create like a grid to generate electricity." • "Probably about the time I read about the survey" • "Probably been about a year or so…just reading about it from building trades and online" • "Three years ago, when studying for my CHST exam…or in one of my occupational safety and health classes. In my industrial hygiene courses, nanotechnology was one of the units we studied."

Describing Nanotechnology to Others

We continued this line of inquiry but took a different tack by asking respondents to tell us how they would explain nanotechnology to a colleague who did not know that term. Two respondents said they could not or would not explain it to a colleague and 2 others indicated they would need more training and information. Some themes repeated by more than 1 respondent were:

Example of use in a specific product (Insulators)
Generally referenced as being in products
Related to processes or how work is being done
Compared to silica particles
Would tell others to "Google" it

Overall, respondents did not exhibit a strong confidence in their ability to explain nanotechnology to others. One gets the impression that they are not really certain of what to say about nanotechnology. As in the previous question, responses tended to be generalized, indicating that it involves small, unseen particles or robots being used to improve products.

Again, the Insulators focused on the properties of the product they know, which is to be expected.

It is interesting to note the tone of caution that emerges here from respondents when they think about talking to others. While there is recognition that nanotechnology applications in construction have potential to bring positive results, 33% of respondents would advise others to protect themselves, be concerned, take time to research the product and read data sheets. What this tells us is that there is immediate concern; what we don't know is if the concerns are specific to nanotechnology, or if these respondents would take a similar cautious approach with any new product that is not well known. We know for at least one Insulator, it is specific to nanotechnology because they state that upfront. It seems from the other comments that it is the fact that nanotechnology involves particles of a size too small to see, similar to silica dust and other, more well-understood materials. Nevertheless, for several respondents, caution would be their message to others before mention of benefits with regard to nanotechnology.

Question:
If I were a colleague who did not know the meaning of the term nanotechnology, how would you explain it to me?

Trade Group	Key Informant Quotes
Insulators	• "I'd just have to tell somebody it's something that's really smart and really small. That's basically what nanotechnology is" • "Microscopic fibers being embedded in materials to maximize…use level on the product. It's embedded in our insulation…so where you have a 4-inch piece of material that's considered mineral wool as fiberglass pipe covering, you would only need 2 layers of *[informant refers to a nano-enabled insulation product—trade name redacted]* so that's the extremities of this material. That's how powerful nanotechnology can be when it's embedded in the insulation materials. That it minimizes the thicknesses of materials which we apply." • "A new type of gel in our industry that adds a fiber in and it gives them the ability to cut down the thickness of the insulation to compete with insulation that has to be much thicker to have the same resistance to heat transfer. It's a space-age type product that they're adding into insulation…my experience has been a highly negative one with it. So, to protect themselves anytime they see anything to do with nano until they know more about it"
Plumbers/Pipefitters/ Steamfitters	• "I wouldn't. I typically don't explain things that I know nothing about. Unless I'm well educated or well informed on something, I don't explain it to someone, I just tell them to ask somebody who knows. I'll tell them to start with Google"

	• "I'd say Google it because I'm not really versed in it. I've been looking at it and they're talking about things that are microscopic or are so small on spectrum that we don't really see what's going on as these things are being applied. You almost have to just know what the theory is, the application of what's going on. I want to really get more dialed in on what nanotechnology really is" • "I would want you to go through several hours of awareness training to where you would know process and protocol I guess would be a good way. You would need to know process and protocol much like you would if you were going into a semiconductor plant. You need to know what's there, what can harm you, how it affects, how it reacts on the human body, and nanotechnology are the protocols of what to do in what sequence to get the best achievable outcome"
Cement Masons	• "I'd have to do some homework prior to that" • "The restructuring of molecules to enhance the use of product or make things increase longevity, make a better use out of it"
Electricians	• "If someone asked me directly about nanotechnology, I would say that there's a lot of things in our trades that are unseen that we need to go a little bit further with protecting ourselves and making our work environment safer so that we're not finding out things that we can't see that come back, you know, after a time that are harmful" • "It involves doing research and work with very, very small things, and I guess I could take somebody over to the building and let them look at a lot of the poster boards on the wall or something to try to get an idea" *[this informant works at a facility where there are nanotechnology labs]*
Tile Layers/Finishers	• "It's something that is in the product…whether it's tile or the setting materials or the finishing materials, or even some of the tools. So, understanding the products…you have to read the data sheet and understand, really dip into what the products are made of and how they're made" • "It's something we have very little control of…it's something new to us, and it's not really that new because we've been using laser levels in different types of lasers and we know we're supposed to protect ourselves. Really to get into it, into what exactly it is, I think I'll be a little bit short on information on that. I would just try to make you aware…any type of cleaning that's using some kind of a technology that has to do with any type of laser or anything that has to do with something so small as an atom, I would be concerned"
Others (Boilermaker,	• "Just breaking down the word. Nano is something very, very tiny.

Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	More than likely it's gonna be robotic, I assume that means it's gonna be self-sufficient I guess, kind of it can generate itself, like direct itself" • "I would say it's a variety. My experience is it's a variety of smaller particles that kind of work together to help with a bigger picture. Because they're using nanotechnology, and it's like solar too, using some of that for, like, solar panels" • "I think nanotechnology more than anything is trying to improve on…it could be paint, it could be different things, but I'm thinking more than anything it's going to take and replace and fill…I think that nano is something that is slick. It just seals everything up to where it's going to not allow for deterioration so quickly, I think more than anything, the materials make it more efficient…some type of engineering design that applies to material more than anything" • "When we go out now and we see job sites it's so much different than what we grew up with. Just the advancement of tools of technology, the way we did things in the past are done now, although it's the same task, it's just done differently, more efficiently, different tooling. Just the advancement of how work's done" • "Same as other chemicals that we have to deal with today in our industry, that we need to be more prepared and be more conscious about protecting our health because we don't really know what's gonna be tomorrow with all this nanotechnology per se. My understanding is nanotechnology can be like a small little robot, that they're so tiny that we can only see it through a microscope. And what it can do to our body, it's something new, we don't really know. I will tell you, first of all, to protect yourself about it and that if you have the time and access to the internet, you can do some research about what's the nanotechnology used already" • "I might tell them to get out their smartphone and Google it" • "I don't think I could, I mean, I'm not into it. I haven't read up on it enough to how I could explain how it works" • "We've just learned about silica and how small those particles are; now imagine particles even smaller that we definitely can't see with the naked eye still being in your breathing environment and in your environment where you work. You're gonna want to know when they're in your environment and how to protect yourself, what engineering controls your employer is taking to protect you and disclose to you, honestly, that there are those products in here"

Topic of Discussion

In follow-up to this theoretical question, we asked if indeed nanotechnology is ever a topic of discussion with coworkers, peers, union members, or employers. A slight majority of key informants (57%) said it is not a topic of discussion. At the other end of the spectrum, one Insulator called it their number one safety concern and indicated that it is discussed at joint labor/management committees and that members ask 3-4 times per year about allowable exposures. However, other Insulators did not indicate the same level of engagement. We were interested to hear from Plumbers/Pipefitters/Steamfitters that it is a topic of discussion among staff that are developing new training and that one instructor mentions it in each class. It was not clear exactly what aspects of nanotechnology they are referring to however.

A few informants felt that younger workers are more open to new technology and may know more about it than long-time veterans of the trade. There was also the observation that things are starting to change, and the belief that more people will be asking about nanotechnology. One person stated that, while it is not a topic of discussion now, we should start talking about it in the trades. We intentionally did not include quotes with this summary because it was more of a "yes or no" question.

Impact on Construction

One of the main aspects of nanotechnology that we were interested in exploring through this study was how it is impacting construction, in what ways it is surfacing. Our key informants identified many areas where they believe nanotechnology applies even if they weren't certain of its impact. The areas specifically mentioned were:

- Pipe insulation at refineries and chemical plants
- Concrete admixtures; concrete polishing materials
- Solar-enabled liquid-applied waterproofing membranes
- Welding machines
- Robotics
- Lasers

Regarding the impact of nanotechnology and nano-enabled materials on construction, responses were, for the most part, positive. Respondents discussed several ways they believed this new technology had brought improvements to construction. These comments are naturally based upon an individual's understanding of what nanotechnology is and, for those responses that are broader, it is difficult to determine if impacts described are a result of nanotechnology versus other engineering innovations.

Question:
From your perspective, what impact has nanotechnology had on construction?
How has it surfaced in your trade or work that you have done?

Trade Group	Key Informant Quotes
Insulators	• I have no idea. The one thing I know about is Pyrogel and

	Cryogel…the products I've actually used. The way it has to be done, it kind of makes more of a process. I don't know if it's necessarily better…there's other products that do just as well. I don't know if there really could be an impact from nanotechnology. Maybe one day. • [Cryogel/Pyrogel] "It's been helpful to the operators of the facility, I don't see a lot of benefits in it other than the thickness of materials…it's minimized spacing and eventually it's benefitted the end-user really. I don't see it benefitting the Insulators at all. I understand it takes more time to apply insulation materials with nanotechnology as opposed to what they're accustomed to. If you had 4-inches of insulation material of mineral wool, applying 6-7 layers of Pyrogel just takes longer because you're doing the same thing over and over." • [Aerogel] "It hasn't in my opinion, it hasn't advanced anything. It's a new material with a new application method with the intention of trying to be a better insulator. And what I see with it is a just as lengthy installation as some of our more specialized materials. When you actually do the application, it presents a whole new series of challenges. We have members who elect to refuse to work with it…reserve the right to not work. The only other material we allow them to do that with is asbestos. Within petrochemical facilities [Ontario Canada]…main sell to the industry here was that it was an answer to corrosion under insulation. Fast forward eight years, there's a whole lot of rust underneath that stuff. Now for planned outages, the material comes off but it's not looking any different underneath the nanotech, the Nanogel than when we had foam glass on or we had other products." • "It's being spec'd out in a lot of refineries and nitrogen plants because of its quality…a quarter inch of Aerogel equates to three quarters of an inch to an inch of calcium silicate. You can put three layers on, which gives you three quarters of an inch, where that would be almost four inches of another product."
Plumbers/Pipefitters/ Steamfitters	• "I have heard that there are products for the building industry such as cementitious materials…that contain nanotechnology…but I couldn't speak intelligently on them. If I knew what those things were, then I could probably tell you how I thought they were benefitting or making an impact on the building trades." • "I know it is the driving force, but it's not talked about. It's almost like a secret situation. And then, the more information gets put out, people start running the other way with it saying, 'Oh, this is a danger…this can get out of control.' Welding…working around lasers…robotic equipment…with the nano, that's theory. We really

	need to get on top of this technology, because it's much more than we understand. We're physically taking these computers apart that do the welding." • "Making things safer. In the industries that I've been involved with, most of it had to do with the semiconductor, food and dairy, hospital work, research centers, R&D centers, any place where submicron contamination could occur…it is a large and becoming a larger part of our industry as a whole."
Cement Masons	• "With concrete my guess would be where maybe some admixtures that may be added to the concrete are tiny that make it stronger…last longer…more affordable…concrete's relatively simple…been the same way forever. With some of the ingredients that's where I would think that maybe some scientists and/or researchers have found ways to make it stronger…cheaper that kind of thing." • "It may have, but I don't have any knowledge of it. Probably most effective is in the products side of things where they are changing the product that we use to make it more efficient or more safe to use. Concrete polishing industry…there's products that we use that help us…get the first grind done and there is now a liquid that we can use instead of a dry grind. That keeps the dust down so people aren't dealing with airborne particles as well as we get a lot more done faster."
Electricians	• "I think it's starting to. I don't think it has directly as a word that we're using in safety meetings yet, but I think we're aware of the concept and we're covering it and trying to make sure that our crews are aware of things that would probably fall under that category." • "No."
Tile Layers/Finishers	• "That's a tough one to answer because a lot of guys really don't understand it; it's hard to say how nanotechnology had made an impact. Basically, new tools, new materials, new products. Materials are lighter…have longer open time…don't set up as fast, they allow more work time…and they're not as dusty because they're being aware of all the safety procedures now…they're making products way, way different than we used to. In a way, they're making it easier for the worker to actually get their job done. Tools are lighter, they're not as noisy, so it's affected everything. You can tell the difference." • "In the positive end yes. It made a big difference especially when you consider that in the past we had to use transition levels and water levels, we were limited to what we could do. And now with the technology we have, as far as being able to cover big areas…yes

	it made a big impact on it. As far as reconstruction…preservation of buildings they used to clean something, that used to take a lot of sanding and used to take a lot of work, now it's making it a lot easier. I would say in laser levels and in the preservation and reconstruction of buildings…the two big areas that we see it."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "From my knowledge, zero. When I think of nano, I think the smallest of the smallest. We do a lot of welding…and the welding has been taken over by automated robotic machines. The reason Boilermakers are still doing it is because some places are confined, very small. These robotic welders are getting smaller and smaller to get into those locations that currently only human hands can. That sounds to me like that could be how nanotechnology is introduced to boilermaking welder portion." • "More so on the maintenance side…helping out with the serviceability of machinery and equipment, being able to keep something in service longer." Robotics detecting problems with equipment on an assembly line. • "I've got to say it's improved it. I would think the materials are more expensive. You're going to get a longer product. Lifetime, longevity that's going to be better. Maintenance on it should be better. There should be a lot of different pros to it, but with that comes a cost. But I do think it's well worth it." • "It definitely has. It has changed our industry, our outlook on how things are done. It's made things a lot more efficient…cut down on the time that it takes to do a certain task. Back in the day, a lot of our stuff was mechanical and electrical relays and now the majority of this new technology is just plug and play, it's computer-based. It's like going from 'erector sets' to iPhones and Smartphones to interact with elevators and escalators. It's completely a different world." • "The only thing I'm aware of is that there's still the study of solar cells to be able to use in these fluid-applied membranes to become a waterproofing agent on a roof but at the same time able to transform solar power into electricity. What other things are out there, I really don't know more about that." • "I haven't seen it in my trade [Plasterers] yet…it could be in some of the newer materials, but I'm not aware of it." • "I don't know if it's really had an impact because we don't know the new diseases that are popping up, how they're connected. Nanoproducts are being used to create lightweight concretes so they can get more product into a tighter bond…they can get the strength that they need and not have the weight. But what we're finding with regard to silica, we're seeing an increase in Tridymite

	which used to be very, very rare. My last 3 samples were 30% Tridymite, not quartz…that's something new. And it has to be contributed to by the nanotechnology and just making products and bringing other products in that we formerly wouldn't have used because we couldn't get them to bond. I have silicosis…we weren't wearing respirators at all because we didn't know about it. I think it's the same thing, it's an awareness and we have to err on the side of caution without creating a panic. The fact that people are starting to study it and pay attention to it is encouraging."

More Information Needed

Our final question in the awareness section of the interview asks respondents if there is any information about nanotechnology they would like to have that they do not have now. All but one respondent expressed interest in receiving more information. There is a strong desire to become more proficient at understanding nanotechnology. These are the main topics about which respondents desire more information:

- A clear explanation of nanotechnology/what does it mean?
- How it affects the industry and what changes can be expected?
- Where is it found in construction/both products and applications?
- Acute and chronic human health effects/can it cause harm?
- Can it be absorbed into the human body?
- Proper exposure controls/correct use of personal protective equipment.
- Do respirators provide effective protection/which type is needed?
- Better Safety Data Sheets.
- Are nanoparticles released (become airborne) when cutting/grinding/drilling nano-enabled products?
- Handouts and factsheets explaining nanotechnology.

Question:
Is there particular information you'd like to have about nanotechnology in construction that you don't have now?

Trade Group	Key Informant Quotes
Insulators	• I don't know, not really. • I'd like to see its use in other places, not just insulation materials, and hear from other industries that started using nanotechnology. Find out if there are any hazards associated with it. • I want to know what respirators can truly stop the airborne particles. I've heard all kinds of different conversations that these airborne particles, they do enter your body. They're so small they just, they make their way out. Last time I checked, something going from inside of me to outside of me, no matter how small, it is probably leaving something behind. What's the lasting effect? We

	are digesting as much as we are breathing. Is this just going to be another piece of the puzzle? There is some properties in there that are a little alarming when you first start talking about the chemical composition. I get the levels are extremely low, but it doesn't make them non-existent. Is there anything we can do short-term exposure? Is there any way to monitor biological or physiological changes internally…just our biology itself? I want to understand more on measuring what type of respirators. Trying to set up a study in Ontario Canada. NIOSH just has nothing on dealing with nanotechnology or any particulates that are that size. • "I don't know what's out in the construction trades that is nanotechnology or not. There's a real lack of information. What does the word 'nano' mean in products? You hear the word now, but what does it truly mean? There's a real misunderstanding, perhaps, of what 'nanotechnology' is. I don't know what is or is not a nanotechnology product…or what makes a product nanotechnology. If you were to walk up to the average construction worker and say, 'Hey, can you explain what nanotechnology is in products in construction?' they'd look at you like you were crazy."
Plumbers/Pipefitters/ Steamfitters	• "Just what it is and how it affects the industry and what kinds of changes are anticipated that would come about from it." • "The more I could get proficient at knowing nanotechnology, the better I can actually put it out there for everyone as an educator." • "Anything you can send me. Not knowing leads me to be open to receiving as much as I can get…it's because I'm hungry because I want to know."
Cement Masons	• "I like to read…construction magazines and trade magazines…just checking out stuff, seeing what's going on out there."
Electricians	• "I'd always like more information…anything more I can get, it's going to make a better work environment and able to protect ourselves better…we can always use more."
Tile Layers/Finishers	• "Something that I could actually hand out to the guys that clearly explains what nanotechnology is and where it could be found and how it's being used or how it's being implemented…a factsheet or a handout." • "I would like to learn about the safety of it…how to protect ourselves…what kind of risk we get exposed to when we use it…is it going to have any effect on our health and welfare for ourselves and for our families."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor,	• "More information on it would be helpful. It seems like with development, there's an R&D portion that seems like you get so much knowledge and then the information falls off a cliff. It would be nice to have some more knowledge on it."

Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "You've sparked something in me by just asking these questions. More than anything it's making me want to look for more of the health risks…health hazards…how do you properly dispose of some of that stuff…are they biodegradable or are we going to have to have some type of different mechanism for that?" • "I'm always interested in what's the latest and greatest…always interested in new technology and what's going on." • "Any construction materials that they're going to be adding nanotechnology to…I believe that's something important that we need to educate the construction worker on how to protect themselves about any absorption into the human body of these nanos, or whatever technology they're using, because we don't really know." • "Anything that you can give us…carpentry is going to be interested in some of the finishes, the flooring and fillers…the sheetrock, the finished product for hardwood floors and the engineered lumber…plumbing, painting industry, painting and taping those finished products." • "We're always behind the curve on the safety factors…because these new products get pushed out there on all of us, we will probably work with it for years before we realize if there's anything that could be harmful for us. So as much safety data as we can or safety information as we can, and as much information on what materials nanotechnology will be used in, so we could prepare our workers." • "I don't think companies are putting enough information in the Safety Data Sheets to start with. We're training our workers to look at the Safety Data Sheets as your go-to on how to handle and modify the product…if the manufacturers were a little bit more clear on when they add those particles to a product, that they identify and have done some study…they were nano-size when they went in to the product but the binders and bonds that are used will maintain a minimum size X when they're cut and ground. We also worry about when we're welding and cutting the product, from heat, do those same micro-particles become airborne?"

