PRECISION & PORTABILITY AS STANDARD

MAKING THE CASE FOR SELECTIVE PLATING IN AEROSPACE: A TECHNICAL PAPER

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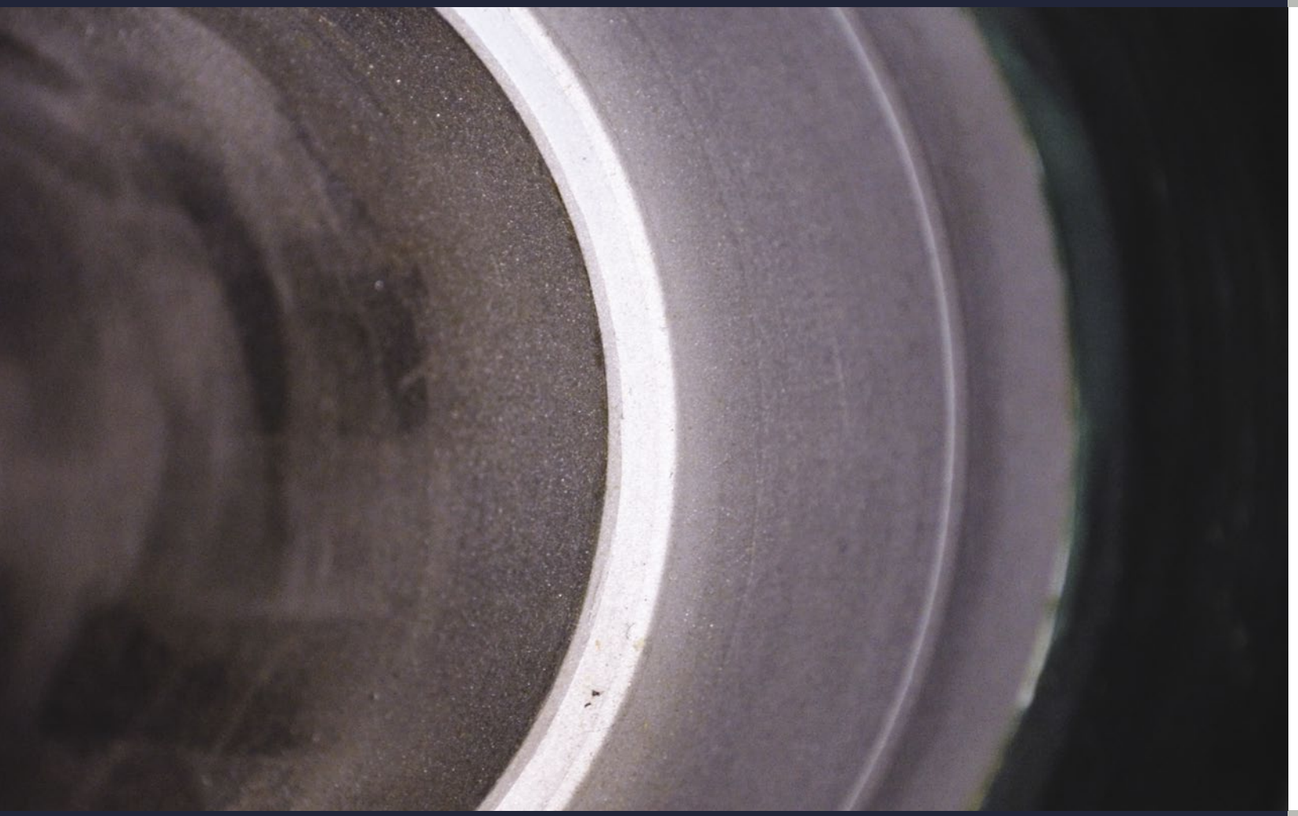
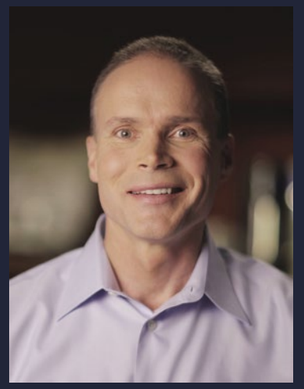


It’s critical to enhance component performance and longevity, and protect or repair equipment. Unlike conventional methods such as tank plating, the SIFCO Process® is fully portable – meaning you can take the process to the aircraft, rapidly depositing the solution to meet your applications’ demands. It speeds up work, reduces cost and minimizes downtime – so you can stay operational for longer. Moreover, it has extensive industry approval.



