Krzysztof Urban
Lodz University of Technology
Faculty of Mechanical Engineering
Institute of Machine Tools and Production Engineering
Department of Management and Economic and Legal Sciences

COMPETENCES OF AIRPORT SERVICES IN MAINTENANCE OF THE MOVEMENT AREA

Abstract

One of the fundamental activities performed at an airport is its maintenance in the condition which enables safe and efficient air operations. The conditions specified in Annex 14 to the Convention on international civil aviation obligate the member states to take any essential measures to remove all contamination from the movement area[1] *as quickly and efficiently as possible in order to ensure a proper adhesion coefficient (friction coefficient) and low rolling resistance. Furthermore, Annex 14 contains a demand for maintaining the surfaces clean and removing stones and other objects which may damage the construction of wings or engines or reduce the efficiency of other airplane subassemblies. It should be emphasized here that the main and the most important responsibility of airport services is to remove all contamination and waste which could have any adverse effect on air operations from the apron and the movement area. Therefore, research is constantly being conducted aiming at the optimization of economic and use conditions as well as the efficiency of mechanic and chemical methods of removing contaminations from the apron and the movement area. In addition, it is also necessary to measure the friction coefficient and, what follows, to develop best possible methods of such measures.*[2] *The efficiency of airport services in the maintenance of the movement area depends, to a great extent, on competences of these services and their experience, which make it possible to perform the assigned tasks and responsibilities properly. A high level of competences of airport services has an influence on making good and correct decisions, what is sometimes critical for safety in the maintenance of the movement area.*

---

[1] The movement area is a part of an aerodrome for taking off, landing and taxiing of air planes, with aprons.
[2] ICAO Doc. 9137/Part 2 *Airport services manual – pavement surface conditions*, edition 3, 1994.

Competences of airport services

The notion of “competences” has many meanings. From the standpoint of legal sciences, “competences” means a scope of authorizations and powers of a body or an official to deal with specific issues and make decisions concerning these issues.[3] In this approach, this notion means that a person who performs a specific public function makes his or her decisions as a part of the powers granted to him or her, according to his or her competences.

Another meaning of “competences” is a notion from management sciences concerning, most of all, the state of having an updated interdisciplinary knowledge of a specific area and essential skills, which make it possible to perform the assigned tasks and responsibilities properly and which ensure that goals of a specific organization are pursued efficiently.[4] In this case, a fact that members of an organization (employees) have suitable competences is sometimes critical to making good decisions. In the event of airport services, suitable competences are a main factor influencing the level of services provided by them. This translates into the efficient course of air operations and, as a consequence, into reduced delays in air traffic. High competences of airport services often decide about lives of dozens or even hundreds people.

According to Józef Penc “the main condition of efficiency includes suitable competences, i.e. rights, knowledge, and skills to act in order to obtain a proper result in a given situation, using specific measures and taking external limitations imposed by the environment into account”.[5] This applies to airport services as well. The conditions of their operation in a specific situation, taking into account the use of available machines and devices and time available for the performance of the task[6], include their competences. The result of airport services operations depends, to a great extent on their individual experience consisting of knowledge or skills of observing certain objects, events, and phenomena. Official documents of the International Civil Aviation Organisation also discern the role of air services competences as a factor which has a positive influence on the course of air operations. The examples include the obligation to inform those interested

---

[3] http://doroszewski.pwn.pl – *Słownik języka polskiego W. Doroszewskiego*, Wydawnictwo Naukowe PWN S.A.

[4] W. Walczak, *Przywództwo i motywowanie w procesach zarządzania kompetencjami pracowników*, E-mentor No. 1 (38) / 2011.

[5] J. Penc, *Kreatywne Kierowanie*, Agencja Wydawnicza Placet, Warsaw 2000.

[6] One of external limitations influencing the operation of air services is the time between operations of airplanes. Airport services may perform the works consisting in maintaining runway strips clean only when no operations are conducted there. However, if contamination on runway strips presents a significant hazard to air safety, operations of air planes are suspended until the contamination has been removed by air services.

with air operations of the condition of runway strips. Pursuant to Annex 15 to the Convention on international civil aviation, such information in a special form should be published in some cases, including when there are changes in the conditions of a runway strip which can be recognized as significant according to experience or local situation. This means that airport service workers, judging by their knowledge and skills supported with many years of experience, publish specific information on the condition of runway strips when they think it is justified. Therefore, a high level of competences of airport services has a significant influence on the process of making correct decisions.