C2b. eLCOSH Inventory

In this section of the interviews we wanted to give respondents a chance to speak more about what stood out to them when they reviewed the list of products. In the online survey, respondents could only identify products; there was no easy way for them to give us more feedback about their experience with products. We realize that, for the purposes of this study, we are just collecting a hand-full of responses to the inventory; it is by no means a thorough

examination or a representative sample. We have very little information regarding the extent to which nano-enabled products are being used in construction. Our intention here was to gather feedback that may be helpful in coming up with better ways to test the inventory and to get a sense of how much, or how little, information our audience may be receiving about these products.

Of our 21 key informants, 16 had reviewed the eLCOSH Inventory in their online survey. The 5 who chose to skip this part of the survey were from these crafts: Cement Mason; Electricians; Roofer/Waterproofer; Sheet Metal Worker. All of the 16 who reviewed the inventory list indicated that they recognized products in their online survey. Of these, 14 went on to actually identify the product codes in the survey; 2 chose to skip this final step. The 14 who we report on here represent the following crafts: Insulator; Plumber/Pipefitter/Steamfitter; Cement Mason; Tile Layer/Finisher; Boilermaker; Millwright; Elevator Constructor; Drywall/Lather; Plasterer.

In follow-up interviews, we reminded these informants that they had recognized products in the inventory list and asked them to tell us more about them. To prompt discussion, we would ask, for example, what is their experience, were they aware products are nano-enabled, had they received any training about the products. Only 5 informants (Insulators, Elevator Constructor, and Millwright) said they knew products were nano-enabled before taking our survey.

We learned only slightly more about applications of these products. Some noted that products had improved from what they "used to be" and gave examples of less dust, more use-friendly, easier to cut, and lighter. Most respondents, with the exception of the Insulators, had little, if any, specific information to share about individual products that could be directly linked to nanotechnology. It is very difficult to say if the information we gathered is very helpful. What we learned from this experiment with the eLCOSH Inventory is that the people we interviewed were not making much connection between these materials and nanotechnology. Indeed, the majority did not even know they were nano-enabled. One caveat is that our participants—union leaders and apprenticeship training staff—mostly no longer work at construction sites and therefore may not be exposed to the new materials to the same extent as front-line construction workers and contractors.

With regard to product documentation such as material data sheets (MDS) or Safety Data Sheets (SDS), no one gave us specific feedback other than to say they try to read them. No one mentioned that they had ever seen references to nanotechnology on either MDS or SDS. Similarly, other than Insulators, no one mentioned that they had received any information regarding health and safety related to working with these materials or product-specific training that included safe practices. A common thread seems to be that product manufacturers are the main source of information, and mostly that is promotional in nature. Our conclusion is that, except for the Insulators, not much exploration has been made into nano-enabled products by this group that serves to illuminate concrete benefits, issues or concerns. It does appear that

participating in this study served to spark a new interest in finding more information among key informants.

We are presenting the interview results below organized by craft so that we can get a better sense of who is using what product. This may help inform future efforts to test the inventory list and target certain crafts for further investigation.

Question: **When you reviewed this product list, what stood out to you?**		
Trade Group	**Products discussed**	**Known to be nano-enabled prior to seeing list?**
Insulators (4)	• Aerogel products: Cryogel, Pyrogel, and other similar forms of the same product (all) • T-tube caulking (1)	No = 1 Yes = 3
Plumbers/Pipefitters/ Steamfitters (2)	• Drywall (1) • Waterproofing membranes (1)	No = 2
Cement Mason (1)	• Joint sealants—Isoflex • Patch Plus Primer • Pro-Seal Power Patch	No
Tile Layers/Finisher (1)	• Sheetrock Brand Ultralight Gypsum Base	No
Boilermaker (1)	• Weld overlays • Sheetrock • Treated lumber	No
Millwright (1)	• Lubricants • Paint coatings	Yes
Elevator Constructor	• 3M Window Films Ceramic Series • Rest Protex Stainless Steel Long Life	Yes (from reading boxes)
Drywall/Lather	• Engineered lumber • Chipboard • Gypsum board	No
Plasterer	• Lumber	No

Question: **You indicated having knowledge of products on the list. What is your experience with these products, what can you tell us about them?**	
Trade Group	**Key Informant Quotes**
Insulators	• [Cryogel/Pyrogel]—because of the way it has to be done, it makes more of a process. Some of it is good to use in certain situations. • "T-Tube caulking" used in pharmaceutical industry cleanrooms, very thin insulation material, so small so expensive, made to order, used for chilled water piping all the way up to steam piping and it was 1/4 – 3-inch thick, was neat to work with. Pyrogel stood out because of fact that hands dried so quickly, it was water repellent. Wait a minute, this is alarming. If it's causing this effect to my hands, what can it cause to my lungs, if I was to ingest it w/o respiratory protection?" • Aerogel, Pyrogel, Cryogel—"I've been fortunate to say that I've never had to use it."
Plumbers/Pipefitters/ Steamfitters	• Drywall—"When I did the survey I was reading and there was nanotechnology and cementitious products…drywall and gypsum falls into that category…that's the only way I was really aware of it. I was totally unaware, I thought nanotechnology was something else. I thought nanotechnology had to do with use of new technology in the building industry like building modeling and 3D. I think I was misinformed." • Waterproofing membranes—"It's the vinyl wrap they're putting on houses to keep the moisture out. That seems to have really come around, I don't remember seeing that stuff in the past and now it seems like everybody's using it."
Cement Masons	• "Basically, for a tilt-up building, we would use Isoflex in the center of it and it's fully expansive so it allows the concrete to shrink and expand. That's one product…cement masons use that quite a bit." • Patching components—"When there's repairs that need to be done on concrete surfaces for whatever reasons…we use that primer as an adhesion product and then the flex material we put that over the top of it."
Tile Layers/Finishers	• "Especially the gypsum base, we use a lot of that, they tile over those…it's lighter, easier to cut, user-friendly…not like it used to be."
Boilermaker	• "I have used these products and am kind of curious to wonder if that was saying that nano was in those particular products. I've done the overlay welding…hung sheetrock. I don't really understand how nano is involved in gypsum…but I recognized a lot

	of those names as products I've used before, been around before. I recognized the name for lumber but again I'm not clear on how nano is involved. At some point during sheetrock hanging, they didn't produce as much dust when they were cut open, when you'd slice…cut a piece in two, it didn't put that much dust in the air. I just happened to remember that being something I noticed about sheetrock…15 years ago."
Millwright	• "More of the lubricants…I know some of the paint coatings. When I first started I was not aware that there was nanotechnology, but as the job progressed…by the way, that stuff does this too…equipment reps, developers, engineers will tell us a little more about it." "A robot we were installing, one of the engineers showed me the whole process…we add it to the oil, to the lubricants. I know that the Carpenters union at their international training center, they're starting to talk about it."
Elevator Constructor	• "Some of those products are actually used on glass elevators…they protect the glass either from vandalism, people etching into it, and having to replace that glass…they put that film on there. Being on construction sites in general, I noticed those products on site…maybe not know specifically what it's used for, but I'll see boxes and things there, it always catches my eye…when I see a 3M box on the job.
Drywall/Lather	• "The hardwood floor industry…a lot of the stuff is pre-finished…like gym floors…professional sports courts…still do the sand and stain and finish as well as painting and striping." "Engineered lumber because traditional dimensional lumber is getting hard to find."
Plasterer	• "I know I read, but I can't remember. Especially in our industry, I haven't heard of any [nano-enabled products] yet."

Reaction

After discussing the eLCOSH Inventory list and how these products are being used, we ended this section with a conversation about respondents' reaction to nanotechnology and whether they viewed it as positive or negative for construction work. The response was overwhelmingly positive with the caveat that there be training, information, and proper use. Only 3 respondents were not prepared to form an opinion or were "indifferent" without further information or a better understanding of how nanotechnology will affect construction. An exception was one Insulator who expressed serious concerns, saying the word "nano" sends up red flags, having had bad experiences with the nano-enabled product they use. This respondent makes a valid point that there is little information available for the lay person/common worker that effectively explains what nanotechnology means. This will be discussed further in the next two sections on training and concerns.

What stood out was an acceptance that new technologies have always entered the construction industry, and that nanotechnology would just be the latest evolution. Also, that change and advancement are inevitable and preferable to remaining static. No one expressed a completely negative reaction, just caution about unknown potential effects that may result from a technology they know little about. There was some sentiment that construction workers are always being given new materials to work with, often without training or knowledge of what it will do to them. Most informants expressed an eagerness and openness to learn more about what nanotechnology means for them and the industry as a whole.

Question: **What is your reaction to using nanotechnology in your work?** **What do you see that is either positive or negative around this new technology?**	
Trade Group	**Key Informant Quotes**
Insulators	• I'm just really indifferent…I mean until something really stands out, like this is the new way to do things…and this is what nanotechnology had brought to us. We're gonna do it all this way, it's ten times better, ten times faster…until that happens, it's whatever. • I'm in the middle…stuck in between. I haven't seen its performance, I hear it's great. There was a humongous job where one of the products was used on the entire job…a liquid natural gas plant in Maryland called Cove Point…if that material stands up to its reputation maybe I'd have an opinion. I don't have an opinion on it because I've not seen its performance first hand. • I look at it from a few perspectives. It's a massive breakthrough in the scientific world and the applications are huge. And I look at the advancements that it's made in medicine for so long…being very successfully researched and utilized. I think when we start getting into construction materials, it's evolution of everything. When we start seeing visibility shift out and the research expand. I think there's huge potential. I'd just like to express a little bit of concern that we would be very diligent in our exploration of anything new, particularly when there's respiratory involved. There's so many innovations coming into the construction world that are amazing…when we start getting into chemicals…we get into man-made chemical cocktails. I start to get very concerned that…let's be cautious of what combinations mean what. No matter how small it becomes…the mixing of anything at extremely small levels still can be problematic. It could take a long time for us to see if it really is a problem. • "Through my experience with the word 'nano' it immediately sends up a red flag for me. I don't know what's out in the construction trade that is nanotechnology or not. There's a real lack of

	information…there's a real misunderstanding perhaps of what nanotechnology is."
Plumbers/Pipefitters/ Steamfitters	• "Without having a vast knowledge base on this stuff, it's really hard to comment on it as to whether I think it's positive or negative. Like anything else, as you learn about stuff, you formulate questions…ideas of whether it's positive or negative." • "At the forefront, I've been doing this all along where it's not being explained. You adhere to doing something not realizing what the driving force is behind it. That's why I think it's a very positive thing, and I'm looking forward to learning a lot more about it." • "I think it is up and coming future and it is going to be infused so much into construction and the methodologies of construction that it is something important to be taught to the workers throughout our industry."
Cement Masons	• I think it's positive…it's just a new dimension of knowledge about the products that we use in the construction industry that we just take for granted, oh, here's a new product. Here's the directions, let's go use it.
Electricians	[did not cover this question]
Tile Layers/Finishers	• "I say it is positive. Having a handout or something that comes from a main source is always helpful for us." • "It's like any new technology coming in as long as you know how to protect yourself, it's gonna work for the benefit of the industry and…to improve any trade. Just as long as it's used correctly."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "I'm accepting. I think there's probably some deep feeling inside of me that robots are replacing humans. • "I think it's positive, it's outstanding, it's the wave of the future. I'd like to see more applications of it in use, because it would save a lot of resources." • "I think it's great. Any advancement is a positive thing as long as it's safe. That sets our biggest concern. And that they are properly trained on it because so many times we're given new products and just not necessarily training on it the way we should be." • "I think it's something amazing what they're trying to create. I really believe that one day we're gonna be applying some of these products, but then again, how can we be prepared to train the construction worker that is going to crash into the high-tech industry? We go back to the importance of training to protect the worker, to protect the product to be able to achieve a good application." • "Because it's so new, there's always skepticism. But I think all in all, if we remain the same then we're stagnant. Especially with the computer industry, but definitely in construction and now that

	they're kind of working together, as long as there's a proven benefit to using the products, whether it be a faster installation or a longer-lasting product…general usability and longevity, I think people are going to embrace it." • "Oh yeah it's definitely a positive. But just like everything, positives sometimes have extra precautions you have to take. With training and information, we just have to be trained to use it properly for sure."

C2c. Training Related to Nanotechnology

The next topic we discussed with key informants was training. Only 5 out of the 21 had received some type of training that could be considered relevant to nanotechnology. 3 of these were Insulators who had only received training from the manufacturer of the one product line. This training focused on how to use the product and promote its benefits; it was not a nanotechnology awareness training. The other 2 respondents who had received training were an Electrician and a Contractor Safety representative. The Electrician told us that they find newer jobs have presented more particles that are unseen that are now being covered at tailgate training and through daily Job Hazard Analysis. This interviewee further explained that they do not use the term nanotechnology, but rather discuss unseen/airborne things that can be detrimental to your health. Again, this is not a training about nanotechnology specifically. This person was the only key informant who said they had delivered tailgate training using handouts. The only interviewee who had received college-level instruction specific to nanotechnology was the Contractor Safety representative who had done course work to obtain their CHST certification. The material for this training came from course textbooks.

Not one person had received comprehensive training about nanotechnology in construction or potential health effects from exposure to nano-enabled products. The Millwright told us that the Carpenters Union is doing some training on nanotechnology at their Las Vegas training center, but he had not participated in it yet. The other Electrician informant, who works at a research lab facility, told us that their Environmental Health and Safety Division provides mandatory training for craft workers who work in locations where that research is being conducted. He described it as "just awareness-type training" about potential hazards so you realize if you go and work in these buildings it's a possibility you could be exposed to some nanoparticles. He did not have information about the source material used at the training. And a Pipefitter/Steamfitter told us that they are going over a curriculum now with their A&J parent corporation, loosely based on a curriculum in the San Jose training center near Silicon Valley and seeing what they can develop. He expressed a special interest around lasers applied to the welding field.

All respondents were open to receiving new training and expressed strong interest in this should it become available. Some, who had taken our SBCTC train-the-trainer course on Silica in Construction, thought a similar training on the topic of nanotechnology would be very effective.

We heard repeatedly throughout the interviews that there is little understanding of what nanotechnology means, and that there is a lack of good information geared to the average construction worker about this topic. Even Insulators, who have the most direct experience working with a nano-enabled product and have received training, say they could not fully explain what nanotechnology means or how it's used in construction beyond their trade.

Interviewees shared several good ideas for what to include if we were to design a new nanotechnology training. These responses are shown below. Some mentioned that they felt a new curriculum would be welcomed into their apprenticeship programs should it become available and that this would benefit their workers.

Question: **If we designed a new training about nanotechnology, what should be included?**	
Trade Group	**Key Informant Responses**
Insulators	• "In depth on how much better the product would be/focus on benefits compared to other products…it's lighter, thinner." • [Respondent referencing the specific product training] "They do a good job, don't think I'd add anything. A little more intricate, more realistic application like a valve assembly station, how product can be used in more extreme environment." • "What does nano mean? If I'm on a job site, are there other crafts using other products that have got nanotech, is it good/bad. Nanotechnology is just a word to me right now, I couldn't tell you what it means. All I can tell you is Aspen Aerogels says that their product is nanotechnology. I've looked it up and they give you all this fancy scientific stuff, and I'm going, what does it mean to the average lay guy out there in the field? A guy that's going to work every day and being told to work with a product that he's really gonna not know a whole lot about. Is it harmful/not harmful? I would put on a training course for my apprentices about nanotechnology."
Cement Masons	• "I think it's pretty neat the building trades is looking at something like this. I think that this is something the apprenticeship committee could appreciate and believe we could easily add this into the curriculum so people understand how this affects construction. I've talked to other people and they think that's all scientific stuff, we don't have anything to do with that. But it does affect us."
Electricians	• "Any time we can get our hands on new information, new items that are coming out or refreshers, make it more interesting." • "Long-term health effects."
Tile Layers/Finishers	• [Referenced SBCTC Silica TOT] "If we could have something like that

	for nanotechnology, believe me then they would listen and be more aware of it, pay attention to it, actually take it in."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "What happens to human body if you have nanotechnology into your body. How to protect from absorption into body. Need to create awareness of what really is nanotechnology, identify products so we can start providing training. Need to start adding some of this information to our curriculum to be able to gather information for the worker." • "Along the same track as the training that was developed for silica [Referenced SBCTC Silica TOT]. Focus on examples of products most commonly used in general building then in modification of that product…precautions…engineering practices…reduce potential for injury…case studies and real-life products."

C2d. Concerns related to nanotechnology

This final section of our key informant interviews is a follow-up to questions 20 and 22 of the online survey. This is where respondents gauged their level of concern using a Likert scale to agree/disagree that nanotechnology raises worker health and environmental concerns. We wanted to explore the nature and origin of these concerns and hear about what people are doing to address them.

We collected a lot of feedback about concerns; each of the 21 key informants had something to say. There is a great deal of concern out there focused primarily on worker health and safety, although environmental issues did come up for a few. Environmental concerns included: airborne carcinogenic particles causing high cancer rates in certain geographic areas; that we are creating something unnatural and anything Man creates has a potential effect on nature and our environment; questioning if products are biodegradable and impacts on our landfills.

The number one theme that emerged across all trades and affiliations that is fueling this concern is a lack of available knowledge and information about nano-enabled products. Collectively our respondents described a vacuum of data, information and understanding of what nano-enabled materials, nanoparticles and generally nanotechnology means for workers and the construction industry. Over and over we heard that no one knows what "this stuff" will do to you. The contractor safety representative, our only respondent to have taken college-level courses that included the topic of nanotechnology, claimed, "it's not the same as dealing with a normal particle. Nanoparticles, they react differently, they bind differently, they go into your body and they are absorbed in tissues differently. They're not normal." Most respondents seemed to perceive nanomaterials in a similar category to respirable dusts and airborne contaminants while a few mentioned skin absorption concerns. One respondent's comment sums up this issue, "They need to be made aware that there's an actual hazard there, that's key. Once everybody knows that there is a hazard there, it's easier to address." At this point,

according to our key informants, there is more product promotion than hazard recognition happening with regard to nanotechnology.