Lee Benson: CEO Able Aerospace Services

Lee Benson is CEO of Able Aerospace Services, a leading MRO provider of FAA approved replacement parts, repairs, overhauls and exchanges. He has invested more than 30 years developing the highly successful Able brand.

Benson founded Able Engineering and Component Services in 1995 and Able Aerospace in 1999. In 2016, Able was acquired by Textron Aviation, Inc., a Textron, Inc. company, a global general aviation authority that includes 21 company-owned facilities dedicated to complete aircraft life-cycle support.

In 2011, Benson also founded Execute to Win (ETW), a Phoenix-based company that helps organizations execute on their strategy.

Benson's affiliations include serving as a 16-year member of Vistage, a 16,000-member international CEO forum, and as a board member on the Arizona District Export Council. He has attended numerous courses at the Jack Welch Management Institute, University of Phoenix and Arizona State University.

Foreword

In late 1993 I purchased a service company that offered only one process and had just lost their only customer overnight. The one process was selective plating. At the time it was clear that selective plating had a big advantage in repairing aircraft components over other processes. We quickly developed eight repairs that incorporated selective plating and started marketing them directly to aircraft operators. Within a few years this lead to thousands of repairs and today we have over 500 employees serving 1,400+ customers in 60 countries. Selective plating was the foundation from which we built our business into what it is today.

We've earned a strong global reputation for safely reducing aircraft operating costs by providing resourceful component repair solutions and much more. Today we save our collective customers $100m+ each year over their next best value alternative. In-many cases selective plating allows you to repair aircraft components that have been subjected to normal wear and tear that were otherwise un-repairable. This also extends to new manufacturing due to machining errors.

One of the first applications we found for selective plating was repairing steel liners in magnesium gearboxes. Traditionally there were three process used to repair (or attempt to repair) the liners. The first was to simply replace the liner. The limitation here was that you could only do this two or three times in many cases before the magnesium casing was damaged beyond repair. The second process was tank electroplating. The problem with this was that if you had even the smallest of masking leaks it would destroy the magnesium casing. The third process was thermal spray. This process had limitations when the liners requiring repair became too small in diameter or too far recessed. It was also quite common for thermal spray to chip off causing FOD damage during service. With selective plating there are no limits to how many times you can repair these steel liners due to normal wear and tear. Some of the gearbox case assemblies we routinely repair can cost over $50K new and be repaired for a fraction of that cost using selective plating.

I think selective plating is a process that is largely overlooked in our sector. This could be a perception issue, or just lack of awareness generally. Either way selective plating is a well-established process already written into hundreds of aerospace specifications. It exceeds the fundamental requirements of aerospace manufacturing, repair and maintenance processes by providing a full circle of benefits including quality, durability, cost saving, portability and time saving.

The lucrative nature of the aerospace industry is not in question, but the pressures of demand mean that we all need to continue innovating by reviewing the way we work and the processes we use.

Any new manufacturer or aircraft operator looking to safely repair aircraft components and lower cost is doing themselves a disservice by not considering selective plating for the right applications. The collective cost savings of our global customer base and safety record proves this.

Lee Benson
CEO, Able Aerospace Services

Overview

The rigors and safety focus of the aerospace industry demand high performance equipment and components that operate at optimum levels, even when subjected to extreme friction and temperature. The industry is equally demanding in terms of its requirements for surface finishing. To protect or enhance the performance of aircraft components, a range of surface coatings are available, including: cadmium, zinc-nickel, tin-zinc, nickel, copper, cobalt, nickel-tungsten, cobalt chromium carbide, silver, gold and platinum. Used across airframes, engines, landing gear and parts, these coatings improve corrosion protection, wear resistance and electrical conductivity, and enhance lubricity, performance and in-service life.

The aerospace industry uses three main technologies to apply these coatings:

- Tank plating – where components are immersed in an electrolyte solution
- High Velocity Oxygen Fuel (HVOF) – a thermal spray technology which uses gas combustion or liquid fuel to spray molten materials onto the component surface
- Selective (brush) plating – an electrolytic process which precisely applies high quality deposits onto localized areas.

Of these processes, the first two are best known and most widely used, while selective plating is often overlooked – despite delivering directly comparable results for most applications, and better performance in many. Moreover, selective plating is the only ‘portable’ technology, meaning it’s possible to take the repair to the airplane, enabling rapid coating, often in situ and without removing the part. The benefits the SIFCO Process® delivers are significant, most notably in minimizing costs and accelerating the repair process.