Competences of air services and safety issues

Ensuring safety is a main task of each service related to aviation. Regardless from whether it is the ATC (Air Traffic Control), FIS (Flight Information Service), or AIS (Aeronautical Information Service), ensuring safety is the most important task upon which all other tasks depend. This also concerns the service which may, seemingly, have a small influence on ensuring the safety of air operations (as well as the efficient and regulated air traffic flow). However, the reality is different. We are talking about the airport service which is often an organizational unit of an airport (e.g. Airport Surface Maintenance Department in the case of civil airports or Airport Service Company in the event of military airports). A serious incident or an airplane disaster always focuses the attention of mass media all over the world. Apart from the spectacular character of such an accident itself, this results from the fact that during such an incident lives, often of hundreds of people, are endangered. Chances of survival of even a small number of passengers during a disaster are slim. Therefore, ensuring a proper level of safety is a very responsible task, one which is crucial in the level of competences of the whole air staff.

It is widely known that the most critical air operations (in terms of safety) are the take-off and the landing of an airplane. This results from the specificity of these operations. In the case of take-offs, the engine (or engines, in the event of airplanes with multiple engines) of an airplane is working in top gear in order to reach the speed required to take off and proper altitude as quickly as possible. As a consequence, large quantities of air with all contaminations on the runway strip are sucked into the engine. This may lead to a damage to turbine blades or, in extreme cases, to a total damage of the engine, what may result in a disaster. The photos below present the consequences of sucking foreign bodies into the engine.

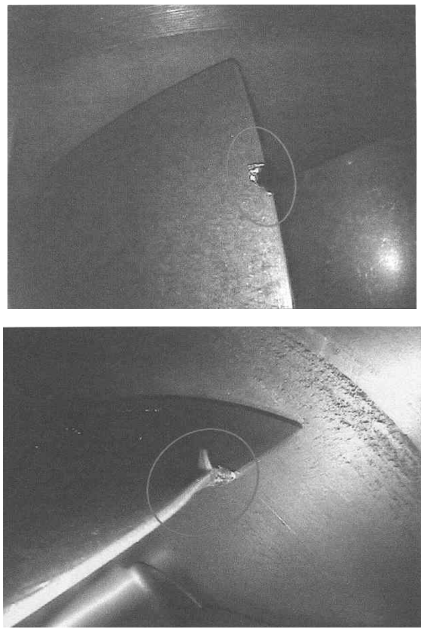

Photo 1. Damage to the blades of a MIG-29 compressor after sucking contamination
Source: 48th Conference of the Safety of the Polish Air Force Flights, Dęblin 2005.

Photo 2. Damage to the blades of a Boeing 757-200 compressor
after sucking contamination
Source: www.pasazer.com

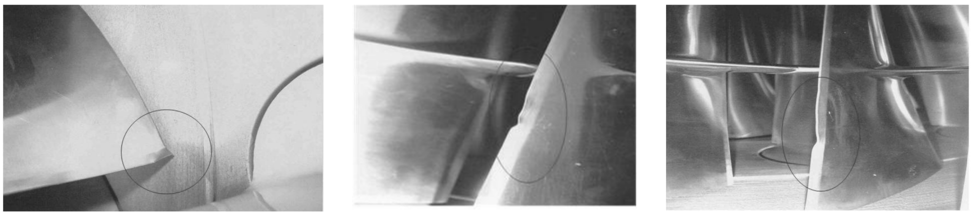

Photo 3. Damage to the blades of a SU-22 compressor after sucking contamination
Source: 48th Conference of the Safety of the Polish Air Force Flights, Dęblin 2005.

The photos presented above show the engines of planes which, fortunately, managed to land safely. However, attention should be paid to Photo 2 of Boeing 757-200. This plane belongs to Fisher Air Sp. z o.o. On December 31, 2005, the plane was damaged at the Warsaw-Okęcie airport as a result of sucking contamination off the runway strip. Both engines of the Boeing were damaged during the take-off, what could have had tragic consequences. The accident made it impossible to use the plane, what caused notable financial losses to the carrier. This put the carrier in a very difficult situation because the company had to pay for the repairs, while the plane was defective and could not bring any income. Obviously, Fisher Air Sp. z o.o. announced that it was going to sue the manager of the airport for the improper maintenance of the airport surfaces[7]. This event shows clearly how important the proper preparation of the movement area is for ensuring safety of air operations and from economic standpoint as well.

