



Aircraft MRO in a World-Class Facility

KLM Royal Dutch Airlines has a history of being first. Founded in 1919 by a Dutch flyer named Albert Plesman, KLM launched the world's first scheduled airplane passenger service in 1920 by flying from London to Amsterdam. By World War II, it had a fleet of 51 planes and served 61 cities in 29 countries. During World War II, KLM's fleet was decimated and by war's end, KLM had only four planes in Europe. Plesman gathered KLM personnel from all over the world and led "the Flying Dutchman" in a remarkable comeback. Today KLM is part of Air France Industry and has 125 aircraft serving 145 cities in 67 countries. KLM ranks seventh among the International Air Transport Association's more than 200 member airlines in terms of international revenue to kilometers.

"Plesman had a very progressive view on how to do business," says Marcel van Wonderen, KLM's Master Engineer on Process, Equipment and Materials Development. "He founded an overhaul shop for aircraft and engines in 1921." Mr. van Wonderen works for KLM's Engineering and Maintenance division. With approximately 5,000 employees, KLM E&M is one of three divisions of KLM, the others are Passenger Transport and Cargo. KLM E&M is one of the larger MRO companies affiliated to an airliner. Located at Amsterdam Airport Schiphol, KLM E&M has a state-of-the-art engine shop facility with a capacity for 350 shop visits a year. Reliable engine support is the backbone of KLM's MRO offerings. The company provides these customized support programs:

- AOG service (Aircraft on Ground) to ensure continuous aircraft operation
- Spare engine programs with guaranteed availability
- Worldwide engine transportation through KLM Air Logistics
- On-wing support from worldwide specialized teams
- Customized engine maintenance programs

- Optimized EGT (exhaust gas temperature) margin with advanced maintenance programs
- Innovative cost-cutting repairs

Fifty to sixty percent of all engines serviced by KLM are for other airlines. KLM E&M is one of the largest GE overhaul shops in the world and it currently overhauls approximately 225 GE engines a year (CF6-50, CF6-80A, CF6-80C2, CF6-80E1). KLM E&M also overhauls Boeing 747, 737, 777, McDonnell Douglas MD11, and Airbus A330 aircraft. KLM performs two kinds of engine overhauls:

- Planned (after approximately three years or 5000 flight hours)
- Unplanned (due to reported vibrations, high fuel consumption, high engine gas temperature, loss of power, and bird strikes)

When an engine arrives in the shop, one or more of the five different modules will be overhauled - Low Pressure Compressor, High Pressure Compressor, Low Pressure Turbine, High Pressure Turbine, and Gearbox. The parts of the modules will go to the pre-route (cleaning, non-destructive testing, inspection, part-disposition) and after that, possibly into the repair route depending on the condition of the part and costs of the repair (the part will be repaired if the repair costs are less than 60% of the cost of a new part). A total engine overhaul (depending on how many modules must be repaired) takes 65 days with a repair-window of 17 days. As part of his responsibilities, the department of Mr. van Wonderen has engineering responsibilities for the following repairs/ treatments on engine parts:

Welding

- manual TIG-welding
- CNC Dabber-TIG-welding
- SWET welding (Superalloy Welding at Elevated Temperatures)



KLM's Engine Services building at Amsterdam Airport Schiphol



Brazing

- nickel brazing
- silver brazing

Heat Treatments

- solution heat treatment
- homogenization
- precipitation hardening
- stress relieve heat treatment
- diffusion heat treatment
- hydrogen embrittlement to relieve heat treatment

Ultra-High Pressure Waterjet Cleaning

Shot Peening

Coatings

- galvanic: silver plating, nickel plating, chemical nickel, chromium plating, phosphating, anodizing, chromate conversion coating
- diffusion: Sermalloy J
- grit blasting prior to thermal spraying
- thermal spraying: plasma spraying, flame spraying, electric arc spraying

Machining

- turning
- milling
- drilling
- tapping
- grinding
- boring
- lapping, super finishing, honing

Measuring

- 3D-measuring
- LASER-measuring
- MK3-measuring
- manual measuring

Balancing

- static
- dynamic

As the world's first airline and MRO facility, KLM E&M has always been a leader in the MRO aircraft industry in innovations, state-of-the-art processes, experience, equipment and materials. For example: KLM E&M was the first MRO shop in the world with a full process approval from General Electric on the Ultra-High Pressure Waterjet process (KLM won the European LIFE award for clean technologies with this process), KLM E&M was also the first in the world with electric arc spraying on GE parts as an alternative for Plasma spraying, the first in superalloy welding at elevated temperatures (SWET) welding, and the laser-cladding of GE parts. (Laser-cladding is a metal surface enhancing process performed by applying a powder metal material onto the base surface with a laser.)

Mr. van Wonderen oversees these innovative programs in the MRO facility, and shot peening is one of his passions. "Given all of

the engine repair steps, shot peening is one of the most important steps," says van Wonderen. "During repair and overhaul there are many processes that introduce tensile stress in the metal parts. Only shot peening is capable of introducing compressive stress to eliminate or compensate for those tensile stresses."

A wide range of components for the world's finest aircraft are shot peened at KLM E&M. All GE engine parts that will be plated or thermal sprayed will be shot peened. Many engine parts with weld or blend repairs will be peened. All total, a minimum of 225 different parts are peened, from a 2-inch long cargo-door hook to a fan frame that is seven feet in diameter. Landing gear parts and flap-tracks are just two examples of aircraft parts shot peened for Boeing, McDonnell Douglas MD-11 and Airbus.

KLM E&M, a Six Sigma company, tests their shot peening processes according to the Six Sigma practices. Six Sigma was originally developed by Motorola to systematically improve processes by eliminating defects. Since shot peening cannot be tested on a part without destroying it, it is important to control, monitor and record the whole process. Intensity, saturation and coverage are calculated and measured indirectly through Almen tests and saturation curves. Highly-skilled operators are a must. The following are the components of the quality control system that KLM E&M incorporates into their shot peening process:

- Machine: calibration, maintenance, controlling, recording
- Manpower: training, qualification, proficiency checks
- Measurement: gauges, timers, monitoring devices
- Method: parameter, manuals, procedures
- Material: certification, standards, specifications, incoming goods inspections

Put into actual practice, KLM utilizes these elements:

- Four state-of-the-art shot peening machines, three with a process integrated monitoring system in accordance with AMS 2432B
- Magnetic media valves
- Spherical conditioned cut wire shot in accordance with AMS 2431/4
- Simulation parts made from original aircraft parts embedded with Almen strip holders
- Highly-skilled and qualified operators that are checked every two years by means of a proficiency test, refreshment courses (theoretical and practical) and examinations
- Almen gages and calibration equipment
- Almen tests strips in accordance with SAE J442
- Following the procedures according to SAE J443, SAE HS-84, SMA 2430L, AMS-S-13165, etc.

Because he is an advocate for shot peening, van Wonderen developed a presentation titled "How can the shotpeened process really be controlled?" that outlines the steps his shot peening team takes to ensure a repeatable, controllable process. The presentation has been an educational tool for aircraft-related industries that aren't familiar with the metal treatment process or have misconceptions about the benefits of a tightly-controlled procedure.

Mr. van Wonderen feels so strongly about shot peening that he sees it as one of the keys to success in the current MRO marketplace. "One of the possible ways of increasing the chances of surviving is to be innovative and introduce new ideas in the MRO market. Innovative techniques include computerized and automated processes such as ultra high pressure waterjet stripping, shotpeening, TIG-welding, laser-cladding and thermal spraying," says van Wonderen. ●

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KLM's Engine Services facility