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Lifelong partnership
FOR THE BENEFIT OF THE CUSTOMER
Perm engines are safe from icing
Perm is against pirated goods
Source of highly qualified specialists training
DETAILS

- COMPANY'S NEWS
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TU-204-300A AIRCRAFT TESTING

In November, 2010 tests of Tu-204-300A aircraft under Precision Regional Area Navigation system (P-rNAV) were carried out successfully in Norway and Finland airports.

During these tests Tu-204-300A (№ 64010) carried out 11 flights. These works have been arranged by the specialists of Tupolev, Aviastar-SP and other related companies. Following the test results pilots and experts of Air Navigation State research and Development Institute (GosNII AN), GosNII GA and Flight Research Institute named after M.M. Gromov gave their positive conclusion.

As reported by press office of Tupolev

In October, 2010 the total running time of PS-90A high-time aero engine developed by Aviadvigatei exceeded the level of 35,000 hours since the start of operation. As of today, this figure is a record-breaking one, i.e. there are no other equivalents having the same hours flying time among modern Russian aircraft engines.

This engine was manufactured by Perm Engine Company in 1990; now it is used as part of the power plant of IL-96-300 long-haul aircraft (tail number is 96 005) by Aeroflot-RAL airline. For twenty years of its operation this working engine has changed eight aircrafts. Not only proper operation and adequate maintenance but design innovations being continuously worked at by the designer contributed greatly to the engine long life. In particular, PS-90A high-time engine was re-equipped with a modified fan, blades with new thermal protection coating, etc.

For four years of its continuous flights (it is 35,000 hours per calendar system) the high-time engine has flown almost all over the world namely: it visited the airports of North and South America, Africa, South-Eastern Asia, Europe and Russia.

Today this «record-breaker» is still being operated by Aeroflot.

In November, 2010 Boris Eliseev, professor, Rector of Moscow State Technical University of Civil Aviation, held negotiations with the representatives of aviation authority of the Republic of Cuba about the possibility of Cuban specialists training on IL-96-300 and Tu-204 aircraft maintenance.

MOSCOW INSTITUTE OF CIVIL AVIATION IS READY TO TRAIN CUBAN SPECIALISTS

The results of this meeting were certain agreements reached which would be bound with respective contracts in the near future. «We are ready to provide training of qualified engineering and technical personnel for Cuba as well as re-education and advanced training for specialists and teachers from this country. Besides, we have an intention to send our teachers to the Cuban training school for pilots and technicians», Boris Eliseev noted.

On December 29, 2010, the first test aircraft Tu-204SM got off to the sky. All aircraft systems were steady and secure. The plane was up over one hour. Operation of new PS-90A2 engine, airborne avionics, high-lift devices and lifting tailplane as well as new air conditioning system has been checked during the flight.

A. Bobryshev, President of Tupolev, thanked the Design Bureau team for its meticulous work as well as the specialists of associated companies and organizations that contributed much to the reliable operation of all systems and components of the new airliner. «I’m sure that Tu-204SM aircraft will become a reliable platform for new development of passenger, cargo, and special purpose», - A. Bobryshev underlined.

Tu-204SM represents a profound modernization of Tu-204 passenger aircraft which has been flying since 1990. According to the experts, the new aircraft match the western equivalents, such as Airbus A320 and Boeing-737, in its parameters.
Preliminary studies of air intake performance of MS-21 aircraft engines, which can be used according to a draft design, have been completed in Central Institute of Aerohydrodynamics n.a. N.E. Zhukovsky. These works have been executed through the request of Irkut and Aviadvigatel.

Specialists of power plant aerodynamics department of the Institute estimated the operation of air intakes of RB 285-70E (Rolls-Royce), PD-14 (Aviadvigatel) and PW 1000G (Pratt & Whitney) engines.

As reported by the press office of Central Institute of Aerohydrodynamics, the air intake models were tested in T-104 wind tunnel using a special screen that simulated a take-off runway. The tests for Foreign Object Ingestion into RB and PW air intakes were carried out at EU-2 test unit. During these investigations the safe operation modes for aircraft with the engine installed were determined.

As a result, the air intake performance at takeoff-landing modes were obtained with a take-off runway screen-simulator available and not. Recommendations on these aircraft operation have been given to the aircraft designer.

In January, 2011 PS-90A3 aircraft engine was certified.

PS-90A3 represents a modification of PS-90A2 engine that was certified in 2009. New development of Perm Design Bureau has kept all the advantages of PS-90A2 relative to the baseline engine: reliability margin of exhaust gas temperature (EGT), longer life of the main parts and improved automatic control system.

PS-90A3 is certified for compliance with Airworthiness Directives 3 (AD-3), Chapter 6, as it provides containment of fan blade over shroud portion in case of its breakoff. At the moment works on PS-90A2 fan case weight reduction are being carried out in Perm.
EVENT

The first phase of the engine core testing has been successfully completed

Viktor OSIPOV

In November, 2010 Aviadvigatel made the first start successfully and testing of PD-14 core-demonstrator for the advanced family of aircraft engines and industrial gas turbines began.

PD-14 core-demonstrator was assembled on October 28, 2010. Aviadvigatel together with other parties of «Engines for MS-21» Project designed and manufactured a core-demonstrator for aircraft engines and industrial gas turbines based on the unified core in a very short time. The work has been done on time which is indicative of the effective work of Design Bureau team.

During his visit to Perm Viktor Khristenko, RF Minister of Trade and Industry, has pointed out that construction of the advanced engine family is a golden opportunity for Russia to gain the world’s recognition for its engine-building industry. «It is the first time in 25 years covering the Soviet and Post Soviet period of the History of Russia that the engine core for the fifth generation engine has been developed. MS-21, a long-haul aircraft of the XXI century, which is now being developed by Irkut it is not the only intended use of it», Viktor Khristenko mentioned. - New Perm engine can be also used at such aircraft as Super Jet-130, Russian-Indian Multirole Transport Aircraft, modifications of IL-76 transport aircrafts, etc. Engines of PD-14 series can be of the utmost significance in gas compressor units and genset of the next generation».

Testing of core-demonstrator started on November 26, 2010. During this testing over 4500 core parameters have been measured. To carry out these tests and engineering follow-up the engine of next generation, a new modern test bench having a unique set of measuring equipment has been upgraded in Aviadvigatel.

Completion of one of the key development stages of a new Russian aircraft engine in time is indicative of the real possibility to implement the Project as well as it proves the technological availability of its participants to do the task set by the Governmental customer within the predetermined deadlines. «We set up a new era of domestic aircraft civil engine-building industry, we constructed a unique and entirely new core which is supposed to be used for future development, certification, and manufacturing of a number of advanced both aircraft engine and industrial gas turbines by our corporation», Alexander Inozemtsev, General Designer, appraised the significance of these events.

The first phase of core testing was completed in December, 2010. At the moment the obtained test data are being processed.
Turbofan by-pass engine. It is designed in 14 ton-force thrust class based on the new low-stage core.

Program status:
• bench running of core and individual engine components;
• technical design completion;
• start of engine-demonstrator manufacturing.

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• bench running of core and individual engine components;
• technical design completion;
• start of engine-demonstrator manufacturing.

MAJOR ADVANTAGE of the aircraft engine
• High efficiency.
• Low life cycle cost.
• Compliance with future environmental standards:
  – noise reduction in reference to the requirements of ICAO, Chapter 4, by 15 EpNdb,
  – NOx emission reduction in reference to ICAO of 2008 requirements by 20...30%.

Work on the development of aircraft engines of the next generation based on the unified core is being carried out in Perm. The baseline engine is represented by PS-14 aircraft turbo-jet engine designed for the advanced aircraft of MS-21 family.

The following leading Russian and foreign companies are involved in «Engines for MS-21» project under the aegis of United Engine Corporation Managing Company:
Perm Engine Company OJSC,
UMPO OJSC and NPO Motor OJSC,
SALUT Engineering Research and Production Center Federal State Unitary Enterprise,
NPO Saturn OJSC GP,
Ivchenko-Progress and others.

The main designer of PD-14 is Aviadvigatel.

Central Institute of Aviation Motors provides scientific support for the project.

Such co-operation aims at decrease the work execution period as well as mitigating technical and financial risks of the Program.
Moscow-Perm videoconference was held in ITAR-TASS (Information Telegraph Agency of Russia) Media Center and Aviadivigtal OJSC conference hall in December, 2010. The day before the 71st anniversary of Aviadivigtal OJSC, Alexander Inozemtsev, Managing Director, General Designer of Perm Design Bureau has answered the questions of Moscow and Perm journalists. The press conference has involved representatives of federal information agencies (ITAR-TASS, ARMS-TASS, Interfax, RIA Novosti and AviaPort), special-purpose mass media (Aviakransportnoe Obozrenie, Vzlet, Aviaglobus, Dvigatel, Turbini i Dizeli, Gas Turbine Technologies, Akademiya Energetiki, etc.) as well as regional television and radio broadcasting companies and periodical publication companies. We are bringing to readers’ notice some extracts from this conference.

ALEXANDER INOZEMTSEV:
<<SUPERPOWER CANNOT EXIST WITHOUT AVIATION!>>

- Mr. Inozemtsev, at the moment the test of PD-14 engine core is in full swing in Perm. Can it be called unique and which advantages does it have in comparison with western equivalents?

- There is no engine core with similar parameters in the world. Works are executed in different companies and they are at different stages: either beginning of testing like in Pratt & Whitney or at the stage of component preparation like in General Electric and Rolls-Royce.

If our engine is successful as we’ve designed it, Russian Aero Engine Industry will be entirely competitive for the nearest 20-25 years. For sure, a new core has been always a risk, it’s an additional risk-taking but we don’t have an alternative because it’s the only way we can come back into the market.

- What are the main advantages of PD-14 in comparison with SaM146, which of its components are ready and what are the terms for its handing over for testing?

- In comparison with SaM146 engine PD-14 is a giant leap forward, speaking about the parameters level. Our engine is of higher efficiency, its specific fuel consumption is 20% less; it has higher pressure ratio, higher by-pass ratio and higher turbine inlet temperature. All that require application of the latest materials and innovative technologies which can be purchased nowhere; and thus, we have to develop them by our own efforts. Virtually, PD-14 is a great step forward regarding theoretical, technical and engineering levels in comparison with SaM146.

As a result, Russian aircraft industry will receive the engine with lower life cycle cost comparing with foreign equivalents, which means that it will be more attractive for air companies.

As of today, engine core, the «heart» of engine, is at the highest degree of completion. It is the main component that comprises 70% of the technical and manufacturing-and-engineering concerns of any aircraft engine. Work on other components is in full swing, such as fan and low pressure turbine. The deadline for demo-engine assembly is April, 2012.

- Mr. Inozemtsev, you’ve managed to establish a good cooperation. Speaking generally, the en-
- We regard the possibilities for cooperation. We’ve made an agreement with Zaporozhe (Ivchenko-Progress, General Contractor – editor’s note) for manufacturing the combustor. Afterwards we will compare Perm and Zaporozhe chambers and make a decision on the best one and which we will use. Beyond all doubts, nowadays it’s impossible to build a competitive engine apart from the world aircraft community.

We are negotiating actively with Fiat branch, Fiat-Avio, and several western companies on establishing a joint venture to manufacture composite engine nacelles. One of the most important competitive tasks is to develop a composite engine nacelle with high level of composite usage. We are negotiating with third-party OEM suppliers who deliver sensors, units etc. We rely on our long-time business partners – Star OJSC and Inkar OJSC – who manufacture fuel equipment and we are looking for suppliers who can hold out us competitive offers.

A high probability exists that western OEM suppliers will appear among those who have been working with us successfully for a long period of time within the serial production of PS-90A and its modifications supplying us plug connectors, bearings and different electronic components. They have been already certified for the serial production. The one reason for involving the foreign companies is that Russian manufacturers are not able to make competitive offers. At the same time we do our best in supporting our Russian colleagues, i.e. we bring them together with western companies for establishing joint ventures.

- How do you think, Perm Engine Company is ready to manufacture the new generation engine?