Analysing the photos above, it should also be realized what requirements must be met by blades of the turbine compressor of an airplane engine and, what follows, how serious damage can be caused by seemingly small stones or pieces of asphalt. During the operation, engine blades are subject to twisting and bending by aerodynamic forces, bending and stretching by centrifugal forces (compressors work at even a few dozen thousand revolutions per minute), changing stresses as a result of vibrations, high temperature (800÷1200°C for turbine blades, 300÷600°C for compressor blades), sudden changes of temperature in transitory states of the engine, the influence of polluted air, electrodynamic corrosion, and gas corrosion in increased temperatures. That is why, titan, among other metals, is used to manufacture turbines and compressors as it is highly mechanically resistant[8]. The engines of airplanes which the compressors shown in the photos come from did not lead to disasters; however, such serious damage had a significant adverse effect on the engine operation.

[7] P. Cybulak, *Fischer kontra PP Porty Lotnicze*, 2006.
[8] J. Sińczak, S. Bednarek, A. Łukaszek-Sołek, P. Chyła, *Wytwarzanie łopatek turbin metodami przeróbki plastycznej – analiza numeryczna*, Mechanik No. 8-9, 2010.

In extreme cases, damage to the leading edge of blades may disturb the air flow, what may lead to an uncontrolled combustion process and, as a consequence, to the switching off of the engine. Losses in the material of blades or even the delicate bending thereof is certain to cause changes in the distribution of mass, what, with a dozen or even a few dozen thousand revolutions per minute, must cause strong vibrations of the whole engine and partial or total damage to bearings supporting the shaft connecting the turbine with the compressor. Such events end with the airplane disaster most frequently. Therefore, the proper maintenance of the manoeuvring area of the airport and informing the parties interested in air operation of the condition of that area is very important.

Competences of airport services concerning equipment

Proper equipment is closely related to a specific level of airport services competences. The highest level of competences does not guarantee a proper performance of some tasks when there is no suitable equipment. In order for airport services to perform their assigned tasks successfully, they must use a wide range of specialist equipment, from ordinary snowploughs, which can be seen on roads in winter, to specialist multifunctional equipment. Obviously, it would be ideal to purchase the most efficient machines and devices in quantities which would ensure the shortest possible time of removing all contamination covering the manoeuvring area of an airport. However, this is related to very high costs. Therefore, if the entity responsible for the maintenance of an airport purchases modern machines and devices in quantities ensuring the shortest possible time of removing the contamination, it will have to recover the invested funds by increasing the payment for the provided services. It should be remembered that airlines are not charities which focus only on the transport of people and cargo from one place to another. Their existence depends on profits from the activities they conduct. Therefore, the increase in airport fees will translate into the increase in the prices of air tickets; this, in turn, may effectively discourage airlines from using such airports. In the era of competition, the winner is the party who offers the same product (service) for a lower price.

That is why, machines and devices used by airport services are different at various airports although the parameters of runway strips of individual airports, civil as well as military ones, are similar. The average runway strip is 2500 metres long and 60 metres wide. Most often, the differences include the number and size of aprons, as they depend on widely understood geographic and economic conditions. It is obvious that the best location for an airport is the area near a city with a large number of residents with the highest possible economic and social status. The closer an airport is located to the city centre, the better. However, great proximity may limit a potential expansion of the airport if it is required as a result of an increase in the number of air operations. Examples of such airports include Chopin Airport in Warsaw, which requires expansion as a result of a constantly increasing number of air operations; however, such expansion is impossible due to high density of the city.

Another factor influencing the location of an airport is its proximity to other airports. Examples include the airport in Zielona Góra, which does not handle international connections due to the proximity of German airports in Berlin and Dresden. In addition, low population and poor business infrastructure within the nearest area of the airport resulted in the fact that in 2011 the airport provided its services to 6,940 passengers only[9]. The Figure below presents the data on the number of passengers served at individual airports in the preceding year.

