



ERGONOMIC PERFORMANCE TESTED AND APPROVED

A Comprehensive Approach
to Optimal Paint Spray Gun Design



PROVEN QUALITY. LEADING TECHNOLOGY.

EXPERT-APPROVED ERGONOMICS:

A Comprehensive Approach to Optimal Paint Spray Gun Design

INDUSTRIAL DESIGNERS, ENGINEERS AND ERGONOMIC EXPERTS TAKE A DETAILED LOOK INTO THE PROCESS AND OUTCOMES OF DESIGNING A SPRAY GUN THAT PERFORMS EXCELLENTLY AND ENSURES THE WELL-BEING OF INDUSTRIAL PAINTERS.

1. Introduction

Creating a paint spray gun with optimal ergonomics requires a detailed, user-centric design process. Graco, known for its advanced fluid and coatings management systems, partnered with United States Ergonomics, an expert in product and workplace ergonomics, to develop an industrial air spray gun line that not only meets the highest standards of performance, but also prioritizes painter comfort and safety.

This white paper outlines the methodical process undertaken to achieve this goal, culminating in the design of Graco's Stellair ACE and Stellair™ manual air spray guns.

2. Understanding ergonomic risks and painters' perspectives

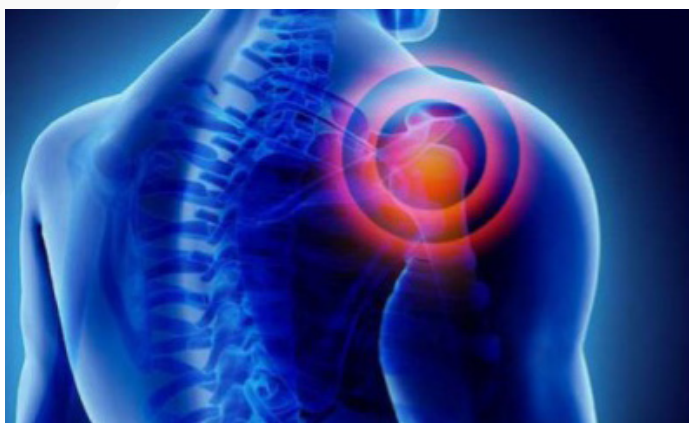
Working in a factory spray booth or on a paint line involves repetitive tasks that carry certain ergonomic risks for industrial painters. These can include shoulder injuries from overstretching the arm, and wrist injuries from constant trigger pulling.

These risks are influenced by factors such as:

- Hours spent spraying per day
- Work setup (vertical, horizontal, or overhead)
- Environmental conditions, such as temperature
- Operator training and technique

Moreover, the actual balance, weight and setup of the spray gun, as well as its fluid and air hoses play a crucial role.

While ergonomics was considered in previous spray gun designs, Graco recognized the importance of continual improvements for industrial painters by collaborating with United States Ergonomics. The collaboration also offered the data needed to justify ergonomic claims about tested products.



Problems painters experience when working in a non-ergonomic environment can include shoulder wrist injuries.

3. Process overview

The development of industrial air spray guns certified for ergonomic performance involved three critical stages: design analysis and optimization; design review and testing; and ergonomic assessment.

3.1 DESIGN ANALYSIS AND OPTIMIZATION

United States Ergonomics conducted a comprehensive ergonomic design assessment of paint spray guns. This included examining leading product designs currently on the market, a literature review of the ergonomic effects of paint sprayers on workers, and measurement-based testing of muscle effort and hand postures.

An initial design review was conducted on 10 pressure feed air spray guns, with a subset of six selected for further comparative testing.

A total of seven subjects experienced with spray applicators were recruited to participate. The testing included posture analysis and electromyography (EMG) measurements of muscle effort during these tasks: holding the tool static, compressing the trigger, cycling the trigger, and simulated painting of vertical and horizontal surfaces.