Even the Insulators, the only respondents with direct experience of a material known definitely to be nano-enabled, do not know what risk this product may or may not pose to worker health. They describe acute health effects that surfaced immediately upon working with this one family of insulation products but have no concrete research information or training to help them address these effects. The symptoms their workers experience (skin drying-out, fingers cracking, nose bleeds, coughing-up blood) are severe enough to cause workers to refuse work if it involves that material. Their only training has come from the manufacturer who focuses on use and application of the product and, we are told, downplays safety concerns. A NIOSH study done in cooperation with the Insulators union on this product was mentioned in passing a couple of times, but never described in any detail or used as a resource. Because of their experience with asbestos in their trade, Insulators tend to be very leery of new technology that they are told is safe by the manufacturer. These participants had so much to say about one product, they perhaps should be studied separately. Several interviewees, including some non-Insulators, compared new nanotechnology to asbestos and silica as well.

Another common theme is the concern that it will take years of use before potential long-term, chronic health effects are discovered and addressed. But this is too late for workers using the materials now. One respondent said, "We work with these materials for a long period of time and don't know the impact of how harmful they are to us. I've seen this happen over and over again, it's a red flag to me when something new comes out." There was a sense that products get "pushed out" into use before they are completely understood and that workers take the impact. A few respondents trusted that the industry or government agencies would be monitoring or regulating these products and vetting them. We asked respondents if they were aware of any standards that currently apply to nano-materials, 100% said no. At no point in these interviews did anyone say they had reached-out to OSHA or Cal/OSHA (or any other agency) regarding their concerns. In fact, for some, participating in this study was their first awareness that nanotechnology is being applied in construction.

Question:
In the online survey you tended to agree that nanomaterials and nanotechnology may pose some risks. What has prompted these concerns for you?

Trade Group	Key Informant Quotes
Insulators	• I don’t know. Everything I work around is dangerous. It's probably gonna kill me one day anyways…it's just kind of the nature of the beast. I guess there's no real concerns; I already know what I'm getting into. The environment's going to hell anyways, nuclear war is gonna happen one day and everything's gonna be done, so I'm not really worried about that. • [Pyrogel] The fact that the material absorbs moisture, it's scary for

	me to think that our guy is gonna be out there breathing it. I've had students come to me and say "Hey, look dude I'm putting on a P-100 respirator, and I'm still feeling something in my lungs" That really…drew my attention…although the [manufacturer] refers to a simple dust mask to be used when installing their material. It's just so scary. • Just the nature of the dust, the nature of this product to get into every nook and cranny and have it difficult to come off of the skin. Its composition, it does something nothing else does. When you put this on your skin, you can't wash your hands…you can't get it off with soap…you have to physically scrape it. But in most cases, because of the size of it, it actually ends up in your pores. You need to have an acid based to get it away. That's extreme for a product. • "This product seems to be very nasty to the human body. Reports when I first started working with this…we had one job at a refinery and they started working with this product…and I'm hearing stories about guys, their hands are drying-out and their fingers are cracking and their skin's drying out…they're getting nose bleeds and coughing-up blood. This product has a hydrophobic quality to it that repels water…and we're being told that's part of the nanotechnology." "All I know is the nanotechnology that I'm being told I'm working with, nobody wants to work on it, because it has such a negative effect on the human body. And they're telling us it's okay. History with insulation products concerns me."
Plumbers/Pipefitters/ Steamfitters	• "Absolutely. Without being knowledgeable about it I know that manufacturers sort of do due diligence. They're supposed to manufacture materials and components that are not harmful, but that is not always the case…when asbestos came out…they told people that is was perfectly safe and the best product for this application and it turns out class action lawsuits everywhere from people getting mesothelioma and all kinds of associated lung disease from it. Am I concerned? Absolutely." • "Lasers are the thing right now, and it scares the hell out of people. A facility I was working at actually came up with a technology, with a laser, they can actually go through 3-inch steel like it's butter. You can hardly even contain this technology…it's very, very dangerous if it's not done correctly. I've been going in these labs where there are just scientists and technicians, and I'm a welder. For me to go into that environment really unnerves some people, it's like, 'Hey, that guy is just a dumb construction worker' but I'm really not, I'm very proficient at what I do…I'm not afraid of technology."

Cement Masons	• "Environment and health…only if it's detrimental…but I doubt it would get that far. I would think that it would be regulated and overseen. When it comes to worker health…we don't want to replace people with machines…as a union, our membership, that's a major part of our make-up. My only concern about the future of nanotechnology, is that would eventually replace workers." • "If it supposedly makes things green, a green product, just because it's a green product doesn't mean it's a healthy product for construction workers if you still have to use PPE in the application or use of materials."
Electricians	• "We've been getting into some different work over the last year that I think present some items…there's a lot of environments that are new to us dealing with and I have concerns that we're going to find out later that we probably should have been a little more aggressive in both information and protection. There was a study on the Greater Bay Area and cancer rates by geographical area…I was doing work at the port and they determined that truck routes were the highest concentration of cancer…highest quantity followed the truck paths. That was my first introduction that there's got to be something in the air that people aren't seeing that is causing this. We instituted a few more levels of protection when down at the container yards." • "Anything man creates has some kind of potential to nature and the environment and I don't think really much is known about the possible implications of the stuff being made and what it could do. It's new technology, I don't know. We're creating something that's unnatural and we don't know what kind of effects it's gonna have. It's always a potential problem, right?"
Tile Layers/Finishers	• "The fact that they don't understand it." • "Like anything that has to do with radiation or exposure to different chemicals, I want to know what reaction there could be with the skin, bones, reproductive capabilities."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "Ignorance. I don't know the potential dangers, the long-term hazards of certain nanotechnologies in different formats." • "The health hazards…how do you properly dispose of that stuff?...I think about the landfills now too, what are you going to do with that?...are they biodegradable or are we going to have to have some type of different mechanism for that? • "Just my field experience…the longer we've been in it, the more stories we have about safety issues." • "What happens to the human skin if you get some of these nanos inside your body? What will this new technology do to the human body?" [re photovoltaic technology] If I have some nanos in my

	body that one day get exposed to the sunlight and produce electricity, I don't want to be walking like a human light bulb." • "A lot of times when new stuff is developed, they'll do standard testing and they want to get it out as soon as possible and then people grab on to that. But they haven't really done the long-term studies of the exposure to workers or reactions to products. What chemical makeup does this have? Is it a carcinogen?" • "New materials are given to us, we don't really know…we see a safety data sheet that's been produced by the manufacturer. We work with these materials for a long period of time and we don't know the impact of how harmful they are to us. I've seen this happen over and over again, it's a red flag to me when something new comes out." • "Just awareness. Until you've been bit by a snake, you're cautious but you don't really fear them. You don't take precautions because it won't happen to you, and then when it does, you're like, 'oh, I guess this is a real thing."

When asked how respondents would deal with their concerns, many expressed the need to do research, educate themselves and check with safety experts. Some indicated they would communicate with workers and other trades. Rarely did interviewees mention employers in this conversation or talk much about employer responsibility for worker safety.

Question: **How have you addressed these concerns?**	
Trade Group	**Key Informant Quotes**
Insulators	• Encouraged worker to talk to foreman request negative air machine to minimize dust levels and protect self. Empowered him to talk to someone at job site where they felt this is a concern we need to address. • [Canada] We developed a safe work policy regarding Aerogel or nano-like technology. We took the safe work procedures combined through the material safety data sheet and from the best practices being used from some of our clients and we developed a written document that would be able to be dispersed amongst all the insulation industry, union, non-union, contractors, members. For anyone that works with that material, there is an industry best practice guide available to anyone. • The International got involved and tried to do research on it. I believe NIOSH did a study of the actual fiber. I teach my apprentices to try to 100% protect themselves the best they can.
Plumbers/Pipefitters/	• "First and foremost, educate myself before I voice any concerns.

Steamfitters	My concerns are pretty silent and unfounded right now because it's something new." • "We do a safety seminar before we even get started…physically show these guys hands-on everything that we do, and we repeat it so it's understood, and we monitor it. If someone is not working correctly in an environment, they can either get with the program or be expelled because…we've got to make sure it's safe."
Tile Layers/Finishers	• "Research it…try to download whatever I can to talk about safety concerns." • "When I got your inquiry, I was prompted to answer it. I want to learn a little bit about it."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "Nothing so far, but I'm going to be looking into it now. You've sparked my interest." • "I reach out to the guys on the job site, talk to them, make sure they have been trained, let them know their rights under OSHA, that you need to be trained by your employer. Sometimes I'll reach out directly to the employer, let them know what they're supposed to do. I've had meetings with companies and safety management and visited job sites, which is a positive thing." • "Read as much as I can…listen and talk with other coordinators in other programs about concerns they may have and how they're addressing it…try to disseminate anything that one person finds to all so we're not reinventing the wheel." • "Try to find out as much about the safety aspects as I can. As much information as possible about the makeup of the materials…safe handling…risk…and training." • "By making sure that everybody that I teach knows what I know."

When asked about controls that could be used to protect workers, many references were made to "teaching the guys how to protect themselves" by using personal protective equipment, particularly respirators. Most comments about controls describe standard respiratory protections. As we would expect with the lack of specific knowledge about nanotechnology, people are going with what they know about familiar protections used for other contaminants and chemicals.

Question:
In your experience, what controls, if any, are being used to protect workers who use nano-enabled materials or other forms of nanotechnology?

Trade Group	**Key Informant Quotes**
Insulators	• They always say wear a dust mask at least, but nobody does, I mean, come on now, let's be honest here. I've heard of people that use Cryogel or Pyrogel they made little containments and they've

	worn a half face respirator, so they're deathly afraid of it. It's so new we don't know if it's gonna kill us, how fast it's gonna kill us, what it's gonna do to us yet or not. Nobody knows. We're talking 10-15 years down the line before we ever know if something it could do to us. Asbestos and leaded paint are taken seriously, not nanotechnology. • Just overall awareness. Workers are made aware of "respirator bill of rights" that they can ask for half face or even PAPR any time they feel a dust mask isn't going to protect them enough. • [Ontario, Canada—Aerogel] Recommended best practices—removable coveralls, nitro gloves, respiratory protection, controlling the cutting environment always minimize dust. Material handling because rolls are heavy. You can go to ihsa.ca and the document's there. • "The guys have told me they're putting on the Tyvek suit, they're putting on latex or nitrile gloves underneath their work gloves, taping their sleeves down…taping the collars of their shirts to their neck. They all want half-face respirators with an N-100 filter, they've told me they've still gone home and could feel it in their nose, sinuses and in their chest. They look like they're ready to get into a spacecraft." "Somebody found a hand balm, like a cream, they could put it on and it sealed the skin…they put it on their face…it seemed to help. Guys ask for this stuff, it's not in our collective bargaining agreement, but most employers are helping the guys get it."
Plumbers/Pipefitters/ Steamfitters	• "I would assume that before any product comes out containing nano…it's gonna be somewhat regulated by agencies like OSHA and Underwriters Laboratories. I would think that any products used in the industry will be first vetted by agencies that are tasked with vetting these products…it makes me feel like they might do a good job to make sure that they're not harmful…but that wasn't the case with silica or asbestos." • "Safety equipment, procedures and protocols, given classes any time you're going into one of these laser labs…safety training…make you aware of different dangers and introduce the safety personnel and the contact personnel. You have to know who your resources are and how to utilize them." • "Test the atmosphere, wear appropriate PPE, get administrative controls. Wear monitors throughout the day. Learn how to don the mask…what mask?...who has to approve them? NIOSH."
Cement Masons	• "Standard respirator, eye protection…nothing specific as they say you need to do this because of nanotechnology, I've never heard of that."

Electricians	• "Try to find out what's in the environment of the places we're going into and what levels of protection we need to work in those areas. Have kick-off safety meetings for each job."
Tile Layers/Finishers	• "Warn you whenever we work around lasers, acrylics, different chemicals…they tell you on the safety sheet how to protect yourself…wear the proper gear and eye covering for light exposure."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "PPE involved in welding, particular type of mask and ventilation system, how long you're exposed to that process." • "Not aware of anything other than just safety procedures, much like what Cal/OSHA puts out." • "Just dust in general is being handled more often with local exhaust ventilation systems, so it's easier for me to get an allocation of funds to buy more air scrubbers than I used to be able to just because of the information that's out there."

We gathered good feedback regarding thoughts on the most important things workers and employers need to know to use nanotechnology safely. Here is a list of the top responses:

- What is nanotechnology—Why it is being used—successes
- Terminology to read and understand
- How nanotechnology has a major impact—how things have changed
- Properties of the products—what's in it; how's it made; how it interacts with human body and environment
- Basic understanding of health concerns
- Potential hazards/risks—is there an actual hazard?
- Short and long-term effects of exposure
- Safe practices for handling/installing/disassembling products
- How to control it—protect workers
- A curriculum for apprentice and journey level classes
- Handouts—to understand what nanotechnology is and how to prepare

Question: **What do you think are the most important things workers and employers need to know to use nanotechnology safely in construction?**	
Trade Group	**Key Informant Quotes**
Insulators	• If it's gonna kill you, what are the exposure limits. If there's certain operating temperatures it can't go past, what's it gonna do if it goes past. • Employers sometimes shy away from their responsibilities…so when guys start asking for PAPRs, PPE, employers try to do the most they can to minimize the expense. If employers were aware

	that the material has these properties, expect that you're gonna have to buy safety PAPRs and they're not cheap. If employers were to be aware of some of the things that employees encounter, some of the effects that they encounter, I think that they will be better prepared financially. • There has to be a conversation about why it's being used. The successes that come from properly installed systems. That way people can have a little bit of ownership with it. Maintaining a comfortable and safe environment involves a lot of education, a lot of conversation. When there's a positive conversation, that doesn't necessarily change what the product is or its potential hazards, but the application just goes better. People just need to be on the same page and willing to ask the tough questions and not settle for the surface answer. We're starting to see some of that evolution now. We hear more and more about people taking the opportunity to study it and try to gather data on it…and nothing has come back to raise alarms. The younger generation's going, "Okay, we have to trust in today's science that this is gonna be okay." • "They need to know the properties of the product, how it interacts with the human body and the environment. We don't want to put products out there that are going to destroy our environment or destroy our body. I would tell employers, 'protect your workers'…I know that with asbestos it drove big companies out of business. I want somebody to show me data that this stuff is not harming the human body or the environment."
Plumbers/Pipefitters/ Steamfitters	• "What's the risk exposure? Is the stuff safe? Has it been properly vetted?" • "Know the rules and abide by them. There's terminology out there for people to read and understand for their safety concerns, but they have to embrace that." • "There needs to be curricula developed…provided in apprenticeship and journey-level classes with some sort of incentive that attracts buy-in."
Cement Masons	• "Go back into what is in the product and how the product is made so they can disseminate that information to workers. How nano has a major effect on how things have changed. I think it's something apprentices could understand and appreciate in course one, brand new people coming into the program, and how things are changed.
Electricians	• "That there are things out there that are going to affect you later in life that, because you don't see them, you don't really recognize the possible danger is immediate. You need to be aware that there are items out there that are unseen that you need to be protected from."

	• "Any hazards associated with the exposure and how engineering controls or administrative controls are put in place to help protect the worker."
Tile Layers/Finishers	• "A handout…something we could give them so they can understand what it is...prepare themselves for it…like what happened with silica." • "Any risk involved with it, we need to be made aware…just need to keep pounding it to the younger ones about how to protect themselves and what they need to do."
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• " A basic understanding of any health concerns. I don't know what health concerns nano may cause to a person because I'm not informed. I'm ignorant, but I'd like to know that. What are the hazards?" • "They need to be made aware that there's an actual hazard there, that's key. Once everybody knows that there is a hazard there, it's easier to address." • "If engineers are putting it into specs, you should have to comply with all safety mechanisms involved for those types of materials. As an employer, I think they should be responsible for educating their employees on working with that…and that would really come through Cal/OSHA. I don't want to see this come back like it did with asbestos back in the day with those researchers." • "Communication is number one…definitely needs to be proper training and information that gets to the field workers from their employer." • "Be aware what it will do to the human body when we get exposed to it, if the body assimilates some of this product." • "What's in the product, how can it affect me, safest way to handle/install/disassemble the products…whether that be well-ventilated areas, working in open areas as opposed to confined space." • "Whatever health and safety bits there are that go along with working with these products…how workers could protect themselves and still be productive with the material." • "What are the risks, how do we control it…should respiratory protection be used…or can we handle it at the point-of-use with ventilation? The key message is it's not the same as dealing with a normal particle. Nanoparticles, they react differently, they bind differently, they go into your body and they are absorbed in tissues differently. They're not normal."

This brings us to the end of key informant interview results. When asked for final comments, respondents expressed their support for our effort in doing this study and the hope that it

would have a good effect. People seemed to be inspired to continue their own investigation of nanotechnology by having participated in our online survey and key informant interviews.

Question: **Is there anything else you'd like to talk about with regard to your concerns that we haven't covered?**	
Trade Group	**Key Informant Quotes**
Insulators	• I think you guys are doing a great thing by conducting this study. I really hope it has an effect, a good effect on our work. I appreciate your guys' efforts, I really do. • I'm just really thrilled you guys are doing this because I think it's gonna bring to light a lot of stuff. Maybe research is being done, the problem is that's not being relayed to…the end user, the guy applying it. He should know everything about that product.
Cement Masons	• I think this is pretty neat the building trades is looking at something like this…this is something the apprenticeship committee could appreciate.
Others (Boilermaker, Millwright, Sheet Metal Worker, Elevator Constructor, Roofer/Waterproofer, Drywall/Lather, Plasterer, Contractor safety rep)	• "I'd definitely like to know more about it." • "I realize how I need to get on the ball with this…more than anything I need to be involved in an evolution because that's what is right. If it's part of construction, workers need to be aware of what they're working with. Anyway, that word 'nano' I'll remember it now." • "I do believe that we're on a cast of the next generation of construction worker and the materials that they're going to be using."

C3. Key Informant Interviews with Government Agency Staff

While studying nanotechnology awareness among organized labor representatives, it made sense to also take a look at the state of current programs within California public agencies. These would be likely places where union staff, apprenticeship staff and contractors would turn for information and help regarding health and safety concerns related to new technologies. We sought out professionals with ties to nanotechnology research and safety who would be willing to share their perspectives as part of this study. Our goal in interviewing these individuals was to determine if they are currently working on any monitoring, control, regulation or educational outreach related to nanotechnology or nanomaterials generally, or any specific to the construction industry. We're also interested in the California experience with nanotechnology regulation. We completed interviews with 5 people on the staff of these California public agencies:

Department of Industrial Relations, Division of Occupational Safety and Health—Cal/OSHA— agency responsibilities:

- Setting and enforcing standards
- Providing outreach, education, and assistance
- Issuing permits, licenses, certifications, registrations, and approvals

Department of Public Health—Occupational Health Branch (OHB)—agency responsibilities:

- Identify and evaluate workplace hazards
- Track patterns of work-related injury and illness
- Develop training and informational materials
- Provide technical assistance to others to prevent work-related injury and illness
- Work with partners to develop safer ways to work
- Recommend protective occupational health standards

Department of Public Health—Environmental Health Investigations Branch (EHIB)—agency responsibilities:

Assists communities and public agencies to address health and exposure concerns related to hazardous waste sites (for example Superfund sites) and releases of hazardous materials.