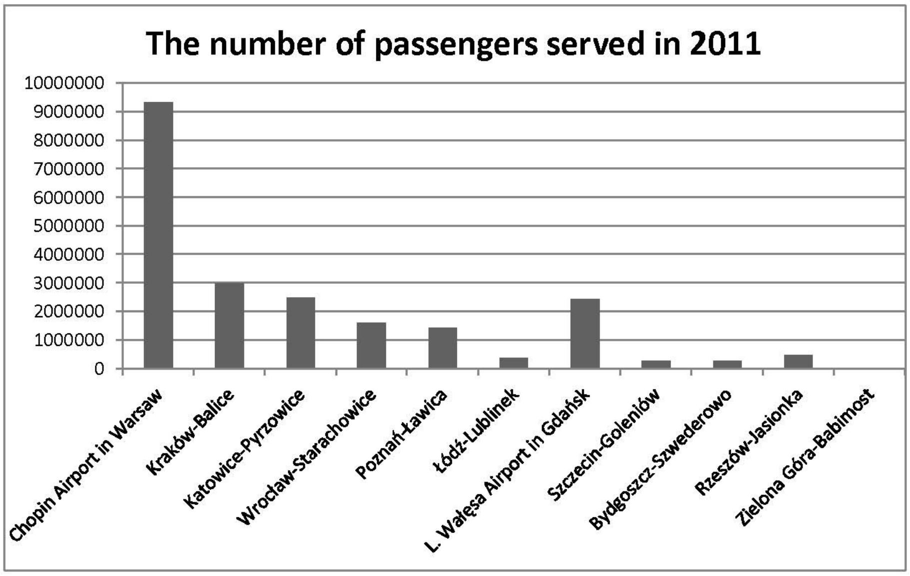

Fig. 1. The number of passengers served in 2011
Source: the authors own work based on information from ULC obtained from airports, Warsaw, January 2012.

The data presented above show the relationship between the number of passengers served and the required airport infrastructure. The more passengers were served at an airport, the more place for planes transporting the passengers is needed. Thus, airport services will have to clean more surfaces. This, in turn, translates into the quantity and quality of equipment.

---

[9] *ULC study based on information obtained from airports*, Warsaw, January 2012.

Airport services have a range of specialist equipment, which may be divided into the following categories:

I. Ordinary airport snowploughs,
II. Snow cutters,
III. Spreaders,
IV. Sprayers,
V. Vacuum cleaning machines,
VI. Cleaning sets,
VII. Auxiliary machines and devices.

The first category of the airport equipment is the largest. It includes all types of 3- and 4-metre mouldboard ploughs (photo 4a), which can be seen on roads in winter, as well as high-efficiency 6- and 8-metre ploughs. In general, these are simple devices hooked up to a truck in order to remove snow lying on the movement area. The efficiency of these devices depends on the width and construction of the mouldboard and the parameters of the carrier, i.e. the truck they are hooked up to. Obviously, the snow pushed aside by ploughs will form mounds which may be a hazard for airplanes with large wingspan. Therefore, it is very important to have auxiliary machines, i.e. ordinary wheel loaders, in order to load the snow on dumper trucks, which will transport it to another place.

Another category of devices (which may replace wheel loaders) include snow cutters (photo 4b). These devices are useful with snow mounds on the edges of a cleaned area and very heavy snowfall, when the snow layer on the ground is a few centimetres thick. The efficiency of such devices is 5000-8000 tonnes per hour and snow thrust of up to a few dozen metres.

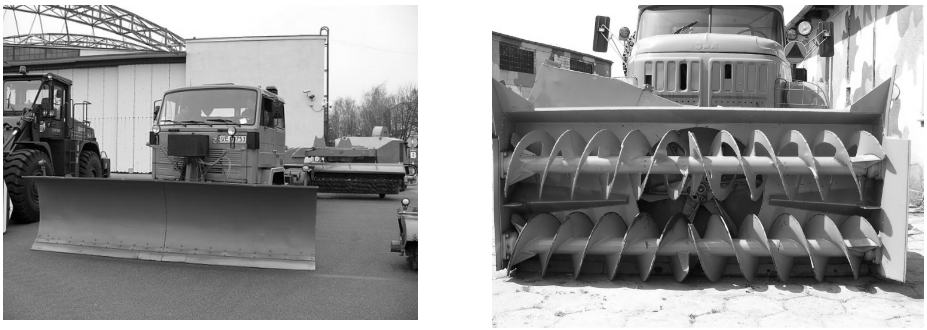

Photo 4. Airport snowploughs: a) 4-metres ordinary mouldboard snowplough, b) snow cutter
Source: the author's own collection.

Another two types of machines are used to cover airport surfaces with solids or liquids. Spreaders (photo 5a) spread solid substances (most frequently saltpetre) which melt snow or ice. However, due to environmental and practical reasons, liquid chemicals are used more often. They are spread on the surfaces of taxiways with special sprayers (photo 5b). These devices can often be seen on roads but, contrary to airport devices, road versions are not very efficient. Arms of airport sprayers are of app. 40-metres span. In most cases, one run of the device is enough to melt the lying snow or ice efficiently.

Photo 5. a) Spreader, b) sprayer
Source: websites of manufacturers.

Airport vacuum cleaning machines (photo 6a) suck all solid contamination, such as dust, sand, small stones, and fragments of surfaces, e.g. asphalt lumps or pieces of concrete; however, they cannot be used to suck snow and large amounts of water. These limitations cause that they are used in summer most frequently. However, these machines are installed on a truck chassis (as most of machines and devices used for airport maintenance are), so it is also possible to install a snowplough (photo 6b). Then, they can also be used in winter, when the manoeuvring area is covered with snow. Machines of this type are highly effective in cleaning surfaces (they can remove all types of contamination efficiently) but are also rather slow, what translates into low efficiency. That is why they are used rarely and during periods of low intensity of air operations.

a) 

b) 

Photo 6. a) airport vacuum cleaning machine, a side view, b) airport vacuum cleaning machine with a snowplough attached
Source: a – the author's own collection, b – 31th Air Base.

