

Experimental Analysis to Improve Weldments Quality and Safety Aspects by Using Modified Fluxes in Shielded Metal Arc Welding Process

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Abstract: In all welding processes, air pollutants are created in the form of fumes and gases. The fume consists mainly of metal oxides and is formed when metal vapour condenses and oxidizes. Gases are created due to the high temperature and ultraviolet radiation from the arc. Examples of hazardous gases formed in welding include ozone, nitrogen dioxide, nitric oxide and carbon mono-oxide. The level of emission of air pollutants and their composition depends on a number of different factors such as; welding method used, welding parameters, filler metal and surface coatings or contaminants on the base metal surface. Air pollutants have different effects on man. In order to evaluate the hazards, many substances have hygienic threshold values. These values can be used in assessing the quality of the breathing air. By taking a number of different precautions, the welder's occupational health can be improved in many ways. Where there is a likelihood of worker exposure to welding fumes and gases, the following controls are used in day to day operations :

- i. Engineering controls;
- ii. Administrative controls; and
- iii. Use of Personal Protective Equipment.

In this paper we try to make an effort to change the design of welding electrodes in such a way Manufacturers of welding electrodes may be able to substitute less hazardous or modify composition of ingredients and using the purest form of chromium in their products without altering important metallurgical or welding characteristics and mechanical properties. This paper concludes reduced toxicity up to 37.5% & 14.28% of Cr&Ni respectively in the fumes and gases generated by modifying composition which also fulfils all the necessary requirements of ASME section II part-A code SA240 for SS304 plate welding.

KEYWORDS: Arc Welding, Safety In Welding, Welding Fumes Reduction, Flux Modification, Weldment Qualities

I. INTRODUCTION

In all forms of welding, unless the proper precautions are taken the welder will probably be exposed to health hazards. Examples of health hazards related directly to the welding process are air pollutants (fume and gases), intensive arc radiation and in certain cases high levels of noise such as during pulsed-arc welding. Other health hazards

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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not directly associated with the welding process itself include noise, difficult and tiring work positions and draughts. By using protective clothing and equipment, local extraction and ergonomic aids, the welder can help reduce or totally eliminate these hazards. The employer can also improve the situation by ensuring that the premises are well organized, that they incorporate adequate lighting and ventilation that it is possible to separate the work stations by screens and that protective equipment and clothing are available. The employer shall also make sure that personnel are well trained and are kept informed about the risks of the work they are doing.

In many welding processes, air pollutants are generated and take the form of fumes and gases, includes particles which are larger than 1 in diameter. Dust particles fall in close vicinity to the arc and consist largely of welding spatter (i.e) meant particles less than 1 in size. These particles generally remain suspended in air and in that way can be carried long distances from the welding arc.

GASES

All welding processes produce hazardous gases. Gases are invisible to the eye, and may or may not have an odour. The heat in both the flame and the arc, and the ultraviolet radiation from the arc, produce gases such as carbon monoxide, carbon dioxide, oxides of nitrogen and ozone. Other gases and vapours may be produced as by-products from the breakdown of solvents or coatings on the metal. Gases used for arc shielding, or as a fuel, are also given off during welding.

FUMES

Welding also produces fumes. Fumes are formed when hot metal vapours cool and condense into very small particles that stay suspended in the vapour or the gas. The particles may be metal or metal compounds, and are often smaller than one micrometer (one-fiftieths the width of a human hair). Fumes may be visible or not. Welding “smoke” is an example of a visible fume. But even if the fume can’t be seen, its particles are still present.

GASES, VAPOURS AND FUMES AFFECT HEALTH

Health Effects of Fumes, Gases and Organic Vapours during Welding, lists examples of the health effects of exposure to materials present during common welding situations. In the table, “acute effects” refers to effects that occur immediately or quickly, while “chronic effects” refers to those that take a long time to appear. Metal fume fever is an example of a common acute effect of exposure to several types of welding fumes. This reaction consists of flu-like symptoms, including alternating chills and high fever. Symptoms usually last one or two days and then subside, although their onset may be delayed. It is possible to experience both acute and chronic effects from a brief exposure to large quantities of a substance, or from repeated exposures to smaller quantities of a substance

II.OCCUPATIONAL EXPOSURE LIMITS

Occupational Exposure Limits (OELs) are the maximum permissible concentrations of a hazardous substance that most healthy adults may be repeatedly exposed to without suffering adverse health effects. Remember, these limits assume the individual exposed to the substance is a *healthy* adult. There may be increased risk, for example, for a smoker, a person with pre-existing health problems or individuals who suffer from allergies. OELs are often assigned in following three values.

