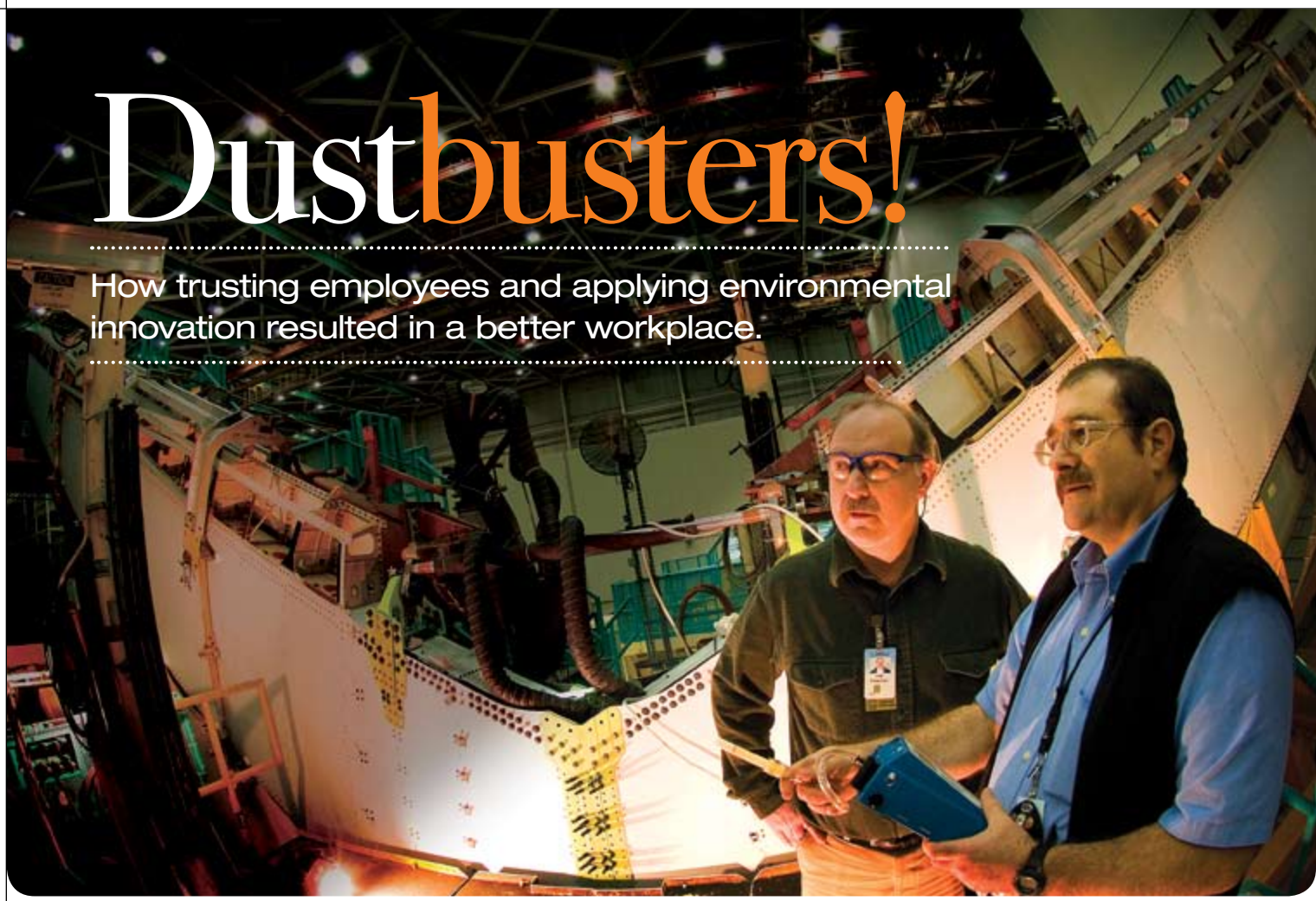
Dustbusters!

How trusting employees and applying environmental innovation resulted in a better workplace.



By Lori Gunter

Composites are the material of choice for many commercial airplane applications because they offer increased strength, reduced weight and a resistance to the two factors that can compromise metallic structure – fatigue and corrosion. An additional benefit is that the material set itself continues to evolve as the composite manufacturing companies develop new ways to enhance the properties of their products.

In 2004, an enhanced composite material was introduced on the 777 production line. It was a new version of the familiar material that had been used on the program from the beginning, known as BMS 8-276.

The new version, BMS 8-276 Form 3, featured a tougher fiber and reduced cost. The new material was made using new production methods that allowed the manufacturer, Toray, to produce a greater volume of the product. This last element was especially critical as the new Boeing 787 Dreamliner development effort was requiring significantly more quantities of composite materials, as would the production program.

Everyone involved in the introduction of the material believed it would be almost transparent to the team building the airplane. It was simply an improved version of the material already being used.

A new composite is now being safely used on the 777 horizontal stabilator as a result of new procedures and equipment. Here, Joe Fletcher (at left), a Material and Process Technology Associate Technical Fellow, and Steve Magasis, a 787 Safety Health and Environment Affairs (SHEA) representative use a particulant monitor to ensure there are no environmental impacts during installation.

A message from the people in Moon suits

But employees in Structural Composites at the Fabrication Division's Frederickson, Wash., site did notice something different when they used the new material to build the 777 empennage. Initial reports focused on handling differences when drilling and sanding the cured form of Form 3. There were concerns about potential quality impacts and increased Foreign Object Debris (FOD). Other employees reported increased rates of skin irritation.