Machines which are used in airports most frequently (owing to their universal character) are cleaning sets which consist of a snowplough, a brush, a blower, and, depending on the version, a magnetic plate. These are specialist high-efficiency machines (the maximum working speed is app. 60 km/h). They may be used in winter, to remove snow and water from melted snow, and in summer, to sweep all contamination and blow off water. In addition, a magnetic plate is used to catch ferromagnetic contamination. The photos below show an example of such a machine.

a) 

b) 

c) 

d) 

e) 

f) 

Photo 7. Cleaning set: a) a cleaner with a tractor unit with no snowplough attached, b) a cleaner with a tractor unit with a snowplough attached, c) a brush, a front view, d) a brush, a side view, e) a blower, f) a magnetic plate

Source: a and f – websites of manufacturers; b, c, d, and e – the author's own collection.

An additional group of machines and devices used by airport services in cleaning airport surfaces includes all types of auxiliary machines and devices (cat. VII), such as wheel loaders, which have already been mentioned, various types of dumper trucks, bulldozers, diggers, and specialist machines for increasing (or reducing) surface coarseness and for de-gumming surfaces.

Thus, there are many different machines and devices used by airport services to maintain airport surfaces properly. The table below presents the equipment possessed by civil airports.

Table 1. Basic equipment of Polish civil airports used to maintain runway strips

	Snowplough	Snow cutter	Spreader	Sprayer	Cleaning set
EPBY	**4**	**1**	**2**	**-**	**2**
EPGD	**2**	**-**	**1**	**1**	**6**
EPKK	**-**	**-**	**-**	**5**	**13**
EPLL	**7**	**2**	**2**	**3**	**7**
EPKT	**12**	**3**	**1**	**2**	**-**
EPPO	**10**	**-**	**2**	**2**	**5**
EPRZ	**2**	**3**	**2**	**2**	**7**
EPSC	**8**	**-**	**2**	**2**	**-**
EPWA	**3**	**3**	**3**	**3**	**11**
EPWR	**2**	**2**	**2**	**2**	**4**
EPZG	**6**	**1**	**2**	**1**	**4**

Source: The author's own study based on AIP Polska.

Analysing the data presented above, it can be seen that the most frequently used machines and devices include cleaning sets and ordinary snowploughs. Their numbers in individual airports is consistent with the number of operations performed in a relevant airport and, as a consequence, with the number of passengers served (refer to table 1). Large differences between the equipment of individual airports may be explained with (apart from economic factors) different levels of airport services competences.

Influence of the competences of an airport service manager on the level of information provided in real time

The proper preparation of the movement area is very important for the safety of the landing operations. However, it is not always possible (or too high costs make it unprofitable) to prepare the surface for the movement of airplanes in a way that ensures the highest possible friction coefficient.[10] Light rainfall or snowfall may have adverse effect on the adhesion of airplane wheels. In such an event, airport services have to provide the airplane crews with all information on the conditions at the airport, in particular the information on the friction coefficient. The safety levels during the ground run of an airplane[11] are closely correlated with the friction coefficient. One should be aware that the average passenger plane weighs app. 100 tonnes[12] and that it comes in to land with the speed of app. 250-300 km/h. Safe stopping of an object with such parameters requires a runway strip app. 2000 long[13] with a good friction coefficient of 0.75 for dry bituminous surface[14]. However, when this coefficient is reduced by 0.05, it is regarded as a significant change in conditions[15] and may have an influence on safety of the performed operation. With too low values of the coefficient, it is easy to get airplane wheels in a skid, what will always result in the longer braking distance and, in extreme cases, may also lead to the plane falling out of the runway strip. In addition, it should be emphasized that, in the case of modern turbojet airplanes, the difference between the braking distance on a dry surface and that on the icy surface may be, in extreme cases and for planes with poor landing parameters, as much as 900 metres.[16] This means that in disadvantageous weather conditions, when the friction coefficient is low and the landing airplane has poor braking parameters, the runway strip may be too short for the ground run. Suitable level of competences of airport service employees should guarantee a proper assessment of the movement area surface, the measurement of the friction coefficient, and the provision of this information to all parties interested with air operations as soon as possible. In this case, time is of material importance; it should be remembered that airplanes travel the average of 10-15

[10] The friction coefficient is a relationship between the friction force between a wheel and a runway strip surface and the value of the standard reaction. A higher value of the friction coefficient means that the braking force of the airplane wheels is higher and, as a consequence, the landing distance is shorter and the landing operation is safer.