- i. **One value** is based on normal working conditions of 8 hours per day, over an average lifetime of exposure. If more than 8 hours are worked (for example, in a 12-hour shift), this value must be adjusted.
- ii. **A second value** provides a limit for a 15-minute, short-term exposure. This is a value to which a worker may be exposed for 15 minutes, a maximum of 4 times per shift, with at least 1 hour between exposures. In this case, the 8-hour OEL cannot be exceeded.
- iii. **A third value** is the ceiling limit. This limit must never be exceeded. If more than one type of contaminant is present, as in most welding situations, and the effects of exposure to each is similar, an exposure limit for the mixture is calculated. This value is lower than the limits set for exposure to individual contaminants.

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OELs permit workers to be exposed to only very small quantities of substances. The amounts are measured in parts-per-million (ppm) or milligrams per cubic metre (mg/m³). One mg/m³ is about the same concentration of sugar water that one sugar cube would create if dissolved in swimming pool 50 metres long, 20 meters wide and 2 meters deep. Such small quantities can only be measured with sophisticated instruments and techniques.

Alberta's health and safety legislation specifies exposure limits for the substances present in welding gases and fumes. OELs represent only minimum standards. Because measurements and workers' susceptibility is expected to vary, the law in Alberta requires that employers keep exposure levels to harmful substances "as low as reasonably practicable." The intent of the law is for employers to reduce exposure to a fraction of the OEL, using ventilation or other control measures. Where it is not possible to reduce levels to below the OEL, workers must use personal protective equipment.

Here we take the one value of the OEL which says that a normal human should work only for 8 hours per day in normal condition. This is as per the code EH40 in OEL.

Hence Chromium VI must be maximum of 0.05mg/m³ and Chromium III must be maximum of 0.5mg/m³ only should present in the working area for 8 hours.

Welder's Exposure

Welding gases and fumes do not normally cause immediate health problems. However, if over the years of working as a welder, you breathe in gases, vapours and fumes in quantities greater than the OELs, it is likely that your health will suffer. The seriousness of the hazard depends on the welding process, including the type of metal being welded

➤ The type of fume generated (not the total number of fume particles). For example, E6010 electrodes used on low-carbon steel generate a large quantity of iron oxide particles. These are relatively non-toxic. However, an E316-15 electrode produces small quantities of highly toxic chromium fumes. The hazard is obviously greater with the E316-15 electrode.

The quantity of gases and fumes generated by welding depend on welding processes and other variables such as:

- Type of shielding gas
- Current
- Voltage
- Type of electrode
- Polarity

III. MATERIALS AND METHODS

Study Area

Here we take three types of stainless steel electrodes such as basic, utile and Cellulosic electrode specifically E309L, E308L and E310 respectively. The aim is to reduce the toxicity of these electrodes during welding in an effective manner. By the observation and analysis of all the three electrodes, we concluded that the most toxic components are Chromium and Nickel. Hence by reducing these two components in the flux during fabrication of electrodes, the toxicity in the gases and fumes will be reduced.

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Table 1: Health Effects of Fumes, Gases and Organic Vapours Produced During Welding:

| Elements | Source | Effect on Human |
|-------------------|---|---|
| Beryllium | Hardening agent found in copper, magnesium, aluminum alloys and electrical contacts. | “Metal Fume Fever.” A carcinogen. Other chronic effects include damage to the respiratory tract. |
| Cadmium Oxides | Stainless steel containing cadmium or plated materials, zinc alloy. | Irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema. Suspected carcinogen. |
| Chromium | Most stainless-steel and high-alloy materials, welding rods. Also used as plating material. | Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens (hexavalent chromium). |
| Copper | Alloys such as Monel, brass, bronze. Also some welding rods. | Acute effects include irritation of the eyes, nose and throat, nausea and “Metal Fume Fever.” |
| Fluorides | Common electrode coating and flux material for both low- and high-alloy steels. | Acute effect is irritation of the eyes, nose and throat. Long-term exposures may result in bone and joint problems. Chronic effects also include excess fluid in the lungs. |
| Iron Oxide | The major contaminant in all iron or steel welding processes. | Siderosis – a benign form of lung disease caused by particles deposited in the lungs. Acute symptoms include irritation of the nose and lungs. Tends to clear up when exposure stops. |
| Lead | Solder, brass and bronze alloys, primer/coating on steels. | Chronic effects to nervous system, kidneys, digestive system and mental capacity. Can cause lead poisoning. |