- Perm Engine Company, our long-time and well-tried business partner, has been selected as the prime manufacturer of the baseline engine family. But, once again, I would like to draw your attention to the fact that we develop a core for the engine family, and we understand well that it would be wrong to place our stakes on one aircraft only because we must be ready for any changes in the market. Thus, engines of different thrust and purposes will be developed on the base of a new core. At the same time it’s not necessary that Perm Engine Company will be the main serial manufacturer but, for sure, it will be a single supplier of core. This is a concept of high reliability and risk mitigation as well as minimum cost of production.

It’s obvious that it’s not correct to speak about the readiness of serial production when first prototypes are being manufactured. Today the plant has a manufacturing engineering program in order to be prepared for serial production of core; this program exists together with the engine certification program. The main work will start when demo engine is manufactured and its performance are evaluated. And only after that we can start discussing the preparation stage for its serial production.

- When are you going to pass the «third gate»? And the second question: How much efficient will be PD-18 engine by its specific fuel consumption comparing with PD-14 baseline engine?

- We’ve signed a joint resolution with Irkut Corporation according to which the «third gate» is planned for April, 2011. The preparation work for this important event involves approximately 25-30% of works related to the aircraft and 75% related to the engine.

«Gate» is the next control point within the project spiral development. The same issues are being reviewed at each higher level: design, technol-

During the media conference. ITAR-TASS. Moscow
ogy, production, marketing, economics, technical risks, etc. I assume that we'll manage to complete all the works within the specified terms and we'll be successful as it has been during the previous «gate».

Speaking about PD-18 efficiency, it is a geared engine of higher by-pass ratio and better parameters. I’ve said many times that by-pass ratio of more than 10 is the advantage of configuration with gearbox. We’ve assumed that PD-18 is approximately 3-5% more efficient than a baseline engine. So, in case of a market demand we are ready to involve our Zaporozhe colleagues in development of this engine.

- **Mr. Inozemtsev, does PD-14 family consider the possibility of developing a helicopter engine? And in case of parallel production of PS-90A2 and PD-14 will it be necessary to expand the production facilities of Perm Engine Company?**

- The helicopter engine is intended to be designed within the program for development of advanced aircraft engines based on the unified core. Dimensions of the baseline core suit perfectly to the engine of the world’s largest commercial transport helicopter Mi-26. Now this helicopter is equipped with a unique Zaporozhe engine D-136 of 10000 h.p. power. Engine based on our core is 10% more efficient and 15% lighter in comparison with its Zaporozhe equivalent.

Perm Engine Company facilities are mostly limited by components and parts manufacturing. The established partnership will allow the leading plant (as for PD-14, it can be Perm, as for PD-18, it can be Rybinsk or Ufa) to increase the plant productive capacity significantly. Now we and NPO SATURN OJSC management are working together on evaluation of our manufacturing capability’s and Rybinsk test facilities in order to «cope with» all three programs: SaM146, PS-90 family and PD-14. Recently we’ve been discussing with colleagues whether it is necessary to provide additional test benches to avoid the lack of test facilities in future. «Enlargement of bottlenecks» includes specialization in components and special processes. It’s a recognized world practice.

- **What is the future of PS-90A2 engine for Tu-204SM aircraft?**

- It cannot be considered that life of this engine is connected to Tu-204SM passenger aircraft only. PS-90A2 can be installed in all types of aircrafts which has PS-90A production engine now.

PS-90A2 engine has comprised our latest knowledge and all our innovative technologies. Its main features are reliability and lower life cycle cost. Thus, future of PS-90A2 engine is connected with both a new aircraft construction and replacement of engines of liner with power plants based on PS-90A, PS-90A1, PS-90A-76, etc. engines.

- **Mr. Inozemtsev, recently there was information in mass media that share of the engine would be approximately 22% in Tu-204SM aircraft cost. Is there any similar estimation regarding PD-14 engine and MS-21 aircraft? And in what way MS-21 with Perm engines will be in competition with an aircraft equipped with American engines?**
One of the main problems of Tu-204SM aircraft is its price. Understanding the fact that we must promote such interesting and necessary aircraft somehow we’ve made a decision to share the costs between all the manufacturers equally where the aircraft is marginal or even loss-making. We’ve agreed that everybody will either benefit or suffer losses equally if we fail to sell this aircraft at the price that satisfies us. We, engine building specialist, were the first who signed the agreement with «Tu» company; the main idea of this agreement is that no matter the selling price of the aircraft would be, we’ve agreed that we would sell two engines for it at 22% of its price. Certainly, it’s great risks. But we cannot see any other way of moving Tu-204SM the world market. We’ll get our own back in case of large order, i.e. about 40 aircraft.

Purchasing complete equipment in lots we will be able to receive discounts and, therefore, reduce all the risks. But, most probably, we will need a governmental support at the initial phase. I don’t know any other project in the world that hasn’t been supported by the government directly or indirectly at its initial phase. It’s a fairy tale about the free market capability to regulate all this. We still haven’t estimated the share of PD-14 engine in MS-21 cost but we understand that one of our competitive advantages over western colleagues and competitors must be the cost of both engine and its life cycle. To reach it we take respective actions. The main idea is that we are designing the engine for the specified production cost for the first time in our practice and, thus, retooling and modernization of the plants is being carried out.

We think that if we manage to offer 15-20% discounts from the price of our competitors and make such a reserve for ourselves, we will be able to compete with well-known western brands. The most important is that due to PS-90A we have a real reputation of selling the life cycle. Now nearly all PS-90A fleet uses western technology; i.e. sale of flight hours. Only the President’s aircraft division uses another technology due to its special conditions. For fifteen years we’ve been demonstrating in actual practice that we are able to sell the engine life cycle in an effective and mutually beneficial way. We count on this when presenting the aircraft and engine to air companies.

- Every fourth person in your Design Bureau is a young man under 30 years old. Is it a tendency for Russian school or an exception? And how do you feel in such a team?

- It’s difficult to say about tendency in the country, but as for us it’s a result of purposeful policy. Haven’t received the governmental support for educating engineers for us, ten years ago we took over our control of the «aircraft engines» department in Perm State Technical University and equipped it. Our specialists teach there, students do their internship with us and after that they start working at our plant. We’re increasing the number of young specialists intensively. There is no any other way out, it must be done in any way.

I’m sure that it’s necessary to keep the aviation capacities of our country. Such a country as Russia cannot bid to become a superpower without aircraft industry. So, we are attracting young specialists actively. This year we’ve recruited 82 persons. There is a small gap among middle-aged employees but these are the consequences of the nineties. Of course, it’s not that easy. It’s common knowledge that for the first 5-7 years a young specialist just disturbs the working process, he/she will make benefit later but there is no any other way for bringing up a true specialist.
IN CLOSE UP

Alexander A. INOZEMTSEV

is a Managing Director, General Designer of Aviadvigatel OJSC, Top Management Head - Chief Designer of the engine of 9...18 ton thrust for MS-21 project of United Engine Corporation Managing Company OJSC.

Born on April 9, 1951 in the town of Kamyshin, Volgograd region. In 1973, graduated from Perm Technical University, specialization in «aircraft engines». The same year started working at Engine Design Bureau (today Aviadvigatel OJSC) as a Design Engineer. Since 1981 - Leading Engineer, Head of Team.

In 1983 at the age of 32 - Chief Designer, Senior Deputy Company Director upon the recommendation of Pavel A. Soloviev. Having high professional reputation in the aircraft industry Alexander Inozemtsev has had a say in complicated technical matters both in Russia and abroad. Since October 1995 Alexander Inozemtsev carries out scientific and technical management of all theme-based works of Aviadvigatel, including civil and military aircraft engines as well as industrial gas turbines based on aircraft engines. Since 1997 he acts as General Designer of Aviadvigatel, Senior Deputy General Director. Since 2001 - General Director - General Designer of Aviadvigatel. From 2003 to 2006 he was the General Director of Perm Motors Group Management Company, General Designer of Aviadvigatel.

Alexander Inozemtsev has participated in design and development of the following engines: D-30-III (Tu-134A aircraft), D-30KU (IL-62M), D-30KP (IL-76), D-30KU-154 (Tu-154M), PS-90A and its modifications (IL-76, Tu-204, Tu-214, IL-96-300 and their modifications), and D-30F6 (MiG-31).

Since October 2006 to the present day – Managing Director - General Designer of Aviadvigatel, head of top management and Designer of the engine of 9...18 ton thrust (for MS-21 project) of United Engine Corporation Managing Company OJSC.

Education of young generation of designers is the key task that is successfully solved by the design bureau and its director. Alexander Inozemtsev combines management of one of the leading design bureaus with his active scientific work. Being a Doctor of Engineering Science, Professor, he is the Head of Aero Engine Department of Perm State Technical University. Alexander A. Inozemtsev is a full member of the Russian Academy of Aviation and Aeronautics Sciences. Mr. Inozemtsev as a scientist is the author of more than 100 scientific and technical publications as well as over 50 patents and inventor’s certificates, 9 textbooks for higher education establishments including «PS-90A Aircraft Gas Turbine Engine», «Design and Operation of Power Plants for IL-96-300, Tu-204 and IL-114 Aircrafts», «Gas Turbine Engines. Design Principles for Aircraft Engines and Power Plants» in 5 volumes, etc.

Alexander Inozemtsev was rewarded for his labor achievements with state and regional industry awards and prizes, namely: Order of Honour, Peter the Great Order and 2nd Class Medal of the Order «For Services to the Homeland». In 2006 Alexander Inozemtsev was awarded the Kosygin Prize for huge achievements in solving the problems of Russia economy development. He was rewarded with the State Prize of Russia in science and technology for construction of a long-haul wide-body passenger aircraft IL-96-300 with PS-90A turbofans.
OPERATION

- STATISTICAL DATA
- REFERENCE INFORMATION
- SHARING OF EXPERIENCE
- PARTNERS
- FOR THE BENEFIT OF THE CUSTOMER
STATISTICAL DATA

RUNNING TIME OF PS-90A ENGINE AND ITS MODIFICATIONS
on the IL-96-300/400T, IL-76TD/MD-90, Tu-204 and Tu-214 aircrafts

<table>
<thead>
<tr>
<th>ENGINES TOTAL RUNNING TIME</th>
<th>IN HOURS</th>
<th>IN CYCLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total running time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• from the beginning of passenger/freight transportations</td>
<td>2,558,114</td>
<td>58,064</td>
</tr>
<tr>
<td>• for the last 12 months (from January, 2010 to December, 2010)</td>
<td>264,642</td>
<td></td>
</tr>
<tr>
<td>Engine maximum total running time</td>
<td>35,471</td>
<td>4,939</td>
</tr>
<tr>
<td>Engine maximum time on-wing</td>
<td>9,936</td>
<td>1,937</td>
</tr>
</tbody>
</table>

FLEET OF AIRCRAFT WITH POWER PLANTS BASED ON PS-90A
AND ITS MODIFICATIONS

<table>
<thead>
<tr>
<th>AIRLINES, AIRCRAFT PLANTS</th>
<th>ENGINE QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Russian airlines</strong></td>
<td><strong>179</strong></td>
</tr>
<tr>
<td>Aeroflot-RAL</td>
<td>41</td>
</tr>
<tr>
<td>Rossiya</td>
<td>43</td>
</tr>
<tr>
<td>Red Wings Airlines</td>
<td>18</td>
</tr>
<tr>
<td>Aviastar-Tu</td>
<td>15</td>
</tr>
<tr>
<td>Orenburg Airlines</td>
<td>2</td>
</tr>
<tr>
<td>Transaero</td>
<td>6</td>
</tr>
<tr>
<td>Kavminvodyavia</td>
<td>4</td>
</tr>
<tr>
<td>Vladivostok Air</td>
<td>17</td>
</tr>
<tr>
<td>Poljot</td>
<td>15</td>
</tr>
<tr>
<td>Volga-Dnepr</td>
<td>17</td>
</tr>
<tr>
<td>ILYUSHIN Aviation Complex</td>
<td>9</td>
</tr>
<tr>
<td>Business-Aero</td>
<td>2</td>
</tr>
<tr>
<td>Airstars Airlines</td>
<td>10</td>
</tr>
<tr>
<td><strong>Foreign airlines</strong></td>
<td><strong>40</strong></td>
</tr>
<tr>
<td>Cubana</td>
<td>24</td>
</tr>
<tr>
<td>Silk Way Airlines</td>
<td>11</td>
</tr>
<tr>
<td>Air Coryo</td>
<td>5</td>
</tr>
<tr>
<td><strong>Aircraft plants</strong></td>
<td><strong>30</strong></td>
</tr>
<tr>
<td>Aviastar-SP</td>
<td>7</td>
</tr>
<tr>
<td>VASO</td>
<td>6</td>
</tr>
<tr>
<td>Kazan Aviation Production Association named after S.P. Gorbunov</td>
<td>9</td>
</tr>
<tr>
<td>Tashkent Aviation Production Association named after V.P. Chkalov</td>
<td>8</td>
</tr>
</tbody>
</table>

**TOTAL:** 249
ENGINES IN-FLIGHT SHUTDOWNs
for 1000 hours of running time according to design and manufacturing defects
(at the end of month, as the average figure for 12 months)

ENGINES UNSCHEDULED REMOVAL
for 1000 hours of running time according to design and manufacturing defects
(at the end of month, as the average figure for 12 months)

DISPATCH OF ENGINES TO THE REPAIRS
for 1000 hours of running time according to design and manufacturing defects
(at the end of month, as the average figure for 12 months)

FACTOR OF DEPARTURES REGULARITY
for aircraft with power plants based on PS-90A and its modifications

IL-96-300/400T, Tu-204-100/300/CE, Tu-214, IL-76TD-90
AIRCRAFT FLIGHTS GEOGRAPHY
Aircrafts with power plants based on the engines of PS-90A family conform meet the Russian and European airworthiness requirements, they feature low operation cost, low noise level and low fuel consumption.