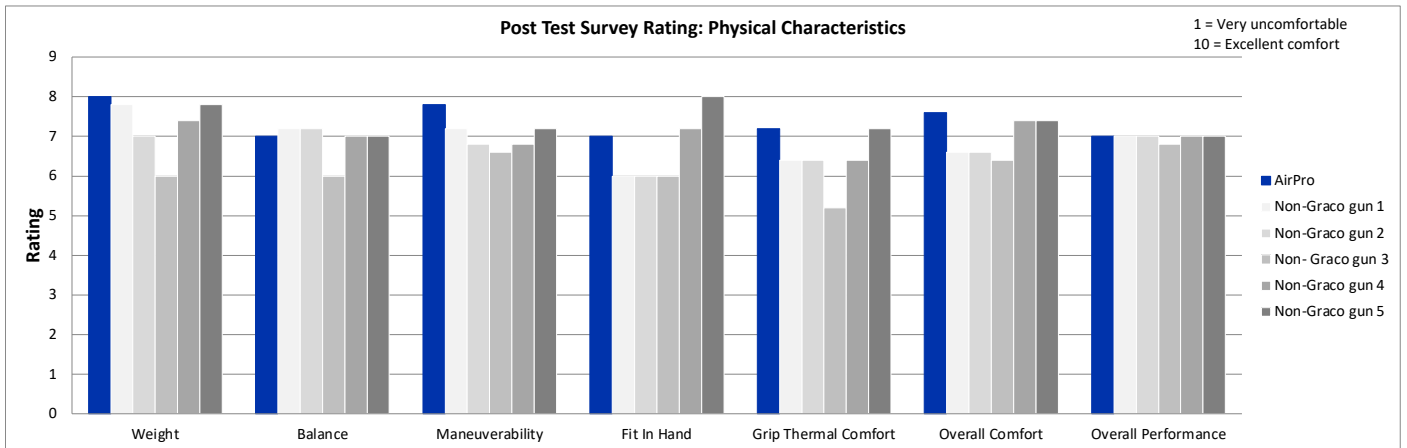
EMG measurements recorded the effort of eight muscle groups in each subject's dominant forearm and hand:

- Two muscle groups on the hand (interosseous and abductor pollicus) involve in thumb and index finger gripping.
- One on the radial (thumb side) of the wrist (thumb extensor) are used to lift the thumb.
- Five on the forearm muscles facilitate gripping and finger control and wrist movement (flexor carpi radialis, flexor carpi ulnaris, extensor carpi radialis, extensor carpi ulnaris, brachioradialis).



Sample EMG measurement also shows simulated painting.

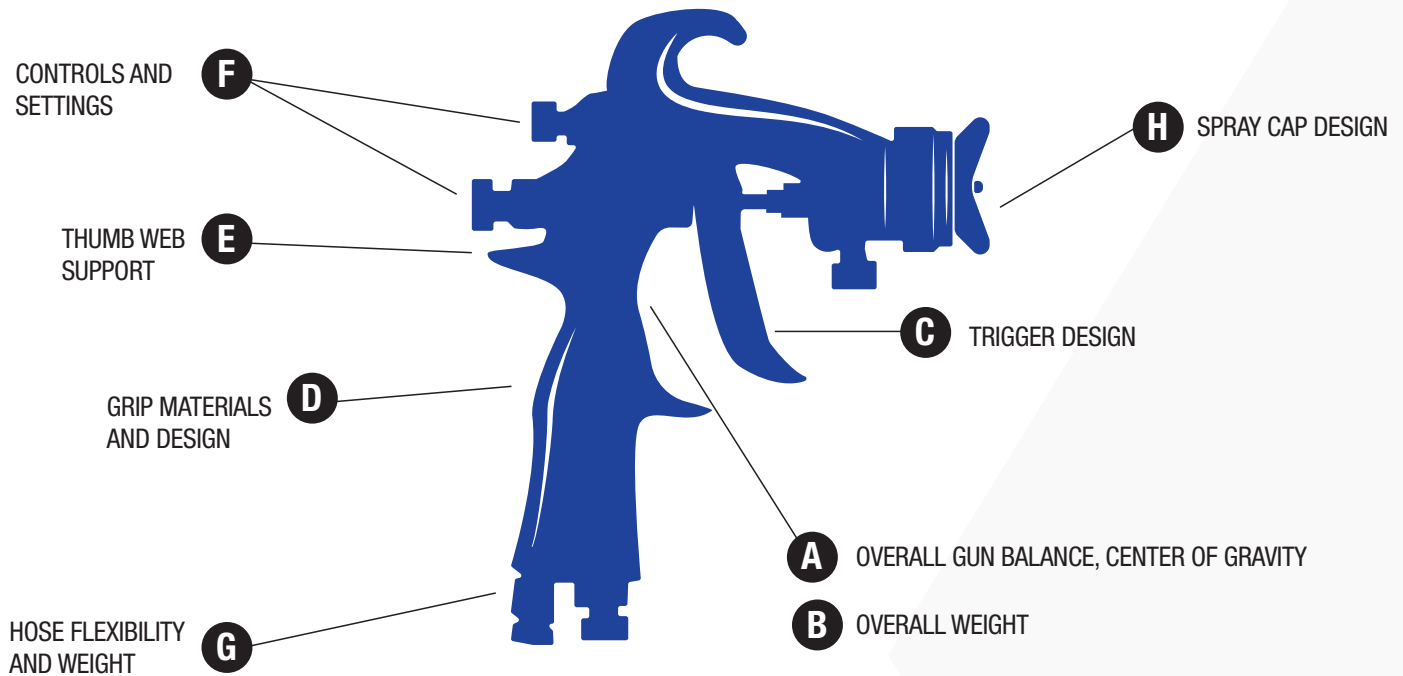
Each subject was asked to rate each of the subset of six air spray guns used during the testing. This graph shows average ratings on a scale of zero to 10, with zero being very poor and 10 being excellent.



