Ergonomics analysis of risk factors of welders during manual welding in manufacturing: A systematic literature review

Humaira Farwin Sattar -- Department of mechanical engineering

Abstract:
A static body posture increases job duration by employing traditional tools and pushing the limits of the welder's ability to handle material, which may induce ergonomic risk factors that can lead to work-related musculoskeletal problems (WRMD). Musculoskeletal diseases (MSDs) are a widespread health concern on a global scale. The risk of injury from occupational risk factors is still quite high for the dangerous task of welding. Particularly, the uncommon nature of the jobs themselves and the workplace dangers that affect the prevalence of MSDs.

In order to fill information gaps in this field, this study is focused on how ergonomic risk variables affect welders' positions. This literature review's objective is to give a general understanding of the ergonomic risk factors associated with welders' positions during various manual welding processes, techniques, and positions. For the production of finished goods in the manufacturing industry, welding is one of the most crucial fabrication techniques. The posture alters when manual handling material tasks, which is a must for welders.

From 2016 to 2022, a systematic review of the literature was carried out and entered into the databases Scopus, PubMed, ResearchGate, and Google Scholar. Using the search term "Ergonomic risk factors and welder's position," 384 articles that cited ergonomic risk factors were included in the first phase of the search. Using the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA), each record was carefully evaluated based on the purpose and scope of the investigation, and the number of records was limited to 28 publications along with other study sources that incorporated review work and analyzed through qualitative risk assessment matrix.

To understand the development of risk variables that have contributed to welder WRMD, such as incorrect welding positions, manual material handling, force, extreme temperature and biomechanical exposures which are associated to several risk factors. It was necessary to conduct a comparative analysis of independent risk factors, considering their interactions with the main risk factors. According to several researches, applying ergonomic design principles may lower the risk of occupational-related risks and musculoskeletal issues. The topic of how to boost productivity and quality affects not just welder but also society as a whole and the organization. Therefore, the essential methods for preventing musculoskeletal problems are ergonomic assessments of process layout design, welding position, and material handling tasks as well.

Keywords: Ergonomic Risk factors, welders, manufacturing, work-related musculoskeletal disorders (WRMD)

Received 03 June, 2023; Revised 11 June, 2023; Accepted 13 June, 2023 ©The author(s) 2023. Published with open access at www.questjournals.org

I. Introduction
Due to the nature of the welding process, the welder must spend a lot of time in the same static position. Over the past few years, there has been a steady rise in the number of workers complaining of musculoskeletal disorders (MSDs), and research studies have been conducted to more thoroughly look at the causes and frequencies of MSDs. Manufacturing, a growing economy sector where number of welders who are exposed to work environment risk, especially ergonomic risk, increases. Welders in industrial industries are most frequently injured at work due to musculoskeletal disorders (MSDs) [1]. Injury or disorder of the joints, muscles, tendons and other body parts are referred to as MSD.
Ergonomics analysis of risk factors of welders during manual welding in manufacturing: A.

Fig 1.1: Different sectors (welding 22% highest of manufacturing sectors).

For instance, welders are typically more inclined to develop musculoskeletal problems connected to physical strain at work (workload > capacity). Assuming that very few employees perform this work. As per studies, the body's posture would become static after a certain period depending on the frequency, length, and intensity of the welding-how hard.[2]

According to studies done by Sachin K. Malave, welder productivity is often poorer in industrialized companies, and they also are more likely to suffer from MSDs that affect operator comfort and performance during repetitive activities.

According to Bharat Sing et al. (2016), the technique of welding positions, workplace features, and environmental factors all play a vital role in work-related musculoskeletal problems. Poorly trained welders are more likely to experience WMSDs while welding. A key part of the ergonomic process is a regular review of the facility, especially process layout designs and work practices, tool designs from an ergonomic perspective through an ergonomic checklist, and questionnaire to provide a safe and comfortable productive workplace. This study does not discuss manufacturing; rather, it discusses ergonomic risk factors in welding-related tasks.

Some researchers have extensively analyzed that if anthropometric data do not match the plant process layout, the plant may operate at a lower efficiency. Welders are aware of WMSD and they need to be trained to report WMSD symptoms early[1].

