THE NATION'S URANIUM PROCESSING FACILITY

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REVISION LOG

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CONTENTS

1.0 INTRODUCTION

1.1 Purpose

This Procedure provides Industrial Hygiene (IH) guidance when managing potential exposures from welding, cutting, brazing, burning, and other applicable hot work activities. This procedure details the framework utilized to manage welding fume exposures during the execution of the Uranium Processing Facility (UPF) scope.

1.2 Scope

This Procedure applies to UPF Project personnel, subcontractors, vendors, and visitors during the course of the Project located at the UPF Construction Site or support areas.

2.0 RESPONSIBILITIES

2.1 UPF Site Manager

The Site Manager is responsible for:

- Implementing the welding fume management program
- Allocating resources to implement this procedure
- Participating in assessments to confirm Environmental Safety & Health (ES&H) compliance

2.2 UPF Environmental, Safety, and Health Manager, BNI

BNI ES&H Manager is responsible for:

- Interpreting the regulations associated with this Procedure
- Interpreting the procedural requirements as to intent and application
- Implementing and administering the requirements of this Procedure
- Assigning personnel to assist Engineering and Supervision with managing welding fumes

2.3 Industrial Hygiene Representative

The Industrial Hygiene (IH) Representative is responsible for:

- Assisting Engineering, Field/Facility Supervision, and the ES&H Manager with development of engineering controls and safe work practices for specific activities
- Selecting, maintaining, calibrating, and using instrumentation necessary for monitoring/sampling of airborne contaminants associated with welding fumes
- Conducting initial and periodic occupational exposure assessments, as required by this procedure using objective data, historical data, and real-time exposure monitoring data
- Evaluating air surveillance data to determine exposure, exposure potential, exposure trends, and necessary control measures
- Communicating health hazard information to employees

2.4 Field Engineering

Field Engineering is responsible for:

- Collaborating with ES&H and Field/Facility Supervision to help evaluate potential welding fume exposure
- Working with the ES&H Manager, Field/Facility Supervision, and IH Representative to identify engineering controls and safe work practices

2.5 Field Supervisors

Field Supervisors are responsible for:

- Confirming that employees associated with welding activities are trained in the hazards associated with the potentially hazardous materials employed in base metals, fluxes, coatings, coverings, and filler materials
- Implementing appropriate engineering controls and safe work practices with assistance from ES&H and Engineering
- Verifying nearby personnel and equipment are protected against heat, sparks, slag etc. when working in occupied workplaces or when working at heights
- Confirming that nearby workers or other personnel adjacent to the welding areas will be protected from the arc welding ultraviolent radiation rays by noncombustible or flameproof screens or required to wear appropriate goggles/glasses
- Providing Personal Protective Equipment (PPE) to employees when engineering controls are not sufficient to protect them
- Periodically inspecting designated areas to be sure that conditions have not become unsafe for welding, cutting, or burning
- Reviewing control measures to verify that they are working as planned

2.6 UPF Project Personnel

UPF Personnel are responsible for acquiring proficiency and adhering to the requirements specified in this Procedure through dedicated training on relevant topics

3.0 WELDING AND HOT WORK PROJECT PROFILE

Welding is a major industrial process used for joining metals together by melting a metal work piece along with a filler metal to form a strong joint. Fumes are produced by vaporization of the core metal and flux components of the electrode. Vaporized metals react with air, producing metal oxides that condense and form fumes consisting of particles. Three major types of welding processes include:

- Gas – Uses gas flame over metals until a molten puddle is formed. Most popular fuels used with oxygen include acetylene, methylacetylene-propadiene propane (MAPP) gas, and hydrogen;
- Arc – Two metals are joined by generating an electric arc between a covered metal electrode and the base metal; and

- Oxygen and Arc Cutting – Metal cutting is the severing or removal of metal by a flame or arc.