EMG measurements are made as a painter participates in the test.

3.1.1 Key findings and recommendations

The analysis identified key factors in manual spray gun design that impact ergonomic performance:



- A. Overall gun balance and center of gravity:** A center of gravity located closest to the wrist was preferable to minimize torque and muscle effort to stabilize the tool.
- B. Overall weight:** All tools weighed less than 2 lbs. (907 grams), with an average weight of 18.0 oz. (510 grams). Lighter tools included the Graco AirPro.
- C. Trigger design:** Factors included trigger force, length, contact pressure, alignment, and throw arc. The average trigger force was 40.2 oz. (1140 grams) with the Graco AirPro having one of the lowest at 27.2 oz. (771 grams).
- D. Grip materials and design:** Metal grips increased thermal conductivity. Grip angle, length, circumference, and contours were evaluated for comfort and fit.
- E. Thumb web support:** Spray gun size, contour, and positioning impacted the effort and comfort essential to supporting tool weight.
- F. Controls and settings:** Knob size and design affected ease of adjustment.
- G. Hose flexibility and weight:** Traditionally heavy and stiff, air and fluid hoses affected physical demands, potentially increasing effort by over 100 percent.
- H. Air spray cap position:** All sprayers were optimized for vertical surfaces, requiring wrist bending for horizontal surfaces.
- I. Balance options:** The ability to hold the tool in different orientations was assessed.

US Ergonomics made specific recommendations for Graco engineers to consider as they designed a new line of manual air spray guns.

3.2 DESIGN REVIEW AND TESTING

After incorporating ergonomic optimizations into new air spray gun designs, Graco asked United States Ergonomics to objectively measure them. The rigorous testing followed processes defined by the International Ergonomic Association to ensure the ergonomic quality in design.

3.2.1 Selection of comparable spray guns

The seven industrial air spray guns chosen for evaluation included:

- three from Graco: the AirPro and two prototypes (one of aluminum metal and one of carbon reinforced polymer)
- four comparable applicators from other brands

3.2.2 Operator participation

Four operators with varying levels of experience performed eight tasks:

- Holding static posture
- Repeated triggering
- Continuous triggering
- Horizontal spraying
- Vertical spraying
- Wrist rotation
- Spraying static part
- Spraying moving part



Operator performs one of eight tasks during testing in a lab setting.

3.2.3 Testing methods

Five methods were employed to gather quantitative and subjective data.

- **Electromyography (EMG)** measured the percentage of Maximum Voluntary Contraction (%MVC) of eight muscle groups in each operator's dominant forearm and hand. (As in the previous testing, they included two muscle groups in the hand that move the thumb, and five forearm muscles involved in gripping, finger control, and wrist movement.)

20%MVC of an individual's maximum strength is the threshold for ergonomic effectiveness.