Ergonomics involves making the workplace fit the needs of workers. It does not simply try to makeworkersadjusttotheworkplace.

Eventhoughthematerialshandlingfacilitiesareequippedwithcutting-edge technology, manual materials handling jobs including lifting materials, transporting tools and equipment are frequently used in the production industry nowadays, changing neutral welder postures while welding in different positions[8]. Most of the chronic ergonomic effects are the result of prolonged exposure [5].

Symptoms of MSD are very common and can occur in welders primarily in the hips, neck, hands, and soft tissues (muscles, tendons, ligaments, and joints [20]. Poor posture can lead to work-related musculoskeletal disorders. WRMSD is caused by a complex interplay of factors related to professional activity, physiology, environment, technology, management, sociology, and non-work-related activities and environment[26].

There is no unique cause related to these disorders, however, literature shows that various job factors can contribute to the development of MSDs.[5]
Ergonomics analysis of risk factors of welders during manual welding in manufacturing: A.

Therefore, if the welder is not in the right condition and in a comfortable reach zone, the quality and strength of the weld can also be affected, which can affect the quality of the product according to ISO standards. Welds have external or internal defects such as porosity, excessive spatter, incomplete penetration, lack of penetration, incomplete fusion, slag entrainment, burn-through, etc., due to reduced strength and quality of the weld. Reworking component or part increases the level of energy (resulting in discomfort, stress, failure), the level of cost, the level of materials, the level of time, etc. Proper ergonomics design for different welding positions require.\[1\]

According to C. Weyh et al (2020), physical workload and risk factor reduction, job rotation, and welder training may emerge as important approaches to work-in-progress or finished products in the manufacturing assembly sector. The purpose of this work is to literature review revealed a gap in the existing risk factors.

II. Methodology

On this basis, a systematic literature search was conducted from 2016 to 2022 and indexed the databases Scopus, PubMed, ResearchGate and Google Scholar. In the first phase, 384 articles mentioning ergonomic risk factors were included in the search using the ergonomic risk factor and welder location searches. Ignore review articles, conference papers, and non-English papers.
to ensure the quality of the paper. After careful evaluation of each dataset based on the purpose and scope of the study, it was reduced to 31 articles and included in a 2020 systematic review and meta-analysis, along with other methods from research sources, including review work after exclusion of screening. Applied using the recommended report item for the data. Analysis Protocol (PRISMA).

**Fig2.0 :PRISMA2020 flowchart**

**TABLE 2.1 - The selection criteria**

<table>
<thead>
<tr>
<th>NO</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion</strong></td>
<td>Studies published over the last six years, between the years 2016 to 2022</td>
</tr>
<tr>
<td></td>
<td>Mostly Journal articles</td>
</tr>
<tr>
<td></td>
<td>Studies performed in the manufacturing industry context and the effects of risk factors</td>
</tr>
<tr>
<td></td>
<td>Research related to ergonomic risk factors for musculoskeletal disorders to mitigate ergonomic solutions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusion</th>
<th>Before 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Duplicate papers</td>
</tr>
<tr>
<td></td>
<td>Excluded studies not associated with the effects of risk factors</td>
</tr>
<tr>
<td></td>
<td>Research focused on common worker tasks, not production environments, and no automation</td>
</tr>
<tr>
<td></td>
<td>Excluded studies not associated with musculoskeletal disorders where welding technology is not involved.</td>
</tr>
</tbody>
</table>
According to a literature review that has been conducted, this systematic review will help analyze ergonomic risk factors for welders in manufacturing jobs.

**ERGONOMICS**

Most researchers define ergonomics in different ways that absorb the concept in a meaningful state. Below Table 3-1 shows some definitions of ergonomics from previous studies.

<table>
<thead>
<tr>
<th>RESEARCHERS</th>
<th>DEFINITION OF ERGONOMICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bharat Singh and Piyush Singh [1]</td>
<td>Ergonomics is concerned with the design and sequencing of what workers use, so it can reduce human fatigue and increase efficiency.</td>
</tr>
<tr>
<td>Sanders &amp; McCormick</td>
<td>Apply information about human behavior, capabilities and limitations to design tools, machines, tasks, workplaces and environments for productive, safe, comfortable and effective human use.</td>
</tr>
</tbody>
</table>

**Risk Factors among welders in manufacturing environments**

A risk factor is a risk character that appears to be associated in some way with the development of a disease. If these risk factors are present, developing the disease is more likely but not certain to develop the disease. Risk factors are primarily categories such as biomechanical exposures, psychological stressors, and individual risk factors [2].