CA Environmental Protection Agency—Department of Toxic Substances Control (DTSC)—agency responsibilities:

- Restore communities whose environment has been degraded by past activities
- Safeguard communities against possible hazards associated with businesses that generate or manage hazardous waste, and help businesses to minimize their generation of hazardous waste

- Protect future generations by encouraging and helping businesses to reduce the use of toxic chemicals in products

We asked each key informant the same series of 13 questions. The two Cal/OSHA representatives chose to do a simultaneous interview. The opinions expressed in these interviews are those of the key informant and do not necessarily reflect the official position of their agencies. These informants hold (or have held) the following positions: Senior Safety Engineer; Toxicologist; Research Scientist; Chief; Deputy Director/Staff Toxicologist/Chief Scientist. Because of their concern for confidentiality since they were not formally speaking on behalf of their agencies, (and in fact, one refused to let us record the interview,) feedback is summarized in aggregate by key topics.

Role agencies play with respect to nanotechnology

Cal/OSHA has three ways they could potentially become involved with nanotechnology. The Enforcement division would deal with any complaints, accidents or hazards observed during inspections related to nanomaterials and would correct by issuing citations. The Consultation Services Branch could be involved with nanomaterial issues if they are invited to workplaces by employers with the agreement that identified hazards would be abated/corrected. The Research and Standards Development Unit would become involved if a specific regulation regarding some nanotechnology product or process were needed, but this has not applied yet. They would begin to develop new standards in this unit with cooperation from other parts of Cal/OSHA. There are currently no specific initiatives or targeted programs on nanomaterials.

OHB currently plays a small role mainly staying informed and informing others through working groups within the agency. The Hazard Evaluation System and Information Service, or HESIS, falls under this agency's control. HESIS investigates new and unrecognized workplace hazards, provides early warning, and works to prevent illness and disease on the job. This program has potential for involvement with nanomaterials.

EIB currently does not have much of a role. They have brought together a working group of staff who are interested in nanotechnology and nanomaterials. While no program has been initiated, this Nanotechnology group stays current on developments and issues and makes informational presentations to leadership.

DTSC has historically been involved with permitting of hazardous waste treatment, storage and disposal along with clean-up of hazardous waste sites. This agency had the most involvement with nanotechnology. They are tasked with enforcing California Safer Consumer Products regulations. We got a lot of interesting information about their history of involvement in data call-ins for nanomaterial manufacturing. That experience will be described separately.

Current Activity

Aside from informational working groups and participation in professional symposiums, none of the informants were aware of active programs or initiatives within their agencies that currently

target nanotechnology. All of these agencies have the potential for action whenever needed, however they operate based on prioritization of concerns. Engineered nanomaterials were definitely on all of their radar screens and, if data were to become available to indicate new concerns or a critical threat to worker or public health, they could take action. None of them had ever targeted construction materials.

Standards and Enforcement

According to our interviewees, there are no standards specific to nanotechnology or nanomaterials, nor are there any enforceable Permissible Exposure Limits (PELs). They did tell us that NIOSH has established two Recommended Exposure Limits (RELs) for carbon nanotubes and titanium dioxide, but these are not legally enforceable. At this time, Cal/OSHA Research and Standards has no pending proposals for PELs for nanomaterials. Thus far, the California legislature has not directed Cal/OSHA to specifically look at engineered nanomaterials.

The fact that we have no specific regulation governing nanomaterials does not mean that they are exempt from enforcement. Cal/OSHA has run across them at least once on the enforcement side. Even though specific health effects of nanomaterials may not have been scientifically elucidated yet, if there is a risk, we have existing standards that apply to require safer practices in the absence of a nanomaterials standard. Cal/OSHA informants explained four performance standards that could apply:

- Injury Illness Prevention Program (IIPP)-requires employers to assess for and address hazards; includes requirement to follow manufacturer's instructions
- 5141—states that hierarchy of controls must be used to control hazards
- Respiratory protection standard—requires that respiratory protection be provided
- Hazard Communication standard—requires training, safety data sheets

These regulations that are general performance requirements for maintaining a safe workplace also apply in construction and could be used initially to cover nanomaterials. Should a more specific risk develop from a common material or process, Cal/OSHA would consider having a more specification type regulation for that process/material. Thus far, no information has led them to conclude that this is needed for any nanomaterials. Our key informant pointed out that Cal/OSHA has had very few inquiries about nanomaterials in construction.

Nano-Enabled Construction Materials

Our group of interviewees uniformly indicated a lack of information about use of nano-enabled materials in construction. A few were familiar with the eLCOSH Inventory but had not used it. None were aware of a specific California agency focus on nanomaterials in construction. One informant explained that, in looking at information on other toxic chemicals associated with construction, they had become aware of engineered nanomaterial usage in construction products. Construction materials are usually a mix of ingredients and Cal/OSHA mentioned that, in looking at standards on other chemicals they currently regulate or are considering for regulation, they have seen that engineered-nanomaterials are increasingly being used and marketed.

When we asked this group to give examples of nanotechnology applications in construction, the following items came to mind: components of solar installations; structural material—panels, shingles; spray-on insulation; paints, coatings and spray materials; cement and cementitious products; asphalt paving products. Some indicated they were still trying to identify what products are nano-enabled, how those products are used in the field and what kinds of exposures a user of that product might encounter. They noted how hard it is to develop a safety strategy when you don't yet know the answers to those questions. This exactly echoes the main concerns of our construction key informants. This lack of information contributes to the lack of awareness and training. We seem to be caught in a "chicken and egg" situation with nanomaterials. We need objective data to set standards and PELs; we need PELs and regulations to motivate employers into action; and, products need to be identified so we know what to research to get the objective data. And all of the above is needed in order to develop effective training.

Issues and Concerns

Similar concerns were elucidated by all those we interviewed. One of the biggest hurdles is determining a standard definition of a nanomaterial. We need to know precisely what we're targeting for monitoring, regulation and training. Our DTSC informant described how they watched the US EPA struggle with its language as they were creating regulation for nanomaterials. The informant told us, "Everything seems to be size-centric. What's the difference between a nanomaterial versus a non-nanomaterial? Because they're of such small size, their properties are much different than materials in the macro scale." This challenge of identifying nanomaterials is yet another concern shared by construction professionals.

Another top concern is that there are very few regulatory criteria for worker protection. One respondent felt that NIOSH was doing "fabulous work" in this area and told us that NIOSH had done monitoring at a nano metal manufacturing facility in Southern California. The DTSC respondent also pointed out that once we start using the regulatory authorities that are in place to focus on nanomaterials, it will have an impact causing people to start providing information up and down the supply chain. He went on to say that one of the biggest problems that we have in modern consumer products is a lack of information across the supply chain. "So an end user, such as someone in the trades, who asks 'what is in this paint,' might go to a SDS but it may not be complete, not list titanium dioxide. This is an issue for all supply chains, not just construction." Hopefully the efforts of our regulatory agencies will push the information exchange all the way through the supply chain to the consumer at every level. Once this happens, we will be able to access much more valuable information to develop worker training and raise awareness.

All agreed that there is little epidemiology on exposure to engineered nanomaterials which would drive scientific assessment of the need to regulate. This dovetails with the supply chain issues just mentioned. Informants mentioned that they have a lot of information on relatively few nanomaterials but there are still many information and data gaps. None felt that they had much knowledge about potential health effects. Some mentioned not knowing the location of

all nanotechnology facilities in California, making it difficult to identify a cohort of workers to study. The focus thus far has been on carbon nanotubes and titanium dioxide. DTSC found that many companies in the carbon nanotube area are very small, with only a few employees, and the amount of carbon nanotubes that goes into manufacturing of some products is very small. Some companies have front offices in California but do their actual manufacturing offshore. These are just the manufacturers of engineered nanomaterials; finding any data on nano-enabled product end users (like construction workers) is almost impossible at this time.

Development of engineered nanomaterials is rapid and outpaces government efforts to monitor and research them. Also, these materials are rapidly being incorporated into many different products, making it nearly impossible to track them all. The Health Effects Advisory Committee (HEAC) within the Division of Occupational Safety and Health holds hearings to assess and consider revising PELs. Carbon nanotubes is on their list of materials they know are an emerging issue. However, the Advisory Committee determined that they don't have enough information to prioritize carbon nanotubes and metals attached to nanotubes to start creating a PEL. So, it remains on a watch list, and the Committee will track usage and any health problems that are reported. Many metals, used as catalysts to produce carbon nanotubes, are toxic and can remain attached to nanotubes which could possibly be released through construction tasks. Some initial concerns were that airborne carbon nanotubes actually could develop certain features and aspects that would mimic asbestos.

The HESIS program has authority to ask manufacturers for information about products containing specific chemicals. This could be used to find all products in California containing specific nanomaterials but isn't currently being applied. Because HESIS has to limit their focus to one chemical or material known to have significant health effects that they're trying to understand better, such as carbon nanotubes or titanium dioxide, their involvement would not be useful for creating a construction product inventory. A few engineered nanomaterials were on the list of first uses for HESIS authority under SB193, but they didn't make the cut. These are still on the list for consideration, but that will still be a few years out.

Education and Outreach

The informants did not identify any specific training that their agencies currently offer, although some spoke of past seminars they had offered that were open to any interested stakeholders. They did recommend some resources that would be helpful. The internet-based "Good Nano Guide" was mentioned multiple times as well as a project done under OSHA Harwood Grant funding several years ago. It was also mentioned that the California Center for Occupational and Environmental Health had put out trainings for industrial hygiene professionals that cover nanotechnology. And the California Industrial Hygiene Council has annual education events at which nanotechnology has been covered more than once. Also mentioned were trade association journals that provide product information, although they acknowledged that this information may be promotional in nature.

A couple of interviewees spoke about a 10-year project (now finished) under a multimillion dollar US EPA/NSF grant that established the UC-CEIN "Center for Environmental Implications of Nanotechnology" to look at health implications of nanomaterials. This was a collaboration of UCLA, UC Santa Barbara, UC Berkeley, UC Davis and other partners. A part of this is the Molecular Foundry at UC Berkeley.

Historic Involvement

We learned that, while regulatory and educational activity around nanotechnology is relatively quiet right now, a lot happened in the last 10-15 years as nanotechnology really came into public awareness. An observation common to all interviewees is the rapid pace at which nanotechnology research and development is occurring. New nano-enabled products are surfacing faster than researchers can investigate them and the government can monitor them. Spurred by this growth and the U.S. Government National Nanotechnology Initiative in 2000, state agencies became involved in researching and monitoring nanomaterials. If we had been writing this study 5-10 years ago, there would have been more activity to report. Within our interviews, DTSC surfaced as the agency that had done the most data gathering on nanomaterials in California. We received a detailed account of ways they had been looking into nanomaterials. We'll share what we learned of their experience as it may be instructive for future efforts by others.

The DTSC Experience

Around 2006, DTSC became interested in looking at the entire life cycle of products. They began by studying products still in use or about to be manufactured and the raw materials going into those manufactured products. This effort eventually lead to the California Safer Consumer Products regulations. DTSC focuses on products and the chemicals that go into them and looks for safer alternatives. In 2006, DTSC held a series of seminars on nanomaterials, trying to understand what they were and their uses. They then started to use authority under California "AB289" legislation to focus on nanomaterials. In conjunction with the seminars, they started reaching out to those nanomaterial manufacturers they could identify to ask what they knew about their product. These were not companies that manufactured nano-enabled products but rather the raw nanomaterials that would go in to those products. They invited many people from around the world to join the manufacturers at these seminars.

Using their authority under AB289, DTSC initiated a data call-in. This is an official information request under the authority of the legislation that requires manufacturers to file a response. Data call-ins are a way for the EPA to gather product information and make it public. DTSC physically went out and visited many of the nanomaterial manufacturing sites in California, in coordination with US EPA and NIOSH. For one year prior to starting this data call-in, DTSC held workshops for people operating manufacturing sites, many in the Silicon Valley, to explain what it was about and prepare manufacturers. The data call-ins done here differed from those being done by US EPA because, under California authority, research facilities and universities such as Stanford were not excluded as they are under US EPA authority. Ultimately as DTSC interacted with US EPA and NIOSH and they moved forward with the California Safer Consumer Products

regulation following legislation (AB1879, SB509). They examined problems that US EPA had in regulating nanomaterials and tried to make sure those same problems were not part of California's regulatory language.

Currently, under Safer Consumer Products regulation, DTSC may now focus upon nano-enabled products and precursors to those products, but they haven't done that yet. The regulation process can be initiated in two ways, through administration policy and through a petition process where outside entities can nominate products or materials for consideration. The petition process involves developing data packages and providing information to make a case that DTSC needs to worry about the product/material. In all of their programs, DTSC never focused on any products related to the construction trades, nor on any nano-enabled product. Their focus was not on end-users of nano-enabled products but rather on actual manufacturing of nanomaterials that would ultimately be incorporated into products as raw materials.

They did give us one interesting example of how they approached a product allegedly made of nanomaterials or enabled by nanomaterial and considered how that product was handled after market. Investigators knew that many high-end bicycle frames incorporate nanomaterials, and also knew that the frames often undergo repairs. They wanted to know whether or not carbon nanotubes escaped into the work environment at the time of repair or modification. That led them back to carbon nanomaterials, and they sought to learn what the manufacturers know about the nanomaterial they produce and sell upstream and what kind of safety information they provide in terms of using it in their products. A similar process could be applied to construction products if there were data to compel investigation.

In 2006-08, as nanomaterials had already come to the forefront and were hailed as miracle materials by the manufacturers, there were growing environmental and health concerns about their use. DTSC explained to us that, years prior to entering this area, they reviewed literature and found that many products would claim to contain "nano" super material. At that time, manufacturers used nano content as a marketing advantage for their products. But DTSC observed, as issues of potential public health and environmental concerns arose, that type of marketing disappeared. Soon the use of nanomaterials within products was no longer as much of a marketing advantage, and "nano" became hidden. This is why, through their data call-in, DTSC was trying to gather information and better understand the supply chain. Even today, the supply chain remains somewhat of a mystery. For example, DTSC doesn't know whether some nanomaterial is in paints or other surface coatings. Historically, they found that the Safety Data Sheets supplied by some manufacturers were not accurately listing nanomaterials. As the industry matures, this will hopefully improve.

In 2010, DTSC issued a data call-in on nano metal oxides and quantum dots to learn the various ways they were being utilized. They found some materials were being injected into the ground for clean-up of hazardous waste. Titanium dioxide and zinc oxide are used in paint. Titanium dioxide is also in sunscreen products. Nanosilver has antibacterial properties and was

incorporated into washing machine drums, socks, clothes, and camping gear. Quantum dots had medical uses and are used in imaging. This was DTSC's last data call-in.

DTSC has offered to help other states by inviting them to collaborate by providing background data/justification that would enable DTSC to move forward with a data call-in. The Safer Consumer Products authority is granted to the agency as a whole, meaning that any office within Cal/EPA could use this authority in ways similar to DTSC. The only drawback is that this authority does not come with any enforcement.

This DTSC experience illustrates the lengthy process involved in identifying and monitoring nanomaterials before they even make their way into consumer products. The creation of new nano-enabled products is moving much more rapidly than the monitoring process. If objective data could be assembled for some nano-enabled construction products, the DTSC could be petitioned to investigate them. This would be a very important step in learning more about nanotechnology in construction.

D. DISCUSSION

We embarked upon this study with open minds and the hope that we would be able to contribute some helpful feedback about a new technology that is finding its way into construction. We truly did not know what to expect, whether we would find participants, if anyone would have anything to say, or if there would be interest at all. Nanotechnology is a word that conjures thoughts of space age, futuristic, scientific, other-worldly, robotic creations that are at the same time amazing and frightening. In our experience it is not a topic that surfaces at health and safety training or in discussions with our affiliates. When we've asked our train-the-trainer participants for suggestions for new safety curriculum topics, nanotechnology has never surfaced. And yet, when we cast a net out, we found curiosity and voices. We believe this small study just scratches the surface of a great potential for engagement and enlightenment within our construction world. What follows is a summary of themes that emerged from the results of our effort.

D1. An Unexpected Response

Construction professionals are busy, production-oriented people. Asking them to spend time taking an extensive online survey about "emerging technology" seemed like it might be futile. But we were pleasantly surprised by the results. Initially we wondered how we could possibly entice 100 people to join in our project, strategizing recruitment back-up plans. But then something happened; we put it out there and surveys started coming in right away. They kept coming and soon we met our goal but they still kept coming. Ultimately we had 253 surveys in hand, more than double what we set out to collect.

Response: Hitting Our Target

As we sifted through the demographic information our study group began taking shape. They came from a variety of 24 different crafts, were mostly veterans of the construction trades, and over 45 years old. They had worked their way through the ranks to become union leaders, training directors, instructors, safety professionals, foremen, and superintendents. Many had moved from working with the tools into other jobs and some had multiple roles. They had a wealth of experience with nearly 70% being in the trades for more than 20 years. And all but one quarter of them provide training to others. While our survey-takers would be the bones of our project, the 21 key informants would be the voice in this exploration of nanotechnology. As it turned out, they had a lot to say and we thought it important to include their own words in our findings. They came from 13 different crafts as well as safety management and were eager to share their thoughts and experiences.

Response: Conspicuously Absent

We feel we successfully reached our target audience, but we are disappointed that contractors seemed to keep their distance from the project, with only 22 (9%) participating. We looked forward to hearing from contractors on this topic. Why their participation rate was so low is open to speculation. There did appear to be some resistance right from the start as we were promoting the study and recruiting participants. Our union contractor association contacts who normally help recruit for our safety trainings showed little interest in assisting with this effort.

They did not tell us specifically why this was the case and we have no way of proving any theory. We wondered if perhaps the timing of our study coinciding with the implementation of the new silica standard might have had an effect. Contractors large and small were busy trying to come into compliance and silica topped everyone's list. Participating in a lengthy survey amidst this priority may have been daunting. Contractor groups formed a coalition in opposition to the California Standards Board horcher of the federal silica standard. All of the associations we hoped would support our nanotechnology study were part of this coalition. The SBCTC openly supported the horcher, which was eventually passed by the Standards Board. It was within this climate that we asked them to help us look at nanotechnology, another concern about small particles. While they were not a big part of our study we hope they can be engaged in future projects around this topic.