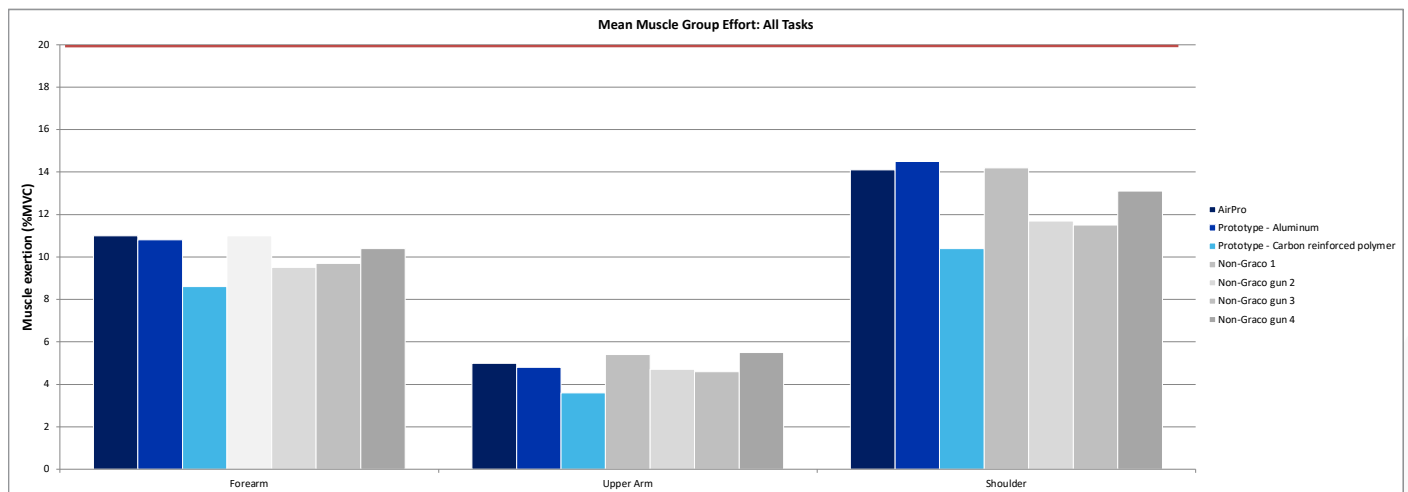
- Higher muscle exertion increases the potential for fatigue and the risk of injuries.
- Lower muscle exertions allows effective blood flow, minimizing fatigue risks.

- **Anthropometric analysis:** Data about body size, shape, range of joint motion, and strength was used to assess spray gun fit across a wide range of user hand sizes.
- **Subjective ratings:** After testing each gun, each operator was asked to rate different aspects on a scale of zero to 10, with zero being the worst and 10 being the best.
- **User comments:** Ergonomic testers asked the painters what they thought about each gun and had them point out areas of discomfort after using each gun.
- **Testing observations:** The researchers also recorded their observations about each session, taking special note of elements that may affect subjective or quantitative data collection.

3.2.4 Key findings and recommendations

Overall, testing was positive for both Graco prototypes. Key findings indicated that the new air spray gun designs were optimized for painter comfort. However, more testing was recommended for ergonomic certification and to ensure statistically significant results.

