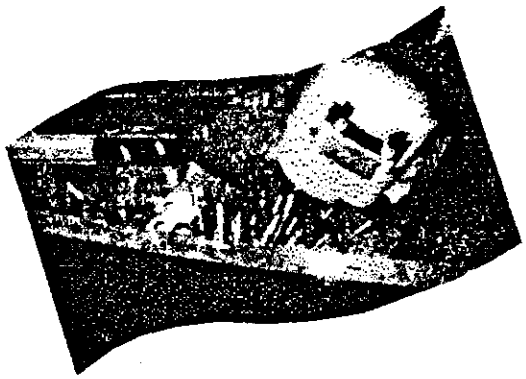
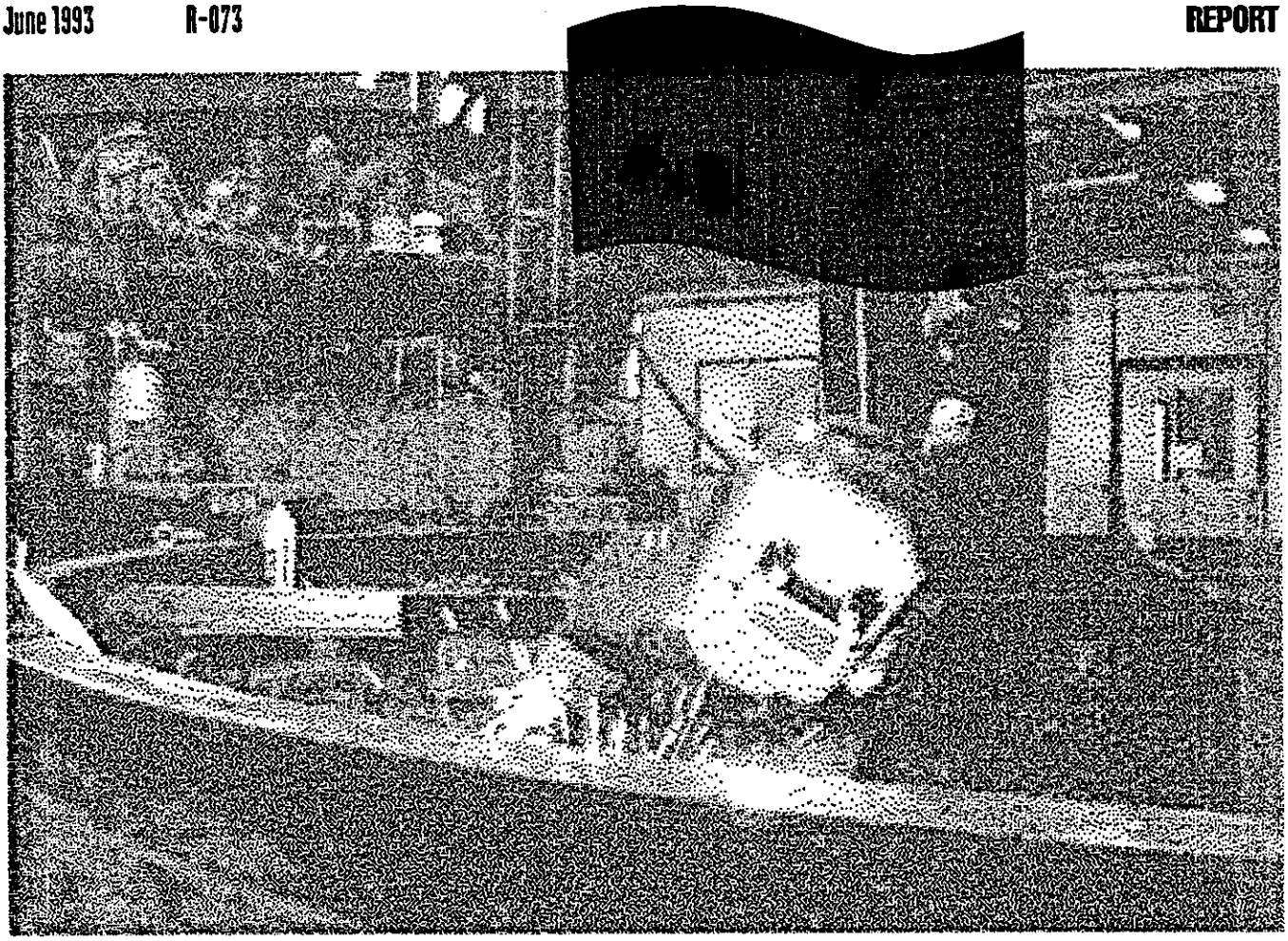
Welding-fume collection effiency of MIG-MAG aspirating welding guns