The types of arc welding performed on the project include:

- "Stick" or Shielded Metal Arc Welding (SMAW)
- Gas-shielded method of Metal Inert Gas (MIG)
- Tungsten Inert Gas (TIG)
- Flux Cored Arc Welding (FCAW)

Welding fumes are a complex mixture composed of different metals and their oxides. The composition and the rate of generation of welding fumes depend on the components of the metal being welded, flux, coatings, types of electrodes or filler materials, operating conditions of the welding process (temperature, current), and the technique and skill of the welder.

4.0 ASSOCIATED HAZARDS

Welding, cutting, and brazing are hazardous activities that pose a unique combination of safety and health risks (refer to **Attachment 1**). Protecting employees during welding operations depends on hazard recognition and understanding of control methods. Mitigation of welding hazards can include eye protection, ventilating the work area, using safe equipment, implementing specific work practices and procedures, wearing protective clothing, and using respiratory protection.

4.1 Physical Hazards

Physical hazards associated with welding, cutting and brazing include:

- Potential heat stress among workers performing welding operations in elevated ambient temperatures, as described in UPF-CP-314, *Heat and Cold Stress Prevention*
- Radiation exposure for tungsten sharpening activities (refer to **Section 6.2**)
- Eye strain based upon location of the weld, as well as lighting in the work area.

4.2 Musculoskeletal

Welding may result in back strain from lifting/pushing, muscle strain from working in awkward positions, and other types of injuries that develop over time because of repetitive motion. These hazards are controlled in accordance with Y73-95-805, *Musculoskeletal Injury Prevention*. Ways of minimizing the risk of musculoskeletal disorders include:

- Designing the layout of the work area and positioning the workpiece in a way that allows workers to adopt a comfortable position
- Reducing the amount of force necessary to perform tasks, such as using rigging and other mechanical handling devices to lift heavy workpieces, and using trolleys to transport cylinders
- Take breaks to rest and recover from stagnant awkward positions

4.3 Non-Ionizing Radiation/Welding Arc

Infrared radiation can cause retinal burning and cataracts and even a brief exposure can cause an eye burn known as “welder’s flash.” This condition is not apparent until several hours after exposure. Symptoms of welder’s flash include extreme discomfort, eye swelling, fluid excretion, and temporary blindness. Normally, welder’s flash is temporary, but repeated or prolonged exposure can lead to permanent eye injury.

To minimize risk of welder’s flash, whenever practicable, all arc welding and cutting operations shall be shielded by noncombustible or flameproof screens that protect employees and other persons working in the vicinity from the direct rays of the arc. Employees in the area not protected from the arc by screening shall be protected by filter lenses. When two or more welders are exposed to each other’s arc, filter lens goggles or a suitable type shall be worn under welding helmets.

5.0 WELDING FUME MANAGEMENT

5.1 Hazard Identification

Hazard identification should be a collaborative effort for ES&H, Engineering, and Field/Facility Supervisors. Persons involved in risk assessment should understand welding operations and have knowledge of safe practices and required procedures. Hazard identification and control must be performed in accordance with Y17-95-64-823, *UPF Field Level Hazard Assessment/Job Hazard Analysis Program (FLHA/JHA) Process*.

Factors to be considered in assessing risks associated with welding include general information, working environment, and task-specific information as follows:

5.1.1 General Information

- Type of welding process
- Base metal – Cut Sheets (refer to Safety Data Sheet – [SDS])
- Welding rod, filler metals, or wire feed composition (refer to SDS)

5.1.2 Working Environment

- Location (outside versus enclosed space, confined space)
- Air movement and use of ventilation controls
- Workplace lighting
- Presence of flammable vapors or airborne substances that would decompose into toxic materials at high temperatures
- Simultaneous operation with other welders or adjacent employees
- Working near combustible or flammable materials
- Possibility of slag or sparks coming into contact with combustible materials.