With such an obvious advantage, the status of selective plating is therefore perhaps hard to understand. Certainly, tank plating and thermal spray are written into many specifications. Equally, compared with a wide network of suppliers, selective plating is delivered by fewer specialists, many with small operations. This is not the case with SIFCO ASC, a world-leading business with a global footprint and track-record of R&D in the aerospace sector. In the vanguard of selective plating technology, SIFCO ASC introduced its market-leading SIFCO Process® over 50 years ago, gaining early acceptance by the US Navy and now comprising a family of portable electrochemical processes for use on aircraft components in both OEM and repair applications. The case for selective plating with the SIFCO Process® is as compelling today as it has ever been.

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The science behind the SIFCO Process®

Instead of thermal spray or immersing parts in a tank, selective plating is commonly applied via a hand-held tool – which is why it is also referred to as 'brush' plating. The operator soaks the tool in the plating solution and then applies it via an absorbent cover wrapped over the anode of the plating tool.

A direct current is supplied via a portable power pack, and the operator keeps the tool in motion, ensuring an even deposit. The SIFCO Process® can handle most metals traditionally applied by tank electroplating, along with others including copper, cobalt, nickel-tungsten, cobalt chromium carbide, silver, gold and platinum. Key features of the process include:

- Safety – it requires lower volume, and less toxic chemicals, than other processes
- Flexibility – it can be applied to a wide range of geometries and sizes
- Integrity – performed at room temperature, selective plating eliminates the risk of heat distortion
- Choice – the SIFCO Process® family includes electroplating, anodizing and electropolishing
- Excellent adhesion – comparable or superior to tank plating in most applications
- Quality – most brush plated deposits are metallurgically dense and free of defects, and meet or exceed the requirements for tank electroplates
- Low hydrogen embrittling – without the need for a post-plating bake
- Speed – in addition to faster deposition rates (30-60x faster), the SIFCO Process® often requires no component disassembly, and less masking
- Hardness of finish – lies within the broad range of performance obtained with tank deposits
- Plate to size – often no requirement for post machining
- Portability – the SIFCO Process® is a mobile technology which can be performed on site or in the field.

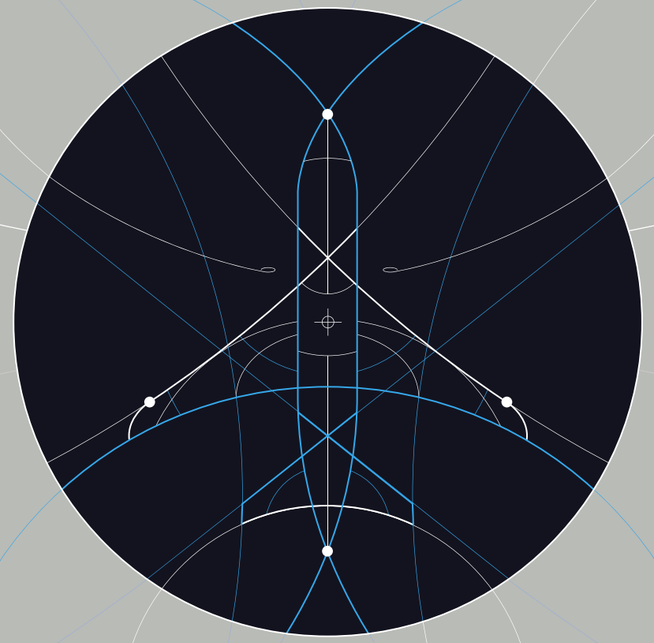
In addition to delivering a high quality finish which extends service life, these factors combine to enable immediate and cost-effective repairs caused by damage, wear, corrosion or mis-machining. Without the need to remove the part from the aircraft, logistical costs are eliminated and downtime and production delays are minimized. In terms of a broad overview, selective plating has many advantages. But how does it compare in direct comparison with its competitor technologies?

The SIFCO Process® vs tank plating

With tank plating, parts have to be removed – and usually shipped to a sub-contract plating company – while extensive masking may also be necessary, all adding time to the process. Selective plating can be carried out in situ, without the need for extensive masking.

It is also suitable for a wider variety of geometries and sizes, including inside diameters as small as 1/4".