ÉTUDES ET RECHERCHES

Guy Perrault
Louis Lazure
Van Hiep Nguyen
Claude Létourneau

June 1993 R-073 REPORT



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IRSST - Direction des communications
505, boul. de Maisonneuve Ouest
Montreal (Quebec)
H3A 3C2
Telephone: (514) 288-1551
Telecopieur: (514) 288-7636
Internet site : www.irsst.qc.ca

Welding-fume collection effiency of MIG-MAG aspirating welding guns

Guy Perrault, Louis Lazure
Van Hiep Nguyen and Claude Létourneau

Laboratories Division, IRSST

R-069

REPORT

This study was financed by the IRSST. The conclusions and recommendations are those of the authors.

2nd Quarter 1993.

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Introduction

Certain MIG (*metal inert gas*) and MAG (*metal active gas*) welding guns are equipped with built-in fume extractor to protect the workers. Some Swedish researchers became interested in the performance of these systems (1,2), to arrive at a conclusion on the possibility of improving them through a series of modifications to welding guns of commercial design (modifying the extraction nozzle, increasing the aspiration flows, varying the suction pressures, etc.) A recent study (3) described the use of tracer gases to measure the collection efficiency. However, these studies did not report measurements of the performance of the aspirating welding guns in an actual work situation in industry. Furthermore, the previously mentioned studies were carried out in Europe where welding guns may differ from those models currently used in the Quebec-North American context.

In addition to fume collection, aspirating welding guns must not impose ergonomic constraints on the welders who often work in uncomfortable positions (4).

A study was therefore carried out to compare the welding-fume collection rates of aspirating welding guns in the laboratory and in industry with a fume-collection system that is comparable to the generation-rate measuring system. An ergonomic study was also carried out to briefly explore, first, the muscular load imposed on the shoulder, elbow and wrist in relation to the type of aspirating welding gun, and second, a few indices of the subjective acceptability of the welding guns by the welders.

1- Material and methods

1.1 Material

Four models of welding guns were tested. Their main characteristics have already been described (5). In the laboratory, a *Powcom 300 SM* welder was used with a *Power Drive II* reel. The shielding gas was supplied by a CO_2 cylinder (Médigaz) equipped with a pressure reducer and a rotameter. ARCRITE 55 tubular wire electrodes 0.16 mm (1/16") in diameter (Certified: BCS A CSA W48.5M, E4801T-9-CH according to the Canadian classification or E71T-1-CO_2 according to the American Welding Society classification) were used in all operations. In the laboratory as in industry, welding was carried out on type A-36 soft steel at an amperage of 300 A.

1.1.1 Fume sampling

When a welding gun with integrated aspiration is used in the laboratory or in industry, a filter holder is inserted at the outlet of the ventilation hose of the welding gun just before the pump. This filter holder consists of two superimposed cones with flat sides and rectangular bases (Figure 1). The base of the cones consists of a rectangular collar 2.54 cm x 3.81 cm and with outside dimensions of 31.11 cm x 26.03 cm. Closed-cell nitrile sponge seals are installed on each of the bases with teflon® tape. Under the filter, a metal screen, held in place by adhesive tape, supports the filter and prefilter unit. The two parts are held by four 0.63 cm (0.25") screws and bolts.