D2. The Extent of Awareness

Attempting to assess the level of nanotechnology awareness among our study subjects was the number one goal of our study. This was not an easy task to accomplish with an online survey. We had to establish some criteria that would be straight-forward and easy to translate to the survey instrument. Beginning with recognition of common terminology seemed like a good way to make the first determination. If someone had never heard of nanotechnology, nanoparticles, nano-enabled materials, or engineered nanomaterials, it would be a good indicator that they did not have awareness. This immediately filtered out only 19% of survey participants, meaning that 81% did have some level of awareness. There was a small cohort (47) who weren't sure if they had heard these terms or not. But it is interesting that some who said they weren’t sure also checked some of the terms. We treated this group who was on-the-fence about terms as if they had some awareness. The results were surprising to us, as we did not anticipate so many to have heard these terms.

The umbrella term "nanotechnology" was recognized most, but awareness diminished as the terms increased in complexity, with "nano-enabled materials" being the least recognized. This is curious since it is the term most descriptive of end-user products. As each subsequent question drilled deeper, people quickly dropped off the spectrum of awareness. Whereas 62% of survey participants had heard the term nanotechnology, only 25% were aware that it applied to construction. In the end, only 13 people indicated they had actually worked with a nano-enabled material and only 5 people had received training related to nanotechnology. Most of the 13 came from one craft, the Insulators. The only non-Insulators were a Painter and a Pipefitter/Steamfitter. Of the handful who had been trained, all except one contractor safety rep were Insulators. This indicates a rather shallow awareness of nanotechnology among survey respondents.

We acknowledge that there is a big difference between having heard a term and actually knowing the meaning of that term. So, we must distinguish between awareness and knowledge. We make an assumption that people who know they are using a nano-enabled product at work have some understanding of nanotechnology. But we found through our key informant interviews that this understanding can be vague and subjective. The case could also

be made that members of the group who had heard terms but were unaware they applied to construction, may actually have a better understanding of nanotechnology generally. Within the scope of this study we would be focusing on those who knew it applied to construction.

Awareness: Nano, an Enigma Wrapped in a Riddle

What is nanotechnology? Even people with awareness struggled to articulate a clear description of nanotechnology. Is it particles, lasers, robots, computers, tools, or just something new and very, very small? Does it refer to a process or a material? Is it natural or engineered by humans? Is it here now or in the future? We found that all of the above came to mind within our pool of key informants when thinking about nanotechnology. Just shy of half of interviewees immediately related it to size. A consistent, uniform definition never surfaced in our discussions. And as we got deeper into discussions of concerns and training we realized just how critical this is to how people feel about products and whether or not they react positively to working with this new technology. If your perception is that it has to do with robots and computers, then you may not be looking for it in paint coatings. One Insulator stated this issue very well,

> *"There's a real misunderstanding, perhaps, of what 'nanotechnology' is. I don't know what is or is not a nanotechnology product…or what makes a product nanotechnology. If you were to walk up to the average construction worker and say, 'Hey, can you explain what nanotechnology is in products in construction?' they'd look at you like you were crazy."*

> *"Nanotechnology is just a word to me right now, I couldn't tell you what it means. I've looked it up and they give you all this fancy scientific stuff, and I'm going, what does it mean to the average lay guy out there in the field? A guy that's going to work every day and being told to work with a product that he's really gonna not know a whole lot about."*

And this is coming from one of the few people in our study who had received training.
Our construction key informants weren't the only ones who struggled with defining aspects of nano. Even a scientist from our public agency key informants told us,

> *"One of the biggest issues is defining what is a nanomaterial. If you can't define what you're after in a regulation then you can't do anything because you can't describe your target. DTSC watched US EPA struggle with its language. Everything seems to be size-centric; what's the difference between a nanomaterial versus a non-nanomaterial? Because they're such small size, their properties are much different than materials in the macro scale."*

The informant explained that ultimately the California agency decided to define chemicals with a flexible definition that had nothing to do with size but rather uses a series of parameters based on characteristics.

When we asked the construction key informants how they would describe nanotechnology to a colleague or peer, we got an interesting range of responses. Here are some examples from the findings:

"I'd just have to tell somebody it's something that's really smart and really small. That's basically what nanotechnology is." (Journeyman)

"It's a space-age type product that they're adding into insulation." (Apprenticeship Coordinator)

"I wouldn't. I typically don't explain things that I know nothing about." (Union Rep)

"The restructuring of molecules to enhance the use of product or make things increase longevity, make a better use out of it." (Apprenticeship Director)

"It's something that is in the product…whether it's tile or the setting materials or the finishing materials, or even some of the tools." (Apprenticeship Coordinator)

"It's something we have very little control of…it's something new to us, and it's not really that new because we've been using laser levels in different types of lasers and we know we're supposed to protect ourselves." (Instructor)

"My understanding is nanotechnology can be like a small little robot, that they're so tiny that we can only see it through a microscope. And what it can do to our body, it's something new, we don't really know." (Business Manager)

"I might tell them to get out their smartphone and Google it." (District Coordinator-Ret)

Perhaps this explains why more than half of our informants told us nanotechnology is never a topic of discussion among their co-workers, peers, union members or employers. Some people thought that younger workers may be more attuned or open to nanotechnology. It would be interesting to follow-up on our study with a similar survey of apprentices. Front-line workers were not in our target audience.

Awareness: Health Effects and Risk…Where's the Data?

If we take this awareness theme one step further and look at nanotechnology from a worker risk standpoint, it can become more mystifying. How does one describe the nature of nanotechnology hazards if we're still unclear as to whether a hazard actually exists? If we cannot answer this question, then it will be difficult for construction workers to care about understanding nanotechnology.

A common theme expressed throughout all key informant interviews is that we just do not have enough information to know if and how nanotechnology poses a risk to workers in construction. There simply isn't enough research available right now to definitively tell us this

construction nanomaterial will do these things to your body. If such information does exist, then it isn't getting out to the people who need it.

This concern was shared by the government agency informants who told us there is little epidemiology on exposure to engineered nanomaterials, which would drive scientific assessment of the need to regulate. If this information is not available to these professionals who come from the research world, we can safely assume it is not making it to construction sites either. Even if research shines a light on how a particular engineered nanomaterial interacts and affects the human body, we need to take it a step further. What happens when these nanomaterials are incorporated as an ingredient in construction products? Does it change when it transforms from a raw material into the matrix of a finished product? What types of tasks and tools might cause engineered nanoparticles to be released into the work environment? How could they be absorbed into the body—what's the route of entry? We desperately need this information to know how to raise awareness and protect end-users. But, as we discovered through our study, we're not even past "what's nanotechnology" yet. This knowledge gap opens the door to many fears and concerns that we'll be discussing further in Section D3. We have a lot of ground work to do to create a better base level of nanotechnology awareness among construction unions and apprenticeship programs. This is where we can have an impact.

Awareness: Do People Notice Nano Impact?

Our sense of this comes mostly from key informant comments. The areas where they felt it had surfaced were: insulation; concrete; roofing tiles and waterproofing membranes; orbital welding. On the positive side, many identified ways they felt nanotechnology had brought benefits to the industry through improved product strength and longevity, better efficiency, and more user-friendly materials (less dusty, lighter weight, increased open time, less noisy, safer). One of the benefits cited was that it "makes work easier." This is somewhat humorous because in our 2011 study on ergonomics in construction, using ergonomics to make work easier on the body was perceived by some as a weakness, an insult to the toughness of the union worker! Perhaps nanotechnology isn't as personal.

There were some who felt that nanotechnology was having no effect at all or, even worse, a negative impact, such as robots taking away jobs, or photovoltaic systems embedded in roofing materials causing a jurisdictional dispute between the Electricians and the Roofers/Waterproofers.

Once again the uncertainty of what nanotechnology really means affects people's perception of its impact. If a person has a misapprehension of what constitutes nanotechnology, then their understanding of impact may not be accurate either. This trepidation is illustrated in these quotes:

> *"I have heard that there are products for the building industry such as cementitious materials…that contain nanotechnology…but I couldn't speak intelligently on them. If I knew*

what those things were, then I could probably tell you how I thought they were benefitting or making an impact on the building trades." (Business Agent)
"I know it is the driving force, but it's not talked about. It's almost like a secret situation. And then, the more information gets put out, people start running the other way with it saying, 'Oh, this is a danger…this can get out of control.' Welding…working around lasers…robotic equipment…with the nano, that's theory. We really need to get on top of this technology, because it's much more than we understand." (Supervisor/Instructor)

"Back in the day, a lot of our stuff was mechanical and electrical relays and now the majority of this new technology is just plug and play, it's computer-based. It's like going from 'erector sets' to iPhones and Smartphones to interact with elevators and escalators. It's completely a different world." (Business Rep)

Awareness: Testing the eLCOSH Inventory

When we were designing our online survey, colleagues recommended that we skip this part of the research. They felt it was just too daunting to put out there and that no one would take the time to look at more than 500 entries. We respectfully included it anyway because we thought there would be value in just testing the waters on it even if the results might be hard to interpret. As it turned out, 71% of survey respondents agreed to view the list. This response told us that there is a willingness and a curiosity to know more about where nanotechnology is showing up in construction. As reported in our findings, about one third of survey respondents said they recognized or had used products on the list, and about 25% actually took the time to tell us which products those were. Out of this group of intrepid construction workers, 11 were people who had never heard of nanotechnology.

We're proud that we attempted to test the eLCOSH Inventory but, given our small sample size, and the fact that some of the entries on the inventory were very generic, we really can't draw too many conclusions. Perhaps those who are much more involved with it can derive more meaningful insights. What we learned from the experience is that it is possible to test the inventory, and that simply reviewing the product list generated interest and raised awareness of nanotechnology as evidenced by these comments:

"When I did the survey, I was reading and there was nanotechnology and cementitious products…drywall and gypsum falls into that category…that's the only way I was really aware of it. I was totally unaware, I thought nanotechnology was something else. (Business Agent)

"I have used these products and am kind of curious to wonder if that was saying that nano was in those particular products. I've done the overlay welding…hung sheetrock. I don't really understand how nano is involved in gypsum…but I recognized a lot of those names as products I've used before, been around before. (Apprenticeship Coordinator)

"More of the lubricants…I know some of the paint coatings. When I first started I was not aware that there was nanotechnology, but as the job progressed…by the way, that stuff does this too…equipment reps, developers, engineers will tell us a little more about it." (General Foreman)

D3. Concerns About Risk

Both survey respondents and key informants voiced concern around this new technology. The tone could be described as cautious optimism. On the one hand respondents could see the potential benefits that nanotechnology could bring to construction; they want to keep union building trades on the cutting-edge. But they also have past experience that makes them question whether long-term consequences may exist. They are searching for a context for this new technology and how to approach it. The information void described in the last section is spawning fears and, for those in the trades for many years, a déjà vu feeling related to another product that was once promised to be safe for workers, asbestos. This is exacerbated by the fact that, as government agency informants described, manufacturing of nanomaterials and nano-enabled products is outpacing epidemiological research and regulation.

The comparison to asbestos came up many times from different crafts but it is especially profound for the Insulators, formerly known as Asbestos Workers, who lived through the years of law suits and watching their union members die from asbestos-related diseases. In the absence of good data about potential long-term health effects from exposure to engineered nanomaterials, many questions come to the forefront. Respondents logically wanted to know what the properties of the product are, can it hurt us, what are the acute and chronic health effects, what do we need to do to protect workers. All excellent questions that deserve respect and attention. Examples of these concerns come through in these comments:

"New materials are given to us, we don't really know…we see a safety data sheet that's been produced by the manufacturer. We work with these materials for a long period of time and we don't know the impact of how harmful they are to us. I've seen this happen over and over again, it's a red flag to me when something new comes out." (Program Administrator)

"Just awareness. Until you've been bit by a snake, you're cautious but you don't really fear them. You don't take precautions because it won't happen to you, and then when it does, you're like, 'oh, I guess this is a real thing." (Contractor Safety Rep)

"If I have some nanos in my body that one day get exposed to the sunlight and produce electricity…I don't want to be walking like a human light bulb." (Business Manager)

"Anything man creates has some kind of potential impact to nature and the environment and I don't think really much is known about the possible implications of the stuff being made and what it could do. It's new technology, I don't know. We're creating something that's unnatural." (Logistics Superintendent)

> *"Lasers are the thing right now, and it scares the hell out of people. A facility I was working at actually came up with a technology, with a laser, they can actually go through 3-inch steel like it's butter. You can hardly even contain this technology…it's very, very dangerous." (Supervisor/Welding Instructor)*

We can't be certain that the technology they're referring to actually involves nano-enabled materials. We've come full circle back to the question of what nanotechnology is and how do we know if a product is nano-enabled or not. In the section of the survey where respondents rated their concern for worker safety and the environment, the majority were neutral or answered, "I don't know." Those who did have a definite opinion tended to agree that there was potential for harm to workers and the environment. The key informant from DTSC shared an interesting insight with us explaining:

> *"A number of years prior to entering this area, we looked at literature, found that many products would say 'contains nano super material,' using nano content as a marketing advantage. As issues of potential public health and environmental concerns arose, that type of marketing disappeared and soon, whether or not a product had some sort of nanomaterial in it started to be unknown, hidden."*

We have to trust that the manufacturers are doing the right thing in disclosing the correct information on Safety Data Sheets and product data sheets. But manufacturers want to sell product. The Insulators are the only trade we found that is actually working with a known nano-enabled material. The manufacturer says it's safe but the workers hate to use it and claim acute health effects from it. This again raises the specter of asbestos. Some Insulators are trying to keep an open mind about the product while others are adamantly opposed to its use. Their experience with this family of products warrants its own study.

The point here is that construction trades have a long history of new technologies and products being pushed into their hands because they're better or stronger, only to find out later they could be deadly. Silica was also brought up several times and was referred to in the same vein as nanomaterials. When we asked about how they might approach controlling nanomaterial exposures, respondents often described similar controls as those used for silica and other airborne contaminants.

Many of these questions and concerns about nanotechnology can be addressed through effective training. This leads us to the final discussion section.

D4. Nanotechnology Training

We discovered through our survey and interviews that comprehensive nanotechnology training is virtually non-existent. As revealed in our findings, barely 2% of survey participants had received training and most of these were Insulators. The training they received was presented by product manufacturer reps and focused more on proper techniques for applying the product rather than understanding the nano-enabled aspects of the material. This was described as

being more product promotion than comprehensive training. The only safety component was question and answer with the recommendation to use PPE. Government agency representatives were not aware of any worker or end-user training being offered either.

The good news is that the vast majority of study participants are interested in being trained about nanotechnology and believe it would be of value to construction workers. We believe delivering effective, interactive multi-craft awareness training and train-the-trainer courses would go a long way in demystifying nanotechnology and giving construction workers and employers the tools they need to understand and work safely with the innovations coming out of nanotechnology. Key informants gave us many good ideas for what should be covered in an effective nanotechnology training. These will be summarized in the Recommendations section. Some of the informants who had taken our SBCTC Silica in Construction train-the-trainer class mentioned that they would like to have a nanotechnology curriculum that followed that template. The interest is there and trainers are ready and willing to incorporate this topic into their training repertoire. We have a great opportunity to breach the knowledge gap.

D5. California Government Agencies

It was so informative to speak with these scientists and get a different perspective on nanotechnology. We discovered that their concerns overlap very much with those of our construction study participants. Our sense of the current situation with state agencies is that they are like idling racecars ready to take action when data compels them to do so. There appears to have been a surge of public sector activity around nanotechnology over the last 15 years, but this seems to have slowed now that the initial wave of funding and research has run its course.

There are two programs with authority to oversee nanomaterials, Safer Consumer Products run by California EPA's Department of Toxic Substances Control, and the Hazard Evaluation System and Information Service (HESIS) run by the Occupational Health Branch of the Dept. of Public Health. Both programs have the potential to gather information from nanomaterial manufacturers and make that information public. Neither program is doing anything with nanomaterials at this time. We learned that the Health Effects Advisory Committee under the Division of Occupational Safety and Health has carbon nanotubes on its "watch list" and would be prepared to initiate a PEL if data warranted that action. Their concern is that carbon nanotubes could develop aspects that mimic asbestos.

So, like everybody else, these agencies are waiting for more data to surface about engineered nanomaterials. They have many of the same questions as our construction respondents do. We're left thinking it would be a good idea to get everybody in the same room and start working together.

E. RECOMMENDATIONS

A strategic plan to increase awareness and improve understanding of nanotechnology and nanomaterials in the construction industry must include a combination of research, outreach, training, and stakeholder collaboration. Significant gaps in information need to be filled so that a comprehensive training about the implications of nanotechnology in construction can be developed. Collaboration with public agencies, researchers, manufacturers, trainers and end-users is essential to get this done. Nanotechnology is developing and changing rapidly so it will be challenging to keep up. Perceptions of what nanotechnology is and how it is being applied in construction are all over the map; we need to get everyone on the same page and develop a clear message that can easily be brought to a diverse audience.

1. Clearly Define Nanotechnology Terms

It became evident in this study that recognizing nanotechnology terms does not equate to understanding what they mean. In the absence of clear definitions, people come up with their own idea of what the terms mean that may or may not be accurate, making it difficult to have meaningful discussions within a diverse, multi-craft environment. To a non-scientist or anyone outside the nanomaterial research and development sector, the concepts of nanotechnology are difficult to comprehend let alone translate to practical use. Standardizing terminology in layman's terms for construction professionals would help to alleviate confusion about what does and does not fall under the umbrella of nanotechnology and establish a common starting point for dialogue. For example, what is the difference between a nanoparticle, a nanomaterial and a nano-enabled product? Simple fact sheets and handouts, similar to the existing CPWR Hazard Alert on Nanomaterials, that can easily be disseminated at apprenticeship training centers, union meetings and awareness trainings, would be useful tools.

2. Collect epidemiological data

End-users and government agency staff agree that potential acute and long-term health effects from worker exposure to nanomaterials is largely an unknown. This information is critical to monitoring manufacturers, establishing permissible exposure limits, understanding potential hazards and developing control strategies. Product end-users have two immediate concerns when asked about nanomaterials: what they are and what they will do to the human body. We must build support for programs that research potential health effects and measure worker exposures and make this a top priority so that we can fill these gaps in our understanding of nanotechnology. If this data continues to lag, we will never catch up with the production of nanomaterials. As data is collected, there must also be a plan for disseminating it to all stakeholders.

3. Develop multi-craft training curriculum

There is a big need for effective training about nanotechnology in construction. This study revealed interest in the topic among unions and apprenticeship programs and a willingness to support training. This is an opportunity and the timing is right to create a highly visual nanotechnology awareness curriculum. The following topics should be covered: Explanation of nanotechnology and related terms, applications in construction, ways this technology differs from others, nano-enabled product identification, potential acute and chronic health effects,

hazard evaluation, risk assessment, control strategies, and best practices for workers and employers. There is great potential to design a training that is interactive and fun, translating scientific research and theory into practical information for construction end-users. Incorporating product samples, props, Safety Data Sheets, product data sheets, and expert guest speakers would make training both effective and enjoyable. Once a curriculum is developed it could be pilot tested at apprenticeship training centers.