[11] The ground run is a part of the landing operation consisting in stopping the airplane after its wheels touch the surface of a runway strip. This parameter is expressed in metres and describes the way travelled by the landing airplane from the moment of touching the surface of a runway strip until the complete stop.

[12] A 100-tonnes airplane belongs to the “medium” wake turbulence category. There are also the categories of “heavy”, from 136 to 540 tonnes, and “jumbo”, over 540 tonnes.

[13] For instance, the ground run for Tu-154 is 2100 m. http://pl.wikipedia.org/wiki/Tu-154.

[14] Politechnika Wrocławska, Instytut Inżynierii Lądowej Zakład Dróg i Lotnisk, Projekt wstępny drogi klasy technicznej G, Wrocław 2002.

[15] Annex 15 to the Convention on international civil aviation. Służba informacji lotniczej, edition 13, 2010.

[16] ICAO Doc. 9137/Part 2 *Airport services manual – pavement surface conditions*, edition 3, 1994.

kilometres per minute when flying. Below, the issues related to the measurement of the friction coefficient are presented as well as the SNOWTAM form, which is used to provide significant information on the condition of the movement area.

Measurement of the friction coefficient

Airport authorities are obliged to determine, for their own purposes, the friction coefficient in winter by performing daily measurements. They are held responsible for the decision whether the condition of the surface ensures safety of air operations. Obviously, certain specific weather conditions require special attention. These include, for example, the fluctuations of the temperature around the point of freezing or changing conditions when, for example, warm damp air touches a very cold surface. In addition, it should be expected that, if weather forecasts warn against a coming snowfall or black ice, it is likely that reports on the surface condition will have to be drawn up each hour or even more frequently as well as each time when it is suspected that the conditions on the runway strip have significantly changed (or when it is a consequence of other obvious reasons).

It should also be underlined that in difficult situations of this type, different values of the friction coefficient may occur depending on the material of the surface and on a part of the runway strip. When touching the surface, airplane wheels leave thin layers of gum, what also has an adverse effect on the friction coefficient. Therefore, the measurements of the friction coefficient should be performed on the surface of an actually used runway strip rather than on nearby strips or taxiways, which may be made of a completely different material.

The friction coefficient is determined through assessment or measurement. The selection of the method is not random; this means that specialist measurement devices should always be used if available. The assessment is performed if an airport does not have specialist equipment, what is often the case at airports with small traffic or military airports. The assessment is performed by a trained employee who, using a car, performs the braking test repeatedly on various parts of a runway strip, taxiways, and aprons. Based on the braking test, the braking efficiency is expressed using the 6-point scale. The accuracy of this method depends closely on the knowledge, skills, and experience of the employee. Braking, assessed this way, can be:

- 5 – good,
- 4 – medium/good,
- 3 – medium,
- 2 – medium/poor,
- 1 – poor,
- 9 – unreliable.

The assessment of braking is not accurate; therefore, the airplane pilot is obliged to exercise due care during the ground run.

Another method of determining the friction coefficient is the measurement. The measurement makes it possible to provide the pilot with a precise value of the coefficient and, what follows, to select the maximum possible braking force. The measurement can be performed using a device with an additional wheel which measures the skid when touching the examined surface. This device may have the form of an additional set towed with any vehicle or even a vehicle itself if it is equipped with an additional wheel. Depending on the method of leading or braking the testing wheel, the methods of measurement of the friction coefficient of aerodrome surfaces may be divided into 4 groups as follows:

1. Devices for the measurement of crosswise friction. This is a group of measurement devices where the testing wheel is not braked; it rolls freely and it deviates from the motion direction by a specific angle which depends on the general concept of the construction. The friction coefficient is determined according to the classical definition of friction by comparing the crosswise force having an effect on the wheel in a free rolling movement diagonal to the motion direction with a static load on the wheel (or wheels if the measurement system is equipped with two wheels). This group of devices includes Mu-Meter and SCRIM.
2. Devices for the measurement of the longitudinal friction coefficient with a permanent skid of the testing wheel on the surface. This is a large group of measurement devices, where the testing wheel moves, on the surface, with a skid forced kinematically or hydraulically, with a zero deviation from the motion direction. These devices measure the longitudinal friction coefficient by comparing the friction force with static pressure (load). This group of measurement devices include Griptester, DWW Trailer, and Skiddometer BV-11, which can often be seen at airports.
3. Devices for the measurement of the friction coefficient in conditions of a changing skid of the testing wheel. This is a specific group of measurement devices, where the testing wheel is braked with a controlled skid during the measurement. These devices are supposed to make it possible to determine complete parameters of longitudinal friction. These group includes Norsemeter.
4. Devices for the measurement of the friction coefficient with a full blockade of the testing wheel. This is a large group of measurement devices used as many construction versions (one or two wheels). During the measurement, the testing wheel (wheels) is completely blocked. The friction coefficient is measured according to the classical definition of friction (the testing wheel is not turning). This group of measurement devices includes Skiddometer BV-8, Stuttgarter Reibugsmesser, and Skid Resistance Tester.