1.1.2 Prefilter and filter

The prefilter (23.5 x 18.4 cm) is cut from fiberglass insulating panels 38 mm thick. These panels are available from *Isolation Manson Inc.* as "*AK Board*". The initial density of this material is 29.9 kg/m^3.

The filter (type GA55) consisting of borosilicate microfibers is from *Micro Filtration Systems*. This filter has dimensions of 20.3 cm x 25.4 cm, a thickness of 0.06 cm, and a porosity of 1.6 μm. The effective porosity of this type of filter is 0.03 μm.

1.2 Methods

1.2.1 Generation rates

Welding-fume generation rates were measured in a generation chamber of the type already described in the technical literature (6,7) (Figure 2). The characteristics of the chamber have already been described (5). For the purposes of the study, the prefilter and filter unit was inserted between the chamber outlet and the main ventilation hose.

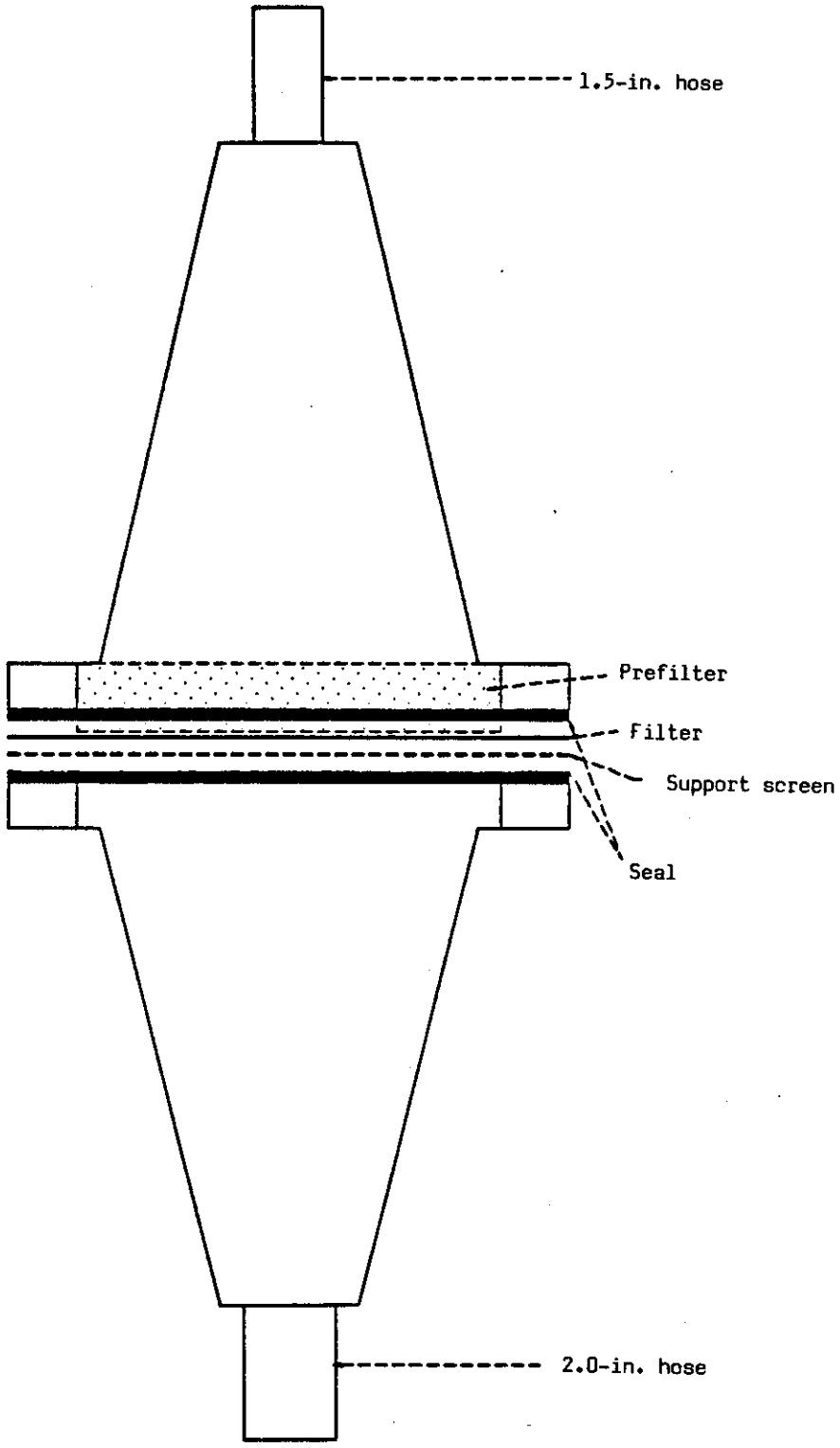

Figure 1 - Diagram of the filter holder

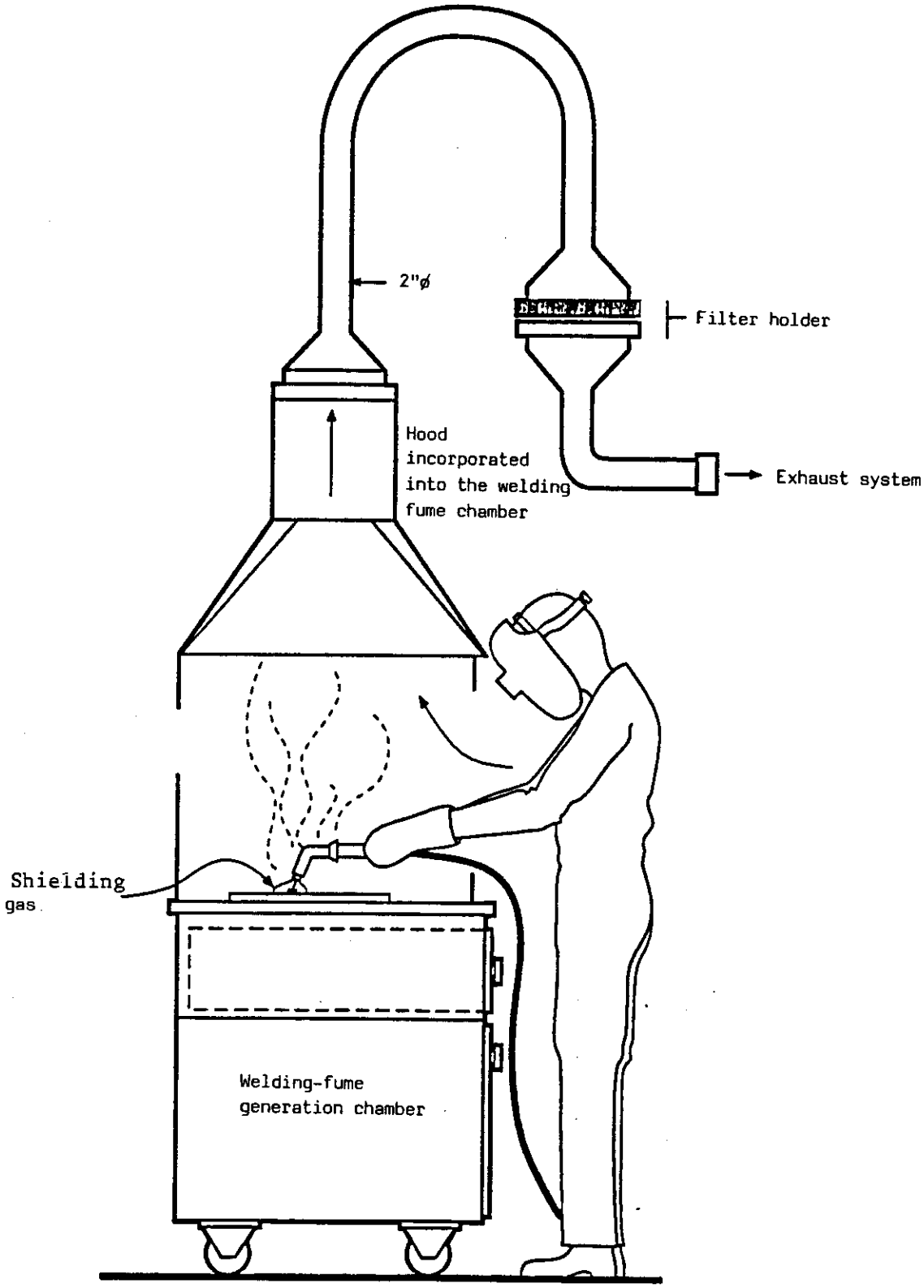

Figure 2 - Diagram of the generation-rate measuring chamber

A professional welder carried out all the welding operations. During the preliminary tests at the start of each series of tests, the welder checked that the welding equipment was operating properly, as well as the operating and exhaust parameters. The maximum aspiration flow that did not cause any anomalies to appear on the weld bead was determined experimentally, using a Pitot tube # 0.48 cm (3/16") and a manometer (Magnehelic, 0-0.63 cm (0-0.25") H_2O). This aspiration flow was maintained for the entire operation. The