5.1.3 Task Specific Information

- Welder work process and procedure
- Duration and frequency of the welding operation; and

- Size, shape, weight and construction of the workpieces

5.2 Air Sampling

Air Sampling is performed in accordance with PL-SH-801768-A024, *Industrial Hygiene Program* and Y73-95-804, *UPF Project Industrial Hygiene Exposure Assessment & Surveillance Strategy and Process*.

5.3 Hazard Control

The exposure assessment and control strategy are detailed in Y73-95-804.

If not reasonably practicable to eliminate a risk, the most effective control measures that are reasonably practicable must be used. The hierarchy of control measures must be applied and remain effective for the duration of risk (refer to Figure1).

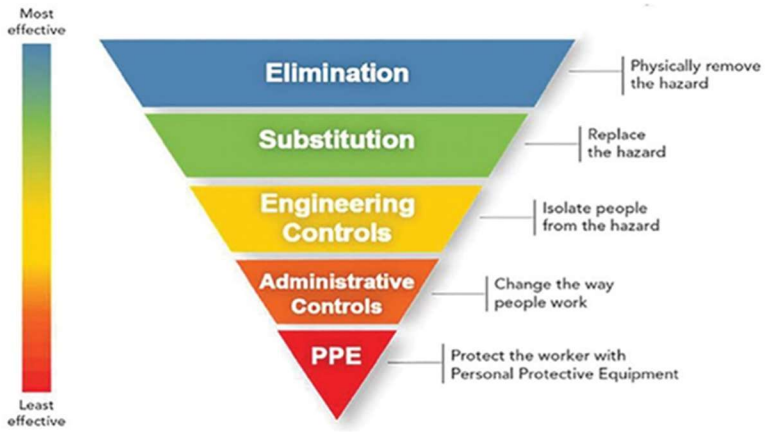

Figure 1. Hierarchy of Controls

5.4 Engineering Controls

There are two types of ventilation control methods:

- Breathing zone ventilation, where hazardous substances are prevented from entering the employee's breathing zone by a cross draft of air
- Local exhaust ventilation, where some or most of the hazardous chemicals are captured at the source

Ventilation can remove heat from the environment and reduce exposure to fumes and other atmospheric contaminants in the work area. The main types of ventilation are:

- General Mechanical Ventilation (GMV)
  - Forced dilution ventilation
  - Natural dilution ventilation
- Local Exhaust Ventilation (LEV)

When selecting a ventilation system, the following should be considered:

- Toxicology of the fumes being generated
- Amount and type of fumes and contaminants produced
- Proximity and location of the welding process relative to the ventilation system
- Level of ventilation, natural or mechanical, both for the whole workplace and the welding area (this depends on screens and partitions that may restrict crossflow at the work area)
- Proximity of the welder's breathing zone to the fume source
- Need to maintain a safe oxygen level and verify that the concentration of flammable gas, vapor, mist, or fumes stays below 10% of the Lower Explosive Limit (LEL)

5.5 Personal Protective Equipment

UPF-CP-205, *Personal Protective Equipment and Safe Work Apparel*, details how PPE is selected, inspected, and maintained.

The requirements for the use, cleaning and sanitation, storage, inspection, maintenance, medical evaluation, and training for respiratory protective equipment is detailed in UPF-CP-318, *Respirator Use and Issuance*.

5.6 Workplace Environment

There are multiple work environmental factors that can impact the potential exposures to welding fumes. The following factors may contribute to higher exposures:

- Low volume areas (i.e., confined spaces, small rooms, 4-sided fabrication areas)
- Low airflow areas

The applicable workplace environmental factors are considered and evaluated during the exposure assessment process detailed in Y73-95-804.