IV.MODIFICATIONS DONE ON FLUX

The actual available electrodes are analysed first. Their fluxes are analysed and found the composition of the fluxes, In which I consider only the toxic content present in that fluxes a electrode. Here I take the toxic content in the welding fumes is chromium and nickel from the analysis of fluxes. I found that all manufactures used the ferrous mixed

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component which is of with high level of ferrous content. Due to this mixture of ferrous content only produces the toxic content more in the welding gas (i.e.,) chromium and nickel. Here, they use Ferro – chromium and Ferro – nickel to reduce the manufacturing cost.

Hence, I in our product of electrode flux, I reduced on minimizing the ferrous content in the electrode flux and increased the purity form of chromium and nickel which is adhesive is the parent metal of the welding. Hence, the purest form of chromium and nickel will never react with the gases in the atmosphere and emitted to the atmosphere. By this form of substitution, I have attained the minimum amount of toxic content in the welding fumes.

EXISTING ELECTRODES TESTS

Table 2:Flux Composition Data

| Flux coating | E308L, E309L, E310 |
|--|--------------------|
| Limestone and/or Calcium Carbonate | 0-20 |
| Mica (total inhalable dust) (respirable dust) | 0-13 |
| Kaolin (respirable dust) | 0-15 |
| Cellulose (total inhalable dust) (respirable dust) | 0-2 |
| Mineral Silicates (total inhalable dust) (respirable dust) | 0-30 |
| Inorganic Fluorides (as F) | 0-6 |
| Silicon and Silicon alloys, (as Si) (total inhalable dust) | 0-5 |
| Molybdenum compounds (as Mo) (soluble compounds) | - |
| Chromium Chromium III compounds Chromium VI | 0-30 |
| Antimony oxide | 0-2 |
| Silicate Binders | 0-25 |
| Others | Cu <3 |

V.COMPARISON

By comparing the both the tests done before and after notification of flux in electrode. I notice that the toxicity content is reduced in the welding fumes. Also there is no major variations in the weldment qualities of the welding area. This I can clearly notice by comparing the mechanical test done before and after modification of flux in electrode. Also, it fulfils the minimum and maximum required values of Mechanical properties as per ASME Regulations. The test results are tabulated below.

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ASME section II part-A code SA240 for SS304 plate welding.

Table 3: Mechanical & Chemical Test for existing electrode

| Electrode | Material (plate) | Mechanical | | | | Chemical | | Toxicity(fumes) | |
|-----------|------------------|--------------------|----------------------|--------------|-------------------|----------|------|-----------------|------|
| | | Yield strength MPa | Tensile strength MPa | Elongation % | Hardness test BHN | Cr % | Ni % | Cr % | Ni % |
| E308 | SS304 | 355 | 550 | 42 | 180 | 18 | 10 | 16 | 42 |
| E309 | SS304 | 420 | 575 | 44 | 195 | 19 | 10 | 14 | 38 |
| E310 | SS304 | 445 | 620 | 49 | 190 | 19.5 | 10.5 | 11 | 35 |

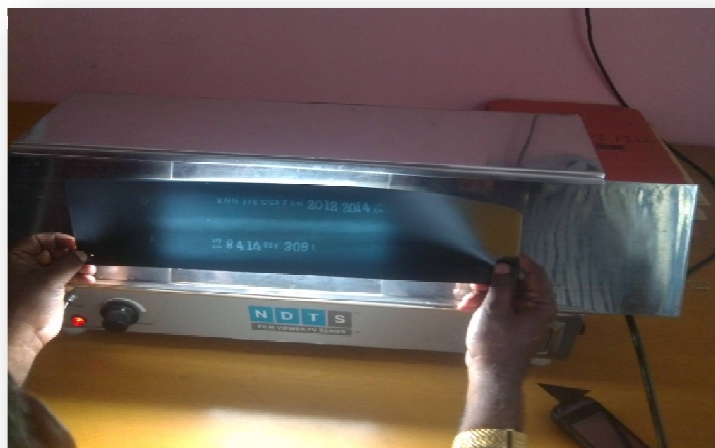
Table 4: Mechanical & Chemical Test for modified electrode