These reports came to the attention of Joe Fletcher, a Material and Process Technology Associate Technical Fellow, who began to investigate. Health and Safety Institute (HSI) and Safety Health and Environmental Affairs (SHEA) personnel also began to look at the reports, and under the leadership of Arnie Chavez, Fabrication Division, SHEA Industrial Hygienist, additional dust-control, protective equipment upgrades and housekeeping efforts were introduced.

To further address the concerns, Everett personnel Rod Sigvartson, HSI Representative, and Steve Magasis, 787 SHEA representative, assisted 777 Empennage management in providing New Chemical Introduction training.

Magasis recalls, "The first-shift training session was fairly routine. We handed out the Hazard Communication Information Sheet for 777 composite drilling operations and reviewed it with shop personnel. There was no reason to expect that the recent substitution of BMS 8-276 Form 1 with Form 3 would have any health impact." However, when the second-shift crew arrived for training, two of the employees were wearing head-to-toe "moon" suits and carrying respirators. Supervisor Elizabeth Wiens took the trainers aside and said, "Those guys are two of the best workers in my crew. They've had years of experience drilling BMS 8-276.

"It's always been a fairly dusty job, so they've worn respirators. They've never had a health or safety problem. But ever since we switched to the Form 3, they say they've been itchy all the time."

Action and innovation

There was no information available at that time to explain this type of response. But the word of experienced Boeing employees was all that it took for Boeing to launch an extended investigation that included SHEA, Boeing Toxicology, Boeing Medical, and Material and Process Technology. The team went looking for the reasons why Form 3 would cause irritation in employees who had significant experience in safely handing the earlier form of the same material.

While the investigation continued, SHEA also identified new controls to help reduce exposure to the dust by-products of drilling and sanding BMS 8-276 Form 3.

Kraig Penrod, Site Services, and Material and Process Technology's Jim Deland and Matt Kesterson began to develop ventilation engineering controls to reduce FOD and dust levels inside the Empennage and surrounding shop.

The team took three steps to address the employees' concerns.

First, SHEA worked with a safety equipment vendor to find a better protective suit for the employees. Simple design improvements like better sealed seams and the addition of wrist and ankle elastics made an immediate difference.

Second, Site Services designed and built an improved vacuum to help isolate dust within the Empennage platform.

Finally, Material and Process Technology introduced new prototype "integral exhaust" tools to extract dust as close to the source of its generation as possible.

Meanwhile, back at the investigation

While solutions had been found on the shop floor, the experts still wanted to understand the cause of the reaction to the new Form 3 material.

Development of Form 3 had involved two phases of extensive testing, including a Boeing Toxicology health hazard evaluation. Those findings indicated that the new Form 3 resin system was essentially identical to the resin used in the classic material, differing only slightly in the relative proportion of the components used. These differences would not be expected to have a negative impact on workplace health and safety.

So, it was out to the factory and then back to the labs for the experts. "SHEA collected numerous air samples, most under worst-case drilling operations," says Magasis. "The samples were split, and were then analyzed by both an outside industrial hygiene laboratory and Boeing's Particle Identification Lab. Both analyses further characterized the dust, and aided in the assessment of the severity of any potential workplace hazards.

According to Magasis, the findings from both labs confirmed that dust concentrations were well below state and federal Permissible Exposure Levels. In addition, the information regarding dust and fiber shape derived from the findings matched the general descriptions provided to Boeing by the supplier.

A deeper analysis of the general description confirmed that there was one difference between the two forms of the material. Form 3 featured a smoother surface, which in a cross-section view appears round. The earlier version of the material had a bumpy surface that appeared to have a kidney-bean shape in the cross-section view.

While the difference did not impact the toxicology assessment, the itch reaction of shop floor personnel demonstrated that it was a noticeable difference, one that could be controlled with the new measures implemented by the team.

Applying the lessons to the 787

The lessons learned on the 777 empennage have been applied robustly to the 787 program, which uses BMS 8-276 extensively for primary structure.

All partners and suppliers have been advised of recommended control measures for handling the material – including the use of protective gear and the introduction of vacuum and ventilation systems.

Program leadership also mandated that dust control measures capable of capturing air contaminants at their source or capable of preventing the generation of dust would be used for all 787 Boeing composite machining operations.

In addition, Material and Process Technology engineers Matt Kesterson and Jim DeLand developed a new line of vacuum cutting tools and exhaust shrouds. Patent applications have been submitted for these inventions. The cutters, in combination with a modified drilling system, are capable of vacuuming the composite material as soon as the chip and/or dust is generated from the cutting edge, regardless of depth of cut. The system has a 99 percent collection capability. Additional benefits have been realized as a result of these tools. The instant removal of the debris also reduced the heat generated by drilling, enabling dry drilling (no lubrication), which helps to extend the life of the tools. Eliminating need the for lubrication also simplifies cleanup and reduces the requirements for aggressive solvent cleaning.

Finally, Site Services' Penrod led the development of a sophisticated dust-collection plan for the 787 operations. A team of Boeing experts worked with Donaldson Company to design and certify a portable dust collector unique to Boeing that could safely and effectively remove the dust gathered through the new vacuum cutting tools and shrouds. Portable collection devices of the size and type required – with proper certification – did not exist before this effort and are essential in implementing Lean operations without infrastructure "monuments".

"Working across organizational and program lines, Boeing people worked together to improve workplace safety and employee comfort, reduce FOD, and improve quality," says Magasis. "It took real organizational integrity and technical expertise to change established processes and tools designs; but we did change them, because we valued the experience of our fellow employees. As a result, hundreds of workers around the world will have a better environment in which to build the 777, 787 and other composite structures." ■