When comparing the listed groups of measurement devices, it should be emphasized that different measurement conditions (mainly skid) cause that each of these devices measures the friction coefficient using a different scale with different numerical values. This is presented in Fig. 2, which shows all groups of the measurement devices with the example of longitudinal friction measurements at an aerodrome surface.[17]

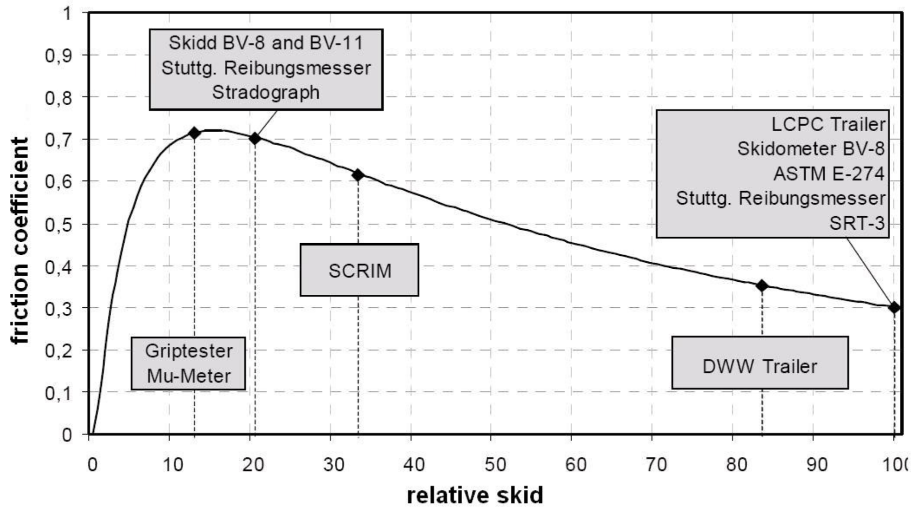

Fig. 2. Diversification of the methods of measuring the friction coefficient with exemplary measurements[18]
Source: http://www.gddkia.gov.pl

After a measurement, results should be recalculated and referred to a uniform scale, to provide airplane crews and air traffic services with a complete view of conditions on the runway strip. It is assumed that the following values of the friction coefficient (measured or calculated) are equal to the braking:

- 0.40 or more – GOOD,
- 0.39 to 0.36 – MEDIUM/GOOD,
- 0.35 to 0.30 – MEDIUM,
- 0.29 to 0.26 – MEDIUM/POOR,
- 0.25 and less – POOR.

[17] T. Mechowski, *Sprawozdanie z realizacji pracy TD-71.*
[18] For the purposes of this work, an example of real longitudinal friction measurements of a road surface treated as an airport surface have been adopted. Owing to the similarities between technical characteristics of both surfaces, the differences are negligible.

Advantages of devices of this type include accurate measurements; their disadvantages include high costs of the device (vehicle) itself as well as of the tire, which wears rather quickly. Examples of such devices are presented in the photos below.

Photo 8. Examples of devices for the measurement of the friction coefficient:
a) towed with a vehicle, b) attached to a car
Source: websites of manufacturers.

Another type of a device which measures the friction coefficient is a group of devices fixed on a vehicle and measuring the delay of the vehicle during braking. They include a braking force measurement devices – dynamometers – and Tapley meters. Advantages of this solution include a simplicity of measurements; its drawbacks include the possibility of using the devices only in specific conditions, i.e. on tamped down snow, ice, and very thin layers of dry snow. Delay meters cannot be used when the surface is covered with melting snow or slush or when there is a thin layer of water on an icy surface because the measurements can be misleading in such conditions. Measurements of other devices may also be unreliable when surfaces are covered with a certain mixture of contamination and when there are differences between the temperature of the air and that of the surface. The measuring employee should have suitable knowledge and experience in measuring the friction coefficient.