**Biomechanics** is the study of forces acting on the human body and their effects, describing properties of biological systems such as repetitive forces and force exertion.

**Psychological stressors** are social and external physical environmental stressors that challenge the capacity and limits of physical health.

**Individual risk factors** include demographic parameters such as age, gender, inadequate leisure activity and additional workload [3]. For example, not everyone who welds develops MSD, and not everyone with MSD is a welder, but welding activities create ergonomic risk factors for MSD.

Specially welders from industries may experience different types of musculoskeletal symptoms (MSDs) and the number of reported cases are still increasing due to inappropriate methods, demanding higher capabilities and limitation, mental workload and improper ergonomics forming awkward postures. Past years' risk factors have affected the ergonomic context by increase in musculoskeletal health problems and the research focus of finding the gap [4]. Many welding-related accidents, such as UV and IR radiation, occupational heat stress, welding fumes, and particle generation, have much higher particle concentrations in enclosed spaces than in the open air [5].

Most symptoms include discomfort, pain, swelling, sensory disturbances, tingling, limited range of motion, and decreased motor control. High working conditions and environments may cause to develop MSDs, considered the greatest cause of lost working hours, increased costs and suffering from human violence, and the greatest occupational health problem in the developed world [2, 6, 7]. There may be associations between occupational risk factors and the prevalence of MSDs affecting different parts of the body, with some of the most important major risk factors being poor posture, repetitive use of force, overuse of force, and hand-arm vibration that leads to an increase at MSD. Recent studies have focused on the impact of risk factors in the lumbar zone that may affect quality of life at work [8].

### 3.0.1 AWKWARD POSTURE

When welders need to perform tasks in unusual postures as squatting, bending, kneeling, straightening, flexion/twisting of the neck and hands through improper work positioning or improper performance of tasks.

Static when the welder stays for a long time, often done manually in different welding positions/techniques and job rotation to ensure high quality standards according to ISO standards [9].

Awkward posture is a vital ergonomic risk factor of welders which can lead to work-related MSD. Low back pain causes flexion, hip and pelvic tilt during forward bending due to increased tensile loading of the lumbar spine [17, 18, 19]. Wearing underwear with high Clo values (synthetic materials with low permeability of perspiration) while squatting reduces the concentration of sperm production in welders, which can lead to delayed fertility and infertility [10].

Unfavorable posture during static and dynamic work strains the muscles. A static position in which the muscles are held for more than 4 seconds is considered tiring and ergonomically unhealthy for the welder,
Ergonomics analysis of risk factors of welders during manual welding in manufacturing:

leading to musculoskeletal problems and widespread discomfort throughout the body. These diseases are categorized from minor to severe chronic diseases i.e. slight body paint to severe chronic diseases of the musculoskeletal system.
Without proper ergonomic improvements, the effects will continue to affect both individuals as a consequence organization.

3.0.2 Repetition:
Repetition is the average number of periodic and repetitive movements per unit time. Repetitive movements are especially dangerous when they consistently use the same joints, body connections, and muscle groups, and when they perform the same movements often, frequently, and for long periods of time. Repetitive motions always require interactions with other risk factors such as awkward static postures and application of force (welders’ shoulders position, wrists and neck in static positions to apply external forces). A common cause of incidence of causes is complaints in the neck, lumbar spine, hips, shoulders, and wrists. The force is exerted on the filler rod in form of lateral pinch and welding torch in palm grasp when handling manual arc welding, both hands are used in a repetitive form and neck flexion is continuous throughout the weld. Hence neck pain is also an independent ergonomic risk factor [11]. In general, the higher the number of repetitive motions, the higher the risk associated with the welder’s risk factors and the relative stress associated with neuropathy (diseases of the central and peripheral nervous system) due to nerve entrapment within the carpal tunnel.