4. Produce a Video

Video is a very popular media among construction trainers. Used in conjunction with a comprehensive multi-craft curriculum, a 6-8 minute video (or a collection of short videos) can be a powerful and valuable training tool. Especially for a topic such as nanotechnology, which can be difficult to grasp for audiences that do not have college-level education, the visuals from a video can be easier to retain. They make good ice-breakers and are now easily shared online. A short video would also be very effective for raising nanotechnology awareness for unions, apprenticeship centers, building trades councils, contractor associations and legislative representatives. At a minimum, a Spanish version of the video should be available.

5. Continue Surveying Efforts and Testing the eLCOSH Inventory

We observed through this study process how simply participating in an online survey can raise awareness, stimulate interest in nanotechnology and create a conversation that engages construction professionals. More than just data collection, the inventory can be used as a first step toward building a network of stakeholders and nano-enabled product end-users. We broke the ice here in California, so the opportunity exists for expanding surveying to a wider audience. It is particularly important to get contractors to participate in surveys about nanotechnology without creating fear that the end goal is simply to create more regulations. Testing the eLCOSH Inventory list is possible and actually helps to raise awareness that it exists as a resource. It is important to include a way to share survey results with participants and other stakeholders.

6. Connect Unions with Researchers

Unions and researchers share a common interest in collecting data that would support worker protections. Through our study we found that they are asking the same questions but operate in two different worlds. We need to foster better communication with one another around the topic of nanotechnology; such partnership and information-sharing would be mutually beneficial. California public health agencies periodically plan seminars about nanotechnology that are open to the public; perhaps this also happens in other states. Union health and safety staff need to be encouraged to participate in these programs to establish research-to-practice connections. An organization like CPWR is well-positioned to locate and connect with nanotechnology working groups active now that would be willing to welcome worker advocates to their group. Both sides have a lot to offer one another but they need to find each other first.

F. CONCLUSION

Nanotechnology is here to stay, and it is developing at an extremely fast pace. With regard to construction applications of nanotechnology, we currently seem to have more questions than answers. Products that contain engineered nanomaterials are already being used in construction even though the workers using them may have little or no understanding of nanotechnology. We must help union leaders and apprenticeship programs get up-to-speed and raise awareness about the benefits and concerns associated with this new technology. We don't want to repeat the experiences of the past that ultimately cost workers their lives. Construction professionals may already be "late-to-the-game" but now is the time to be engaged. We heard that, even those in public agencies that monitor products and enforce standards have paid little attention to construction applications of nanomaterials. Their focus has been on the manufacturing/supply side of products and they too lack information about what's happening further downstream once products make it to market and enter a different phase of their lifecycle. We simply do not know enough about how these engineered nanomaterials will impact the environment and workers across the entire lifecycle of the product.

Conducting this study was both rewarding and challenging. We did not realize how big it could become and how deep the rabbit hole could go as you dive in to nanotechnology. It is a fascinating and exciting field, filled with mind boggling innovations that tempt us to push further and further into the unknown just because we can. Our union construction workers pride themselves on being "cutting-edge" but also want to be safe and enjoy life long into retirement. We hope that our relatively small exploration into nanotechnology has been the first of many steps that will illuminate this new technology and assure that construction unions are well-informed, engaged stakeholders.

G. APPENDICES

1. Survey Monkey On-Line Survey Instrument
2. Key Informant Interview Questionnaire
3. Public Agency Key Informant Interview Questionnaire
4. ELCOSH Inventory List – Responses of those with awareness of terms
5. ELCOSH Inventory List – Responses of those with no awareness of terms

Study Information and Confidentiality Agreement

Thank you for participating in this survey. This is part of a study that the State Building and Construction Trades Council of California (SBCTC) is conducting with the Center for Construction Research and Training (CPWR) on the topic of Nanotechnology in Construction. Previous knowledge of this topic is not required to complete this survey.

You have been invited to participate in this study because you are a construction contractor, union representative or union apprenticeship representative in California. Your participation in the study is completely voluntary. This survey is designed to assess your knowledge about nanotechnology and nanomaterials used in construction; it will be as important for us to know what you are NOT aware of as what you are.

To complete the survey, you will be guided through a series of specific questions, and also be asked to review an extensive list of construction products and identify any that you recognize and/or have used. We estimate that the survey will take 10-15 minutes on average to complete. It may require more or less time depending upon your individual responses.

Results of the study will be used to guide the development of training and educational resources on nanotechnology in construction. The final study report will be posted on our SBCTC and Safety HUB websites, and on the CPWR website. Findings may also be published in industry journals.

We agree to strictly maintain your confidentiality:

- We will not reveal your name or personal information in any summaries, reports or publications. Survey responses will be analyzed in aggregate, no responses will be tied to any individual participant.
- You do not have to answer any question that you don't want to and may end the survey at any point.
- To minimize the risks to confidentiality, we will store all survey results in secure files at the SBCTC office in Sacramento. All identifying information will be removed. Only study research staff will have access to these files.

We will randomly select some of the people who have completed the on-line survey to participate in a more extensive follow-up interview by telephone. If you are among those selected, you are not obligated to complete that interview unless you choose to participate. At that time, we will ask again for your consent and provide you with information regarding the policies and procedures to ensure your confidentiality is protected.

If you have any questions about this agreement, please contact Laura Boatman (lboatman@sbctc.org). If you're ready to begin the survey and agree to this confidentiality agreement, check the "I Agree" box below. Then click the "Next" button to begin the survey.

Thank you again for your interest in our study.

* 1. By clicking "I Agree" I acknowledge the following:

- My participation in this study is completely voluntary,
- I have read and understand the information above,
- I understand what is required as a participant in this survey,
- I accept the confidentiality agreement.

○ **I Agree**

SBCTC Nanotechnology Awareness Survey

Survey Instructions

The survey is designed to move you through questions efficiently. Scroll through questions until you reach the bottom of each page then click the "Next" button to continue. The status bar at the bottom of each page shows the percentage of the survey you've completed.

If you have to stop before completing the survey, you can access your questionnaire to finish at a later time using the same web link. You must do this from the same computer/device that you originally used.

Your responses are not submitted until you reach the end of the survey, click the "Done" button, and see a pop-up message indicating that your survey was submitted successfully.

Should you encounter any difficulties in using this survey tool, please contact Laura Boatman, Project Coordinator at 916-443-3302 or email lboatman@sbctc.org

You're ready to start the survey, please click "Next"

SBCTC Nanotechnology Awareness Survey

Information about you and your experience

2. Contact Information:

Name:

Email Address:

Phone#:

3. What is your age group?

- 18-24 years old
- 25-34 years old
- 35-44 years old
- 45-54 years old
- >55 years old

4. Which one of the following best describes your current affiliation:

- Union Representative
- Union Apprenticeship Representative
- Construction Contractor Representative
- Construction Craft Worker (journeyman or apprentice) currently working with the tools
- Other (please specify)

5. What is your current job title?

6. What is the size of your company/organization?

- ○ Less than 20 employees
- ○ 20-50 employees
- ○ 50-100 employees
- ○ 100-200 employees
- ○ More than 200 employees
- ○ I don't know

7. What is your primary trade?

- ○ Boilermaker
- ○ Bricklayer (Brick/Marble/PCC/Terrazzo)
- ○ Carpenter
- ○ Cement Mason
- ○ Drywall Finisher
- ○ Drywall Lather
- ○ Electrical Worker
- ○ Elevator Constructor
- ○ Floor Covering Installer
- ○ Glazier
- ○ Heat and Frost Insulator
- ○ HVAC
- ○ Iron Worker
- ○ Laborer
- ○ Millwright
- ○ Operating Engineer
- ○ Pile Driver
- ○ Plasterer
- ○ Painter
- ○ Roofer or Waterproofer
- ○ Sheet Metal Worker
- ○ Teamster
- ○ Tile Layers/Finishers
- ○ Pipefitter/Steamfitter
- ○ Plumber
- ○ I have not worked in a trade
- ○ Other (please specify)

8. How many years have you worked in this trade?

- ○ Less than 4 years
- ○ 5-9 years
- ○ 10-19 years
- ○ 20-29 years
- ○ 30+ years

9. Do you provide training to others?

- ○ Yes
- ○ No

10. Primarily who do you train?

- [ ] Apprentices at a union JATC
- [ ] Front-line workers on-the-job
- [ ] Management
- [ ] Union staff
- [ ] Journeymen at a union JATC
- [ ] Foremen
- [ ] Other (please specify)

11. How many years have you been a trainer?

- ○ Less than 4 years
- ○ 5-9 years
- ○ 10-19 years
- ○ 20-29 years
- ○ 30+ years

Awareness of study topic

12. Have you heard of any of the terms listed below? (Check all that apply)

- [ ] Nanotechnology
- [ ] Nanoparticles
- [ ] Nano-enabled materials
- [ ] Engineered nanomaterials
- [ ] I have never heard of any of these terms
- [ ] I'm not sure if I've heard them or not

13. Are you aware of nanotechnology being applied in the construction industry and/or that construction products containing nanomaterials are commercially available in the USA?

- ○ Yes
- ○ No
- ○ Not sure

14. Regarding your personal experience with construction materials, which of the following applies to you? (check all that apply)

- [ ] I've noticed product(s) incorporating nanotechnology or marketed with the word "nano" on-the-job
- [ ] I've actually worked with a nano-enabled product first-hand
- [ ] I know other workers who use nano-enabled products on-the-job, but I haven't used any myself
- [ ] I've neither seen nor worked with any nano-enabled products or nanotechnology
- [ ] I don't know

If you've used nano-enabled products, please tell us the product name and its purpose:

Training experience

15. Have you received and/or delivered any training related to nanotechnology or nanomaterials in construction?

- ○ No
- ○ I'm not sure
- ○ Yes--Delivered training
- ○ Yes--Received training (please tell us more details in the box below: who presented it; where was it held; for how long)

16. What training materials have you used?

17. What are your sources for training materials about nanotechnology/nanomaterials?

18. How would you rate the nanotechnology training materials you currently use:

Not Useful	Somewhat Useful	Useful	Very Useful
○	○	○	○

19. Would you be interested in getting new training materials regarding nanotechnology in construction?

- ○ Yes
- ○ No
- ○ I'm not sure

Nanotechnology benefits and concerns

Indicate your level of agreement with the three statements below by marking one response for each statement.

20. Occupational exposures to nanomaterials likely pose a significant health risk to construction workers.

Strongly Disagree	Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Agree	Strongly Agree	I don't know
○	○	○	○	○	○	○	○

21. Use of nanotechnology in construction has the potential to provide significant environmental and public benefit.

Strongly Disagree	Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Agree	Strongly Agree	I don't know
○	○	○	○	○	○	○	○

22. Use of nanotechnology in construction has the potential to significantly harm the environment.

Strongly Disagree	Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Agree	Strongly Agree	I don't know
○	○	○	○	○	○	○	○

23. Do any nanoparticles listed below raise concerns for you in regards to occupational health and safety? (Check all that apply)

- [ ] Zinc Oxide Nanoparticles
- [ ] Aluminum Oxide Nanoparticles
- [ ] Titanium Dioxide Nanoparticles
- [ ] Carbon Nanotubes
- [ ] Cerium Oxide Nanoparticles
- [ ] I Don't Know
- [ ] Copper Nanoparticles

24. What are your concerns?

25. Are you aware of any worker health issues or complaints related to working with nanomaterials?

- ○ No
- ○ Yes (please describe)

26. What would be your most trusted sources if you wanted to learn about potential hazards of working with nanomaterials?

- ☐ Cal/OSHA
- ☐ My employer
- ☐ Federal OSHA
- ☐ NIOSH
- ☐ CPWR (Center for Construction Research and Training)
- ☐ Internet search
- ☐ Other (please specify)
- ☐ Union
- ☐ Trade/employer association
- ☐ Industry journals/magazines
- ☐ Colleagues
- ☐ None of these

27. Are you interested in getting more information about nanotechnology and nanomaterials in construction?

- ○ Yes
- ○ No
- ○ Not sure

28. Do you think that providing training to workers about nanomaterials in construction would be valuable?

- ○ Yes
- ○ No
- ○ Not Sure

SBCTC Nanotechnology Awareness Survey

Product List

Below you will find a list of construction product names divided into groupings by type of application. Headings for each group are highlighted in yellow. We realize this list is quite long, but it will be of great help to our project if you are willing to scroll through the list and identify any products that you recognize. As you look through the listings, we ask that you make a note of the code numbers for any product that stands out to you as either something you've heard about, have seen on-the-job or have actually worked with. At the end of the list you will be prompted to enter the code numbers for products you recognize in the field provided. This should only take a few minutes to complete. We appreciate your time in participating in this part of the survey. If you would rather not do this task, please indicate that by clicking the appropriate box below.

29. Are you willing to review the product list and note codes for products you recognize or have used?

Yes I will review the list	No I prefer to skip the list review
○	○

Product List

PRODUCT CODE	PRODUCT
	Additives for asphalt
A-1	FASS-DRI Pavement Sealer Additive
A-2	LMGI Asphalt Additives
	Additives for coatings
B-1	Laromer PO 9026
B-2	Mowilith Nano 9420
B-3	NANO SHIELD Hardener (Formerly PreFin Additive)
B-4	NANOBYK-3600
B-5	NANOBYK-3601
B-6	NANOBYK-3602
B-7	NANOBYK-3603
B-8	NANOBYK-3605
B-9	NANOBYK-3610
B-10	NANOBYK-3620
B-11	NANOBYK-3630
B-12	NANOBYK-3650
B-13	NANOBYK-3651
B-14	NANOBYK-3652
B-15	NANOBYK-3810
B-16	NANOBYK-3812
B-17	NANOBYK-3820
B-18	NANOBYK-3821
B-19	NANOBYK-3840
B-20	NANOBYK-3841
B-21	NANOBYK-3842
B-22	NANOBYK-3860
B-23	Nanoparticle Additives for Exterior Coatings
B-24	nanoZ
B-25	SunCare TopCoat UV protection additive
B-26	SurfaPore ThermoDry
	Additives for concrete/cement
C-1	EffLock Liquid Admixture
C-2	EffLock Powder Admixture
C-3	Exvila
C-4	Master X-Seed 100
C-5	Nano Bond - Concrete Bonding Agent
C-6	Pro-Seal Drycrete
C-7	Pro-SealPro-Cure A
C-8	SurfaMix C
	Adhesives
D-1	Aroply 250
D-2	Aroply 350
D-3	BIO-ECOLOGIC GLUE
D-4	CNTstix
D-5	CONTAK (bonding adhesive)
D-6	Epovex Adhesive Liquid
D-7	Epovex Adhesive Paste
D-8	PING (PURETi Inorganic Nano Glue)
D-9	Pro-Seal Flash Guard Tape
D-10	ZNT-fuse
	Boiler additives
E-1	LMGI high concentration oil soluble magnesium
	Caulking
F-1	Pro-Seal 34
F-2	Pro-Seal Pro-Thane 230
	Cement-based
G-1	Agilia
G-2	Aridus Rapid Drying Concrete

G-3	ce200
G-4	Chronolia
G-5	CleanCrete
G-6	Ductal
G-7	EdenCreteSOO Cement Admixture
G-8	EMACO Nanocrete AP
G-9	EMACO Nanocrete R2
G-10	EMACO Nanocrete R3
G-11	EMACO Nanocrete R4
G-12	GFRC SPRAY COAT AND REINFORCEMENT MIXES
G-13	iactive Saylor's TX Aria
G-14	iactive Saylor's TX Arca G-
15	Nanocrete NST
G-16	**n-Foam, n-Form, n-FoamGen, n-Pumps**
G-17	PCINanoflott
G-18	PCINanofug Premium
G-19	PCINanolight
G-20	PCINanosient
G-21	Pol-Ee Tecnosoil
G-22	SiliconeUltra K & R Finish Through-Coloured Renders
G-23	Tee-Cement
G-24	ThermoSan-Fassadenputz NQG R+K
G-25	TiCem TX Active
	Coatings - glass/ceramic
H-1	3M Window Films - Ceramic Series
H-2	3M Window Films - Prestige Series
H-3	DryWired Glass & Ceramics
H-4	Fluowet ETC 100 & ETC 140
H-5	Fluowet ETC 300
H-6	Glass & Ceramic
H-7	Glass Clear
H-8	Glass Pro
H-9	Home Improvement Oriented Water Repellent Window Glass and Ceramic Tile Coating
H-10	HYBRIDSIL Hydrophobic Optical Coatings
H-11	Hydrophobic Glass Coating
H-12	Nano Surface Solutions glass protection system
H-13	NanoBionics ESF
H-14	NanoBionics GC-P
H-15	Nanonext Glass Care SR
H-16	Nanonext Nano Glass & Ceramic Sealant
H-17	Nanotechnology sealants/coatings for ceramic
H-18	NanoUltra
H-19	NewPro-Nano Glass and Ceramik-Kit
H-20	NG 1010 Glass Coating
H-21	NG 1314/D
H-22	Perma-Clean Glass
H-23	PURETiClear
H-24	SC Glass - self cleaning window
H-25	Self Cleaning Glass Treatment
H-26	Shower and Tile Treatment
H-27	Shower Protect
H-28	SurfaShield G
	Coatings - metal
11	ARC S7
12	Chrome & Stainless Steel Treatment
13	CorShield VpCI-386 HP powered by Nano-VpCI
14	Fluowet ETC 400
15	Nano Surface Solutions metalcoating
16	NanoBionics AF-P
17	Nanolia Powercoat
18	NANOMYTE PT-10
19	NANOMYTE PT-20
110	NANOMYTE PT-60
111	NANOMYTE SuperCN
112	NANOMYTE TC-1001
H13	NANOMYTE TC-3001
114	NANOMYTE TC-4001
115	NANOMYTE TC-5001
116	Nanonext Nano Chrome & Stainless Steel Sealant 1
17	Nanopretreat