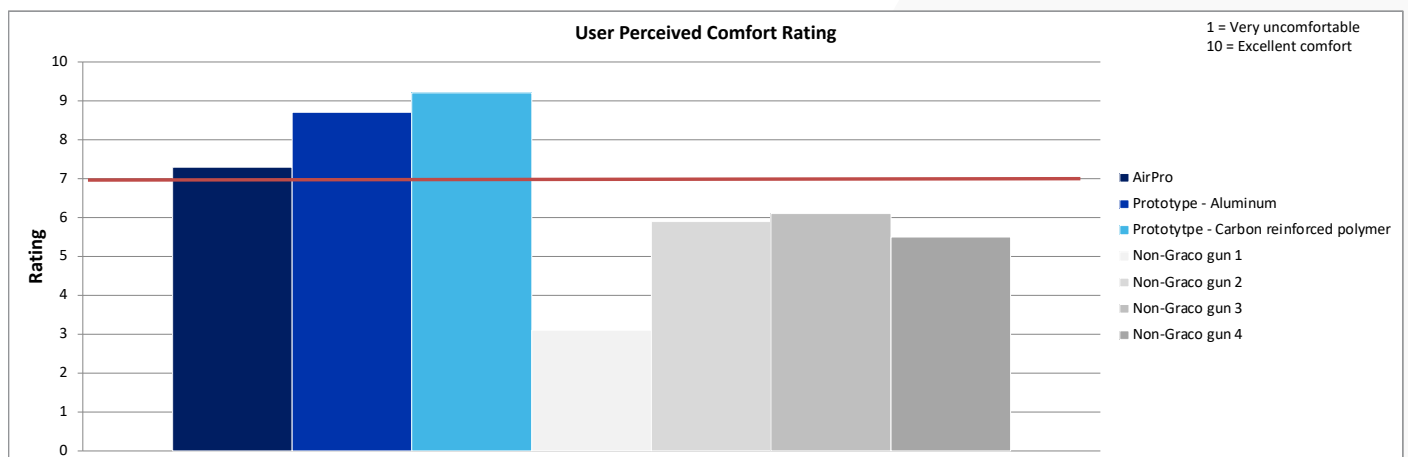
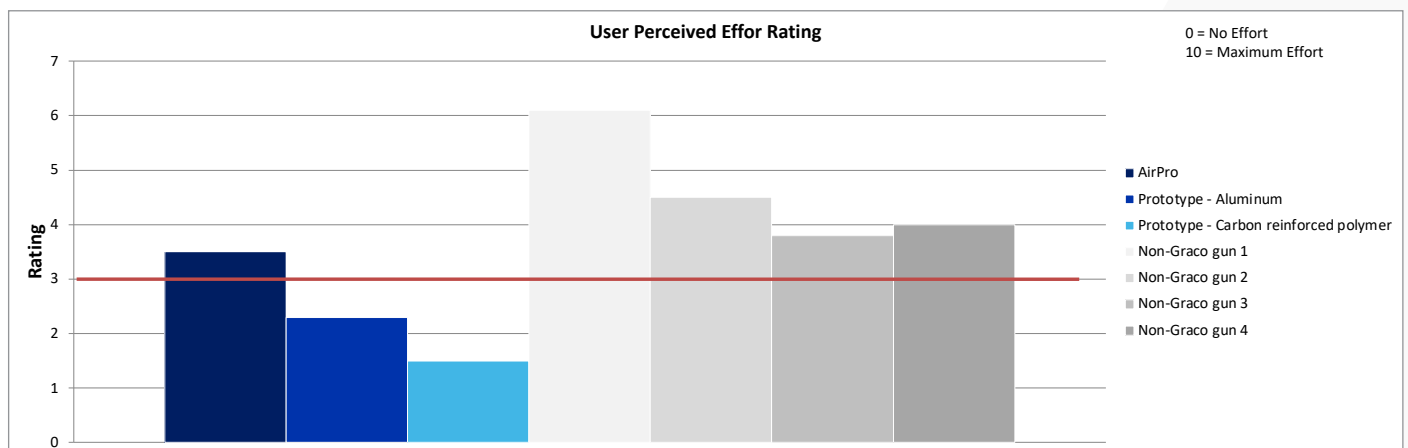
MUSCLE EXERTION



Of the seven air spray guns tested, the prototype made of carbon reinforced polymer consistently had the lowest average muscle exertion (%MVC) across all muscle exertion tasks. The lowest %MVC indicates it requires less effort to support the weight of the carbon reinforced polymer gun.

SUBJECTIVE RATINGS

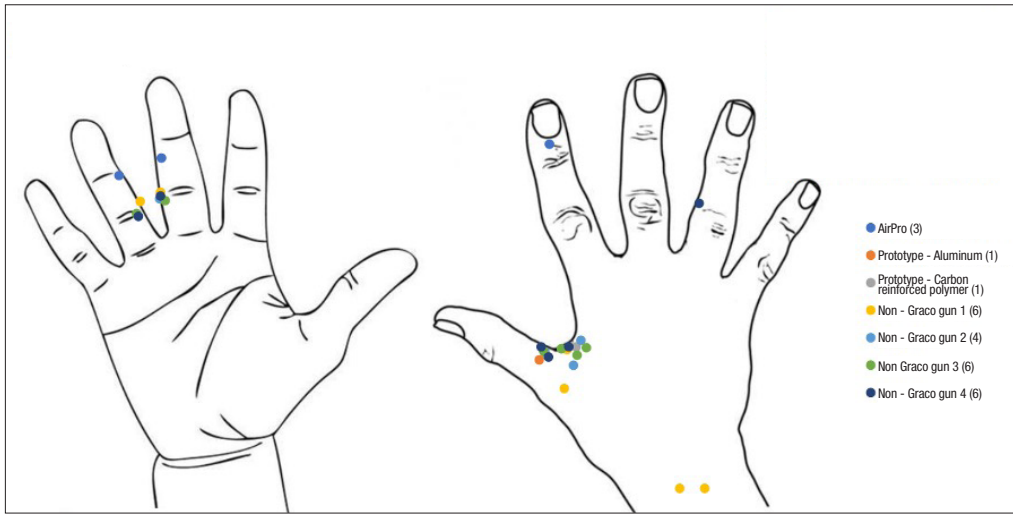
Of the seven air spray guns tested, the four operators gave the two Graco prototypes the highest ratings for comfort, performance, and fit.



According to experienced painters, the prototype made of carbon reinforced polymer had the lowest perceived physical exertion (1.5 out of 10) and the highest comfort rating (9.2 out of 10).