welding parameters such as voltage, amperage, and the speed of unwinding of the electrode, were noted and kept constant throughout all the tests. The welding gun was held as much as possible at an angle of 60° to the type A-36 steel plate (30.48 cm x 20.32 cm x 0.95 cm) laid flat. The slag on the weld beads was removed with a steel brush and a hammer.

The prefilter/filter unit was weighed before and after each test to obtain the amount of fume collected. The electrode was cut into lengths that were weighed before each test, and the remaining section after each test, to measure the quantity of electrode consumed. A sampling time of approximately two minutes was determined empirically to avoid plugging of the filter and to collect approximately 1 g of fume.

1.2.2 Collection rates

When the fume-collection rate was measured with the welding-gun aspiration system, the same procedure was used except that the flow of shielding gas was increased to maintain the quality of the weld.

In industry, an identical procedure was proposed to the welders on the premises who were carrying out their usual task. The position of the electrode in relation to the surfaces to be welded varied with the job requirements.

1.2.3 Statistical analysis

The factors g_1 (skewness) and g_2 (Kurtosis) (8) were calculated for each series of samples that served in calculating the generation and collection rates. These factors were within the expected limits for a normal distribution with a confidence level of 95%.

1.2.4 Biomechanical evaluation

The evaluation of the muscular load and the psychophysical study were carried out by a team of ergonomists from the Université du Québec à Trois-Rivières. The methodology has been described and the results already presented in a report which is available from the IRSST upon request (9). The muscular load was evaluated with the cooperation of ten welders with 2 to 19 years of experience. Three working postures were evaluated: standing with the platform at the subject's mid-height, with the welding operations being carried out in the horizontal plane; standing with the platform at 82% of the subject's height, with the welding operations being carried out in the frontal plane; and sitting with the platform located at 55% of the subject's height, with the welding operations being carried out in the frontal plane. The subjects' preferences regarding the different types of welding guns were evaluated by means of a questionnaire on the weight, angle of the nozzle, the trigger, the flexibility of the hose, and the degree of general satisfaction.

2- Results and discussion

The generation-rate results for the different welding guns used without aspiration at source are summarized in Table 1. At a significance level (σ) of 0.01, the statistical analyses of the generation rates for the four welding guns indicates no statistically significant difference in the results. The results are slightly higher than the generation rates reported by Henderson et al. (7), namely 0.0097 g of fume/g of electrode at 275 A, for an electrode of the same classification, which seems acceptable, considering the differences in the operating amperages.