High efficiency and safe operation of «IL» and «Tu» aircrafts is achieved due to gliders aerodynamic efficiency in combination with reliable Perm engines.

**Passenger Aviation**

**Tu-204SM**
Medium-haul passenger aircraft.
It is at flight testing phase at the moment

**Tu-214**
Long-haul passenger aircraft.
Operators: Rossiya, Transaero and Airstars

**IL-96-300**
Long-haul passenger aircraft.
Operators: Aeroflot-RAL, Rossiya and Cubana

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**Specification of the Main Types of Passenger Aircrafts with Engines of PS-90A Family**

<table>
<thead>
<tr>
<th>Characteristics/ Aircraft Main Types</th>
<th>Tu-204-100</th>
<th>Tu-204-300</th>
<th>Tu-214</th>
<th>IL-96-300</th>
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<tr>
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<td>105</td>
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<td>Max payload, t</td>
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<tr>
<td>Course speed, km/h</td>
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<tr>
<td>Max take-off thrust (ISA, H-0), kgf</td>
<td>2x16000</td>
<td>2x16000</td>
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<td>4x16000</td>
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<tr>
<td>Power Plant</td>
<td>PS-90A</td>
<td>PS-90A</td>
<td>PS-90A</td>
<td>PS-90A</td>
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<tr>
<td>Service ceiling, m</td>
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<tr>
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<td>300</td>
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<tr>
<td>Flight crew, persons</td>
<td>3</td>
<td>3</td>
<td>3</td>
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ROSSIYA, SPECIAL AIRCRAFT DIVISION

**IL-96-300PU**
Special purpose aircraft for transportation of the President of Russia, Prime Minister and great officers of the state

**Tu-214PU**
Special purpose aircraft for transportation of the President of Russia, Prime Minister and great officers of the state

**Tu-214SP**
Airborne relay aircraft designed for communication with the great officers of the state, including the areas where receive/transmit signal can be otherwise difficult

### SPECIFICATION OF THE MAIN TYPES
of Cargo Aircrafts with Engines of PS-90A family

<table>
<thead>
<tr>
<th>Characteristics/ Aircraft Main Types</th>
<th>Tu-204C</th>
<th>IL-76TD-90</th>
<th>IL-76MF</th>
<th>IL-96-400T</th>
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<td>Max payload, t</td>
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<td>Course speed, km/h</td>
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<td>PS-90A1</td>
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<tr>
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<td>3</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

CARGO AIRCRAFT

**Tu-204C**
Medium-haul cargo aircraft.
Operators: Aviastar-Tu and Cubana

**IL-76TD-90**
Cargo aircraft.
Operators: Volga-Dnepr and Silk Way Airlines

**IL-76MF-EI**
The modification of the military transportation aircraft.
Operator: Jordan government

**IL-96-400T**
Long-haul cargo aircraft.
Operator: Polyot
### Bulletin Information

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<td>Improvement of engine diagnostics quality.</td>
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<td>94474-БД-Г</td>
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<td>Operability assurance of NP-90A unit in case of MKT-163 and MKT-2032 solenoid failure.</td>
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<td>Power plant – replacement of the mounting brackets of bypass duct fuel manifold installed at the engines with KS 94-03-809 and 194-03-800.</td>
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<td>94481-БД-Г</td>
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<td>Elimination of indicating filter fault signal.</td>
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POLYOT IS SATISFIED WITH THE PERFORMANCE OF A LONG-HAUL «AIR TRUCK»

In December, 2010 Polyot airlines held a flight and technical conference on the results of the first one year of operation of IL-96-400T transport aircraft.

The following representatives of the project teamwork participated in this conference: United Engine Corporation, Ilyushin Finance Co, ILYUSHIN Aviation Complex, Civil Aeronautics State Research and Development Institute (GosNII GA), VASO, Aviadvigatel, and Perm Engine Company. During this conference specialists of flight and technical departments of the airline submitted their reports as well as the analysis of flight and technical performance of IL-96-400T aircraft and PS-90A1 engines was given.

The airlines’ customers expressed appreciation of the aircraft, i.e. its loadlifting capacity, freight compartment volume, nonstop flight range; and fuel consumption complies with the specifications stated which are demonstrated by commercial interest in cooperation with our company. The logical supply chain of cargos by IL-96-400T aircraft to the North and Far East regions of Russia has been developed. For the one first year of its operation the airline permitted 23 Russian airports to accept the aircraft. More than six thousand tons of cargos including high-tech equipment for oil and gas industries, medicines, food products, consumer goods and other have been transported to Yakutsk, Magadan, Petropavlovsk-Kamchatsky and Khabarovsk airports.

Polyot airline positions itself successfully and renders services at international market of the all-cargo service. For the period of its commercial service more than 17 thousand tons of pallet cargo has been transported in transit through Russia from South-East Asian countries and China to Europe. IL-96-400T was accredited successfully abroad and it carries out flights to China, Korea, EC countries, Africa, Asia, Middle East and Australia.

When summarizing the work undertaken, A.S. Kar-pov, General Director of Polyot Airlines, emphasized that IL-96-400T was considered to be the most successful product of Russian aircraft industry. According to the airline Head, Polyot will purchase the fourth IL-96-400T cargo aircraft in first quarter, 2011 and it will ensure a positive growth dynamics of freight transportation in the company as well as future development of cargo traffic services rendered by air transport in Russia and abroad.

Within the period from 2011 to 2016 Polyot airline’s strategy forecasts the increase of IL-96-400T fleet up to 10-12 aircraft.
IL-96-400T long-haul wide-bodied aircraft, transport modification of IL-96, has been developed considering the airlines’ requests and it meets all modern and advanced world requirements. It is designed for transportation of 92 tons payload of 776 m³ total volume for 5000 km range. Range can be 13 000 km at max fueling up (40 tons payload). These figures exceed the transport opponent capacity of equivalent foreign aircrafts.

**Main technical and performance advantages of IL-96-400T transport aircraft**

- High Technical and Economic Parameters.
- Developed support services for aircraft and engine maintenance as well as trained flight and maintenance personnel for these types aircrafts operation.
- Competitive prices for the aircraft and engine compared with foreign equivalents.

**Main design features**

Universal floor mechanization system with standard cargo-loading device and ground equipment allows pallet and container loading onto the upper deck through 4850x2875 mm loading door along the left board and onto the lower deck through 2690x1730 mm and 2690x184 mm loading doors along the right board.

All cargo-loading devices are of a modular type which contributes to reduction of the cargo-loading devices range, its weight as well as facilitation of its operation. There is a compartment for cargo attendants with passenger seats installed.

Avionics updated complex with six LCD displays allows carrying out flights under RVSM conditions.

The aircraft is equipped with rails for floor mechanical means designed for international pallet and container loading.
State research and development institute of a Civil Aviation (GosNII GA) and Aviadvigatel Design Bureau have been working together over decades. At the eighth, anniversary year for GosNII GA, we’ve met with members of the Institute to talk about the mutual work done and prospects for the development.

Alexander Kuleshov, Deputy General Director of Research Scientific Center for Aircraft Engines and Power Plants, and Yuri Tyurin, head of Aircraft Engine and Power Plant System Research Department have taken a share in the conversation.

Alexander Kuleshov:
- We are dealing with D-30, D-30KU/KP and D-30KU-154 continued airworthiness for Tu-134, Tu-154M, IL-62M and IL-76 and we extend their flying lives as well. But, for the most part, we cooperate with NPO SATURN which has been handed over the manufacture of engines in due time. As for Aviadvigatel, we cooperate less with it as with the main designer of these engines.

As for refusal from Tu-134 and Tu-154M aircraft, it’s not a technical issue and it’s out of our sphere. D-30KU/KP engines could still be in operation. The matter is that despite existing equivalents (I mean dimension), their high efficiency and even reliability; there are no many these engines. We do not have a domestic production equivalent for D-30 engine with a big fleet. Thus, our goal it to keep the continued airworthiness of the operable engines.

Yuri Tyurin:
- The first technical requirements for PS-90A engine were given in 1983 and the final one was given in 1985. Engine performances have been constantly modified, particularly the engine thrust was increased from 13 to 16 tons. State testing and certification were completed in 1990. And engine manufacturing started in 1991-1992. Unfortunately, changes that were in process in our country at that period of time had a negative effect onto the engine. For a number of reasons the temperature at the turbine outlet is 1640 K and it could reduce the engine life and reliability of its hot section.

There is one more drawback; it’s an outdated can-type combustor. All modern engines are equipped with annular combustors. In general, the main problem of PS-90A engine is that we do not have a type design. Even a certified engine has approximately 100 deviations from the drawings. Each and every new PS-90A represents another type of an engine, not production one. So, it means that Perm Design Bureau is able to manufacture a good engine. An-
other concern is that in what way it will be manufactured by a serial production factory?

You cannot deny good results of Perm designers’ work regarding the high-temperature turbine and compressor. Among the latest mutual projects with Aviadivitel I can name certification of PS-90A1 for IL-96-400T and certification of PS-90A2 which were completed in 2009.

This engine has a complete modification especially in its hot section. None of domestic civil engines have temperature of approximately 1800 K. And that’s very good! While having developed such turbine, Perm Design Bureau has laid good groundwork for PD-14. It’s very important. Now we are working hard for PS-90A3 engine. And, certainly, we are working hard for PD-14 engine, i.e. technical requirements for it were given in June, 2010 and in November Perm demonstrated new core to the whole world.

- Perm Design Bureau has developed PS-90A-76 engine for IL-76TD-90. But as for modernization of unique «air vehicles», it’s going very slowly. Why?

Alexander Kuleshov:
- First, the process of aircraft modernization and its avionics for PS-90A-76 engine is very expensive. And the cost of engines must be added to this as well. Besides, our civil aviation does not need a great number of ramp cargo aircrafts. To meet the demand for transportation in Russia, 30 to 35 aircrafts will be enough. For the moment only three aircrafts are in operation in Russian airlines, Volga-Dnepr, and two ones are used by Azerbaijan Silk Way Airlines. So, it means that there’s future for fleet development. If western colleagues do not market having more advantageous offers of course. The program for fleet development could be changed at any time depending on the state of the market.

Second, the issue related to the integration of PS-90A-76 for IL-76TD is complicated. For sure, the aircraft acquires great advantages; it permitted to fly all over the world without any restrictions. But there are still remaining problems regarding the effect of engine reverser onto the aircraft design, engine mounting and nacelle; there are some issues concerning the compressor stall margins.