USER COMMENTS

Of the seven sprayers, the two Graco prototype guns had the fewest reported discomfort points.



Painters indicated pain points for the different guns tested.

3.3 ERGONOMIC ASSESSMENT

Before Graco introduced the prototypes to the market as Stellair ACE (made of carbon reinforced polymer) and Stellair (aluminum metal construction), US Ergonomics conducted further testing to assess the Graco devices in relation to Ergonomic Performance Thresholds.

The assessment involved the same five methods to gather quantitative and subjective data used in the previous design review and testing phase.

Twelve experienced industrial painters were recruited to evaluate a subset of four air spray guns: three from Graco (AirPro, Stellair ACE, Stellair) and one from another brand.

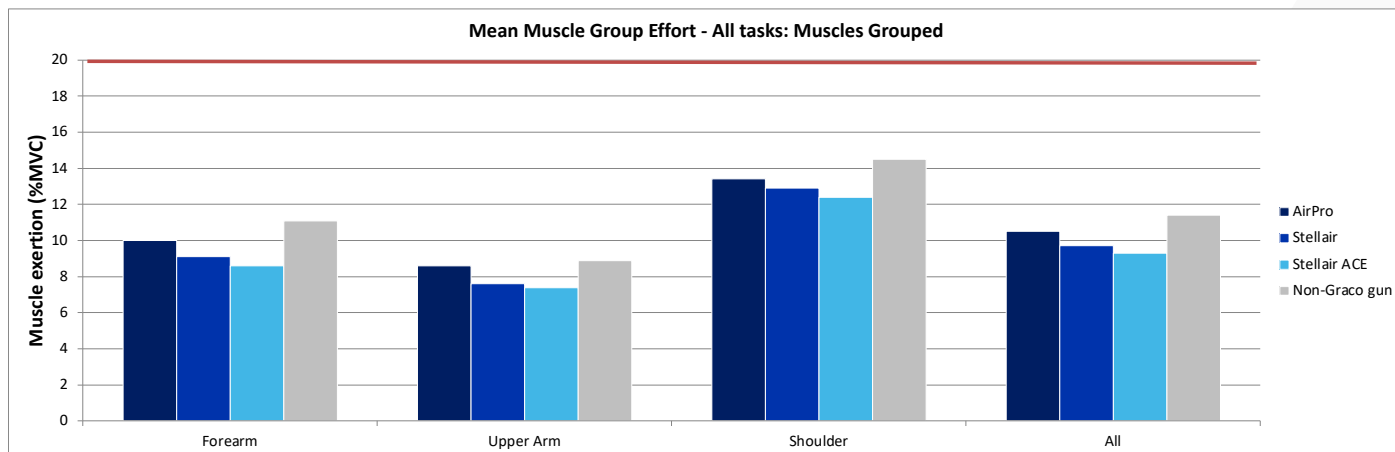
3.3.1 Key findings and certification

Results showed that the two new manual pressure feed air spray guns qualified to become the first industrial paint sprayers to earn Ergonomic Performance Certification.

- **Stellair ACE** weighs 209 grams (7.4 ounces) – up to 50 percent lighter than almost any other manual pressure feed sprayer, due to its durably unique carbon reinforced polymer construction. Stellair ACE uses up to 25 percent less muscle effort than other industrial air spray guns.
- **Stellair**, with its standard aluminum metal construction, weighs 410 grams (14.46 oz.). Still among the lightest industrial sprayers available, Stellair lessens muscle exertion by up to 18 percent.

