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Products evolved during hot gas welding of fluoropolymers

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Research Report

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Products evolved during hot gas welding of fluoropolymers

Chris Keen BSc CertOH
Mike Troughton BSc PhD CPhys MInstP
Derrick Wake BSc, Ian Pengelly BSc, Emma Scobbie BSc
Health and Safety Laboratory
Broad Lane
Sheffield
S3 7HQ

This report details the findings of a research project which was performed as a collaboration between the Health and Safety Executive (HSE) and The Welding Institute (TWI). The project aim was to identify and measure the amounts of products evolved during the hot gas welding of common fluoropolymers, to attempt to identify the causative agents of polymer fume fever.

Carbonyl fluoride and/or hydrogen fluoride were detected from certain fluoropolymers when these materials were heated to their maximum welding temperatures. Significant amounts of ultrafine particles were detected from all of the fluoropolymers investigated when they were hot gas welded.

The report concludes that fluoropolymers should be hot gas welded at the lowest possible temperature to reduce the potential for causing polymer fume fever in operators. If temperature control is not sufficient to prevent episodes of polymer fume fever, a good standard of local exhaust ventilation (LEV) should also be employed.

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EXECUTIVE SUMMARY

This report details the findings of a research project which was performed as a collaboration between the Health and Safety Executive (HSE) and The Welding Institute (TWI). The practical work was lead for HSE by the Health and Safety Laboratory (HSL).

OBJECTIVES

To identify and measure the amounts of products evolved during the hot gas welding of the fluoropolymers PVDF, ECTFE, PFA and FEP and also during the heating of PTFE.

MAIN FINDINGS

Very little in the way of general volatile organic compounds (VOCs) was detected from any of the fluoropolymers during heating trials.

Neither carbonyl fluoride nor hydrogen fluoride were detected from PVDF or PTFE during heating trials to the recommended and maximum welding temperatures.

Hydrogen fluoride was detected when ECTFE was heated to the recommended welding temperature in air. Carbonyl fluoride was detected when ECTFE was heated to its maximum welding temperature in air. The manufacturers of ECTFE recommend that it is hot gas welded under nitrogen. Neither hydrogen fluoride nor carbonyl fluoride were detected when ECTFE was heated under nitrogen.

Carbonyl fluoride and/or hydrogen fluoride were detected from both PFA and FEP when these materials were heated to their maximum welding temperatures.

Significant amounts of ultrafine particles were detected from all of the fluoropolymers investigated when they were hot gas welded.

Other researchers have suggested that polymer fume fever is caused by a combination of ultrafine particulate and toxic chemical agents (predominantly carbonyl fluoride and/or hydrogen fluoride). The fact that these materials were detected during this work lends further weight to this theory.

The use of hot bar welding for joining PTFE to PFA, PTFE to FEP and ECTFE to ECTFE, was briefly investigated. No carbonyl fluoride or hydrogen fluoride was detected from this activity.

RECOMMENDATIONS

Air monitoring for carbonyl fluoride and/or hydrogen fluoride may be useful when investigating cases of polymer fume fever. However, it should be remembered that, where ultrafine particles are also present, these chemical agents may exhibit toxic effects at much lower levels than where they are present alone. Urinary fluoride monitoring may be useful when investigating polymer fume fever. However, this would require further investigation.

Fluoropolymers should be hot gas welded at the lowest possible temperature to reduce the potential for causing polymer fume fever in operators.

If temperature control is not sufficient to prevent episodes of polymer fume fever, a good standard of local exhaust ventilation (LEV) should be employed. LEV systems should be designed to enclose the welding process as much as possible. If portable, 'flexible arm' type LEV systems are used, the operators should receive adequate training to allow them to be used effectively. It is possible that on-tool extraction systems may be applicable in this setting.

Correctly used, P3 rated respiratory protective equipment can offer good protection against the ultrafine particulate material which is implicated in the cause of polymer fume fever. As always, however, RPE should only be employed when engineering controls alone do not offer adequate protection.

Any industrial process which involves gross overheating of fluoropolymers, such as laser cutting, should be the subject of a rigorous risk assessment.