Selective plating has a faster deposition rate per hour (0.015") compared with tank plating (0.001"), meaning plating can be up to 60 times faster. These and other factors mean lead times for the SIFCO Process® are shorter. Importantly, tank plating requires large quantities of potentially harmful chemicals which generate hazardous waste. Which is not a consideration with the SIFCO Process®.



The SIFCO Process® vs thermal spray

Thermal spray provides a mechanical bond, while the SIFCO Process® creates a powerful atomic bond which is resistant to cyclical temperature fluctuations and sharp, direct impact.

Tests run in accordance with ASTM C633-79 on the SIFCO Process® show that two commonly used nickel deposits had a bond strength exceeding the strength of the cement.

Furthermore, while deposit thickness can be precisely controlled in the SIFCO Process®, thermal sprayed parts require machining to the required dimension. And selective plating is carried out at room temperature, and therefore eliminating the risk of heat distortion. However, perhaps the single most important factor differentiating the SIFCO Process® is convenience.

The ‘portability’ factor

Equipment for tank plating and thermal spray tends to have a large footprint, and demands its own specialist facilities including ventilated surroundings. In both cases, parts and components have to be delivered to the site – a process which always involves removal from the aircraft, and often incurs transportation costs.

In comparison, the SIFCO Process® is a mobile technology which can often be applied direct to the component in situ – in the hangar, for example – greatly accelerating turnaround times without compromising quality. For additional convenience, SIFCO ASC has developed a suite of ultra-portable solutions which includes a Cadmium Travel Kit which can be carried by hand. Designed specifically for the aerospace industry and ideally suited for aircraft on ground (AOG) operations, it offers a practical and cost-effective option for repairing and enhancing the surfaces of components.

The aerospace industry was one of the first to widely accept and approve selective plating to restore worn and corroded metal components, and it is approved worldwide by most major airlines and landing gear and engine manufacturers. It is also specified in overhaul manuals and standard practice manuals. Today SIFCO ASC stands as a leading provider in the sector.

Aerospace credentials

In addition to holding many key approvals - including MIL-STD 865 and AMS 2451 – SIFCO ASC facilities are AS and NADCAP certified, and comply with MIL-I-45208 and FAA Approved Repair Stations standards.

SIFCO ASC has also worked directly with leading aerospace businesses, including Bell Helicopter, Messier-Bugatti-Dowty, UTC Aerospace Systems, Pratt & Whitney, Sikorsky, Honeywell and Rolls Royce.

Typical applications

Suitable for a comprehensive array of aerospace equipment, including airframes and engines, electronic housings, landing gear, turbine blades, actuators, bearing journals, bushing bores, flap tracks and axles, the SIFCO Process® can be used for a range of applications, including:

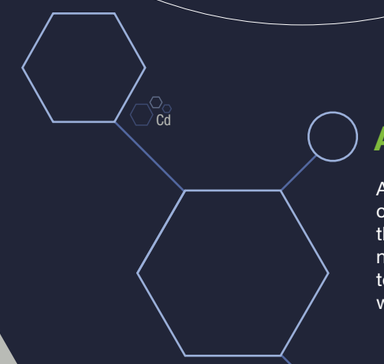
- **Corrosion Protection.** With low hydrogen embrittlement and no baking required, repairs can be made in situ with minimal or no disassembly.
- **Pre-Braze.** Turbine components and frames are nickel plated to ensure proper wetting of the surfaces to be brazed. Selective plating offers a fast, consistent and cost-effective method of application.
- **Surface Enhancement.** The application of nickel or a nickel alloy improves the hardness and wear resistance of the component.
- **Refurbishment.** MRO applications use nickel or sulfamate nickel for dimensional restoration of an inside or outside diameter on the component.
- **Anodizing.** Repair applications replace worn or damaged hardcoat with a new, anodized hardcoat coating.
- **Viable alternatives.** Above all, the SIFCO Process® offers viable alternatives to applications using cadmium.

A safe, high quality alternative to cadmium

One of the most pressing challenges facing industry today is the question of cadmium. A known carcinogen, cadmium is being replaced in many sectors but remains the plating of choice in aerospace because of its performance.

However, government and environmental concerns are forcing manufacturers to find alternatives. Calling on years of experience and significant investment in R&D, SIFCO ASC has developed a range of well-engineered and proven deposits that deliver excellent performance, while posing minimal risk to either operator or the environment.

While detailed studies show these alternatives do not perform well in either tanks or thermal spray application, they deliver excellent results via selective plating, offering superior sacrificial corrosion protection for steel by combining the barrier protection of tin, with the galvanic protection of zinc.