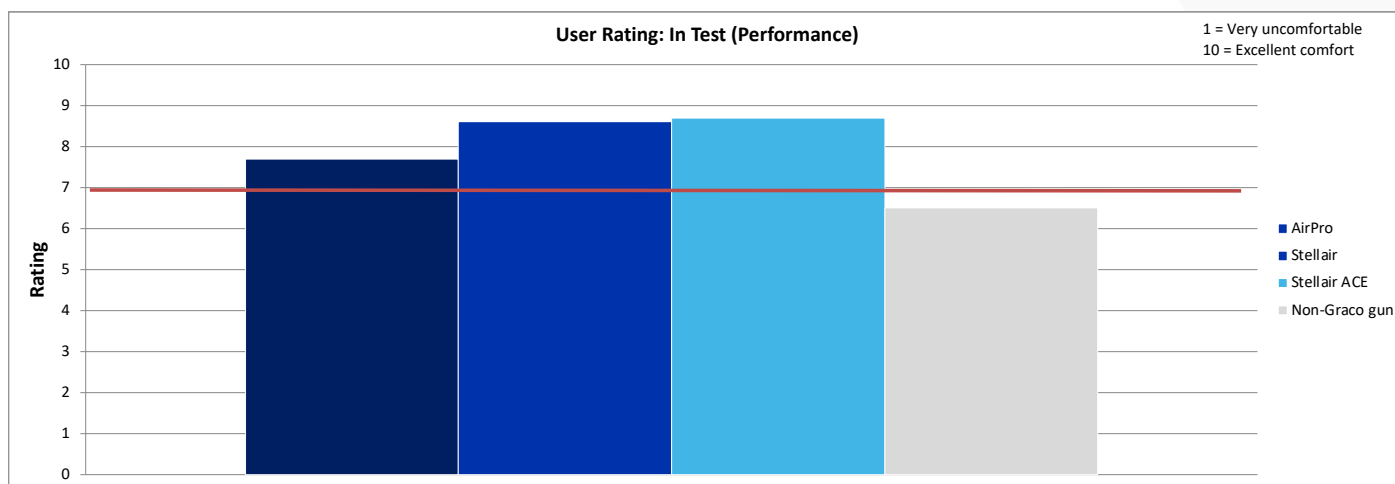
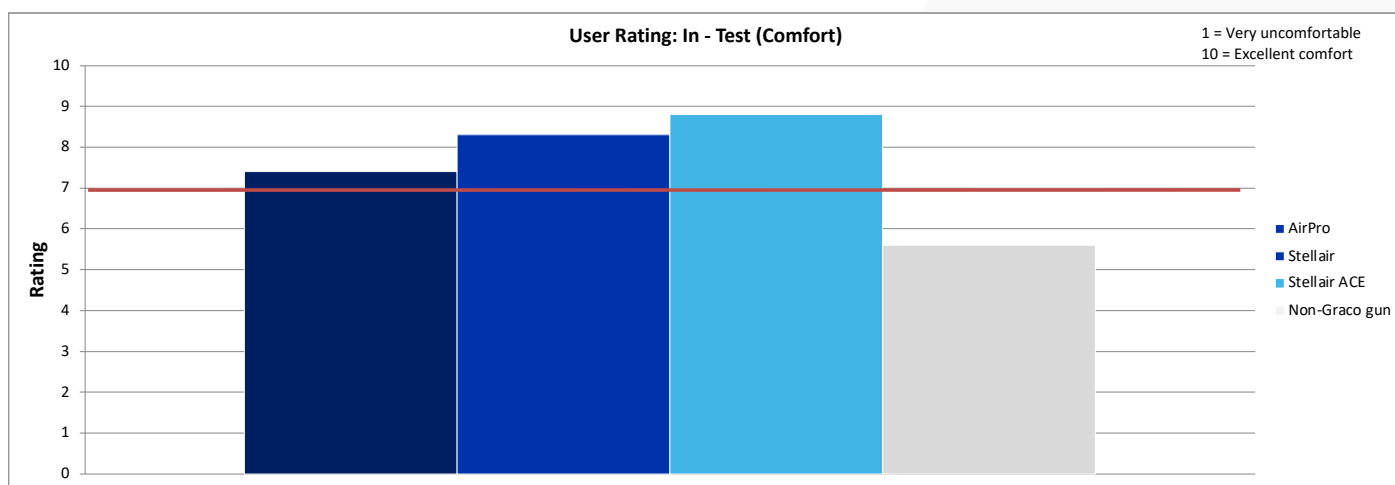
MUSCLE EXERTION

Stellair ACE showed the lowest average muscle exertion across all tasks, reducing overall muscle exertion by 13 percent compared to AirPro, 5 percent compared to Stellair, and 22 percent compared to a comparable spray gun from a different company.



PAINTERS' RESPONSES

Of the four paint sprayers tested, Stellair ACE and Stellair received significantly higher ratings for comfort and performance.



USER COMMENTS

During the testing process, the industrial painters commented not only on the ease of use and light weight Stellair ACE and Stellair, they also noticed the easy maneuverability of their fluid and air hoses.

STELLAIR ACE

“Crazy light and compact”

“I can feel the lighter weight in my neck.”

“I feel that I could spray with that one all day and not really get fatigued.”

STELLAIR

“The Stellair definitely fits my hand better. I like the texture of it. And just overall, it seemed really smooth.”

“I like the trigger, very light; it’s very light.”