Yuri Tyurin:
- Our Institute has made an agreement with Volga-Dnepr airlines, using IL-76TD-90, for scientific and technical support of engine integration to the aircraft. It covers both certification and support in continued airworthiness. Our suggestion was to modify design and engine adjustments. We assume that it is necessary to modify reversal thrust of PS-90A-76 engine and its reverser because these engines are very high-power ones. The distance between pylons is the same as in D-30KP but midsection is much larger and reversal thrust is large as well and, thus it causes process that affects the compressor stall margins, aircraft design and its strength. In accordance with the technical requirements the weight of reversal thrust is more than three tons.

According to our estimations, in terms of impact on braking function, engine damaging and impact on the wing design as well as the engine mounting (rear mount assembly is not strong enough), it is necessary to reduce this thrust approximately up to two tons.

In this case we are ahead twice: the aircraft design is retained and foreign objects are not ingressed into the engine at the reverse thrust switching. Take-off runways designed for IL-76 are not ideal. Even using D-30KU engine, pilots, as a rule, switch off reverse at 100 km/h speed. Why? It is done not because it’s an appropriate time but because of foreign objects ingestion in engine by airflows. But in improved
IL–76 equipped with PS-90A-76 it occurs less often. So, it means that it is necessary to change setting of the some gas-dynamic parameters that cause the necessity to modify the engine control components. We are busy with it at the moment. This work is very challenging; in my opinion, it requires good knowledge in theory and practice, cooperation with designers of aircraft and engine, experience in operation, some knowledge in history and understanding of the process itself. By the way, Superjet will undergo the same procedure. Despite the fact that this aircraft has been already manufactured. As soon as we start installing the «heart» it will lead to geometry modifications; so, it means that issues related to compressor stall margins, foreign objects ingestion in and moments of take-off and landing must be taken into consideration.

- Let's come back to our attractive project. Is there any program of cooperation between your Institute and our Design Bureau for development of PD-14 engine?

Alexander Kuleshov:
- There is a Federal special-purpose program for development of civil aviation equipment of Russia for 2002-2010 as well as for the period till 2015. In accordance with it there is a program for development of PD-14 engine that covers development of nacelle and engine acoustic panels, technology development for high load parts of future aircraft engines that will be made of composite materials based on polymer metal and ceramic matrix.

We’ve made an offer to Aviadvigatel, within its competence, to develop future and more efficient (it has been shown by experiments) cascade type thrust reverser. This work has been included in our plan for 2011. In 2010 we made estimations for foreign objects ingestion into the engine of MS-21 aircraft. It’s a very long-range work. Both Irkut as a designer of MS-21 and Aviadvigatel as a designer of the engine are interested in it. Despite the fact the Pratt & Whitney engine is designed for MS-21 as well, we’ve made estimations for PD-14 engine. They will determine some criteria for a designer of the engine, nacelle and aircraft.

- In any case, severe requirements for MS-21 aircraft and PD-14 are becoming higher even more. Wouldn’t it become an insuperable obstacle for Russian aviation industry?

Yuri Tyurin:
- It has always been like this. If we are not engaged in development of new technology by cut-and-try method and do not move forward, we can cancel all programs and give way to western manufacturers. If we do nothing, we will never have a chance to win. Besides, designers of aircraft never can materialize their ideas at 100%. And it’s a kind of insurance for them to stiffen requirements for engines. But, anyhow, we must do our best to develop new aircrafts. Presently, there are many complaints against Sukhoi
Company and Superjet. But regarding all the defects and problems, it’s a giant leap forward without which MS-21 would not exist.

In general, this issue covers not even the capacities of our aviation industry. This issue relates to our state and government attitude towards the work of our manufacturers. Recently, MS-21 mockup that is equipped with Pratt & Whitney engines has been discussed. It strikes me that in Perm employees work on three shifts, like during wartime, they manufacture PD-14 for MS-21, but our management still prefers American engines! About 70% of components and materials for MS-21 are made by foreign manufacturers. Regarding Pratt & Whitney engines it will be 85%. How can it be a Russian aircraft?

- But still, which engine is better: PD-14 or PW1400G?

Yuri Tyurin:
- For the moment none of them is ready. But they can be compared by some parameters that are already known. Some confusion is made by Irkut, designer of MS-21. Now MS-21-200 aircraft is designed for 150 passengers and MS-21-300 is designed for 181 passengers. As for MS-21-400, it is designed for 212 passengers. But if we increase the number of passengers, it is necessary to increase the engine thrust as well. Besides, when increasing the number of passengers for MS-21, the route length will be also increased. It means that fuel consumption and engine power will be also increased.

PW1400G engine as an alternative for MS-21-200 is 11 tons and as an alternative for MS-21-300, it is 12 tons. Frankly speaking, it’s very little.

Russian engine has one more advantage: PW1400G has higher by-pass ratio comparing with PD-14. But the higher by-pass ratio is the quicker thrust drop at the run. At test bed PW1400G demonstrates good thrust but in practice during run-up it must drop quicker. But at the same time PW1400G has the best fan speed due to the reduction gear. Therefore, they have more advantages regarding noise environmental measures. And there is one more argument for them. Due to such optimization, PW1400G has less number of stages and 1500 blades less than PD-14. So, it means the engine weight will be less as well.

- Everybody says that it is not possible to develop a new aviation product alone; it requires cooperation of several parties. What do you think about cooperation? In what way will it be better to arrange cooperation: external cooperation as for development of SaM-146 or internal cooperation as for development of PD-14?

Alexander Kuleshov:
- Even if we managed to cooperate with leading companies regarding components, it could be a big progress. It would involve new technologies, standards, industrial standards, new machinery equipment and many other positive issues. But, for sure, it would be better if we manufactured everything by ourselves. Especially, it concerns military equipment. But life shows that it is necessary to take all the opportunities for exchanging resources and technologies. The main idea is that this exchange must be equal but not humiliating. Integration processes must involve more participants. For example, practically all leading engine companies of the world, such as Rolls-Royce, Pratt & Whitney and General Electric were involved in the process of engine development for Airbus-400.

Yuri Tyurin:
- I’m a patriot of my country and I’m sure that PD-14 is the last chance for modern engine development. In 1960, when I started working in this sphere, there were good designers in the USSR, the science was at its best, there were good materials but awful technologies. And they haven’t become better. We have just fallen behind during «perestroika» and «post-perestroika» years and lost the key group. Today, NPO SATURN is the best serial production factory in Russia by its equipment that had started purchasing up-to-date equipment earlier than different state programs were implemented. But its share in manufacture of SaM-146 is about 7-10% only. Is it a good cooperation?

Cooperation of European companies is a justified step. They follow harmonize rules and they are located not far from each other. But MS-21, declared as short-medium haul aircraft, in what way will it be used at our distant areas? And in case of breakage, in what way will foreign spare parts, which it is 70-80% made of, be delivered here? This situation is the same as with foreign cars. It’s rather cheap to buy parts but maintenance is very expensive; and our roads differ greatly. The situation is similar: Russia needs an aircraft that can be used under harsh conditions of domestic aviation industry.

- But despite the problems of Russian engine-building industry it is not only alive, it is still capable. Core, developed for PD-14, could be a good evidence for this. What would you wish Perm designers and entire Russian engine-building industry?

Alexander Kuleshov:
- I would like to wish new projects as well financial abilities for their implementation and qualified specialists to the aviation industry. Well, and, for sure, cooperation with GosNII GA.

Yuri Tyurin:
- I would like to wish power, patience and good knowledge to develop good technology for our domestic aviation. We must remember that Russia has always been, is and must be a superpower of aviation. And we must do our best to ensure it this status.

Viktor OSIPOV, interviewer
AVIADVIGATEL OJSC

RELIABLE PROTECTION FOR YOUR BUSINESS
PERM ENGINES ARE SAFE FROM ICING

In 2010 certification tests of PS-90A engine in simulated ice forming conditions were carried out at the altitude test facility of Central Institute of Aviation Motors n.a. P.I. Baranov. According to the test results in November of the last year the Presidium of Air Register of Interstate Aviation Committee made a decision on issuing a Supplement to type-certificate data sheet to Aviadvigatel regarding lifting of restrictions on the engines of PS-90A series when operated in ice forming conditions.

ISSUE BACKGROUND

Reliability assurance of anti-icing protection is an important part of the general requirements for the aircraft engine reliability. When certifying PS-90A engine during 1989-1991, the engine tests were carried out at the designer’s test bench (Perm Design Bureau) in simulated ice forming conditions at the main operation modes at natural outside air temperature of \( t_{\text{ambient}} = 0 \ldots -22 \) °C.

As a result the methods of ice clearing, formed at the parts of engine inlet (repeated «throttling» in every two or three minutes of operation at «idle» and «0.4 rated» power) were tried out and restrictions on the operating time in ice forming conditions at nominal mode as well as on outside air temperature when operating engine in ice forming conditions \( t_{\text{ambient}} \geq -16.5 \) °C were imposed.

During 1991-1995 a heated fan cowl was integrated in PS-90A engine design and additional certification bench run tests in simulated ice forming conditions at the modes with maximum ice formation were carried out. According to the additional test results the requirement for obligatory throttling when operating in ice forming conditions has been lifting as well as the permitted operating time at rated mode has been increased.

Operability of PS-90A engine in ice forming conditions has been checked both during flight test of IL-96-300 and Tu-204/214 aircraft and during PS-90A operation in natural ice forming conditions.

Hereafter, bench run tests of PS-90A engine in simulated ice forming conditions within the temperature range of \( t_{\text{ambient}} < -16.5 \) °C have been stopped.

The was a number of reasons to proceed with additional certification tests in simulated ice forming conditions of up to \( t_{\text{ambient}} = -30 \) °C.

First, to competitiveness growth of the aircraft of Tu-204/Tu-214 family in the world market it is planned to certify them in accordance with ETOPS-120 regulations. At the same time the mandatory requirement for the engines of PS-90A family is the extension of ambient air temperature limits while ensuring engine safety operation in ice forming conditions of up to \( t_{\text{ambient}} = -30 \) °C instead of the current limitation of up to \( t_{\text{ambient}} = -16.5 \) °C. However, the values must not be lower than the ones specified by the engine certification results.
Second, PS-90A2 engine has been certified as per Aviation regulations (AR-33) according to which the engine anti-icing protection must be proved up to $T_{\text{ambient}} = -30 \, ^\circ\text{C}$ in ice forming conditions.

**PRE-TEST ACTIVITIES**

To carry out certification tests of PS-90A engine and its modifications in simulated ice forming conditions the following preparatory works have been done:

- the most critical icing conditions for engine parts have been determined by the calculation-and-analytical investigation made in Central Institute of Aviation Motors;
- upon the investigation made, the specialists of Central Institute of Aviation Motors and Perm Design Bureau have developed the engine test program for the most critical icing conditions.

To carry out tests, such unique equipment as 2.2 m DN water-spray manifold, including 11 pylons and 85 water spray nozzles, air supply line, video-section with heated inspection windows, supports for video camera installation and other have been designed and manufactured in Central Institute of Aviation Motors.

Prior to engine installation onto the test bench, such calibration tests as aerodynamic calibration, test bench calibration for water drop uniform distribution in the incoming air flow, drop water content and size, drop overcooling level and other have been carried out.

The specialists of Aviadvigatel have designed and manufactured an adapter to connect the engine with the test bench air inlet, control and alarm panel, electric wiring harness and jumper cables to connect the equipment to power supply, engine electric connectors and test instrumentation systems; test bench equipment for engine installation and its connection to the test bench systems has been prepared and sent to Central Institute of Aviation Motors. To register the engine parameters and running signal, provide data exchange between the test instrumentation systems of Central Institute of Aviation Motors and Aviadvigatel, adequate high-technology software for «Parus-M» measurement system has been developed within a short period of time. It has been interfaced with the intelligent system of Central Institute of Aviation Motors and endured parameters measuring and data and warning recording as well as the information exchange between the intelligent system during testing.

In accordance with the test program requirements additional pressure and temperature probes that meet PS-90A2 configuration as well as additional vibration...
measuring transducers and pressure pulsation sensors have been installed at PS-90A engine inlet.