Aeroshield® 4025

A cobalt metal matrix composite in which chromium carbide particles are incorporated, this creates an adherent, dense, ductile and non-porous deposit that combines high temperature oxidation protection with superior wear resistance in high temperature applications.

Zinc-Nickel LHE® 4018/5970

A less toxic alternative to repairing cadmium, zinc-nickel, and damaged IVD aluminum on high strength steels, Zinc-Nickel LHE® can be applied in the shop or in the field, and does not require a post-plating, hydrogen embrittlement relief bake.

Tin-Zinc LHE® 4019

This solution provides an environmentally friendly and superior quality deposit that provides excellent corrosion protection, good lubricity, and eliminates the need for a hydrogen embrittlement relief bake after plating.

The SIFCO Process® in practice – case studies

Johnson Technology – automated process of AeroNikl® on turbine castings

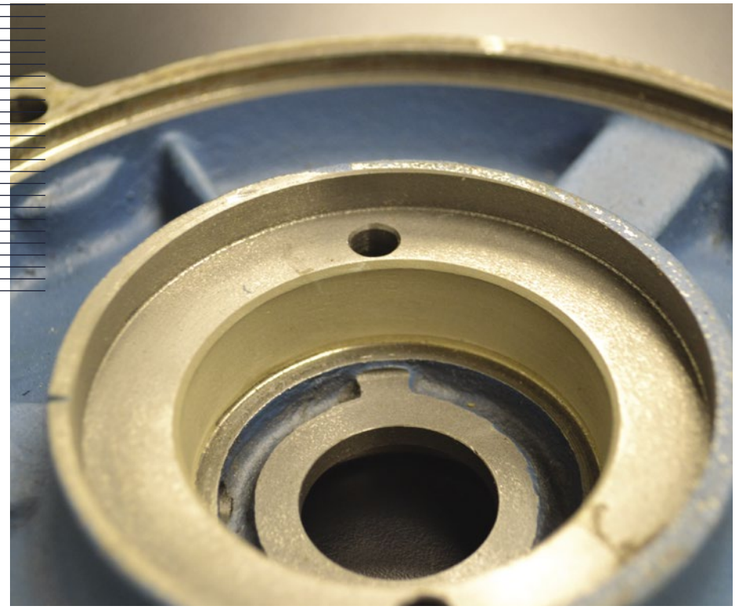
Due to the EHS issues and ergonomic risks associated with their in-house plating operation, Johnson Technology, Inc. contracted with SIFCO ASC to outsource the operation. SIFCO ASC dedicated space in their job shop for a custom workstation to effectively plate the turbine castings. In this reoccurring service job, a uniform application of SIFCO Process® solution AeroNikl® 250 Sulfamate Nickel is needed on the irregular-shaped face of the turbine castings in order to improve the brazing process. When plating manually, each part takes approximately 7.5 minutes to plate from start to finish. With 48 parts to plate per day, a technician could expect to spend 6 working hours at the workstation each day. To relieve the ergonomic strain on the technician, SIFCO installed an automated, robotic workstation. A robotic arm holds the turbine casting, carefully bringing it to the solution and anode, oscillating at the optimum anode-to-cathode speed, rinsing and then continuing the SIFCO Process® until the part is complete. Automating the plating process for Johnson's turbine castings has proven to be extremely successful. Not only has the ergonomic risk to the technicians been significantly reduced, component plating process time has also been reduced by 50% – increasing the available capacity.

Touch-up on support lugs of a SH-60B Seahawk helicopter – Sikorsky

Selective plating significantly reduced downtime by re-cadmium plating the ID and faces of the support lugs in situ. Components were cleaned with solvent and a wire brush before being plated with SIFCO Process® code 2023 Cadmium No Bake using a FT-40 and ID-10 anode with cotton jackets – a process which took only five minutes per lug.

Anodizing Type 1 of lead lag from helicopter rotor – Lord Corporation

The heat generated in tank anodizing caused a loss of dimension on the ID of the component, requiring re-boring and the consequent removal of the anodic coating. Selective brush anodizing removed this issue while also improving corrosion protection and lead-times. Allowing 24 parts to be processed in one day, compared to almost four days when processed one at a time.



