AIR DYNAMICS
Industrial Systems Corporation™

CASE STUDY

Engineering Controls: Reducing Ozone Exposure Levels (OEL) for High-Intensity Alumnium Arc Welding Operations

Air Dynamics Industrial Systems Corporation

Serving the industrial manufacturing industry since 1991.

CASE STUDY

Transforming air quality from poor to compliant.

OVERVIEW

High-intensity aluminum gas metal arc welding (GMAW), particularly when performed by robotic systems, presents a unique and often underestimated air quality challenge: rapid ozone generation driven by high UV energy and reflective aluminum surfaces. In this case study, Air Dynamics Industrial Systems Corporation partnered with a heavy industrial defense manufacturer to engineer and deploy a compliant, energy-efficient, and scalable solution to control ozone and associated arc welding byproducts—without disrupting shield gases, production or requiring facility modifications during the one-week installation period.

The engineered air pollution controls reduced ozone concentrations from peak levels **exceeding 0.28 ppm within 15 minutes to below 0.03 ppm**, significantly outperforming OSHA, NIOSH, and ACGIH exposure limits while supporting continuous, 24/7 operation.

BACKGROUND

Ozone Exposure in Robotic Aluminum Welding

The customer operates robotic aluminum GMAW cells producing large defense-related components fabricated from aluminum sections 2–3 inches thick. While aluminum welding is well known for its productivity advantages, it also generates elevated ozone (O_3) concentrations due to:

- High ultraviolet (UV) radiation intensity
- Reflective Aluminum surfaces amplifying O_3 generation from UV arc
- Rapid, continuous robotic weld cycles

Measured ozone levels exceeded **0.28 ppm in under 15 minutes**, well above recognized occupational exposure limits. Workers in adjacent areas reported **sore throats, bronchial irritation, and cold-like symptoms**, indicating ongoing exposure risk.

Seasonal conditions further exacerbated the issue. During winter months, facility doors remained closed, reducing dilution ventilation and allowing ozone concentrations to accumulate. This risk profile is common across heavy metal processing industries involving welding, gouging, cutting, grinding, and heavy steel fabrication, including ship building, wind tower manufacturing and large-scale electrical infrastructure production.

A COMMON QUESTION REGARDING GMAW

How do we manage these pollutants safely, continuously, and compliantly?

THE CHALLENGE

The Engineering Challenge: Robotic vs. Human Welding Dynamics

A critical factor identified early in the evaluation was the difference in ozone generation between **human-operated** and **robotic welding**:

- Human welding is intermittent and slower, producing ozone at a lower average rate.
- Robotic welding is continuous, highly repeatable, and significantly faster than human-operated welding, resulting in substantially higher energy input and UV radiation output. When welding aluminum, these conditions can generate elevated concentrations of ozone.

Robotic weld speeds ranged from **6 to 14 inches per minute**, with shielding gas consumption of approximately **150 cubic feet per hour (cfh).** The scale of welded assemblies—some measuring approximately **250” × 115” × 80”**—made traditional source capture impractical without interfering with production.

The UV-driven ozone formation process also produced **stratified ozone layers** within the facility, similar to atmospheric ozone layers. Higher concentrations were observed in the immediate welding envelope, with secondary accumulation in surrounding occupied areas.

As collaborative robotic welding (“cobotics”) becomes more prevalent in defense manufacturing, this condition represents an emerging industry-wide challenge rathar than an isolated case.

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Regulatory Context and Exposure Limits

Ozone exposure limits are defined by multiple regulatory and advisory bodies:

- **OSHA / NIOSH:**
  - Ceiling exposure limit: **0.1 ppm**
- **ACGIH Threshold Limit Values (TLVs):**
  - **A1 Threshold:** 0.1 ppm
  - **A2 Threshold:** 0.2 ppm

Exposures above these levels are associated with respiratory irritation, chest tightness, reduced lung function, and long-term pulmonary damage.