5.7 Training

General awareness training is provided for all welders on the recognition of hazards associated with welding, cutting, burning, and brazing operations. The general awareness training includes the following elements:

- Health hazards associated with welding fume and how to detect hazardous situations
- Contents of the applicable occupational exposure limits for welding fume
- The hazards associated with welding fume exposure and related respiratory health effects
- Project activities involving welding fumes that could result in exposure
- Control methods that must be used to mitigate the potential for exposure
- Respiratory protection and PPE requirements

6.0 ADDITIONAL REQUIREMENTS

6.1 Protective Coatings

Before performing welding, cutting, or heating activities, all protective coatings must be adequately removed to avoid heating them to the point of combustion.

In confined and enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches (10 cm) from the area of heat application. In the open air, preservative coatings shall be removed at least 2 inches (5 cm) from the area of heat application. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

6.2 Thoriated Tungsten Welding Electrodes

Tungsten electrodes are used as the heat source for the Gas Tungsten Arc Welding (GTAW) process and may range from 1% to 4% Thorium Oxide (commonly 2%). Thorium is slightly radioactive naturally and emits mainly alpha (α) particles. Alpha particles cannot penetrate skin or even paper; however, particles may be considered harmful if ingested or inhaled into the lungs, where they act as a carcinogen.

Thoriated tungsten welding electrodes are not allowed for use on the Project.

6.3 Hexavalent Chromium

The project has not encountered and is not anticipating exposures above 0.5 micrograms per cubic meter (µg/m3) as an eight-hour Time-Weighted Average (TWA). This is achieved through the implementation of the hierarchy of controls where less fume producing welding processes are selected. The project is not going to deviate from these practices and all changes will be evaluated in accordance with Y73-95-804, *UPF Project Industrial Hygiene Exposure Assessment & Surveillance Strategy and Process*.

Activities that have the potential to generate exposures above 0.5 micrograms per cubic meter (µg/m3) as an eight-hour TWA will be handled in accordance 29 Code of Federal Regulations (CFR) 1926.1126, *Chromium (VI).*

7.0 RECORDS

None

8.0 REFERENCES

8.1 Source References

None

8.2 Interfacing References

29 CFR 1926.1126, *Chromium (VI)*

PL-SH-8017680-A024, *Industrial Hygiene Plan*

UPF-CP-205, *Personal Protective Equipment and Safe Work Apparel*

UPF-CP-314, *Heat and Cold Stress Prevention*

UPF-CP-318, *Respirator Use and Issuance*

Y15-95-800, *UPF Document Management*

Y17-95-64-823, *UPF Field Level Hazard Assessment/Job Hazard Analysis Program (FLHA/JHA) Process*

Y73-95-802, *Confined Space Entry Program*

Y73-95-804, *UPF Project Industrial Hygiene Exposure Assessment & Surveillance Strategy and Process*

Y73-95-805, *Musculoskeletal Injury Prevention*

8.3 Forms

None

9.0 SUPPLEMENTAL INFORMATION

Appendix A, *Acronyms and Definitions*

Attachment 1, Health Effects of Welding By-Products

APPENDIX A
Acronyms and Definitions

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Acronyms

Definitions

Confined Space	A confined workspace is not a normal work area and meets the definition in Y73-95-802, *Confined Space Entry Program*. Work areas that: (1) are large enough for an employee to enter, (2) have limited means of entry or exit, and (3) are not designed for continuous occupancy.
Enclosed Space	A space where general ventilation and free cross-ventilation do not occur and the pollutant plume, and fume dispersion, are obstructed.
Gas Tungsten Arc Welding (GTAW)	Arc-welding process where arc is constituted between a non- consumable electrode and the conductive base metals.
Metal Inert Gas (MIG)	Arc-welding process in which a continuous solid wire electrode is fed through a welding gun and into the weld pool, joining the two base materials together. A shielding gas is also sent through the welding gun and protects the weld pool from contamination.