TESTING

The altitude test facility represents an environmental chamber where the specified atmospheric conditions are maintained during testing. Test of each operating condition required much electrical power and PS-90A engine operation involved all power of the altitude compressor station of Central Institute of Aviation Motors. Thus, prior to each mode testing long preparatory work has been done. Several hours before the engine start compressors and cooling plants of the station were activated and then environmental chamber was started. And only after that the command to start the engine was sent. The most difficult point of this testing was to ensure the required parameters at the engine inlet and after the exhaust nozzle. The specified altitude, airspeed, ambient air temperature and humidity were maintained simultaneously and accurately.

During testing there was a continuous video monitoring of the engine elements subject to icing and it allowed watching the icing process and ice clearance. Ice bodies at engine parts were measured thoroughly and photographed after each operating mode.

Prior to changing the engine operation mode it was necessary to change the air parameters in the environmental chamber beforehand, i.e. mismatch of air flow through the environmental chamber and the engine could cause engine surge or damage to the environmental chamber equipment. It complicated the test engineers' task significantly because besides the engine parameters they had to control additional parameters and synchronize its modes with the air parameters of the environmental chamber.

RESULTS

The tests carried out proved the efficiency of anticing protection as well as the operability of engines of PS-90A family in ice forming conditions. Under similar conditions there is no inadmissible thrust reduction, EGT increase and engine vibration in excess of the permissible level and there is no intolerable parts damage either. Having made all necessary inspections in ice forming conditions, including the engine acceleration, the engine is controlled steadily and its running states change according to the TLA position.

Damage of the fan rotor caused by the ice ingestion into the engine during testing, did not have a negative influence on the engine operability. Though having damage sustained, the engine continued to operate steadily, which was indicative of the possibility for further safe flight. The engine damage can be repaired by cleaning or replacement of fan blades.
PERM IS AGAINST PIRATED GOODS

Mikhail P. KEDALO
Sergei A. GACHEGOV

In October, 2010 Multiregional Research and Development Aviation Association under the aegis of the Federal Customs Service organized and held all-Russian research and practice conference called «Product Quality Assurance in Aircraft Engine Industry and Prevention of Pirated Components Supply». The reason for this conference was the critical conditions appeared in the aircraft engine industry due to the continuous supply of pirated goods.

Urgency of the problem as well as the necessity to take immediate anti-pirated measures has determined the composition of the conference.

Representatives of the government of Russia, Federal Customs Service, Ministry of Transport, Ministry of Trade and Industry, representatives of State Duma and Federation Council as well as leading specialists of Federal Air Transport Agency (Rossaviatsiya), Air Register of Interstate Aviation Committee and GosNII GA, departments, factory managers of aircraft engine industry and others participated in this Forum. Perm engine industry has been represented by A. Inozemtsev, General Designer of Aviadvigatel OJSC; M. Dicheskul, Managing Director of Perm Engine Company OJSC and S. Gachegov, Head of Quality Management and Certification Department; and T. Voronina, Chief Controller of Reductor-PM OJSC.

At the conference areas of focus and measures implemented by the companies to assure the product quality and protect it against falsification have been demonstrated as well as proposals for the activity improvement have been worked out.

The report of Perm Engine Company OJSC representatives on putting into service «Manufacturer» module which is an integral part of the information and analytical system for monitoring of the aircraft airworthiness has drawn special attention of the conference participants. It has been developed and put into service in accordance with the special-purpose programs called «Development of Civil Aviation Technology of Russia for 2002-2010 as well as for the Period till 2015» and «Government Program for Aviation Safety of Civil Aircraft» and it has become the first phase in the company’s activity for protecting the output product against pirated goods.

«Manufacturer» module provides computer-generated forms of engine log books and certificates of incoming purchased components. The data on the engine design, life and other is entered in the computer generated forms and certificates from the automation systems applicable at the company. At the same time subscription lists are photographed and attached to the relative file. After that the information is transmitted automatically to the central database of the information and analytical system.
FOR THE BENEFIT OF THE CUSTOMER

for monitoring of the aircraft airworthiness via the secure information channels on weekly basis. Airline logs in the central database via the «Operator» module, opens a computer-generated log book or certificate and compares it with the original one. The authenticity of the aircraft component or a component part can be confirmed in such a way. Currently, the specialists of such airlines as Volga-Dnepr, Polyot and Red Wings are utilizing this algorithm successfully.

As of the beginning of October, 2010 the information on 89 PS-90A engine log books, 9000 certificates for incoming purchased components, 360 certificates for component parts, replaced in operation, was entered in the central database of the information and analytical system for monitoring of the aircraft airworthiness.

In the near future «Perm Engine Company Representative in Operating Organization» module (including foreign operators of the engine of PS-90A family) as well as «Perm Engine Company Representative in Aircraft Construction Company» module (20 and 4 computer workstations accordingly) are planned to be developed and put into service at Perm Engine Company. These modules provide on-line information entry into the central database using the computer-generated forms of engine log books and certificates of incoming purchased components when replacing in operation, installing engine into the aircraft frame and completing bulletin. Modules configuration and procedures of their functioning have been already agreed with the specialists of GosNII GA. The work will be continued when the funding source is determined.

One of the trends to improve the maintenance process of aerotechnics in operation and its protection against falsification is the integration of radio-frequency proximity identification into the information and analytical system for monitoring of the aircraft airworthiness. This technology is based on RFID principles and provides application of special radio-frequency (RF) marks onto the components and LRUs of the aircraft engine. RF mark includes the information that is identical to the one contained in the engine log book and component certificate. Currently, GosNII GA carries out works to determine the hardware base and assesses the possibility for RF marks implementation. Later the information will be handed over to Perm Engine Company to proceed with the issue regarding its implementation.

According to Mikhail Diceskul, Managing Director of Perm Engine Company, early implementation of the adequate software has already let Perm engine manufacturers and GosNII GA specialists start developing common information space for timely monitoring of the aircraft engine airworthiness and protection of the operator against the pirated goods.
PS-90A aircraft engine, being the most complex invention of a human thought, must be maintained by highly qualified personnel. Customer Training Center of the Customer Support Department, Perm Engine Company, has taken responsibility for training such specialists. Every year in this training center over 200 specialists improve their qualification and the specialists of both Russian and foreign airlines having aircraft equipped PS-90A engines are trained here as well.

«When our specialists are away from Perm in any place of the world where Perm engines are in operation, they face various problems not only of technical nature. In such situations people must have encyclopedic knowledge and they must be able to make responsible decisions instantaneously, - believe Mikhail Dicheskul, managing director of the plant. - Company’s management must pay special attention to the training of specialist of such a level».

The Training Center activity meets all the modern requirements for the educational establishments. Advanced training methods are used, methodical literature is prepared and published as well as new educational technologies are being introduced in this Training Center. Training programs includes seminars and meetings, professional skill competitions and presentations of new scientific and technical achievements.

As of today the following software has been developed and is used successfully:
- «BAZIS» software and hardware complex designed for continuous improvement of engineering operation personnel skills for PS-90A engine;
- «Test» software to control the attendees knowledge in specified courses;
- «ZOOMER», information and analytical software to estimate HPC and HPT defects;
- «Kadr» software designed for electronic registration of the Customer support department ployees’ certification.

At the moment we are introducing a training program for preliminary accreditation in HSEA for managers and specialists of the Customer support department in Perm Engine Company. A study room for practical training in maintenance of PS-90A engines is equipped...
with a set of visual aids and samples of standard components of the aircraft engine: PS-90A engine mockup and its core, booster compressor and turbine module, fan shaft, combustor, etc.

Attendees are provided with up-to-date personal computers having respective software, maintenance and technical documentation (engine operation manuals, bulletins, maintenance engineering guidelines and techniques), training manuals issued under supervision of leading specialists of Perm Design Bureau (designer of PS-90A engine and its modifications), repair instructions and other technical documentation. «Test PS-90», special software, is used to test the attendees’ knowledge.

Without doubt, all these facilities contribute both to the proficiency improvement of Perm Engine Company representatives in operating companies and competent and accurate system for maintenance of Perm engines at Customers’ sites.

Representatives of Perm Engine Company and Silk Way Technics. Testing of engine systems after a regular flight

THE FOLLOWING TRAINING PROGRAMS ARE AVAILABLE:
(including the ones for representatives of operating companies)

- PS-90A and PS-90A-76 Aircraft Engines (Power Plant) | 118 hours
- PS-90A and PS-90A-76 Aircraft Engines (Aircraft Equipment) | 118 hours
- PS-90A and PS-90A-76 Aircraft Engines (Modules and Components Replacement) | 152 hours
- PS-90A and PS-90A-76 Aircraft Engines (Replacement of Units) | 140 hours
- PS-90A and PS-90A-76 Aircraft Engines (PKN-90 Control Panel Operation) | 56 hours
- PS-90A and PS-90A-76 Aircraft Engines (Gas Path Inspection) | 40 hours
- Training and accreditation of operating companies’ specialists how to eliminate damages at compressor blades and vanes of PS-90A and PS-90A-76 engines as well as gas turbine units during operation | 118 hours
MODERN ENGINE BUILDING

• NEW HORIZONS
• APACE WITH SCIENCE
Almost all Russian aircraft engines that have ever launched aircrafts were developed with direct involvement of Central Institute of Aviation Motors n.a. P.I. Baranov, Federal State Unitary Enterprise. Perm engines developed by Aviadvigatel OJSC, are not exception. Over a period of its seventy-year existence Perm Design Bureau together with Central Institute of Aviation Motors have been determining characteristics of the engines developed, tendencies for their components improvement, provide engineering and technological groundwork for elements and components of the engines with high level parameters including those that are based on application of conceptually new materials and processes. Recently, Central Institute of Aviation Motors has celebrated its 80th anniversary. Aviadvigatel and Central Institute of Aviation Motors keep their cooperation and here we would like to present some of their joint projects and latest achievements.

COMPRRESSOR

Within the program of PD-14 base-line engine development for the advanced engine family of 9-18 ton-force thrust for a short-medium haul aircraft, Perm Design Bureau and Central Institute of Aviation Motors have made a joint aerodynamic design of fan and add stages. S-179 (D=400 mm) fan fabricated model has been tested successfully in Central Institute of Aviation Motors. Tests of S180-2 (D=700 mm) LPC model are planned to be carried out at TS-3A test bench in 2011.

At present the specialists of both companies are developing of evaluation methods for structural strength of a hollow wide-chord fan blade and study the properties of nanopatterned titanium. It is necessary in order to determine both the influence of blade manufacturing process onto WT6 material properties and mechanical characteristics of nanopatterned titanium.

Today, aerodynamic and strength optimization of HP compressor design for PD-14 advanced engine and wide range of teamwork for the project technical supervision are being implemented with active participation of Central Institute of Aviation Motors.

A range of joint analyses and experimental works for A1 high-pressure stage development can be considered as the latest common achievement; these works provided the basis for aerodynamic design of HP compressor of advanced turbofan engine family. Within the scope of these works they investigated the efficiency of high-pressure stage application throughout the operating range as well as they substantiated the application efficiency of over rotor unit at high-pressure stage by experiments.

To improve the acoustic efficiency of PS-90A engine, the specialists of Central Institute of Aviation Motors have designed the air intake alternative with negative inlet scarf angle; they made 3D-computations of its airflow and received aerodynamic performance. The results of this work are used for development of PD-14 air intake.
COMBUSTOR

Aviadvigatel Design Bureau agreed with Central Institute of Aviation Motors the technical requirements, grounds and proposals for development of the low emission combustor of long life for PD-14 engine.

For the first time in Russian practice the specialists of Aviadvigatel, basing on the industry experience, developed the annular combustor of modern design with conceptually new construction solutions for the civil engine:
- multimodule flame tube head having forty-eight like-on-like superimposed nozzles which uses the airflow for the fuel atomizing,
- three-collector fuel supply system,
- liner with segmentary cooling system, etc.

Full-scale tests of the combustor and independent test of full-size combustor carried out in Central Institute of Aviation Motors and Aviadvigatel proved the possibility to achieve the majority of specifications required, which is a great success.

When Central Institute of Aviation Motors executed some works on the initial design of combustor for PD-14 advanced engine, activities for its engineering follow-up have been worked out to improve its design. The solutions offered to improve starting, extend steady-state combustion range, enhance combustion efficiency at idle power, extend liner life, etc. These are based on the results of 3D-computations, combustor tests, independent tests of nozzle modules and liner segment and tests of full-size combustor.