![Fig3.1: Lateral pinch and Palm pinch respectively](image)

3.0.3 FORCE
Power is the mechanical or physical effort the human body must exert to accomplish a particular task, movement, or effort such as lifting objects, using tools and equipment, grasping holders, or moving muscles, tendons, and ligaments beyond force will result in inadequate recovery time and increased work fatigue. Therefore, stress fatigue occurs when force is applied. [12]. Overexertion force in hand is hazardous practice eventually fatigue loading. Overexertion force includes in lifting, palm pinch and lateral grasping, bending for forward reach which may also contribute in the prevalence of MSD.

Vibrating tools such as grinders, drills, etc. affect muscle parts of the welders’ body, subjected for long exposure to perform necessary tasks [2]. It has also been suggested that welding equipment produce vibration that cause damage to the soft tissues and circulation of the fingers in the hands and arms, a condition known as hand-arm vibration syndrome (HAVS) that mimics Raynaud’s disease [13], resulting in discomfort and cause pain in the upper extremities and joints.

Excessive manual load handling by lifting, holding and lowering create overexertion which has a greater prevalence to welders’ complaints.

3.0.4 Welding Hazardous Fumes
Welding in manufacturing is most often done in closed confined spaces. In this space, exposure to chemicals and inhalation of fumes and fine particles can cause inflammation in the lungs and organs throughout the body, and metal accumulation can lead to respiratory diseases such as asthma, tuberculosis, mild cough, wheezing, and mild respiratory illness may increase the incidence of cough and lung disease.

According to Firouz Amani et al., toxic chemical particles in base metal and filler metal welding are dependent on open or closed chamber welding techniques, if adequate ventilation is provided, and exposure time, frequency, type of welding technique, procedure, conditions, and poor safe PPE practices pose a health hazard. Many chemicals in the air we breathe in high concentrations may damage the lungs and cause human cancerous disease in both welders and non-welders (microbes attack more easily and ultimately causing inflammation) [5]. Some evidence suggests that some people are allergic to welding fumes and exposure to chemicals, causing only skin rashes [5].
3.0.5 Extreme Temperature

It is not surprising that welding temperature in relation to thermal energy affects welder and non-welder risk factors. Exposure to this extreme temperature can cause discomfort, alter static posture, and lead to fatigue, stress and body pain[13]. Findings show that contact muscle strained due to increasing of lactate and phosphate in the muscle and positively induces muscular stress. These hazards may have an immediate effect or become apparent only over the long term. [13] On the other hand, working in extreme cold induces cold stressors and hot environments induce heat stressors. As a result, heat stressors from excessive heat can lead to heat stroke if PPE is not appropriate for safety reasons or if natural ventilation is not well established or done properly. May reduce effects associated with heat exhaustion, heat cramps and heat exhaustion (physical-mental workload). Poor ergonomic design and workplace hazards constraints may increase the likelihood of musculoskeletal injuries[12]. For long exposure to welding heat exposure had a significant effect on sperm concentration, but short-term exposure had no significant effect on sperm concentration[10].

3.0.6 Light Intensity and Radiation

The electromagnetic field including visible light, ultraviolet, and infrared rays. Welding arc emits very high intensity of UV radiation where welders and non-welders who are close to the working spot may get exposed. Some researchers identified that not only very frequent welders get affected but also occasional welder and non-welder who are close to the exposure of extreme UV radiation. When detecting quality of the weldment, gamma radiation is carried out to inspect the internal welding defect (non-destructive testing) whereas welder exposed to this vicinity lead to severe musculoskeletal disorder. Similarly, exposure to high intense arc for less than 60 seconds may cause or increase the incidence of eye blindness which affects the retina of the eye. Most of elderly welders of age above 50 get affected with this type of disease which impair eye and form poor quality in weldment resulting in lower productivity[7,27]

3.0.7 Psychological Effects

Several studies suggest a relatively high prevalence of cognitive disorders among welders. [14]. This may be for various incidence of cause-related reasons as lack of regular work and rest periods, attempts to prepare for urgent work, lack of proper sanitation and equipment, exposure to direct lighting glare, lack of discipline in the workplace, violence, poor awareness of welding hazards, lack of proper ergonomic conditions in industry. But it is mainly due to high stress felt at work, fatigue when demands are higher than abilities and limitations, stress due to tight schedules, lack of social support and high emotional stress. Shift work and fewer breaks are some of the associated factors leading to cognitive impairment. [13] All of these factors well psychological stress and cause musculoskeletal disorders in welders.[4]

It has been proven that welder's strength remains the same while he is awake. It also depends on the environment, the physical (physiology) and cognitive state of the environment.