119	NanoTech Metal Coating
120	NanoTech Stainless Steel Coating
121	1 Pro-Seal PC-V Top Kote
122	RC-850
123	Rust Protect
124	Stainless Steel Long-Life with anti-fingerprint
125	SurfaGuard Metals
126	TESLAN 1101 Zinc CNT Primer
127	TESLAN 1500 Aluminum CNT Low-VOC Primer
128	Teslan 1700 Magnesium CNT Primer
129	Teslan 3100 Epoxy CNT Low-VOC Topcoat
130	THERMOCYL X2
131	TruNano Metal Armor
132	Water and Dirt Repellent Metal Coating
	Coatings - mineral surfaces
J-1	519 Primer
J-2	Alpha Stone 11
J-3	Aqualon Nano Guard
J-4	ARDEX PC 10
J-6	BEHR PREMIUM Basement & Masonry Waterproofer
J-7	SETON SKUDO C
J-8	Brickform
J-9	Concrete Countertop Sealer 660
J-10	Cool Slurry Seal
J-11	Creteseal WB Nano
J-12	Cryl-Tek 5500
J-13	Cryl-Tek 5505
J-14	DriveHard PRO
J-15	DryWired Anti-Graffiti
J-16	DryWired Microporous
J-17	DryWired Stone & Porous
J-18	EFFLOCK TI Topical Efflorescence Treatment
J-19	FLOR-GUARD
J-20	FLOR-SIL
J-21	FN2 Coating
J-22	FN3 Coating
J-23	Graf-X WB
J-24	H&C Clear Liquid Hardener & Densifier
J-25	HS340 ACRYLIC OVERLAY SEALER LOW VOC
J-26	INTELPAINT 110 ANTIMICROBIAL
J-27	Lithi-Tek 4500
J-28	Lithi-Tek LS 9500
J-29	Lythic Densifier - Concrete Densifier and Hardener
J-30	Lythic SPD Protector
J-31	MINERAL SEALANT
J-32	Mold Proofer & Concrete Curing Agent SMP-81
J-33	NANO 1000 CONCRETE AND STONE SEALER
J-34	Nano Guard
J-35	Nano Surface Solutions sealants/coatings for mineral
J-36	NanoBionics G-FX
J-37	NanoBionics G-FX F
J-38	NanoBionics G-XB
J-39	NanoBionics MG F
J-40	NanoBionics PG
J-41	NanoBionics PG-F (Oleophobic and high grade)
J-42	NanoBionics PG-54 (highest grade)
J-43	Nano-Clear Stone Impregnator
J-44	Nano-Crete Cool Pavement
J-45	Nanolia Concrete Protect
J-46	Nanolia Graffiti Guard for Porous Surfaces
J-47	Nanolia Stone Coat
J-48	Nanolia Stone Guard (HO)
J-49	NanoLok 90
J-50	Nanonext Nano Concrete & Flooring Sealant
J-51	NanoPave Concrete Sealer
J-52	NanoPave Hardscape Sealer
J-53	NanoSet Densifier NS
J-54	NanoSet Protector
J-55	Nano-Shield OSP
J-56	NANOSTONE ANTIGRAFFITI
J-57	NanoTech Concrete Coating

J-58	NanoTech Polished Stone Sealer
J-59	NanoTech Stone Coating
J-60	NativeStone Sinks
J-61	NewPro Nano Stone 172
J-62	NewPro-Nano StonePlus with Graffiti Protection for
J-63	NP 120 INVISIBLE ANTIGRAFFITI
J-64	NP COLOUR CONCRETE
J-65	NP INVISIBLE HYDROPHOBIC
J-66	NS30 easy-to-clean
J-67	NS60 & NS90 easy-to-clean
J-68	Pentra-Guard (EXT)
J-69	Pentra-Guard (HP)
J-70	Pentra-Sil (NL)
J-71	Pro-Seal Aqua Crete
J-72	Pro-Seal Aqua Flex
J-73	Pro-Seal DP-36
J-74	Pro-Seal Prime Flex 111
J-75	Pro-Seal R.O.C. Hard
J-76	Pro-Seal TVB Top Kote
J-77	Pro-Seal Ultra Shield II-A Decorative
J-78	Pro-SealHydro Paint I
J-79	Pro-SealHydro Paint 11
J-80	Pro-SealHydro PaintRubberized
J-81	Pro-SealTVBMastic
J-82	SCS-002-SP Sealer Prime
J-83	SCS-003 Sealer Light Water Base
J-84	SCS-004 Sealer Heavy Duty Water Base
J-85	Seal-Once Concrete Masonry Waterproofing
J-86	Seal-Once Marine Concrete Masonry Sealer
J-87	SelectSeal Plus Clear Concrete Sealer
J-88	SenGuard
J-89	Sila-Tek 3500
J-90	Siloxa-Tek 8500
J-91	SmartColor
J-92	SmartSeal AU
J-93	SmartSeal WB
J-94	Stone conservation CaLoSiL-E
J-95	Super Dye
J-96	SURESEAL HS 240
J-97	SURESEAL HS 260
J-98	SURESEAL HS 360
J-99	Surface Saver Sealer
J-100	Surface Saver Sealer- Brick, Masonry, Stone Concrete
J-101	SurfaPore C
J-102	Surfapore M
J-103	Surfapore R
J-104	SurfaporeT
J-105	SurfaShield C
J-106	SurfaShield Cx
J-107	TruNano Aqua Enhancer Plus
J-108	TruNano Concrete Armor
J-109	TruNano Enhancer Plus
J-110	WATER-RESISTANT SEALANT
	Coatings • multi-surface
K-1	3001 Concentrate
K-2	A Wide Array of Coatings
K-3	Cerablak HTP
K-4	Cerablak HTS
K-5	Cerablak SHS
K-6	Cerablak UTF
K-7	Cetosil
K-8	CLOUCRYL Filland high-gloss varnish
K-9	Countertop Treatment
K-10	Diamon Fusion
K-11	Diamon-Fusion ULTRA
K-12	DryWired Plastic & Metals
K-13	FN1 Coating
K-14	Forta-Kote Multi-Surface Waterproofer
K-15	Gens Nano Photocatalyst
K-16	HYBRIDSHIELD Fire Retardant Coating
K-17	HybridShield Icephobic
TC1R	[illegible]

K-19	INTELPAINT ANTIPOLLUTION
K-20	INTELPAINT PHOTOACTIVE 23 K
K-21	INTELPAINT PHOTOACTIVE 23 2K
K-22	LumActiv
K-23	Moldex Deck Protector
K-24	Nano Surface Solutions anti-graffiti-system
K-25	NanoChar
K-26	Nanohide Industrial & Nanohide Marine
K-27	Nanolia Graffiti Guard for Non-porous Surfaces
K-28	Nanolia PowerCoat M Series
K-29	Nanolia Powercoat Pro
K-30	Nanolia RainOff (H)
K-31	NANOMYTE MEND 1000
K-32	NANOMYTE SR-lOOEC
K-33	NANOMYTE SuperCN Plus
K-34	Nanonext Fire Protection AllIhone
K-35	Nanonext Nano Wood & Stone Sealant
K-36	NANOPROTECH Electric Industry
K-37	NANOPROTECH Home and Garden Electric
K-38	Nanosolar
K-39	NanoTech Anti-Graffiti Coating
K-40	NanoTech Floor Coating
K-41	NanoTech Multi-Purpose Sealer
K-42	NanoTech Quick Seal & Enhance
K-43	NanoTech Wood and Concrete Sealer
K-44	Nanovis
K-45	NIX-IT
K-46	NTP - WOOD & STONE SEALANT
K-47	OXI SEAL CONCRETE SEALER
K-48	P&T 230
K-49	P&T 230Ag
K-50	Pentra Protective Coating
K-51	Pro-Seal Deck Flex HT
K-52	Pro-Seal PD-400
K-53	Pro-Seal SP-12
K-54	Pro-Seal Ureflex AL
K-55	Pro-Seal Weathermaster
K-56	Pro-SealAnti-Graf
K-57	Pro-SealPC-V Kote
K-58	Pro-SealPC-V Primer
K-59	Pro-SealPower Kote I
K-60	Pro-SealPower Kote 11
K-61	Pro-SealPower Kote 111
K-62	Pro-SealUS 11-A
K-63	PURETi Base
K-64	PURETiClean
K-65	PURETiCoat
K-66	SCS-002 Mineral Sealer Water Base
K-67	SealBack Nano-Particle Clear Sealer
K-68	Seal-Once Marine Waterproof Multi Surface
K-69	Seal-Once Multi Surface Industrial Concentrate
K-70	SMP-200 Mold Proofer Fluorobase
K-71	SMP-80 Mold Proofer Construction Spray
K-72	SMP-82 Mold Proofer Sealer
K-73	Stone & Wood coating
K-74	THERMOCYL Xl
K-75	TPE AG
K-76	TiPE C
K-78	TPE E
K-79	TiPE H
K-80	TiPE PT
K-81	TiPE S
K-82	TruNano Aqua Armor
K-83	TruNano Graffiti Armor
K-84	Ultra-Ever Dry
K-85	Water and Dirt Repellent Coat ngfor Water Proofing of
K-86	X-Series
	Coatings-paints
L-1	Airlite Purel ght Interior
L-2	Airlite Sunlght Exterior
L-3	Amplsi an

L-4	Antibacterial Water-resistant Paint
L-5	BEHR PREMIUM PLUS ULTRA
L-6	Bioni Medical
L-7	Bioni Nature
L-8	Bioni Perform
L-9	Bioshield
L-10	Coat of Silence - Acoustical Paint
L-11	EPX NanoPrime
L-12	Exterior Paint
L-13	Interior Paint
L-14	Johnstone's Stormshield Self-Cleaning Masonry Paint
L-15	KNOxOUT Acrylic Air Cleaning Paint
L-16	KNOxOUT Silicone Air Cleaning Paint
L-17	MINERAL FILLER (primer)
L-18	Nano-Clear for Industrial Applications
L-19	PAINT SHIELD
L-20	PHOTO CATALYTIC PAINT
L-21	Shielding Paint Yshield HSF54
L-22	SMP-100 Mold Proofer Paint
L-23	STUKI (stucco)
L-24	SurfaPaint ThermoDry Elastomeric Roof Paint
L-25	SurfaPaint ThermoDry Exterior Paint
L-26	SurfaPaint ThermoDry Interior Paint
L-27	SurfaPaint ThermoDry Metals Paint
L-28	Sylitol NQG
L-29	ThermoSan
L-30	TopLasur NQG
L-31	Transil
	Coatings - wood
M-1	CLOUCRYL 2012
M-2	CLOUCRYL 2012 super matt
M-3	DEFY Extreme Clear Wood Stain
M-4	DEFY Extreme Wood Stain
M-5	DryWired Wood Shield
M-6	GORI 2937 Professionel Transparent
M-7	INTELPAINT 110 WOOD SEAL MATT
M-8	NANO SHIELD Advanced Floor Finish
M-9	NANO SHIELD Advanced Floor Sealer
M-10	NANO SHIELD Fast Dry Floor Stain
M-11	NANO SHIELD Professional Polyurethane Rapid Cure
M-12	NANO SHIELD Rapid Cure
M-13	Nanonext Fire Protection Wood
M-14	NanoTech Wood Coating
M-15	NANOWOOD
M-16	NewPro Nano Wood
M-17	Norfok Oak Nano-Coating Treatment
M-18	NP 110 WOOD SEAL GLOSS
M-19	Seal Ends Once High Solids End Sealer for All Wood
M-20	Seal-Once Composite Wood Deck Sealer
M-21	Seal-Once Eco-Friendly Exotic Wood Waterproof
M-22	Seal-Once Marine Waterproofer Total Wood
M-23	Seal-Once Waterproof Wood Protector - Eco Friendly
M-24	Surface Saver- Composite Deck Sealer
M-25	Surfapore F
M-26	Surfapore W
M-27	TWP Total Wood Preservative
M-28	Varathane Nano Defense
M-29	Wood Fresh
M-30	Wood ProDeck
M-31	WoodBoost
	Drywall
N-1	SHEETROCK BRAND ULTRALIGHT GYPSUM BASE
N-2	SHEETROCK BRAND ULTRALIGHT PANELS 1/2 inch
N-3	SHEETROCK BRAND ULTRALIGHT PANELS FIRECODE X
N-4	SHEETROCK BRAND ULTRALIGHT PANELS MOLD
N-5	SNiPER
N-6	USG SHEETROCK BRAND ULTRALIGHT PANELS
	Fasteners
O-1	NanoMate 1810/1811
	Flooring
P-1	Burke 12 MIL Luxury Vinyl Tile Natural Wood Planks

P-2	Burke Luxury Vinyl Solid, Concrete & Tile
P-3	Nanolinx HD and Nanolinx Commercial
P-4	Performance Plus Hardwood
P-5	Regal Hardwood Flooring
P-6	SmartStrand Forever Clean
P-7	Teknoflor
P-8	Ultima Vinyl Sheet Flooring
	Fuel Additives
Q-1	DieselFusion
	Glass and solar panels
R-1	Ceramic Series window film
R-2	Hurd Ultra-R
R-3	Irrington Active
R-4	SageGlass
R-5	Select Series window film
R-6	SGG BioClean
R-7	SGG BIOCLEAN COOL-LITE ST
R-8	Sunclean Self-Cleaning Glass
	HVAC
S-1	Hydromx
S-2	HydroPhil
S-3	NPS 100 & NPS 200
S-4	OxiTan 4oz. Liquid Spray
S-5	PREDATOR A-Frame Coil & Plenum Kit
	Insulation
T-1	Aeroclad blanket
T-2	AerogelCompression Pack
T-3	AerogelThermalWrap
T-4	Cryogelx201
T-5	CryogelZ
T-6	EcoSky3
T-7	Heat Shield CX
T-8	Heat Shield: Roof Protect
T-9	HYBRIDSIL Foam Insulation
T-10	Insulated Glass Units with Lumira aerogel
T-11	IPN-Nano
T-12	Kalwall+ Lumira Aerogel
T-13	KevothermalVacuum Insulation Panels
T-14	Liquid Nanotint
T-15	Lumira aerogelblanket
T-16	Lumira aerogelparticles
T-17	Nansulate Diamond
T-18	Nansulate Energy Protect
T-19	Nansulate EPX
T-20	Nansulate HomeProtect Clear Coat
T-21	Nansulate Solar Insulation Coating
T-22	Nansulate Translucent GP - NSF
T-23	Nansulate Translucent High Heat
T-24	Nansulate Translucent PT
T-25	NP 110 INSULATOR PIGMENTED
T-26	PyrogelXT
T-27	PyrogelXT-E
T-28	PyrogelXTF
T-29	Silentite
T-30	SOLERA
T-31	Spaceloft
T-32	Spaceloft Subsea
T-33	Structural Composite Panels with Lumira aerogel
T-34	Vacuum Insulation Panels
T-35	Wasco Skylights with Lumira Aerogel
	Interior Design
	FENIX NTM
	Joint Sealants
U-1	Iso-Flex 825
	NanoPave 2-in-1 joint stabilizer and sealer
V-1	**Lubricants**
V-2	AtomCore product line
	Cera-Lube
W-1	CerMet Nano-Particle Ceramic Conditioner
W-2	DAYLube NanoCeramic Lubricating Grease
W-3	NANO Dry Lubricant NDTIID
W-4	[illegible]

W-7	NanoLub GH-X
W-8	NanoLub MP-X
W-9	NanoLub RC-X
W-10	NDT14GR
W-11	NDT14MG
W-12	New Nuts
W-13	TriboTuff product line
	Lumber
X-1	MicroPro Treated Lumber
X-2	Treated Lumber
	Metal
Y-1	Cemented Carbides & Tooling
Y-2	ComAR Glass Fiber Reinforced Polymer Nano-Modified
Y-3	Light Alloys
Y-4	MMFX2 Steel
Y-5	NSG 4280
Y-6	Reynobond with EcoClean
Y-7	Sandvik Nanoflex (Strip Steel or Wire)
	Miscellaneous
Z-1	Carbon Nanotube Enhanced Glass Fiber
Z-2	Carbon Nanotube-reinforced Epoxy (CNT Epoxy)
Z-3	FOGuard TRI-CLEAR ANTI-FOG FILM
Z-4	LiteWire
Z-5	Nansulate LDX
Z-6	TruNano VCT Armor
	Patching compounds
AA-1	ECOLOGICAL MORTARS IN PASTE: Base, Fine and
AA-2	FLLMASSE (Natural putty)
AA-3	KRATZPUTZ: 2mm-3mm
AA-4	PATCH Plus Primer
AA-5	Pro-Seal CWA
AA-6	Pro-Seal CWA-U
AA-7	Pro-Seal Power Kate Casting Grade
AA-8	Pro-Seal Power Kate Injection Grade
AA-9	Pro-Seal Power Patch
AA-10	Pro-Seal Power Patch Flexible
AA-11	Pro-Seal PPW
AA-12	Pro-Seal PPWS
AA-13	Pro-Seal Quick Fix
AA-14	RADIANT SLABS
	Prepregs
BB-1	Arovex 180
BB-2	Arovex 250
BB-3	Arovex 350
BB-4	Arovex HT 250
	Roofing
CC-1	Bini Roof
CC-2	BoralPure SMOG-EATING Tile
CC-3	Eagle Platinum Tile
CC-4	Isonit roof coating
CC-5	Mold Proofer Roof Coat SMP-300
CC-6	Nansulate Crystal
CC-7	NXT Cool Zone
CC-8	Pro-Seal LMS 110
CC-9	Pro-Seal LMS 130
CC-10	Pro-Seal LMS 170
CC-11	Pro-Seal LMS Cool Roof
CC-12	Pro-Seal 180T
CC-13	Smart Shield
CC-14	TILEFLEX 2000 ROOF COATING SYSTEM
	Surface preparation
DD-1	AQUA MIX NANOSCRUB
DD-2	BS 309
DD-3	CRMX Surface Refining Agent
DD-4	NANO SHIELD Pre-Fin Cleaner
DD-5	Nano-Clean NMC
DD-6	NanoUltra Architectural Glass Stain Remover & Polish
DD-7	NH 2015 Metal
DD-8	Pro-Seal De-Graf
DD-9	Pro-Seal DG-7
DD-10	Pro-Seal Multi-Clean

DD-11	TILELAB NANOCLEAN
	Thermal spray coating materials
EE-1	PComP M 144
EE-2	PComP MB 05
EE-3	PComP-T 45
EE-4	PComP-T 48
EE-5	PComP-W 104
EE-6	PComP-W 333
EE-7	PComP-W 611
EE-8	SHS 7570 TWAS
EE-9	SHS 8000 TWAS
EE-10	SHS 9172 TWAS
EE-11	Thermal Spray Powders & Coatings
	Weatherproofing membranes
FF-1	Pro-Seal Flex System I
FF-2	Pro-Seal Flex System II
FF-3	Pro-Seal Flex System II RG
FF-4	Pro-Seal Weather Guard
	Weld overlays
GG-1	SHS 9192 GMAW / OAW
GG-2	SHS 9290 PTAW
GG-3	SHS 9500 GMAW / OAW
GG-4	SHS 9700 GMAW / OAW
GG-5	SHS 9700 PTAW
GG-5	SHS 9700E SMAW
GG-6	SHS 9800 GMAW / OAW

30. Great, you finished the list review. Did any of the products listed stand out as ones you recognize or have used?

- ○ Yes
- ○ No
- ○ I'm not sure

31. Please enter the code numbers in the appropriate boxes below for any any products you noted as having recognized and/or used. To make this easier, we've created boxes for each product category. You just need to enter the numbers for that category. For example, if you recognize/use the product coded C-6, simply go to "C- (Additives for Concrete/Cement)" and type "6" in the box. To make multiple entries in a single category, please separate the numbers with a comma or a space.