Central Institute of Aviation Motors has unique experimental facilities to test combustor and their components including those for to carry out tests under off-design or severe operation conditions at high and low ambient temperatures and fuel temperatures and high air humidity. Central Institute of Aviation Motors carried out tests of combustor of baseline turbofan engine at special operating conditions at Tk air inlet temperature of up to 900K, Pe pressure of up to 3.6 MPa and at low-thrust power with air humidity of up to 50mg/m³ and determined basic parameters (steady-state combustion range, combustion efficiency, liner sections thermal state, etc.). At present independent tests of full-size combustor are at their final stage (combustor prototype of PD-14 engine); these tests are carried out at ICAO takeoff-landing cycle to determine emission level, temperature field as well as other characteristics. In the near future Central Institute of Aviation Motors will carry out full-scale independent integrity tests of PD-14 combustor under wide range of operating conditions.

Considering their own experience the Institute's specialists design and manufacture test bench equipment to carry out engineering follow-up on the combustor at Aviadvigatel test facilities. By Perm Design Bureau order Central Institute of Aviation Motors develops methods for combustor design improvement, studies the possibility of applying new materials and thermal protection coatings inside it.

TURBINE

When developing and certifying PS-90A2 engine, the specialists of Central Institute of Aviation Motors have been reviewed HP turbine aerodynamic design, cooling system design and thermal state of HP and LP turbines. Design models have been verified by joint efforts of Central Institute of Aviation Motors and Aviadvigatel. As a result PS-90A2 engine was successfully certified that proved the declared parameter of efficiency for HP and LP turbines.

During aerodynamic design of HP turbine for PS-90A2 engine the software and methods, developed by Central Institute of Aviation Motors, were widely used. At present during aerodynamic design Aviadvigatel Design Bureau applies software for three-dimensional continuous computation of multi-stage turbines for inviscid (3D-Euler) and viscous flow (3D-Navier-Stockes), and software for 2D viscous flow of airfoil row (2D-Navier-Stockes). Methods integrated in this software summarize longstanding theoretical and experimental experience of the Institute and the most sophisticated approaches to numerical simulation are used during their implementation. Application of software solutions developed by Central Institute of Aviation Motors that
have been integrated during aerodynamic design allows improving the computation accuracy significantly as well as reducing the turbine design period.

In 2009 the tests of full-size single stage HP turbine with high pressure ratio, developed by Aviadvigatel specialists, were carried at TS-2 test bench in Central Institute of Aviation Motors within Federal special-purpose program «Development of Civil Aviation Technology of Russia». This turbine has been designed according to the following unexampled parameters: total pressure ratio was 4.7 and efficiency = 87.2%. Pressure ratio $\pi^* = 4.7$ implemented in the design is unparalleled in the world. HP turbine of CFM56, E3 and PW6000 engines has a $\pi^* = 4.0 – 4.15$; HP turbine with $\pi^* = 4.6…$ has been investigated in LEAP56 advanced program. To ensure the required aerodynamic efficiency, much work has been done to optimize the geometry of a turbine flow passage as well as new engineering techniques have been applied. According to the test results the initial efficiency of HP turbine was ca. 88% with $\pi^* = 4.8$ peak pressure ratio at HP turbine. When working on this turbine the specialist of Central Institute of Aviation Motors carried out experimental studies of different airfoils alternatives at U-300S test bench to prove their design characteristics.

Now Perm Design Bureau is working extensively with Central Institute of Aviation Motors for purposes of PD-14 engine development. Considering technical solutions and methods tested in PS-90A2 engine turbines and single-stage HP turbine with high pressure ratio as well as recommendations of the Institute's specialists Aviadvigatel has developed HP turbine for a demo-engine. Methods and software developed by Central Institute of Aviation Motors have been widely used during its design. HP turbine design optimization which was made considering comments and recommendations of the specialists of Central Institute of Aviation Motors provided the required design parameter for efficiency, service life and weight.

Central Institute of Aviation Motors it was decided to change one-layer acoustic panel to two-layer one (acoustic panel of the second generation). This allowed extending the acoustic absorption band without reducing efficiency at the main frequencies of fan blades and their harmonic. Calculation and experimental works were carried out and parameters of two-layer acoustic panel were determined by mutual efforts of the specialists. The results of specimen test at «duct with flow» test unit were of great importance; where the most complex acoustic analyses of acoustic panel parameters and aircraft noise with engines equipped with these acoustic panel was made prior to, during and after the tests. The results of these works have been agreed between the Institute's specialists and other organizations. The combination of several variants (sizes) of two-layer acoustic panel...
has been found and it allowed proceeding to serial production of the components.

During the period from 2003 to 2006 the following systems and components were tested as part of PS-90A engine:
- initial noise supression system to compare with flight acoustic certification data;
- separate components with acoustic panel of the second generation to estimate the noise supression system efficiency elementwise;
- new (modified) noise supression system to confirm the stated characteristics and type certification;
- different combinations of initial and new components were tested to evaluate the possibility for further reduction of aircraft noise.

Involving the specialists of Central Institute of Aviation Motors, Aviadvigatel Design Bureau developed experimental facilities and improved the accuracy of tests carried out at its open test bench in Perm. Now this test bench meets OST 1 00036-84 requirements for acoustics, it is equipped with adequate set of Bruel & Kjaer equipment to measure the acoustic parameters both in far and near fields.

Aircraft of IL-96 and Tu-204 families with PS-90A engines that are provided with acoustic panel of the second generation are certified for compliance with the standards of ICAO, Chapter 4. Today these airliners are permitted to fly all over the world without any environmental noise restrictions.

Besides a number of joint analyses for sound-wave propagation, related to the rotor-stator-fan interaction and outlet straightener in air intake of PS-90A engine, were made. The analyses were made by means of high-order solver (3DAS) developed by Central Institute of Aviation Motors. The results allowed Aviadvigatel to estimate the contribution of noise interaction to the engine cumulative noise level at the forward hemisphere as well as develop and verify its own software to analyse the sound propagation in ducts.

At the moment Aviadvigatel and Central Institute of Aviation Motors cooperate actively in the sphere of acoustics and simulation for complex non-steady-state flows in turbomachines. The Institute’s specialists investigated sound propagation in ducts with noise-attenuating walls; the results of computational investigation of combined noise supression system for the air intake have been submitted. It includes a standard acoustic panel and spacer ring. Use of similar systems will provide the aircraft equipped with advanced PD-14 engine compliance with the international environmental noise requirements.

In addition under partnership with Central Institute of Aviation Motors research works regarding the simulation of bleed air influence onto the transient loads and vibro-stress state of turbomachine airfoil are being carried out. Using the theoretical estimates and experience of Central Institute of Aviation Motors, the specialists of Perm Design Bureau are able to evaluate the accuracy of their own predictions and improve the quality of models used for design. Continuous sharing of experience contributes to new knowledge acquisition which provides the designed products with the required reliability as well high efficiency and environmental parameters.

Today in Perm PD-14 baseline engine core is assembled and its testing is started. The «heart» of the whole family of advanced engines for short-medium haul aircraft started beating. Cooperation with Central Institute of Aviation Motors contributed greatly to the success of Perm Design Bureau. We are sure that such a big event as a construction of the advanced core will become the starting point for a new phase in the longstanding history of effective cooperation between Aviadvigatek OJSC and Central Institute of Aviation Motors n.a. P.I. Baranov, Federal State Unitary Enterprise.
Now the phrase «Redline parameter» is often used during technical meetings of different levels regarding thermodynamic performances of aircraft engines and industrial gas turbines. It points to the fact that this issue is significant and important.

What is the meaning of this imposing foreign phrase, «Redline»? It is the maximum allowable values of main parameters that determine the engine operational reliability and their exceeding is not allowed during operation.

The values of Redline parameters are determined at the engine design stage and they are used in gas-dynamic, thermal and structural analysis. It should be demonstrated that engine life and reliability including Redline parameters are ensured in accordance with the Technical Requirements for the engine.

Certainly, engineering estimates play key role when determining Redline parameters but the most important point is the experimental demonstration of engine operational capability having Redline parameters.

In accordance with the requirements of the Aviation Regulations (AR-33) Redline parameters are confirmed with a special 150 hrs endurance certification test. For sure, the higher Redline parameters are, the more difficult is to ensure and confirm them. But at the same time it is necessary to understand that the level of Redline parameters is the level of reliability and future for engine development; generally speaking, it’s the level of an engineering company.

The main Redline parameter is gas temperature at turbine inlet (at 4.1 critical section) We will talk about this parameter, i.e. \( T_{4.1}^{*} \) RL. It should be mentioned that various engine-building companies may use absolutely different approaches to determine \( T_{4.1}^{*} \) RL. It is caused by differences in the engine design, various levels of technological advance during engine development, company’s achievements in developing this or that engine component, customer’s requirements, etc.

But when determining \( T_{4.1}^{*} \) RL there is one common point for all the companies, it is «increments», one more foreign word that means «increase, deviations». In other words, when determining \( T_{4.1}^{*} \) RL it is necessary to know not only all the factors that influence \( T_{4.1}^{*} \) during service life, i.e. from the moment of engine manufacturing till its decommissioning, but it is also necessary to know possible values of \( T_{4.1}^{*} \) increase (deviations) that are caused by these factors.

For the first time we met such an approach in determining Redline parameters at the beginning of nineties when we were working on the project for PS-90PSKh engine with SNECMA company and later when we were working on the projects for PS-90P and PS-90A2 with Pratt & Whitney.

Some examples of the approach in determining \( T_{4.1}^{*} \) RL for CFM-56 and RB-211 engines are shown in the figure. Clearly, that \( T_{4.1}^{*} \) of so called «poor» engine is taken as basis, i.e. temperature of the engine having the highest \( T_{4.1}^{*} \) level according to the test results prior to its commissioning. At the design stage \( T_{4.1} \) deviations from the average new engine related to the variation during manufacture, are estimated according to the statistical data gained by testing of prototypes and equivalents. This value for each manufacturer can vary. \( T_{4.1} \) variation coming from manufacture is 4% for CFM-56 engine.
NEW HORIZONS

TEMPERATURE MARGIN for CFM-56, RB-211 and PS-90A2 engines

CFM-56 ENGINE

<table>
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<th>RL</th>
<th>T*4.1</th>
<th>acceptance tests, «poor» engine</th>
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</thead>
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<tr>
<td>100</td>
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<td>90</td>
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<tr>
<td>80</td>
<td>80</td>
<td>Manufacturing variation of parameters</td>
</tr>
</tbody>
</table>

RB-211 ENGINE

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<th>acceptance tests, «poor» engine</th>
</tr>
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<tr>
<td>100</td>
<td>100</td>
<td>3.7%</td>
</tr>
<tr>
<td>96</td>
<td>96</td>
<td>2.6%</td>
</tr>
<tr>
<td>90</td>
<td>90</td>
<td>Manufacturing variation of parameters</td>
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</table>

PS-90A2 ENGINE

<table>
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<th>T*4.1</th>
<th>acceptance tests, «poor» engine</th>
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<tbody>
<tr>
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<td>100</td>
<td>1.2%</td>
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<tr>
<td>94</td>
<td>94</td>
<td>3.1%</td>
</tr>
<tr>
<td>88</td>
<td>88</td>
<td>Manufacturing variation of parameters</td>
</tr>
</tbody>
</table>

Another important characteristic of $T_{*4.1}$ is the possibility to develop engine modification with augmented thrust (power). So, margin for EGT of GE90-76B engine with thrust $R_{\text{takeoff}} = 34.6$ ton-force, which is $\Delta T_{*4.1}^{\text{RL}} \sim 160$ °C, has been used partially to develop a modification of GE90-85B having thrust of $R_{\text{takeoff}} = 38.4$ ton-force with margin $\Delta T_{*4.1}^{\text{RL}} \sim 120$ °C as well as a modification of GE90-90B having thrust of $R_{\text{takeoff}} = 40.8$ ton-force with margin $\Delta T_{*4.1}^{\text{RL}} \sim 80$ °C.

At the moment the achieved $T_{*4.1}$ margin of PS-90A2 engine, that was received according to the results of successful certification test of engine No 93-02, is 9.8%; and this allows us to put this engine into operation.