3.0.8 Noise Level

Further stated that the welders are also exposed to audible sounds of up to 120 decibels (dB), which are extremely dangerous to the hearing system. Exposure to high noise levels (>90 dB) for more than 8 hours likely causes noise-induced hearing loss (NIHL), which damages sensory hair cells in the cochlea, leading to permanent hearing loss, increases psychological fatigue, and nervousness sometimes.

3.3 Approaches on methods for evaluating the risk factors

Previous studies have used ergonomic assessments such as QEC, Rapid Upper Limb Assessment (RULA), Rapid Whole-Body Assessment (REBA), and Whole-Body Complaint Map (WBDM) to assess welder's human parameters of working conditions. Assess engineering ergonomic risk factors and check correlations between risk levels and risk factors to check severity to improve ergonomics. Demographic variables such as age, height, weight, education, and work history have been shown to play important and effective roles in assessing ergonomic risk factors for welders.
Table 3.2: Approaches applied on methods for evaluating the ergonomic risk factors

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Methodology</th>
<th>Contribution to the research</th>
</tr>
</thead>
<tbody>
<tr>
<td>[15]</td>
<td>Descriptive and empirically QQC and REBA methods</td>
<td>Demographic variables such as age, height, weight, education and work history play important and effective roles in explaining ergonomic risk factors.</td>
</tr>
<tr>
<td>[2]</td>
<td>Descriptive–analytical study through PATH method</td>
<td>Training on how to carry loads correctly to reduce disorientational soseem effective</td>
</tr>
<tr>
<td>[7], [11]</td>
<td>MSD (Nordic questionnaire) and LTPA (International Physical Activity Questionnaire)</td>
<td>Demographics, health behaviors, work-related factors (welding process, hours of welding per day, years of service, shift work, ergonomic tools)</td>
</tr>
<tr>
<td>[5]</td>
<td>Textured questionnaire</td>
<td>Inquired about working hours, smoking, chewing, and health-related issues.</td>
</tr>
<tr>
<td>[16]</td>
<td>Interview and questionnaire</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.3: Qualitative Risk assessment matrix through others literature reviews study

<table>
<thead>
<tr>
<th>Challenges for risk factors</th>
<th>References</th>
<th>Complaints</th>
<th>Likelihood</th>
<th>Impact effects</th>
<th>Risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomechanical Exposures</td>
<td>(Sajad Zareeta et al., 2016)</td>
<td>Body pain discomfort/ MSD problems/fatigue/cognitive loading</td>
<td>48%</td>
<td>0.8</td>
<td>0.384</td>
</tr>
<tr>
<td>(Awkward posture/ Repetitive force)</td>
<td>(Lilian Lourencort al., 2021); (C. Weyhet al., 2020); (Ehsan Astivandazadehet al., 2018); (Firooz Amani, 2017); (Uday V. Aswalekar Vinod B. Tungikar, 2017); (Bharat Singh and Piyush Singhal, 2016); (Khairul Fahzan bin Salleh et al., 2020); (Satish B Mohan, 2018); (Kristīne Bokše, 2018); (Anwar Johari, 2019)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welding temperature</td>
<td>(N.S.M.D.K. Nanayakkara, 2017); (Sunil Kumar et al., 2019); (Stephen Bao et al., 2019); (Astrid Skovmand et al., 2020); (Khairul Fahzan bin Salleh et al., 2020); (Stephen Bao et al., 2019)</td>
<td>Allergictothe heat sensation</td>
<td>26%</td>
<td>0.9</td>
<td>0.234</td>
</tr>
<tr>
<td>Welding fumes</td>
<td>(Bharat Singhand Piyush Singhal, 2016); (Arshad Husain, 2018); (Astrid Skovmand et al., 2020); (Rejo Jacob Joseph et al., 2018)</td>
<td>Respiratory problem allergic issues Chronic effect</td>
<td>10%</td>
<td>0.75</td>
<td>0.075</td>
</tr>
<tr>
<td>Psychologic effects</td>
<td>Yetunde O. Tagurum et al., 2018); (Zeinab Almasi et al., 2020); (Kristīne Bokše, 2018); (MOHAMMA DHOSSEIN BEHESHTI 2016); (Hélène Sultan-Tajeb et al., 2017)</td>
<td>Cognitivedisorder</td>
<td>14%</td>
<td>0.6</td>
<td>0.084</td>
</tr>
<tr>
<td>Sound Effects</td>
<td>Martin D’Gwomson, 2018); (Kristīne Bokše, 2018); (Khairul Fahzan bin Salleh et al., 2020)</td>
<td>Exposure to high noise levels (&gt;90 dB) for more than 8 hours likely causes noise</td>
<td>13%</td>
<td>0.8</td>
<td>0.024</td>
</tr>
</tbody>
</table>
Ergonomics analysis of risk factors of welders during manual welding in manufacturing: A.