“Very easy to run”

HOSES

“I can still feel the hoses, but they are a lot lighter.”

“The Stellair ACE is so light, and the hoses are nice and flexible.”

“The hose on the Stellair is way better than the other guns. It just seemed more maneuverable.”

4. Implementation and impact

Testing by United States Ergonomics allowed Graco engineers to objectively measure the impact of improvements in paint spray gun design. The design process was a balancing act, considering practical feasibility alongside ergonomic benefits.

“We started by ranking all possible recommendations in order of possible impact,” explained Joseph Daniski, senior product engineering manager. “This way we could start working on the biggest improvers and de-list the ones with the smallest impact.”

The team focused on four main areas, while developing Stellair ACE and Stellair:

- **Reduce gun weight:** Made of carbon reinforced polymer, the Stellair ACE weighs just 7.4 ounces (209 grams), or half the weight of Graco’s AirPro and the new Stellair, which still rank among the lightest aluminum metal industrial air spray guns available.
- **Improve overall balance:** Design adjustments addressed the common issue of front-heaviness in spray guns, reducing muscle effort required to maintain the correct position. Daniski noted, “Most guns tilt forward. We fixed this. Part of the answer was an improved trigger design.”
- **Minimize hand pressure points:** A ledge added to the trigger creates a third resting point to evenly distribute weight and enhance balance.
- **Enhance hose flexibility and weight:** Hoses, traditionally heavy and stiff, were made more flexible and reduced to one-third the weight of alternatives, significantly improving maneuverability.

5. Conclusion and industry opportunities

As a result of the positive testing performance, Stellair ACE and Stellair became the industry's only paint sprayers to earn Ergonomics Performance Certification. The product performance will be further verified through field trials in production paint shop applications.

United States Ergonomics noted that the new paint sprayers employ lighter weight materials, improved gripping biomechanics, and enhanced control adjustments. They also solve issues related to hose management.

Professional painters consistently rated Stellair and Stellair ACE superior to other industrial air spray guns during the dynamic arm movement test, which included the following tasks:

- Left-right movement
- Up-down movement
- Arm-twist movement
- Paint spraying part



A painter's muscle effort is being measured as he uses the Stellair air spray gun during dynamic arm movement testing.

Overall, Graco's Stellair ACE and Stellair air spray guns provide significant advantages over other sprayers, resulting in measurable reductions in effort and fatigue potential, allowing painters to more comfortably work longer:

- **Stellair ACE** uses up to 25 percent less hand and forearm muscle effort, 19 percent less upper arm muscle effort, and 13 percent less shoulder muscle effort than other sprayers.
- **Stellair** uses up to 18 percent less hand and forearm muscle effort, 15 percent less upper arm muscle effort, and 11 percent less shoulder muscle effort than other sprayers.

The development of Stellair ACE and Stellair air spray guns demonstrates how focused research and collaboration can lead to substantial improvements in user safety and comfort.

For more about how Stellair ACE and Stellair manual air spray guns provide industrial painters with the all-star ergonomics, serviceability and spray performance they need to enjoy and excel at their jobs, visit www.graco.com/stellairWin.



6. About the companies

GRACO

Graco Inc. supplies technology and expertise for the management of fluids and coatings in both industrial and commercial applications. It designs, manufactures and markets systems and equipment to move, measure, control, dispense, and spray fluid and powder materials. A recognized leader in its specialties, Minneapolis-based Graco serves customers around the world in the manufacturing, processing, construction, and maintenance industries.

Graco's Industrial Division makes liquid finishing and advanced fluid dispense equipment primarily for use in industrial applications. This division's products include liquid finishing equipment that applies liquids on metals, wood and plastics, with emphasis on solutions that provide easy integration to paint monitoring and control systems.

For additional information about Graco Inc:

[visit www.graco.com](http://www.graco.com).

UNITES STATES ERGONOMICS

United States Ergonomics specializes in product and workplace ergonomics. The company delivers sustainable productivity gains while reducing ergonomic risks and ensuring health and safety. United States Ergonomics operates a state-of-the-art ergonomics laboratory providing advanced workplace design, product testing and certification.

Certification by United States Ergonomics indicates the completion of a rigorous testing process defined by the International Ergonomics Association. A product that has received certification provides measurable ergonomic benefits to the user by improving comfort and fit and by minimizing the risk factors that may cause injuries.

For additional information about United States Ergonomics:

[visit us-ergo.com](http://us-ergo.com).



We are here to answer questions and help address your needs.

www.graco.com/stellair

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