A- (Additives for Asphalt):

B- (Additives for Coatings):

C- (Additives for Concrete/Cement):

D- (Adhesives):

E- (Boiler Additives):

F- (Caulking):

G- (Cement-based):

H- (Coatings-glass/ceramic):

I- (Coatings-metal):

J- (Coatings-mineral surfaces):

K- (Coatings-multi-surface):

L- (Coatings-paints):

M- (Coatings-wood):

N- (Drywall):

O- (Fasteners):

P- (Flooring):

Q- (Fuel Additives):

R- (Glass and Solar panels):

S- (HVAC):

T- (Insulation):

U- (Interior Design):

V- (Joint sealants):

W- (Lubricants):

X- (Lumber):

Y- (Metal):

Z- (Miscellaneous):

AA- (Patching compounds):

BB- (Prepregs):

CC- (Roofing):

DD- (Surface preparation):

EE- (Thermal spray coating materials):

FF- (Weatherproofing membranes):

GG- (Weld overlays):

Thank you for identifying the products you recognized. We appreciate your willingness to review such a lengthy list. You're nearly finished, please continue to the next page to complete and submit your survey.

Congratulations, you have reached the end of the survey. Thank you for participating in our study; we greatly appreciate your time. Your feedback is invaluable in helping us to better understand the extent to which nanotechnology is being applied in our construction industry. The SBCTC will announce when the final study results are available at the end of 2017.

To complete and submit your survey responses you must Click the "Done" button below.
After doing this successfully, you will see an immediate message indicating that we received your survey.

NOTE: If that message does not appear, you have NOT successfully submitted your survey. You will need to go back into the survey and try to submit it again.

SBCTC Nanotechnology Study—Key Informant Interview Script

INTRODUCTION

Thank you for agreeing to participate in this follow-up interview as part of our study project on nanotechnology in construction, we appreciate your time. You were randomly selected for this interview based upon your responses to our initial online survey. Your survey answers indicate that you have some awareness of nanotechnology that we'd like to explore in more detail with you in this interview. I have about XXX questions I'd like to discuss with you, which should take about XXX minutes to complete, however, feel free to take as much time as you like in your responses.

As you may remember from the online survey introduction, the SBCTC is conducting this study through a grant from CPWR (Center for Construction Research and Training) to further our understanding of how this technology is emerging in the construction industry. The results of the study will be compiled into a report to CPWR which will ultimately be made public via the CPWR and SBCTC websites. The findings of the study will be shared with other researchers and may also be published in professional journals.

I want to assure you that, throughout this process, your confidentiality will be strictly maintained and inform you of the following 5 agreements:

A. Your participation in this interview is completely voluntary,

B. We will not use your name or identifying information in any summaries, reports or publications,

C. Interview responses will be analyzed in aggregate, no responses will be tied to any individual respondent,

D. You do not have to answer any question that you don't want to and you can stop the interview at any time,

E. With your consent, I will digitally record the interview and take notes. This is to assure that I capture everything that you say accurately and completely. As the Primary Investigator I will be the only person to have access to the recording and notes after the interview. If at any time during the interview you feel uncomfortable, I can stop recording at your request. Do I have your permission to record your interview?

   Thank you. When we begin recording the interview, I will ask you once again for your permission on the recording.

Do you have any questions or concerns about the study, this interview or process before we begin?

[START RECORDING]

State the participant's identification number

Thank you for voluntarily participating in this interview as part of our SBCTC study of nanotechnology in construction. Do you acknowledge that I have informed you of our confidentiality agreement and do you give permission for me to record this interview?

DEMOGRAPHIC INFORMATION

Without stating your name, please tell us about yourself:
What is your occupation?
What is your trade? Do you still work with the tools?
Are you an employer or employee?
What is your current title or position?
How long have you worked in construction?

INTERVIEW QUESTIONS:

1. What's the first thing that comes to mind when I say nanotechnology?

Your answers to our online survey indicate that you have a general awareness and knowledge of construction nanotechnology. We'd like to explore that further with you.

2. How did you first become aware that nanotechnology was being applied in construction?

3. If I were a colleague who did not know the meaning of the term "nanotechnology" how would you explain it to me?

    Is nanotechnology ever a topic of discussion among you and your coworkers, peers, union members, employers?

4. From your perspective, what impact has nanotechnology had on construction?

    How has it surfaced in your trade or work that you have done?

5. Is there particular information you'd like to have about nanotechnology in construction that you don't have now?

6. Is there anything else you'd like to add about your awareness of nanotechnology that we haven't already covered?

In the online survey, you reviewed an extensive list of products and identified one or more specific products that you recognize or have used.

Note: These questions will only be asked if they identified products in the online survey.

7. When you reviewed this product list, what stood out to you?

8. You indicated having knowledge of (XXXX) products on the list. What is your experience with these products, what can you tell us about them?

    How did you first learn about them?
    Have you actually used them on commercial jobs?
    If no, have you seen them used by others?

9. Were you aware they are nano-enabled? If so, how did you know?

    What information were you provided about the products? (Product label? Product information sheet? Safety Data Sheet (SDS)?)

10. What specific training were you given about proper use of these products?

11. What is your reaction to using nanotechnology in your work? What do you see that is either positive or negative around this new technology?

From the online survey, I see you've experienced training related to nanotechnology in construction.
[Review responses to online questions before the interview]

Note: These questions on training will only be asked if they responded in the online survey that they have previously received or delivered training.

For training received:	**For training delivered:**
12. What prompted the training? 13. What did the training consist of? Materials received? 14. What key messages from this training do you recall now? 15. What did you find most useful? Not useful? 16. What changed for you as a result of participating in this training? 17. . If we were to design new training on nanotechnology, what would you recommend be included? 18. Before we move on, is there anything else you want to say about the training you received?	12. What is your purpose for training about nanotechnology and who are you training? 13. . How did your program get started? How did you become prepared to teach about nanotechnology? 14. What topics do you cover in your curriculum? Is it trade specific or general? Are you willing to share a copy with us? 15. What is the average length of your training sessions and how often do you teach them? 16. Are there any teaching tools or materials you wish you had available that would enhance your training? 17. What's the most important thing you think workers should know about nanotechnology in construction? 18. Before we move on, is there anything else you want to tell us about the training you deliver?

In the online survey you tended to agree that nanomaterials and nanotechnology may pose some risks. You listed (XXX) as your concerns.

Note: These questions will only be asked if respondents indicated on questions 20 and 22 in the online survey that they agree there are health or environmental concerns.

19. What has prompted these concerns for you?

20. . How have you addressed these concerns?

21. Are you aware of any standards that currently apply to nano-materials, such as RELs (recommended exposure limits) or PELs (permissible exposure limits), or any other regulation of nanotechnology in construction?

22. . In your experience, what controls, if any, are being used to protect workers who use nano- enabled materials or other forms of nanotechnology?

23. What do you think are the most important things workers and employers need to know to use nanotechnology safely in construction?

24. Is there anything else you'd like to talk about with regard to your concerns that we haven't covered?

That's all the questions I have for you. Is there anything else you'd like to say regarding nanotechnology or nano-enabled materials before we conclude the interview?

[Stop Recording]

Thank you for being generous with your time and participating in this study.

Would you like me to inform you when the results of the study are reported?
What is the best way to contact you.

SBCTC Nanotechnology Study
Interview Questions for Government Agency Representatives

Thank you for agreeing to participate in this interview as part of our study project on nanotechnology in construction, we appreciate your time. The SBCTC is conducting this study through a grant from CPWR (Center for Construction Research and Training) to further our understanding of how this technology is emerging in the construction industry. We are surveying building trades union staff, union apprenticeship staff and contractor representatives to determine the level of awareness and knowledge that exists related to nanotechnology in construction.

We're also interviewing staff within key California government agencies that may be involved in regulation, monitoring, and tracking of nanotechnology and nano-enabled materials in our state. You were recommended to us a having expertise in this arena.

California is known as a leader in public policy governing nanotechnology. This public policy experience can inform policy-makers in other parts of the nation with regard to nanotechnology. We're specifically interested in identifying successful legislative and governing strategies employed in California to ensure proper oversight of nanotechnology, dissemination of hazard information, safeguards and protections for workers, consumers and the environment that may be replicated in other states. We'd like to hear about ways your agency is engaged in programs related to these efforts.

The results of the study will be compiled into a report to CPWR which will ultimately be made public via the CPWR and SBCTC websites. The findings of the study will be shared with other researchers and may also be published in professional journals.

With your consent, I will digitally record the interview and take notes. This is to assure that I capture everything that you say accurately and completely. As the Primary Investigator I will be the only person to have access to the recording and notes after the interview. If at any time during the interview you feel uncomfortable, I can stop recording at your request. Do I have your permission to record your interview?

Thank you. When we begin recording the interview, I will ask you once again for your permission on the recording.

Do you have any questions or concerns about the study, this interview or process before we begin?

What is the name of your agency?
Your title?
How long have you been in this job?

What role does your agency play with respect to nanotechnology?

What specific programs do you know about that monitor, regulate or research use of engineered nanomaterials?

How were these programs initiated? How are they funded?

To what extent do these programs relate to use of nanotechnology in the construction sector?

What specific issues or concerns, if any, have you encountered regarding nanotechnology?

What laws/regulations are you aware of that control the use of nanomaterials at the state level? County? City?

Who would I contact to get more information about enforcement?

What outreach or education programs are available pertaining to nanotechnology?

What type of collaboration/data sharing occurs between California agencies or with groups and government agencies outside the state?

What are the main uses of nanotechnology in construction?

What is the relationship between green building and nanotechnology?

Who are the key stakeholders with regard to nanotechnology in California?

What are your trusted sources for information/data about nanotechnology and nanomaterials?

eLCOSH Inventory List
Entries Recognized By Respondents Who Indicated Awareness Of Nano Terms

Category (in descending order) N = (# of respondents)	Materials Noted	# Times Noted
Additives for asphalt (2)	FASS-DRI Pavement Sealer Additive	1
	LMGI Asphalt Additives	2
Additives for coatings (3)	Laromer PO 9026	1
	Nano Shield Hardener	1
	SunCare TopCoat UV protection additive	2
Additives for concrete/cement (7)	Efflock Liquid Admixture	1
	Efflock Powder Admixture	1
	Exvila	2
	Master X-Seed 100	1
	Nano Bond – Concrete Bonding Agent	2
	Pro-Seal Drycrete	4
	Pro-Seal Pro Cure A	3
	SurfaMix C	1
Adhesives (9)	Aroply 250	2
	Aroply 350	1
	Bio-Ecologic Glue	1
	CNT stix	1
	Contak (bonding adhesive)	2
	Pro-Seal Flash Guard Tape	3
Boiler Additives	LMGI high concentration oil soluble magnesium	1
Caulking (12)	Pro-Seal 34	6
	Pro-Seal Pro-Thane 230	4
Cement-based (8)	Agilia	1
	Aridus Rapid Drying Concrete	1
	Ce200	1
	Chronolia	1
	CleanCrete	4
	Ductal	2
	EdenCrete500 Cement Admixture	1
	GFRC Spray Coat and Reinforcement Mixes	2
	Tec-Cement	2
Coatings – Glass/Ceramic (13)	3M Window Films – Ceramic Series	5
	3M Window Films – Prestige Series	4
	DryWired Glass & Ceramics	2
	Flouwet ETC 100 & ETC 140	2
	Fluowet ETC 300	1
	Glass & Ceramic	4
	Glass Clear	3
	Glass Pro	3
	Home improvement oriented water repellent window glass and ceramic tile coating	4
	Perma-Clean Glass	2

	SC Glass Self Cleaning Window	1
	Self Cleaning Glass Treatment	2
	Shower and Tile Treatment	7
	Shower Protect	2
Coatings – Metal (11)	Chrome & Stainless Steel Treatment	3
	Nanolia Powercoat	1
	Nanomyte TC-3001	1
	NanoTech Metal Coating	1
	Pro-Seal PC-V Top Coat	1
	Rust Protect	5
	Stainless Steel Long Life with anti-fingerprint	5
	SurfaGuard Metals	1
Coatings – Mineral Survaces (10)	ARDEX PC 10	2
	Behr Premium Basement & Masonry Waterproofer	1
	Brickform	1
	Concrete Countertop Sealer 660	1
	Cool Slurry Seal	3
	Creteseal WB Nano	1
	DryWired Anti-Graffiti	1
	EFFLOCK TT Topical Efflorescence Treatment	1
	Flor-Guard	3
	Flor-Sil	1
	Mineral Sealant	1
	Pro-Seal Aqua Flex	2
	Pro-Seal Prime Flex III	1
	Seal-Once Concrete Masonry Waterproofing	1
	Seal-Once Marine Concrete Masonry Sealer	1
	Selected Plus Clear Concrete Sealer	1
	Water-Resistant Sealer	1
Coatings – Multi-Surface (8)	Nano Anti-Graffiti Coating	2
	NTP Wood & Stone Sealant	1
	Oxi Seal Concrete Sealer	1
	Pro-Seal Ureflex AL	1
	Pro-Seal Weathermaster	1
	Pro-Seal Power Kote 1	1
Coatings – Paints (12)	Airlite Sunlight Exterior	1
	Amphisilan	1
	Antibacterial Water-resistant Paint	2
	Behr Premiun Plus Ultra	7
	Bioni Medical	1
	Bioni Nature	1
	Exterior Paint	8
	Interior Paint	8
	Mineral Filler (Primer)	1
	Paint Shield	1
	Photo Catalytic Paint	1
	Thermo San	1

Coatings – Wood (8)	Cloucryl 2012 super matt	1
	Defy Extreme Clear Wood Stain	1
	Defy Extreme Wood Stain	1
	Seal-Once Composite Wood Deck Sealer	1
	Varathane Nano Defense	1
	Wood ProDeck	1
Drywall (15)	Sheetrock Brand Ultralight Gypsum Base	9
	Sheetrock Brand Ultralight Panels ½ inch	5
	Sheetrock Brand Ultralight Panels Firecode X	6
	Sheetrock Brand Ultralight Panels Mold	6
	Sniper	2
	USG Sheetrock rand Ultralight Panels	4
Fasteners (5)		
Flooring (6)	Burke 12 MIL Luxury Vinyl Tile Natural Wood Planks	1
	Performance Plus Hardwood	1
	Regal Hardwood Flooring	2
	Teknofloor	2
Fuel Additives (5)	DieselFusion	2
Glass and solar panels (2)	Ceramic Series window film	1
	Pilkington Aditiv	1
HVAC (3)		
Insulation (21)	Aeroclad blanket	8
	Aerogel Compression Paxk	7
	Aerogel Thermal Wrap	11
	Cryogel x201	15
	Cryogel Z	14
	Ecosky3	2
	Kalall+ Lumira Aerogel	1
	Nansulate EPX	1
	Sansulate Solar Insulation Coating	1
	Nansulate Translucent GP-NSF	1
	Nansulate Transluscent High Heat	1
	Nansulate Transluscent PT	1
	NP 110 Insulator Pigmented	2
	Pyrogel XT	13
	Pyrogel XT-E	11
	Pyrogel XTF	9
	Spaceloft	1
Interior Design (1)		
Joint Sealants (7)	Iso-Flex 825	2
Lubricants (3)		
Lumber (18)	MicroPro Treated Lumber	1
	Treated Lumber	16
Metal (6)	ComAR Glass Fiber Reinforced Polymer Nano-Modified	2
Miscellaneous (2)	Carbon Nanotube Enhanced Glass Fiber	1
	Carbon Nanotube-reinforced Epoxy (CNT Epoxy)	1

Patching compounds (6)	Patch Plus Primer	2
	Pro-Seal Power Patch Flexible	1
	Radiant Slabs	2
Prepregs (1)		
Roofing (4)	Nansulate Crystal	1
	Tileflex 2000 Roof Coating System	1
Surface Preparation (4)	Aqua Mix Nanoscrub	1
	Tilelab Nanoclean	1
Thermal Spray coating materials (2)		
Weatherproofing membranes (10)	Pro-Seal Flex System I	3
	Pro-Seal Weather Guard	4
Weld overlays	SHS 9192 GMAW/OAW	3
	SHS 9290 PTAW	2
	SHS 9500 GMAW/OAW	3
	SHS 9700 GMAW/OAW	2
	SHS 9700 PTAW	4
	SHS 9700E SMAW	3

eLCOSH Inventory List—
Entries Recognized By Respondents Who Had No Awareness Of Nano Terms:

Category (in descending order) N = (# of respondents)	Materials Noted	# Times Noted
Coatings—paints (5)	Airlite Sunlight Exterior	1
	Behr Premium Plus Ultra	3
	EPX NanoPrime	1
	Exterior Paint	3
	Interior Paint	2
	Paint Shield	1
Coatings—mineral surfaces (3)	ARDEX PC 10	1
	Lythic Densifier—Concrete Densifier And Hardener	1
	Nanolia Graffiti Guard for Porous Surfaces	1
Lumber (3)	Treated Lumber	3
Coatings—metal (2)	Stainless Steel Long-Life with anti-fingerprint	2
Drywall (2)	Sheetrock Brand Ultralight Gypsum Base	2
	Sheetrock Brand Ultralight Panels 1/2 inch	1
	Sheetrock Brand Ultralight Panels	1
	Sheetrock Brand Ultralight Panels Mold	1
	SNiPER	1
	USG Sheetrock Brand Ultralight Panels	1
Metal (2)	Light Alloys	2
Weatherproofing membranes (2)	Pro-Seal Weather Guard	2
Additives for Asphalt (1)	FASS-DRI Pavement Sealer Additive	1
Additives for Coatings (1)	SunCare TopCoat UV protection additive	1
Additives for Concrete/Cement (1)	Pro-Seal Drycrete	1
Adhesives (1)	Pro-Seal Flash Guard Tape	1
Caulking (1)	Pro-Seal 34	1
Cement-based (1)	SiliconeUltra K&R Finish Through-Coloured	1
Coatings—glass/ceramic (1)	Shower and Tile Treatment	1
Coatings—multi-surface (1)	Pro-SealPC-V Primer	1
Coatings—wood (1)	DEFY Extreme Clear Wood Stain	1
	DEFY Extreme Wood Stain	1
Flooring (1)	Burke 12 MIL Luxury Vinyl Tile Natural Wood	1
	Performance Plus Hardwood	1
Patching compounds (1)	Pro-Seal Quick Fix	1
Surface preparation (1)	AQUA MIX NANOSCRUB	1
Thermal spray coating materials (1)	Thermal Spray Powders & Coatings	1

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