| Demographic effects | N.S.M.D.K. Nanayakkara, 2017 | Adel Mazloumieal., 2016 | Uday V. Aswalekar Vinod B. Tungikar, 2017 | Satish B Mohan, 2018 | induced fatigue | more absenteeism's, poor productivity, more productivity | 0.1% | 0.6 | 0.006 |
**IV. Discussion and Conclusion**

This systematic review focuses on reviewing ergonomic risk factors. Critically evaluated on the literature reviews through Qualitative Risk assessment matrix according to Table 3.3. The majority of the literature revealed that the higher risks are due to biomechanical stressors (awkward posture, repetitive forces,) and welding temperature which are comparatively higher than other risk factors. Meantime, periodic medical records reveal long-term potential has a higher risk effect on welders’ health than short-term exposure.

Welding is a highly skilled job that takes years to complete. Welding is a precision job that requires the welder to remain in a stationary position for a relatively long time to complete the job. Risk factors may increase the welder’s risk level, which may lead to a possible or disorder of the musculoskeletal system. Risks vary according to weld type, frequency, duration, fillermaterial,electrodefluxand basematerial, working conditions, and layout in confined spaces.

The ergonomic risk factor considered in this study was clumsy posture, and the high prevalence of MSDs is due to biomechanical force exposure resulting in postural changes and also extreme temperatures from radiant heat from arcs and ambient temperatures in confined spaces can cause attitude changes. Personal protective equipment also another factor which may be welder’s negligence in using PPE without realizing the seriousness of these ergonomic problems. Discomfort in the human body therefore ultimately increases the likelihood of fatigue or injury that triggers WRMD.

Thermal comfort is an effective powerful force in reducing fertility rates among male welders heavily involved in welding compared to female welders. This can significantly increase the growth of sperm concentration in the male reproductive system. In-depth studies have shown that even squatting and low-permeability underwear are as effective in slowing the production of sperm fertility in welders as they are in non-welding. Long exposure to radiant welding heat can cause discomft in the human body and productivity, resulting in lower productivity, reliability, and quality of life. These welding activities human health in improving welder’s working posture and preventing welder fatigue and injury, as well as ergonomic analysis to improve correction and reduction of future MSD problems can be applied, but also develop research ideas to promote safety from an ergonomic point of view.

**Some Suggestions for Future Studies**

- To include some social demographic factors and identify independent risk factors that cause MSDs.
- To investigate further why welders still suffer work-related injuries (reduce or prevent strategy) and incidence for other independent risk factors.
- To investigate the determinants of financial outcomes of prevention related to the implementation process (which are seldom) for prevention-oriented decision-making in the occupational health and safety of welders.

**References**


[4]. Sajad Zare1, NaserHashemnezad1, TanaiDehes2, DavoudHasanvand3*, SaeedAhmadi4, RasoulHemmatjo5,*‘The Relationship between Mental Workload and Prevalence of Musculoskeletal Disorders among Welders of Tehran Heavy Metal Structures Company in 2016’, Nov. 2016.