Out of tolerance end bells – Allied Signal Aerospace

Here, selective plating allowed non-conforming parts which were out of acceptable engineering drawing tolerance, to be plated in thicknesses ranging from 0.0002" to 0.0300" per surface [per side]. The service shop was able to plate 0.005" thickness of SIFCO Process® code 2080 Nickel (Acid) in 30 carbon steel bores, which were approximately 2" in diameter by 1/2" deep.

Nickel plating of landing gear – Professional Aircraft

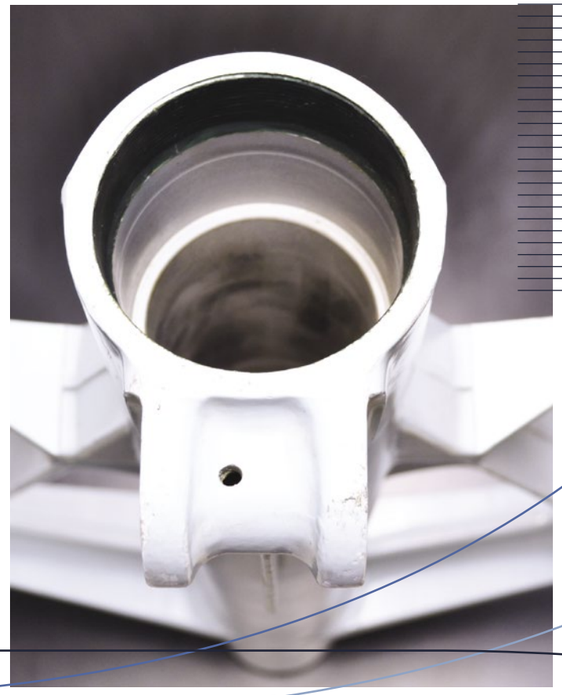
Plating two internal bores – 2.7" dia. X 2.0" long was complicated for tank plating due to their location. But selective plating with SIFCO Process® code 5070 Cadmium LHE® facilitated the work in situ with minimum masking, and to FAA Approval.

Urgent repairs to port and starboard undercarriage of a leading commercial airline

During a Type C inspection and overhaul, engineers discovered areas of damaged cadmium protection. Carrying all equipment as hand baggage, a SIFCO service technician completed repairs in situ within 1 day, helping keep the overhaul on schedule.

Repair of a landing gear strut for a leading commercial airline

A chrome defect was noted at two locations on the landing gear strut – one with a 0.50" diameter, the other 1.50 x 1.80". After masking, technicians selectively plated both locations with SIFCO Process® code 5644, affecting a fast and effective repair.



Adding value through automation

A precise and effective method for the enhancement of localized surfaces on OEM components, the SIFCO Process® is typically manual. However, it can be mechanized or fully automated to meet the demands of higher volume plating applications, or where greater data logging and traceability is required.

One example where this method has had a beneficial impact on both cost and production efficiency is that of a leading aerospace landing gear manufacturer. The company initially approached SIFCO ASC to design a machine for landing gear repair. The key challenge was localized areas on the bogie beams were getting damaged while being retracted into the fuselage. As a result, SIFCO ASC's Engineering team worked extensively to design and manufacture a robotic system that would automate the selective plating process and be installed into their production line. This has had a beneficial impact on both cost and production efficiency for the customer, as well as enhancing component supply chain control and traceability. For UK based companies, there's an extra incentive: as an extension of the Annual Investment Allowance (AIA), the Chancellor has pledged £200,000 for each company looking to upgrade and introduce new plant and machinery such as SIFCO Process® Automation.

SIFCO ASC's Engineering team worked extensively to design and manufacture a robotic system that would automate the selective plating process.

The SIFCO Process® for MRO, OEM – and MRO within OEM

In addition to superior and more consistent coating quality for many applications, the SIFCO Process® is easier and faster, resulting in less downtime. Moreover, by having the process in-house or in situ, traceability is improved and risks inherent in the supply chain are reduced with less dependence on sub-contract plating. The net result is improved production flexibility and efficiency and a reduction in total product cost. Critically, the SIFCO Process® uses safe materials, minimizing EHS concerns.

The SIFCO Process® for engineers, contractors, specifiers, procurement, compliance

	Engineers	Contractors	Specifiers	Procurement	Compliance
Cost		✓	✓	✓	
Consistency	✓	✓	✓		✓
Portability	✓	✓			
Time saving	✓	✓		✓	
Quality	✓	✓	✓		✓

SIFCO PROCESS® SELECTIVE PLATING
FOR THE GLOBAL AEROSPACE INDUSTRY

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