| Electrode | Material (plate) | Mechanical | | | | Chemical | | Toxicity(fumes) | |
|-----------|------------------|--------------------|----------------------|--------------|-------------------|----------|------|-----------------|------|
| | | Yield strength MPa | Tensile strength MPa | Elongation % | Hardness test BHN | Cr % | Ni % | Cr % | Ni % |
| E308 | SS304 | 320 | 525 | 40 | 185 | 17.5 | 8.2 | 10 | 38 |
| E309 | SS304 | 380 | 570 | 45 | 192 | 17.9 | 8.76 | 9 | 35 |
| E310 | SS304 | 400 | 600 | 44 | 188 | 17.6 | 8.9 | 9.5 | 30 |

RADIOGRAPHY TESTS

Radiography test is done only for the modified flux electrode welding. It is found to be no defect and it is acceptable (Certified by the standard NDT testing laboratory). The reports are attached below.

Figure 1:Radioactive Film Of Modified Electrode Welding



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VI.OBSERVATION AND CONCLUSION

By observing the table 3 and table 4, As per ASME section II part-A code SA240 for SS304 plate, all the necessary requirements are fulfilled. It also shows us the reduced toxicity up to 37.5% & 14.28% of Cr&Ni respectively in the fumes and gases generated during the welding process. By reducing this toxicity, welders are able to maintain their health and lot of diseases caused due to welding fumes can be able to reduce. Hence achieved the results that the toxicity content is reduced to the required level(OEL) in the welding fumes by reducing the ferrous content and using the purest form of chromium of the consumables in the electrode flux without change of its weldment qualities.

REFERENCES

1. Gray, C.N., Hewitt, P.J., Dare, P.R.M. New approach would help control weld fumes at source. *Welding and Metal Fabrication*, October 1982.
2. Heile, R. F., Hill, D. C. Particulate Fume Generation in Arc Welding Processes. *Welding Research Supplement*, July 1975.
3. Eichhorn, F., Oldenburg, Th. Welding fumes emitted during welding of high-alloyed materials. *International Conference on Hazards and Biological Effects of Welding Fumes and Gases*, Copenhagen, February 1985.
4. E. Emission of fume and gases in gas metal arc welding. AGA AB, Internal report.

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5. Gray, C.N., Hewitt, P.J. Control of particulate emissions from electric arc welding by process modification. *Ann. Occup. Hyg.*, Vol. 25, No 4, 1982.
6. Press, H., Florian, W. Formation of toxic substances in gas shielded arc welding. *Welding in the World*, Vol. 23, No 1/2 1985.
7. Health and safety in welding and allied processes. The Welding Institute, Abington Hall, Abington, Cambridge, CB1 6AL, 1983.
8. The facts about fume. The Welding Institute, Abington Hall, Abington, Cambridge, CB1 6AL, 1986.
9. Welding Data Sheet. Occupational Safety and Health, Canada Safety Council. Ottawa, Ontario. www.safety-council.org
10. Safety and Health in Welding. Industrial Accident Prevention Association. Toronto, Ontario. www.iapa.on.ca
11. Code for Safety in Welding and Cutting — CSA W117.2-01. Canadian Standards Association. Rexdale, Ontario. www.csa.ca
12. Welders' Health and Safety Guide. Canadian Centre for Occupational Health and Safety. Hamilton, Ontario. www.ccohs.ca
13. Occupational Safety and Health Administration, 29 CFR 1910.252. www.osha.gov
14. http://employment.alberta.ca/documents/WHS/WHS-PUB_ppe001.pdf
15. Respiratory Protective Equipment – Employers' Guide (PPE001)
16. http://employment.alberta.ca/documents/WHS/WHS-PUB_ppe004.pdf
17. 15. 2013 ASME Boiler and Pressure Vessel Code(An International Code); Section II - Material; Part-A
18. EH40/2005 Workplace exposure limits; (Health and Safety Executive).