Accurate measurement and compliance verification require certified industrial hygienist testing, with properly calibrated instrumentation, particularly important when evaluating gases, vapors, and fine particulates in occupied workspaces.

Engineering Process: Quantification Before Design

Air Dynamics began with an on-site evaluation to document welding operations, facility layout, airflow paths, and contaminant sources. From this assessment, the primary regulated pollutant was identified:

- **Ozone (O3)** – OSHA PEL: **0.1 ppm**

Using a **mass-over-time approach**, Air Dynamics quantified pollutant generation rates and determined the required exhaust and air exchange needed to remain within acceptable exposure limits.

For ozone, the engineering requirement was clear:

- **125,000 cubic feet of air volume**
- **Complete effective air scrubbing and cycling every 15 minutes**
- **Continuous 24/7 operation**

This established the performance envelope for the pollution control system.

Scrubber cap manufactured and assembled inhouse.

ActiveWall Dust Collector System

Design Philosophy: Treat the Pollutant, Not Just the Symptom

Air Dynamics applies a minimum of **14 core design review criteria** when engineering air pollution control systems, including:

- Pollutant chemistry (reactive vs. inert)
- Combustibility and explosivity
- Capture velocity requirements
- Equipment, placement and integration of the APCD
- Regulatory compliance and secondary waste handling

Particles are treated via filtration; gases and vapors—such as ozone—require **chemical or media-based treatment** that neutralizes or scrubs the contaminant without transferring liability elsewhere (e.g., to wastewater or other waste stream discharge).

Safety factors were incorporated after baseline calculations, Method of Change (MOC) including a 3D facility model was developed to validate system placement and performance prior to fabrication.

THE SOLUTION

1. Active Wall Air Pollution Control Devices (Qty 2)

- Modular **4-module units** with **10 HP exhausters**
- **High-velocity slot capture** to intercept ozone close to the source
- **Pulse-jet cleaning system** provides reliable sustained airflow to the polluting process
- Multi-stage media filtration with proprietary ozone abatement scrubber
- Reduces ozone from **up to 0.6 ppm to <0.03 ppm**
- One-year media changeout intervals at 0.6 ppm inlet concentrations
- Compact footprint to avoid incursion into the workspace
- No explosion venting required
- No Class II, Div-2 electrical upgrades required
- No ducting or makeup air system required, preserving energy efficiency during winter/summer operations

2. Ozone Treatment Discharge Systems (Qty 2)

- Louvered discharge design for ultra-low velocity reintroduction of treated air
- Configured to adapt to facility airflow and layout requirements

3. Simple HOA Controls and Instrumentation

- Simple HOA (Hand/Off/Auto) based controls with analog filter differential and multiple, continuous digital ozone monitoring
- Variable airflow control to protect welding shielding gas integrity
- Real-time data for compliance verification and operational insight
- Klaxon integrated multi-stage ozone monitoring instrumentation

4. Turnkey Execution and Support

- Post-award site visit and commissioning
- Installation guidance for mechanical and electrical installers
- Method of change (MOC) safety review with all client stakeholders
- Operator training and maintenance instruction
- UL 508A mechanical and electrical schematics
- **1-year warranty** from startup (or 18 months from ship date)

RESULTS

Results and Performance Outcomes

The engineered solution delivered measurable improvements:

- Ozone levels reduced to well below regulatory thresholds
- Continuous compliance during 24/7 robotic welding operations
- Reduced operating costs through long media life and low maintenance
- Elimination of makeup air and hazardous-area electrical retrofits
- Seamless integration with existing welding infrastructure

CONCLUSION

This project demonstrates how disciplined engineering, quantitative analysis, and pollutant-specific treatment can transform a complex environmental health challenge into a stable, compliant, and energy-efficient system. By addressing ozone generation (or any pollutant) at its source and treating it appropriately, Air Dynamics enabled safer working conditions while supporting high-throughput defense manufacturing.

Equipment is professionally loaded and transported from Air Dynamics to the customer site.

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