Table 1. Fume generation rate of the various welding guns

Welding gun	Average generation rate (g of fume/g of electrode consumed)	Standard deviation	Number of measurements
1	0.0129	0.0009	30
2	0.0116	0.0008	30
3	0.0121	0.0009	29
4	0.0114	0.0018	28
All guns	0.0120	0.0013	117

The collection rates for the fumes emitted by the aspirating welding guns operating under standardized laboratory conditions are given in Table 2. At a significance level, σ, of 0.01, the results indicate no statistically significant difference between the generation rates and the collection rates measured in the laboratory. This result indicates that under standardized welding conditions, the aspiration systems at source for the three welding guns collect the same quantity of fume as during welding inside a hood. By assuming that the initiation of aspiration at source had no effect on the generation rate value, it can be concluded that these ventilation systems collect all of the fumes emitted. However, the standard deviations for the collection rates are generally higher than those for the generation rates. The necessary increase in the shielding gas flow (to maintain the quality of the weld during aspiration at source) may have produced turbulence near the welding gun, which expressed itself in a slight dispersion of the results of each test.

Table 2. Fume-collection rate of aspirating welding guns under standardized laboratory conditions

Welding gun	Average collection rate (g of fume/g of electrode consumed)	Standard deviation	Number of measurements
1	0.0121	0.0028	30
2	0.0119	0.0014	14
3	0.0125	0.0026	30

Table 3 indicates the collection-rate results in the workplace. The measurements were carried out in two different industries which will be called A and B. The results indicate that the differences in the collection rates of the aspirating welding guns in the two industries A and B are not statistically significant. In addition, in industry, the standard deviations are of the same order of magnitude as in the laboratory with aspiration at source. This observation indicates that the normal operating conditions in these two industries did not change the distribution of the results.

Under these experimental conditions, the aspirating systems of the welding guns gave lower collection rates in industry than under standardized operating conditions in the laboratory, namely 57% for model 1, 88% for model 2, and 84% for model 3. The fact that the difference in the collection rates measured in the two industries A and B is not statistically significant seems to support the interpretation that differences in performance between the welding guns result from the welding equipment and not from the facilities or the modes of operation. However, it is impossible to arrive at a conclusion on the performance of the different welding guns without accepting the assumption that the generation rate was not modified by the modes of operation and the plant facilities.

Table 3. Fume collection rate of aspirating welding guns in the plants

Welding gun	Plant	Average collection rate (g of fume/g of electrode consumed)	Standard deviation	Number of measurements
1	A	0.0070	0.0026	25
	B	0.0069	0.0012	29[1]
2	A	0.0109	0.0031	28
	B	0.0101	0.0020	30
3	A	0.0115	0.0030	29
	B	0.0095	0.0022	29

[1] : a rejected value based on the Dixon criterion (7)

2.1 Biomechanical evaluation

The results indicate that aspirating welding guns compare very well in relation to muscular demands that they impose. The percentages of muscular use are still less than 13.6% of the individual's maximum strength. Author (9) considers that "there does not seem to be any contraindication to using any working position". The analyses of variance indicated no significant difference which would lead to one model of welding gun being recommended over another.

In the psychophysical evaluation, a statistical analysis of the welders' overall assessment reveals no significant difference between the different models of aspirating welding guns.

Conclusion

Under standardized laboratory conditions, it can be concluded that the efficiency of the tested welding guns is excellent (approximately 100%, accurate to within the experimental error). The collection rates measured in industry were 12 to 46% below the generation rates. It is difficult to interpret these results without measuring the generation rate in industry. However, the decreased efficiency was reproduced in two different industries with different welders. The biomechanical evaluations do not reveal any contraindications regarding the use of any of the aspirating welding guns.

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