SNOWTAM form

SNOWTAM is a message sent via fixed communications measures (Aeronautical Fixed Telecommunication Network – AFTN, Internet etc.) containing information which is significant for the safety and regularity of air traffic flow, such as the friction coefficient, and type and thickness of contamination on the runway strip, taxiways, and aprons. This is a special

NOTAM series[19] sent when the conditions on a runway strip have changed significantly via air traffic services to an airplane. The following changes in the conditions on a runway strip are considered significant:

1) change of the friction coefficient by 0.05,
2) change of the contamination layer exceeding 20 mm for dry snow, 10 mm for wet snow, and 3 mm for melting snow,
3) change of the available runway strip length or width by 10% or more,
4) all changes of the type or size of contamination which require reclassification in fields F) or T) of the SNOWTAM form,
5) formation and/or changes in the height or distance from the central line of dangerous snow mounds on one side or both sides of a runway strip,
6) any changes of visibility of runway strip lights as a result of the lights being covered,
7) formation or changes of any other conditions recognized as significant according to experience or local situation.[20]

Each of the listed items means that all parameters which have influence on the ground run of an airplane are recognized as significant by the International Civil Aviation Organization and should be sent to airplane crews. In case of a relatively changing weather, airport services may have to measure the friction coefficient and the contamination thickness repeatedly during a day (apart from the cleaning). In addition, after each measurement, appropriate messages should be prepared and sent to those interested in air operations. The time of completing these tasks depends on many factors; however, only one of them changes. The equipment with machines and devices and the system of taxiways, runway strips and technical ways can be qualified as permanent factors because each airport has specific equipment (Table 1) and a permanent system of roads. A changing factor, one which often decides about the performance of tasks by airport services, is the level of competences of the employees. This parameter is changing because knowledge, skills, and experience change in time; they increas after each training and each period of duty. In addition, each employee may have a different level of competences. Therefore, the performance of tasks may depend on which employee is on duty at the given moment.

[19] NOTAM (NOtice To Air Man) – a message sent via telecommunications measures containing information the knowledge of which at an appropriate time is significant for the staff related to air operations.

[20] Annex 15 to the Convention on international civil aviation. *Służba informacji lotniczej*, edition 13, 2010.

Conclusions

Airport services are formed in order to maintain the movement area of an aiport clean, measure the friction coefficient, and draw up and send special messages describing the conditions in the movement area. Proper preparation of this part of an airport has a direct influence on the safety of air operations on ground and the orderly air traffic flow. Precise determination of the friction coefficient and quick provision of all information on the condition of the movement area to those interested in air operations also contributes to the high level of safety. Two methods of determining the friction on a runway strip are widely used, i.e. measurement and assessment. A more precise, though more expensive and complex, method is the measurement using a special device. The assessment of friction is performed by a qualified airport service employee using an ordinary car; the accuracy of this method depends closely on the knowledge, skills, and experience of the employee. Thus, proper performance of airport service tasks depends not only on the quantity and quality of the possessed equipment but also on the level of competences of the employees, which reflects their professionalism. This includes many factors, such as knowledge, qualifications, learnt skills, experience, and adopted attitudes and model behaviours.

Bibliography

1. ICAO Doc. 9137/Part 2 *Airport services manual – pavement surface conditions*, edition 3, 1994.
2. Penc J.: *Kreatywne Kierowanie*, Agencja Wydawnicza Placet, Warsaw 2000.
3. Cybulak P.: Fischer kontra PP Porty Lotnicze, 2006.
4. Sińczak J., Bednarek S., Łukaszek-Sołek A., Chyła P.: *Wytwarzanie łopatek turbin metodami przeróbki plastycznej – analiza numeryczna*, Mechanik No. 8-9, 2010.
5. Politechnika Wrocławska, Instytut Inżynierii Lądowej Zakład Dróg i Lotnisk, *Projekt wstępny drogi klasy technicznej G*, Wrocław 2002.
6. Annex 14 to the Convention on International Civil Aviation *Lotniska*, edition 5, 2009.
7. Annex 15 to the Convention on International Civil Aviation *Służby informacji lotniczej*, edition 13, 2010.
8. ICAO Doc. 4444 *Air traffic management*, Edition 15 – 2007.
9. Mechowski T.: *Sprawozdanie z realizacji pracy TD-71.*
10. Walczak W.: *Przywództwo i motywowanie w procesach zarządzania kompetencjami pracowników*, E-mentor No. 1 (38) / 2011.
11. http://doroszewski.pwn.pl – *Słownik języka polskiego W. Doroszewskiego*, Wydawnictwo Naukowe PWN S.A.
12. Politechnika Wrocławska, Instytut Inżynierii Lądowej Zakład Dróg i Lotnisk, *Projekt wstępny drogi klasy technicznej G*, Wrocław 2002.
13. http://www.gddkia.gov.pl
14. www.pasazer.com