Aviadvigatel is working on the increase of $T_{*4.1}$ margin up to the design level of 12.5% from the «poor» engine level. It will allow Perm Design Bureau to meet the best foreign equivalents and, as a result, have possibilities to improve the performances of both aircraft engines of PS-90A series and industrial engines based on the core of PS-90A engine.

The «margin» value for TET and equivalent «margin» value for EGT play the key role both for aircraft engines and engines of ground application. Foreign and domestic experience shows that more than half of the engines being in operation are taken out of services due to the defects of their hot gas path. Thus, the higher $T_{*4.1}$ RL level is, the more time engine will be in successful operation and, therefore, it will bring dividends. Besides, the engine will produce declared parameters being in operation for a longer period of time and, thus, it will sustain a high brand image of the engine engineering company and manufacturer as well it will maintain great demand for this product with all the consequences that come with it.
UP TO THE WORLD STANDARDS

- DESIGN BUREAU TEST FACILITIES
- CERTIFICATION
PD-14 IN NEW DIMENSION

The test bench equipped with a unique set of equipment for measurement, information transfer, storage and processing has been reconstructed to carry out tests and development of PD-14 engine in AviadvigateL The technology of maximum engine preparation in the assembly shop has been applied for the first time. We asked Khamit FATYKHOV, Deputy Chief of Test Measurement Technique and Metrology Department, to tell us more about the test bench measurement systems.

AviadvigateL new test bench includes many subsystems, from the engine control to video monitoring systems, and it differs radically from all other test benches having been previously used by the company. The experience of leading domestic and foreign engine building companies have been considered during its design.

The modern conceptual design of computer-aided information and measuring systems intends integration of all measuring and control subsystems into a single complex. To carry out tests of AviadvigateL PD-14 engine core, NPP MERA and ENRIMA LLC have developed «PARUS-M9» computer-aided two-level system in a very short time.

This system allows test engineers to monitor the parameters, within their responsibility, as well as it provide access to all the parameters that are registered at the test bench. In addition to data translation, the system processes and visualizes estimates of the selected parameters and issues warnings about the increased and unsafe levels. It ensures quick decision making during testing.

«PARUS-M9» comprises measuring subsystems for slowly varying and alternating parameters, video monitoring subsystems, and control subsystems for engine and test bench processing equipment including data receipt from the engine digital units. Subsystems of digital type contributed greatly to the interference protection for weak-current measuring channels as well as the measurement accuracy. Adapter principle of engine installation at the test bench has reduced the time for measuring equipment connection significantly.

All measuring subsystems of the test bench are integrated into the local computer network having an out port to the company’s general network which has network resources for storage, processing and analysis of the data registered during and after testing.

The system upper level is based on «PARUS» software that has been developed by AviadvigateL This level provides functions of computer workstations for operators and engineers at the test bench.
DESIGN BUREAU TEST FACILITIES

as well as it provides receipt and integration of data received from all the lower level subsystems, data processing and visualization, processing equipment control, protocol generation, HD record and online delivery of data to the company’s network.

The measurements are recording with the prescribed frequency. When tests are completed, data from all the test bench information systems are transmitted to IBM DS3400 subsystem for HD record and storage which ensures necessary mirroring, safe storage, high-rate access as well as it contains migration and backup systems. For the period of one month of the first test stage data amount exceeded one terabyte and the number of registered and design parameters was more than 4.5 thousand.

During test procedure to provide on-line monitoring and analysis of the engine parameters there is data transfer from the upper level of «PARUS-M9» data measuring system to the remote workstations at experimental design bureau departments via computer network in real-time mode.

The system lower level provides registration of up to 2 thousand parameters and it includes a set of subsystems based on software/hardware developed by NPP MERA, pressure and temperature scanners as well as other measuring equipment.

The subsystem for alternating parameters measurement registers the parameters of strain-gauging and vibration metering, receives and processes data of rotor parts from Datatel digital telemetry system at up to 100Hz frequency.

The subsystem for test bench processing equipment control is based on programmable logic controllers and it is controlled from the engineer workstation of PARUS-M9» data measuring system.

A special video monitoring system is used to control the test process. Video image from four cameras is sent to the monitors of the test bench observation room as well as it is recorded in the HD-subsystem. There is a two-way communication between the observation and strain-gauging rooms in video conference mode that excludes data delay or loss when investigating test rapid processes.

Application of modern measuring equipment and software ensured successful first stage testing of PD-14 core-demonstrator with continuous monitoring of critical parameters of core operation, such as cases vibration speed, blade vibration tension of all the compressor and turbine stages, total pressure pulsation in the combustor, gas temperature and pressure as well as design parameters of the corrected speed and operating line. At the moment Aviadvigatel and NPP MERA are working on the further optimization for measurement data storage and development of automatic measurement data processing means.

Recorded by Viktor OSIPOV
In autumn, 2010 a reconstructed open test bench for special testing of aircraft engines was certified in Aviadvигател. We asked the representatives of Perm Design Bureau: Valery CHURSIN, Head of Aircraft Engine External Characteristics Department, Aleksei ALEKSENTSEV, Chief Deputy of Exhaust System Department, Christopher Horley and Yakov Kabakov, Aero Support Corporation MDS to give their comments.

**OS-5**

multifunctional open test bench for aircraft engine testing which includes determination of acoustic characteristics was in operation since the beginning of eighties of the last century. Test bench reconstruction made in 2004 allowed to use it for carrying out preliminary, acceptance, endurance and certification tests of full scale pilot and production engines of PS-90A family. In future OS-5 test bench is supposed to be used for testing of the fifth generation of PD-14 engine and its modifications.

The test engine is fixed at the universal rigid vertical load frame. The engine mounting attachments to the load frame is removable. The load frame is fixed to the dynamometric platform that allows measuring both forward and reverse thrust. The engine is mounted to the mounts similarly as it mounted to the aircraft. Mounting layout allows installing the engine at 2.0m, 3.1m, and 5.0m height from the site. Test bench design, performances properties as well as equipment arrangement and location provide free air supply to the engine, free access to the test equipment to necessary service purposes (unit maintenance, inspection, adjustment, and replacement), safe gas flow discharge preventing direct influence on the surrounding buildings, vegetation and soil landscape as well as gas to be drawn into the running engine inlet.
Today the following types of tests can be carried out at OS-5 test bench:

- Estimation of engine parameters its components and systems at forward and reverse thrust operations with standard and special instrumentation.
- "Cold" stages of cyclic, equivalent-cyclic and 150-hour tests.
- Research of engine acoustic characteristics and its means of sound absorption.
- Tests with bench lemniscate and aircraft air intakes.
- Engine tests at asymmetric airflow (cross wind simulation), strain-gauging of fan blades and LP compressor.
- Check the fuel control system functionality when operating with contaminated fuel under low temperature conditions with water-cut fuel.
- Ingestion test, etc.

- Determination of power plant acoustic characteristics to certification of aircraft on environmental noise.
- Special tests (including check of reverser operation and its influence on the engine parameters, measurement of temperature and pressure fields in the engine gas path, vibration trending and strain-gauging of the engine casings, compressor and turbine blades, and reverser).

The following types of tests can be carried out at OS-5 test bench:

- Investigation tests (determination of noise sources, principle of noise generation in the engine components and noise distribution via engine and air intake ducts, optimization of acoustic parameters for engine and air intake design);
- Determination of power plant acoustic characteristics to certification of aircraft on environmental noise.
- Special tests (including check of reverser operation and its influence on the engine parameters, measurement of temperature and pressure fields in the engine gas path, vibration trending and strain-gauging of the engine casings, compressor and turbine blades, and reverser).
DESIGN BUREAU TEST FACILITIES

• development tests (development of procedures for engine noise reduction);
• certification test (determination of engine set acoustic parameters to certification of aircraft on environmental noise in accordance with ICAO Technical Guidance).

The main method for determination of engine acoustic parameters is a measuring method for sound pressure levels in the far field by pressure microphones installed at near ground plane.

For certification the passenger aircraft on environmental noise the world’s practice applies methods developed on the flight test basis as well as it applies the equivalent method based on the results of engine bench running. It should be noted that the equivalent method can be used only if the aircraft has been already certified according to the results of flight tests and next certification is related with the engine modification, takeoff weight or other «insignificant» changes. Recently, type aircraft as IL-96 and Tu-204 have been certified in accordance with the equivalent method to meet the noise regulations of ICAO, Chapter 4.

At the beginning of OS-5 open test bench reconstruction it conformed fully to OST 1 00036-84 requirements and ICAO Technical Guide for environment protection (Doc. 9501, third edition, 2004) regarding bench platform geometry, bench surface reflection parameters, engine mount design and its location relative to the bench platform, number of measuring channels and acoustic equipment.

The only significant inadequacy was the absence of inlet control device that provides equivalent acoustic certification for the aircraft equipped with Perm engines simulating engine acoustic characteristics during the flight. In accordance with ICAO standards it’s obligatory to use inlet control device during engine acoustic tests for certification of the aircraft on environmental noise. This fact is also confirmed by the Air Register of Interstate Aviation Committee.

MDS Aero Support Corporation, Canadian company with great experience in development of inlet control device for the world’s leading engine building companies, has become a partner of Aviadvigatel for the project of OS-5 reconstruction.

Aviadvigatel’s inlet control device is a reduced spherical cone of 6.9m diameter. It consists of six- and five-sided flat plates which rectify the airflow going through the perforated steel shell and cellular aluminum ducts of the plates and they distribute pressure inside the cone surface evenly, at the engine inlet. The cone is installed on the steel wheel-mounted frame. When in operation, the inlet control device is installed on four jacks that provide adjustment of the device axis height as well as its inclination to carry out test of any engine.

The device has been developed in Canada. The load frame and chassis have been manufactured in Germany, and cone with the entire inlet control device mock-up assembly have been manufactured by Darchem Engineering Ltd, English company. Thus, new equipment of Perm Design Bureau is the result of the latest groundwork of leading western companies. During reconstruction Perm Design Bureau specialists made a hangar, access ways as well they developed a special structure to operate engine with the inlet control device (lemniscate with cylindrical section made of polymeric composites and inner flow passage of the aircraft air intake with acoustic panels); the respective equipment and tools have been purchased. The required set of aerodynamic, strength and acoustic calculations has been made prior to commissioning.
It must be emphasized that such works have been executed in Russia for the first time and Kachestvo CA, Prochnost CA, Aviation Certification Body for State research and development institute of a Civil Aviation (GosNII GA) and Aircraft Certification Authority for Research Institute named after M.M. Gromov took part in their execution. United Engine Corporation has played the key role in the project implementation having contributed greatly in its financing.

Two certification committees had been working hardly when testing three PS-90A engines prior the inlet control device was put into operation, approved and certified. In accordance with the Operational manual inlet control device was inspected for defects and contamination, acoustic calibration was made with the use of specially developed associated programs and techniques agreed with «Kachestvo» CA, «Prochnost» A, Aircraft Certification Authority for Research Institute named after M.M. Gromov and Aviation Certification Body for GosNII GA.

Records of the certification committee confirmed the declared by Aviadvigatel characteristics of the reconstructed test bench. This allowed approving and certifying OS-5 test bench, equipment and software for acoustic tests of engines developed by Perm Design Bureau.

Air Register of Interstate Aviation Committee approved the results of performed works and recommended aircraft designers to use the acoustic data of OS-5 test bench when preparing documentation for the equivalent certification at the aircraft on environmental noise.
Within the scope of aircraft equipment certification reliability assurance issues shall stand first. The most precise product reliability data is the field test results and conclusions based on the results of operation. Where this data is not enough for product certification, then analytical methods are used.

As of today, analytical methods for functional system fail-safety between Air Register of Interstate Aviation Committee, EASA and FAA are not harmonized. Besides, Russian and international requirements differ essentially from each other by their extent and analysis complexity.

Main analytical method approved by Air Register of Interstate Aviation Committee is the analysis of functional failure types. EASA and FAA recognize the following methods that are stated in ARP-4761 and ARP-4754:

• FHA – Functional Hazard Assessment.
• FMEA – Failure Mode and Effect Analysis.
• Dormant (Latent) Failure Analysis.
• FTA – Fault Tree Analysis.
• CCA – Common Cause Analysis.