APPENDIX A
Acronyms and Definitions

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Open Workspace / Building	Building where there is adequate general ventilation and free cross-ventilation occurs. Operators are able to keep their heads out of the pollutant plume, and fume dispersion is not obstructed by the workpiece, partitions, or screens.
Shielded Metal Arc Welding (SMAW)	Arc-welding process with an arc between a covered electrode and the weld pool. The process is used with shielding from the decomposition of the electrode covering.
Tungsten Inert Gas (TIG)	Arc-welding process that uses the heat generated by an electric arc struck between a non-consumable tungsten electrode and the workpiece to fuse metal in the joint area and produce a molten weld pool.

ATTACHMENT 1
Health Effects of Welding By-Products

Health Effects of Metal Exposure

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Fume Type	Source	Health Effect
Aluminum	Aluminum component of some alloys (e.g., nickel-chromium, copper, zinc, steel, magnesium, brass and filler materials)	Respiratory irritant
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 nickel-copper, 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 oxides	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; ototoxic and therefore risk of hearing loss
Manganese	Most welding processes, especially high- tensile steels	'Metal Fume Fever'; chronic effects may include central nervous system problems; ototoxic and therefore risk of hearing loss
Molybdenum	Steel alloys, iron, stainless steel, nickel alloys	Acute effects are eye, nose, and throat irritation and shortness of breath
Nickel	Stainless steel, nickel-chromium, nickel- copper and other high-alloy materials, welding rods and plated steel	Acute effect is irritation of the eyes, nose, and throat; increased cancer risk has been noted in occupations other than welding; also associated with dermatitis and lung problems
Vanadium	Some steel alloys, iron, stainless steel, nickel alloys	Acute effect is irritation of the eyes, skin, and respiratory tract; chronic effects include bronchitis, retinitis, fluid in the lungs, and pneumonia.
Zinc oxides	Galvanized and painted metal	'Metal Fume Fever'

Attachment 1
Health Effects of Welding By-Products
(Page 2 of 2)

Source and Health Effects of Welding Gases

Gas Type	Source	Health Effect
Carbon monoxide	Formed in the arc	Absorbed readily into the bloodstream, causing headaches, dizziness or muscular weakness; high concentrations may result in unconsciousness and death; ototoxic and therefore risk of hearing loss
Hydrogen fluoride	Decomposition of rod coatings	Irritating to the eyes and respiratory tract; overexposure can cause lung, kidney, bone, and liver damage; chronic exposure can result in chronic irritation of the nose, throat, and bronchi
Nitrogen oxides	Formed in the arc	Eye, nose, and throat irritation in low concentrations; abnormal fluid in the lung and other serious effects at higher concentrations; chronic effects include lung problems such as emphysema
Oxygen Deficiency	Welding in confined spaces, and air displacement by shielding gas	Dizziness, mental confusion, asphyxiation and death
Ozone	Formed in the welding arc during open arc welding processes including Manual Metal Arc Welding (MMAW), Flux Cored Arc Welding (FCAW), especially during plasma-arc, Metal Inert Gas (MIG) and Tungsten Inert Gas (TIG) processes	Acute effects include fluid in the lungs; very low concentrations (for example one part per million) cause headaches and dryness of the eyes; chronic effects include significant changes in lung function
Phosphine	Metal coated with rust inhibitors; Phosphine is formed by reaction of the rust inhibitor with welding radiation	Irritant to eyes and respiratory system; can damage kidneys and other organs

Source and Health Effects of Organic Vapors as a Result of Welding

Organic Vapor Type	Source	Health Effect
Aldehydes (such as formaldehyde)	Metal coating with binders and pigments; Degreasing solvents	Irritant to eyes and respiratory tract
Di- isocyanates	Metal with polyurethane paint	Eye, nose, and throat irritation; high possibility of sensitization, producing asthmatic or other allergic symptoms, even at very low exposures
Phosgene	Metal with residual degreasing solvents; Phosgene is formed by reaction of the solvent and welding radiation	Severe irritant to eyes, nose, and respiratory system; symptoms may be delayed