Certification of PS-90A family let Perm Design Bureau gain continuous experience to prepare Russian standards supporting information. Within the scope of advanced engine and power plant development for MS-21 aircraft, Aviadvigatel set its sights on studying the international methods of reliability and fail-safety demonstration as well as on preparing the supporting information in compliance with EASA requirements.

During the period of 2008-2009 the Reliability Department and Certification and Quality Control Department of Design Bureau were busy with selecting the company that would have all necessary knowledge to carry out the analysis according to the international requirements in the shortest time possible. For this purpose meetings and consultations with specialists of Irkut, Central Institute of Aviation Motors, NPO Saturn, BEE-PITRON and others were arranged.

As a result, in 2010 the contract for training Aviadvigatel specialists in preparation of supporting documentation to the certification aviation authorities according to the requirements of world standards and supply of RAM Commander software was made with ALD (Advanced Logistics Development Ltd), Israeli company.

Now the specialists of Perm Design Bureau are learning how to work with RAM Commander program. Preliminary fail-safety analysis of engine and nacelle has been already carried out at PD-14 concept design phase. Preliminary analysis of FHA, FMEA and FTA have been carried out in accordance with ARP-4761 requirements.
FLYING ACROSS CENTURIES…

• WINGED HISTORY
WINGED HISTORY

Nikolai D. TALIKOV

Deputy General Director
General Designer
of ILYUSHIN Aviation Complex OJSC.

Opening of Antarctic sky is closely connected to ILYUSHIN Experimental Design Bureau and SH-VETSOV Engine Experimental Design Bureau. In January, 2011 it will be 55 years from the beginning of regular flights of IL-12 aircraft equipped with ASh-82FN air-cooled engines in Antarctica. And in February of the same year it is 25 years from the day of the first flight of IL-76TD aircraft equipped with jet engines of D-30KP-II in Antarctica.

Today very few of us remember Antarctica opening by aircrafts in such a combination as Ilyushin-Novozhilov wings and Shvetsov-Soloviev «heart». So, before the anniversary dates let’s remember about the involvement of two teams, i.e. designers of aircraft and aero engines, in opening and examination of a mysterious glacial continent.

The first aircraft division in Antarctica included two Li-2 aircraft, IL-12, An-2, and two Mi-4 helicopters. All air vehicles were equipped with the engines of Shvetsov development design bureau: ASh-62IR, ASh-82FN, and ASh-82V. I. Cherevichniy, Hero of the Soviet Union and a well-known polar pilot, was at the head of the aircraft division.

TWO POLES OBEY IT

In February, 1956, a group of polar explorers headed by Mikhail Somov, head of the First Soviet Antarctic Expedition, made the first long-distance reconnoitring flight by IL-12 aircraft to the Southern earth magnetic pole area where it was planned to locate «Vostok» inland station. On March 3, the same aircraft carried out the flight to the area of relative inaccessibility pole.

Since that time aviation has become a reliable assistant in research works of Soviet polar explorers at the severe continent. Except research flights aircraft carried out delivery flights as well. Aircrafts transported polar explorers, various cargos, scientific equipment and foodstuffs, i.e. all those things that were necessary for any expedition, in particular under the most severe Antarctic conditions. Aviation has been also helpful in emergency situation, providing emergency care to polar explorers under conditions threatening their health and life. For example, Li-2 aircraft (V.Perov, aircraft commander) gave a hand to polar explorers suffered distress in the area of Crystal Mountains.

In October, 1958 IL-12 equipped with ASh-82FN engines carried out the flight over central areas...
of Antarctica continent and back. So, IL-12 has become the first Soviet aircraft that flew over the South Pole and the first Soviet aircraft that flew over the two Earth poles.

IT IS NOT AFRAID OF WINDS AND WEATHER...

Within 1960-1990s IL-14T aircraft carried out main air transport for polar explorers and cargos within Antarctica. The aircraft high operational efficiency performance was due to powerful and reliable ASh-82T reciprocating engines developed by Perm design bureau under the supervision of Arcady Shvetsov.

Words of polar pilots are the best evidence for reliability of these machines.

E. Kravchenko, a well-known polar pilot, wrote in his book «Respectful addressing to Antarctica…»:

«How microscopically small and lonely our IL-14 must have been seemed to be from the space against the background of Antarctica and ocean having endlessness of great spaces and power of spontaneous forces that sometimes nothing can resist. But it flies, protecting and warming us, giving us a feeling of safety and hope by its every minute of flight, ensuring us that everything is going to be all right. And we feel gratitude to the employees of ILYUSHIN experimental design bureau who developed this aircraft».

With the course of time goals and objectives of polar aviation have been changed. In 1961 it was decided to use heavy turbo prop An-12 and IL-18 aircraft. But IL-14 was still the key aircraft for the Soviet polar explorers in Antarctica. Unfortunately, on March 9, 1990, it carried out its final flight over the sixth continent.

IL-14 aircrafts have been operated in Antarctica over 30 years: from 1959 to 1991. At present, there are five IL-14 aircraft preserved and buried by snow at the aerodrome of «Molodezhnaya» station.

ANTARCTICA IS IN EXPECTATION OF IL-76TD-90

In 1986 flights, carried out by An-12 and IL-18, were added by the flights of IL-76TD aircraft (in the USSR it is 76479) equipped with D-30KP-II engines. The first flight of IL-76TD was carried out on «central» route Moscow – Leningrad- Larnaka- Djibouti – Maputo – «Molodezhnaya» station – Novolazarevskaya station and back.

«IL-76 transport aircraft and its modifications is not just good or great airplane. The most exact description for this aircraft could be a «unique plane». «Even if the designers of ILYUSHIN complex constructed just one IL-76, it would be enough to put down the company’s name into the world aviation history with golden letters», remembered Zh. Shishkin, honored pilot of the USSR. Such words about the aircraft can be equally referred to its engines.

Regular flights of IL-76TD from the USSR to Antarctica have been carried out till 1991. Delivery of scientific personnel and cargos directly from the USSR by these airplanes allowed enlarging the possibilities for expeditions. Besides due to the aviation it has become possible to study the...
In 1989 a crew team of ILYUSHIN development and design bureau headed by S. Bliznyuk, honored test pilot of the USSR, carried out the first flight to Antarctica on the «western» route and landed at rather difficult for IL-76MD (in the USSR - 76822) «March» Chilean aerodrome, located in King George island near the Soviet station «Bellinghausen». The matter is that the aerodrome had runway with a dirt surface and of 1265 m length. To shorten aircraft run during the landing all means have been applied: reverse of two inboard engines by touchdown and further reverse of two outboard engines during the run, application of all modes of wing-flap system, low pressure of all landing wheels and use of entrance side doors as brake flaps. That flight delivered the international Antarctic expedition «Transantarctica» which transferred from King George Island through Antarctic Peninsula and the South Pole to «Miri» station. Before this time the largest plane that had ever landed this aerodrome was C-130 American plane.

On June 14, 1991 IL-76MD aircraft evacuated participants of the Antarctic expedition from «Molodezhnaya» and «Novolazarevskaya» stations to Capetown because of the very challenging environment at the station and «Mikhail Somov» research ship.

In the world's practice it was the first time that Antarctica aerodrome received a heavy wheeled aircraft landed on the snow under the conditions of polar winter and short daylight hours. The most difficult for this expedition, except complex and unprepared cargo, was the aircraft take off with polar explorers aboard from «Molodezhnaya» station aerodrome. Total number of passengers together with the crew was 197 persons: the team of polar explorers from «Molodezhnaya» and «Novolazarevskaya» stations, aerodrome personnel, part of the crew of «Mikhail Somov» ship icebound at Antarcctica coast as well as the aircraft maintenance personnel. The aircraft take-off gross weight was approximately 185 tons. The aircraft allowable take-off weight under conditions of snow-covered aerodrome is 170 tons.
Take-off conditions were complicated with strong side wind and reduced visibility due to the heavy storm of drifting snow. Runway side boards as well as runway end boards were almost invisible. The weather kept worsening. Under critical conditions the crew commander has the final say. He has made it and it appeared to be correct!

At the end of October, 1991, IL-76MD aircraft (in the USSR it is 78839) carried out the flight to Antarctica on the following route: Moscow - Larnaka – Nairobi – Antananarivo – Capetown – «Molodezhnaya» station – «Novolazarevskaya» station – «Molodezhnaya» station – «Vostok» station – «Molodezhnaya» station. The unique character of this flight was the first container airdrop in Antarctica at «Vostok» inland and high-mountain station as well as the first container airdrop from the height of 3-5 meters.

The collapse of the USSR caused great finance difficulties and almost total cease of air communication between the USSR and Antarctica. But since 2001 in summer IL-76TD flights have been renewed due to the efforts of specialists of Arctic and Antarctic Research Institute, State research and development institute of a Civil Aviation (Gos-NII GA), «NTAARi» enterprise and ILYUSHIN Aviation Complex. Snow and ice landing field of «Novolazarevskaya» station has been reconstructed.

R. Esayan, Hero of the Russian Federation, honored test pilot, test aircraft division director of Gos-NII GA, has been continuous crews’ commander since 2001. ALCI specialists headed by A.Turchin made a great contribution to the development of air transportations to Antarctica. Unfortunately, for the present these flights are carried out not only by Russian airlines but also by Hungary, Azerbaijan, and Byelorussia ones.

In 2008 IL-76TD cargo aircraft landed at the landing field of Norwegian «Troll» Antarctic station, thus the number of landing fields that are capable to receive IL-79TD has become five: «Molodezhnaya», «Novolazarevskaya», and «March» stations, «Patriot Hills» landing field located at ice tableland and «Troll» station.

«Patriot Hills» landing field has certain difficulties for aircraft landing. I.R. Zakirov, Hero of the Russian Federation, honored test pilot of the USSR, wrote the following about this landing field: “In the light of a polar day blue and white glacier surface merge together with the sky at the horizon; there are no contrasts, your eyes cannot catch anything and you lose the feeling of height. Landing skid made impossible to use standard braking. Maneuvering due to engines control only we’ve prevented our plane from overrunning the strip and managed to cope with side wind that drew the aircraft towards the rocks protruding in the glacier.”

ILYUSHIN Aviation Complex together with Aviadvigatel executed much work by equipping IL-76TD and IL-76MD aircraft with new PS-90A-76 fuel-efficient by-pass turbo-jet engines. Nowadays such aircraft is being operated successfully by Volga-Dnepr airlines and Azerbaijan Silk Way Airlines.

It should be noted that PS-90A-76 engines are able to make flights to Antarctica more effective and safe because during the flight from Capetown to «Novolazarevskaya» station aerodrome the return point of the aircraft with such engines will be after the arrival aerodrome. But for the moment negotiations with Volga-Dnepr airlines for providing
ILE-76TD-90VD retrofit aircraft to carry out flights to Antarctica have not given any positive results due to the aircraft’s severe load. Actually, IL-79TD-90VD aircraft flies over the world and due to its engines it meets ICAO requirements for noise and emission.

Flights of retrofit IL-76TD aircraft equipped with PS-90A-76 engines have one more positive effect. Now IL-76TD is able to carry out 7-8 flights to Antarctica only because of the expedition and logistic capabilities of Russian Antarctic Expeditions. If the flights to Antarctica are carried out by IL-76TD aircraft the specified restrictions can be removed and number of flights to Antarctica can be increased significantly. Besides it will provide environment safety of airline network due to the decrease of fuel handling. All said above encourage and give confidence that Russia will continue its active presence in Antarctica.

Now IL-76TD is being operated again in Antarctica with D-30KP-II engines for the moment. Ruben Esayan’s crew has returned back in the sky. During this expedition the aircraft and Perm engines as well as their «elder brothers», ASh-82FN and ASh-82T of IL-12 and IL-14 aircraft, once again turned out to be at the second geographic pole of our planet. In November 2010 to provide flights for VT-67 Canadian aircraft operating in Antarctica on behalf of Russian Antarctic Expedition, IL-76TD cargo aircraft (tail number is EW-76799) carried out two non-stop flights on the route of «Novolazarevskaya» station – «South Pole» – «Novolazarevskaya» station – «Amundsen-Scott» American station aerodrome located at the geographical South Pole.